FUNCTIONAL CAPABILITIES, HEALTH, AND QUALITY OF LIFE IN INDIVIDUALS WITH PARKINSON'S DISEASE

By

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(Under the Direction of Michael Horvat)

ABSTRACT

Introduction. Parkinson's disease (PD) is a progressive neurodegenerative disorder of the basal ganglia which affects the motor control of planned and unplanned movements. The impact of this neurodegeneration on function, health, and quality of life is not fully understood. The purposes of this study were to compare individuals with and without early – moderate PD on: 1) cognitive functioning, mood, and quality of life; 2) spatial and temporal aspects of gait while performing several dual-tasking activities; and 3) center of gravity control. **Methods.** Twenty individuals (mean age = 70.42 ± 7.07) with stage 2 PD were compared to 20 matched non-diseased peers (mean age = 69.53 ± 9.30). **Results.** Multivariate analysis indicated significant group differences for cognition ($\Lambda = 0.70$, $F_{4, 35} = 3.79$, $p < 0.05$, $\eta^2_{partial} = 0.62$), mood ($\Lambda = 0.39$, $F_{7, 32} = 7.53$, $p < 0.01$), and quality of life ($\Lambda = 0.41$, $F_{10, 29} = 4.12$, $p < 0.01$), while walking and carrying a tray with cups ($\Lambda = 0.63$, $F_{7, 32} = 2.67$, $p < 0.05$, $\eta^2_{partial} = 0.37$), walking and talking on a cell phone ($\Lambda = 0.65$, $F_{7, 32} = 2.47$, $p < 0.05$, $\eta^2_{partial} = 0.35$), and walking and buttoning a shirt ($\Lambda = 0.62$, $F_{7, 32} = 2.77$, $p < 0.05$, $\eta^2_{partial} = 0.38$), but do not significantly differ from controls on limits of stability (LOS) ($\Lambda = 0.622$, $F_{5, 18} = 2.19$, $p > 0.05$).

Independent ANOVAs with Bonferroni adjustments on LOS components indicated movement velocity ($F_{1, 22} = 10.95$, $p < 0.01$) was significantly different between groups. **Conclusions.** The combined results from these studies indicate that individuals with early – moderate Parkinson's disease have reduced functional status and quality of life but they are still able to perform many tasks successfully. Future research should develop specific intervention strategies that challenge the physical and cognitive capabilities of this population at this stage of the disease which may result in improved mood and quality of life and therefore result in prolonged life.

INDEX WORDS: Parkinson's disease, Cognition, Mood, Quality of life, Gait, Dual-tasking, Balance

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DEDICATION

For my wife, Dr. Cynthia Ware Zagrodnik, and all of her love, patience, and support.

For my parents, who push me through all of my faults to become something better.

For my sisters and brother-in-laws for their continuous encouragement and eager support.

For my grandparents who encouraged educational growth.

Finally, for myself. CONGRATS!!!

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CHAPTER 1

INTRODUCTION

Parkinson's disease is a progressive neurodegenerative disorder of the basal ganglia which affects the motor control of planned and unplanned movements (Rosenbaum, 2006). Parkinson's disease gets its name from the more modern 'discoverer' of the disease, James Parkinson who observed and reported the condition of six men with shaking and impaired movements and termed the condition as *paralysis agitans*, which is Latin for "weakness shaking". Recently, Parkinson's disease has a prevalence of 1.4 – 1.6% (de Rijk, et al., 1995; de Rijk, et al., 1997), has an incidence rate of 16 – 14 / 100,000 / year (Twelves, Perkins, Counsell, 2003), and is associated with reduced functional ability and early death (Berger, et al., 2000; Fall, Saleh, Fredrickson, Olsson, & Granérus, 2003; Morgante, et al., 2000).

The motor output of planned and unplanned movements in Parkinson's disease is impacted by the disruption of the direct and indirect motor pathways within the basal ganglia motor circuit caused by the reduction of the neurotransmitter dopamine in the brain (Sohn and Hallett, 2003; Swinn, 2005). The basal ganglia are a group nuclei located in the deep portion of the brain and consist of afferent structures, such as the striatum (caudate and putanem) and the subthalamus, and efferent structures, such as the globus pallidus and substantia nigra (pars reticulate and pars compacta). Nearly all input from the cerebral cortex (excluding information from the primary visual and auditory areas) is received by the striatum and controls movement via neurological impulses from the efferent structures of the basal ganglia. The globus pallidus descends neurons to the thalamus which in turn projects neurons to the motor, premotor, and supplementary motor cotices. The substantia nigra pars compacta is not an efferent structure but

an intrinsic nucleus which receives and sends info from and to other parts of the basal ganglia and is densely populated with dopamenergic cells and projects dopaminergic neurons to the striatum. Hence, when a movement is received from the executive areas of the brain, the substantia nigra pars compacta releases dopamine to the striatum which results in a reduction of globus pallidus activation, via increased inhibition of the direct pathway and reduced excitation of the indirect pathway, for appropriate activation of the thalamus and finally excitation of the motor cortex for the movement to be selected and executed. With Parkinson's disease, reduction in the number and function of dopamine cells in the substantia nigra pars compacta results in reduced dopaminergic neuron activity to the striatum. This reduces the inhibition of the direct pathway and increases the excitation of the indirect pathway resulting in an increase in inhibitory activity of the globus pallidus. Inhibition of the globus pallidus consequently results in inhibition of the thalamus which produces a reduced excitatory signal being sent to the motor cortex resulting in inhibition or exaggerated movement. From a functional standpoint this is evident among individuals with Parkinson's disease who have difficulty starting or stopping during the gait cycle or controlling their arms while performing such tasks as putting on a shirt.

