The relation of physical activity to quality of life, balance, and cognition in adults with Parkinson's Disease: A pilot study

Alexandra Ziepke

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THE RELATION OF PHYSICAL ACTIVITY TO QUALITY OF LIFE, BALANCE, AND COGNITION IN ADULTS WITH PARKINSON’S DISEASE: A PILOT STUDY

by

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A Thesis Presented in Partial Fulfillment Of the Requirements for the Degree Master of Science in Kinesiology

COLLEGE OF EDUCATION LOUISIANA TECH UNIVERSITY

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ABSTRACT

As the 2nd most common neurodegenerative disorder, Parkinson’s disease (PD) is compiled of motor and nonmotor symptoms (Dashtipour et al., 2015). Motor symptoms include bradykinesia (slow movement), resting tremor, rigidity, and postural instability, and nonmotor symptoms include cognitive delays (Steib et al., 2018). Many studies have found positive results using exercise as therapy, but few have inspected daily levels of physical activity on balance, cognition, and quality of life in adults with PD. Therefore, the purpose of this investigation is to examine the relationship between physical activity level and progressive symptoms of PD - specifically bradykinesia, balance, cognitive function, and QoL, compared with healthy older adults (HOA). After an initial meeting, participants wore accelerometers on their hip for two weeks to track daily physical activity. Then, they completed a timed up and go (TUG), quality of life inventory, Eriksen Flanker test, and 1-back assessment. Results indicate that moderate & moderate-vigorous activity levels may provide the best outcomes on the cognitive tasks for the PD group, however, there was limited significance for HOA. No significant outcomes were observed for the TUG or QoLI. Moderate and MVPA provided favorable cognitive effects for PD. With so much stacked against those with PD, daily physical activity simply added to one’s routine may be the best adjunctive strategy to combat symptoms of the disease.
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DEDICATION

This is dedicated to my dear friend, Edie O’Conner. She lived with Parkinson’s disease for years and never allowed it to slow her down. I trained Edie for three years in various strength and balance activities where we became extremely close. Edie’s constant drive, love of life, and witty humor enlivened everyone around her. As a retired professor, she highly valued education and research. This will carry on in her memory.
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I very deliberately chose my committee to best support me, so I thank you, Dr. Mu Qiao and Dr. Tara Haskins, for your expertise to shape this project into what it is. I appreciate each of you having strong, diverse backgrounds to guide and educate me in your areas.

Last, but certainly not least, a massive thank you to Dr. Andrew Parks for his work as my committee chair. I absolutely would not be here without his support through this process. With exceptional behind-the-scenes work, Dr. Parks is the reason I present this project proudly. I thoroughly enjoyed working with him and appreciate the limitless lessons I am able to take with me as I move forward in my education.
**KEY TO ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>HHD</td>
<td>Health History Demographic</td>
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<tr>
<td>HOA</td>
<td>Healthy Older Adult</td>
</tr>
<tr>
<td>MVPA</td>
<td>Moderate-to-Vigorous Physical Activity</td>
</tr>
<tr>
<td>PAR-Q</td>
<td>Physical Activity Readiness Questionnaire</td>
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<tr>
<td>PD</td>
<td>Parkinson’s Disease</td>
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<tr>
<td>QoLI</td>
<td>Quality of Life Inventory</td>
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<tr>
<td>TUG</td>
<td>Timed-Up-and-Go</td>
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CHAPTER 1

Introduction

As the 2nd most common neurodegenerative disorder, Parkinson’s disease (PD) is currently projected to surpass 1.2 million diagnoses in the U.S. by 2030 – reflecting an 82% increase in diagnoses from 2010 for individuals over the age of 45 (Marras et al., 2018). Comprised of motor and nonmotor impairments (Dashtipour et al., 2015), PD currently has no known cure and often results in a steady decline in independence, cognitive control, and quality of life (QoL; (Baatile et al., 2000; Loprinzi et al., 2018; Steib et al., 2018)) for diagnosed adults. As a result of the mortal nature of this disease, the only recourse for many impacted by PD (i.e., doctors, patients, caregivers) is to treat symptoms with hope of finding any relief from the adverse effects of this debilitating condition (LaHue et al., 2016). Though various treatments have been implemented (e.g., medication, surgery; (Sveinbjornsdottrir, 2016), it has been posited that that physical activity may be beneficial for managing the symptoms of PD and improving function & QoL (Baatile et al., 2000; Combs et al., 2011; Steib et al., 2018; Tokarsky, 2018).

With research indicating that aerobic exercise is an effective and inexpensive intervention to reduce the decline associated with PD, among other symptomologies (Baatile et al., 2000; Combs et al., 2011; Roig et al., 2012), there has been a recent surge in group-exercise programs designed to aid members of this growing population, including: dance, Tai Chi, and boxing (King & Horak, 2009). However, although physical activity programs for those with PD have shown success, accessibility to these
exercise programs remains an issue – particularly concerning availability, transportation, and cost. As a common barrier observed for physical activity engagement, lack of accessibility can often lead to increased sedentary behaviors, which may in turn further exacerbate impairments observed in a population like those diagnosed with PD (LaHue et al., 2016; Nimwegen et al., 2011). There has been limited research exploring the influences of daily physical activity engagement levels on both motor and nonmotor symptoms of PD. Therefore, the purpose of this investigation is to examine the role of physical activity level on progressive symptoms of PD - specifically bradykinesia, balance, cognitive function, and QoL, compared to healthy older adults (HOA).

The prevalence of PD is expected to double within the next decade (Martinez-Martin et al., 2019). While the first symptoms that impact daily function coincide with approximately 80% dopaminergic neuronal loss (Tokarsky, 2018), PD has no known cure and progresses at various rates thus impacting each potential patient in different ways. This variation in progression of PD and delayed onset of noticeable symptoms has further complicated the diagnostic process by elevating the complexity of pinpointing an accurate prognosis as early as possible. The disease is characterized by its symptomology, particularly with regard to motor-related impairments. Motor symptoms include bradykinesia (slow movement), resting tremor, rigidity, and postural instability. However, while much of the research has focused on motor-related symptoms, nonmotor challenges such as cognitive delays, reduced socialization, and changes in affect, also play a significant role in how each individual is impacted by this disease (Baatile et al., 2000; Steib et al., 2018). While some symptoms are not represented in each person, the
symptoms that do present vary in their expression giving a unique presentation of the disease for each diagnosed individual.

Physicians will treat patients with levodopa, currently the most effective PD medication (Mayo Clinic Staff, 2020). Levodopa is known to decrease motor symptoms, but the benefits diminish with time and have unreliable effects on cognitive function (Cruise et al., 2011; Steib et al., 2018). While this drug is extremely effective at providing the brain with increased levels of dopamine, this influx in chemicals does not show an impact on nonmotor symptoms and can even lead to dyskinesia at high dosages. Due to the variations in results associated with levodopa, many treatment teams will adapt patient plans accordingly to substitute or supplement this drug with others (i.e., dopamine agonists, MAO B inhibitors, anticholinergics, etc.) or even going so far as surgical options to directly influence the brain's electrical signaling (e.g., deep brain stimulation). With all the possibilities for treating and potentially slowing the progression of PD, the disease can place a large economic burden on the patient and their family totaling a national economic burden of more than $14.4 billion in 2010 (Kowal et al., 2013; Martinez-Martin et al., 2019). Due to the high demand to attempt any and all treatments to slow the progression of PD, this can be an overwhelming burden to everyone experiencing this situation and contribute to a decrease in QoL. Increasingly, physical activity has been used as a part of PD care as an effective, low-cost option (LaHue et al., 2016).

Physical activity is an accepted intervention to maintain or improve symptomatic conditions, such as PD (Inskip et al., 2016; LaHue et al., 2016). Specifically, physical
activity has been shown to delay the progression of motor symptoms (e.g., rigidity, bradykinesia, freezing, mobility, etc.; Altmann et al., 2015; Combs et al., 2011; Dashtipour et al., 2015; Domingos et al., 2019; King & Horak, 2009). Physical activity has improved motor function in PD which is the main objective of most PD treatments (Hashimoto et al., 2015; Loprinzi et al., 2018; Uc et al., 2014). By participating in aerobic walking (Uc et al., 2014) or dance (Hashimoto et al., 2015), motor function improves PD at various stages of the disease. Overall, physical activity is necessary to maintain motor function as long as possible. Loss of motor function may indicate a decrease in motor coordination and cognitive control (Hashimoto et al., 2015). Collectively, motor function, motor coordination, and cognitive control contribute to how well an individual can maintain their balance. As motor coordination deteriorates, mobility is greatly reduced contributing to a higher incidence of hip fractures due to falling (Hackney & Earhart, 2008; King & Horak, 2009). Higher levels of physical activity have shown a greater ability to improve or maintain balance for individuals (Combs et al., 2011, 2013; Hackney & Earhart, 2008; Mak et al., 2017). While known, PD populations are less likely to participate in physical activity due to fatigue and physical impairments (Nimwegen et al., 2011). As the challenge of introducing physical activity into the daily lives of those with PD has become a focal point of many treatments for the disease to address motor symptoms, it is not as often used to target nonmotor symptoms.

Physical activity has been able to maintain or slow cognitive declines of PD where pharmaceutical interventions have been less successful (Altmann et al., 2015; Baatile et al., 2000; Dashtipour et al., 2015; LaHue et al., 2016; Ridgel et al., 2011; Roig et al., 2012; Steib et al., 2018). While PD is a neurodegenerative disorder, cognitive
impairments such as memory declines are expected. A study by Aarsland et al. (2003), explained that after eight years, dementia rates increased over 50% in PD, amounting to a prevalence of 78.2%. While dementia is defined as progressive cognitive decline, PD patients without dementia show increased cognitive impairment (Tanaka et al., 2009). Delays in cognitive control may contribute to difficulties in cognitive flexibility and navigating various types of knowledge. Cognitive control is critical for working memory relative to our experiences, inhibition to regulate how we interact within our world, and cognitive flexibility to adapt to new environments; however, all of which decline naturally with age (Chang et al., 2013; Chang & Etnier, 2009). In samples of HOA, physical activity has displayed maintenance effects or improvements in working memory (Chang et al., 2013) and spatial memory (Nagamatsu et al., 2013). Similarly, higher levels of physical activity in HOA have shown increased inhibition, another aspect of cognitive control (Hillman et al., 2004). While physical activity is ideal, sedentary individuals with PD are at increased risk of cognitive impairments (Nimwegen et al., 2011). With so much stacked against individuals with PD, physical activity has been linked to providing benefits all-around for motor and nonmotor symptoms (Cruise et al., 2011; Loprinzi et al., 2018; Tanaka et al., 2009).

