Physical Activity Behavior and Health-Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables

Dissertation

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Abstract

Introduction: Parkinson’s disease (PD) is a chronic neurodegenerative disease of the brain, characterized by motor symptoms—tremor, rigidity, bradykinesia, slowness/smallness, and postural instability— as well as non-motor symptoms including anxiety, depression, sleep disorders, and cognitive deficits. The average age of onset for PD is 60, with earliest patients diagnosed at age 18. One out of 100 people over age 60 have PD. PD patients’ symptoms increase over time and medication does not slow down the progression of PD. Physical activity (PA) is one lifestyle behavior that may slow the progression of the disease and improve the quality of life of PD patients by maintaining their ability to accomplish functional activities of daily living and preserve their independence. However, knowledge of the motivational factors associated with PA in PD patients remains limited. Methods: The current study aimed to i) explore the relationship of select Social Cognitive Theory (SCT) constructs: self-efficacy (SE), outcome expectations (OE), and self-regulation (SR) with PA and health-related quality of life (HRQoL); ii) explore the relationship between PA and HRQoL; and iii) determine if SCT constructs mediate the relationship between PA and HRQoL in PD patients. Results: In this online cross sectional survey of 500 idiopathic PD patients, participants self-reported an average of just over 200 minutes of moderate to vigorous physical activity per week. SE and SR were the most significant predictors of PA. SE and OE were predictive of physical HRQoL, and the addition of BMI, age, Hoehn and Yahr Score, and total number...
of comorbidities more than doubled the amount of variance explained. To a smaller extent, SE, OE, and SR were predictive of mental HRQoL. SCT correlates mediated the relationship of PA to HRQoL. **Discussion:** The study population represented a population of PD patients with a high interest in physical activity. Self-reported average weekly moderate-to-vigorous physical activity (MVPA) was much higher than expected. Future studies should attempt to validate MVPA with some type of exercise monitor that would not be sensitive to tremor or other PD specific considerations. Analysis of self-regulation subscales may provide insight into why SR was predictive of physical HRQoL when modeled alone, but not with the other SCT correlates. A deeper evaluation of outcome expectation subscales might also provide a further explanation of why OE was predictive of MVPA when modeled alone, but not with SE and SR. Physical activity was a significant predictor of both mental and physical HRQoL. The covariates BMI, age, Hoehn and Yahr Score, GDS depression score, and total number of comorbidities significantly added to the explanatory power of the relationship between PA and physical HRQoL. These factors should be considered both potential mediators and moderators in future studies in the PD population.
Dedication

I would like to dedicate the following dissertation to my fiancée, Dan, for his tireless patience and willingness to read draft after draft during this process, and my cat, Felix, for his company and paper-laying abilities.
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Chapter 1: Introduction

Parkinson’s disease (PD) is a chronic neurodegenerative disease of the brain characterized by the motor symptoms: tremor, rigidity, bradykinesia, slowness/smallness, and postural instability (gait and balance are issues), as well as non-motor symptoms: anxiety, depression, sleep disorders, gastrointestinal issues and cognitive deficits. In addition to its impact upon the brain, it also affects the cardiovascular, gastrointestinal, and urinary systems of PD patients.

The onset of PD is gradual, with one side of the body typically demonstrating a unilateral tremor. Not all PD patients experience tremor, however; other signs and symptoms include loss of sense of smell, decreased eye blinking, reduced facial expression, and micrographia (small hand-writing). Speech may become low-pitched and inaudible. PD is highly prevalent in the Midwest and Northeastern portions of the United States, with about 450,000 new cases of PD diagnosed per year in the U.S. (Wright Willis, Evanoff, Lian, Criswell, & Racette, 2010). The average age of onset for PD is 60, with patients diagnosed as early as age 18. One out of 100 people over age 60 have PD (Hirtz et al., 2007). It is more common in Caucasians and is evenly distributed between genders. On average, PD patients live with their disease for 15 to 25 years from diagnosis to death, making PD a chronic condition. Approximately 60 to 80 percent of the dopamine-producing cells in the substantia nigra are lost before motor symptoms of PD

**Etiology of Parkinson’s Disease**

Although the causes of PD remain unknown, genetic and environmental factors are both thought to play a role. In terms of genetic factors, 15 to 25 percent of PD patients report a relative with PD, and there is a 4 to 9 percent increased risk of PD if a first-degree relative has PD. PD can be caused directly by several gene mutations, but these affect only a small number of families. Early-onset PD develops in individuals with genetic mutations in PINK1, LRRK2, DJ-1, and glucocerebrosidase. Overexpression of alpha-synuclein and PARKIN induce mitochondrial defects in DJ-1 and PINK1 mitochondrial proteins in response to oxidative stress. LRRK2 is currently the largest known genetic contributor to PD, but only a small percentage of PD cases are felt to be related to inheritance. Alpha-synuclein is also currently a focal area of research interest (www.michaeljfox.org).

Environmental factors associated with PD include exposure to environmental toxins and traumatic brain injury. Epidemiologic studies have identified rural living, well water, manganese, and pesticides as factors linked to PD. Prolonged occupational exposure to insecticides (Permethrin and beta-HCH), herbicides (Paraquat and 2,4-dichlorophenoxyacetic acid), the fungicide Maneb, and, potentially, exposure to Agent Orange. Synthetic neutorotoxins (MPTP) cause immediate and permanent Parkinsonism, and MPTP is one of the chemicals used to induce PD in animal studies. Human exposure
to synthetic neurotoxins are rare except for the case of injected heroin contaminated with MPTP (www.pdf.org).

PD patients experience increasing amounts of motor and non-motor symptoms of the disease over time which can cause reduced mobility, decreased balance, increased falls, increased anxiety, increased depression, decreased quality of sleep, increased cognitive decline, loss of independence, and overall reduced quality of life. Stress, poor sleep habits, changes in the weather, sedentary behavior, and lack of regular exercise tend to exacerbate PD symptoms.

**Current Approaches to Treatment of Parkinson’s Disease**

The primary treatment of PD typically includes cholinesterase inhibitors, such as Carbidopa/Levodopa or other drugs which reduce the motor symptoms of rigidity, tremor, and slowness/smallness (Gelb, Oliver, & Gilman, 1999). PD patients frequently suffer “ON” and “OFF” periods as medication effects increase and decrease before and after dosing. Deep Brain Stimulation (DBS) was developed in the 1990s as a neuro-surgical treatment for the symptoms of advanced PD, particularly the motor impairments. It is now a standard treatment option for PD patients who may no longer be benefitting from medication.

Physical therapy is often prescribed for PD patients, particularly those with gait and balance issues; however, the number of treatment sessions are typically limited while the patients continue to experience neurodegenerative decline over the course of the disease. Speech and voice therapy are also prescribed to counteract problems with speech and swallowing.
Healthy eating, as well as exercise and PA, are also recommended for PD patients. Healthy eating is recommended, especially for homebound patients who can be particularly at risk for malnourishment. Loss of mobility and independence make shopping for food, preparing food, and cooking difficult, and results in decreased ability to maintain functional activities of daily living.

Physical activity is recommended because it is a lifestyle behavior that leads to increased cardiovascular and muscular fitness, which improves patients’ ability to perform activities of daily living through better mobility, gait and balance, thus allowing them to maintain their independence. PA may also improve the non-motor symptoms of the disease by slowing cognitive decline, reducing depression, and improving stress management (Ahlskog, 2011; Cotman, Berchtold, & Christie, 2007; Monteiro-Junior et al., 2015).

Potential Limitations to Current Standard-of-Care Approaches to Treatment

There are several salient limitations to standard-of-care approaches to PD treatment. Medication, for example, does not slow down the progression of PD, and over time medications become less effective and PD patients increasingly suffer from difficulties with movement and activities of daily living. In addition to tolerance and decreased effectiveness of L-dopa over time, there are side effects with PD medications, including: hallucinations, delusions, psychosis, and dyskinesia. It is imperative that healthcare providers not limit research to finding a cure for PD and other related neurological disorders, but also investigate ways to improve quality of life during the
several decades that patients may suffer from both the motor and non-motor symptoms of the disease, so that they can live well with PD.

Although it is well established that regular exercise participation is an important aspect of a healthy lifestyle, adoption and adherence remain a challenge, with many individuals falling short of recommended guidelines. Physical inactivity in PD patients may initiate a cycle of deconditioning followed by increased disability (Speelman et al., 2011). PD patients are about one-third less active than older adults, with a 13% decrease in PA between Hoehn and Yahr Stages I-II, increasing to an 84% decline in PA by the time a patient reaches Stage IV (van Nimwegen et al., 2011).

Research by (Baatile, Langbein, Weaver, Maloney, & Jost, 2000) suggests that a regular exercise program can increase dopamine levels and metabolism, which in turn, can increase functional independence in PD patients. Although these findings provide support for the potential benefits of PA participation in PD patients, knowledge of the motivational factors associated with PA behavior in PD patients has yet to be adequately delineated. In this regard, it has been proposed that social cognitive theory correlates should be further investigated to determine which constructs best predict PA behavior in PD patients, and better inform the development of interventions tailored to the needs of this population (Sweet, Fortier, Strachan, & Blanchard, 2012). A more comprehensive understanding of the relationship of physical activity to health-related quality of life outcomes in PD patients is also important in determining the extent to which PA may be linked with more favorable levels of clinically relevant outcomes.
Unfortunately, evidence suggests that exercise adherence in older adults in general is poor following physical therapy, leading to loss of initial gains that resulted from therapy, a return to a sedentary lifestyle, and worsening disability over time (Ellis et al., 2005; Forkan et al., 2006). Furthermore, access to physical therapy as a treatment modality for PD patients is limited in our current medical system in the U.S. Additionally, neurodegenerative diseases like PD, too often have limited treatment plans that do not fit into the continuum of care for this and other chronic disease populations who need care from diagnosis through end-of-life. Examining the relationship of self-efficacy, outcome expectations, and self-regulation to physical activity would contribute to developing a more comprehensive understanding of the association of these established correlates of PA behavior in PD patients. This evidence could subsequently aid in determining how best to integrate PA into the medical management of PD.

**Definition of Terms**

**Basal Ganglia Movement Disorders:** These range from hypokinetic disorders with too little movement to hyperkinetic disorders with excessive movement. The basal ganglia inhibit the motor thalamus, the pedunculopontine nucleus (PPN), and the midbrain locomotor region (MLR). Excessive inhibition of the basal ganglia results in hypokinetic disorders, and inadequate inhibition results in hyperkinetic disorders.

**Parkinson’s Disease (PD):** The reference to PD is primarily referring to idiopathic PD, which is the most common of the hypokinetic basal ganglia motor disorders and is the focus of this study. There are three subtypes: 1) akinetic/rigid—characterized by shuffling gait, muscular rigidity, drooping posture, rhythmic muscular
tremors, and a mask-like facial expression, and patients are prone to falls because of their inability to generate adequate muscle force quickly; 2) tremor dominant—characterized by the presence of both action and resting tremors as observed when getting dressed and during eating with little rigidity and slowing of movement; and 3) mixed, which is characterized by both akinetic/rigid and tremor dominant traits.

**Parkinson-Plus Syndromes (PPS):** PPS refers to other disorders that cause signs similar to that of PD but are not true idiopathic PD. Early postural instability, rapid progression of disease, abnormal postures, respiratory problems, uncontrollable and inappropriate laughter or crying, and signs of cerebellar, corticospinal, or voluntary gaze dysfunction are red flags indicating that the disease is not idiopathic PD. PPS include: dementia with Lewy bodies, which causes early rapid cognitive decline and visual hallucinations and resembles akinetic/rigid PD; multiple system atrophy (MSA) which is characterized by akinetic/rigidity, cerebellar signs (dysarthria–uncoordinated speech, truncal and gait ataxia or lack of coordination); autonomic dysfunction (postural hypotension, bladder and bowel incontinence, abnormal respiration, decreased salivary function in addition to decreased sweating and tears, and impotence in men); corticospinal tract dysfunction (difficulty directing attention and decreased goal-oriented cognitive ability); and progressive supranuclear palsy (freezing of gait, tendency to fall backward, axial rigidity, depression, psychosis, rage attacks, and supranuclear gaze palsy–inability to voluntarily control gaze). Idiopathic PD is distinguished from MSA by the presence of autonomic and cerebellar signs characteristic of MSA but missing from PD.
**Parkinsonism:** This describes disorders that mimic PD but differing in that the origin of the disorder is known to be a traumatic brain injury, toxic exposure, or of infectious origin and is characterized by lesions of the lentiform nucleus. Parkinsonism can be a side-effect of drugs used to treat psychosis or digestive issues, and it is often mistaken for PD in the elderly, leading to unnecessary treatment.

**Physical Activity (PA):** The World Health Organization (WHO) defines PA as any bodily movement produced by skeletal muscles that requires energy expenditure. The Centers for Disease Control and Prevention (CDC) states that regular physical activity helps improve your overall health and fitness, and reduces your risk of chronic disease. The American College of Sports Medicine’s Position Stand for Older Adults (Chodzko-Zajko et al., 2009; Nelson et al., 2007), recommends that all older adults engage in regular PA and avoid an inactive lifestyle. The term ‘physical activity’ is often used interchangeably with exercise; however, ‘exercise’ is a subset of PA that is planned, structured, repetitive, and purposeful. In this study, we use PA broadly to include both structured exercise as well as walking and stair-climbing. Lifestyle physical activities such as physical work and gardening were not included in this study.

**Quality of Life (QoL) and Health-related Quality of Life (HRQoL):** Health-related disciplines often reference QoL as a person’s satisfaction with life overall (Diener, Emmons, Larsen, & Griffin, 1985; B. C. Focht, Lucas, et al., 2014; R. Gobbi et al., 2009). In this study, we used the Satisfaction with Life Scale to measure an individual’s cognitive judgement of their life satisfaction. The term HRQoL is a reference to quality of life as a measure of health status. For HRQoL measurement, we used the
Short Form-12, which was originally developed for the Medical Outcomes Study over several years of studying patients with chronic conditions. It includes eight subdomains: general health, physical function, physical role functioning, bodily pain, vitality, emotional role functioning, mental health, and social functioning (Ware Jr, Kosinski, & Keller, 1996).

**Social Cognitive Theory (SCT):** SCT correlates are important to understand because human beings actively think about their behaviors and the consequences of behaviors through cognitive processes. It is based on the tenet that people try to control events that impact their lives and this motivates all volitional behavior. Bandura coined the term “reciprocal determinism” which references the bi-directional link between behavior (type, frequency, and duration), personal factors (cognitive, affective and biological—thoughts, attitudes, mood), and the environment (built, facility, social). Bandura believed personality represents the interaction between psychological processes, behavior and the environment. SCT presumes that cognitive processes influence an individual’s ability to control personal, behavioral, and environmental factors. SCT can be helpful in identifying methods for behavior change by developing an understanding of individual or group behavior (A. Bandura, 1977; Albert Bandura, 1989, 1991, 1993, 1994, 1997, 2001, 2004).

Of SCT’s core constructs, self-efficacy (SE) refers to a person’s innate belief that an action will produce the desired effect. SE is derived from four major sources of information: past performance accomplishments, vicarious experience, social or verbal persuasion, and physiologic or affective states. SE’s role and influence in behavioral
interventions changes over time. In an exercise intervention with a goal of increasing exercise participation in individuals, the adoption of exercise initially is strongly related to the individual’s SE. During the maintenance phase of the new exercise behavior, SE is moderately related to the individual’s participation. At the end of the structured program or when an individual relapses from the exercise program, SE is again strongly related to the individual’s success in continued exercise participation. SE is higher if the individual had a successful experience (mastery) and had to overcome barriers to succeed.

Observing the success of others—those who an individual perceives to be less capable—can be a powerful motivator to change or achieve a behavior; seeing a less-fit friend complete a half-marathon may increase an individual’s SE and inspire the goal to achieve and complete a half-marathon. Social modeling is less powerful at increasing SE than mastery but can be powerful in certain situations.

Social persuasion in the form of meaningful, specific feedback from an individual whose opinion matters is a moderately effective means of enhancing SE. This can be particularly important to individuals who are currently struggling with a situation. Social support can be a strong motivator to encourage individuals to explore a new behavior, in addition to being a source of increasing SE.

SE can also be influenced by changes in how an individual’s body feels or responds as the result of a behavior. An individual’s perceptions of somatic sensations influence their SE either positively or negatively. For example, a first-time half-marathoner who trains appropriately, and successfully completes the race may experience the high of running and completing the race without lingering fatigue or body aches. This
individual’s SE should increase for running as a result of their experience. Another individual in the same situation who thought they could complete a half-marathon without the appropriate training may feel like they were “run over by a truck” upon completion or even need to walk to finish the race. This person’s running SE will likely decrease as a result of the experience.

The individual’s psychological response to a situation can either negatively or positively impact their SE. Similar to the example above, the runner who easily completed the half-marathon likely feels positive about the experience and their SE increases, where the runner who doesn’t complete the race feels disappointed and dissatisfied, negatively impacting their SE. SE is situation and behavior specific. It’s an individual’s confidence in their ability to achieve a desired outcome. One may have high SE to fly a plane and low SE to ride a bike.

Outcome expectations reflect what an individual expects to happen based upon a certain set of behaviors. OE are formed both from an individual’s past experiences and by vicariously observing others. They encompass the desired social, physical, and self-evaluative aspects that go along with behavior to help an individual to decide when to take action or when to suppress a behavior.

The goal-setting (GS) and self-regulation (SR) construct is related to the self-determined management of goal-directed behaviors and an individual’s ability to create a plan of action to achieve a desired outcome. The goals themselves represent anticipated, preferred, or desired outcomes. GS exemplifies the point SCT makes that beyond learned
behavior, individuals can think about the future and create a plan of action to achieve a desired outcome. Goals are interconnected with a person’s perceived SE and OE.

**Hypotheses and Goals**

**Objectives**

The purpose of this observational cross-sectional study was to determine correlates of lifestyle behaviors (PA) and health-related quality of life.

The hypotheses were: higher levels of PA would be associated with higher levels of HRQoL; higher levels of PA would be associated with higher levels of SE, OE, and SR; Higher levels of SE, OE, and SR would be associated with higher levels of HRQoL; and SCT constructs—SE, OE, and SR—would mediate the relationship between PA and HRQoL.

**Significance and Background of Parkinson’s Disease**

Early diagnosis is not possible in PD for several reasons. First, because 60 to 80 percent of the dopamine in the brain has died before symptoms appear. Secondly, because there is no currently available biomarker test or tests that could be used to diagnosis and screen individuals. At this time, a PD diagnosis cannot be confirmed until death. Current standard of care is to give patients presenting with PD-like symptoms the drug combination Carbidopa/Levodopa, and if the medication works to alleviate symptoms, then PD is diagnosed. Often times, how the disease progresses over time may change the initial diagnosis to Parkinsonism or one of the Parkinson’s Plus Syndromes. In the context of discovering effective disease management strategies to alleviate the long-term impact of this chronic disease, identifying theory-based behavioral strategies to help
PD patients make positive lifestyle changes in regards to PA is an important step towards designing large scale randomized controlled trials (RCTs) to improve clinically relevant outcomes over the decades that patients will have to live with this disease.

**Innovation**

Background and Rationale

Regular PA in PD can increase dopamine levels and improve metabolism (Baatile et al., 2000; Ellis et al., 2005). The actual degree of increase in dopamine levels depends on the frequency, intensity, and duration of exercise. The benefit of exercise training for PD patients has appeared in the research literature in the past decade (Kwakkel, de Goede, & van Wegen, 2007; Tomlinson et al., 2013).

The body of evidence in the physical therapy and rehabilitation literature supports the association between PA and improvements in quality of life for PD patients. However, few studies have examined the underlying variables that may account for this relationship in PD patients. Researchers have examined stages of readiness to exercise in PD patients and barriers to exercise and found a strong association between SE and exercise in PD patients, rather than disability (Ellis et al., 2013; Ellis, Cavanaugh, Earhart, Ford, Foreman, & Dibble, 2011; Ellis, Cavanaugh, Earhart, Ford, Foreman, Fredman, et al., 2011).

It is well established that SCT constructs are consistently associated with PA across the lifespan. However, the evidence of the extent to which SCT constructs are associated with PA behavior in PD patients remains limited. Nevertheless, it has been proposed that these constructs should be targeted in interventions for PD patients (Ellis et
al., 2013). In an overview of PA behavior change in neurological patients, examples from both PD and MS were compared, suggesting that research results from each disease should be used to further inform the research in neurological diseases, including Alzheimer’s, PD, and MS. Both PD and MS patients face loss of independence related to significant declines in mobility and activities of daily living which further results in decreasing health-related quality of life over the course of their disease. Neuro-rehabilitation through participation in PA and exercise may attenuate loss of function. Physical inactivity is prevalent in both diseases and may be related to deconditioning and worsening of disease outcomes (Ellis & Motl, 2013).

In the past few years, SCT research-based interventions designed to increase PA in persons with PD and MS have been highlighted as a promising area of continued study (Ellis et al., 2013). PD participants with high SE were more than twice as likely to regularly exercise than those with low OE, lack of time to exercise, and fear of falling (Ellis, Cavanaugh, Earhart, Ford, Foreman, & Dibble, 2011; Ellis, Cavanaugh, Earhart, Ford, Foreman, Fredman, et al., 2011).

In summary, the purpose of the present study is: i) explore the relationship of select SCT constructs—SE, OE, and SR with PA; ii) explore the relationship between PA and HRQoL; and iii) determine if SCT constructs mediate the relationship between PA and HRQoL in PD patients. Findings from this study will expand knowledge addressing PA behavior in PD patients in multiple ways. First, relative to studies in the extant literature, the proposed study provides a comprehensive evaluation of key SCT-based correlates of PA in a large, representative sample of PD patients. Additionally, the
present study is among the first to evaluate the relationship of PA and HRQoL in PD patients or to explore the potential mediational relationships of key SCT constructs among PD patients. This study’s results will provide a more comprehensive understanding of the motivational factors associated with PA, the link between PA and HRQoL, and the extent to which key SCT-based constructs may mediate the PA and HRQoL relationship among PD patients. Expanded knowledge of these factors will aid in informing future efforts to promote PA as part of the medical management of PD.
Chapter 2: Literature Review

Epidemiology of Parkinson’s Disease

Incidence

James Parkinson first described the disease named after him in England in 1817. A cross-sectional study of U.S. Medicare beneficiaries aged 65 and older between 1995 and 2005 found PD to be more common in Whites and to be non-randomly distributed in the Midwest and Northeastern part of the United States (Wright Willis et al., 2010). Further, the study found that incidence rates varied by race and ethnicity, with Hispanics having the highest incidence (476 per 100,000), followed by non-Hispanic Whites (452 per 100,000), African-Americans (362 per 100,000), and Asians (339 per 100,000). The incidence rates from this slightly older population also displayed a gender bias, with male incidence rates about 50% higher than female incidence rates across races and ethnicities. A 1994–1995 study of PD patients enrolled in Kaiser Permanente Medical Care Program of Northern California reported incidence rates rapidly increasing after 60 years of age, with only 4% of patients under the age of 50 (Van Den Eeden et al., 2003). The average age of onset for PD is 60, with earliest patients diagnosed at age 18.

Prevalence

In 2014, the Michael J. Fox Foundation estimated the worldwide prevalence of PD to be 5 million, including approximately 1 million people in the U.S. living with PD. Age-standardized PD prevalence in the Wright Willis et al. (2010) study was 1,672 per 100,000 in non-Hispanic Whites, compared to 1,036 per 100,000 in African Americans, and 1,139 per 100,000 in Asians. One out of 100 people over age 60 have PD.
Mortality

PD patients do not die from PD; they die with PD from complications of the disease. Difficulty swallowing can lead to aspiration of food into the lungs causing pneumonia or other potentially fatal pulmonary problems. Also, balance issues may result in falls causing serious injury or death. Deaths from PD complications make it the fourteenth highest cause of death in the U.S. according to the Centers for Disease Control and Prevention (CDC). In 2011, 23,107 PD patients died from complications of the disease, resulting in an age-adjusted death rate of 7.0 (Hoyert & Xu, 2012).

Etiology of Parkinson’s Disease

PD is a basal ganglia movement disorder. The basal ganglia is comprised of the putamen, caudate nucleus, nucleus accumbens, internal and external globus pallidus, subthalamic nucleus, and the substantia nigra, and its role is to control muscle tone and movement from somatosensory and motor cortex input. Neurons in the brain produce dopamine in the substantia nigra pars compacta (SNpc) and to a lesser degree the ventral tegmental area (VTA). Dopamine is a neurotransmitter that chemically relays messages from the substantia nigra to other parts of the brain, particularly the motor cortex part of the brain that controls movements. The motor symptoms of PD appear when 60 to 80 percent of the dopamine-producing cells in the substantia nigra have died. This process is called “neurodegeneration”. Figure 1 displays an overview of dopamine and the circuitry of the brain.
Genetic and environmental factors are both thought to play a role in the disease pathology. In terms of genetic factors, 15 to 25 percent of PD patients report a relative with PD, and there is a 4 to 9 percent increased risk of PD if a first-degree relative has PD. However, PD can be caused directly by several gene mutations, but these affect only a small number of families. Early-onset PD develops in individuals with genetic mutations in PINK1, LRRK2, DJ-1, and glucocerebrosidase. Overexpression of alpha-synuclein and PARKIN induce mitochondrial defects in DJ-1 and PINK1 mitochondrial
proteins in response to oxidative stress. LRRK2 is currently the largest known genetic contributor to PD, but only a small percentage of PD cases are felt to be related to inheritance (Pankratz et al., 2009). Alpha-synuclein (α-syn) is currently a strong area of research interest.

One current theory regarding α-synuclein, Braak’s hypothesis, posits that the disease process starts in the lower brainstem; specifically, it begins in the dorsal motor nucleus of the vagus nerve (DMV) and the olfactory bulb or anterior olfactory structures (Braak, Rüb, Gai, & Del Tredici, 2003). Central to Braak’s theory is that the disease progresses from the DMV through the medulla, pontine tegmentum, midbrain, and the basal forebrain, before reaching the cerebral cortex (Hawkes, Del Tredici, & Braak, 2009). Braak and his colleagues developed a staging system to assess this process by measuring the regional distribution of α-syn immunoreactive structures (Visanji, Brooks, Hazrati, & Lang, 2013). Early appearance of the non-motor symptoms of PD, such as loss of sense of smell (hyposmia), sleep disorders, and constipation tend to precede the motor symptoms of the disease by several years and seem to support this hypothesis. In order to find methods for early detection of PD, researchers continue to explore “non-motor” symptoms as a potential avenue to treat PD as early as possible to prevent disease progression.

Environmental factors associated with PD include exposure to environmental toxins or traumatic brain injury. Epidemiologic studies have identified rural living, well water, manganese, and pesticides as factors linked to PD (Lotti & Bleecker, 2015). Prolonged occupational exposure to insecticides (Permethrin and beta-HCH), herbicides
(Paraquat and 2,4-dichlorophenoxyacetic acid (2,4-D)), the fungicide Maneb, and potentially exposure to Agent Orange. Synthetic neurotoxins e.g. 1, 2, 3, 6 - tetrahydropyridine (MPTP) causes immediate and permanent Parkinsonism and is one of the chemicals used to induce PD in animal studies. Human exposure to synthetic neurotoxins are rare except for the case of injected heroin contaminated with MPTP (Langston, Ballard, Tetrud, & Irwin, 1983).