The reduction in the number and function of dopaminergic cells within the substantia nigra have both physical and pathological consequences. Although there are many variations of functioning in Parkinson's disease the primary physical characteristics of Parkinson's disease include: akinesia (failure of a willed movement to occur), bradykinesia (slowness of movements), postural instability (loss of ability to maintain an upright stance), rigidity (increased muscle tone), and tremors or uncontrolled shaking (Lang and Lozano, 1998; Marsden, 1990; Rosenbaum, 2006; Sohn and Hallett, 2005). In addition to these physical manifestations, there are several pathological aspects of Parkinson's disease including the presence of Lewy bodies

(intracytoplasmic, eosinophilic inclusions), variable neuron loss in the midbrain particularly in the substantia nigra pars compacta and the locus ceruleus, depletion of melanized neurons by up to 45-66%, and up to 60 – 85 % depletion of the total number of dopamenergic neurons which project to the striatum (Jellinger, 2005). The presence of these physical characteristics and especially the loss of functional ability often lead to the initial diagnosis of Parkinson's disease.

A basic characteristic of Parkinson's disease (PD) is an inability to initiate and control gait. This is apparent in restricted stride lengths as well as reduced walking velocity and the inability to stop and start a movement (Morris, Iansek, Matyas, & Summers, 1994; Morris, Iansek, Matyas, & Summers, 1994; Sofuwa, Niewboer, Desloovere, Willems, Chavret, & Jonkers, 2005; Frankel-Toledo, Giladi, Peretz, Herman, Gruendlinger, & Hausdorff, 2005). From a biomechanical perspective, Rogers (1996) highlighted additional variations including, discrepancies in hip and knee extension, rotation of the hips and torso, and reduced ground reaction forces. Increased cadence and increased time of double-support phase are also listed but additional findings on cadence (Morris, et al., 1994) and double support (Sofuwa, et al.2005) have reported conflicting results.

In addition to the deficiencies that are evident while performing a preferred gait is the difficulty in allocating resources to perform a simultaneous task. Investigations about how the addition of another task will impact gait among individuals with PD are limited and vary in methodologies. In addition, the dual tasks vary in the amount of cognitive or motor engagement that was required to perform the task. Despite these differences, a majority of the dual-tasking studies demonstrate individuals with PD have decreased stride length and reduced velocity while spending more time in double support (Morris et al., 1996; Bond & Morris, 2000; Bloem,

Valkenburg, Slabbekoorn, & van Djik, 2001; O'Shea, Morris, & Iansek, 2002; and Rochester, Hetherington, Jones, Niewboer, Willems, Kwakkel, & Van Wegen; 2004).

Investigating the impact of dual-tasking on gait is important because the overall function and performance of activities of daily living (ADL's) and instrumental activities of daily living (IADL's) frequently involve the capability to ambulate while simultaneously performing another task. A loss of independent mobility has been identified as a primary determinant of disability in Parkinson's disease (Schenkman, Cutson, Zhu, & Whetten-Goldstein, 2002) and the transition of PD from a limitation to a disability has shown to occur between Hoehn-Yahr stages 2 and 3 (Shulman, Gruber-Baldini, Anderson, Vaughan, Reich, Fishman, & Weiner, 2008). Further, the existing literature is devoid of research that studies the spatial and temporal components of gait as well as dual-tasking conditions that require cognitive and motor engagement.

Falling in Parkinson's disease (PD) is another common and frequent occurrence. Recent studies have identified falling rates from 46 – 68% for at least 1 fall and 25 – 50% for multiple (2 or more) falls among this population (Bloem et al., 2001; Wood et al., 2002; Balash, et al., 2005; and Dibble; et al., 2006). This contrasts to 15% single falls and 4% for multiple falls among reported non-diseased control groups (Bloem et al, 2001). Pickering et al. (2007) found a 46% 3 – month fall rate, 57% 1 year fall rate, and a 40% 1 year multiple fall rate during their meta-analytical review of 6 additional reports on PD falling. In addition, individuals with PD fear the potential for future falls more than their non-diseased peers (Adkin, et al., 2003; Bloem, et al., 2001) and have expressed a reduction in daily activities because of their higher rates of falling and fear of future falls (Bloem, et al, 2001).