Physical activity is often viewed as a panacea for many medical conditions, but as a society, participation in everyday physical activity is significantly below the recommended levels for each age group but especially in adults. The Centers for Disease Control and Prevention (CDC) and American College of Sports Medicine (ACSM) recommend HOA should participate in at least 30 minutes of moderate-vigorous physical activity across five days per week to maintain proper health (American College of Sports
Medicine, 2018). It is currently unknown whether physical activity slows the progression of PD or if sedentary behaviors increase the progression, but it is accepted that physical activity provides a favorable result related to PD symptoms (Nimwegen et al., 2011). With the costly traditional treatments, the integration of physical activity into the daily routines of patients with PD may provide a supplemental option for addressing underlying symptomologies associated with the disease (Schenkman et al., 2001). However, PD populations face larger roadblocks due to time and expenses (LaHue et al., 2016). Further, fewer individuals with PD are engaging in physical activity due to time constraints, financial burdens associated with the disease, and lack of education regarding the benefits of physical activity for those living with PD (Hirsch et al., 2011). Due to this low number of physical activity engagement, the dose-response relationship of how physical activity impacts PD is limited. LaHue and colleagues (2016) outline the difficulties of not having common language and protocol for physical activity and PD research to be relatable. Many investigations do not have a control group making it difficult to understand if the relationship of physical activity is similar in PD and HOA and if current research is transferable.

The current investigation is designed to understand the dose-response relationship of physical activity and balance, QoL, and cognition within and between groups. If a strong correlation exists in either group, there will be a better understanding of the benefits of physical activity, ultimately providing insight to those with PD on maintaining proper functioning for as long as possible. This study will explore any potential differences in physical activity relationships with the outcome variables presented in a sample of adults diagnosed with PD relative to HOA. Ultimately, by furthering our
understanding of how these measures of function may be related to physical activity participation, we can provide a foundation for the role physical activity plays in the maintenance of and potential improvement of daily functions for those experiencing deficits associated with PD.
CHAPTER 2
Review of Literature

In the next few decades, Parkinson’s disease (PD) is projected to exponentially increase, trailing just behind Alzheimer’s disease as a leading diagnosis in the U.S. (Marras et al., 2018). With motor and nonmotor impairments, individuals experience a steady decline in quality of life (QoL), balance, and cognitive function with no thought of reprieve as there is no known cure for PD at this time. While medications and surgery are beneficial, typically their effect is weakened over time. The effects of physical activity seem to consistently persist for maintaining function or delaying potential progression of the disease (Combs et al., 2011; Steib et al., 2018; Tokarsky, 2018).

Parkinson’s Disease

Although PD is projected to surpass 1.2 million diagnoses in the U.S. within the next decade (Marras et al., 2018), the procedure for diagnosing this potentially devastating disease is a difficult and challenging process. Presently, PD is not capable of being diagnosed through any direct measurements (i.e., blood test, neurological assessment, etc.) making it extremely difficult to provide a conclusive diagnosis for the disease (Jankovic, 2007). Therefore, in order to provide a diagnosis for PD, examinations focus on the accompanying symptomologies that are characteristic of the disease, such as bradykinesia, rigidity, resting tremor, and postural instability (Gelb et al., 1999; Larsen et al., 1994). At least two of these cardinal symptoms must be present, or occurring with a unilateral onset, for physicians to make the diagnosis (Gelb et al., 1999). In addition to
observations focused on these symptoms, an individual’s response to levodopa or other dopamine agonists (Larsen et al., 1994) can also provide insight into the accuracy of a prospective PD diagnosis. When PD is suspected, physicians may present the confirmatory nature of the diagnosis based on level of certainty in three groups: clinically possible, clinically probable, and clinically definite PD (Larsen et al., 1994). Often PD is accompanied by major neurocognitive disorder, or cognitive decline, occurring in approximately 75% of PD patients at some point throughout the disease (American Psychiatric Association & American Psychiatric Association, 2013). Cognitive decline is a natural developmental progression in later life that is exacerbated by the disease. Commonly, PD occurs in adults at least 50 years or older, but can occur at any age.

In a recent review including multiple regions of North America, PD prevalence was estimated to be 572 per 100,000 for individuals over 45 years old in USA and Canada (Marras et al., 2018). Further, the 2010 U.S. census accounted for 680,000 individuals with PD and projected an estimated increase to 930,000 by 2020 (Marras et al., 2018). With the prevalence rate increasing by 1% by age 60 in the US, and another 4% increase by age 80, aging populations in the U.S. are at an elevated risk of experiencing a PD diagnosis in their lifetime and, by 2030, it is estimated that 1,230,000 American’s will encounter this disease firsthand (American Psychiatric Association & American Psychiatric Association, 2013; Kowal et al., 2013; Marras et al., 2018). Moreover, individual risk does appear to be dependent on sex, as it has been consistently suggested that men show higher prevalence rates of PD (American Psychiatric Association [APA], 2013; Gillies et al., 2014; Larsen et al., 1994; Martinez-Martin et al., 2019). Estradiol, found pervasively in females, provides resilience to dopamine loss...
while higher levels of testosterone, found in mainly in males, either fails to protect or worsens dopamine loss (Gillies et al., 2014). With increasing prevalence of PD, it carries great societal impacts.

As PD progresses, the direct costs of medical treatment escalate due to an influx of doctor’s visits, highly specified pharmaceutical treatments, potential hospitalizations, and nursing home care in later stages of the disease (Kowal et al., 2013; Martinez-Martin et al., 2019). With all the treatment options to slow progression to potentially slow the progression of PD, the disease places a large economic burden on the patient. The national economic burden of PD in the U.S. was more than $14.4 billion in 2010, about $8.1 billion more than populations without PD (Kowal et al., 2013; Martinez-Martin et al., 2019). Additionally, Medicare, Medicaid, and other government-funded programs account for approximately 48% of the medical needs, or $3.8 billion, for patients with PD (Kowal et al., 2013). In 2010, it was estimated that people with PD accounted for 1.9 million inpatient hospital days, over 800,000 more days than those without PD (Kowal et al., 2013), adding to the growing medical expenses incurred by these patients as the cost for hospitalization has grown exponentially in recent years. Exacerbating the issues associated with a high economic burden of PD, those diagnosed often find it difficult to maintain employment and may find themselves unemployed or as an early retiree only a few years after their initial diagnosis. It was estimated that nearly 108,900 PD individuals were employed in the U.S. in 2010, resulting in approximately $1.7 billion in reduced productivity (Kowal et al., 2013). Furthermore, those employed earned about $13,600 less per year than similar populations without PD (Kowal et al., 2013). For those not able to work, individuals with PD were paid $207 million in disability benefits, with about
16,000 more receiving aid than similar-aged HOA. (Kowal et al., 2013). The high
demand to attempt all treatments to slow PD progression can become an overwhelming
financial, psychological, and physical burden for patients and their caregivers.

The disease trajectory for a patient with PD is an overwhelming and life-changing
series of events that alter many facets of the individual’s daily life. Patients commonly
require caregiver support (i.e., spouse, family member, friends, in-home medical
professional, etc.) as the burden increases. Caregivers may help with transportation,
socialization, safety, medication compliance, and activities of daily living (Martinez-
Martin et al., 2012; Martinez-Martin et al., 2019). The weight of responsibility for
another begins to compromise the caregiver’s physical and mental health and reduce
work productivity and income (Martinez-Martin et al., 2019). About 30-40% of total
indirect costs of PD are associated with earnings lost by caregivers and hours spent
caregiving, with over 25% of caregivers spending 70 or more hours a week caring for
patients (Martinez-Martin et al., 2012; Martinez-Martin et al., 2019). Beyond economic
impacts, depression is the most constant predictor of QoL in caregivers (Martinez-Martin et al., 2012). While the caregivers burden grows as it falls on friends and family, it could
decrease the economic burden of allowing a patient with PD to remain in their home
(Martinez-Martin et al., 2012). Life changes for the caregivers, such as moving the
patient into their own home or vice versa, are taxing and challenging decisions for all
involve. The growing number of PD diagnoses and no current options to abate the
disease, caregivers will need expanded support themselves in the years to come.
Without a known cure, PD is often treated with levodopa and is considered the most effective and first-line medication (Mayo Clinic Staff, 2020). While levodopa targets and decreases motor symptoms, its overall effectiveness decreases overtime (Cruise et al., 2011; Steib et al., 2018). Additionally, levodopa is unreliable on cognitive function, even with the increased dopamine it provides the brain. As levodopa treatment effectiveness decreases, providers modify treatment with supplemental or alternative medications (i.e., dopamine agonists, MAO-B inhibitors, anticholinergics, etc.). As a last resort, individuals may decide to undergo surgical options to directly influence the brain’s electrical signaling (e.g., deep brain stimulation). Physical activity has shown to be effective in maintaining or reducing motor and nonmotor symptoms of PD throughout the disease (LaHue et al., 2016).

Quality of Life

Quality of life (QoL) is an encompassing term used to quantify an individual’s life satisfaction and subjective well-being (Frisch et al., 1992). With QoL being a subjective measure, it is important to note a person’s positive as well as negative affect (Frisch et al., 1992). For many, the presence of disease may have adverse effects on QoL. The quality of life inventory (QoLI) is a short questionnaire developed to weigh importance of a particular domain of life with life-satisfaction to calculate a composite score (Frisch et al., 1992). Domains addressed include areas such as health, love, family, community, etc. (Frisch et al., 1992). After reading the operational definition for a particular domain, individuals are first asked to rate the importance (0 equating not at all important to 2 equating extremely important), followed by their satisfaction of the category (-3 equating very dissatisfied to 3 equating very satisfied) (Frisch et al., 1992).
Overall score is comprised of each importance multiplied by its corresponding satisfaction and summed, after excluding any nonimportance (zero) values.