**Diagnosis of Parkinson’s Disease**

PD is diagnosed during a physical examination by a neurologist by using a combination of symptomology and diagnostic tests. For a diagnosis of PD to be made, patients must present with two of the four main motor symptoms: (1) shaking or tremor; (2) bradykinesia; (3) stiffness or rigidity of arms, legs, or trunk; and (4) postural instability. Theses motor symptoms must be present over time for a neurologist to consider a diagnosis of PD. The doctor reviews current and past medications to make sure they are not causing the symptoms that are similar to PD. The neurologist will perform tests to assess gait, balance, muscle tone, and agility of arms and legs. A DAT scan may also be used to help diagnose PD. However, DAT scans can only differentiate PD from essential tremor—DAT scans cannot differentiate PD from other subtypes. Clinically, the diagnosis of PD is made by prescribing Carbidopa/Levodopa or another medication that imitates or stimulates the production of dopamine. If motor symptoms improve significantly, the diagnosis of PD is made. Currently, confirmation of diagnosis cannot be done until autopsy at death. However, if current research successfully develops biomarkers of PD, this should improve diagnosis and treatment.
Neurologists, preferably with a specialization in movement disorders, evaluate the progression of the disease using several tools. In Table 1, the Hoehn and Yahr (H&Y) staging scale is a simple tool to monitor the progression of the motor symptoms of PD.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No signs of disease.</td>
</tr>
<tr>
<td>1</td>
<td>Unilateral symptoms only. Mild symptoms do not interfere with daily activities. Friends and family may notice lack of facial expression, changes in walking and posture.</td>
</tr>
<tr>
<td>1.5</td>
<td>Unilateral and axial involvement.</td>
</tr>
<tr>
<td>2</td>
<td>Bilateral symptoms.</td>
</tr>
<tr>
<td>2.5</td>
<td>Mild bilateral disease with recovery on pull test.</td>
</tr>
<tr>
<td>4</td>
<td>Severe disability, but patient is still able to walk or stand unassisted.</td>
</tr>
<tr>
<td>5</td>
<td>Needing a wheelchair or is bedridden unless assisted.</td>
</tr>
</tbody>
</table>

The Unified Parkinson’s Disease Rating Scale (UPDRS) is a detailed, universal measurement scale of PD symptoms that clinicians use to assess the patient during a physical exam (Christopher G Goetz et al., 2008). The UPDRS allows movement disorder specialists to comprehensively assess and document a patient’s progression and is useful for comparison over time or communicating with other clinicians. The UPDRS is comprised of four parts and includes a total summed score—Part I: Non-motor
experiences of daily living; Part II: Motor Experiences of Daily Living; Part III: Motor Examination; and Part IV: Motor Complications (C. G. Goetz et al., 2010).

**Outcomes of Parkinson’s Disease**

Similar to the Framingham Heart Study, The *Parkinson’s Outcomes Project* is a clinical study which began in 2009 and currently has approximately 10,000 patients in four countries participating. It is being conducted by principal investigators affiliated with National Parkinson’s Foundation Centers of Excellence in order to obtain comprehensive longitudinal data on PD. Research is focused on treatment effectiveness, best candidates for each treatment, benefits of therapy, benefits of exercise interventions, and impact on caregivers.

Project researchers have found that interventions targeted to provide neuroprotective effects, such as exercise, may change the course of the disease. For example, increasing PA to at least 2.5 hours per week was associated with a slowing in the decline of quality of life (Rafferty et al., 2015). Depression and anxiety are the most frequently reported non-motor symptoms of PD in terms of impacting the overall health status of patients. Although anxiety reduction through exercise is not currently supported in the PD literature, studies using exercise or PA to treat depression are well-supported (Quelhas & Costa, 2009; Rojo et al., 2003).

Other important highlights of the project include encouraging patients to receive regular care from a neurologist, and more importantly, a neurologist specializing in movement disorders in order to prevent complications that may lead to further morbidity and mortality. Another issue is that PD patients receive vastly different treatment plans
depending upon where they receive care. Research can support evidence-based medicine to develop more consistent standards of care.

**Treatment Options for Parkinson’s Disease**

PD patients have depleted dopaminergic neurons in the substantia nigra in the brain. This depletion results in problems in both initiation and coordination of muscle movement. Primary treatment of PD is directed to replenish dopamine in the brain or simulate the action of dopamine in the brain. Dopaminergic medications are designed to lessen tremor, reduce muscle rigidity, and decrease bradykinesia (or improve the speed and coordination of movement). Dopamine administered peripherally is ineffective because it cannot penetrate the blood-brain barrier. The precursor to dopamine is levodopa, which can penetrate the blood-brain barrier for conversion into dopamine by the amino acid decarboxylase or dopa decarboxylase enzyme.

Levodopa was the first medication found to be effective in treating PD. It was developed in the late 1960s, and in pill form, it is absorbed into the blood and travels from the small intestine through the blood to the brain via the blood-brain barrier. Levodopa is typically given in combination with another medication called Carbidopa. Carbidopa is a dopa decarboxylase inhibitor, so it slows the peripheral conversion of levodopa to dopamine. This is important because orally administered Levodopa rapidly converts to dopamine peripherally before it passes the blood-brain barrier, which not only decreases the desired therapeutic effect, but also causes undesirable GI side effects such as nausea and vomiting. Carbidopa paired with Levodopa enhances the effect of Levodopa, allowing more Levodopa to cross the blood-brain barrier at a much lower dose
so side-effects are minimized. Common side effects include nausea, vomiting, loss of appetite, lightheadedness, low blood pressure, confusion, and dyskinesia. Sudden onset of sleep and compulsive behaviors are other, less common, side effects. Protein consumption within 30 to 60 minutes of a dose of Carbidopa/Levodopa can interfere with the absorption of the medication.

Carbidopa/Levodopa is now available through a dopamine intestinal infusion pump (DUOPA™), which infuses the drug continuously for 16 hours directly into the small intestine. DUOPA patients may have reduced “OFF” times compared with the oral medication; however, because the pump involves a percutaneous gastrojejunostomy tube, infections are a potential complication, along with an increased risk of hallucinations, psychosis, and confusion.

Dopamine agonists are another class of drugs approved by the FDA in 1997. The most commonly prescribed dopamine agonists are Pramipexole, Ropinirole, and Rotigotine (skin patch). These drugs work by mimicking the effects of dopamine without being converted. Dopamine agonists are effective in treatment of early motor symptoms and help control motor fluctuations. Apomorphine is another dopamine agonist first used to treat PD in 1950 although with severe side effects. A self-injectable form was created in the 90’s for use as a “rescue” drug for patients with advanced PD and severe “OFF” episodes. Excessive daytime sleepiness, visual hallucinations, confusion, ankle swelling, dyskinesia, and compulsive behaviors are potential side effects of dopamine agonists.

Amantadine is used in combination with Levodopa to treat dyskinesia in the later stages of PD. It was originally developed in the 60’s as an antiviral medication to treat
influenza. Side effects include nausea, lightheadedness, insomnia, confusion, hallucinations, ankle swelling, and–infrequently–livedo reticularis, which is a purplish discoloration of the skin on the legs.

The earliest medications used to treat PD in the early 1900s were anticholinergics. This class of drugs is most helpful to younger patients with tremor-predominant PD. The side effects of anticholinergic drugs may limit their usefulness. These include confusion, hallucinations, decreased short-term memory, dry mouth, blurry vision, and urinary retention.

Entacapone and Tolcapone are two catechol-o-methyltransferase (COMT) inhibitors which can be effectively used in combination with Levodopa. COMT inhibitors block the COMT enzyme from converting Levodopa into an unusable form. COMT inhibitors reduce the “OFF” symptoms between doses of Levodopa, but without Levodopa, COMT inhibitors have no effect on PD symptoms. The side effects of COMT inhibitors include potential exaggeration of Levodopa-related side effects like dyskinesia, confusion, hallucinations, reddish brown or rust-colored urine, and diarrhea.

Another class of drugs currently used to treat PD are called monoamine oxidase B (MAO-B) inhibitors. Selegiline and Rasagiline are examples of MAO-B inhibitors used with Levodopa to enhance its effect. MAO-B is an enzyme that breaks down dopamine in the brain. MAO-B inhibitors block the breakdown of dopamine, making more dopamine available and reducing the motor symptoms of PD. MAO-B inhibitors may be used early in the treatment of PD, however, they are more commonly used with other medications to reduce “OFF” time and extend “ON” time.
The most common side effects of this drug class include mild nausea, dry mouth, lightheadedness, constipation, confusion, and hallucinations. Taking some MAO-B inhibitors while consuming aged cheeses or wines high in tyramine is contra-indicated as it may raise blood pressure to dangerously high levels. The “cheese effect” has not been observed with Selegiline or Rasagiline.

There are several surgical procedures available as treatment options for PD patients. Deep brain stimulation (DBS) is currently used to treat patients whose symptoms cannot be adequately controlled with medications. The process uses a surgically implanted neurostimulator to deliver electrical stimulation to targeted areas of the brain. The targeted areas for implantation of the neurostimulator are the thalamus, the subthalamic nucleus (STN), and a portion of the globus pallidus interna (GPi). The electronic signals interfere with or block the electrical impulses that cause PD symptoms. The procedure is used to treat tremor, rigidity, stiffness, slowness of movement, and gait problems. DBS works similarly to a pacemaker for the heart. The neurostimulator is implanted under the skin, usually near the collarbone with a wire connecting it to the electrode in the brain.

After undergoing DBS, most patients experience a reduction in their PD symptoms and a concomitant reduction in medication. This leads to a reduction in dyskinesia caused by long-term use of Levodopa. This is a good option for patients who have experienced some of the negative side effects from the medications and whose PD is poorly managed and controlled. For these patients, DBS may greatly improve functional abilities and quality of life.

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Less common surgical treatment options include thalamotomy, pallidotomy, and subthalamotomy which involve destroying specific areas of the brain (thalamus, globus pallidus, and subthalamus). These procedures are rarely done today, but prior to DBS they were used to reduce the motor symptoms of PD.

**Physical Activity for Parkinson’s Disease Patients**

Physical inactivity in PD patients may initiate a cycle of deconditioning followed by increased disability (Speelman et al., 2011). PD patients are about one-third less active than older adults, with a 13% decrease in PA between Hoehn and Yahr Stages I-II, increasing to an 84% decline in PA by the time a patient reaches Stage IV (van Nimwegen et al., 2011).

This highlights the importance of exercise as an important part of healthy living for PD patients, as it is vital to preserving balance, mobility, and activities of daily living. Baatile et al. (2000) suggests that a regular exercise program can increase dopamine levels and metabolism, which in turn can increase functional independence in PD patients. The actual degree of increase in dopamine levels depends upon the frequency, intensity, and duration of exercise.

People with a history of moderate to vigorous exercise may have a decreased risk of developing PD (Thacker et al., 2008), and individuals with consistent and frequent participation in moderate to vigorous activities had approximately a 40% lower risk of developing PD than those who were inactive (Xu et al., 2010). Exercise has been demonstrated to have neuro-protective effects in PD patients (Hirsch & Farley, 2009). In addition, researchers found that PA reduces the risk of cognitive decline, which is of
concern in PD, as well as other neurodegenerative diseases like Alzheimer’s (Hamer & Chida, 2009).

In 1986, a prospective study of 48,574 young adult men and 77,254 young adult women providing PA information found 252 males and 135 females were identified with PD. Greater baseline PA and strenuous exercise in early adulthood were inversely related to PD risk in men (about 60% lower than men who regularly exercised less than two months per year). In women, only strenuous exercise in early adulthood was inversely related to PD risk (Chen, Zhang, Schwarzschild, Hernan, & Ascherio, 2005).

F. Yang et al. (2015) followed 43,368 individuals for an average of 12.6 years to evaluate PD risk prospectively. Researchers identified 286 PD cases. Individuals with greater than 6 hours of household and commuting activity per week had a 43% lower risk of PD. Physically demanding occupational activity was not significantly associated with PD risk; however, with increasing occupational activity demands, a decreasing risk of PD was suggested. A medium level of PA of 39.1 MET-h/day was associated with a 45% lower PD risk in males. General PA was associated with a lower risk of PD in both genders combined and males alone. Leisure time exercise was not associated with PD risk when analyzed alone. Higher PA levels were associated with lower PD risk in both genders. The authors concluded that total energy expenditure represents a more comprehensive picture of daily physical activities in risk prediction. Aerobic exercise and strength training have been associated with improved outcomes in PD patients—UPDRS-III motor scores and functional capacity improved in a small study of 22 patients
recruited to participate in an exercise intervention twice per week for 12 weeks (Carvalho et al., 2015).

During aging, cognitive function and neural processes do not degrade in a uniform manner. The prefrontal and frontal lobes of the brain and the executive control functions undergo large and disproportionate changes as we age. Kramer et al. (1999) studied 124 previously sedentary older adults aged 60 to 75 years old. The participating adults were randomly assigned to an aerobic (walking) group or anaerobic (stretching and toning) group and observed over six months. Those in the aerobic group showed improvements in tasks requiring executive control compared to the anaerobic group. Aerobic exercise training alone in a recumbent bike training program three times per week over 12 weeks resulted in significant improvement in aerobic capacity. In addition, executive functioning significantly improved for inhibition but not flexibility in this group, leading the authors to conclude that aerobic exercise can be a valuable non-pharmacological intervention to promote fitness and improve cognitive and procedural functioning in PD patients (Duchesne et al., 2015).

Neuroplasticity

Neuroplasticity is a term that describes the neuronal addition and formation of new circuits in the brain. The addition of new neural circuits slows after adolescence but does not stop. Regular PA contributes to the development and maintenance of optimal neural circuitry in middle and older ages (McArdle, Katch, & Katch, 2010). Exercise may reduce risk for common neurodegenerative diseases and age-related cognitive decline by enhancing brain connectivity and protecting synapses from age-related deterioration. The
essential components of neuroplasticity are neurotransmission, synaptogenesis, and neurogenesis. Exercise-induced changes at the molecular and circuit level of the brain include these essential components (Paillard, Rolland, & de Souto Barreto, 2015; Petzinger et al., 2015).

Neurotrophic factors are a family of proteins responsible for growth, development, and maintenance of mature neurons. Insulin-like growth factor (IGF-1), nerve growth factor (NGF), and brain-derived neurotrophic factor (BDNF) promote neuroplasticity. Exercise supports brain health through IGF-1 mediated mechanisms (Carro, Nuñez, Busiguina, & Torres-Aleman, 2000; Trejo, Carro, & Torres-Alemán, 2001), such as influencing synaptic and cognitive plasticity (L. J. White & Castellano, 2008). NGF is involved in neuronal protection, activity dependent plasticity, and repair and influences memory (Hennigan, O'callaghan, & Kelly, 2007; Sofroniew, Howe, & Mobley, 2001). BDNF binds to receptors in the synapses, increasing voltage and improving signal strength and protects the brain from degeneration. Concentrations of BDNF increase in proportion to exercise intensity, so exercise induces BDNF mediation that promotes neuroplasticity.

A randomized controlled trial of 120 older adults receiving aerobic exercise for six months displayed increases in the size of the anterior hippocampus which lead to improvements in spatial memory. The hippocampal volume increased by 2%, reversing normal age-related loss in hippocampus volume by one to two years. Increased hippocampal volume is also associated with increased serum levels of BDNF which mediate neurogenesis (Erickson et al., 2011). Hippocampal BDNF remained elevated and
maintained with intermittent exercise over a 14-day period (Berchtold, Chinn, Chou, Kesslak, & Cotman, 2005).

Monteiro-Junior et al. (2015) propose two specific hypotheses regarding the mechanisms of action of exercise on neurobiology: (1) Exercise reduces chronic oxidative stress, increases the activity and effectiveness of antioxidant enzymes like superoxidase dismutase, and stimulates mitochondria biogenesis and up-regulation of autophagy in PD patients; and (2) exercise stimulates dopamine and neurotrophic factors: BDNF, GDNF, FGF-2, and IGF-1 synthesis.

Researchers have suggested that the best time for the brain to relearn is after a short burst of aerobic activity (Erickson et al., 2011), and BDNF stays high for about two minutes after an exercise interval (Smith, Goldsworthy, Garside, Wood, & Ridding, 2014). Exercise promotes increased blood flow to the brain as well as upregulation and increased production of BDNF, and in addition improves cognition and mood (Hoffman, Froemke, & Golant, 2010).

Establishing exercise habits soon after diagnosis may be an essential part of increasing the neuroplasticity of the brain and managing the neurodegenerative effects of PD. Recommendations for PD patients from the National Parkinson’s Foundation’s Parkinson’s Outcomes Project include flexibility or stretching exercises, aerobic exercise, and strength or resistance training. The National Parkinson’s Foundation recommends biking, walking, running, Tai Chi, yoga, Pilates, dance, weight training, non-contact boxing, and Qigong as exercises that have demonstrated positive effects on PD symptoms.
Gait and Treadmill Training

Some PD patients experience gait impairments, including hypokinesia (decreased step length and speed), festination (decreased step length with increased cadence), freezing of gait, decreased coordination, and difficulty with dual tasking during walking (Morris, Martin, & Schenkman, 2010). Gait issues combined with balance issues increase the risk and rate of falling and potential injury. The basal ganglia in the brain are responsible for cueing the rhythmic movement of gait. In PD, this cueing function is impaired. Visual and auditory cues, such as horizontal lines on a floor, music during dance, or the use of a metronome can provide external cues to compensate for the impaired basal ganglia. Treadmill training may provide external cues to improve gait function in PD patients. It may also be viewed as a “forced-use” therapy because patients are forced to use faster gait cycles at higher velocities than they would self-select.

Mehrholz et al. (2010) conducted a Cochrane Review of randomized controlled trials comparing treadmill training to a control group. The review assessed walking speed and stride length as primary outcomes, along with the secondary outcomes of cadence and walking distance, while also assessing the acceptability and safety of treadmill training.

Eight trials with 203 participants were included in this review, and the results found that treadmill training improved gait speed, stride length, and walking distance, but not cadence. Trials varied in patient characteristics, duration and frequency of training, and the types of treatment used. Three of the studies were conducted over an eight-week period (Cakit, Saracoglu, Genc, Erdem, & Inan, 2007; Fisher et al., 2008; Protas et al.,
2005); however other studies used four or six-week training periods (Canning et al., 2009; Kurtais, Kutlay, Tur, Gok, & Akbostanci, 2008; Miyai et al., 2000; Miyai et al., 2002).

Two of the studies used body-weight supported treadmill training (Miyai et al., 2000; Miyai et al., 2002), while another two studies used speed-dependent treadmill training using modified Bruce protocols (Cakit et al., 2007; Pohl, Rockstroh, Rückriem, Mrass, & Mehrholz, 2003). The frequency of the training ranged from a single session to four times per week with the duration of training ranging from 30 to 45 minutes per session. Reviewers concluded that the use of treadmill training in PD patients may improve gait speed and stride length, in addition to walking distance, with no supported change in cadence. Body-weight supported training on 13 PD patients over an eight-week period, training three times per week for an hour, resulted in statistically significant improvements in UPDRS scores, quality of life, and six-minute walking distance (Rose, Lokkegaard, Sonne-Holm, & Jensen, 2013).

Schlick et al. (2015) found that in 12 training sessions over a five-week period, the 12 PD patients receiving visual cues combined with treadmill training, and the 11 PD patients receiving treadmill training only, both improved gait speed and stride length. However, the 12 PD patients receiving the combined training scored better in the Timed Up and Go Test and maintained better results in gait speed and stride length and Timed Up and Go Test in a two-month follow-up.

Transcranial Magnetic Stimulation (rTMS) combined with treadmill training in 20 PD patients conducted for 12 sessions over four weeks resulted in a significantly
increased resting motor threshold, longer duration of the cortical silent period, improved short interval intracortical inhibition, improved walking speed, and Timed-Up-and-Go Test (Y. R. Yang et al., 2013). The resting motor threshold is a basic unit of dosing in TMS research that indicates the minimum stimulus intensity that produces a minimal motor-evoked response. The cortical silent period refers to the interruption of voluntary muscle contraction by TMS of the contralateral motor cortex, and short interval intracortical inhibition is a marker of intracortical neuronal processing used to interpret function and pathophysiology in neurological disorders like PD. This type of research could be helpful to build better understanding of freezing of gait, dyskinesia, and tremor in PD.

High-intensity treadmill training significantly improved lower extremity function in many studies; however a limitation is the inconsistent results for UPDRS motor scores. Study methodologies for treadmill training varied from unassisted treadmill training to holding onto the handrails to fully-supported training. Studies also differed on type of treadmill training, as well as the frequency and total duration of training. Many studies were also limited by small numbers of patients.

Future randomized controlled trials are needed to determine what type (assisted/unassisted), frequency, intensity, and duration of treadmill training should be prescribed for PD patients at different severity levels. The external validity of treadmill training outside of the physical therapy setting should be considered as a long-term goal of these studies, so that balance and motor improvements can be maintained over time. The body-weight supported treadmills are expensive, specific tools for use in a
supervised clinical setting and may be necessary for safety in more severe cases of PD. Shulman et al. (2013) suggest considering combination trainings using the treadmill and resistance exercise to obtain better outcomes for PD patients. Studies of the neuroplastic effects of high-intensity exercise in humans need to be conducted.

**Cycling**

High-intensity forced exercise cycling at 90 rpms (Alberts, Linder, Penko, Lowe, & Phillips, 2011; A. L. Ridgel, Abdar, Alberts, Discenzo, & Loparo, 2013; A. L. Ridgel, Kim, Fickes, Muller, & Alberts, 2011; A. L. Ridgel, Muller, Kim, Fickes, & Mera, 2011; A. L. Ridgel, Peacock, Fickes, & Kim, 2012; Angela L Ridgel, Phillips, Walter, Discenzo, & Loparo, 2015; A. L. Ridgel, Vitek, & Alberts, 2009) reinforced the hypothesis that high-intensity treadmill walking would be represented in improved UPDRS-III scores. Several smaller studies looked at forced exercise (FE) cycling, passive cycling, and active-assisted cycling (AAC) and found higher-intensity cycling at 90 rpm resulted in improved motor control scores, bimanual and dexterity scores, changes in central motor processing, and improvements in tremor and bradykinesia both after a single bout of ACC and at follow-up four weeks after FE (Alberts et al., 2011; Beall et al., 2013; A. L. Ridgel, Kim, et al., 2011; A. L. Ridgel, Muller, et al., 2011; A. L. Ridgel et al., 2012; A. L. Ridgel et al., 2009). The improvement in motor function was observed both “ON” and “OFF” medication.

More recent cycling studies from these researchers expanded the duration of the sessions to one hour, three times per week for eight weeks for a total of 24 sessions. Improvement in motor function scores (UPDRS-III) were replicated, as were
improvements in cardiovascular fitness. With the addition of resistance training, muscular
strength, endurance and flexibility also improved (C. A. Peacock et al., 2014; Corey A
Peacock et al., 2013).

In a recent study, Lauhoff, Murphy, Doherty, and Horgan (2013) investigated a
cycling intervention that was limited to one, thirty minute session per week for six weeks
at 60 to 80 percent of heart rate maximum. Cycle ergometry significantly improved PD-
related balance, function, and disability; however there were no measurable
improvements in exercise tolerance or quality of life. A case study of two mildly
impaired PD patients cycling one hour, three times per week for eight weeks at
progressively increasing intensity showed improved executive function following aerobic
exercise.

A recent study by (Arcolin et al., 2015) compared 13 PD patients randomized to
treadmill training and 16 PD patients randomized to cycle ergometer training for a period
of three weeks for one hour per day and found that cycle ergometer training improved
walking parameters and clinical signs of PD as much as treadmill training. Outcomes
measured were the Six-Minute Walk Test, speed, step length, cadence of gait, TUG,
Mini-BESTest, and UPDRS.

External validity of these studies is limited by several factors: first, many studies
were conducted with very small numbers of PD patients and were underpowered;
secondly, tandem cycling at 90 rpm with a healthy partner is difficult to implement in the
community, since one has to not only have access to a tandem bike, but also a healthy
partner who can maintain high intensity by keeping the cadence high; third, active-
assisted cycling also requires a special bike, which may make it a viable piece of equipment for larger numbers of patients in a physical therapy setting, but once again, may not be affordable and easily obtained and utilized in a community setting. In addition, the Lauhoff et al. (2013) study may not have been sufficient to show fitness gains as the intervention was severely limited in frequency, intensity, and duration. Cycling interventions studying a larger population of PD patients applying these findings are warranted. Exercise adherence and the ability to externally replicate the results at the community level should be considered.

Dance

Argentine Tango dance lessons for mild to moderate PD patients conducted for an hour and a half per day, five days per week, for two weeks resulted in significant improvements in balance and motor scores, as well as non-significant improvements in the Timed-Up-and-Go Test and Six-Minute Walk Test (M. E. Hackney & G. M. Earhart, 2009d). Dancing provides external cues from either the music or the partner which may allow patients to bypass the dysfunctional basal ganglia by accessing the cortical circuitry. This led to a larger study of 58 PD patients comparing Argentine Tango, Waltz/Foxtrot, and no intervention. The dance participants received dance lessons for one hour, two times per week, completing 20 lessons within a 13 week period. Both dance groups’ participants improved in balance, Six-Minute Walk Test, and backward stride length. Tango participants experienced larger changes on the Timed-Up-and-Go Test and forward and backward gait, which was fairly consistent with the higher intensity, shorter dance lessons in the first study (Hackney & Earhart, 2009b). Tango may be more
impactful than Waltz/Foxtrot because it employs strategies similar to those taught to PD patients who suffer from freezing of gait.

Next, Hackney & Earhart (2010) compared partnered Tango to non-partnered Tango and discovered that both classes showed significant improvement in balance, walking velocity, and walking distance. This allows individuals who may not have a partner to participate. A longer term, randomized controlled trial of 62 PD participants assigned to a twice weekly, one-hour community-based Argentine Tango class vs a control group showed significant improvements in motor skills, balance, freezing of gait, Six-Minute Walk Test, forward and dual tasking walking velocity, and upper extremity function at three, six, and 12 months (Duncan & Earhart, 2012). McKee and Hackney (2013) found that community-based tango also displayed significant improvements on disease severity, spatial cognition, balance, and executive function, which were maintained 10 to 12 weeks post-intervention.

Sharp and Hewitt (2014) conducted a meta-analysis of five randomized controlled trials, and results suggested dance therapy has positive effects on motor impairment (UPDRS-III), balance, gait speed, and health-related quality of life. The authors concluded that dance promotes short-term clinically meaningful benefits to PD patients. In another review article to appraise dance interventions and collate information on frequency, intensity, duration, and type of dance, researchers identified 13 articles, most of which have been cited above (Shanahan, Morris, Bhriain, Saunders, & Clifford, 2015). The authors concluded that two, one-hour dance classes per week over a period of 10 to 13 weeks may have beneficial effects on endurance, motor impairment, and balance.
Another overlapping review of 13 dance studies concluded that tango significantly improved the motor severity (UPDRS-III) scores, balance as measured by the Mini-BESTest, and gait as measured by the Timed Up and Go Test (Lötzke, Ostermann, & Büsself, 2015).

LSVT Big Training

LSVT BIG training was developed based on the highly successful Lee Silverman Voice Treatment (LSVT), using its concepts of multiple repetitions, intensity, and complexity. The objective was to demonstrate that large amplitude movements involving the entire body translate into speed improvements using a one-hour therapy session conducted four times per week for 14 weeks, for a total of 16 sessions (a parallel treatment plan to LSVT LOUD). Significant increases in wrist velocity reaching at the preferred speed for the longest two distances were observed; however, for the fast as possible speed, significant improvements were only observed for the longest distance. For preferred gait speed, significant increases in gait velocity but not cadence were observed. Training BIG resulted in increased gait velocity and stride length for preferred gait speed (Farley & Koshland, 2005).

Additional, larger trials were conducted following the same treatment protocol. LSVT BIG showed clinically significant improvements over Nordic Walking and home exercise as measured by improvements in motor performance scores, Timed-Up-and-Go tests, 10-meter walk time, and cued reaction times (Georg Ebersbach et al., 2010; G. Ebersbach et al., 2014; Fox, Ebersbach, Ramig, & Sapir, 2012).
A randomized controlled trial compared LSVT BIG therapy to a general exercise group (a combined treadmill plus seated trunk and limb exercise) on motor and non-motor symptoms of PD. It was a small study of early-stage PD patients with five patients in the general exercise group and six patients in the LSVT BIG group. Participants received 16 one-hour supervised training sessions over a period of four weeks. Both interventions showed significant improvements in UPDRS total and motor scores, Beck Depression Inventory, and Modified Fatigue Impact Scale scores; however, the numbers are too small to evaluate differences in treatment groups (Dashtipour et al., 2015).