Horak (2006) discussed 6 areas of resource allocation necessary for postural stability: 1) biomechanical constraints such as degrees of freedom, strength, and limits of stability; 2)

movement strategies to return to and maintain equilibrium; 3) sensory information utilization; 4) spatial orientation; 5) control of one's center of mass during dynamic movements; and 6) cognitive processing. Also, it has been previously highlighted that there is a need for proper postural instability analysis among PD populations to identify why such a high fall incidence occurs (Grimbergen et al. 2004). Despite these recommendations there are few studies which examine dynamic balance among individuals with PD. However, these few studies indicate that individuals with PD demonstrate reduced control of their center of gravity (Ashburn, et al., 2001; Nallegowda et al., 2004; Yang et al., 2007; & Mancini et al, 2008).

In addition to physical limitations and manifestations, cognitive deficits are associated with PD. Cummings (1988) reported the prevalence of overt dementia at 39.9% among individuals with PD with a range of 30.2% - 69.9% while Riedel, et al. (2008) indicated that cognitive impairment was existent in 17.5% - 43.6% of the PD population depending on the instrument being used. Cross sectional studies have also shown that individuals with PD differ than their non-diseased peers (Muslimović, et al., 2005; Verbaan, et al., 2007) and it has been established that cognitive impairment increases as disease severity increases (Cummings et al., 1988; Muslimović, et al., 2005; Verbaan, et al., 2007; Riedel, et al., 2008).

It appears that cognitive impairments are not linked nor has a relationship to the motor deficits of Parkinson's disease (Cooper, et al., 1991) while more recent research has indicated that cognitive declines among PD are due to impaired frontostriatal circuitry (Owen, et al., 1992; Lewis, et al., 2003; Zgaljardic, et al., 2003; Owen, 2004). Although deficits in motor and cognitive function are evident, it is apparent that PD impacts the motor pathways and the cognitive pathways simultaneously and independent of each other. Likewise, the debilitating

decline of cognitive function is evident but the impact on overall function and independence is not clear.

While much is understood about PD, there are still gaps in the knowledge base. There are limited studies which examine walking while performing another task, such as carrying a tray with cups on it or walking and talking on a cell phone. These commonly performed simultaneous tasks may indicate changes individuals with PD experience in order to maintain independence and life skills. Similarly, few studies address one of the foundations for walking: dynamic balance. Successful control of one's center of gravity while the body moves underlies the capability and willingness to ambulate. It is relatively unknown how individuals with PD control their center of gravity and how this control may impact their gait. Finally, while it is evident that cognitive declines exist among individuals with PD, it is unknown how these declines impact the individuals quality of life. Therefore the purposes of these investigations are to: 1) compare spatial and temporal aspects of gait between individuals with and without PD while performing several dual-tasking activities; 2) to compare the control of individuals with PD's center of gravity to healthy peers; and 3) compare the cognitive functioning of individuals with and without PD and identify the relationships between cognition and quality of life.

Specific Aims

The specific aims of this study are to:

1) identify and compare the cognitive capabilities between individuals with and without Parkinson's disease.

2) identify and compare gait performance during dual tasking activities between individuals with and without Parkinson's disease.

3) identify and compare the dynamic balance between individuals with and without Parkinson's disease.

Hypotheses

The research hypotheses for this study are:

1. Individuals with Parkinson's disease will demonstrate lower cognitive function compared to non-diseased peers.

2. Individuals with Parkinson's disease will demonstrate a greater influence of a second task on their gait pattern than their non-diseased peers.

3. Individuals with Parkinson's disease will demonstrate poorer dynamic balance than their non-diseased peers.

Significance

Parkinson's disease is a progressive neurological disease which has been widely studied. It is generally understood that these individuals have difficulty walking, balancing, and performing cognitive tasks especially as disease progression occurs. It is less known, however, how and when these aspects of functioning begin to deteriorate. Early-moderate stage PD, when individuals are still able to self-ambulate and perform life skills independently, may be the best opportunity for intervention strategies to delay disease progression and maintain independence. The purpose of this dissertation is to identify how individuals with PD differ from their non-diseased peers in terms of gait, balance, and cognitive capabilities so that effective interventions can be developed.

CHAPTER 2

REVIEW OF THE LITERATURE

An Introduction to Parkinson's Disease

James Parkinson and An Essay on the Shaking Palsy

James Parkinson was a model of the Age of Enlightenment with a Renaissance flair. He was involved in many scientific pursuits ranging from chemistry, paleontology, geology, politics, and social reform (Kempster, Hurwitz, & Lees, 2007). His wide ranging curiosity led Parkinson's to observe, follow, and record the plights of individuals (some of whom he met in the street, others in a physicians office) with a peculiar inability to control one's bodily movements. From this method, Parkinson recorded his findings and "conjuncture in the place of experiment" which became a seminal work for nearly 200 years.

"An Essay on the Shaking Palsy" (1817) is a descriptive account and discussion of 6 individuals with, what he termed, Paralysis Agitans (Shaking Palsy) in the nosologic style. Parkinson defined Paralysis Agitans as "involuntary tremulous motion, with lessened muscular power, in parts not in action and even when supported; with a propensity to bend the trunk forwards, and to pass from walking to a running pace: the senses and intellects being uninjured." In his seminal work, Parkinson describes several stages of disease progression, details the difference between tremors associated with Paralysis Agitans and other diseases or normal age related changes (in Paralysis Agitans the tremors occur even when the body is at rest and are uncontrollable), describes gait and posture, and offers a proximate cause (a diseased state of the medulla spinalis).