**Influence of PD on QoL**

As PD effects all aspects of an individual, the summation of the disease weighs heavily on QoL. The onset of the disease is often from 40 to 70 years of age (Baatile et al., 2000), leading to a long and challenging disease journey. This brings along devastating physical, emotional, social, and mental effects for patients and their caregivers. From the onset of the disease, cost of treatment and loss of work may begin as the main disruptions to one’s life (Martinez-Martin et al., 2012; Martinez-Martin et al., 2019). After this initial disruption, many patients choose to take medication with unavoidable side effects like tremors (Baatile et al., 2000; Martinez-Martin et al., 2019).

Throughout disease progression, individuals may begin to experience cognitive decline requiring more attention from a caregiver. Day-to-day life changes mental state, function, and cognitive impairment may persist for the remainder of the patient’s life, possibly another 40 or more years. This persistence of the symptoms can change how much a patient may feel like they can participate in, or enjoy, their own life, leading to a decline in the satisfaction they may feel in a number of dimensions of life. Beyond the patients, this issue can extend to their caregiver as well, who may experience a similar decline (Martinez-Martin et al., 2012). One particularly challenging dimension to is loss of independence, which is greatly affected by the functional mobility. Due to the progressive nature of PD to impact this aspect of someone’s life, balance and fall risk become key indicators when assessing disease progression and effectiveness of therapeutics.
**Balance**

Balance is operationally defined as the ability to maintain stability throughout functional mobility movements (King & Horak, 2009; Silva et al., 2017). Balance is crucial in aging adults as fall consequences may result in worse outcomes (e.g., broken bones, head trauma, disability, etc.) (Hackney & Earhart, 2008). To assess balance, the timed up and go (TUG) is a frequently used and reported measure (Herman et al., 2011; Silva et al., 2017). As a simple and quick assessment, TUG is regularly used as a clinical performance measure and has been thoroughly studied in various populations of older adults (Herman et al., 2011). Similar to daily activity, the procedure for TUG asks participants to stand up from a chair, walk, turn around, and return to the chair (Herman et al., 2011; Silva et al., 2017). In a large sample of 265 HOA, TUG scores ranged from 5.4 to 15.6 seconds with an average of 9.5 ± 1.7 seconds (Herman et al., 2011).

**Impact of PD on balance and fall-risk**

Of the motor symptoms associated with PD, balance is motor indicator focused on for this study. As one of the more noticeable symptoms, bradykinesia has a profound impact on an individual’s balance, which is especially important in patients with PD to avoid falls and hip fractures (Hackney & Earhart, 2008; Sparrow et al., 2016). Gait hypokinesia and short, shuffle-like steps are common concerns associated with PD. Injuries due to a fall from any of these three mobility deficits individuals tend to lose independence or other movement-related disability in addition to their PD diagnoses (Ni et al., 2016; Sparrow et al., 2016). Individuals with PD fall at two times greater frequency than HOA, with over 50% encountering at least two falls over one year (Sparrow et al., 2016). Impaired walking pattern is caused by many factors, but people with PD face
further difficulty adapting to changing environmental conditions (Rogers, 1996). Due to the everyday trials associated with balance for individuals with PD and the elevated risk for fall and subsequent injury, motor symptoms like this have received a great deal of attention in the field. But, nonmotor-related deficits may also have a substantial impact on the independence of someone diagnosed with PD making declines in cognitive function potentially problematic for both the mental and physical state of the individual.

**Cognitive Control**

Cognitive control is made up of three concepts: inhibition, working memory, and cognitive flexibility. This study focused on inhibition, the ability to ignore distractions and stay focused, and working memory, the ability to hold information in the mind and manipulate it (Diamond, 2006). Working memory remains steady throughout most of one’s adult life, with a rapid decline after age 60 in HOA (Chang et al., 2013). Conversely, a recent meta-analysis revealed that there are many discrepancies in research about inhibition ability potentially declining with age (Rey-Mermet & Gade, 2018).

While both inhibition and physical activity are critical to maintain everyday functioning, physical activity has shown to improve working memory and inhibition (Chang et al., 2013; Kao et al., 2017; Pontifex et al., 2015).

The Eriksen Flanker Task (Eriksen & Eriksen, 1974) is often used to prompt an interference control. Participants are asked to respond as quickly and accurately as possible to a stimulus surrounding by flanking stimuli which are congruent with the target or incongruent with the target. During a congruent target, all stimuli are identical (i.e., EEEEE) not requiring inhibition from the participant. While congruent trials are found to be easier, participants more often respond quicker. Conversely, an incongruent
target requires the flanking stimuli to oppose the target (i.e., EEFEE) which elicits the inhibitory response of the participant. As the difficulty of this task increases, participants typically respond slower. The flanker assessment will provide reaction times as well as response accuracy of the trials.

The N-back task is employed to assess working memory (Kao et al., 2017). As participants are presented with six locations in a circle, a red target ball moves between the various locations. In a 1-back, the participant is asked to determine if the current location is the same or different than the previous location. The participant is required to constantly update their memory as the ball continues to move. In a more difficult assessment, participants are given the 2-back assessment. Similar to the 1-back, participants are given the same picture, but asked if the ball is in the same or different location relative to two trials ago. Participants are required to hold the information of the current location and the 1 previous, while accessing the location of 2 previous. Again, this requires the participant to constantly update as the stimuli changes. The n-back provides the reaction times as well as response accuracy.

**Effect of PD on Inhibition and Working Memory**

Although not as visible as bradykinesia, cognition is heavily affected by PD (Aarsland et al., 2003; Nimwegen et al., 2011; Tanaka et al., 2009). The etiology of the disease can be traced to the degradation and death of neurons in the brain, which leads to disruptions in the production and function of dopamine – a neurotransmitter essential to many motor and cognitive related functions of the brain. This reduction in dopaminergic pathways of the brain impacts all three facets of cognitive control (Hashimoto et al., 2015; Tanaka et al., 2009). Comorbidities of PD with other diagnoses like dementia and
Alzheimer’s that are memory-related impairments, this study has chosen to focus by examining the working memory aspects of the system through completion of a 1-back and 2-back assessment. The disturbance in the basal ganglia is associated with memory decline beyond the natural age-related reductions in performance is observed in HOA (Costa et al., 2003; Gurvich et al., 2007; Morris et al., 1988). The compounded decline can vastly impact the life and independence of those with PD appearing as though they are less capable of completing daily tasks due to the difficulties in reasoning and decision-making. Additionally, decision-making and planning are associated with the inhibitory control aspect of cognitive control, which is another area of diminished performance for those diagnosed with PD (Bokura et al., 2005; Gurvich et al., 2007; Obeso et al., 2011). As such, an assessment of inhibition has been included within this study to observe the execution of this system in those with and without PD. Although we know that the aforementioned symptoms of PD are more severe when compared to the natural declines in these areas for HOA, physical activity engagement has been shown to positively relate to each of these areas leading to improved function, mobility, cognition, and overall quality of life.

**Physical Activity**

The Centers for Disease Control and Prevention (CDC) and American College of Sports Medicine (ACSM) recommend HOA should participate in at least 30-minutes of moderate-vigorous physical activity across five-days per week to maintain proper health (American College of Sports Medicine, 2018). Worldwide, physical activity recommendations are not being met with most studies reporting 40-80% of HOA participating under the guidelines and 3.2 million deaths attributed to inactivity each year.
(Notthoff et al., 2017; Taylor, 2014). Moreover, in the U.S. alone, only about 28-34% of older adults meet the minimum requirements established for their age-groups (Elsawy & Higgins, 2010). Physical activity is critical to maintain as it reduces the risk of cardiovascular disease, cancer, osteoporosis, Alzheimer’s disease, improves cognition, and QoL (American College of Sports Medicine, 2018; Elsawy & Higgins, 2010; Notthoff et al., 2017). Additionally, physical activity combined with poor diet has contributed to the obesity epidemic (Elsawy & Higgins, 2010; Reiner et al., 2013).

Problematically, the most sedentary population is said to be adults 50 years and older with substantially higher medical costs for inactive adults (Elsawy & Higgins, 2010; Notthoff et al., 2017). As a potential remedy, physical activity was found to have increased life expectancy even in adults who did not begin regular exercise until after age 75 (Elsawy & Higgins, 2010).

Resulting from the positive nature of physical activity on health, there has been a growing surge in exercise programs designed to target motor and nonmotor symptoms (Altmann et al., 2015; Baatile et al., 2000; Combs et al., 2011; Dashtipour et al., 2015; LaHue et al., 2016; Steib et al., 2018). Classes include boxing (Combs et al., 2011, 2013), aerobic walking (Uc et al., 2014), dance (Hashimoto et al., 2015), and Tai Chi (Hackney & Earhart, 2008). Many PD studies have reported favorable effects of long-term interventions, usually in group settings, resulting from participation in these programs (Baatile et al., 2000; Combs et al., 2013; Dashtipour et al., 2015; Hackney & Earhart, 2008). Additionally, researchers have investigated transient effects on physical activity, finding immediate improvements on symptoms of PD (Pohl et al., 2003; Uygur et al., 2015). As important as these findings are, they are limited to a controlled setting.
(Loprinzi et al., 2018), such as the laboratory or gymnasium, and the translational application to activity done in the home is still not well understood. This is problematic as those with PD are already a restricted population who may have challenges traveling to a facility capable of providing these physical activity opportunities. Furthermore, this approach limits participation to higher SES groups and being more able-bodied, as they need to have the means and capability to travel to the research or exercise space. Many with PD may find themselves in the position of having limited, or no options for activity within their community when so many investigations have laid out all the benefits of participating, thus leading to an incongruous message about physical activity. On the other hand, sedentary activity has shown detrimental effects, especially on PD (LaHue et al., 2016; Nimwegen et al., 2011), and these barriers to physical activity may lead to many individuals with PD leading exceedingly more sedentary lives. Therefore, this project seeks to better understand the role that physical activity can have on the lives of those with and without a PD diagnoses.