Tai Chi

Tai Chi studies have shown improvements in balance and mobility for PD patients (Gao et al., 2014; M. E. Hackney & Earhart, 2008; M. E. Hackney & Wolf, 2014; Li et al., 2012; Li et al., 2014). Study sample sizes ranged from a pilot study in 2008 of 33 PD patients to a randomized controlled trial of 195 patients in 2012. Tai Chi groups had significantly better performance than resistance training, stretching or control groups on balance, motor skills, postural stability, Timed-Up-and-Go Test, Six-Minute Walk Test, and directional control with the exception of the Gao et al. (2014) study which observed improvements in balance, but not in motor scores or Timed-Up-and-Go Test. This difference may be related to the exclusion criteria and the use of a more complicated 24-form Yang style of Tai Chi exercise where the other studies used six movements in an eight-form routine.

The best results were observed in the Li et al. (2012) study with the longest duration of training—one hour twice per week for 24 weeks. Tai Chi improves balance,
mobility, motor skills, and helps reduce the number of falls in PD patients. A small, recent Tai Chi study of 44 subjects found minimal benefits in specific motor tasks and mood but without improvement in global measures (Kurlan et al., 2015).

**Wii Fit™**

Another area of research that may benefit motor re-learning in neuro-rehabilitation to improve static and dynamic balance, mobility, and motor function in PD patients is the Wii Fit™ (dos Santos Mendes et al., 2012; Esculier, Vaudrin, Beriault, Gagnon, & Tremblay, 2012).

Pompoe et al. (2012) investigated activities of daily living in a study of two types of therapy; one group used Wii Fit™-based motor cognitive training and the other group completed balance training. Thirty-two early stage PD patients participated in 14 training sessions which consisted of 30 minutes of stretching, strengthening, and axial mobility exercises, in addition to 30 minutes of balance training. The experimental group performed 10 Wii Fit™ games, while the control group performed balance exercises. Both groups showed improvement in UPDRS-II scores; however, no differences in activities of daily living were observed between the groups after the 14 sessions of training.

Future research of Wii Fit™ as an adjunct therapy to improve balance, mobility, and functional abilities could result in a fun, easy-to-use home-based training for less severe PD patients. Wii Fit™ has similarities to treadmill training in the use of cueing, and the front, side and back steps mimic Tai Chi and dance.
Theories of Behavior Change in Parkinson’s Disease Patients

It is well established that theory-based behavioral interventions result in the most favorable changes in physical activity and exercise adherence (R. Dishman & Buckworth, 1996). Designing interventions to create changes in behavior is best accomplished by understanding behavioral change theories and being able to put this knowledge into practice. Behavioral change theories are attempts to define or explain why behaviors change and under what circumstances these changes occur.

Recently, efforts have been made to separate the concept of theories from models to help us better conceptually understand the relationships between psychological factors and a specific outcome or behavior. Theories of change are suggested to be more process-oriented towards changing a given behavior of interest. Models of behavior are aimed toward understanding the psychological factors that explain or predict a specific behavior. These nuances are designed to distinguish between two complementary areas of scientific research—understanding behavior and changing behavior.

Theory-based research allows us to look at certain factors in an attempt to explain behavior change; thus, we can take abstract thoughts and put them into a conceptual model that we can measure. Theories provide the framework to accomplish this, and they can be modified over time as the body of evidence grows to support this.

Social Cognitive Theory (SCT)

Albert Bandura developed SCT from his work on social learning theory. The basic tenet of social learning theory is that the behavior is learned from the environment through observation (Rotter, 1982). Bandura believed that human beings are “information
processors” that actively think about their behaviors and the consequences of those behaviors through cognitive processes, and that these cognitive processes have a prominent role in the acquisition and retention of new behavior. SCT takes social learning theory constructs of attention, memory or retention, reproduction, and motivation a step further—SCT posits that observational learning takes place in a social context, and learning can occur without an immediate change in behavior. Reciprocal determinism describes the bi-directional dynamic interaction between a person’s beliefs, expectations, and attitudes, the social and physical environment, and their behaviors themselves (Albert Bandura, 1986, 1989).

Figure 2 displays a conceptual model of the interactions between behavior, environment, and personal factors; this model represents the reciprocal determinism of social cognitive theory. In our study, this model represents PD patients (Person) who participate in leisure time PA (Behavior) based on personal factors and whether or not their surroundings (Environment) support this activity. Under certain conditions, these factors—person, behavior, and environment—in certain circumstances may lead to improved physical functioning and health-related quality of life.

SE is considered a primary mechanism of behavior change, and the most frequently studied of the SCT constructs. PA mediators such as SE and social support have been scrutinized and supported empirically (Sallis & Owen, 1999; Dishman & Sallis, 1994). Models of health behavior frequently include SE as a construct to measure the adoption and maintenance of behavioral change.
SE refers to a confidence in their ability to satisfy specific situational and/or behavioral demands. In other words, SE reflects one's belief (efficacy beliefs) that an action will produce the desired effect. A central tenet of SCT is that without this belief, people have no incentive or motivation to act. Expectations of personal efficacy are derived from four principal sources of information: past-performance accomplishments, vicarious experience, social or verbal persuasion, and physiological or affective states. Keller, Fleury, Gregor-Holt, and Thompson (1999) reviewed 27 studies that looked at the relationship between SE and PA and found statistically significant relationships between the two. Intervention studies demonstrated that participation in an exercise program improved SE (McAuley, 1993; E. McAuley, G. J. Jerome, D. X. Marquez, S. Elavsky, & B. Blissmer, 2003).

Efficacy beliefs effect how a person perceives accomplishments, thought patterns (self-aiding or self-hindering), mood, resiliency, perseverance at a task, amount of effort set forth, and the chosen course of action. SE’s role and influence in behavioral
interventions changes over time. SE is situation and behavior specific. It’s an individual’s confidence in their ability to achieve a desired outcome. SE is higher if the individual had a successful experience (mastery) and had to overcome barriers to succeed. Observing the success of others—those whom an individual perceives to be of similar capabilities or less capable than themselves—can be a powerful motivator to change or achieve a behavior. Parschau et al. (2014) found that a positive exercise experience was directly associated with motivational and volitional SE and intention. Positive exercise experience was indirectly associated with action planning via motivational SE and intentions predicted changes in exercise levels.

Social modeling is less effective at increasing SE than mastery, but can be powerful in certain situations. Social persuasion in the form of meaningful, specific feedback from an individual whose opinion matters is a moderately effective means of enhancing SE. This can be particularly important to individuals who are currently struggling with a situation. Social support can be a strong motivator to encourage individuals to explore a new behavior, in addition to being a source of increasing SE. Anderson, Winett, Wojcik, and Williams (2010) conducted an online SCT based nutrition, PA, and weight gain prevention intervention. The authors found that perceived social support and use of self-regulatory behaviors were strong predictors of nutrition and PA behavior, and SE was a good predictor of healthier levels of PA. Social support and SE indirectly predicted behavior change through SR, and social support also indirectly predicted behavior change through SE.
Outcome expectations describe what an individual’s expectations are based on a certain set of behaviors, both from personal past experiences as well as by vicariously observing others. It has been well-documented in PA literature that individuals who participate in PA regularly have more realistic and positive OE (McAuley, Motl, White, & Wojcicki, 2010; Resnick & Nigg, 2003; Wojcicki, White, & McAuley, 2009).

S. M. White, Wojcicki, and McAuley (2012) prospectively tested the utility of the SCT model of PA behavior in 321 middle-aged and older adults ($M$ age = 63.8) at baseline and again at 18 months. They hypothesized that SE would directly influence PA, as well as indirectly influence PA through OE. Using a panel analysis within a covariance modeling framework, the authors found that the model provided an excellent fit to the data ($\chi^2 = 36.16, df = 30, p = .20$ with a CFI = 1.0 and RMSE = .03). Results showed modest, but significant increases in physical, self-evaluative, and social OE over the course of the study. There was also a significant decline in exercise SE. These changes in SE were significantly related to residual changes in OE, disability limitations, goals, and PA. Indirect changes in SE were related to residual changes in PA through changes in both physical and social OEs.

In another study of 179 community-dwelling older adults, Wojcicki et al. (2013), conducted a 12-month exercise intervention and examined the association of psychosocial and health-related outcomes. The older adults were randomly assigned to a walking group or a flexibility, toning, and balance group. Subjects were given physical, psychological, and cognitive assessments at 0, 6, and 12 months. The authors found that involvement in a 12-month exercise program increased the importance that participants
placed on PA across gender and exercise group. Changes in importance of PA were only related to OE and changes in physical health at the program midpoint. The authors concluded that regular participation in PA can positively influence the participant’s perception of the behavior.

Goal setting and Self-regulation constructs are SCT measures of the self-determined management of goal-directed behaviors and an individual’s ability to plan to achieve desired goals or outcomes. Exercise SR involves planning, organizing, and managing exercise activities and is an important component of maintaining regular exercise because motivation alone is insufficient (Albert Bandura, 1997).

Rovniak, Anderson, Winett, and Stephens (2002) prospectively studied 277 university students over eight weeks to test the relationship between social cognitive variables and PA. Measures of social support, SE, OE, and SR were completed at baseline and used to predict PA at the end of the study. Authors evaluated the data using structural equation modeling. The social cognitive model had a good fit, and showed SE had the greatest total effect on PA, mediated by SR. SR directly predicted PA. Social support had a direct effect on SE, and an indirect on PA through SE. OE had a small, but not significant effect on PA. Overall, the model explained 55% of the variance observed in PA.

Although SCT has been one of the most widely used theoretical models in PA studies and interventions, researchers have typically used only one to two constructs to evaluate relationships between the constructs, PA, and health-related quality of life in populations. Conducting a more comprehensive evaluation of the relationships between
Quality of Life

Often, the terms quality of life (QoL) and health-related quality of life (HRQoL) are used almost interchangeably in the psychological, behavioral, and medical literature. There is a distinction however—QoL describes the general well-being of an individual or overall life satisfaction, while the term HRQoL is more frequently found in medical literature and is used as a measure of health status (Focht, 2012). Unifying these concepts and terminology would be helpful in the research arena both in terms of structuring how quality of life is operationally measured and compared across studies.

In this study, we used the Medical Outcomes Study Short Form-12, which is a smaller, more concise version of the Short-Form 36, measuring HRQoL (Ware Jr et al., 1996). In our study, results from both physical and mental HRQoL were examined in relationship to idiopathic PD. These results will not be used to make inferences about overall well-being or satisfaction with life. However, the five-item Satisfaction With Life Scale was used to assess global QoL (Diener et al., 1985), and in a population experiencing potentially significant declines in physical function, this could provide important information on overall satisfaction with life in general.

Exercise and PA have been evaluated extensively in PD patients in regards to both its efficacy in improving HRQoL, but also the more global QoL. Exercise and PA’s impact on cardiovascular fitness and muscle strengthening are particularly important for
movement disorders like PD where loss of physical functioning, particularly loss of mobility, have a marked impact on both QoL and HRQoL.

An early study by Koplas et al. (1999) interviewed 86 individuals from five different stages of clinical disability. Stage of disease, physical disability, depression, mastery and health locus of control were the measured independent variables, which explained 48% of the variability in QoL ($R^2 = 0.48$). Mastery was the only significant predictor ($p = .0001$) of QoL. Significant differences in QoL scores were observed at all stages of PD ($p < .05$), suggesting that the psychosocial profile of PD patients may change with disease progression. Similar to this study, (A. Schrag, Jahanshahi, & Quinn, 2000a, 2000b) found that QoL decreased significantly with increasing disease severity, suggesting that PD interferes with the physical and social functioning aspects of QoL.

In a study of 188 PD patients, participants were given the 36-item Short-form Health Survey (SF-36) at the time of diagnosis and prior to the start of medication to assess HRQoL. Follow-up measurement of 166 patients was performed three years later. Depression, fatigue, and sensory complaints were the non-motor symptoms associated with a reduction in SF-36 scores. Gait and activities of daily living (ADLs) were the motor symptoms most often associated with decreased SF-36 scores. Non-motor symptoms were more explanatory of the variance in HRQoL scores both at baseline and after three years (non-motor scores at baseline, $R^2 = 0.372$; non-motor scores at 3 years, $R^2 = 0.468$), compared to motor symptom scores at baseline and after three years (motor scores at baseline, $R^2 = 0.322$; motor scores at 3 years, $R^2 = 0.315$). Results suggest that
non-motor symptoms impact health-related quality of life more than the motor symptoms of PD in the early stages (Muller, Assmus, Herlofson, Larsen, & Tysnes, 2013).

Duncan et al. (2014) also reported the major impact that non-motor symptoms have upon HRQoL in PD patients in a study of 158 patients and healthy controls recruited as part of the Incidence of Cognitive Impairment in Cohorts with Longitudinal Evaluation PD Study. Both motor and non-motor symptoms negatively impacted HRQoL. Patients reported the lowest levels of HRQoL in the domains assessing mobility, ADLs, and bodily discomfort. PD patients with postural instability and gait difficulties reported lower HRQoL compared with tremor-dominant PD patients. Other factors which significantly, negatively impacted HRQoL included: depression ($p < 0.001$), incomplete bowel emptying ($p < 0.001$), impaired concentration ($p < 0.001$), memory complaints ($p < 0.001$), and sleep disturbances ($p < 0.001$).

Awick et al. (2015) examined 179 low-active older adults randomly assigned to an aerobic walking group or a strengthening and flexibility group. Both HRQoL and QoL were measured at baseline, six, and 12 months. Results indicated that the walking group experienced improvements in the mental aspects of both HRQoL and global QoL when compared to the non-aerobic intervention; however, these patterns were not linear over time.

In summary, regular physical activity in PD can increase leg strength, stride, ability to sit, stand, and walk. In addition, PA in PD patients can increase dopamine levels, BDNF, and improve the neuroplasticity of the brain to promote new learning.
Chapter 3: Methods

Overview

The purpose of this observational cross-sectional study was to determine correlates of lifestyle behaviors (PA) and health-related quality of life. The hypotheses were: 1a) higher levels of PA would be associated with higher levels of SE, OE, and SR; 1b) higher levels of SE, OE, and SR would be associated with higher levels of HRQoL; 2) higher levels of PA would be associated with higher levels of HRQoL; and 3) SCT constructs – SE, OE, and SR would mediate the relationship between PA and HRQoL.

Study Design

For this cross-sectional experimental design, we calculated a target goal of 404 geographically diverse idiopathic PD patients, using the Fritz and MacKinnon (2007) article on the required sample size necessary to detect mediated effects. Using the empirical estimates from Table 3 from the article for the Baron and Kenny test with \( t^* = .59 \), \( \alpha = .59 \) and \( \beta = .14 \), we determined the sample size needed for a power of .8 would be 404. In this population, we expected that some PD patients would begin the survey and be unable to finish. For this reason, we oversampled by 25% for a final target of 505 participants. After cleaning the data and eliminating cases with more than 25% of the data missing, we ended up with 500 self-identified idiopathic PD patients (see Recruitment).
**Objective 1:** The primary aim of the study was to explore the relationship of three select SCT construct—SE, OE, and SR—with PA. Knowledge of these relationships will provide a comprehensive evaluation of these key SCT-based correlates of PA, providing a better understanding of the motivational factors associated with PA.

**Hypothesis 1a:** Higher levels of PA will be associated with higher levels of SE, OE, and SR in PD Patients.

**Hypothesis 1b:** Higher levels of SE, OE, and SR will be associated with higher levels of HRQoL in PD Patients.

**Objective 2:** The secondary aim of the study was to examine the relationship between PA and HRQoL. This study will be one of the larger studies to evaluate this relationship in a sample of English-speaking PD patients drawn from across the United States, as well as some parts of the World.

**Hypothesis 2:** Higher levels of PA will be associated with higher HRQoL in PD Patients.

**Objective 3:** The tertiary aim of the study was to determine if SCT constructs mediate the relationship between PA and HRQoL. Expanding the knowledge base of these factors informs future efforts to promote PA in this population.

**Hypothesis 3:** SCT constructs will mediate the relationship between PA and HRQoL in PD Patients (See Figure 3).
Recruitment

Strategy

Upon Institutional Review Board (IRB) approval, letters were sent through the U.S. Postal Service to The Ohio State University Movement Disorder Clinic, the Ohio Health Neuroscience Center, the following foundations and non-profits (Michael J. Fox Foundation (MFF), Mohammed Ali Foundation (MAF), Davis Phinney Foundation (DPF), Parkinson’s Disease Foundation (PDF), National Parkinson’s Foundation (NPF), and NPF’s Parkinson’s Centers of Excellence). One week later, the same institutions were contacted via email and requested to direct their patients and support-group members to our study via web link.

Both the letter and the email contained either a hard copy or electronic version of a poster/flyer for placement in clinics containing suggested talking points about the study and the web link for publication. Each foundation or institution was asked to place the
study link on their website, in newsletters, in email blasts, as well as placing the poster/flyer with the study link in the neurology clinic waiting areas.

ResearchMatch was also used to recruit PD patients by sending a letter with the study link requesting their participation. ResearchMatch is a National Institute of Health (NIH) sponsored secure website where volunteers can register with their particular research interests. Researchers then requested that their study be registered in ResearchMatch. After IRB approval, researchers conducted a feasibility search to identify potential study participants. At this time, an email was sent out to matches describing the study and asking volunteers if they were interested in participating. If participants indicated interest, they were sent the study web link.

Participation in the study was purely voluntary, patient responses were anonymous, and no protected health information was stored with the study data. The study data was password protected in a controlled environment with access limited to the investigators. There was no patient risk to participation in this survey-based study.

The website TinyURL.com was used to create a short, user-friendly URL link to the study which directed participants to the PDQ Survey in Qualtrics. The Qualtrics software was provided for use by the investigators and licensed through The Ohio State University. The data was managed in accordance with IRB protocols regarding anonymity and patient privacy as determined in the HIPAA guidelines. Qualtrics provided a secure, web-based application with an intuitive user interface that facilitated ease of data entry. It also provided straightforward survey creation with a variety of preset question types, real-time rule validation, as well as various options to minimize
data errors and control data flow. Qualtrics provided an export utility to SPSS, which was the statistical software being used in this study.

Participants were electronically consented using language provided and approved by the IRB. Accrual follow-up as outlined in the research protocol was not instituted due to the overwhelming positive response of the PD community. Many hospitals posted flyers in their clinics, and some physicians emailed the information along to their peers in other institutions. Some of the non-profits emailed their support groups, posted the information on their Facebook pages, and used Twitter to tweet the study information. PD patients retweeted the study link, and the information spread throughout the PD twitter community. After the initial outreach, The Michael J. Fox Foundation requested and were accorded permission to include the study in the Fox Trial Finder. The Fox Trial Finder process was handled very similarly to the ResearchMatch process. IRB-approved information about the study was placed on Fox Trial Finder. Volunteer matches were sent the same information as the ResearchMatch volunteers about the study with the web link (Figure 4).
Recruitment of Idiopathic Parkinson’s Patient’s

- 64 Letters to Hospitals & Non-Profits
- 64 Emails to Hospitals & Non-Profits
- 293 Emails to Research Match Volunteers

Hospitals & Non-Profits post flyers in clinics, place study information in newsletters, social media, and emails to supporters & support groups

- Michael J Fox Foundation requests study be added to Fox Trial Finder
- 414 Emails to Fox Trial Finder Volunteers

1,092 individuals visited survey site

707 individuals completed informed consent

550 individuals fulfilled eligibility requirements

498 individuals finished survey

52 individuals partially completed survey

497 individuals with < 25% of data responses missing

500 individuals with < 25% of data responses missing
Eligibility

We targeted idiopathic PD only because this population represents the majority of patients. The following were the inclusion and exclusion criteria for participation in the study:

Inclusion criteria

• English speaking
• Clinical validation of idiopathic PD
• Have you been diagnosed with PD by a neurologist
  □ If so, name of the facility where you were diagnosed________________
• Living in the community: own or rent home, condo or apartment
• Ability to answer online survey

Exclusion criteria

• Atypical Parkinson’s
• Progressive supranuclear palsy
• DBS or other surgical management of PD
• Living in assisted-living or skilled-nursing facilities
• Caregiver/spouse answering survey
• Unwilling to give consent

Informed Consent

Upon accessing the survey via web link, the patients were presented with an electronic version of informed consent. The volunteer could not proceed into the survey without electronically consenting. After signing the electronic consent, volunteers had to
successfully proceed through the eligibility criteria to access the survey itself. The survey was designed to randomize the individual survey blocks within the larger study with the exception of the cognition questions, which were always presented last. This was to minimize the amount of missing information in any one question.

**Minority Representation**

The global exposure of the survey should have allowed equal access to the survey for all racially and ethnically diverse PD populations with access to the internet who self-selected participation. Third-world countries or remote areas without internet access would be unlikely to participate in the study.

**Risks to the Study Participant**

Minimal risks were associated with study participation. This one-time survey included self-reported lifestyle behaviors which may have caused some psychological risk to an individual who may or may not experience some guilt or embarrassment in reporting sedentary behavior or negative feelings related to their functional abilities.

**Confidentiality**

First, as an online survey study, this allowed individuals to participate in the comfort of their own home without traveling and in a secure environment. This allowed the participants control over when and where they chose to participate. Next, the administrators of the Qualtrics software maintain the security of the survey through password protection with access limited to study investigators. Participants can only attempt to complete the survey one time from a particular computer, thus averting the need for individual logins and passwords for security maintenance. Also, no names, addresses, or social security numbers were collected. The only personal health
information collected initially was month and year of diagnosis and date of birth. After exporting the data from Qualtrics to an SPSS dataset, calculated fields were created for “years since diagnosis” and “age at the time of survey completion.” After these two variables were created, the original fields were deleted from the dataset per IRB requirements. The data was stored on a password protected, encrypted drive.

The study data was essentially de-identified, as it contains no identifiers which could be used to track an individual. There was no risk of disclosure of confidential information. This study followed proven procedures that have been implemented successfully in Dr. Focht’s past research.

**Benefits of Participation**

Individual participants received no direct benefits as a result of their participation in this study. However, participation provides investigators with scientific data that may prove useful in the future treatment and management of their disease. The benefits to the PD scientific community and population are potentially large. There were no monetary incentives or any kind of remuneration for participation in this study. Study participation was purely voluntary with no external motivations that might have impacted participation rates.

**Measures**

The Ohio State University acquired an institutional license for Qualtrics—a web-based survey tool. It was flexible and easy to navigate. Features included the ability to control text, questions, messages, choices, reports, graphs, images, colors, exports, code, emails, fonts, themes, sharing, panels, logics, and blocks. Survey instruments utilized in
this study were replicated into survey blocks in Qualtrics, and investigators endeavored to make the online version look as much like the paper instruments as possible.

The initial block consisted of informed consent, and if that was completed successfully, participants went on to the eligibility question block. If participants failed to sign their informed consent, they were exited from the study and thanked for their time and interest. If the eligibility block was also completed successfully, eligible participants continued on with the study. Once again, if they did not meet the study inclusion criteria, they were exited from the study and thanked for their time and interest. At this point, each survey block was set to randomize, so that if participants did not complete the study, the missing questions would not occur in one block. However, the final study block before exiting the study was the cognitive block, and it was not part of the randomization. The cognitive question block had the most incomplete answers of all the blocks administered. The following self-reported measures were included in the study:

**Hoehn and Yahr (H&Y):** The traditional H&Y staging scale has been widely utilized and accepted by clinicians. Progressively higher stages of H&Y correlate well with standardized scales of motor impairment, disability, quality of life, and neuroimaging studies of dopaminergic loss. However, it is a non-linear (ordinal) scale weighted heavily toward postural instability and does not completely capture disability from other motor features and non-motor features of PD (Christopher G Goetz et al., 2004). Studies have documented kappa scores ranging from 0.44 to 0.71, indicating moderate to significant inter-rater reliability (Geminiani et al., 1991; Ginanneschi et al., 1991; Ginanneschi et al., 1988). For our current study, a self-reported proxy measure of
the Hoehn and Yahr Severity Score was created with guidance from Dr. Deborah Kegelmeyer (See Appendix I). This proxy measure was scored in reverse order. Many studies have used the H&Y scale as the gold standard against which the validity of other scales were assessed reporting significant correlations between H&Y, Unified Parkinson’s Disease Rating Scale (UPDRS), Columbia Scale, and Short Parkinson’s Evaluation Scale (Hely et al., 1993; Martínez-Martín et al., 1994; Rabey et al., 1997; Van Hilten, Van Der Zwan, Zwinderman, & Roos, 1994).

**Demographics:** Information was collected regarding height and weight for a BMI calculation, date of birth for an “age at time of study participation” calculation, date of diagnosis for a “years since diagnosis” calculation, marital status, gender, education, income, employment status, and household composition were collected. We also asked questions in the demographics block about social activities, presence of comorbidities, typical level of activity during the week, and whether or not the treating neurologist recommended exercise.

**Physical Activity (PA):** Participation in PA was the primary lifestyle behavior of interest in this study. PA was measured using the modified Paffenbarger Questionnaire (PAQ) (Paffenbarger Jr, Blair, Lee, & Hyde, 1993). The PAQ records time spent by an individual on a variety of PA including stair-climbing, walking, as well as moderate and vigorous intensity sports, fitness, or recreational activities. The level of weekly accumulated PA can be calculated to compare with the current Department of Health and Human Services (DHHS) guidelines of 150 minutes of moderate-to-vigorous PA per
week. The validity and reliability of the PAQ has been demonstrated and well-established in the literature.

**Quality of Life (QoL) and Health-related Quality of Life (HRQoL):**
Assessments of both global and generic QoL and HRQoL were obtained. The global QoL assessment was obtained using the Satisfaction with Life Scale (SWLS), a reliable and valid instrument to measure cognitive judgements of one’s life satisfaction (Cronbach’s $\alpha$ ranged from 0.81 to 0.90). SWLS did not measure positive or negative affect in PD patients (Lucas-Carrasco, Den Oudsten, Eser, & Power, 2014; Rosengren, Jonasson, Brogårdh, & Lexell, 2015). Participants indicated how much they agreed or disagreed with each of the five items using a 7-point Likert scale that ranges from 1–“strongly disagree” to 7–“strongly agree” (Diener et al., 1985). We focused on HRQoL in this study.

For the generic measure of HRQoL, we used the Short-form 12 (SF-12) to measure a patient’s functional health and well-being from their perspective (Ware Jr et al., 1996). This instrument, the shorter version of the SF-36, has been validated in the PD population (Steffen & Seney, 2008). The SF-12 has been found to be both valid and reliable (Cronbach’s $\alpha = 0.89$) in older adults. The SF-12 used only 12 items to cover the same eight health domains covered in the SF-36 (Resnick & Nahm, 2001). The construct validity of the SF-12 was also validated in PD (Jakobsson, Westergren, Lindskov, & Hagell, 2012).

**Geriatric Depression Scale Long Form (GDS-LF):** We administered the GDS-LF, a widely used, reliable (Cronbach’s $\alpha = 0.91$), and valid measure of depression in the
PD literature (Ertan, Ertan, Kızıltan, & Uygucgil, 2005; Anette Schrag et al., 2007). This was a 30 item, easy to use depression scale asking a subject to provide “Yes/No” responses regarding how they felt over the past week. A score of 0 to 9 was considered normal, a score between 10 and 19 was considered to be suggestive of mild depression, and a score from 20 to 30 indicated severe depression (Yesavage et al., 1983). Depression in PD was not typically accompanied by feelings of guilt, self-blame or worthlessness (Brown, MacCarthy, Gotham, Der, & Marsden, 1988; Ehrt, Brønnick, Leentjens, Larsen, & Aarsland, 2006). Depression was thought to be a variable that may influence an individual’s motivation to exercise, and since the majority of PD patients experience depression, evaluation of this variable along with PA was considered to be important.