According to Parkinson (1817), Paralysis Agitans progresses through 4 distinct stages. In the first stage, unbeknownst to the individual, "a slight sense of weakness, with proneness to trembling in some particular part; sometime in the head, but most commonly in one of the hands and arms" occurs. Symptoms gradually increase over a period of 12 or more months so that bilateral involvement has occurred; making writing, pointing, and reading difficult and even impossible. In stage 2, a pronounced postural instability with leg tremble appears which diminishes the desire to walk. In stage 3, an exaggerated forward lean occurs, so much so that individuals are forced to walk on their toes, and are prone to running rather than walking. In addition, sleep disturbances occur due to the "tremulous motion of the limbs" and bowel control is reduced. Individuals can no longer feed themselves or speak clearly. Finally, a loss of salivary control is experienced so that fluid continuously drips from the mouth. In the fourth stage of Paralysis Agitans, the tremors have become violent and unceasing even while the individual sleeps, the head has dropped so much that one's chin rests on his sternum, the stricken can no longer speak, has no control over bowel movements, has become delirious and announces for "wished-for release".

Despite James Parkinson's disease classification, it wasn't until the late 1800's that Paralysis Agitans began to be accepted by neurologists, primarily due in large part to Jean Charcot's acknowledgment of Parkinson's observations. It was Charcot after several years of careful patient examinations that renamed paralysis agitans, Parkinson's disease after he noticed that individuals did not demonstrate muscle weakness as paralysis suggests. By the beginning of the 20th century, Charcot and his contemporaries had established the 4 cardinal characteristics of Parkinson's disease: 1) tremor; 2) rigidity (increased muscle tone); 3) bradykinesia (slowness of movements); and 4) postural instability (loss of ability to maintain an upright stance)

(Rosenbaum, 2006). Brain pathology in Parkinson's disease soon followed as Konstantin Tretiakoff established that the substantia nigra was discolored among those who died with Parkinson's disease. This discoloration was soon identified as a result of neuronal cell loss. Then in 1912, Fredrich Lewy discovered the Parkinson diseased brain contained abnormal material in some nerve cells. Tretiakoff would soon label these intracytoplasmic, eosinophilic inclusions "Lewy bodies". Neuronal cell loss in the substantia nigra and the presence of Lewy bodies are still the two pathological hallmarks of Parkinson's disease (Takahashi & Wakabayashi, 2001).

Since 1912, no additional major identifying symptom or pathophysiological consequence has been documented for Parkinson's disease. Although, the greatest medical breakthrough in Parkinson's disease occurred when Arvid Carlsson (1959) identified that the reduction in the neurotransmitter dopamine was the culprit to Parkinson disease symptoms. The reduction in the number and function of dopaminergic cells within the substantia nigra resulted in the physical and pathological consequences which were observed previously. Bradykinesia, postural instability, rigidity, tremors or uncontrolled shaking, and the addition of akinesia (failure of a willed movement to occur), remain the physical hallmarks of the disease (Lang and Lozano, 1998; Marsden, 1990; Rosenbaum, 2006; Sohn and Hallett, 2005). Likewise, the presence of Lewy bodies and the depletion of neurons remain the primary neural markers. What has become more apparent since the early 1900's is where and how much neuron loss occurs. There is a substantial yet variable neuron loss in the midbrain particularly in the substantia nigra pars compacta and the locus ceruleus (not in the medulla spinalis as predicted by Parkinson) and depletion of melanized neurons by up to 45-66%, and up to 60 – 85 % depletion of the total number of dopamenergic neurons which project to the striatum (Jellinger, 2005).

Parkinson's Disease Before Parkinson?

James Parkinson's 1817 seminal work on his observations of 6 individuals with peculiar gait and uncontrollable shaking, which he classified as Paralysis Agitans (Shaking Palsy), led to the distinction of the disease which now bears his name. Since this publication, however, questions have risen as to whether or not Parkinson's disease occurred prior to the 1800's. The reason for such knowledge is to primarily ascertain if Parkinson's disease is more environmentally based in origin (for instance, if the industrial revolution resulted in increases in Parkinson's disease cases) or if Parkinson's disease has more of a genetic predisposition. Finding such an answer may lead to different treatment and/or prevention strategies.

Stern (1989) provides a synopsis of Shaking Palsy-like reports dating earlier than James Parkinson's report. For instance, Johannes Baptist Saga in 1776 reported on his observations of a fifty year old man who demonstrated involuntary running and hypersalivation, and Hieronymus David Gaubius in 1758 described an individual who could not walk but who could run, displayed tremors, and speech disturbances. Stern (1989) and Calne, Dubini, and Stern (1989) contend that Leonardo da Vinci observed individuals with Parkinson's disease as he described individuals with uncontrollable and unwarranted trembling. Stern (1989) continues a look into the past of Parkinson's disease as the mathematician-physician Galen reported on individuals with unstable gait and uncontrollable limbs. Even further back in history, Egyptian scribes recorded a king from the 19th dynasty (c1350 – 1200 BC) with hypersalivation, and in ancient India (c2500 BC) a text on tremor patterns and their differences exists.