**Physical Activity and QoL, Balance, & Cognitive Control**

*Impact of Physical Activity on QoL*

An overarching theme to all health is QoL: feeling better, functioning daily, and living independently (Spirduso & Cronin, 2001), and for many older adults, QoL is preferred over longevity of life (Rejeski & Mihalko, 2001). As expected, QoL is positively related to physical activity and health, even when proper motor and cognitive function is present. Physical activity has seen to increase QoL in multiple studies (Acree et al., 2006; Elsawy & Higgins, 2010; McAuley et al., 2006; Rejeski & Mihalko, 2001), with just one hour of physical activity per week having been shown to increase QoL.
compared with sedentary individuals (Acree et al., 2006). As a result, physical activity has been suggested as a means for improving QoL for individuals who may be experiencing changes in their life, like those with PD, that may negatively impact their QoL. Because individuals with PD typically live with the diagnosis over many years, it is crucial to maintain a higher QoL as much as possible. For example, depression is often one of the biggest predictors of QoL (Cruise et al., 2011), yet anti-depressants can exacerbate the motor symptoms of PD, leaving individuals with little options to improve (Cruise et al., 2011). Physical activity has shown the ability to positively influence depressive symptoms, but also improve motor-related symptoms as well.

**Influence of Physical Activity on Balance**

About 40% of older adults aged 65 and older encounter negative experiences with falls annually (Pau et al., 2014). While many instances can contribute to a fall, gait and balance are said to be the most common risk factors (Pau et al., 2014). Proper amounts of participation in physical activity, it has been found adults to reduce the risk of functional limitations and disability of adults by 30-50% (Taylor, 2014). Additionally, balance exercises are recommended for at least 90-minutes per week combined with 1-hour of moderate-intensity walking (Elsawy & Higgins, 2010).

As PD can exhibit noticeable motor symptoms, physical activity has shown significant delays in the progression of rigidity, bradykinesia, freezing (Altmann et al., 2015; Combs et al., 2011; Dashtipour et al., 2015; Domingos et al., 2019; King & Horak, 2009). With motor symptoms greatly limiting mobility an individual’s mobility, physical activity has been used to improve motor functions in many treatments (Hashimoto et al., 2015; Loprinzi et al., 2018; Uc et al., 2014). Bradykinesia, rigidity, and freezing all
contribute to impaired balance to increase the risk of falling (Sparrow et al., 2016). It is reported that people with PD fall twice as much as HOA in one year, with 68% reporting falls (Sparrow et al., 2016). However, 13% of participants, out of 100 total with PD, reported falling at least multiple times per week (Rogers, 1996). Additionally, as falls can often lead to hospital stays, the healthcare economic impact in doubles for PD patients that fall compared to non-fallers (Spottke et al., 2005). The cost of falling and hip fractures for PD is about $192 million annually (Hackney & Earhart, 2008). It seems like physical activity may aid in reducing this potentially preventable issue. Higher levels of physical activity have shown to improve balance (Combs et al., 2011, 2013; Hackney & Earhart, 2008; Mak et al., 2017). Parkinson populations are less likely to participate in physical activity due to fatigue and physical impairments (Nimwegen et al., 2011). As the challenge of introducing physical activity into the daily lives of those with PD has become a focal point of many therapeutic treatments for the disease to address motor symptoms, a lesser explored potential for this treatment has been associated with the nonmotor symptoms linked to PD.

**Effect of Physical Activity on Cognition**

While many people participate in physical activity for overall health reasons, there are additional cognitive benefits to be gained. While information about specific doses of exercise for cognitive benefits are being developed, all investigations agree that physical activity shows positive effects for aspects of cognitive control (Elsawy & Higgins, 2010; Taylor, 2014; Zhu et al., 2017). Overall, active adults display lower cognitive decline than inactive adults indicating a promising outlook at moderate PA to reduce the risk of decline and have potential protective effects (Elsawy & Higgins, 2010;
Taylor, 2014). In a study of 1,740 older adults without dementia at baseline, those who exercised at least 3 days per week were less likely to develop any form of dementia than the inactive group (Elsawy & Higgins, 2010). Physical activity showed positive effects on inhibition in older adults (Boucard et al., 2012). Physical activity exhibited more attention and shorter response time in a cognitive task than the control group in a study by Chang et al. (2013).

In addition to the benefits of PA for balance, it is associated with promising results for cognitive control. While still novel, physical activity and cognitive control are indicating an exceptional reciprocal relationship (Cruise et al., 2011; Hashimoto et al., 2015; Loprinzi et al., 2018). Aarsland et al. (2003) found that dementia rates increased by 1.5x in under a decade, affecting 80% of individuals living with PD and dementia. While dementia is defined as progressive cognitive decline, PD patients without dementia show increased cognitive impairment (Tanaka et al., 2009). Additionally, with PD comes deficits in attention, memory, and visuospatial cognition (Hashimoto et al., 2015). To address the lagging satisfactory results for cognitive impairments by medications, physical activity has been implemented (Cruise et al., 2011). Particularly, dance was associated with improved mental effects overall (Hashimoto et al., 2015). With regular physical activity, light-to-moderate activity has been linked to improvements in cognitive functioning for PD (Loprinzi et al., 2018). Improvements in cognitive control have been linked to improvements in cardiovascular fitness for individuals with PD (Cruise et al., 2011). Individuals with PD that participate in moderate physical activity have improved working memory over inactive counterparts (MacCosham et al., 2019). With so much stacked against individuals with PD, physical activity has been linked to providing
benefits all-around for motor and nonmotor symptoms (Cruise et al., 2011; Loprinzi et al., 2018; Tanaka et al., 2009). However, cognitive impairments have been a better predictor of QoL more than physical impairments with PD (Cruise et al., 2011).

**Purpose**

The purpose of this investigation is to examine the relationship between physical activity level and progressive symptoms of PD - specifically bradykinesia, balance, cognitive function, and QoL, compared with HOA. This proposal is specifically interested in everyday physical activity and the impact of these levels on individual QoL, balance, and cognitive control. Results will indicate preliminary relationships for physical activity and QoL, balance, and cognitive control in individuals with PD. Additionally, by using age- and gender-matched controls, results will indicate if trends associated with the amount of physical activity are consistent within a PD population relative to HOA, or if these trends diverge from the healthy control group.

**Rationale**

Much of the current research in PD is based on exercise classes, rather than daily physical activity observed in free-living adults. With medication primarily acting to influence motor symptoms, but with diminishing effects over time, individuals are not left with many options that may aid in the maintenance, or even improvement, of function. Physical activity may be a straightforward, cost-effective addition to one’s daily routine, and holds the potential to influence many of the ongoing symptoms commonly associated with PD. Therefore, the proposed study seeks to better understand the relationship between physical activity and QoL, balance, and cognitive control in PD and HOA groups. By furthering our understanding of these relationships, it may emphasize
the encouragement of physical activity beyond the exercise programs for individuals with PD, while also facilitating a basis for the role physical activity may play in the intricate ties between PD symptoms.

**Hypotheses**

The purpose of this investigation is to examine the role of physical activity level on progressive symptoms of PD - specifically bradykinesia, balance, cognitive function, and QoL, compared with HOA. Therefore, the following specific hypotheses are proposed:

1. Reports of higher physical activity levels will be associated with greater QoL in individuals with PD and HOA.
2. Greater levels of balance will be associated with higher levels of physical activity engagement in individuals with PD and HOA.
3. Higher levels of physical activity engagement will correspond with greater performance outcomes associated with both inhibition and working memory in individuals with PD and HOA.
4. With the sample diagnosed with PD, the relationships between QoL, balance, and cognition (inhibition and working memory) will be influenced by the individual’s level of physical activity engagement.
5. Individuals with PD will experience a divergence from physical activity trends associated with QoL, balance, and cognition (inhibition and working memory) in HOA, with those diagnosed with PD presenting with strong relationships among each variable of interest.
CHAPTER 3
Methodology

Participants and Recruitment

A sample of 11 older adults with PD and 10 age- and sex-matched healthy peers were recruited throughout the greater Northern Louisiana area, with a primary focus placed on fitness centers or programs focused on older adults and individuals diagnosed with PD (i.e., Rock Steady Boxing, etc.). All interested participants were notified that participation in this study was voluntary and they may withdraw at any time is within their right. They were then asked to complete a written informed consent in accordance with the Louisiana Tech University Institutional Review Board procedures. At this time, initial screenings for those expressing interest in the study were conducted with all individuals who met the necessary inclusionary criteria (Table 3.1) invited to participate in the research study. Those who did not meet the inclusionary criteria, or who express any of the exclusionary criteria presented in Table 3.1, were thanked for their time and their participation was discontinued.

Exclusionary criteria

All participants were screened for any physical or neurological impairments that would inhibit their ability to complete the physical activity (Physical Activity Readiness Questionnaire; PAR-Q) and cognitive components (Health History Demographic; HHD) of the study. Additionally, any participants unable to complete at least 10 meters of
independent walking without using an assistive device were excluded from the study.

Finally, participants who did not meet these exclusionary criteria were bifurcated into
two groups (PD Group & Healthy Group) based on physician verified diagnosis for
Parkinson’s Disease. See Table 3.1 for a full breakdown of all inclusionary and
exclusionary criteria for this study.

Table 3.1.