**Self-Efficacy for Exercise Scale (SEE):** An eight item measure designed to assess a subject’s beliefs in their ability to continue exercising three times per week at moderate intensities for 40 or more minutes (McAuley, 1993). Individual item responses ranged from 0 to 100 percent in increasing increments by tens. A composite score was calculated by summing all items and dividing by 8. This instrument was found to be valid (Λ X ≥ 0.81) and reliable (α = 0.92) in older adults (Resnick & Jenkins, 2000) and confirmed in a Swedish study in PD (α = 0.91) (Ahlström, Hellström, Emtner, & Anens, 2015).

**Multidimensional Self-Efficacy Scale (MSES):** A nine item instrument designed to rate how confident an individual was that they can be physically active under certain conditions (Rodgers & Sullivan, 2001; Rodgers, Wilson, Hall, Fraser, & Murray, 2008). Responses ranged from 0—“Not at all Confident” to 10—“Completely Confident.” This
assessment used a combination of the strength and the magnitude of the dimensions of self-efficacy (Albert Bandura, 1986). “Strength” represented the person’s confidence in their ability to perform a task, and “magnitude” represented the level of task performance an individual can reach. The nine items were grouped into three categories of self-efficacy—task, coping, and scheduling efficacy—with three items in each group. In a community population, this instrument showed high Cronbach’s α scores for task efficacy (.84), coping efficacy (.81), and scheduling efficacy (.85) indicating internal consistency and reliability.

**Multidimensional Outcomes Expectations for Exercise Scale (MOEES):**
Fifteen items on a 5-point scale that reflect three sub-domains (physical, social, and self-evaluative outcomes expectations) designed to reflect older adults’ beliefs or expectations about the benefits of exercise or regular physical activity (Wojcicki et al., 2009). Each dimension was scored by summing the numerical responses. In a multiple sclerosis population, this instrument showed excellent construct validity for physical, social, and self-evaluative outcome expectations, as well as internal consistency for all three sub-scales, with Cronbach’s α’s as follows: physical = 0.76, social = 0.77, and self-evaluative = 0.77 (McAuley et al., 2010).

**Self-Regulation of Exercise:** A short Physical Activity Self-Regulation Scale (PASR-12) (Umstaddt et al., 2009), which assessed how subjects use behavioral strategies to regulate exercise using 12 items with six sub-scales—self-monitoring, goal-setting, eliciting social support, reinforcement, time management, and relapse prevention. The self-regulation score was calculated by summing the 12 responses (range 12 to 60).
Internal consistency Cronbach’s $\alpha$ measurements range from 0.72 to 0.92 (Olson & McAuley, 2015).

**Exercise Interests and Preferences:** A nine item questionnaire used to determine the level of interest Parkinson’s patients have for participating in exercise and diet programs in the future. Levels of interest range from 0–“Not at All Interested” to 10–“Very Interested.” This instrument was developed as part of Dr. Focht’s research and was adapted for this study.

**FACT-Cognitive Function (Version 3):** A 37 item questionnaire designed to self-assess cognitive function using a 5-point Likert scale ranging from 0–“Never” to 4–“Several times a day.” Comprised of four sub-scales—Perceived Cognitive Impairments (20 items), Impact on Quality of Life (4 items), Comments from Others (4 items), and Perceived Cognitive Abilities (9 items). Item subscale scores were prorated: subscale score = ([Sum of item scores] x [N of items in subscale]) / [N of items answered]. This instrument was originally developed for use with cancer patients (Wagner, Sweet, Butt, Lai, & Cella, 2009). Although the FACT-C has not been validated for use in PD patients, it was the most well-validated assessment of cognitive function available within the literature that could be readily utilized in an online survey.

**Data Analysis**

The study was conducted from August 31, 2015 through October 22, 2015. In accordance with the August 26, 2015 IRB approval, the study closed within three months, when the accrual goals were met. After the study closed, the Qualtric’s utility to export data to SPSS was used. Statistical analysis was performed using SPSS (Statistical
Package for the Social Sciences), Version 23 (SPSS Inc., Chicago, IL) for Windows™. Initially, data cleaning was performed, eliminating participants who did not complete informed consent or who had more than 25% of their data missing. Descriptive analyses of demographic and clinical variables were conducted to identify outliers and missing data. If more than 25% of the data was determined to be missing for an individual, the case was deleted from the study. For the remaining missing scale data, each question underwent a missing value analysis, and through multiple imputations, imputed missing data values were calculated. For ordinal data, missing values were replaced with the median value. Next, variables were created for age at the time of study participation, BMI, and years since diagnosis and the original fields containing date of birth, height, weight, and date of diagnosis were deleted from the database per IRB instructions.

Personal characteristics such as age, BMI, and years since diagnosis were treated as continuous variables. Interval- or ratio-level (scale) data means (M) and standard deviations (SD) were calculated. Marital status, gender, education, income, employment status, social support, and comorbidities were treated as categorical variables. Frequencies and percentages were calculated for categorical variables and ordinal data. Bivariate correlations were conducted to determine the significance of relationships between SCT constructs, PA, and HRQoL. Pearson’s correlations were conducted for scale level data vs scale level data, and Spearman’s correlations were calculated for ordinal level data vs ordinal level data and ordinal level data vs scale data.

Data analysis addressing the primary study aims was conducted using a multiple linear regression analysis approach. Andrew Hayes, PhD’s PROCESS add-on to SPSS
was used to calculate direct and indirect effects of the mediation model (Hayes, 2012). The initial models tested for each Objective follow:

**Objective 1:** to test the hypotheses for the primary objective to explore the relationship of SCT variables—SE, OE, and SR with PA behavior—several statistical analyses were performed. Multiple linear regression analysis was used to examine the relationship between the social cognitive theory constructs and self-reported physical activity. In Model 1a, the regression model tested the direct effects of SCT correlates on PA behavior. Secondly, the Model 1b regression analysis tested the direct effects of SCT variables on HRQoL.

**Objective 2:** to test the hypotheses for the secondary objective to explore the relationship between PA behavior and HRQoL. The Model 2 regression analysis tested the direct effects of PA behavior on HRQoL.

**Objective 3:** to test the hypothesis for the tertiary objective to determine if SCT variables mediate the relationship between PA behavior and HRQoL. Model 3—a hierarchical linear regression analysis model—tested the indirect effects of PA behavior on HRQoL through the SCT variables.
Chapter 4: Results

In this section, we examined the results of the 500 study participants remaining in the sample after cleaning the data. Table 2 displayed an overview of some basic demographic information. We began with a summary of descriptive statistics, and subsequently report the findings of the correlational and regression analyses to address the questions posed in the hypotheses.

Demographics

Study participants were fairly evenly split between genders with 47% males and 53% females. Age was calculated at the time of survey completion using date of birth. The average age of PD participants was 63 years old with a range from 31 to 100. Years since diagnosis was also calculated at the time of survey completion using date of diagnosis. The average time since diagnosis was 4.8 years with a range from newly diagnosed in the past year to 28 years since diagnosis. Body Mass Index (BMI) was calculated based on height and weight. The average BMI for PD participants was 26.8 which would be classified as overweight. BMIs ranged from 16.9 (underweight) to 50.3 (obese). Over 60% of the participants in this study were overweight or obese.

This population was well-educated with more than 85% of participants being college-educated, and in addition, 51% of these participants had graduate or professional degrees. About one-third of study participants were still working, 63% were retired, and
<table>
<thead>
<tr>
<th>Demographics</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>236</td>
<td>47.2%</td>
</tr>
<tr>
<td>Female</td>
<td>264</td>
<td>52.8%</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight (&lt;18.5)</td>
<td>4</td>
<td>0.8%</td>
</tr>
<tr>
<td>Normal (18.5 - 24.9)</td>
<td>194</td>
<td>38.8%</td>
</tr>
<tr>
<td>Overweight (25.0 - 29.9)</td>
<td>192</td>
<td>38.4%</td>
</tr>
<tr>
<td>Obese (30.0 and above)</td>
<td>110</td>
<td>22.0%</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than High School</td>
<td>2</td>
<td>0.4%</td>
</tr>
<tr>
<td>High School / GED</td>
<td>72</td>
<td>14.4%</td>
</tr>
<tr>
<td>College Degree</td>
<td>171</td>
<td>34.2%</td>
</tr>
<tr>
<td>Graduate / Professional</td>
<td>255</td>
<td>51.0%</td>
</tr>
<tr>
<td><strong>Employment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>115</td>
<td>23.0%</td>
</tr>
<tr>
<td>Part-time</td>
<td>52</td>
<td>10.4%</td>
</tr>
<tr>
<td>Voluntary Retirement</td>
<td>259</td>
<td>51.8%</td>
</tr>
<tr>
<td>Forced Retirement</td>
<td>59</td>
<td>11.8%</td>
</tr>
<tr>
<td>Unemployed</td>
<td>15</td>
<td>3.0%</td>
</tr>
<tr>
<td><strong>Household Income</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 25,000</td>
<td>19</td>
<td>3.8%</td>
</tr>
<tr>
<td>25,000 to 49,999</td>
<td>72</td>
<td>14.4%</td>
</tr>
<tr>
<td>50,000 to 74,999</td>
<td>108</td>
<td>21.6%</td>
</tr>
<tr>
<td>75,000 to 100,000</td>
<td>114</td>
<td>22.8%</td>
</tr>
<tr>
<td>&gt;100,000</td>
<td>187</td>
<td>37.4%</td>
</tr>
<tr>
<td><strong>Household Composition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living with spouse</td>
<td>420</td>
<td>84.0%</td>
</tr>
<tr>
<td>Living with caregiver</td>
<td>14</td>
<td>2.8%</td>
</tr>
<tr>
<td>Living alone</td>
<td>66</td>
<td>13.2%</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>22</td>
<td>4.4%</td>
</tr>
<tr>
<td>Married</td>
<td>403</td>
<td>80.6%</td>
</tr>
<tr>
<td>Divorced</td>
<td>32</td>
<td>6.4%</td>
</tr>
<tr>
<td>Widowed</td>
<td>20</td>
<td>4.0%</td>
</tr>
<tr>
<td>Living with a partner</td>
<td>23</td>
<td>4.6%</td>
</tr>
</tbody>
</table>
12% of the 63% were forced to retire. More than 37% of participants reported an annual combined household income over $100,000. About 87% of participants “Lived with a spouse or caregiver”, which corresponds with the approximately 85% that are “Married or Living with a partner”.

Investigators expected that the majority of participants would have a Hoehn and Yahr score ≤ 3 resulting in a distribution positively skewed to the right. The data reported in Table 3 shows that over 95% of PD study participants had scores in this range.

<table>
<thead>
<tr>
<th>Distribution of Hoehn and Yahr Severity Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>3.0</td>
</tr>
<tr>
<td>4.0</td>
</tr>
<tr>
<td>5.0</td>
</tr>
</tbody>
</table>

In regards to social activities reported by participants: 51% were involved with an exercise group, 40% were involved in a PD support group, and 59% were involved in other social activities. The vast majority of participants reported that their neurologist encouraged them to exercise (92%). We also asked participants what comorbidities they experienced, so that we might better understand other factors that impact their physical activity (see Table 4). With an average age of 63, participants were expected to have one or more comorbidities. Participants were asked to check off all the comorbidities that
they had been diagnosed with from a list of common comorbidities. The most commonly reported comorbidity was “Other”, followed by “Arthritis” and “Depression”. Of the “Other” reported comorbidities, hypothyroidism, spinal stenosis, and anxiety were among the most frequently reported.

Table 4

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthritis</td>
<td>121</td>
<td>24.2%</td>
</tr>
<tr>
<td>Depression</td>
<td>114</td>
<td>22.8%</td>
</tr>
<tr>
<td>Heart disease</td>
<td>72</td>
<td>14.4%</td>
</tr>
<tr>
<td>Cancer</td>
<td>46</td>
<td>9.2%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>31</td>
<td>6.2%</td>
</tr>
<tr>
<td>Diseases affecting vision</td>
<td>29</td>
<td>5.8%</td>
</tr>
<tr>
<td>Lung disease</td>
<td>20</td>
<td>4.0%</td>
</tr>
<tr>
<td>Kidney disease</td>
<td>7</td>
<td>1.4%</td>
</tr>
<tr>
<td>Alzheimer's / dementia</td>
<td>2</td>
<td>0.4%</td>
</tr>
<tr>
<td>Other</td>
<td>373</td>
<td>74.6%</td>
</tr>
</tbody>
</table>

*Participants may report more than one comorbidity if appropriate. **Percentage denominator was the number of study participants (n=500).

Physical Activity

Figure 5 displays the average times per week that study participants engaged in leisure time mild (minimal effort), moderate (not exhausting), or strenuous exercise (heart beats rapidly) for more than 15 minutes. Examples were provided describing what types of exercise fall into each level of exertion. Each variable exhibited non-normal distributions with high levels of skewness and kurtosis. Moderate exercise was the most frequent activity level report with a mean of just under 5 times per week. Fewer PD participants reported engaging in strenuous exercise – the mean reported was 1.7 times
per week. Thirty-two percent of participants reported no mild exercise; 24% of participants reported no moderate exercise; and 53% of participants reported no strenuous exercise.

Figure 5. Typical Average Weekly Exercise by Activity Level

Table 6 is a summary of the results of the modified Paffenbarger physical activity questionnaire. Over 89% of study participants reported moderate or vigorous activity. Singles and doubles tennis, baseball, volleyball, badminton, cross country and downhill skiing, basketball, hockey, football, and soccer were all eliminated from Table 5 since very few participants reported these activities.
Moderate intensity activities (88.4%) were reported more frequently than vigorous intensity ones, although 35% of PD participants reported vigorous physical activity. An average of 203.9 minutes of moderate intensity PA per week was reported by

Table 5

<table>
<thead>
<tr>
<th>Physical Activity Characteristics</th>
<th>N</th>
<th>%</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stairs (flights / day)</td>
<td>406</td>
<td>81.2%</td>
<td>10.2</td>
<td>16.5</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Walking (mins / wk)</td>
<td>414</td>
<td>82.8%</td>
<td>107.3</td>
<td>120.2</td>
<td>0</td>
<td>840</td>
</tr>
<tr>
<td>Water Aerobics (mins / wk)</td>
<td>31</td>
<td>6.2%</td>
<td>7.2</td>
<td>35.1</td>
<td>0</td>
<td>420</td>
</tr>
<tr>
<td>Moderate Cycling (mins / wk)</td>
<td>110</td>
<td>22.0%</td>
<td>26.9</td>
<td>76.8</td>
<td>0</td>
<td>840</td>
</tr>
<tr>
<td>Vigorous Cycling (mins / wk)</td>
<td>47</td>
<td>9.4%</td>
<td>10.6</td>
<td>52.4</td>
<td>0</td>
<td>600</td>
</tr>
<tr>
<td>Easy swimming (mins / wk)</td>
<td>35</td>
<td>7.0%</td>
<td>6.0</td>
<td>31.5</td>
<td>0</td>
<td>360</td>
</tr>
<tr>
<td>Vigorous swimming (mins / wk)</td>
<td>15</td>
<td>3.0%</td>
<td>2.7</td>
<td>19.6</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>Dancing (mins / wk)</td>
<td>51</td>
<td>10.2%</td>
<td>13.9</td>
<td>71.2</td>
<td>0</td>
<td>840</td>
</tr>
<tr>
<td>Jogging (mins / wk)</td>
<td>39</td>
<td>7.8%</td>
<td>6.3</td>
<td>26.6</td>
<td>0</td>
<td>225</td>
</tr>
<tr>
<td>Other Moderate (mins / wk)</td>
<td>121</td>
<td>24.2%</td>
<td>39.1</td>
<td>128.9</td>
<td>0</td>
<td>1600</td>
</tr>
<tr>
<td>Other Vigorous (mins / wk)</td>
<td>87</td>
<td>17.4%</td>
<td>25.5</td>
<td>74.9</td>
<td>0</td>
<td>540</td>
</tr>
<tr>
<td>MI activity per week</td>
<td>442</td>
<td>88.4%</td>
<td>203.9</td>
<td>227.4</td>
<td>0</td>
<td>2020</td>
</tr>
<tr>
<td>VI Activity per Week</td>
<td>175</td>
<td>35.0%</td>
<td>48.8</td>
<td>98.9</td>
<td>0</td>
<td>600</td>
</tr>
<tr>
<td>Total PA per week</td>
<td>445</td>
<td>89.0%</td>
<td>252.7</td>
<td>263.9</td>
<td>0</td>
<td>2520</td>
</tr>
</tbody>
</table>

88.4% of study participants, which is more than the 150 minutes per week recommended in the ACSM guidelines (Garber et al., 2011). Eight-six of the subjects did not report brisk walking as part of their moderate physical activity, and of these, 58 subjects reported no moderate physical activity at all. The total of moderate and vigorous physical activity reported by 89% of study participants averaged 252.7 minutes per week. The total of moderate and physical activity without brisk walking reported per week averaged
about 124 minutes per week; however, thirty percent of study participants reported a weekly average of 150 minutes of MVPA per week without including brisk walking.

The “Other” moderate physical activity reported included: strength/weight training, Yoga, Pilates, Tai Chi, aerobics exercise classes, and golf. The “Other” vigorous physical activity reported included: working with a trainer, boxing, rowing, spinning, weight training, and aerobic exercise classes. Both categories overlapped, perhaps based on subjective perception of difficulty or perceived exertion. These findings were similar to those displayed in Figure 5 with differences likely being due to slight differences in categorization of activities and level of intensity. If subjects reported identical numbers for biking, swimming, and other in both the moderate and vigorous activity sections, the duplication was eliminated during the data cleaning. Combining moderate and vigorous activity minutes per week into one variable, MVPA, allows the data to be utilized without knowing if it was moderate or vigorous intensity activity.

Figure 6 displayed the distribution of self-reported MVPA by Hoehn and Yahr Severity Score. As the severity score progressed, the average MVPA hovered around 200 minutes per week. A marked increase in variability of reported MVPA for participants with bilateral involvement (score of 3) with a high number of outliers. With the stage 4 participants, we observed a drop in average MVPA reported.

It is well-established that self-reported physical activity is frequently overestimated (Sallis & Saelens, 2000), and it is preferable to have an objective measure of physical activity, such as an accelerometer, to validate the amount of activity reported. However, this online survey study was limited by the self-reported nature of the data
collected. Self-reported information tends to be inflated and subject to memory recall bias. Nevertheless, it is possible that the relatively high level of self-reported physical activity observed in the present sample is associated with self-selection into the study based on interest in exercise/physical activity, social desirability bias, and the PD severity level being less than a Hoehn and Yahr score of 3 or lower for most subjects.

Figure 6. Distribution of Moderate to Vigorous Physical Activity (MVPA) by Hoehn and Yahr Score

Health-Related Quality of Life (HRQoL)

The disease specific measure of HRQoL was derived from the Short-Form 12 (SF-12). The SF-12 is a well-known measure of functional health and well-being within the chronic disease literature for assessing HRQoL in older adults. It includes norm-based
subscale scores for physical functioning (PF), role physical (RP), bodily pain (BP),
general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and
mental health (MH). SF-12 also includes a physical composite score (PCS) and a mental
composite score (MCS).

The Short Form 12 (SF-12) was used to measure health-related quality of life.
Composite scale scores for SF-12 traditionally differ over the life span—e.g. as we age,
mental health scores increase and physical health scores decrease. The SF-12 scoring
software transformed both component and subscale scores to norm-based scores ($\mu=50,$
$\sigma=10$) which can be compared across the eight health domains, as well as the larger,
Short Form-36 (SF-36) health-related quality of life instrument. Two composite scores –
the mental component score (MCS) ($r=50.5, s = 8.5$) and the physical component score
(PCS) ($r=46.4, s = 9.0$) were evaluated in this study. Figure 7 displayed the SF-12 norm-
based scores for the study participants. The MCS score and Mental Health subscale were
close to the norm while the PCS score, Role Emotional, Social Functioning, Vitality,
Bodily Pain, Role Physical, Physical Functioning, and General Health subscale scores
were below the norm. Overall, the descriptive statistics for HRQoL indicate the sample
reported values on the SF-12 are consistent with age-related normative values.
Depression

The 30 item Geriatric Depression Scale Long Form (GDS_LF) was used to assess how PD study participants felt over the week prior to the survey. Signs of depression included: depressed mood, inability to take pleasure in things that were once pleasurable, inability to sleep or excessive sleeping, change in appetite, fatigue, activity level changes, difficulty concentrating, low self-esteem, and thinking about death. The Parkinson’s Disease Foundation website stated that up to 60 percent of PD patients experience mild to moderate depression, in part due to the fact that according to the National Institute of Mental Health, PD causes chemical changes in the brain that might lead to depression.

The distribution of the GDS_LF scores was skewed to the right with a mode of 3, median of 7, and sample mean of 8.3. Score results were categorized as: normal or no depression scored from 0 to 9; mild depression scored from 10 to 19; and severe
depression scored from 20 to 30, although the actual scale scores were utilized in the regression models. This study sample reported less depression than estimated by the National Parkinson’s Foundation as the normal prevalence of depression with over 66% (332) of individuals not having symptoms of depression, almost 27% (26) scored as having mild depression, and 7% (38) scored as severely depressed. No information was collected to determine if participants were being clinically treated for depression. In addition, depression could have impacted the likelihood of a PD patient completing the survey. The results were reported in Figure 8.

![Figure 8. Depression Score Results from GDS_LF](image)

**Social Cognitive Theory Constructs**

**Self-Efficacy**

First, we used the 8 item self-efficacy for exercise scale (McAuley, Konopack, Motl, et al., 2006), which measured each participant’s beliefs in their ability to exercise.
three times per week in the next week at moderate intensities for at least 40 minutes without quitting. The composite score represented the average scores on the 8 items with responses ranging from 0—“Not at All Confident” to 10—“Extremely Confident.” Responses were non-normally distributed and negatively skewed (-1.085) with \( \mu = 7.4, \sigma = 3.1, \) median of 9.0, and a mode of 10.0.

Thirty-seven percent (185) of participants were extremely confident in their ability to exercise at moderate intensity for at least 40 minutes without quitting in contrast to 6.0% (30) of participants who were not at all confident. Over 80% (401) of participants scored an average of 5 or higher, indicating the majority of participants reported moderate to high levels of exercise-related self-efficacy (Figure 9). Next, we used the 9 item multidimensional self-efficacy scale to measure an individual’s task, coping, and scheduling efficacy. Responses ranged from 0—“Not at All Confident” to 10—“Completely Confident.”

All three types of efficacy displayed non-normal negatively skewed distributions (Table 6). Over 75% of participants reported scores of 7 or above for both task efficacy and scheduling efficacy, which indicated confidence in their ability to schedule and complete exercise. Coping efficacy scores were lower, with only 44% scoring a 7 or above. In the results and discussion sections of this document, we refer to self-efficacy for exercise as “SE”.
Self-efficacy for exercise scores were highly correlated with multidimensional self-efficacy scores, and after leveraging and identification of outliers, additional modifications led to a more normal distribution. As with Self-Efficacy for Exercise scores, task, coping, and scheduling efficacy scores were also slightly non-normally distributed and negatively skewed. Table 6 displayed the characteristics of the multidimensional self-efficacy measures, which when regressed on exercise self-efficacy,
showed multicollinearity issues. Only self-efficacy for exercise scores were used in regression models to avoid multi-collinearity violations of regression assumptions.

Table 6
*Characteristics of Task, Coping and Scheduling Efficacy*

<table>
<thead>
<tr>
<th>Types of SE</th>
<th>Task Efficacy</th>
<th>Coping Efficacy</th>
<th>Scheduling Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.8340</td>
<td>6.0840</td>
<td>7.9133</td>
</tr>
<tr>
<td>Median</td>
<td>8.3333</td>
<td>6.3333</td>
<td>9.0000</td>
</tr>
<tr>
<td>Mode</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>2.01867</td>
<td>2.57699</td>
<td>2.51728</td>
</tr>
<tr>
<td>Skewness</td>
<td>-1.226</td>
<td>-.420</td>
<td>-1.281</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.372</td>
<td>-.683</td>
<td>.681</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

Outcome Expectations for Exercise

We measured beliefs or expectations about the benefits of exercise or physical activity using the 15 item, 5-point Likert scale MOEES. Mean and median were consistently close across physical, social, self-evaluative, and overall outcome expectations. The distributions were all negatively skewed with physical outcome expectations and self-evaluative outcome expectations having the highest skewness and kurtosis. Eighty-five percent of participants reported high physical outcome expectations, followed by 77% of self-evaluative outcome expectations, 35% of social outcome expectations, and 63% of total overall outcome expectations for exercise (Table 7).
Table 7

*Characteristics of Multidimensional Outcome Expectations Scores*

<table>
<thead>
<tr>
<th>Outcome Expectations</th>
<th>Physical</th>
<th>Social</th>
<th>Self-Evaluative</th>
<th>MOEES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>22.3</td>
<td>18.3</td>
<td>21.6</td>
<td>62.2</td>
</tr>
<tr>
<td>Median</td>
<td>23.0</td>
<td>18.4</td>
<td>22.0</td>
<td>63.2</td>
</tr>
<tr>
<td>Mode</td>
<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
<td>71.0</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>3.2</td>
<td>3.6</td>
<td>3.4</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Individual subscale scores ranged from five to twenty-five, which resulted in total composite scores ranging from fifteen to seventy-five since there were three subscales.

The MOEES composite score is displayed in Figure 10.

Figure 10. Distribution of Multidimensional Outcome Expectations Composite Score
Self-Regulation of Exercise

Subjects were assessed on their use of self-monitoring (SM), goal-setting (GS), eliciting social support (SS), reinforcement (Re), time management (TM), and relapse prevention (RP) by a 12-item questionnaire. Study participants reported high levels of self-regulation (“Often” or “Very Often”) for the following subscales: self-monitoring (55%), reinforcement (51%), time management (49%), goal-setting (45%), relapse prevention (33%), and social support (20%). The overall Physical Activity Self-Regulation (PASR) composite score showed high levels of self-regulation with scores > 7 across all six sub-scales (PASR12 score of 42/60 for 44% of participants) (Table 8).

Table 8

<table>
<thead>
<tr>
<th>Characteristics of Self-Regulation Subscales and Composite Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR Scores</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Std. Deviation</td>
</tr>
</tbody>
</table>

All distributions were negatively skewed with the exception of the social support subscale, which was positively skewed with 80% of the responses reported as “Never”, “Rarely”, or “Sometimes” indicating lower self-regulation for eliciting social support. The PASR-12 composite score displayed a slight negative skewness (-.259); however, the mean and median were fairly close giving the distribution a normal appearance (Figure 11).
Cognitive Function

The FACT-Cognitive Function (Version 3) instrument used in this study consisted of 37-items covering four areas of cognition: perceived cognitive impairments (20 items); impact on quality of life (4 items); comments from others (4 items); and perceived cognitive abilities (9 items). Out of the four areas of cognition, eight sub-scales were created—mental acuity (3 items), memory (6 items), concentration (6 items), verbal fluency (5 items), functional interference (5 items), multitasking (4 items), noticeability (4 items), and quality of life (4 items). The 5-point Likert scale responses ranged from 0—“never” to 4—“several times per day”; hence, a lower score would indicate less cognitive impairment.

The elementary statistics for the cognitive subscales and composite score are displayed in Table 9. It is important to note that of the people who did not complete the
survey, 98.1% did not complete the 36 items in the FACT-Cog instrument. Only about 10% of the participants who finished the survey did not complete the cognitive portion. The unfinished survey participants contributed the majority of the individuals with more than twenty-five percent of their data missing, and hence were excluded from the study during the data cleaning process.