While it is not clear if these earlier descriptions of tremors, gait disturbances, and hypersalivation are in fact characteristics of Parkinson's disease, one must contend the possibility. Why then was James Parkinson's work so influential? Calne, Dubini, and Stern

(1989) provide two theories: first, it wasn't until the early late 1700's and early 1800's that life expectancies increased to the point of the possibility of large numbers of individuals presenting symptoms; second, (and probably most importantly to James Parkinson's infamy) a clear distinction between normal advancing age related effects and that of shaking palsy had not been previously identified.

The findings of palsy like symptoms and tremors in ancient texts provide some basis for a genetic basis for PD. Recent genetic research (see de Lau & Breteler, 2006; Olanow & Tatton for reviews), 1999 has shown numerous genetic markers for PD, including the PARK family (a genetic mutation linked to chromosome 4 which has up to 12 different subtypes), and α-synuclein gene mutation (produces an abnormal protein which is thought to be a major component of Lewy body formations) provide strong evidence of genetic factors causing PD. However, it is also known that environmental factors can also cause PD or PD-like symptoms. Possibly the most famous environmental basis for PD comes from the MPTP story (Langston, Ballard, Tetrud, & Irwin, 1983). In 1982 four individuals were hospitalized for PD-like symptoms following illicit drug use. It was found the individuals had effects from an incorrect opioid-like substance. The individuals were attempting to get the effects of morphine through a compound called MPPP (1 – methyl-4-phenyl-proprionoxpiperidine) and inadvertently created MPTP (1 – methyl-4-phenyl-1, 2, 3, 6-tetrahydropyridine. MPTP is converted to MPP+ once past the blood-brain barrier and disrupts the complex I electron transport chain of dopaminergic cells and results in cell death. In addition, there have been reported cases of isolated towns having large PD populations in Iowa and Canada, with the culprit thought to be chemical compounds in the drinking water possibly due to herbicides (Rosenbaum, 2006).

The debate on genetic predisposition or environmental toxicity resulting in PD remains. It is evident however that there are both genetic and environmental factors that could increase the risk for PD, but these do not necessarily result in an individual being diagnosed with PD. It may be a culmination of an increased aging population, environmental interactions, and genetic predispositions that eventually lead to disease acquisition and the interaction of these three factors confound the current capabilities to find a specific cause.

Prevalence and Incidence of Parkinson's Disease

Prevalence studies have indicated Parkinson's disease occurs in 1.4% - 1.7% of the global population (de Rijk, Breteler, Graveland, Ott, Grobbe, van der Meche, & Hofman, 1995; de Rijk, Tzourio, Breteler, Dartigues, Amaducci, Lopez-Pousa, Manubens-Bertran, et al., 1997; Zhang, Roman, Hong, Wu, Qu, Huang, Zhou, et al, 2005). As age increases so too does Parkinson's disease from 0.3% for ages 55 – 64 to 5.1% for those 85 – 89 years old (de Rijk et al., 1995; de Rijk, et al., 1997). Global incidence rates have been reported to be 16 – 19/100,000/year (Twelves, Perkins, & Counsell, 2003) with the United States having an incidence rate of 13.4 / 100,000 / year (Van Den Eeden, Tanner, Bernstein, Fross, Leimpeter, Bloch, & Nelson, 2003). Incidence increase with age: 9.8 / 100,000 / year for 50 – 59 year olds to 119.0 / 100,000 / year for 80 – 89 year olds; and being male: 19.0 / 100,000 / year for males to 9.9 / 100,000 / year for women. Age and gender adjusted 100,000 is greatest for Hispanics (16.6) followed by non-Hispanic Whites (13.6), Asians (11.3), and Blacks (10.2).

The Natural History of Parkinson's Disease

James Parkinson, as previously noted, differentiated PD progression into 4 stages based on the appearance of particular symptoms and the increasing debilitation of these symptoms. In 1967, Margaret Hoehn and Melvin Yahr published their observations on PD progression and

provided a hallmark scale for disease classification and progression. Hoehn and Yahr (1967) followed 672 individuals with PD between 1949 and 1964 and used a subset of 183 individuals not taking levedopa (essentially dopamine with a blood-brain barrier companion that was developed by Arvid Carlsson to replace the depleted dopamine concentration in the brain) to identify the degree and progression of motor disability in this population. In 70.5% of these 183 individuals, their first symptom was tremor. Tremor and rigidity were the most frequent physical findings: only 10% were free of tremor and 10% were free of rigidity. The authors also reported delayed initiation of movement, slowness of movement, gait disturbances, and postural deformities as frequently occurring especially in advanced disease progression. Based on their initial observations, Hoehn and Yahr developed a scale consisting of 5 stages to more accurately classify individuals with PD and track disease progression. The Hoehn-Yahr scale takes into account the level of clinical disability of the individual with an increase in disability resulting in higher stage level classification:

Stage I: Unilateral involvement only, usually with minimal or no functional impairment.