*Inclusion Criteria for Participant Acceptance into the Current Project*

<table>
<thead>
<tr>
<th>Inclusion Criteria for All Participants</th>
<th>Inclusion Criteria for PD participants</th>
<th>Inclusion Criteria HOA participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physically capable of completing physical activity based on the PAR-Q</td>
<td>1. Verified clinical status from a physician</td>
<td>1. Free of neurological impairments</td>
</tr>
<tr>
<td>2. Able to walk 10m without the use of an assistive device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Free of neurological impairments</td>
<td></td>
<td>2. Age- and gender-matched</td>
</tr>
</tbody>
</table>

*Note: Physical Activity Readiness Questionnaire – PAR-Q

**Quality of Life Inventory**

Overall, QoL was assessed in all participants using the Quality of Life Inventory
(QoLI; Frisch, 1994, 2009). The QoLI measures life satisfaction from an overall sum of
domains regarding well-being, positive health, happiness, and contentment from sixteen
areas of life. It is written at a sixth-grade reading level and takes 5 minutes to complete.
Often implemented as a tool to gauge psychological aspects of well-being associated with
physical and mental illnesses, the QoLI has shown high internal consistency with
coefficients ranging from 0.77 to 0.89 in both clinical and non-clinical samples (Frisch et
al., 1992). The QoLI utilizes a 6-point Likert scale ranging from very dissatisfied (-3) to
very satisfied (3), and an importance multiplier ranging from not important (0) to
extremely important (2). Each value is multiplied by its importance value to find the importance value from most negative (-6) to most positive (6). The sum of all domains will be used for analysis.

**Balance Assessment**

The Timed Up and Go (TUG) was used to assess balance in all participants (Podsiadlo & Richardson, 1991). Participants will begin in a standard armchair with their back flat against the chair, arms on the rests, and feet flat on the floor. On the word “Go,” participants will stand up, walk to a line three meters away, turn around, and return to a seated position in the chair. Participants were given one practice trial to familiarize themselves with the task, then two full trials. During each trial, practice and full, there was a researcher on both sides of the individual throughout the test to assist in the case of elevated fall risk. The performance was based on time, in seconds, the participant leaves the chair and ends as the participant returns to the seated position. The shortest time of the two trials was used for analysis.

**Cognitive Control Tasks**

**Flanker task**

Participants completed a modified Eriksen Flanker Test (Eriksen & Eriksen, 1974) to assess inhibitory aspects of cognitive control. In this task, participants were required to correctly identify a centrally located stimuli within a number of flanking stimuli. This study utilized a letter-based flanker, tasking the participants with responding to several perceptually similar letter stimuli combinations (e.g., I – T, P – R, Q – O, etc.), presented either congruently [PPPPP or RRRRR] or incongruently [PPRPP or RRPRR]. Equiprobable distribution for directionality of the centrally located stimuli and
congruency of each stimuli set was maintained through each trial. Stimuli were presented as white letters on a black background at a 400ms display rate, a 1000ms response window, and with variable 1500ms/1600ms/1700ms intertrial intervals (ITI). Participants were instructed to respond as quickly and accurately as possible to the central stimuli by pressing the corresponding button on a keypad. Following these instructions, they were given one practice block containing 80 trials to become familiar with the task. After asking questions following the practice trial, they then completed two blocks containing 156 trials each (Pontifex et al., 2010). The flanker task will be performed after the experimental condition. The primary measures of interest for this assessment were the average reaction time (ms), response accuracy (%), and omission & commission errors (%).

**N-back task**

Following the completion of the flanker task, participants completed a Spatial N-Back Test to assess working memory (Drollette et al., 2012). The N-back provides a continuous stimulus on the participant’s working memory load requiring constant updating. The participant saw six squares in the shape of a circular design on a 4.3’ radius from the center of the screen (Drollette et al., 2012; Pontifex et al., 2014). A ball flashed as the stimuli on the screen with participants tasked with determining the relation of the ball’s location to the previous trial (1-back) or the relation of the ball’s location to the location two trials prior (2-back). Instructed to respond as quickly and accurately as possible, the participants were required to press a button on the keypad corresponding with if the ball is or is not the corresponding spatial location for each level of the assessment. The presentation of the ball stimuli was presented as a red ball in white
squares on a black background, with a 200ms display window, 1000ms response window, and a variable 1500ms/1600ms/1700ms ITI. Each participant began with instructions for either 1-back or 2-back and completed a practice block prior to completing two blocks of 144 trials. They repeated this for the other condition, with the order of these conditions randomly assigned for each participant to control for potential learning effects. Target trials appeared at a 33% probability throughout each of the tests to maintain engagement and limit impulsiveness. The primary measures of interest for this assessment were the average reaction time (ms), response accuracy (%), and omission & commission errors (%).

**Physical Activity Assessment**

Habitual energy expenditure associated with physical activity was assessed using the Actigraph GT9X Link accelerometer (Actigraph, LLC., Pensacola, FL, USA) during all daily activities, excluding water-based activities (i.e., swimming and bathing) and night-time sleep. Participants were instructed to wear the monitor for two weeks, to obtain a minimum of five weekdays and two weekend days of usable data for analysis to determine habitual physical activity patterns associated with the participants’ standard weekly schedule. Each participant was instructed to wear the monitor at the right mid-axillary line level with the iliac crest (i.e., the right hip), using the elastic belt provided by the research team. Adherence with these procedures is consistent with prior evidence demonstrating test-retest reliability ($r = 0.85$; Mcclain et al., 2007) and criterion validity ($r = 0.85-0.92$; Berlin et al., 2006; Kelly et al., 2013) with indirect calorimetry measures of energy expenditure for the Actigraph GT9X Link.
Procedure

Using a between-subjects design, this study asked participants to engage with research staff on two separate days. The first session was approximately 45-minutes in duration, while the second session was approximately 1 hour in total. On the first day, participants were asked to complete all preliminary paperwork, including: 1) informed consent, 2) health history demographics (HHD), 3) physical activity readiness questionnaire (PAR-Q; (Thomas et al., 1992), 4) the Wechsler Abbreviated Scale of Intelligence – Version 2 (Wechsler, 2011), and for the PD group 5) provide physician verification of diagnosis. After completing the paperwork, participants were then given a brief tutorial on the use and procedures of wearing the accelerometer. This tutorial included information regarding when to/and not to wear the monitor, and how the monitor tracks their activity, and how to complete the accompanying activity log. Following the accelerometry tutorial, the participant was asked to schedule the second session for 2-weeks after the first meeting.

At the start of the second session, participants were asked to turn in their accelerometer and the activity log. At this time, they were given the opportunity to ask any questions and update any items on the log to better represent their activity. Following this, participants completed the cognitive assessment battery, including the modified Flanker task (Eriksen & Eriksen, 1974) and the n-back (Drollette et al., 2012). Before beginning the assessment, participants were given a block of practice trials to acclimate to the assessment. Participants all completed the flanker task first, followed by a counterbalance of the n-back assessment with half the participants randomly assigned to complete the 1-back followed by the 2-back assessment. The remaining participants were
randomly assigned to complete the 2-back and then the 1-back assessment. Immediately following completion of the cognitive assessments, participants were then asked to complete the TUG, followed by completing the QoLI. Upon completion of the study, participants were thanked for their time.

**Statistical Analysis**

All data derived from the activity monitors were first reduced using a combination of 1 second, 5 second, 15 second, and 1-minute epochs. This variation in epoch length is consistent with literature suggesting short 1-second or 5-second epochs are necessary to capture variation in the highly variable environment of free-living adults, and timeframes implemented in previous research (Berlin et al., 2006; McClain et al., 2007). Epochs were then assessed for time spent in five categories (sedentary, light activity, moderate, moderate-to-vigorous activity, and vigorous activity) with cut points for the categories based on standards set for older adult research. Statistical analysis was conducted using PASW Statistics, 26.0 (IBM, Armonk, NY). Demographic data was analyzed between the two groups to detect any potential variations in descriptive statistics for the groups. All study variables were then screened for homoscedasticity and normality. Bivariate correlation analysis was then conducted between all demographic factors in each group, and each outcome measure using Pearson product-moment correlation coefficients. Hierarchical linear regression was used to examine the variance between each of the outcome variables as they relate to physical activity. Significant correlates identified were included as covariates in step 1 of this regression model as a means to deduce any independent contribution physical activity may have in explaining the variance in the
model beyond these covariates. The Familywise alpha level of 0.05 was used for all analyses.
Figures

Figure 3.1. Illustration of the instructions (a), congruent (b), and incongruent (c) letter stimuli used in the modified flanker task.

Figure 3.2. Illustration of three successive trials for the 1-back task. Sequence from trials (a) to (b) indicate non-target response, while trials (b) to (c) would indicate a target.

Figure 3.3. Illustration of three successive trials for the 2-back task. Sequence from trials (a) to (c) indicate a target.
CHAPTER 4

Results

Participant Characteristics

Participant data was initially analyzed for any potential exclusionary criteria, descriptive statistics, and differences between groups. While all participants engaged in each of the components of the study one participant in the PD group withdrew from the study after their initial screening session due to medical challenges not associated with the study. One participant from the PD group did not meet the minimum weartime criteria for the accelerometer data. Therefore, each of these participants has been removed from all subsequent analyses. Descriptives for the sample were assessed for several demographic variables (Table 4.1), and no significant group differences were observed between the PD group or the HOA group on any potential confounding variables, $t’s(9) \leq 1.27, p \geq .22$.

Quality of Life

PD Group

Potential confounding variables (age & IQ) were assessed for and relationships with activity levels and the QoLI scores. No significant relationships were observed ($r’s \leq .61, p’s \geq .08$). Therefore, a simple linear regression was conducted for physical activity at each level to see if time spent in the activity level was an adequate predictor for QoLI. For each activity level, the time spent in the level was not a significant predictor of QoLI for PD ($r’s \leq .61, R^2’s \leq .37, F’s(1,8) \leq 4.1, p’s \geq .08$).
**HOA Group**

Likewise, no confounding variables were found to be significantly correlated with the activity levels or the QoLI scores for the HOA group ($r's \leq .55$, $p's \geq .12$), leading to simple linear regression analyses to assess physical activity with QoLI in the HOA group. There was no significance for physical activity at any level to predict QoLI in HOA ($r's \leq .55$, $R^2's \leq .31$, $F's(1,8) \leq 3.1$, $p's \geq .12$).