In terms of the subscales, the numbers were averaged or prorated in order to make them more comparative because the number of items per scale differed. Comments from others or noticeability resulted in the lowest average score (0.16), followed by mental acuity (0.37), and quality of life (0.45). Memory had the second highest average score (1.73); however, multitasking had the highest average score (7.41). Dual tasking and memory issues align with what’s commonly reported in the Parkinson’s literature.

Table 9
*Characteristics of Cognition Subscales and Composite Scores*

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mental Acuity Subscale Summary Score</th>
<th>Memory Subscale Summary Score</th>
<th>Concentration Subscale Summary Score</th>
<th>Verbal Fluency Subscale Summary Score</th>
<th>Functional Interference Subscale Summary Score</th>
<th>Multitasking Subscale Summary Score</th>
<th>Noticeability Subscale Summary Score</th>
<th>Quality of Life Subscale Summary Score</th>
<th>Total Cognitive Composite Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>488</td>
<td>479</td>
<td>481</td>
<td>485</td>
<td>485</td>
<td>500</td>
<td>495</td>
<td>484</td>
<td>446</td>
</tr>
<tr>
<td>Missing</td>
<td>12</td>
<td>21</td>
<td>19</td>
<td>15</td>
<td>15</td>
<td>0</td>
<td>5</td>
<td>16</td>
<td>54</td>
</tr>
<tr>
<td>Mean</td>
<td>.37</td>
<td>1.73</td>
<td>1.47</td>
<td>1.04</td>
<td>1.07</td>
<td>7.41</td>
<td>.16</td>
<td>.45</td>
<td>52.87</td>
</tr>
<tr>
<td>Median</td>
<td>.32</td>
<td>1.78</td>
<td>1.30</td>
<td>.95</td>
<td>1.08</td>
<td>8.00</td>
<td>0.00</td>
<td>.32</td>
<td>49.00</td>
</tr>
<tr>
<td>Mode</td>
<td>2a</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>.142</td>
<td>.336</td>
<td>.740</td>
<td>.440</td>
<td>.390</td>
<td>1.613</td>
<td>.249</td>
<td>.438</td>
<td>15.601</td>
</tr>
<tr>
<td>Skewness</td>
<td>.663</td>
<td>-.788</td>
<td>.746</td>
<td>.779</td>
<td>.612</td>
<td>- .458</td>
<td>2.253</td>
<td>.922</td>
<td>.952</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.540</td>
<td>1.244</td>
<td>-1.194</td>
<td>.413</td>
<td>.071</td>
<td>2.083</td>
<td>5.417</td>
<td>.042</td>
<td>.706</td>
</tr>
</tbody>
</table>

a. Multiple modes exist. The smallest value is shown

Overall cognition scores were positively skewed with a range from 14—“minimal cognitive impairment” to 112—“severe cognitive impairment” with a $\tau$=52.9, $s = 15.6,$
median of 49.0, and a mode of 40 (Figure 12). Most participants indicated they experienced some level of cognitive impairment with 72.9% scoring 60 or less.

Figure 12. Distribution of Cognitive Composite Scores

Correlation Analysis

Our hypotheses (1a & b) were that higher levels of physical activity (PA) would be associated with higher levels of self-efficacy (SE), outcome expectations (OE), and self-regulation (SR), which in turn, would be associated with higher health-related quality of life (HRQoL). Our second hypothesis was that higher levels of PA will be associated with higher HRQoL, and our third hypothesis was that SE, OE, and SR would mediate the relationship between PA and HRQoL in PD Patients.

To test these hypotheses, we began by examining the bivariate correlations between all variables of interest: PA (stairs, walking, MVPA), SE (overall, task, coping, scheduling), OE, SR, and HRQoL (physical, mental). Pearson correlations were
performed between interval/ratio level scale data, and Spearman’s correlations were performed between ordinal level data or ordinal data, as well as ordinal data vs ratio level data. The level of significance for a two-tailed test was used \((p<0.05)\). With sufficiently large sample sizes, statistical significance may be demonstrated even with very small, and sometimes meaningless differences. If this were an interventional study, we would calculate effect size to evaluate the significance observed. Statistical power is the probability that a study will find a statistically significant different between two measures when an actual difference exists. Statistical power, like statistical significance, depends upon both sample size and effect size. Large sample size studies may detect small differences and should be interpreted with caution.

The significant bivariate correlations between lifestyle and psychosocial variables are reported in Table 10. From Table 10, we can see that PA as measured by Walking and MVPA demonstrated significant positive correlations \((p<0.01)\) with all types of self-efficacy—overall SE and stairs \((r=0.198)\), walk \((r=0.404)\), and MVPA \((r=0.548)\); task SE and stairs \((r=0.115)\), walk \((r=0.253)\), and MVPA \((r=0.328)\); coping SE and stairs \((r=0.132)\), walk \((r=0.258)\), and MVPA \((r=0.350)\); scheduling SE and stairs \((r=0.124)\), walk \((r=0.401)\), and MVPA \((r=0.532)\). Outcome expectations (OE) were not correlated with stairs but were significantly correlated to walking \((r=0.202)\) and MVPA \((r=0.312)\). Self-regulation (SR) scores were correlated with stairs \((r=0.102)\), walking \((r=0.403)\), and MVPA \((r=0.492)\). Physical HRQoL scores were correlated with stairs \((r=0.243)\), walking \((r=0.339)\), and MVPA \((r=0.329)\). Mental HRQoL scores were correlated with only walking \((r=0.246)\) and MVPA \((r=0.246)\). MVPA consistently showed the larger
significant positive correlations with the SCT constructs. Also, stairs, walking, and MVPA showed significant correlations to each other, which would result in multicollinearity if used together in regression analysis. Therefore, after further multicollinearity testing, MVPA was the physical activity variable selected for use in the regression models. These results provide some support for our hypothesis that greater physical activity was related to more favorable quality of life.

The significant bivariate correlations between demographic, physical activity, and psychosocial variables are reported in Table 11. Notable results included in Table 11 included the following: BMI showed significant negative correlations to MVPA ($r = -.173$,
p < 0.01), self-efficacy (r = -0.217, p < 0.01), outcome expectation (r = -0.141, p < 0.05), and self-regulation (r = -0.235, p < 0.01), physical HRQoL (r = -0.247, p < 0.01), and mental HRQoL (r = -0.092, p < 0.05). BMI showed significant positive correlations to total number of comorbidities (r = 0.196, p < 0.01), Hoehn and Yahr scores (r = 0.137, p < 0.01), and depression scores (r = 0.150, p < 0.01).

Depression (GDS) also showed significant negative associations to MVPA (r = -0.286, p < 0.01), SE (r = -0.334, p < 0.01), OE (r = -0.319, p < 0.01), and SR (r = -0.321, p < 0.01), physical HRQoL (r = -0.402, p < 0.01), mental HRQoL (r = -0.668, p < 0.01), and age (r = -0.144, p < 0.01). GDS showed significant positive correlations to total number of comorbidities (r = 0.209, p < 0.01), Hoehn and Yahr scores (r = 0.259, p < 0.01), and cognition scores (r = 0.545, p < 0.01).

### Table 11

<table>
<thead>
<tr>
<th>Comorbidities</th>
<th>Yrs Since Dx</th>
</tr>
</thead>
<tbody>
<tr>
<td>H &amp; Y</td>
<td>1</td>
</tr>
<tr>
<td>MVPA</td>
<td>-0.209** -0.151** 1</td>
</tr>
<tr>
<td>SE</td>
<td>-0.242** -0.241** 0.548** 1</td>
</tr>
<tr>
<td>OE</td>
<td>-0.142** -0.065 0.312** 0.393** 1</td>
</tr>
<tr>
<td>SR</td>
<td>-0.135** -0.106** 0.492** 0.561** 0.486** 1</td>
</tr>
<tr>
<td>GDS</td>
<td>0.209** 0.259** -0.286** -0.334** -0.319** -0.321** 1</td>
</tr>
<tr>
<td>COG</td>
<td>0.158** 0.319** -0.147** -0.158** -0.128** -0.131** 0.545** 1</td>
</tr>
<tr>
<td>PQoL</td>
<td>-0.325** -0.450** 0.329** 0.398** 0.277** 0.324** -0.402** 0.113* 1</td>
</tr>
<tr>
<td>MQoL</td>
<td>-0.130** -0.126** 0.246** 0.297** 0.204** 0.258** -0.668** 0.045 -0.103* 1</td>
</tr>
<tr>
<td>BMI</td>
<td>0.196** 0.137** -0.173** -0.217** -0.141** -0.235** 0.150** -0.665 -0.247** -0.092* 1</td>
</tr>
<tr>
<td>Age</td>
<td>0.142** 0.106** -0.104** -0.019 -0.024 -0.069 -0.144** -0.001 -0.116** 0.152** -0.080 1</td>
</tr>
</tbody>
</table>

Note: p < 0.05*, p < 0.01**
Age showed significant positive correlations to the number of total comorbidities \((r=.142, p<0.01)\) and mental HRQoL \((r=.152, p<0.01)\), and significant negative correlations to GDS \((r=-.144, p<0.01)\) and physical HRQoL \((r=-.116, p<0.01)\).

Self-efficacy showed significant negative correlations to total number of comorbidities \((r=-.242, p<0.01)\), Hoehn and Yahr severity score \((r=-.241, p<0.01)\), GDS \((r=-.334, p<0.01)\), cognitive scores \((r=-.158, p<0.01)\), and BMI \((r=-.217, p<0.01)\). SE showed significant positive correlations to MVPA \((r=.548, p<0.01)\), OE \((r=.393, p<0.01)\), SR \((r=.561, p<0.01)\), physical HRQoL \((r=.398, p<0.01)\), and mental HRQoL \((r=.297, p<0.01)\).

Outcome expectations were negatively correlated to total number of comorbidities \((r=-.142, p<0.01)\), depression scores \((r=-.319, p<0.01)\), cognition scores \((r=-.128, p<0.01)\), and BMI \((r=-.141, p<0.05)\). Outcome expectations were positively correlated to MVPA \((r=.312, p<0.01)\), SE \((r=.393, p<0.01)\), SR \((r=.486, p<0.01)\), physical HRQoL \((r=.277, p<0.01)\), and mental HRQoL \((r=.204, p<0.01)\).

Self-regulation scores were negatively correlated to total number of comorbidities \((r=-.135, p<0.01)\), Hoehn and Yahr severity score \((r=-.106, p<0.05)\), GDS \((r=-.321, p<0.01)\), cognition score \((r=-.131, p<0.01)\), BMI \((r=-.235, p<0.01)\), and years since diagnosis \((r=-.120, p<0.01)\). SR scores were positively correlated to MVPA \((r=.492, p<0.01)\), SE \((r=.561, p<0.01)\), OE \((r=.486, p<0.01)\), physical HRQoL \((r=.324, p<0.01)\), and mental HRQoL \((r=.258, p<0.01)\).

Multicollinearity testing was performed after centering of outcome expectation and self-regulation variables to look for high correlations among the subscales and
composite scores to prevent missing a significant effect due to an inflated standard error or large confidence interval. The bivariate correlations were examined to identify any $r > 0.7$, and those independent variables near this value were regressed on each other to determine which variables should be used in the regression models to prevent violating the assumptions.

The self-efficacy (SE) variables – composite score, task, coping, and scheduling self-efficacy had $r$ values between 0.586 and 0.748; outcome expectation subscales – physical, social, and self-evaluative all had $r$ values between 0.640 and 0.853. The SE score and the OE composite score were chosen for the regression models to avoid multicollinearity issues within the subscales. The self-regulation (SR) subscales – self, goal-setting, social support, reinforcement, time management, and relapse were all highly correlated with the composite score; however the subscales were not all highly correlated to each other. Within the self-regulation subscales, $r$ values ranged from 0.326 to 0.740.

Social support was the one variable not correlated with the others and not as well-correlated to the PASR12 composite score as the other subscales ($r = 0.595$, range 0.595 to 0.850). Goal-setting, time management, and relapse were the most correlated with the PASR 12 ($r > 8$) and accounted for more than 70% of the variability in the composite score when regressed on it.
Regression Analysis

Hypothesis 1a

To test the hypothesis that higher levels of PA would be associated with higher levels of SE, OE, and SR (Hypothesis 1a), regression analysis was conducted regressing MVPA onto SE, OE, and SR one at a time. Figure 13 modeled this relationship.

Figure 13. Model for Hypothesis 1a of SCT Variables Relationship to Physical Activity

Self-efficacy predicted 23% of the variance in physical activity ($R^2 = 23.1$). The relationship of self-efficacy to MVPA was significant ($F(1,498) = 150.012, p<.001$), ($\beta = 0.481, p<.001$). Tables 12 and 13 displayed the regression results for SE regressed onto MVPA.
Table 12

ANOVA results for Self-Efficacy regressed onto MVPA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3600859.638</td>
<td>1</td>
<td>3600859.638</td>
<td>150.012</td>
<td>.000b</td>
</tr>
<tr>
<td>Residual</td>
<td>11953858.644</td>
<td>498</td>
<td>24003.732</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15554718.282</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA
b. Predictors: (Constant), SE

Table 13

Coefficients for Self-Efficacy regressed onto MVPA

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>14.443</td>
<td>17.734</td>
</tr>
<tr>
<td>SE</td>
<td>27.018</td>
<td>2.206</td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA

Outcome expectations predicted almost 6% of the variance in physical activity ($R^2 = 5.8$). The relationship of OE to MVPA was also significant ($F (1,498) = 30.392$, $p < .001$, $\beta = .240$, $p < .001$). Tables 14 and 15 represented the results of regressing OE onto MVPA.
Table 14
*ANOVA results for Outcome Expectations regressed onto MVPA*

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>894667.638</td>
<td>1</td>
<td>894667.638</td>
<td>30.392</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>14660050.644</td>
<td>498</td>
<td>29437.853</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15554718.282</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA
b. Predictors: (Constant), OE

Table 15
*Coefficients for Outcome Expectations regressed onto MVPA*

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>-69.660</td>
</tr>
<tr>
<td></td>
<td>OE</td>
<td>4.567</td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA

Self-regulation predicted 21% of the variance in physical activity ($R^2 = 21.0$). The relationship of SR to MVPA was also significant ($F (1,498) = 132.050$, $p < .001$), ($\beta = .458$, $p < .001$). Tables 16 and 17 represented the output from regressing SR onto MVPA.
When SE, OE, and SR were regressed onto MVPA in a SCT combined model, the SCT constructs predicted 28% of the variance in physical activity ($R^2 = 28.1$). The revised model was significant ($F(3, 496) = 64.694, p < .001$); however, outcomes expectations were no longer a significant predictor in the combined model ($\beta = .024, p = .565$), while both SE ($\beta = .322, p < .001$) and SR ($\beta = .263, p < .001$) remained significant. Tables 18 and 19 displayed the results of the SCT combined model with all three variables—SE, OE, and SR regressed onto MVPA.
Table 18
ANOVA results for SE, OE, and SR regressed onto MVPA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4374666.551</td>
<td>3</td>
<td>1458222.184</td>
<td>64.694</td>
<td>.000b</td>
</tr>
<tr>
<td>Residual</td>
<td>11180051.730</td>
<td>496</td>
<td>22540.427</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15554718.282</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA
b. Predictors: (Constant), SE, OE, SR

Table 19
Coefficients for SE, OE, and SR regressed onto MVPA

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>-124.766</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>18.068</td>
</tr>
<tr>
<td></td>
<td>OE</td>
<td>.461</td>
</tr>
<tr>
<td></td>
<td>SR</td>
<td>4.450</td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA

Multiple linear regression (MLR) models examined the addition of other variables thought to be important revisions to the model testing Hypothesis 1a. Regressing the additional variables BMI, Hoehn and Yahr Severity Score, GDS depression score, and total number of comorbidities were not significant predictors and did not add any explanatory power to the model. The equation for the best fitting model 1a was:

\[ \text{MVPA} = -102.739 + 18.29(\text{SE}) + 4.576(\text{SR}) \]

The intercept for this model
(B₀ = -102.739) would reflect that SE and SR cannot be zero, since the reported MVPA would result in a negative 103 minutes of MVPA per week (t = -3.888, p<.001). For every one point increase in SR, MVPA would significantly increase by 18.29 points (β=.326, t = 7.0131, p<.001), similarly, for every one point increase in SE, MVPA would significantly increase by 4.576 points (β=.271, t = 5.835, p<.001). These two variables had the largest positive relation with MVPA. These results are represented in Tables 20 and 21. Results of the regression analysis supported hypothesis 1a that higher levels of PA were associated with higher levels of SE, OE, and SR separately, and SE and SR when controlling for the effects of the other.

Table 20
ANOVA results for SE and SR regressed onto MVPA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Regression</td>
<td>4367180.903</td>
<td>2</td>
<td>2183590.452</td>
<td>97.005</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>11187537.378</td>
<td>497</td>
<td>22510.136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15554718.282</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA
b. Predictors: (Constant), SE, SR

Table 21
Coefficients for SE and SR regressed onto MVPA

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>-102.739</td>
<td>26.425</td>
</tr>
<tr>
<td>SE</td>
<td>18.290</td>
<td>2.608</td>
</tr>
<tr>
<td>SR</td>
<td>4.576</td>
<td>.784</td>
</tr>
</tbody>
</table>

a. Dependent Variable: MVPA
Hypothesis 1b

Regression analysis of physical HRQoL, regressed on SCT constructs were performed to test the hypothesis that higher levels of SE, OE, and SR would be associated with higher levels of HRQoL (Hypothesis 1b) (See Figure 14).

Figure 14. Model for Hypothesis 1b of SCT Variables Relationship to Health-Related Quality of Life

SCT Constructs relationship to Physical Health-Related Quality of Life

SCT constructs predicted 19.1% of the variance in physical HRQoL. The model was significant ($F (3,496) = 38.956, p<.001$) (See Table 22). The relationship of self-efficacy to physical HRQoL, controlling for outcome expectations and self-regulation, was significant ($\beta=.329, t = 6.598, p<.001$). The relationship of outcome expectations to physical HRQoL, controlling for self-efficacy and self-regulation, was also significant ($\beta=.096, t = 2.146, p=.032$). In Table 23, the relationship of self-regulation to physical HRQoL was significant when regressed on physical HRQoL without SE or OE ($t=7.584,$
$p<.001$); however, when the relationship of SR to physical HRQoL was examined controlling for SE and OE, the relationship was no longer significant ($\beta=.095$, $t=1.847$, $p=.065$).

Table 22

ANOVA results for SE, OE, and SR regressed onto Physical HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>7692.292</td>
<td>3</td>
<td>2564.097</td>
<td>38.956</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>32646.707</td>
<td>496</td>
<td>65.820</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>40338.999</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL
b. Predictors: (Constant), SE, OE, SR

Table 23

Coefficients for SE, OE, and SR regressed onto Physical HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>30.388</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>.941</td>
</tr>
<tr>
<td></td>
<td>OE</td>
<td>.093</td>
</tr>
<tr>
<td></td>
<td>SR</td>
<td>.081</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL

In summary, results of this regression analysis supported hypothesis 1b as higher levels of SE and OE, but not SR, were associated with higher levels of physical HRQoL in this sample of PD patients.
Multiple linear regression (MLR) model 1b_PHRQoL (Hypothesis 1b) of psychosocial variables (SE and OE) onto physical HRQoL was revised by adding the variables BMI, Age, Hoehn and Yahr Severity Score, and total number of comorbidities. This model explained 39% of the variance in physical HRQoL ($R^2 = 39.3$). In model 1b_SE, OE, BMI, Age, H&Y, and total comorbidities together were significantly related to physical quality of life ($F (6,493) = 53.265, p<.001$). The equation for model 1b_PHRQoL was: $PHRQoL = 57.831 + .578(\text{SE}) + .110(\text{OE}) -.290(\text{BMI}) - .067(\text{Age}) - 3.702(\text{H&Y}) - 1.439(\text{Comorbidities})$. The intercept for this model ($B_0 = 57.831$) would reflect that when SE, OE, BMI, Age, H&Y, and total comorbidities were zero, the reported the physical HRQoL score would be positive ($t = 15.344, p<.001$). Controlling for H&Y severity score decreases physical HRQoL by 3.702 points ($t = -9.023, p<.001$), similarly, for every one point increase in total comorbidities, physical HRQoL would decrease by 1.439 points ($t = -4.924, p<.001$) (See Tables 24 and 25).

Table 24
ANOVA results for SE and OE regressed onto Physical HRQoL with BMI, Age, Hoehn & Yahr, and Total #Comorbidities

<table>
<thead>
<tr>
<th>ANOVAa</th>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>15865.256</td>
<td>6</td>
<td>2644.209</td>
<td>53.265</td>
<td>.000b</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>24473.742</td>
<td>493</td>
<td>49.642</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40338.999</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL  
b. Predictors: (Constant), SE, OE, BMI, Age, Hoehn and Yahr, Total of All Comorbidities
Table 25

Coefficients for SE and OE regressed onto Physical HRQoL with BMI, Age, Hoehn & Yahr, and Total #Comorbidities

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>57.831</td>
<td>3.769</td>
</tr>
<tr>
<td>SE</td>
<td>.578</td>
<td>.114</td>
</tr>
<tr>
<td>OE</td>
<td>.110</td>
<td>.036</td>
</tr>
<tr>
<td>BMI</td>
<td>-.290</td>
<td>.064</td>
</tr>
<tr>
<td>Age</td>
<td>-.067</td>
<td>.034</td>
</tr>
<tr>
<td>Hoehn &amp; Yahr</td>
<td>-3.702</td>
<td>.410</td>
</tr>
<tr>
<td>#Comorbidities</td>
<td>-1.439</td>
<td>.292</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL

The Hoehn and Yahr Score and total number of comorbidities had the largest negative impact on physical HRQoL. The addition of BMI, Age, Hoehn & Yahr, and number of comorbidities increased the amount of physical HRQoL variance explained.

SCT Constructs relationship to Mental Health-Related Quality of Life

Mental HRQoL regressed on SCT constructs were performed to test the hypothesis that higher levels of SE, OE, and SR would be associated with higher levels of mental HRQoL. SCT constructs explained 11% of the variance in mental HRQoL ($R^2 = 10.7$). The model was significant ($F(3,496) = 19.860, p<.001$) (Table 26). The equation for the model was: mental HRQoL = 36.808 + .481(SE) + .099(OE) + .101(SR). The intercept for this model ($B_0 = 36.808$) would reflect that when SE, OE, and SR were zero, the reported mental HRQoL score would be positive ($t = 14.703, p<.001$). The relationship of self-efficacy to mental HRQoL, controlling for outcome expectations and
self-regulation, was significant ($\beta=.177, t=3.383, p=.001$). The relationship of outcome expectations to mental HRQoL, controlling for self-efficacy and self-regulation, was also significant ($\beta=.107, t=2.289, p=.022$).

Table 26
ANOVA results for SE, OE, and SR regressed onto Mental HRQoL

| ANOVAa |
|------------------|------------------|------------------|------------------|
| Model            | Sum of Squares   | df | Mean Square | F | Sig. |
| Regression       | 3895.860         | 3  | 1298.620    | 19.860 | .000b |
| Residual         | 32433.492        | 496| 65.390      |        |      |
| Total            | 36329.352        | 499|            |        |      |

a. Dependent Variable: Mental HRQoL
b. Predictors: (Constant), SE, OE, and SR

Further, the relationship of self-regulation to mental HRQoL was significant ($\beta=.124, t=2.312, p=.021$), when regressed on mental HRQoL (Table 27), controlling for SE and OE. Thus, hypothesis 1b was supported in that higher levels of SE, OE, and SR were associated with higher levels of mental HRQoL.

Table 27
Coefficients for SE, OE, and SR regressed onto Mental HRQoL

| Coefficientsa |
|------------------|------------------|------------------|
| Model            | Unstandardized Coefficients | Standardized Coefficients |
|                 | B         | Std. Error | Beta | t | Sig. |
| (Constant)       | 36.808    | 2.503      | 14.703 | .000 |
| SE               | .481      | .142       | .177  | 3.383 | .001 |
| OE               | .099      | .043       | .107  | 2.289 | .022 |
| SR               | .101      | .044       | .124  | 2.312 | .021 |

a. Dependent Variable: Mental HRQoL
The hypothesis that higher levels of the SCT constructs would be associated with higher levels of both physical and mental HRQoL appeared to be significantly predictive, with a slight but small explanatory value. A revised model regressing SE, OE, SR, BMI, Age, Hoehn and Yahr Score, and total number of comorbidities onto mental HRQoL explained 52.8% of the variance in mental HRQoL but only SE and GDS depression score remained significant predictors. However, when a revised model with only SE and GDS depression score was regressed onto mental HRQoL, 52% ($R^2 = 52.0$) of the variance was explained, but SE became a nonsignificant predictor ($\beta = .057, p = .083$) (Tables 28 and 29).

| Table 28 |
| ANOVA results for SE and GDS Depression Score regressed onto Mental HRQoL |

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>18890.620</td>
<td>2</td>
<td>9445.310</td>
<td>269.189</td>
<td>.000b</td>
</tr>
<tr>
<td>Residual</td>
<td>17438.732</td>
<td>497</td>
<td>35.088</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36329.352</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental HRQoL
b. Predictors: (Constant), SE, GDS

This indicated that depression was a strong predictor of mental health-related quality of life ($F (2,497) = 269.189, p < .001$). This would indicate that although hypothesis 1b supported the association of higher levels of SCT correlates with higher levels of physical and mental HRQoL, depression should be considered
as a strong predictor of mental HRQoL.

Table 29
Coefficients for SE and GDS Depression Score regressed onto Mental HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>57.047</td>
<td>.888</td>
<td>64.213</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>.155</td>
<td>.089</td>
<td>1.738</td>
</tr>
<tr>
<td></td>
<td>GDS Score</td>
<td>-.922</td>
<td>.043</td>
<td>-.700</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental HRQoL

Hypothesis 2

Physical and mental HRQoL variables were each regressed on to MVPA to test Hypothesis 2 that higher levels of PA will be associated with higher HRQoL. Figure 15 represented this relationship.

Figure 15. Model for Hypothesis 2 of Physical Activity's Relationship to Health-Related Quality of Life
Physical Activity’s relationship to Physical Health-Related Quality of Life

MVPA predicted 9% of the variability in physical HRQoL. In Table 30, the model was significant ($F (1,498) = 50.023, p<.001$).

Table 30
ANOVA results for MVPA regressed onto Physical HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3682.137</td>
<td>1</td>
<td>3682.137</td>
<td>50.023</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>36656.861</td>
<td>498</td>
<td>73.608</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>40338.999</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL
b. Predictors: (Constant), MVPA

MVPA was a significant predictor of physical HRQoL ($\beta=.302, t=7.073, p<.001$) as shown in Table 31.

Table 31
Coefficients for MVPA regressed onto Physical HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>43.056</td>
</tr>
<tr>
<td></td>
<td>MVPA</td>
<td>.015</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL
Next, the revised model 2_PQoL (Hypothesis 2) regressed MVPA onto physical HRQoL, while controlling for BMI, Age, Hoehn and Yahr Severity Score, GDS depression score, and total number of comorbidities. This model explained 39% of the variance in physical HRQoL ($R^2 = 39.0$). In model 2_PQoL, MVPA, BMI, Age, Hoehn and Yahr Score, GDS depression score, and total number of comorbidities were significantly related to physical health-related quality of life ($F (6,493) = 52.591$, $p<.001$). Table 32 depicted the ANOVA results for the revised model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>15742.905</td>
<td>6</td>
<td>2623.817</td>
<td>52.591</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>24596.094</td>
<td>493</td>
<td>49.891</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40338.999</td>
<td>499</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL  
b. Predictors: (Constant), MVPA, GDS Score, Age, BMI, Hoehn and Yahr Score, Total of All Comorbidities

Table 33 produced the equation for model 2_PQoL was: physical HRQoL = 70.553 + .007(MVPA) - .291(BMI) - 0.088(Age) - 3.514(H&Y) -.264(GDS) - 1.472(Comorbidities) – 0.264 (GDS). The intercept for this model ($B_0 = 70.553$) would reflect that when MVPA, BMI, Age, Hoehn and Yahr Score, GDS depression score, and total number of comorbidities were zero, the reported physical quality of life score would
be positive \((t = 23.014, p < .001)\). As hypothesized, MVPA appeared to have a significant positive relationship to physical HRQoL \((t = 3.778, p < .001)\).