Stage II: Bilateral or midline involvement, without impairment of balance.

Stage III: First sign of impaired righting reflexes. Patients are physically capable of leading independent lives, and their disability is mild to moderate.

Stage IV: Fully developed, severely disabling disease; the patient is still able to walk and stand unassisted but is markedly incapacitated (for example, unable to feed or clothe themselves).

Stage V: Confinement to bed or wheelchair unless aided.

Stages I – III are considered to be minimally disabled while stage IV and V are severely disabled.

Hoehn and Yahr (1967) acknowledge that identifying individuals with Stage I PD is infrequent because of a delayed disease diagnosis. Often, individuals with PD do not seek physician consultation until the disease has progressed to bilateral involvement (Stage II) and has significantly impacted their lives. In their sample, they only identified 17% of their sample as stage I, compared to 28% for stage II, 24% for stage III, and 26% for stage IV. Stage V is often the most difficult to identify possibly due to the severity of the disease and the capability to visit a physician. Indeed, Hoehn and Yahr had only 9 individuals (5%) with stage V PD.

In general, the more severe stages are associated with longer disease duration. Hoehn and Yahr observed that people who are diagnosed with PD and do not receive treatment that: within 5 years of diagnosis 25% are either dead or disabled (stages IV or V); between 5 – 9 years since diagnosis, 60% are either dead or disabled; between 10 – 14 years since diagnosis, 80% are either dead or disabled; and 15 years since diagnosis, nearly 90%. The rate of disease progression is variable from person to person, however. For example, 45% of stage II individuals had been diagnosed with 5 years, 26% between 5 – 9 years, and 17% between 10 – 14 years. Yet there were three individuals who were stage II 20+ years after initial diagnosis. Similar trends are found for stages I, III, and IV. Despite this variability, untreated PD progression is generally rapid in the first 4 – 9 years of diagnosis and then tends to reduce in rate of progression but remain constant (Bonnet, Loria, Saint-Hilaire, Lhermitte, & Agid, 1987; Goetz, Tanner, & Shannon, 1987; Hoehn & Yahr, 1967). Among individuals taking levedopa (which is still the primary antiparkinsonian drug therapy), disease progression is slowed but the mechanisms behind such slowing are unknown (Powe & Wenning, 1996). For example, Hoehn (1983) found only 21% of individuals with PD with a 5 – 9 year diagnosis to be disabled or dead as compared to 61% for untreated PD individuals.

Clinical Features and Diagnosis of Parkinson's Disease

Although there are many variations of functioning in Parkinson's disease, the primary physical characteristics of Parkinson's disease include: akinesia (failure of a willed movement to occur), bradykinesia (slowness of movements), postural instability (loss of ability to maintain an upright stance), rigidity (increased muscle tone), and tremors or uncontrolled shaking (Jankovic, 2008; Lang and Lozano, 1998; Marsden, 1990; Rosenbaum, 2006; Sohn and Hallett, 2005). The diagnosis of PD relies on the presence of one or more of these cardinal features.

As mentioned previously, the Hoehn – Yahr scale is one method of identifying disease progression, but it is not ideal for diagnosis. The United Parkinson's Disease Rating Scale (UPDRS) is the most well established scale for diagnosis (Jankovic, 2008). The UPDRS consists of 6 sections: 1) Mentation, Behavior and Mood; 2) Activities of Daily Living; 3) Motor Examination; 4) Complications of Therapy; 5) Modified Hoehn and Yahr Staging; and 6) the Schwab and England Activities of Daily Living Scale. The Mentation, Behavior and Mood section identifies the occurrence of any intellectual impairments, thought disorders, depression, and level of motivation. Section 2, Activities of Daily Living, assess a wide array of 13 commonly performed activities necessary for general functioning, such as swallowing, cutting food, walking, and bed turning. The Motor Examination examines 14 aspects of bodily control (or lack of control), such as speech, tremors, rigidity, rising from a chair, and gait. Section IV identifies the impact dyskinesias and clinical fluctuations (such as "on" and "off" periods of medication) have on the individual. This section is only assessed after PD has been diagnosed (from the previous sections) and a a treatment program has been implemented. Section 5 of the UPDRS is the Modified Hoehn Yahr Scale in which two additions (1.5 and 2.5) to the original scale indicate more specifically potential disability changes between stages 1 and 2 and stages 2

and 3. The final section is the Schwab and England Activities of Daily Living Scale, which assess as percentage the impairment an individual has on performing activities necessary for independent care and functioning (100% indicates the individual is completely independent, with no slowness in movements, and unaware of any difficulties; 0 indicates the individual is in a vegetative state and cannot swallow, control bladder, and is bedridden.). Despite the easily observable cardinal features of PD and the thoroughness of the UPDRS, incorrect diagnosis of PD occurs in an alarming number of individuals, however. It is estimated that up to 25% of individuals with PD are incorrectly diagnosed (Nutt & Wooten, 2005; Tolosa, Wenning, & Poewe, 2006).