**Timed-Up and Go**

**PD Group**

Checking for any influence from age and IQ, these variables were again assessed for any relationship with the physical activity levels and the TUG in this group and the HOA group. No significant correlations were observed for either group ($r's \leq .60$, $p's \geq .09$). Using linear regression, all levels of physical activity were assessed with the fastest TUG time. None of the activity levels were significant to predict TUG for PD ($r's \leq .60$, $R^2's \leq .36$, $F's(1,8) \leq 3.9$, $p's \geq .09$).

**HOA Group**

As there were no confounding variables to include in this analysis, simple linear regressions were used to assess all levels of physical activity with the fastest TUG time. Again, no activity level was significant to predict TUG for HOA ($r's \leq .21$, $R^2's \leq .05$, $F's(1,8) \leq 0.40$, $p's \geq .55$).

**Flanker**

**Reaction time**

**PD Group.** Using a stepwise linear regression, all levels of physical activity were assessed with mean RT of congruent, incongruent, and all trials with IQ and age
controlled for within the model. Moderate physical activity was significant with congruent \( (r = -0.68, \ R^2 = .46, F_{(1,8)} = 6.06, \ p = .04) \), incongruent \( (r = -0.66, \ R^2 = .43, F_{(1,8)} = 5.26, \ p = .05) \), and all \( (r = -0.68, \ R^2 = .46, F_{(1,8)} = 6.06, \ p = .04) \) trials. MVPA was also significant with congruent \( (r = -0.68, \ R^2 = .46, F_{(1,8)} = 5.91, \ p = .05) \), incongruent \( (r = -0.65, \ R^2 = .42, F_{(1,8)} = 5.13, \ p = .05) \), and all \( (r = -0.68, \ R^2 = .46, F_{(1,8)} = 5.91, \ p = .05) \) trials. No other levels of physical activity were significant at \( r’s \leq .61, R^2’s \leq .38, F’s_{(1,8)} \leq 4.21, \ p’s \geq .08 \).

**HOA Group.** Similarly, stepwise linear regressions were used with all levels of PA and mean RT for congruent, incongruent, and all trials with IQ and age controlled for within the model. No model reported significant for HOA with \( r’s \leq .61, R^2’s \leq .37, F’s_{(1,8)} \leq 4.1, \ p’s \geq .08 \).

**Response accuracy**

**PD Group.** Using stepwise linear regressions, all levels of physical activity were assessed with response accuracy of congruent, incongruent, and all trials with IQ and age controlled for within the model. Moderate physical activity was significant with only incongruent \( (r = -0.82, \ R^2 = .68, F_{(1,8)} = 14.54, \ p = .01) \) and all \( (r = -0.68, \ R^2 = .47, F_{(1,8)} = 6.09, \ p = .04) \) trials. MVPA was also significant with only incongruent \( (r = -0.82, \ R^2 = .67, F_{(1,8)} = 13.97, \ p = .01) \) and all \( (r = -0.68, \ R^2 = .46, F_{(1,8)} = 5.93, \ p = .05) \) trials. No other levels of physical activity were significant at \( r’s \leq .62, R^2’s \leq .39, F’s_{(1,8)} \leq 4.46, \ p’s \geq .07 \).

**HOA Group.** Again, stepwise linear regressions were used with all levels of physical activity and response accuracy for congruent, incongruent, and all trials with IQ
and age controlled for within the model. No model reported significant for HOA with $r$'s ≤ 0.63, $R^2$'s ≤ 0.40, $F$'s(1,8) ≤ 4.69, $p$'s ≥ 0.07.

1-Back

Reaction time

PD Group. Using stepwise linear regression, all levels of physical activity were assessed with mean RT of target, nontarget, and all trials with IQ and age controlled for within the model. Light physical activity was significant with only target ($r = -0.70$, $R^2 = 0.48$, $F_{(1,8)} = 6.45$, $p = 0.04$) and all ($r = -0.65$, $R^2 = 0.43$, $F_{(1,8)} = 5.21$, $p = 0.05$) trials. Moderate physical activity was significant with target ($r = -0.65$, $R^2 = 0.43$, $F_{(1,8)} = 5.24$, $p = 0.05$), nontarget ($r = -0.68$, $R^2 = 0.46$, $F_{(1,8)} = 5.94$, $p = 0.05$), and all ($r = -0.71$, $R^2 = 0.50$, $F_{(1,8)} = 7.05$, $p = 0.03$) trials. MVPA was also significant with target ($r = -0.65$, $R^2 = 0.42$, $F_{(1,8)} = 5.15$, $p = 0.05$), nontarget ($r = -0.67$, $R^2 = 0.45$, $F_{(1,8)} = 5.75$, $p = 0.05$), and all ($r = -0.70$, $R^2 = 0.49$, $F_{(1,8)} = 6.83$, $p = 0.04$) trials. No other levels of physical activity were significant at $r$'s ≤ -0.59, $R^2$'s ≤ 0.35, $F$'s(1,8) ≤ 3.80, $p$'s ≥ 0.09.

HOA Group. Likewise, stepwise linear regressions were used with all levels of physical activity and mean RT of target, nontarget, and all trials with IQ and age controlled for. Light activity was significant with nontarget ($r = 0.83$, $R^2 = 0.69$, $F_{(2,8)} = 6.64$, $p = 0.03$) and all ($r = 0.82$, $R^2 = 0.67$, $F_{(2,8)} = 5.97$, $p = 0.04$). Sedentary was significant with nontarget ($r = 0.80$, $R^2 = 0.64$, $F_{(2,8)} = 5.24$, $p = 0.05$) and with all ($r = 0.80$, $R^2 = 0.64$, $F_{(2,8)} = 5.36$, $p = 0.05$). Moderate was significant with nontarget ($r = 0.82$, $R^2 = 0.68$, $F_{(2,8)} = 6.24$, $p = 0.03$) and all ($r = 0.81$, $R^2 = 0.66$, $F_{(2,8)} = 5.80$, $p = 0.04$). Vigorous was significant with nontarget ($r = 0.84$, $R^2 = 0.70$, $F_{(2,8)} = 6.92$, $p = 0.03$) and all ($r = 0.84$, $R^2 = 0.71$, $F_{(2,8)} = 7.19$, $p = 0.03$). MVPA was significant with nontarget ($r = 0.82$, $R^2 = 0.68$, $F_{(2,8)} = 6.31$, $p =
(.03) and all ($r = .81, R^2 = .66, F_{(2,8)} = 5.85, p = .04$). No other model reported significance for HOA with $r’s \leq .82, R^2’s \leq .67, F’s_{(2,8)} \leq 5.1, p’s \geq .06$.

Response accuracy

**PD Group.** In stepwise linear regression, all levels of physical activity were assessed with response accuracy of target, nontarget, and all trials with IQ and age controlled for within the model. The only significant value was sedentary and nontarget ($r = .67, R^2 = .44, F_{(1,8)} = 5.55, p = .05$). No other levels of physical activity were significant at $r’s \leq .63, R^2’s \leq .40, F’s_{(1,8)} \leq 4.66, p’s \geq .07$.

**HOA Group.** Additionally, stepwise linear regressions were used for all levels of physical activity were with response accuracy of target, nontarget, and all trials with IQ and age controlled for within the model. Vigorous was significant with nontarget ($r = -0.82, R^2 = .67, F_{(1,8)} = 14.21, p = .01$) and all ($r = -0.77, R^2 = .59, F_{(1,8)} = 9.90, p = .02$) trials. No other levels of physical activity were significant at $r’s \leq .57, R^2’s \leq .32, F’s_{(1,8)} \leq 2.85, p’s \geq .14$.

2-Back

While data was collected for the 2-back, preliminary analysis of the data indicated insufficient performance in each group. Upon exploration with the participants, many reported confusion, became ‘flustered’, or the feeling of ‘giving up’ on this task; leading to several participants reporting in follow-up that they either did not answer or ‘guessed’ with each response. As such, after the 3rd occurrence of this issue in each group, the task was discontinued for any future participants. Therefore, with limited sufficient data, inferential analysis was not conducted on this task for either group.
Table 4.1.

Participant demographic values (Mean ± SD).

<table>
<thead>
<tr>
<th>Measure</th>
<th>PD</th>
<th>HOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>9 (1 female)</td>
<td>9 (0 female)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>69.8 ± 8.5</td>
<td>68.5 ± 7.9</td>
</tr>
<tr>
<td>Education (years)</td>
<td>16.7 ± 3.0</td>
<td>17.11 ± 4.3</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Race</td>
<td>100% Caucasian</td>
<td>100% Caucasian</td>
</tr>
<tr>
<td>Income</td>
<td>55% &gt; $80,000</td>
<td>50% &gt; $80,000</td>
</tr>
<tr>
<td>IQ</td>
<td>97.4 ± 23.0</td>
<td>104.8 ± 11.4</td>
</tr>
<tr>
<td>Age of Diagnosis</td>
<td>64.4 ± 10.8</td>
<td></td>
</tr>
<tr>
<td>Length of Diagnosis</td>
<td>5.4 ± 3.3</td>
<td></td>
</tr>
<tr>
<td>Sedentary (mins)</td>
<td>7183.7 ± 1855.9</td>
<td>8190.1 ± 1343.3</td>
</tr>
<tr>
<td>Light (mins)</td>
<td>1522.8 ± 718.1</td>
<td>2202.4 ± 751.1</td>
</tr>
<tr>
<td>Moderate (mins)</td>
<td>166.21 ± 158.3</td>
<td>511.4 ± 207.1</td>
</tr>
<tr>
<td>MVPA (mins)</td>
<td>168.8 ± 158.6</td>
<td>520.8 ± 209.2</td>
</tr>
<tr>
<td>Vigorous (mins)</td>
<td>2.4 ± 2.3</td>
<td>8.9 ± 5.9</td>
</tr>
</tbody>
</table>

*Note:* *p* ≤ 0.05; **p** ≤ 0.001; PD = Parkinson's Disease; MVPA = Moderate to Vigorous Physical Activity
Figures

Figure 4.1. Average time spent in each activity level by each group. Vigorous activity is not depicted as it had less than 10 minutes on average for each group.
Figure 4.2. Regression trends observed for Moderate and MVPA activity for mean reaction time on each trial type from the Flanker task.
Figure 4.3. Regression trends observed for Moderate and MVPA activity for mean reaction time on each trial type from the 1-Back task.
CHAPTER 5
Discussion

The purpose of this study was to examine daily physical activity on QoL, balance, and cognitive function in adults with PD compared to HOA. None of the 5 classifications for physical activity levels were able to predict TUG or QoLI in either of our groups. Time spent in moderate, and MVPA in the PD group correlated with faster mean RT and incongruent response accuracy in the Flanker test, however it did not fit the model for HOA. Time spent in light, moderate and MVPA levels could significantly predict RT in the 1-Back for the PD participants but was a poor predictor within the HOA group. Response accuracy of nontarget variables in the 1-back was significantly predicted by time spent in sedentary activity for the PD group. Conversely, response accuracy in HOA was significantly predicted by vigorous activity for nontarget variables. The 2-back assessment did not result in sufficient data for analysis.