Table 33

<table>
<thead>
<tr>
<th>Coefficients for MVPA with BMI, Age, Hoehn and Yahr Score, GDS Depression Score, and Total Number of Comorbidities regressed onto Physical HRQoL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>(Constant)</td>
</tr>
<tr>
<td>MVPA</td>
</tr>
<tr>
<td>BMI</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Hoehn &amp; Yahr</td>
</tr>
<tr>
<td>Total Comorbidities</td>
</tr>
<tr>
<td>GDS Score</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL

BMI \((t = -4.534, p < .001)\), Age \((t = -2.539, p = .011)\), Hoehn and Yahr severity score \((t = -8.451, p < .001)\), GDS depression score \((t = -4.929, p < .001)\), and total number of comorbidities displayed significant negative \((t = -5.039, p < .001)\). Controlling for H&Y severity score would decrease physical HRQoL by 3.514 points, similarly, controlling for total comorbidities would decrease physical HRQoL by 1.472 points. These two variables had the largest negative impact on physical HRQoL. In summary, higher levels of MVPA were significantly associated with higher levels of physical HRQoL as hypothesized. The addition of BMI, Age, Hoehn and Yahr score, total number of comorbidities, and GDS
depression score added explanatory power to the model improving its ability to explain the variation in physical HRQoL by thirty percent.

*Physical Activity’s relationship to Mental Health-Related Quality of Life*

MVPA predicted 4% of the variability in mental HRQoL. This model was also significant ($F(1,498) = 21.259, p < .001$) as shown in Table 34.

Table 34
*ANOVA results for MVPA regressed onto Mental HRQoL*

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1487.343</td>
<td>1</td>
<td>1487.343</td>
<td>21.259</td>
<td>.000b</td>
</tr>
<tr>
<td>Residual</td>
<td>34842.009</td>
<td>498</td>
<td>69.964</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36329.352</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental Component Score  

b. Predictors: (Constant), Total Moderate Intensity plus Vigorous Intensity PA per week

Table 35 displayed the coefficients and corresponding t values for MVPA and mental HRQoL ($\beta = .202, t=4.611, p < .001$).

Table 35
*Coefficients for MVPA regressed onto Mental HRQoL*

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>48.437</td>
<td>.589</td>
</tr>
<tr>
<td>MVPA</td>
<td>.010</td>
<td>.002</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental HRQoL
However, when the revised Model 2_MQoL (Hypothesis 2) regressed MVPA, BMI, Age, Hoehn and Yahr Score, total number of comorbidities, and GDS Depression Score onto mental HRQoL. This model explained almost 53% of the variance in mental HRQoL ($R^2 = 52.5$). However, in this model 2b_MQoL, only MVPA and GDS Depression Score were significantly related to mental health-related quality of life ($F(6,493) = 90.944, p<.001$). Taking this into account, the model was again revised to include only MVPA and GDS as predictors, and this model explained 52% of the variance in mental HRQoL ($R^2 = 51.9$), and Table 36 shows that this model was significantly predictive of mental HRQoL ($F(2,497) = 268.049, p<.001$).

### Table 36

**ANOVA results for MVPA with GDS Depression Score regressed onto Mental HRQoL**

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>2</td>
<td>9426.070</td>
<td>268.049</td>
<td>.000b</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>497</td>
<td>35.165</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36329.352</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental HRQoL
b. Predictors: (Constant), MVPA, GDS Score

Similar to the results for Hypothesis 1b on mental HRQoL, MVPA became a non-significant predictor in the final model containing GDS Depression Score shown in Table 37. The equation for model 2_mental HRQoL was: mental HRQoL = 57.831 + .002(MVPA) – 0.933 (GDS). The intercept for this model ($B_0 = 57.831$) would reflect that when MVPA and GDS score were zero, the reported mental quality of life
score would be positive ($t = 97.339, p<.001$).

Table 37
*Coefficients for MVPA with GDS Depression Score regressed onto Mental HRQoL*

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>(Constant)</td>
<td>57.831</td>
<td>.594</td>
</tr>
<tr>
<td>MVPA</td>
<td>.002</td>
<td>.002</td>
</tr>
<tr>
<td>GDS Score</td>
<td>-.933</td>
<td>.042</td>
</tr>
<tr>
<td></td>
<td>t</td>
<td>Sig.</td>
</tr>
<tr>
<td></td>
<td>97.339</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>1.386</td>
<td>.166</td>
</tr>
<tr>
<td></td>
<td>-.709</td>
<td>-22.222</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental HRQoL

Hypothesis 3

Our third hypothesis was that psychosocial variables mediated the response between MVPA and HRQoL. To test this hypothesis, we first ran a multistep forced-entry hierarchical linear regression (HLR), and followed this with a regression analysis using Andrew F. Hayes, Ph.D.’s Process Procedure for SPSS Release 2.15 (Hayes, 2012).
Figure 16. Model for Hypothesis 3 of Physical Activity’s Relationship to Health-Related Quality of Life Mediated by SCT Constructs

1. Figure 16 represented the mediational model tested by the HLR on physical HRQoL. First, we regressed three blocks onto physical HRQoL. Tables 38 and 39 displayed ANOVA results and Coefficients for this HLR. All *F* statistics are significant. The 1st block regressed MVPA onto physical HRQoL which explained 9% of the variance in physical HRQoL (*R*² = 8.9);
2. The 2nd block regressed MVPA and SE, OE, and SR onto physical HRQoL which explained 19% of the variance in physical HRQoL (*R*² = 19.3);
3. The 3rd block regressed MVPA, SE, OE, SR, BMI, Age, Hoehn and Yahr severity score, comorbidities, and GDS depression score onto physical HRQoL which explained 41% of the variance in physical HRQoL (*R*² = 41.5).
   a. Only SE and OE were significant predictors in the HLR, SR was not significant. In the 2nd model, the *R*² increased by 10.8%.
   b. The addition of BMI, Age, Hoehn and Yahr score, total comorbidities, and GDS score increased the *R*² by 21.5%. The 3rd block proved significantly better than the grand mean model (*F* (9,490) = 38.551, *p* < .001).
   c. The improvements in the both model 2 and 3’s ability to explain the variance in physical HRQoL, while MVPA lost its significance, indicated that SE mediated the response of physical HRQoL.
**Physical Health-Related Quality of Life**

The model of SE, OE, and SR mediating the relationship between MVPA and physical HRQoL is shown in Table 38. This model was significantly predictive of physical HRQoL in block 1 \((F(1,498) = 50.023, p<.001)\); block 2 \((F(4,495) = 30.759, p<.001)\); and block 3 \((F(9,490) = 38.551, p<.001)\).

### Table 38

ANOVA results for HLR with SCT Constructs Mediating the Relationship between MVPA and Physical HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Regression</td>
<td>3682.14</td>
<td>1</td>
<td>3682.14</td>
<td>50.023</td>
<td>.000b</td>
</tr>
<tr>
<td>Residual</td>
<td>36656.9</td>
<td>498</td>
<td>73.608</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>40339</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Regression</td>
<td>8030.48</td>
<td>4</td>
<td>2007.62</td>
<td>30.759</td>
<td>.000c</td>
</tr>
<tr>
<td>Residual</td>
<td>32308.5</td>
<td>495</td>
<td>65.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>40339</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Regression</td>
<td>16722.3</td>
<td>9</td>
<td>1858.03</td>
<td>38.551</td>
<td>.000d</td>
</tr>
<tr>
<td>Residual</td>
<td>23616.7</td>
<td>490</td>
<td>48.197</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>40339</td>
<td>499</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL  
b. Predictors: (Constant), MVPA  
c. Predictors: (Constant), MVPA, SE, OE, SR  
d. Predictors: (Constant), MVPA, SE, OE, SR, BMI, Age, Hoehn & Yahr, Total of All Comorbidities, GDS Score

In Table 39, MVPA significantly predicts physical HRQoL in the first regression block \((\beta=.302, t=7.073, p<.001)\). SE (SEE Composite Score) and OE (Total of all scores) remain significant in the 2\(^{nd}\) block, SE \((\beta=.294, t=5.664, p<.001)\), OE \((\beta=.093, t=2.096, p=.037)\), and MVPA remains a significant predictor of physical HRQoL in block 2
(\(\beta=.108, t=2.276, p=.023\)). In block 3, MVPA loses its significance (\(\beta=.062, t=1.500, p=.134\)). Of the SCT constructs, only SE remained significant as a predictor of physical HRQoL (\(\beta=.136, t=2.929, p=.004\)). OE was not a significant mediator; however, BMI, age, Hoehn and Yahr Severity Score, total number of comorbidities, and GDS depression score all remained significant predictors in block 3.

Table 39
Coefficients for HLR with SCT Constructs Mediating the Relationship between MVPA and Physical HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>43.056</td>
<td>0.604</td>
<td>71.293</td>
</tr>
<tr>
<td>2 (Constant)</td>
<td>31.075</td>
<td>2.519</td>
<td>12.335</td>
</tr>
<tr>
<td>MVPA</td>
<td>0.005</td>
<td>0.002</td>
<td>0.108</td>
</tr>
<tr>
<td>SE</td>
<td>0.841</td>
<td>0.149</td>
<td>0.294</td>
</tr>
<tr>
<td>OE</td>
<td>0.09</td>
<td>0.043</td>
<td>0.093</td>
</tr>
<tr>
<td>SR</td>
<td>0.057</td>
<td>0.045</td>
<td>0.066</td>
</tr>
<tr>
<td>3 (Constant)</td>
<td>60.992</td>
<td>4.019</td>
<td>15.177</td>
</tr>
<tr>
<td>MVPA</td>
<td>0.003</td>
<td>0.002</td>
<td>0.062</td>
</tr>
<tr>
<td>SE</td>
<td>0.389</td>
<td>0.133</td>
<td>0.136</td>
</tr>
<tr>
<td>OE</td>
<td>0.064</td>
<td>0.038</td>
<td>0.066</td>
</tr>
<tr>
<td>SR</td>
<td>0.033</td>
<td>0.04</td>
<td>0.039</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.256</td>
<td>0.064</td>
<td>-0.149</td>
</tr>
<tr>
<td>Age</td>
<td>-0.084</td>
<td>0.034</td>
<td>-0.088</td>
</tr>
<tr>
<td>Hoehn &amp; Yahr</td>
<td>-3.395</td>
<td>0.414</td>
<td>-0.304</td>
</tr>
<tr>
<td>Total Comorbidities</td>
<td>-1.333</td>
<td>0.291</td>
<td>-0.172</td>
</tr>
<tr>
<td>GDS Score</td>
<td>-0.194</td>
<td>0.056</td>
<td>-0.14</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Physical HRQoL
To continue testing the hypothesis that psychosocial variables mediated the response between MVPA and HRQoL, we conducted another. In this HLR, we regressed two blocks onto mental HRQoL. Figure 16 represented the mediational model tested by the HLR on mental HRQoL. Tables 40 and 41 displayed ANOVA results and coefficients for this HLR.

1. The 1st block regressed MVPA onto mental HRQoL, which explained 4% of the variance in mental HRQoL ($R^2 = 3.9$). The model was significant ($F(1,498) = 21.259, p<.001$).

2. The 2nd block regressed MVPA, SE, OE, and SR onto mental HRQoL which explained 11% of the variance in mental HRQoL ($R^2 = 10.9$), an increase in the $R^2$ of 7%, while MVPA lost its significance. The model was significant ($F(4,495) = 15.122, p<.001$).

3. The 3rd block regressed MVPA, SE, OE, SR, BMI, Age, Hoehn and Yahr severity score, total number of comorbidities, and GDS depression score onto mental HRQoL resulted in a model that explained 53% of the variance in mental HRQoL, an increase in $R^2$ of 42%. The model was significant ($F(9,490) = 61.215, p<.001$).
Table 40
ANOVA results for HLR with SCT Constructs Mediating the Relationship between MVPA and Mental HRQoL

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>1487.343</td>
<td>1</td>
<td>1487.343</td>
<td>21.259</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>34842.009</td>
<td>498</td>
<td>69.964</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36329.352</td>
<td>499</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Regression</td>
<td>3956.020</td>
<td>4</td>
<td>989.005</td>
<td>15.122</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>32373.333</td>
<td>495</td>
<td>65.401</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36329.352</td>
<td>499</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Regression</td>
<td>19228.060</td>
<td>9</td>
<td>2136.451</td>
<td>61.215</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>17101.292</td>
<td>490</td>
<td>34.901</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36329.352</td>
<td>499</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental HRQoL  
b. Predictors: (Constant), MVPA  
c. Predictors: (Constant), MVPA, SE, OE, SR  
d. Predictors: (Constant), MVPA, SE, OE, SR, BMI, Age, Hoehn & Yahr, Total of All Comorbidities, GDS Score

Table 41 reported MVPA losing its significance predicting mental HRQoL in block 2 where ($\beta=.048, t=.959, p=.338$). All three SCT constructs were significant predictors of mental HRQoL in block 2 ($SE\beta=.162, t=2.951, p=.003; OE\beta=.106, t=2.263, p=.024; SR\beta=.112, t=2.016, p=.044$), and mediated the relationship of MVPA and mental HRQoL. In block 3, only GDS depression score remained a significant predictor of mental HRQoL when BMI, Age, Hoehn and Yahr Score, total comorbidities, and GDS score were added to the block. GDS depression score may be acting as a mediator of the SCT constructs in this model.
<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>48.437</td>
<td>.589</td>
</tr>
<tr>
<td>2</td>
<td>(Constant)</td>
<td>37.097</td>
<td>2.522</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>.439</td>
<td>.149</td>
</tr>
<tr>
<td></td>
<td>OE</td>
<td>.098</td>
<td>.043</td>
</tr>
<tr>
<td></td>
<td>SR</td>
<td>.091</td>
<td>.045</td>
</tr>
<tr>
<td>3</td>
<td>(Constant)</td>
<td>52.986</td>
<td>3.420</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>.198</td>
<td>.113</td>
</tr>
<tr>
<td></td>
<td>OE</td>
<td>-.031</td>
<td>.032</td>
</tr>
<tr>
<td></td>
<td>SR</td>
<td>.003</td>
<td>.034</td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>.052</td>
<td>.054</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>.044</td>
<td>.029</td>
</tr>
<tr>
<td></td>
<td>Hoehn &amp;Yahr</td>
<td>.288</td>
<td>.353</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>.372</td>
<td>.248</td>
</tr>
<tr>
<td></td>
<td>Comorbidities</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GDS Score</td>
<td>-.939</td>
<td>.047</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Mental HRQoL

Two models were run using Dr. Hayes “Process Model”—one with physical HRQoL as the outcome variable; MVPA as the predictor variable; SE, OE, and SR as the mediators. Hoehn and Yahr Score, GDS, BMI, and total number of comorbidities were entered into the model as covariates. The inclusion of SE, OE, and SR in the model
completely explained the relationship between MVPA and physical HRQoL; the direct
effect was no longer significantly different from zero as mediators resulted in MVPA
(estimate=.0034, $t = 1.5965, p = .110$). Instead, the effect of MVPA on physical HRQoL
was captured by SE, OE, and SR as indirect effects (SE estimate=.0031, confidence
limits (.0009 to .0056); OE estimate=.0010, confidence limits (.0002 to .0023) which do
not include zero; and SR estimate=.0013, confidence limits (-.0005 to .0033). In total,
40% of the variance in physical HRQoL was explained.

The second “Process” mediation model was run with mental HRQoL as the
outcome variable; MVPA as the predictor variable; SE, OE, and SR, as the mediators.
Hoehn and Yahr Score and age were entered into the model as covariates. The inclusion
of SE, OE, and SR in the model completely explained the relationship between MVPA
and mental HRQoL; the direct effect was no longer significantly different from zero as
mediators resulted in MVPA (estimate=.0030, $t = 1.2684, p = .2052$). Instead, the effect of
MVPA on mental HRQoL was captured by SE, OE, and SR as indirect effects (SE
estimate=.0024, confidence limits (.0003 to .0049); OE estimate=.0011, confidence limits
(.0002 to .0025); SR estimate=.0024, confidence limits (.0002 to .0047) which do not
include zero). In total, 15% of the variance in physical HRQoL was explained.
Chapter 5: Discussion

This primary aims of the present cross-sectional survey study were: 1) Examine the relationship of select social cognitive theory constructs with physical activity, and evaluate the relationship of these theory-based constructs with health-related quality of life; 2) Explore the relationship of physical activity and health-related quality of life; and 3) Determine the extent to which these select social cognitive theory-based constructs mediated the relationship between physical activity and health-related quality of life in a sample of Parkinson’s disease patients.

Our findings supported hypothesis 1a with physical activity being associated with exercise self-efficacy, outcome expectations, and self-regulation. However, exercise self-efficacy and self-regulation were more predictive of physical activity than outcome expectations. Further, the addition of BMI, Hoehn and Yahr severity score, depression score, and total number of comorbidities did not improve the model of self-efficacy and self-regulation predicting physical activity.

Regarding hypothesis 1b, our findings supported all three social cognitive theory constructs to be predictive of physical health-related quality of life when modeled separately. Interestingly, the relationship of self-regulation to physical health-related quality of life was no longer significant when controlling for self-efficacy and outcome expectations.
The addition of BMI, age, Hoehn and Yahr Severity Score, and total number of comorbidities to the hypothesis 1b model more than doubled the revised models prediction of physical health-related quality of life. Also, SE, OE, and SR were associated with higher levels of mental health-related quality of life but not to the extent that the SCT constructs were associated with physical health-related quality of life. All three SCT constructs were significant predictors of mental HRQoL. These findings are consistent with prior quality of life research in older adults with chronic disease (Brian C. Focht, 2012; B. C. Focht, Garver, et al., 2014) and knee osteoarthritis patients (Rejeski et al., 2002) demonstrating that physical activity-related social cognitive variables are more strongly related to the physical health dimension of HRQoL relative to the mental health dimension of HRQoL. The present results extend these findings to Parkinson’s disease patients.

**Hypothesis 2** was that higher levels of physical activity would be associated with higher physical and mental health-related quality of life, which was supported by the study results. Both physical and mental HRQoL were significantly, positively related to MVPA. When added to the MVPA_physical HRQoL model, BMI, age, Hoehn and Yahr Severity Score, GDS depression score, and total number of comorbidities were all significantly, negatively related to physical HRQoL, as would be expected in the physical activity literature. Hoehn and Yahr had the largest negative impact on physical HRQoL, followed by total number of comorbidities, BMI, GDS depression score, and age. For the MVPA_mental HRQoL model, both MVPA and age were significantly, positively predictive of mental HRQoL, with Hoehn and Yahr Severity Score having a significant,
negative impact. When GDS depression score was added to this model, MVPA, age, and Hoehn and Yahr were no longer significant, indicating that depression could be a mediator of MVPA and mental HRQoL, which warrants further investigation. Similar to the results of the analysis testing for Hypotheses 1a and 1b, the findings of the analysis of Hypothesis 2 were also consistent with prior physical activity research in older adults (Edward McAuley, Gerald J Jerome, David X Marquez, Steriani Elavsky, & Bryan Blissmer, 2003; McAuley, Konopack, Motl, et al., 2006) and multiple sclerosis patients (Latimer-Cheung et al., 2013; Motl & McAuley, 2014), and now extend these findings to Parkinson’s disease patients.

**Hypothesis 3** examined the mediation of the relationship between physical activity and health-related quality of life by self-efficacy, outcome expectations, and self-regulation. The findings provided partial support for the mediation of MVPA and physical HRQoL in that only self-efficacy and outcome expectations remained significant predictors in the mediation model, with Hoehn and Yahr, Age, BMI, and total number of comorbidities as covariates. The direct effect of MVPA on physical HRQoL was not significant, indicating that SE and OE mediated the relationship between MVPA and physical HRQoL. For mental HRQoL, all three SCT correlates remained significant in the mediation model, while the direct effect of MVPA on mental HRQoL became nonsignificant. In this model, Hoehn and Yahr Score, Age, BMI, and total number of comorbidities were entered into the model as covariates.
Significance

A recent study combined nationally representative surveys to create a burden of Parkinson’s disease model. In 2010, researchers estimated PD prevalence at approximately 630,000 people in the U.S., with diagnosed prevalence predicted to double by the year 2040 (Kowal, Dall, Chakrabarti, Storm, & Jain, 2013). The economic burden in the model of PD included over $14 billion dollars in direct medical expenses in 2010 alone, in addition to another approximately $6.3 billion lost indirect expenses, such as reduced employment. As a chronic condition that most PD patients live with for an average of twenty years or more, the importance of delaying the onset and progression of the disease, and providing new and innovative treatments to alleviate symptoms and improve quality of life becomes paramount. Discovering effective disease management strategies and identifying theory-based behavioral strategies to help PD patients make positive lifestyle changes in regards to PA are important steps in this process. Research looking at the extent to which self-efficacy, outcome expectations, and self-regulation are associated with physical activity behavior in the PD population has been limited. Ellis and colleagues conducted a cross-sectional study of 260 PD patients and examined self-efficacy and outcomes expectations in exercisers and non-exercisers and found a strong association between self-efficacy and exercise in PD patients; however, this is the first study of its size to comprehensively look at the role of SCT correlates to physical activity and health-related quality of life.
Recruitment

Recruitment of chronic disease patients into physical activity studies is consistently challenging and often undermines the utility of conducting physical activity research in select patient populations. The strategy for recruitment to this study involved a multi-phase approach which was quite successful in accruing the target sample of Parkinson’s disease patients. First, letters were sent through the U.S. Postal Service to ask institutions that treat PD patients, as well as non-profits that serve this population to direct their patients to the study by posting flyers in their clinics, placing the study link on their websites, in their newsletters, in email blasts, and through their support group newsletters. This letter was followed up by an email to the same institutions which reinforced the language in the letter that could be forwarded along to patients. Both the letter and the email included a study poster/flyer that could be printed and posted or handed out to patients.

Most Successful Strategies

Movement disorders specialists across the U.S. emailed information about the study to their peers and asked for their cooperation in letting patients know about the study. Many expressed delight in being able to let their patients know of a study they could participate in from the privacy of their own home without a medical intervention. Dissemination of flyers by practitioners through movement disorders clinics solicited participation not only in Central Ohio, but throughout the U.S.

Social media was used by The Davis Phinney Foundation, who posted the study link on their FacebookTM page, and tweeted about it on their Twitter™ account. The
Michael J. Fox Foundation posted the study on their website—Fox Trial Finder™. This provided a wider than expected exposure to PD patients around the world and contributed the majority of participants. Several institutions and a few of the non-profits disseminated the study link through communications with their support groups.

Least Successful Strategies

ResearchMatch recruitment was also part of the strategy, although it contributed less than 50 patients to the study, indicating that a disease-specific site like Fox Trial Finder™ was a better strategy for this population. Most hospitals or similar institutions did not agree to post information on their websites or in their newsletters. Another local health system in direct competition for movement disorders patients would not agree to participate without being included in all resulting publications. Several institutions requested reimbursement if they were to agree to participate. Caregiver’s who attempted to complete the survey for their spouses were disappointed in their exclusion from the study.

Summary

Almost 1,100 people attempted to access the study via the internet. Of this number, 707 individuals completed the informed consent, and 550 individuals fulfilled the eligibility requirements. After completion of the data cleaning process, 500 individuals were left that had at least 75% of their data completed. Study accrual goals were met relatively quickly in about six weeks. These results were very positive and demonstrate the PD population’s interest in physical activity and willingness to participate in studies that they feel have potential value for them to spend their time
completing (the average completion time was longer than anticipated at about 45 minutes).

The cross-sectional nature of this study made participation particularly easy and without travel requirements. The ease of access to a home computer for participation may be a key consideration in future studies of this type. Social media and the importance of websites for dissemination of information and direct linkage to studies is evolving and will become increasingly important in the future. Engagement of key physicians and their support in dissemination of information and linkage to a study with their peers was one of the key components of this study’s successful recruitment of patients.

Many participants emailed and requested to be notified of study results upon completion and were advised that no personal health identifiers were collected with this study, so dissemination would be difficult, if not impossible; however, once published, study results would be available to health-care practitioners and patients.

**Demographics**

The average age of participants was 63 years old with 10% of the participants being under age 50, which is higher than the national estimates of 4% of the population being young onset. Over 50% of the participants were diagnosed less than three years prior to the study and 90% were diagnosed within 10 years. The average BMI for participants was 26.8 (overweight) which accounted for over 60% of the participants; however, moderate to vigorous physical activity was reported by patients at all levels of BMI. Ninety-two percent of participants reported being encouraged to exercise by their neurologist.
In 2013, the CDC reported about 50% of U.S. adults are meeting the recommended guidelines for aerobic activity. Van Nimwegen et al. (2011) reported PD patients being about one-third less active than older adults, as well as noting a 13% decrease in PA between Hoehn and Yahr Stages 1-2, increasing to an 84% decline in PA by the time a patient reaches Stage 4.

In this study, 89% of participants reported MVPA in the modified Paffenbarger instrument (88% moderate; 35% vigorous). MVPA reported an average of 253 minutes per week. Also, 51% of participants reported being involved with an exercise group, while almost 66% of participants reported 150 or more minutes of MVPA per week, as suggest by the American College of Sports Medicine (Garber et al., 2011). Individual participants’ preferential to physical activity may have self-selected to participate in the study.

In addition, participants reported over a median value of 200 minutes of MVPA per week in Hoehn and Yahr Stages 1 to 1.5, slightly under the median value of 200 minutes of MVPA per week in stages 2 and 2.5, another slight decrease in the median value at stage 3 despite a number of high outliers, and the median value fell to less than 150 minutes of MVPA per week by stage 4. Ninety-five percent of participants had a Hoehn and Yahr Score of 3 or less, but the majority were stage 2.5 to 3. However, self-reported physical activity tends to be inflated and needs to be confirmed in the future by an activity monitor of some sort that is not sensitive to tremor (Sallis & Saelens, 2000).

Only 55 participants (11%) reported no MVPA, over 65% of these were considered overweight or obese. In 2016, the Centers for Disease Control and Prevention
(CDC) reported the age-adjusted overweight and obesity rate for adults aged twenty and over in the U.S. to be 70.4 for selected years 2013-2014, which were slightly higher than this older PD population (National Center for Health Statistics, 2016).

Of the study participants reporting no MVPA, 56% reported having fallen, about 35% having fallen in the last year, 44% having fallen in the last six months, and 16% having fallen in the past week. This was in contrast to the participants reporting MVPA, where 36% reported having fallen, 29% having fallen in the last year, 23% having fallen in the last six months, and 5% having fallen in the past week. Fear of falling wasn’t addressed in this study, but researchers have related fear of falling to a decrease in mobility and declines in functional independence (Allen et al., 2010; Cakit et al., 2007; Tinetti, De Leon, Doucette, & Baker, 1994). The participants with no reported MVPA reported higher rates of falling, and potential falls should be considered in interventional study designs for this population.

Other factors that can interfere with a participants’ ability to engage in MVPA were comorbidities—almost one-fourth of the participants reported having arthritis (24%), followed by depression (23%), heart disease (14%), and cancer (9%). The other category included hypothyroidism, spinal stenosis, and anxiety. Having one or more of these comorbidities would not be unusual in a group of participants with an average age of 63. Depression results were vastly different from the literature in this study. Estimates of depression in PD range from 60% mild to moderate depression from the National Parkinson’s Foundation to 46 to 49% of participants reporting depression in two recent studies (Ghaddar, Fawaz, Khazen, Abdallah, & Milane, 2016; Julien, Rimes, & Brown,
Our study group of participants reported far less depression than expected with only 27% reporting mild depression and 7% reporting severe depression.