In addition to the cardinal physical manifestations (akinesia, bradykinesia postural instability, rigidity, and tremors), there are several pathological aspects of Parkinson's disease including the presence of Lewy bodies (intracytoplasmic, eosinophilic inclusions), variable neuron loss in the midbrain particularly in the substantia nigra pars compacta and the locus ceruleus, depletion of melanized neurons by up to 45-66%, and up to 60 – 85 % depletion of the total number of dopamenergic neurons which project to the striatum (Jellinger, 2005). Ramsden, Parsonsand Waring (2001) suggest it is not until approximately 50% of the dopaminergic neurons are dead and the reaming surviving ones can only supply the striatum with 20 – 30% of the necessary dopamine demand that the physical (i.e. tremors) features become present. Unfortunately, the pathological characteristics cannot yet be identified among living individuals and can only confirm the diagnosis of Parkinson's disease upon death via an autopsy, however Larsen, Dupont and Tandberg (1994) indicate even the presence of Lewy bodies and sizeable neuron loss may not always confirm a PD diagnosis.

Of growing interest are those aspects of the disease which do not outwardly impact motor control and function: the non-motor symptoms (NMS) of Parkinson's disease. NMS are often categorized into 5 distinct categories: 1) autonomic dysfunctions; 2) cognition; 3) psychiatric; 4) sensory disorders/olfactory dysfunction; and 5) sleep disorders (Adler, 2000; Chaudhuri, Healy, & Schapira. 2006; Ziemssen & Reichmann, 2007; and Powe, 2008). Recent NMS research has provided evidence to suggest certain NMS are strong precursors to PD, such as constipation, olfactory deficit, REM sleep behavior disorder, and depression (Chaudhuri, Healy, & Schapira. 2006) and that they should begin to be used as early identifiers for probable PD candidates (Ziemssen & Reichmann, 2007). Despite organized classifications and the potential use as precursors, how often and when NMS occur are not well understood. Hillen and Sage (1996) documented 17% of their potential sample self-reported NMS during the "off" period. Shulman, Taback, Bean, and Weiner (2001) reported 88% of their sample had at least one NMS, 59% had at least two, 39% demonstrated three or more, 23% had four or more, and 11% had 5 or more NMS, and that increasing PD severity was associated with more NMS. In addition, Witjas, Kaphan, Azulay, et. al. (2002) reported 100% of their sample reported some form of non-motor symptom during the "on", "pre-on", "off", of "pre-off" period in response to a 54 non-motor symptom question interview. The authors acknowledge that most of the NMS were associated with the "off" state, however, and in general, reported NMS increased in reference to the "off" state. For example, anxiety was reported by 66% of the sample during the "on state" and 88% of the sample during the "off" state.

Pathophysiology of Parkinson's Disease

Parkinson's disease impacts the motor output of planned and unplanned movements by the disruption of the direct and indirect motor pathways within the basal ganglia motor circuit

caused by the reduction of the neurotransmitter dopamine in the brain (Sohn and Hallett, 2003; Swinn, 2005). The basal ganglia are a group of afferent and efferent nuclei in the deep portion of the brain. Afferent structures of the basal ganglia include the striatum, which is consisted of the caudate and putamen, and the subthalamus. Nearly all input from the cerebral cortex (excluding information from the primary visual and auditory areas) is received by the striatum which controls the neurological impulses from the efferent structures of the basal ganglia. Efferent structures of the basal ganglia include the globus pallidus and the substantia nigra, which is composed of two parts: 1) pars reticulate; and 2) pars compacta. The globus pallidus descends neurons to the thalamus which in turn projects neurons to the motor, premotor, and supplementary motor cotices. The substantia nigra pars compacta is not an efferent structure but an intrinsic nucleus which receives and sends info from and to other parts of the basal ganglia and is densely populated with dopamenergic cells and projects dopaminergic neurons to the striatum.

Hence, when a movement is received from the executive areas of the brain to be executed, the substantia nigra pars compacta releases dopamine to the striatum which results in a reduction of globus pallidus activation, via increased inhibition of the direct pathway and reduced excitation of the indirect pathway, for appropriate activation of the thalamus and finally excitation of the motor cortex for the movement to be selected and carried out. With Parkinson's disease, reduction in the number and function of dopamine cells in the substantia nigra pars compacta results in reduced dopaminergic neuron activity to the striatum. This in turn, reduces the inhibition of the direct pathway and increases the excitation of the indirect pathway which results in an increase in inhibitory activity of the globus pallidus. Inhibition of the globus

pallidus results in inhibition of the thalamus which sends a reduced excitatory signal to the motor cortex and movement is inhibited or performed incorrectly.