The first hypothesis was that reports of higher physical activity levels would be associated with greater QoL in individuals with PD and HOA. While the data does not support this claim, it may be explained by the limited amount of time spent in MVPA for all participants. Even with a smaller sample size (N = 6), Baatile et al. (2000) were able to detect improvements in QoL with more strenuous activity. Presumably, this may be due to the idea that it takes higher levels of physical activity to elicit a dopaminergic response in the brain (Baatile et al., 2000). Similarly, the second hypothesis was greater levels of balance would be associated with higher levels of physical activity engagement.
in individuals with PD and HOA. Again, the current data does not support this premise. Similar to QoL, Dibble et al. (2009) found improved TUG scores with an almost identical sample size to the current investigation. However, their participants completed high-intensity training, in addition to daily life activity. In the current sample, many PD participants participated in a group boxing class two times per week. Presumably, the class was not able to allow participants to reach MVPA; however, participants may have thought the class was enough physical activity and did not seek activity elsewhere.

The third hypothesis was higher levels of physical activity engagement would correspond with greater performance outcomes associated with both inhibition and working memory in individuals with PD and HOA. Faster reaction times were consistent in the Flanker and the 1-back for light (1-back only), moderate, and MVPA in the PD group. While limited, this is consistent with current literature on PD and mean RT (Ebersbach et al., 2014). Increased incongruent response accuracy for the Flanker was found with higher levels of moderate and MVPA. This is important to note because the incongruent trials are much more difficult to identify as they invoke a greater inhibitory response. While participants received instructions to ‘respond as quickly and accurately as possible,’ they may have focused more on speed overall.

At present, no articles could be located with the Flanker task and physical activity for PD. Conversely, increased nontarget response accuracy in the 1-back was significant with sedentary activity in the PD group and vigorous activity and the HOA group. While it suggests conflicting results, it may be explained by nontarget variables appearing 66% of the time, providing more opportunity to choose correctly even when guessing. To
explain the significance of response accuracy with sedentary activity in the PD group, current literature may point to the speed-accuracy relationship (Kao et al., 2016). While the sedentary activity was not related to faster RT, this may indicate participants here took longer to answer and, in turn, answered correctly more often. Similarly, vigorous activity in the HOA group related to higher response accuracy, potentially indicating another example of the speed-accuracy relationship.

The fourth hypothesis was with the sample diagnosed with PD, the relationships between QoL, balance, and cognition (inhibition and working memory) will be influenced by the individual’s level of physical activity engagement. The current data supports moderate and MVPA elicit a cognitive response, however, no specific level of physical activity seemed to predict QoL or TUG scores. Light activity only correlated with nontarget response accuracy for the 1-back. Further research will be needed to determine if light activity is enough for other categories as well, or if it can be attributed to the small sample size. These results coincide with CDC and ACSM recommendations of at least 30-minutes of moderate-vigorous physical activity across five-days per week. While very few of the participants did meet the threshold, many participants scored well below these recommendations. It would be expected to see this relationship continue with more participants added that meet or exceed the minimum recommendations for physical activity.

The final hypothesis was individuals with PD would experience a divergence from physical activity trends associated with QoL, balance, and cognition (inhibition and working memory) in HOA, with those diagnosed with PD presenting with strong
relationships among each variable of interest. The current data supports that PD may experience increased cognitive benefits from physical activity, over HOA. However, this could potentially be explained because of the cognitive deficits PD experiences, they could have more to gain than HOA without cognitive declines. More research is required to explore this potential relationship.

**Practical Implications**

Overall, it seems the time spent in moderate and MVPA activity levels result in potentially ideal outcomes for individuals with PD. This aligns well with physical activity recommendations for adults, in addition to potentially combatting a further progression of the disease. Specifically, physical activity in this sample resulted in favorable cognitive outcomes, which is a large concern for many individuals with PD. Overall, the use of accelerometers was suitable to track physical activity for these groups, with limited issues with adherence to the waist monitor usage. The flanker and 1-back assessment were at appropriate speeds to elicit a response; however, the 2-back test left many participants frustrated and confused rather than able to collect usable data. For future, it may be more appropriate to remove the 2-back for PD and HOA populations.

**Limitations & Future Directions**

The current sample is a limitation due to its small sample size. As this study was deliberately a pilot investigation, it is well underpowered to be able to detect all potential effects these variables may present. Additionally, the sample is comprised of mostly Caucasian males of a wealthy status which excludes a large number of people overall. A large, more diverse sample would be ideal for future investigations to expand generalizability. Lastly, simple RT was not collected for each participant to understand
their baseline speed in response to a stimulus. For future research, a baseline RT should be collected for reference in the more difficult tasks. This could help understand if deficits are found in the movement RT or the cognitive demands of the task. Lastly, as this investigation was completed during the COVID-19 pandemic, it presented difficulties for recruiting participants as well as practicing all appropriate safety measure (i.e., social distancing, mask compliance, etc.) to ensure the well-being of all participants.

**Conclusion**

Physical activity may present preliminary evidence that individuals with PD may benefit more from the effects than HOA, potentially due to deficits in various life dimensions, motor function, and cognitive health allowing for greater room for improvement. Time spent in moderate and MVPA levels appear to show favorable effects in cognitive tasks for PD, while not impacting any of the other domains assessed. With the limitations of PD physically, mentally, and economically, daily physical activity simply added to one’s routine may be the best adjunctive strategy to combat symptoms of the disease.


APPENDICES

Appendix A: IRB Approval Letter

MEMORANDUM

TO: Ms. Alexandra Ziepeke, Dr. Andrew Parks, Dr. Tara Haskins
and Dr. Mu Qiao

FROM: Dr. Richard Kordal, Director of Intellectual Property & Commercialization
(OIPC)
rkordal@latech.edu

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: November 16, 2020

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

HUC 21-037

"The Relation of Physical Activity to Quality of Life, Balance, and Cognition in Adults with Parkinson’s Disease"

The proposed study’s revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. This approval was finalized on November 16, 2020 and this project will need to receive a continuation review by the IRB if the project continues beyond November 16, 2021. ANY CHANGES to your protocol procedures, including minor changes, should be reported immediately to the IRB for approval before implementation. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of Sponsored Projects.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Sponsored Projects or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.
Appendix B: Health History Demographic

Basics

Participant ID

Date of Participation
11/9/2020

General Information

General Information

What is your date of birth?
Month
Day
Year

What is your current age?

How many years of education have you completed?
(High School = 12; College = 16)

What is your sex?

Male
Female

Which is your dominate hand?
Left
No Preference
Right

Do you wear contacts or glasses?
If yes, what is their prescription for?

Demographics

**Demographics**

Please answer the following questions about your home environment:
(If a specific question is not applicable, please skip it.)

- Do/Did you work?  
  Yes  
  No

- Does/Did your significant other work?  
  Yes  
  No

What is the highest level of education obtained by you and your significant other:
(If a specific question is not applicable, please skip it.)

- You
- Significant Other

How many biological siblings do you have?

Do you consider yourself to be Hispanic or Latino?
*(A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race)*

- Yes  
- No

What race/ethnicity do you consider yourself?
(Select one or more options below)
☐ American Indian or Alaska Native: a person having origins in any of the original peoples of North and South America (including Central America) and who maintains tribal affiliation or community attachment.

☐ Asian: a person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.

☐ Black or African American: a person having origins in any of the Black racial groups of Africa.

☐ Native Hawaiian or Other Pacific Islander: a person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.

☐ White or Caucasian: a person having origins in any of the original peoples of Europe, the Middle East or North Africa.

What is your approximate gross household income?
(Income includes wages and salaries, unemployment insurance, disability payments, child support payments received, as well as any personal business, investment, or other kinds of income received routinely.)

☐

Habits

Habits

On an average day during the WEEK, how much time do you spend:

- Watching Television
- On the Computer
- Playing Videogames
- Being Physically Active

On an average day during the WEEKEND, how much time do you spend:

- Watching Television
- On the Computer
- Playing Videogames
- Being Physically Active

How much sleep do you get:
On an Average Week Night
On an Average Weekend Night
Last Night

How many drinks of the following substances do you consume on an average day?

Water
Caffeinated Soft Drinks
Cups of Tea

How often would you rate your stress level as HIGH?

Never Rarely Sometimes Most of the Time Always

What is your current relationship status?

How long has this been your relationship status?

How stressful would you rate your relationship/relationship status?

Low Stress Moderate Stress High Stress

How many drinks do you regularly have in a WEEK?

Beer
Glasses of Wine
Ounces of Liquor (1 shot = 2 ounces)

How many cigarettes/cigars/pipes do you regularly smoke in a WEEK?

If you have quit smoking, how long has it been since you quit?
Do you take Ginkgo Biloba supplements?

Yes  No

Do you take any stimulant or sedative medications?

Yes  No

How many hours since you last:

- Had a Caffeinated Substance
- Ate a Meal or Snack
- Exercised

**General Health**

**General Health**

When was the last time you saw a doctor?