Additionally, study participants were more educated than the general adult population with more than 85% having college degrees, and an additional 51% holding graduate or professional degrees. This was correlated to 60% of the participant’s having a combined household income over $75,000 per year, which is higher than the 2010-2014 U.S. median household income of $53,482 reported by the U.S. Census Bureau (U.S. Census Bureau, 2014). This number varies by geography and could be influenced by the participation of a large number of PD patients from California or some of the northeast coastal states. This was potentially a dual household income for many as 87% of participants lived with a spouse or caregiver. Further, the median household income was a retirement income for 64% of the participants—52% of participants were voluntarily retired, with another 12% were forced into retirement. Only 23% of participants were working full-time, and another 10% of participants worked part-time.

Studies have shown age-related declines in physical activity in the general population, with lack of PA predicted by worsening health and changes in employment status. Interestingly, these changes varied by level of education, with health issues being strongly associated with reduced physical activity in more highly educated individuals. Highly educated individuals may have advantages in facing disability and morbidity, including increased knowledge of the benefits of physical activity, healthy social networks that promote physical activity, strong sense of personal control and self-efficacy.
for physical activity, and a greater access to resources that facilitate physical activity (McAuley, Konopack, Morris, et al., 2006; Shaw & Spokane, 2008).

The FACT-Cognitive Function (Version 3) instrument was the most likely instrument in the study to not be completed or to be only partially completed. The study was not part of the randomization of the instruments after the eligibility criteria, and it was placed last in the study, first, because it has not been validated in a Parkinson’s population, and secondly, because it was felt to be lengthy and cumbersome. As such, we did not want participants to stop the study, because they didn’t want to complete this instrument. It was felt that participant’s with higher levels of cognitive decline would be unable to complete the study and self-select out during the eligibility process. This adapted use of this instrument was to give investigators a sense of the cognitive abilities of those who completed the study. We were unable to calculate a total cognitive composite score for 54 participants. For the remaining 446 participants, over 51% of the scores were below the median (49), with the majority of scores falling between 36 and 46. Thus, few of the participants in this study were experiencing severe cognitive impairment; however, there are no published cut-points for comparison purposes.

Important to note in the FACT-Cog subscales, multitasking and memory had the highest average scores indicating participants experienced more multitasking and memory issues compared to the other subscales. Approximately 95% of study participants were in the early to middle stages of the disease, so these results correspond to the FACT-Cog subscale results. In the literature, PD patients complain of task and attention difficulties in early stages of the disease (working memory). These PD patient’s
chief complaints include being easily distracted or losing their train of thought. In the middle stages of the disease, decision-making, problem-solving, memory and word-finding difficulties become more apparent. More serious cognitive disturbances—hallucinations, delusions, agitation, and confusion may happen in the PD population in general, but only a small percentage of study participants were in the later stages of disease (Montero-Odasso et al., 2009).

**Social Cognitive Theory**

One of the primary goals of this study was to assess the role of social cognitive variables in the relationship between the lifestyle behavior, physical activity, and health-related quality of life. Results revealed that exercise self-efficacy and self-regulation were more predictive of physical activity than outcome expectations. These findings suggest that theory-driven approaches to designing lifestyle interventions should consider self-efficacy and self-regulation to potentially enhance the treatment effect.

Previous studies have demonstrated that participation in an exercise program improved exercise self-efficacy in older adults (McAuley, 1993; McAuley & Blissmer, 2000; McAuley, Blissmer, Katula, Duncan, & Mihalko, 2000; E. McAuley et al., 2003). This study similarly found higher levels of physical activity to be related to higher levels of self-efficacy in this population of idiopathic Parkinson’s patients, which is consistent with the predictions of social cognitive theory.

Employment of self-regulatory behaviors were strong predictors of physical activity in an interventional study to improve nutrition, to improve levels of physical activity, and to prevent weight gain (Anderson et al., 2010). Rovniak et al. (2002), in a
prospective study of 277 university students, created a structural equation model to examine the relationship of self-efficacy, outcome expectations, and self-regulation and physical activity. Results indicated that self-efficacy had the greatest total effect on physical activity mediated by self-regulation with outcome expectations having a small insignificant effect. Their social cognitive model explained 55% of the variance in physical activity.

Similar to this, our study found that—Self-efficacy alone predicted 23% of the variance in physical activity; Self-regulation alone predicted 21% of the variance in physical activity; and Outcome expectations alone predicted only 6% of the variance in physical activity. We did not examine self-regulation or social support as potential mediators of the relationship between exercise self-efficacy and physical activity as these authors did, but this would be an interesting avenue to pursue in the future.

Regression analysis of SCT constructs on health-related quality of life showed that the relationship of self-regulation to physical HRQoL was no longer significant when controlling for self-efficacy and outcome expectations, although the relationship of each SCT construct alone was significantly predictive of HRQoL. Another intervention study of 664 employees of 16 geographically diverse worksites by R. K. Dishman, Vandenber, Motl, Wilson, and DeJoy (2010) found a dose response relationship of increased physical activity with changes in goal setting, satisfaction, self-efficacy, commitment, and intention. Future further examination of the self-regulation subscales—self-monitoring (SM), goal-setting (GS), eliciting social support (SS), reinforcement (Re), time management (TM), and relapse prevention (RP), potentially through a structural equation
model, may help elucidate what aspect of self-regulation should be considered in future intervention development in this population.

SCT constructs regressed onto mental HRQoL in the current study demonstrated that SE, OE, and SR predict about 11% of the variance. Thus, as hypothesized, SCT constructs were significantly predictive of both physical and mental health-related quality of life, although SCT constructs predicted a higher level of physical HRQoL (19%) versus 11% of mental HRQoL.

Physical activity was a significant predictor of the variance in both physical (9%) and mental HRQoL (4%). BMI, Age, Hoehn and Yahr Severity Score, GDS depression score, and total number of comorbidities were all significantly, negatively related to physical HRQoL (Aarsland, Marsh, & Schrag, 2009; Koplas et al., 1999; A. Schrag, Hovris, Morley, Quinn, & Jahanshahi, 2003; A. Schrag et al., 2000a, 2000b; A. Schrag, Jahanshahi, & Quinn, 2001). For mental HRQoL, both MVPA and age were significant positive predictors, while Hoehn and Yahr Severity Score was a significant negative predictor. When GDS depression scores were added to the model, the other predictors were no longer significant. Muller et al. (2013) found that non-motor scores were more explanatory of the variance in HRQoL in Parkinson’s patients at baseline and after three years compared to motor scores suggesting that non-motor symptoms impact HRQoL more than motor symptoms in the early stages. The average number of years since diagnosis in this study was 4.8 years, so perhaps this supports Muller’s findings that non-motor symptoms like depression may be an important predictor of mental HRQoL. Investigating whether GDS mediates the MVPA and mental HRQoL bears further study.
A 2014 study of 158 PD patients and health controls found that both motor and non-motor symptoms negatively impacted health-related quality of life (Duncan et al., 2014). In this study, PD patients with postural instability and gait disabilities reported lower levels of HRQoL compared to tremor-dominant PD patients. This was not assessed in the current study, since it was an online survey study and physical assessment would be necessary to evaluate these aspects of PD.

Our third hypothesis was that psychosocial variables mediate the response between physical activity and health-related quality of life. The findings provided partial support for this in that only exercise self-efficacy remained a significant predictor in the mediation model for physical HRQoL, with Hoehn and Yahr Severity Score, GDS, BMI, and total number of comorbidities as covariates. All three SCT constructs remained significant predictors in the mediation model for mental HRQoL, with Hoehn and Yahr Severity Score and Age entered into the model as covariates. This finding suggests that exercise self-efficacy beliefs may be particularly integral in the association between physical activity and HRQoL in PD patients; however further investigation of task, coping, and scheduling efficacy may yield further insights.

Limitations

The results of this large survey study expands the current knowledge of the role of social cognitive variables and the relationship of physical activity to health-related quality of life in Parkinson’s disease patients. Nonetheless, there are several study limitations that should be acknowledged.
First, given that subjective assessments of physical activity are prone to over-reporting of total physical activity volume, reliance on self-reported physical activity is a primary limitation. As with any self-reported data, upward reporting bias tends to be an issue which results in overly inflated total moderate-to-vigorous physical activity minutes per week. The use of a physical activity measurement instrument to validate the actual amount of physical activity could not be accomplished in a cross-sectional survey study. Those idiopathic Parkinson’s patients with a pre-existing interest in physical activity likely self-selected to participate in the study. We also did not have any baseline physical activity information to explore whether or not the subjects participating were exercisers prior to their PD diagnosis.

Conducting the study online also limits study participants to those who have adequate computer knowledge to use a link to go to a study online and complete it, in addition to those who may potentially lack access to a computer. Initially, the study was designed to take only 20 to 30 minutes because participant fatigue was of concern. The actual average time it took participants to complete the study was 45 minutes, which is much longer than anticipated. Investigators allowed an individual to leave the study open and come back to it, which may have lengthened the time to complete. However, if interested individuals tried to participate in the study and accidentally exited the study before completion, which may explain the loss of participants prior to informed consent and after completion of eligibility requirements. Only 50 individuals were lost to the study based on having less than 25% of their data completed after the eligibility section.
Investigators also did not collect information regarding whether or not participants were being treated for depression. Because depression may have impacted a participant’s likelihood of completing the survey, this could have influenced the depression results.

The expectation-maximization method was used to replace missing values in scale level data. A variation of mean substitution was used for the ordinal data where the mode was used to replace missing values instead of the mean. However, this can still cause reduced variability and convergence problems, biased estimates, and data becoming non-normally distributed.

Some participants appeared confused by the defined differences between moderate and vigorous physical activity and occasionally entered the same answers in both sections of the Paffenbarger. This only occurred in the sports that overlapped both categories e.g. cycling and swimming. Exact duplicate responses were kept in only one category, and with the utilization in the statistical analysis of only total moderate to vigorous physical activity (MVPA). This ensured more robust results than if we tried to separate moderate from vigorous activity in the analysis.

The SF-12 was chosen over the SF-36 as the measure for health-related quality of life to minimize the amount of time each participant spent completing the study. As a result, there are potential floor and ceiling effects, as the range of observed scores is greatest among the SF-36v2 health domain scales compared to the SF-12v2, potentially defining a smaller ranger for each measured construct.
Lastly, caution should be used when interpreting large sample sizes as statistical significance may be demonstrated even with very small, and sometimes meaningless differences. If this were an interventional study, we would calculate effect size to evaluate the significance observed. Statistical power, like statistical significance, depends upon both sample size and effect size. While this study had a relatively large sample size with 500 participants, one could assert that it’s sufficiently powered to detect differences, but not discern whether those differences are of practical significance.

**Summary and Implications for Future Research**

In summary, the present cross-sectional investigation was one of the first to examine the relationships among select social cognitive theory constructs, physical activity, and HRQoL in a large sample Parkinson’s disease patients. Findings of this study yielded support for the all study hypotheses. First, higher levels of the three selected SCT correlates predicted higher levels of physical activity. Separately, self-efficacy, outcome expectations, and self-regulation were predictive of physical activity in this PD population; however, only self-efficacy and self-regulation remained significant predictors of physical activity when modelled together.

Secondly, higher levels of SCT correlates predicted higher physical and mental health-related quality of life. All three variables were significantly predictive of physical HRQoL when modeled alone. However, when modeled together, SE and SR were the only significant predictors of physical HRQoL. Also, SE, OE, and SR were associated with higher levels of mental health-related quality of life but not to the extent that the SCT constructs were associated with physical health-related quality of life.
Hypothesis 2 was that higher levels of physical activity would be associated with higher levels of health-related quality of life. Results showed that physical activity was a significant predictor of the variance in both physical and mental HRQoL.

Our third and final hypothesis was that psychosocial variables mediate the response between physical activity and health-related quality of life. The findings provided partial support for this, in that only exercise self-efficacy remained a significant predictor in the mediation model for physical HRQoL, with Hoehn and Yahr Severity Score, GDS, BMI, and total number of comorbidities as covariates. All three SCT constructs remained significant predictors in the mediation model for mental HRQoL, with Hoehn and Yahr Severity Score and Age as covariates.

Taken collectively, the present findings are consistent with results of prior studies examining the association among physical activity, social cognitive theory variables, and HRQoL among older adults (Edward McAuley et al., 2003; McAuley, Konopack, Motl, et al., 2006; Motl, McAuley, & Klaren, 2014), chronic disease patients (Focht, 2012; Focht, 2014) (Brian C. Focht, 2012; B. C. Focht, Garver, et al., 2014) and multiple sclerosis patients (Latimer-Cheung et al., 2013; Motl & McAuley, 2014), and extend these findings to Parkinson’s disease patients. These findings have important implications for both future physical activity research and applied efforts targeting the promotion of physical activity and well-being among Parkinson’s disease patients. These findings demonstrate that higher levels of physical activity are associated with more favorable HRQoL. Furthermore, from a behavioral perspective, the results also suggest that higher physical-activity related self-efficacy beliefs are associated with greater volume of self-
reported physical activity. Thus, these findings underscore the potential importance of 
enhanced self-efficacy in physical activity participation as well as the link between 
regular physical activity and more favorable HRQoL.

Finally, the findings suggest that the link between physical activity and HRQoL is 
mediated by select physical activity-related social cognitive variables. The unique 
associations among physical activity, social cognitive variables, and HRQoL observed in 
this study have meaningful implications for future research examining predictors of 
physical activity in PD patients and can serve as a foundation to guide and/or inform the 
development of efforts to promote physical activity in PD patients. Future studies using 
prospective cohort designs are needed to examine if the cross-sectional associations 
observed between physical activity, social cognitive variables, and HRQoL in this 
investigation are replicated in longitudinal assessment of these variables. Additionally, 
given the relationships observed in this study, future research establishing the feasibility 
efficacy of social cognitive theory-based interventions for promoting increase in physical 
activity in PD patients is also warranted.

Conclusion

Developing a better, more complete understanding of behavior change using 
theory-based approaches is key to developing effective interventions in the future. Better 
understanding of these correlates of physical activity and health-related quality of life 
maximizes our ability to produce favorable outcomes. In a chronic disease population 
like idiopathic Parkinson’s disease, finding ways to help an individual be empowered to 
better manage their disease process is a goal. By encouraging individuals to stay
physically active and helping PD patients achieve a sense of control over their health, favorable long-term outcomes may include maintaining independence, continuing to perform functional activities of daily living, and sustaining quality of life. Prevention of this neurodegenerative diagnosis would be ideal. However, in lieu of biomarkers identifying those at risk to begin prevention trials, we need to provide PD patients tools with which they can use to promote their quality of life, health, and well-being.
Bibliography


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study, a randomized controlled trial evaluating the effectiveness of a multifaceted behavioral program to increase physical activity in Parkinson patients. *BMC Neurol*, 10, 70. doi:10.1186/1471-2377-10-70


Appendix A: IRB Approval

Behavioral and Social Sciences Institutional Review Board
Office of Responsible Research Practices
800 Research Administration Building
1060 Kenny Road
Columbus, OH 43210-1063
Phone (614) 688-8817
Fax (614) 688-0162
www.irb.osu.edu

August 26, 2015

Protocol Number: 2015B0269
Protocol Title: Physical Activity Behavior and Health Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables, Brian Focht, Melissa Hill, Human Sciences Administration
Type of Review: Initial Review—Expedited
IRB Staff Contact: Amanda Thompson Phone: 614-688-1059 Email: Thomason.2024@osu.edu

Dear Dr. Focht,

The Behavioral and Social Sciences IRB APPROVED BY EXPEDITED REVIEW the above referenced research. The Board was able to provide expedited approval under 45 CFR 46.116(b)(1) because the research meets the applicability criteria and one or more categories of research eligible for expedited review, as indicated below.

Date of IRB Approval: August 26, 2015
Date of IRB Approval Expiration: August 26, 2016
Expedited Review Category: 7

In addition, the research has been approved for a waiver of documentation of the consent process.

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent forms and process must be used.

Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

This approval is valid for one year from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid expiration of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected, and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s IRB Federal Assurance #00006738. All forms and procedures can be found on the ORSP website — www.orsp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Michael Edwards, PhD, Chair
Behavioral and Social Sciences Institutional Review Board

In-017-06 Exp Approval New CR.
Version 01/0315
Appendix B: Informed Consent

The Ohio State University Consent to Participate in Research

Study Title: Physical Activity Behavior and Health-Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables
Melinda S. Hill, MS, PhD Candidate
Co-Investigator
Department of Human Sciences
Kinesiology Program
The Ohio State University
Email: hill.1238@osu.edu
Phone: 614.293.7112

Researcher: Brian C. Focht, PhD, FACSM, CSCS
Principal Investigator
Associate Professor of Kinesiology
Department of Human Sciences
The Ohio State University
Email: focht.10@osu.edu
Phone: 614.292.2165

Sponsor: None

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary.
Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to check the YES box at the end of the form.
Purpose:
The primary aim of the study will be to examine Social Cognitive Theory (SCT) correlates of lifestyle behaviors - physical activity (PA) and health-related quality of life (HRQoL) in Parkinson’s disease patients to determine if they explain participation in PA.

Procedures/Tasks:
You will be directed to the study via a web link to a Qualtrics survey. The survey should take approximately 30 to 45 minutes to complete.

Duration:
You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

Risks and Benefits:
There is no known physical risk to taking the online survey; however survey questions may elicit a small emotional response due to that nature of the questions regarding Parkinson’s patients’ quality of life and physical activity.

One benefit of participating in this study is that you will be assisting researchers in better understanding what factors influence a Parkinson’s patient to participate in physical activity, and how these factors help researchers better understand the relationship between psychosocial variables, physical activity, and health-related quality of life.

Confidentiality:
Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
- The sponsor, if any, or agency (including the Food and Drug Administration for FDA-regulated research) supporting the study.

We will work to make sure that no one sees your online data without approval. But, because we are using the Internet, there is a chance that someone could access your online data without permission. In some cases, this information could be used to identify you.
If, at any time, you feel uncomfortable about answering a question, you may skip that question. The survey has been designed to allow you to do so.

**Incentives:**
You will not receive compensation for your participation.

**Participant Rights:**
You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits by exiting the survey.

By checking the box to participate, you do not give up any personal legal rights you may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

**Contacts and Questions:**
For questions, concerns, or complaints about the study, or you feel you have been harmed as a result of study participation, you may contact Melinda S. Hill, MS, PhD Candidate by phone at 614.595.1608 or by email at hill.1238@osu.edu.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

**Consenting to participate in the study**
I have read this form and I am aware that I am being asked to participate in a research study. I voluntarily agree to participate in this online study. I am not giving up any legal rights by checking the box that I want to participate in this online study.

I agree to participate in this research project entitled “Physical Activity Behavior and Health-Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables”.

☐ Yes, I would like to participate in this online study.
Appendix C: ResearchMatch Invitation and Email

A research team with The Ohio State University in Columbus, OH, believes you might be good match for the following study:

Have you been diagnosed with Parkinson’s Disease?

Would you like to help researchers better understand what factors influence those diagnosed with Parkinson’s Disease (PD) to be physically active and how physical activity impacts their quality of life?

Researchers at The Ohio State University are seeking volunteers for this survey study that will take approximately 30 to 45 minutes to complete.

Physical activity is one lifestyle behavior that may slow the progression of the disease and improve the quality of life of PD patients by maintaining their ability to accomplish functional activities of daily living and preserve their independence. You may be eligible to participate in this survey if you:

- Have been diagnosed with Parkinson’s Disease
- Are age 18 or over
- Do NOT have Atypical Parkinson’s or Multiple Palsy
- Have NOT had Deep Brain Stimulation or other brain surgery to treat/manage your PD
- Do NOT live in an assisted-living or skilled-nursing facility

If you are interested in this study and having the research team contact you directly, please select the “Yes, I’m interested” link below. By clicking the “Yes, I’m interested” link, your contact information will be released to the research team. If you select the “No, thanks.” link or do not respond to this study message, your contact information will not be released to the research team.

Yes, I’m interested!  
No, thanks.

You are receiving this email message since you have registered in the ResearchMatch registry. Should you wish to edit your profile or remove your contact information from this registry, please login here.

ResearchMatch Disclaimer

ResearchMatch is a free and secure tool that helps match willing volunteers with eligible researchers and their studies at institutions across the country. ResearchMatch is only providing a tool that allows you to be contacted by researchers about their studies. ResearchMatch therefore does not endorse any research, research institution, or study. Any recruitment message that you may receive about a study does not mean that ResearchMatch has reviewed the study or recommends that you consider participating in this study.
To: email address  
From: hill.1238@osu.edu, focht.10@osu.edu  
Subject: Research Match Follow-up with study link

Dear Sir/Madam,

Thank you for your interest in our Parkinson's study.

We appreciate your support and participation. This survey study will take 30 to 45 minutes to complete. We do not collect any personal information, so if you need to walk away from your computer and come back please don’t exit out of the survey, as there will be no way to get back in to where you were. It will remain open until you exit the survey.

To begin the survey copy and click on the following link into your browser: http://tinyurl.com/p5s158ta

Should you have any questions, please contact Melinda Hill at 614.593.1608 or by email at hill.1238@osu.edu.

Thank you in advance for your help with this study,

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Appendix D: Survey Invitation Letter

May 22, 2016
Davis Kimsey Foundation
Lisa Geraci, Program Associate
1722 14th St., Suite 150
Boulder, CO 80302

Dear Ms. Geraci,

The Ohio State University Department of Human Sciences, Kinesiology Program, is contacting leaders in the field of treating Parkinson’s patients to request their assistance with a research study aimed at learning more about what factors are related to physical activity and quality of life in PD patients. The study is titled: "Physical Activity Behavior and Health-Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables".

We are asking you to help get Parkinson’s patients to enroll in this study by posting a link to the survey on your website (http://tinyurl.com/p5h58to) and in email blasts or patient newsletters with the following suggested short message:

Have you been diagnosed with Parkinson’s Disease? Would you like to help researchers better understand what factors influence those diagnosed with Parkinson’s Disease (PD) to be physically active and how physical activity impacts their quality of life? Researchers at The Ohio State University are seeking volunteers for this survey study that will take approximately 30 to 45 minutes to complete. Thank you for your interest.

To begin the survey type the following link into your browser: http://tinyurl.com/p5h58to

We have attached a study flyer that we’d like you to post in your PD clinic waiting areas. Participating in the study takes each patient approximately 30 to 45 minutes.

Should you have any questions, please contact Melinda Hill at 614.595.1608 or by email at hill.1235@osu.edu. Thank you in advance for your help with this study.

Brian C. Focht, PhD, FACSM, CSCS
Principal Investigator
Associate Professor of Kinesiology
Department of Human Sciences
The Ohio State University
Email: focht.10@osu.edu
Phone: 614.292.2165

Melinda S. Hill, MS
Co-Investigator
Department of Human Sciences
Kinesiology Program
The Ohio State University
Email: hill.1235@osu.edu
Phone: 614.293.7112
Appendix E: Survey Invitation Email

THE OHIO STATE UNIVERSITY

To: igeraci@lavishpinneyfoundation.org
Cc: bill.123@osu.edu focht.10@osu.edu
From: Melinda S. Hill, MS
Subj.: PD Survey Study

Dear Mr. Geraci,

The Ohio State University Department of Human Sciences, Kinesiology Program, is contacting leaders in the field of treating Parkinson’s patients to request their assistance with a research study aimed at learning more about what factors are related to physical activity and quality of life in PD patients. The study is titled: “Physical Activity Behavior and Health-Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables”.

We are asking your center for help getting Parkinson’s patients to enroll in this study by posting a link to the survey on your website (http://tinyurl.com/p5h58to) or in email blasts or patient newsletters with the following suggested short message:

Have you been diagnosed with Parkinson’s Disease?
Would you like to help researchers better understand what factors influence those diagnosed with Parkinson’s Disease (PD) to be physically active and how physical activity impacts their quality of life?
Researchers at The Ohio State University are seeking volunteers for this survey study that will take approximately 30 to 45 minutes to complete. Thank you for your interest.
To begin the survey type the following link into your browser: http://tinyurl.com/p5h58to

We have attached a study flyer that we’d like you to post in your PD clinic waiting areas. Participating in the study takes each patient approximately 30 to 45 minutes.

Should you have any questions, please contact Melinda Hill at 614.595.1608 or by email at hill.123@osu.edu.

Thank you in advance for your help with this study;

[Signature]

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Co-Investigator
Department of Human Sciences
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The Ohio State University
Email: hill.123@osu.edu
Phone: 614.295.7112
Appendix F: Survey Invitation Poster

Have you been diagnosed with Parkinson’s?

Would you like to help researchers better understand what factors influence those diagnosed with PD to be physically active and how physically activity impacts their quality of life?

Researchers at The Ohio State University are seeking volunteers for this survey study that will take 30 to 45 minutes to complete: http://tinyurl.com/p5h58to

For more information contact: Melinda S. Hill, MS at 614.595.1608 or email at hill.1238@osu.edu
## Appendix G: Fox Trial Finder Information

### PHYSICAL ACTIVITY BEHAVIOR AND HRQOL IN PD PATIENTS

Physical Activity Behavior and Health-Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables

tinyurl.com/p5h58to

*This is a web-based study; travel is not required*

### RECRUITMENT INFORMATION:

<table>
<thead>
<tr>
<th>Accepts Control Volunteers:</th>
<th>No</th>
<th>Study Type:</th>
<th>Observational</th>
</tr>
</thead>
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<tr>
<td>Eligible Ages:</td>
<td>18 - 100</td>
<td>Status:</td>
<td>No Longer Recruiting</td>
</tr>
<tr>
<td>Time Since Diagnosis:</td>
<td>Any may be eligible</td>
<td>Study Focus:</td>
<td>Cognitive Deficits, Depression, Fatigue, Gait disturbances (e.g., freezing), Postural Instability (failing), Tremors</td>
</tr>
</tbody>
</table>

### STUDY PURPOSE:

The primary aim of the study will be to examine Social Cognitive Theory (SCT) correlates of lifestyle behaviors - physical activity (PA) and health-related quality of life (HRQoL) in Parkinson’s disease patients to determine if they explain participation in PA.

### CONTACT A TRIAL TEAM

If you are interested in learning more about this trial, find the trial site nearest to your location and contact the site coordinator via email or phone.

**United States**

<table>
<thead>
<tr>
<th>The Ohio State University, Columbus, Ohio, United</th>
<th>Status: No Longer Recruiting</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>The Ohio State University, Columbus, Ohio, United States</th>
<th>Melinda Hill</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><a href="mailto:hill.1238@osu.edu">hill.1238@osu.edu</a></td>
</tr>
<tr>
<td></td>
<td>614/595-1608</td>
</tr>
</tbody>
</table>
More Details

The body of evidence in the physical therapy and rehabilitation literature supports that physical activity is associated with improvements in quality of life for PD patients. However, few studies have examined the underlying variables that may account for this relationship in PD patients. Researchers have examined stages of readiness to exercise in PD patients and barriers to exercise and found a strong association between self-efficacy and exercise in PD patients, rather Read More

<table>
<thead>
<tr>
<th>Phase</th>
<th>Observational</th>
<th>Lead Sponsor:</th>
<th>The Ohio State University</th>
</tr>
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<tr>
<td>Trial ID:</td>
<td>004224</td>
<td>Sponsor Type:</td>
<td>Other</td>
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<tr>
<td>Country:</td>
<td>United States</td>
<td>Collaborators:</td>
<td>Melinda Hill, MS, PhD Candidate and Co-PI</td>
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<tr>
<td>Estimated Enrollment:</td>
<td>505</td>
<td>Study Start Date:</td>
<td>September 2015</td>
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<tr>
<td>Estimated Study Completion Date:</td>
<td>December 2015</td>
<td>Source:</td>
<td></td>
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<tr>
<td>Study Website:</td>
<td>tinyurl.com/p5h58to</td>
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</tbody>
</table>

More Inclusion & Exclusion Criteria

INCLUSION CRITERIA

- English speaking
- Parkinson's disease diagnosed by a neurologist

EXCLUSION CRITERIA

- Atypical Parkinson's
- Supranuclear Palsy
- Deep Brain Stimulation (DBS) or other brain surgery
- Not living independently (living in assisted-living or skilled-nursing facility)
- Spouse or caregiver responding instead of PD patient
Appendix H: Hoehn and Yahr Scoring

<table>
<thead>
<tr>
<th>Hoehn &amp; Yahr Score (proxy by self-report)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do your PD symptoms affect you?</td>
<td></td>
</tr>
<tr>
<td>a) One side of my body only</td>
<td>1</td>
</tr>
<tr>
<td>b) One side of my body and my face or trunk are either stiff or have tremors</td>
<td>1.5</td>
</tr>
<tr>
<td>c) Both sides of my body</td>
<td>2</td>
</tr>
<tr>
<td>2. Has your balance changed (or gotten worse) since you were diagnosed? <strong>Yes</strong> or <strong>No</strong></td>
<td>2.5</td>
</tr>
<tr>
<td>3. Have you fallen? <strong>Yes</strong> or <strong>No</strong></td>
<td>3</td>
</tr>
<tr>
<td>i. How many times in the last year?</td>
<td></td>
</tr>
<tr>
<td>ii. How many times in the last 6 months?</td>
<td></td>
</tr>
<tr>
<td>iii. How many times in the last week?</td>
<td></td>
</tr>
<tr>
<td>4. Can walk unassisted? <strong>Yes</strong> or <strong>No</strong></td>
<td>4</td>
</tr>
<tr>
<td>If <strong>No</strong>, do you use a medical device? Walker / Cane / Other?</td>
<td></td>
</tr>
<tr>
<td>5. Do you need the help of another person to get in and out of chairs or to walk safely?</td>
<td></td>
</tr>
<tr>
<td>6. Do you use a wheelchair as your primary means of getting around? <strong>Yes</strong> or <strong>No</strong></td>
<td>5</td>
</tr>
</tbody>
</table>

**Instructions for Scoring:**

In reverse order since the highest score will be used for lower scores.

1. If Question #6 answer is **Yes**, then H & Y score is 5.
2. If Question #6 answer is **No** and Question #4 answer is **No**, then H & Y score is 4.
3. If Question #4 answer is **Yes** and Question #3 answer is **Yes**, then H & Y score is 3.
4. If Question #3 answer is **No** and Question #2 answer is **Yes**, then H & Y score is 2.5.
5. If Question #2 answer is **No** and Question #1c is **Yes**, then H & Y score is 2.
6. If Question #2 answer is **No** and Question #1b is **Yes**, then H & Y score is 1.5.
7. If Question #2 answer is **No** and Question #1a is **Yes**, then H & Y score is 1.
Appendix I: Protocol

Physical Activity Behavior and Health-Related Quality of Life in Parkinson’s Disease Patients: Role of Social Cognitive Variables

Melinda S. Hill, M.S., PhD Candidate
Research Protocol

Introduction

Parkinson’s disease (PD) is a chronic neurodegenerative disease of the brain. It results from the death of dopaminergic neurons in the midbrain, primarily in the substantia nigra, which plays an important role in movement, addiction, and reward. Specifically, the substantia nigra cells produce the neurotransmitter dopamine which allows for coordination of movement in the body. Parkinson’s disease is characterized by the following motor symptoms – tremor, rigidity, bradykinesia, slowness/smallness, and postural instability (gait and balance are issues), as well as non-motor symptoms including anxiety, depression, sleep disorders, and cognitive deficits.

Prevalence and Incidence of PD

James Parkinson first described the disease named after him in England in 1817. In 2014, the Michael J. Fox Foundation estimated the worldwide prevalence of PD to be 5 million, including approximately 1 million people in the U.S. living with PD. The average age of onset for PD is 60, with earliest patients diagnosed at age 18. One out of 100 people over age 60 have PD. Parkinson’s disease is more common in Whites and is non-randomly distributed in the Midwest and Northeastern part of the United States, with about 450,000 new cases of PD diagnosed per year in the U.S. (Wright Willis et al., 2010).
**Etiology**

Although the causes of PD remain unknown, genetic and environmental factors are both thought to play a role. In terms of genetic factors, 15 to 25% of PD patients report a relative with PD, and there is a 4 to 9% increased risk of PD if a first-degree relative has PD. However, PD can be caused directly by several gene mutations, but these affect only a small number of families. Early-onset PD develops in individuals with mutations in PINK1, LRRK2, DJ-1, and glucocerebrosidase. Overexpression of alpha-synuclein and PARKIN induce mitochondrial defects in DJ-1 and PINK1 mitochondrial proteins in response to oxidative stress. LRRK2 is currently the largest known genetic contributor to PD, but only a small percentage of PD cases are felt to be related to inheritance. Alpha-synuclein is a strong area of research interest currently ([www.michaeljfox.org](http://www.michaeljfox.org)).

Environmental factors associated with PD include exposure to environmental toxins or traumatic brain injury. Epidemiologic studies have identified rural living, well water, manganese, and pesticides as factors linked to PD. Prolonged occupational exposure to insecticides (permethrin & beta-HCH), herbicides (paraquat & 2,4-dichlorophenoxyacetic acid), the fungicide maneb, and potentially exposure to Agent Orange. Synthetic neurotoxins (MPTP) causes immediate and permanent parkinsonism and is one of the chemicals used to induce PD in animal studies. Human exposure to
synthetic neurotoxins are rare except for the case of injected heroin contaminated with MPTP (www.pdf.org).

**Epidemiology**

People with a history of moderate to vigorous exercise may have a decreased risk of developing PD (Thacker et al., 2008), and individuals with consistent and frequent participation in moderate to vigorous activities had approximately a 40% lower risk of developing PD than those who were inactive (Xu et al., 2010). Exercise has been demonstrated to have neuro-protective effects in PD patients (Hirsch & Farley, 2009). In addition, researchers found that physical activity reduces the risk of cognitive decline, which is of concern in PD, as well as Alzheimer’s (Hamer & Chida, 2009).

**Treatments**

PD patients experience increasing amounts of motor and non-motor symptoms of the disease over time which causes: reduced mobility, decreased balance, increased falls, increased anxiety, increased depression, decreased quality of sleep, increased cognitive decline, loss of independence, and overall reduced quality of life. The primary treatment typically includes cholinesterase inhibitors, such as Carbidopa/Levodopa or other drugs which reduce the motor symptoms of rigidity, tremor, and slowness/smallness (Gelb et al., 1999). PD patients frequently suffer “ON” and “OFF” periods as medication effects increase and decrease before and after dosing. Medication does not slow down the
progression of PD, and over time medications become less effective and PD patients increasingly suffer from difficulties with movement and activities of daily living.

Deep Brain Stimulation (DBS) was developed in the 1990s as a neuro-surgical treatment for the symptoms of advanced PD, particularly the motor impairments. It is now a standard treatment option for PD patients who may no longer be benefitting from medication.

Healthy eating, as well as exercise and physical activity, are also recommended for PD patients. Physical activity (PA) is one lifestyle behavior that may slow the progression of the disease and improve the quality of life of PD patients by maintaining their ability to accomplish functional activities of daily living and preserve their independence.

Innovation

What’s missing is a better understanding of what behavioral factors influence PD patients to be physically active. The primary aim of the study will be to examine Social Cognitive Theory (SCT) correlates of lifestyle behaviors - physical activity (PA) and health-related quality of life (HRQoL) in PD patients to determine if they explain participation in PA.

Social Cognitive Theory (SCT) correlates are important to understand because human beings actively think about their behaviors and the consequences of behaviors through cognitive processes. It is based on the tenant that people try to control events that
impact their lives and this motivates all volitional behavior. SCT can be helpful in identifying methods for behavior change by developing an understanding of individual or group behavior. Of SCT’s core constructs, self-efficacy (SE) refers to a person’s innate belief that an action will produce the desired effect; outcome expectations (OE) reflect what an individual expects to happen based upon a certain set of behaviors; and goal-setting (GS) and self-regulation (SR) relates to the self-determined management of goal-directed behaviors and an individual’s ability to create a plan of action to achieve a desired outcome (A. Bandura, 1977; Albert Bandura, 1989, 1991, 1993, 1994, 1997, 2001, 2004).

Self-efficacy as a primary correlate of physical activity in the general population has been supported by research for over a decade (McAuley & Blissmer, 2000; McAuley, Blissmer, Katula, et al., 2000; McAuley, Blissmer, Marquez, et al., 2000; Trost, Owen, Bauman, Sallis, & Brown, 2002).

Self-efficacy and goal-setting are two of the SCT constructs that researchers and clinicians should consider when designing an intervention targeting improvements in physical activity (Suh, Weikert, Dlugonski, Balantrapu, & Motl, 2011). Self-regulation is an SCT construct that encompasses goal-setting, planning, self-monitoring and self-reward skills which are believed to increase exercise adherence (Rod K Dishman, Sallis, & Orenstein, 1985). Self-regulation (SR) has been validated as an SCT construct in many age groups (Conn, 1998; Hallam & Petosa, 2004; Petosa, Suminski, & Hertz, 2003;
Umstattd, Wilcox, Saunders, Watkins, & Dowda, 2008). SCT constructs such as self-efficacy, outcomes expectations and self-regulation accounted for 41% of the variance in PA in MS patients, and author’s concluded that PA interventions should aim to increase skills in MS patients (Dunlop, 2006). In addition, Suh, Joshi, Olsen, and Motl (2014) suggested that studying PA correlates in debilitating diseases like MS are critically important for informing the development of targeted interventions for changing PA behavior. A dissertation on increasing motivation for physical activity to reduce falls in older adults employs self-regulation skills in older adults (McMahon, 2012), however, there are no studies validating the self-regulation construct in PD patients.

In an overview of physical activity behavior change in neurological patients, examples from both PD and MS were compared suggesting that research results from each should be used to further inform the research in other debilitating chronic diseases. Both PD and MS patients face loss of independence related to significant declines in mobility and activities of daily living resulting in decreasing health-related quality of life over the course of their disease. Neuro-rehabilitation through participation in physical activity and exercise may attenuate loss of function. Physical inactivity is prevalent in both diseases and may be related to deconditioning and worsening of disease outcomes (Ellis & Motl, 2013).

In the past few years, Social Cognitive Theory (SCT) research based interventions designed to increase physical activity in persons with PD and MS are highlighted as a
promising area of continued research (Ellis et al., 2013). PD participants with high self-efficacy were more than twice as likely to regularly exercise than those with low outcome expectations, lack of time to exercise, and fear of falling (Ellis, Cavanaugh, Earhart, Ford, Foreman, & Dibble, 2011; Ellis, Cavanaugh, Earhart, Ford, Foreman, Fredman, et al., 2011).

**Immediate Benefits of Physical Activity**

Regular physical activity in PD can increase dopamine levels and improve metabolism (Baatile et al., 2000; Ellis et al., 2005). The actual degree of increase in dopamine levels depend on the frequency, intensity, and duration of exercise. The benefit of exercise training for PD patients has appeared in the research literature in the past decade (Kwakkel et al., 2007; Tomlinson et al., 2013).

Much of the literature generally reflects physical therapy exercise interventions: attempts to increase leg strength, stride, ability to sit, stand, and walk in PD patients (Cakit et al., 2007; Georg Ebersbach et al., 2010; Fisher et al., 2008; Frazzitta, Maestri, Uccellini, Bertotti, & Abelli, 2009; Frazzitta, Pezzoli, Bertotti, & Maestri, 2013; Goodwin et al., 2011; Goodwin, Richards, Taylor, Taylor, & Campbell, 2008; M. E. Hackney & Earhart, 2008; M. E. Hackney & G. M. Earhart, 2009a, 2009b, 2009c; Madeleine E Hackney & Gammon M Earhart, 2009; M. E. Hackney & G. M. Earhart, 2009d; M. E. Hackney & Earhart, 2010a, 2010b, 2010c; Madeleine E Hackney, Kantorovich, Levin, & Earhart, 2007; Keus, Bloem, van Hilten, Ashburn, & Munneke,
with the goal of decreasing falls (Allen et al., 2010; Allen et al., 2012), and improving gait (Earhart, Dibble, Ellis, & Nieuwboer, 2013; Earhart, Ellis, Nieuwboer, & Dibble, 2012; L. T. Gobbi et al., 2009) and postural stability (Ashburn et al., 2007; Ashburn, Stack, Ballinger, Fazakarley, & Fitton, 2008; Dibble, Addison, & Papa, 2009; Schenkman et al., 1998; Schenkman, Hall, Kumar, & Kohrt, 2008; Schenkman et al., 2012).

Other benefits include improving rigidity/reduce bradykinesia & tremor (Corbett, Peer, & Ridgel, 2013; A. L. Ridgel, Muller, et al., 2011; A. L. Ridgel et al., 2012), aerobic fitness (A. L. Ridgel et al., 2009), cognitive function (neuroplasticity)(A. L. Ridgel, Kim, et al., 2011), and health-related quality of life (Baatile et al., 2000; Bach et al., 2012; Dereli & Yaliman, 2010; Madeleine E Hackney & Gammon M Earhart, 2009; M. E. Hackney & Earhart, 2010b; Keus, Bloem, Hendriks, Bredero-Cohen, & Munneke, 2007{Goodwin, 2008 #187; Yousefi, Tadibi, Khoei, & Montazeri, 2009}.

Additionally, studies have investigated using exercise or physical activity to treat the non-motor symptoms of PD, such as depression (Aarsland et al., 2009; Burn, 2010; Docherty & Burn, 2010; Quelhas & Costa, 2009; Riedel, Heuser, Klotsche, Dodel, & Wittchen, 2010; Riedel et al., 2008; Riedel, Klotsche, et al., 2010; Rojo et al., 2003; A. Schrag et al., 2001; A. Schrag et al., 2010), fatigue (Friedman et al., 2007; Hoff, Van Hilten, Middelkoop, & Roos, 1997; Van Hilten et al., 1993), health-related quality of life
issues in PD patients, (Bach et al., 2012; Dereli & Yaliman, 2010; Duncan et al., 2014; Ellis, Cavanaugh, Earhart, Ford, Foreman, & Dibble, 2011; Madeleine E Hackney & Gammon M Earhart, 2009; Muller et al., 2013; Qin et al., 2009; Reuther et al., 2007; Rolinski et al., 2014; A. Schrag et al., 2000b; Tickle-Degnen, Ellis, Saint-Hilaire, Thomas, & Wagenaar, 2010) and the potential impact of PA to improve the psychosocial sequelae of PD (Riedel et al., 2008; van Nimwegen et al., 2010).

Despite the American College of Sports Medicine recommendations for physical activity in the U.S., physical inactivity is globally pandemic in the general population (Kohl et al., 2012), and even more prevalent in the PD population.

**Impact of Understanding How Social Cognitive Theory Influence & Motivate PD Patients**

The body of evidence in the physical therapy and rehabilitation literature supports that physical activity is associated with improvements in quality of life for PD patients. However, few studies have examined the underlying variables that may account for this relationship in PD patients. Researchers have examined stages of readiness to exercise in PD patients and barriers to exercise and found a strong association between self-efficacy and exercise in PD patients, rather than disability (Ellis et al., 2013; Ellis, Cavanaugh, Earhart, Ford, Foreman, & Dibble, 2011; Ellis, Cavanaugh, Earhart, Ford, Foreman, Fredman, et al., 2011).
Researchers suggest that SCT constructs are important correlates of PA for PD patients and should be targeted in interventions (Ellis et al., 2013). A more comprehensive study of SCT correlates – Self-Efficacy, Outcome Expectations, and Self-Regulation should provide a better understanding of the factors that contribute to PA participation and the PA / HRQoL relationship in PD patients.

**Downstream Impact of Understanding What SCT Factors Influence & Motivate PD Patients**

Study results may inform and improve the design of future interventions by identifying methods for behavior change specific to Parkinson’s patients, and identifying factors that motivate PD patients to engage in PA. Investigators may use results to encourage and support behavioral factors that increase adherence to exercise programs or routine PA. In addition, results may inform intervention design around increasing SE by reinforcing that specific actions produce specific effects, and by teaching PD patients to set appropriate outcome expectations. Lastly, study results may support the importance of teaching PD patients goal-setting and self-regulation skills to improve exercise adherence and overcome obstacles to PA.

**Research Design**

We are using a cross-sectional experimental design of 404 geographically diverse Parkinson’s patients. Physiologic (Hoehn & Yahr) and psychological (surveys and single-
item measures) measures will be collected via web-based surveys in Qualtrics accessed through a link.

Sample

Using (Fritz & MacKinnon, 2007) article on the required sample size necessary to detect mediated effects, using the empirical estimates in Table 3 for the Baron and Kenny test with $t' = .59$, $a = .59$ and $\beta = .14$, the desired sample size needed for a power of .8 would be 404. In this population, we expect that some PD patients may start the survey and be unable to finish. For this reason, I would like to oversample by 25% with a target of 505 participants.

Recruitment

The Ohio State University Movement Disorder Clinic, the Ohio Health Neuroscience Center, the five largest Parkinson’s Non-Profits (Michael J. Fox Foundation (MFF), Mohammed Ali Foundation (MAF), Davis Phinney Foundation (DPF), Parkinson’s Disease Foundation (PDF), National Parkinson’s Foundation (NPF), and NPF’s Parkinson’s Centers of Excellence in English speaking countries), will be contacted primarily by email, followed by U.S. Postal Service or by phone to ask for their assistance directing patients to our study via web link. The study link will direct potential participants to study questions in Qualtrics software licensed by The Ohio State
University. Each foundation or institution will be asked to place the study link on their website, in newsletters, in email blasts, as well as placing flyers with the study link in the waiting areas of participating institutions Movement Disorders or Neurology clinics. Signage to print & post in their clinics with the study link and my contact information will also be attached to the email requesting their assistance and participation. Research match will also be used to recruit Parkinson’s patients by sending a letter with the study link requesting their participation.

Participation in the study will be voluntary, patient responses are anonymous, and no protected health information will be collected or stored with the study data. Access to study data will be password protected in a controlled environment. There is no patient risk to participation in this survey-based study. Total time for completion of survey is 30 to 45 minutes.

After IRB approval, The Ohio State University Movement Disorders Clinic, The Ohio Health Neuroscience Center, foundations and institutions will be emailed a request to put the survey link on their websites, in their newsletters, and in their clinics. The study time period will be for three months or until accrual goals are met. Participants’ will be electronically consented prior to beginning the study.

**Accrual Follow-up**

Accrual will be monitored weekly, and if initial accrual total is less than 20 after the first two weeks, a follow-up reminder email will be sent. At this time, the survey
items will be reviewed to see if there are any particular problem areas where patients don’t answer or terminate the survey before completion. At the end of the first month of the study, if accrual total is less than 75, websites of the institutions targeted in the sample will be reviewed to see if the study link has been placed as requested. If the study link has not been placed, a follow-up phone call to the institutions will be made to request their assistance and answer any questions they may have. Accrual will again be evaluated after 10 weeks, and if targeted accrual projections do not appear on track for being met at 12 weeks, websites of targeted institutions will again be reviewed to determine if the study link has been placed. If the study link has not been placed, a follow-up phone call to the institutions will again be made to request their assistance and answer any questions.

**Clinical Measure of Parkinson’s Severity: Hoehn & Yahr Score (proxy by self-report)**

1. How do your PD symptoms affect you?
   - One side of my body only
   - One side of my body and my face or trunk are either stiff or have tremors
   - Both sides of my body

2. Has your balance changed (or gotten worse) since you were diagnosed? **Yes or No**

3. Have you fallen? **Yes or No**
   
   **If Yes,**
   a) How many times in the last year? _____
   b) How many times in the last 6 months? _____
   c) How many times in the last week? _____

4. Can you walk unassisted? **Yes or No**
   
   **If No,** do you use a medical device?
5. Do you need the help of another person to get in and out of chairs or to walk safely?
   - YES
   - NO

6. Do you use a wheelchair as your primary means of getting around?
   - YES
   - NO

Demographics

- Height and weight (BMI calculation)
- Date of Birth (Age calculation)
- Date of Diagnosis (Years since diagnosis calculation)
- Marital Status (Single, Married, Divorced, Partnered)
- Gender (Male or Female)
- Education (Grade School, HS Diploma, College Degree, Graduate or Professional Degree)
- Income (<$25K, $25K to $50K, $50K to $75K, $75 to $100K, ≥ $100K)
- Employment Status (Full-Time, Part-Time, Voluntary Retirement, Forced Retirement, Unemployed)
- Household composition (spouse, caregiver, living alone)
- Social Activities (exercise group, PD support group)
- Presence of comorbidities (CVD, CA, DM, arthritis, dementia, depression, Vision, Lung or Kidney disease)
- Typical Level of Activity during the week (Weekly leisure activity score)
- Neurologist recommend exercise

Self-Reported Measures

Cognition

FACT-Cognitive Function (Version 3): 37-item questionnaire designed to self-assess cognitive function using a 5 point Likert scale ranging from 0 “Never” to 4
“Several times a day”. Comprised of four sub-scales – Perceived Cognitive Impairments (20-items); Impact on Quality of Life (4-items); Comments from Others (4-items); and Perceived Cognitive Abilities (9-items). Item subscale scores will be prorated: subscale score = ([Sum of item scores] x [N of items in subscale]) / [N of items answered]. This instrument was originally developed for use with cancer patients (Wagner et al., 2009).

**Physical Activity**

**Physical Activity Questionnaire (Modified Paffenbarger):** This is a short physical activity questionnaire which asks respondents to think about the past week. Question #1 collects information about illness, injury, or vacation impacting physical activity; Question #2 collects information about stair climbing; Question #3 collects information about brisk walking; Question #4 allows the respondent to report moderate and vigorous physical sports, fitness, or recreational activities by specifying the activity, the number of days per week, and the number of minutes per day performing each activity; lastly, Question #5 collects information on whether the past week being reported was “less active than usual”, “more active than usual”, or “about as active as usual” (Paffenbarger, Blair, & Lee, 1993).

**Quality of Life**

**Parkinson’s Disease Quality of Life Questionnaire (PDQ-8)** (Peto, Jenkinson, Fitzpatrick, 1998): This is a short-form version of the more detailed PDQ-39 consisting of 8-items using a 5-point Likert scale ranging from “Never” to 4 “Always or cannot do
at all”. One item was selected from each of the 8 scales in the PDQ-39 (mobility, activities of daily living, emotional well-being, stigma, social support, cognition, communication, and bodily discomfort). The sum of the scores provides a single index score that is almost identical to PDQ-39 results and is ideal when a shorter-form is needed (Jenkinson, Fitzpatrick, Peto, Greenhall, & Hyman, 1997). In addition, the PDQ-39 includes 3 items pertaining to social support, and since social support is an important consideration for PD patients, we are including all 3 of the social support items making this a PDQ-8 plus two social support questions. A composite score of the original PDQ-8 questions and a social support scale score will be examined.

**Satisfaction with Life Scale (SWLS):** A 5-item scale designed to measure global cognitive judgments of one’s life satisfaction (not a measure of either positive or negative affect). Participants indicate how much they agree or disagree with each of the 5 items using a 7-point scale that ranges from 1 strongly disagree to 7 strongly agree (Diener et al., 1985).

**Short-form 12 (SF-12):** This is the short-form version of the more detailed SF-36 with 12-items that covers the same eight health domains as the SF-36. This survey asks 12 questions on a patient’s functional health and well-being from their perspective (Ware Jr et al., 1996).

(Ware Jr et al., 1996)

Depression
Geriatric Depression Scale Long Form (GDS-LF): This is a 30-item depression scale asking a subject to provide Yes/No responses regarding how they felt over the past week. A score of 0 to 9 is considered normal, a score between 10 and 19 is consider to be suggestive of mild depression, and a score from 20 to 30 indicates severe depression (Yesavage et al., 1983).

Self-efficacy

Exercise Self-Efficacy Scale (ESE): An 8-item measure designed to assess in a subject’s beliefs in their ability to continue exercising three times per week at moderate intensities for 40 or more minutes (McAuley, 1993). Each item responses range from 0% to 100% by tens. A composite score is calculated by summing all items and dividing by 8.

Multidimensional Self-Efficacy Scale (MSES): A 9-item instrument designed to rate how confident you are that you could be physically active under certain conditions. Responses range from “0 – Not at all Confident” to “10-Completely Confident”.

Outcome Expectations

Multidimensional Outcomes Expectations for Exercise Scale (MOEES): 15-items on a 5-point scale that reflect 3 sub-domains (physical, social, and self-evaluative outcomes expectations) designed to reflect older adult’s beliefs or expectations about the
benefits of exercise or regular physical activity (Wojcicki et al., 2009). A composite score is calculated by summing all item scores and dividing by the number of responses.

**Self-regulation**

**Self-Regulation of Exercise:** A short Physical Activity Self-Regulation Scale (PASR-12Q1) (Umstaddt et al., 2009) which assesses how subjects use behavioral strategies to regulate exercise (goal-setting, self-monitoring, and self-reinforcement) using 12 items with 6 sub-scales.

**Exercise Interests and Preferences:** A 9-item questionnaire to determine the level of interest Parkinson’s patients have for participating in exercise and diet programs in the future. Levels of interest range from “0 – Not at All Interested” to “10- Very Interested”.

**Hypothesis 1**
- Higher levels of PA will be associated with higher HRQoL in PD Patients.

**Hypothesis 2**
- Higher levels of PA will be associated with higher levels of SE, OE, and SR in PD Patients.

**Hypothesis 3**
- Higher levels of SE, OE, and SR will be associated with higher levels of HRQoL in PD Patients.

**Hypothesis 4**
- SCT constructs will mediate the relationship between PA and HRQoL in PD Patients.
Internal Validity

Because this is a cross-sectional study design for formative research and not an experimental design of an intervention, the study objective is not to make inferences on the data but to look for correlations between variables and develop a potential model to inform the design of future interventions for the Parkinson’s population. Randomization is ensured because participation is voluntary. In addition, the sample should be geographically diverse with the sample frame being drawn from Central Ohio and across the United States - the National Foundation’s websites, and NPF’s Centers of Excellence, which include 39 leading medical centers worldwide, represent institutions that deliver care to more than 50,000 Parkinson’s patients. We will contact only centers in the United
States, and the questionnaires online will only be presented in English. There is no physical risk due to participating in this study. There may be questions that the participants do not like and that may evoke an emotional response, and participants may choose to leave these questions blank and proceed on to the next section. No PHI will be collected in this study, so all participant’s answers will be protected.

Data Analysis

Statistical analysis will be performed using SPSS (Statistical Package for the Social Sciences), version 22.0 (SPSS Inc., Chicago, IL) for Windows. First, a descriptive analysis of demographic and clinical variables will be conducted. Outliers, missing data, linearity, and normality of the variables will be examined and data will be cleaned as necessary according to accepted statistical protocols. Personal characteristics such as age, BMI, and years since diagnosis will be treated as continuous variables. Interval or ratio level data will be presented as means (M) and standard deviations (SD). Marital status, gender, education, income, employment status, social support, and comorbidities will be treated as categorical variables. Categorical variables will be presented as frequencies and percentages. Bivariate correlations will be conducted to look at the relationships between variables.

Primary Aim: multiple linear regression analysis will be used to determine if higher HRQoL is significantly related to self-reported physical activity in PD patients.
Secondary Aim: multiple linear regression analysis will then be used to examine the relationship between the social cognitive theory constructs and self-reported physical activity in PD patients.

Tertiary Aim: multiple linear regression analysis will be used to determine if higher levels of SE, OE, and SR are significantly related to self-reported HRQoL.

Quarternary Aim: a hierarchical linear regression model will be used to examine the SCT constructs as potential mediators between self-reported PA and HRQoL in PD patients. Also, any variables determined to have significant impact in the multiple regression models will be controlled for in the HLR, allowing us to investigate the effects of certain variables while controlling for the effects of others.
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