Have you ever been diagnosed with:

- Any allergies?  Yes  No
- Dyslexia?  Yes  No
- An Attentional Disorder?  Yes  No
- Asthma?  Yes  No
- Epilepsy?  Yes  No
- Diabetes?  Yes  No
- Hearing Impairment?  Yes  No

If you are diabetic, what type do you have?
Have you been hospitalized in the last 6 months?

Yes ☐
No ☐

If so, please explain:

Have you been diagnosed with Parkinson's Disease?

Yes ☐
No ☐

At what age were you diagnosed with PD?

Are you currently taking any medications for you PD diagnosis? If so, what medication and what dosage (i.e., Levodopa - 300 mg/day)

Have you been diagnosed with any medical conditions associated with your PD diagnoses? (i.e., Parkinson's related Dementia, Alzheimer's Disease, etc.)

Yes ☐
Maybe ☐

If so, what condition(s)?

____
Are you currently involved in any physical activity oriented programs designed for individuals with PD?

Yes [ ]

No [ ]

If so, what program(s)?

Cardiovascular Health

Cardiovascular Health

Do you have any of the following:

Pain or discomfort in the chest, neck, jaw, arms, or other areas that may be related to poor circulation?

Yes [ ]

No [ ]

Heartbeats or palpitations that feel more frequent or forceful than usual or feeling that their heart is beating very rapidly?

Yes [ ]

No [ ]

Unusual dizziness or fainting?

Yes [ ]

No [ ]

Shortness of breath while lying flat or a sudden difficulty in breathing that wakes you up while sleeping?

Yes [ ]

No [ ]

Shortness of breath at rest or with mild exertion (such as walking two blocks)?

Yes [ ]

No [ ]

Feeling lamed or pain in the legs brought on by walking?

Yes [ ]

No [ ]
Indicate your preference in what hand you use for each of the following activities:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Only ever with the Left</th>
<th>Sometimes with the Left</th>
<th>No Preference</th>
<th>Sometimes with the Right</th>
<th>Only ever with the Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throwing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using scissors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holding a toothbrush</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using a knife without a fork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Using a spoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Using a broom (the hand on the top of the broom)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Striking a match (the hand holding the match)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening a box (the hand that opens the lid)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kicking a ball</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Looking through a microscope/telescope with one eye</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Powered by Qualtrics
Appendix C: Physical Activity Readiness – Questionnaire

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

Common sense is your best guide in answering these few questions. Please read them carefully and check the □ Yes or □ No opposite the question if it applies to your child.

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>☐</td>
</tr>
<tr>
<td>□</td>
<td>☐</td>
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<td>□</td>
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<td>□</td>
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<tr>
<td>□</td>
<td>☐</td>
</tr>
</tbody>
</table>

P&R-Q (Thomas, Reading, & Shepherd, 1982)
Appendix D: Quality of Life Inventory

Default Question Block

Participant ID

PD

Date of Participation

11/9/2020

Quality of Life Inventory

This survey is designed to learn about how satisfied you are with various aspects of your life, such as your work and your health. There are 16 different aspects examined in the survey with 2 questions each. You will be asked to identify HOW IMPORTANT the aspect is to you, and HOW SATISFIED you are with each aspect in your current life. There are specific definitions and directions for each aspect so please take you time and answer as honestly as you can. Just a reminder, all answers are confidential.

1. **Health** is being physically fit, not sick, and without pain or disability.

How **important** is health to your happiness?

Not Important  Important  Extremely Important

How **satisfied** are you with your health?

Very Dissatisfied  Somewhat Dissatisfied  A Little Dissatisfied  A Little Satisfied  Somewhat Satisfied  Very Satisfied

2. **Self-Esteem** means liking and respecting yourself, in light of your strengths and weaknesses, successes and failures, and ability to handle problems.

How **important** is self-esteem to your happiness?

Not Important  Important  Extremely Important
How **satisfied** are you with your self-esteem?

<table>
<thead>
<tr>
<th>Very Dissatisfied</th>
<th>Somewhat Dissatisfied</th>
<th>A Little Dissatisfied</th>
<th>A Little Satisfied</th>
<th>Somewhat Satisfied</th>
<th>Very Satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

3. **Goals-and-Values** are your beliefs about what matters most in life and how you should live, both now and in the future. This includes your goals in life, what you think is right and wrong, and the purpose or meaning of life as you see it.

How **important** are goals-and-values to your happiness?

<table>
<thead>
<tr>
<th>Not Important</th>
<th>Important</th>
<th>Extremely Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

How **satisfied** are you with your goals-and-values?

<table>
<thead>
<tr>
<th>Very Dissatisfied</th>
<th>Somewhat Dissatisfied</th>
<th>A Little Dissatisfied</th>
<th>A Little Satisfied</th>
<th>Somewhat Satisfied</th>
<th>Very Satisfied</th>
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</thead>
<tbody>
<tr>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

4. **Money** is made up of three things. It is the money you can earn, the things you own (like a car or furniture), and believing that you will have the money and things that you need in the future.

How **important** is money to your happiness?

<table>
<thead>
<tr>
<th>Not Important</th>
<th>Important</th>
<th>Extremely Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

How **satisfied** are you with the money you have?

<table>
<thead>
<tr>
<th>Very Dissatisfied</th>
<th>Somewhat Dissatisfied</th>
<th>A Little Dissatisfied</th>
<th>A Little Satisfied</th>
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5. **Work** means your career or how you spend most of your time. You may work at a job, at home taking care of your family, or at school as a student. Work includes your duties on
the job, the money you earn (if any), and the people you work with. (If you are unemployed, retired, or can’t work, you can still answer these questions).

How important is work to your happiness?

How satisfied are you with your work? (If you are not working, say how satisfied you are about not working)

6. Play is what you do in your free time to relax, have fun, or improve yourself. This could include watching movies, visiting friends, or pursuing a hobby like sports or gardening.

How important is play to your happiness?

How satisfied are you with the play in your life?

7. Learning means gaining new skills or information about things that interest you. Learning can come from reading books or taking classes on subjects like history, car repair, or using a computer.

How important is learning to your happiness?

How satisfied are you with your learning?
8. **Creativity** is using your imagination to come up with new and clever ways to solve everyday problems or to pursue a hobby like painting, photography, or needlework. This can include decorating your home, playing the guitar, or finding a new way to solve a problem at work.

How **important** is creativity to your happiness?

Not Important  Important  Extremely Important

How **satisfied** are you with your creativity?

Very Dissatisfied  Somewhat Dissatisfied  A Little Dissatisfied  A Little Satisfied  Somewhat Satisfied  Very Satisfied

9. **Helping** means helping others in need or helping to make your community a better place to live. Helping can be done on your own or in a group like a church, a neighborhood association, or a political party. Helping can include doing volunteer work at school or giving money to a good cause. Helping means helping people who are not your friends or relatives.

How **important** is helping to your happiness?

Not Important  Important  Extremely Important

How **satisfied** are you with the helping you do?

Very Dissatisfied  Somewhat Dissatisfied  A Little Dissatisfied  A Little Satisfied  Somewhat Satisfied  Very Satisfied

10. **Love** is a very close romantic relationship with another person. Love usually includes sexual feelings and feeling loved, cared for, and understood.  (If you do not have a Love
relationship, you can still answer these questions).

How **important** is love to your happiness?

Not Important  Important  Extremely Important

How **satisfied** are you with the love in your life? (If you are not in a love relationship, say how satisfied you feel about not having a love relationship).

Very Dissatisfied  Somewhat Dissatisfied  A Little Dissatisfied  A Little Satisfied  Somewhat Satisfied  Very Satisfied

**11. Friends** are people (not relatives) you know well and care about who have interests and opinions like yours. Friends have fun together, talk about personal problems, and help each other out. (If you do not have friends, you can still answer these questions).

How **important** are friends to your happiness?

Not Important  Important  Extremely Important

How **satisfied** are you with your friends? (If you have no friends, say how satisfied you are about having no friends)

Very Dissatisfied  Somewhat Dissatisfied  A Little Dissatisfied  A Little Satisfied  Somewhat Satisfied  Very Satisfied

**12. Children** means how you get along with your child (or children). Think of how you get along as you care for, visit, or play with your child. (If you do not have children, you can still answer these questions).

How **important** are children to your happiness? (If you have no children, say how important having a child is to your happiness).

Not Important  Important  Extremely Important
How **satisfied** are you with your relationships with your children? (If you have no children, say how satisfied you feel about not having children).

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**13. Relatives** means how you get along with your parents, grandparents, brothers, sisters, aunts, uncles, and in-laws. Think about how you get along when you are doing things together like visiting, talking on the telephone, or helping each other out. (If you have no living relatives, please mark "Not Important" and do not answer the satisfaction question).

How **important** are relatives to your happiness?

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How **satisfied** are you with your relationships with your relatives?

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**14. Home** is where you live. It is your house or apartment and the yard around it. Think about how nice it looks, how big it is, and your rent or house payment.

How **important** is your home to your happiness?

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How **satisfied** are you with your home?

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15. **Neighborhood** is the area around your home. Think about how nice it looks, the amount of crime in the area, and how well you like the people.

How **important** is your neighborhood to your happiness?

Not Important  Important  Extremely Important

How **satisfied** are you with your neighborhood?

Very Dissatisfied  Somewhat Dissatisfied  A Little Dissatisfied  A Little Satisfied  Somewhat Satisfied  Very Satisfied

16. **Community** is the whole city, town, or rural area where you live (it is not just your neighborhood). Community includes how nice the area looks, the amount of crime, and how well you like the people. It also includes places to go for fun like parks, concerts, sporting events, and restaurants. You may also consider the cost of things you need to buy, the availability of jobs, the government, schools, taxes, and pollution.

How **important** is your community to your happiness?

Not Important  Important  Extremely Important

How **satisfied** are you with your community?

Very Dissatisfied  Somewhat Dissatisfied  A Little Dissatisfied  A Little Satisfied  Somewhat Satisfied  Very Satisfied

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