Parkinson's Disease Treatment and Causes of Death

As mentioned previously, the primary treatment option for PD is levedopa, which replenishes the dopamine in the brain and was established in 1959. Hoehn and Yahr (1967) reported that untreated PD had a 65.9 mean age of death and with the introduction of levedopa, mean death has increased nearly 10 years. In addition to levedopa, numerous alternatives have been developed to supplement the reduction in dopamine. (See Singh, Pillay, and Choonara (2006) provide an exceptional review on current treatments in PD.) For instance, the addition of COMT inhibitors and Monoamine-oxidase – B (MAO – B) inhibitors assist the dopamine in efficient transport from one nerve cell to another. Alternative treatment options have included surgery and cell transplantation, both of which have shown mixed results. Exercise as effective treatment has also begun to be investigated, as animal models have shown moderate – intense exercise increases may have neuroplasticity effects, increasing dopamine neuron concentration and strengthening neuron-neuron communications (Hirsh & Farley, 2009; Smith & Zigmond, 2003; Steiner, Winter, Hosman, Siebert, Kempermann, Petrus, & Kupsch, 2006).

Despite the advances in traditional and non-traditional treatment of PD, individuals with the disease still die earlier than their non-diseased peers by nearly 2 years (Beyer, Herlofson, Årslan, & Larsen, 2001; Fall, Saleh, Fredrickson, Olsson, & Granérus, 2003; Morgante, Salemi, Meneghini, Di Rosa, Epifanio, Grigoletto, Ragonese, et al., 2000). Roughly half of these deaths are directly related to complications from PD and twice as many die from pneumonia than non-diseased individuals (Beyer, Herlofson, Årslan, & Larsen, 2001). Interestingly, PD may have a protective effect on cardiovascular related deaths (Beyer, Herlofson, Årslan, & Larsen, 2001).

In summary, PD is a progressive, incurable but treatable, neurodegenerative disease of the dopamine centers of the brain. It appears PD has been around for millennia and there are many genetic links with the disease. However, environmental causes have also been found. Acquiring PD may well be a complex interaction of genetics, one's environment, and ageing which may never be solved. The primary features of PD include akinesia, bradykinesia, postural instability, rigidity, and tremors or uncontrolled shaking due to substantial dopamine neuron loss (and possible the presence of Lewy bodies). The occurrence of one or more of these physical manifestations typically results in PD diagnosis. Advances in pharmaceutical opportunities for individuals with PD have enabled similar (albeit shorter) life expectancy and may even assist in delaying disease progression.

The following sections will introduce topics of interest in relation to Parkinson's disease. These sections include findings and discussions on balance, gait, cognition, mood, and quality of life among the PD population.

Parkinson's Disease and Balance

Postural instabilities are a hallmark of PD and individuals with Parkinson's disease (PD) are predisposed to falls (Klawans et al., 1974; Aita, 1982). Recent studies have identified falling rates from 46 – 68% for at least 1 fall and 25 – 50% for multiple (2 or more) falls among this population (Bloem et al., 2001; Wood et al., 2002; Balash, et al., 2005; and Dibble; et al., 2006). This contrasts to 15% single falls and 4% for multiple falls among reported non-diseased control groups (Bloem et al, 2001). Pickering et al. (2007) found a 46% 3 – month fall rate, 57% 1 year fall rate, and a 40% 1 year multiple fall rate based on a meta-analytical review of 6 additional reports on PD falling. In addition, falls in individuals with PD exacerbate the potential for and fear of future falls more than their non-diseased peers (Adkin, et al., 2003; Bloem, et al., 2001).

Consequently, a reduction in daily activities may occur because of not only their higher rates of falling but also the fear of future falls (Bloem, et al, 2001).

According to the Hoehn – Yahr scale, the evidence of postural control problems indicates the onset of severe disability. Postural instabilities in PD are thought to occur primarily from a general reduction in postural reflexive control (Jankovic, 2007). Bloem (1992) identifies 4 primary factors that are thought to contribute to the postural instability in PD from a reflexive perspective. The first abnormal adaptation to reflexive postural control is the selection of postural strategies. In non-diseased individuals, postural strategies (i.e. ankle strategy for small and slow perturbations vs. hip strategy for large and fast perturbations) are typically selected in a mixed and sequential pattern based on the amount of perturbation, past experiences, and the amount of sensory information to correctly select the appropriate muscles to counteract the disturbance to equilibrium. Individuals with PD, however, will utilize a mixed pattern that simultaneously uses both ankle and hip strategies. This incorrect selection results in co-contraction and joint stiffness among these individuals and slows their capability to make corrective movements and avoid falls. The second abnormal reflexive adaptation is in the amplitude of the reflex. The primary reflexive responses to postural perturbations involve the gastrocnemius and the tibialis anterior muscles which control initial response around the ankle joint to remain upright. When the gastrocnemius is stretched (for example during a forward lean) a short and medium latency in muscle activation occurs (this is known as a postural destabilization), followed by a long latency in contraction of the tibialis anterior (for postural stabilization). Individuals with PD demonstrate increased medium latency muscle activation and decreased tibialis anterior activation than healthy individuals. Therefore, individuals with PD have increased destabilization and reduced stabilization reflexes which results in more

postural sway and increased instability. The third abnormal postural reflexive response in PD is a delayed onset of the activation signal to respond to a perturbation. This means that individuals with PD respond slower (it takes them longer to fire the appropriate corrective muscles) to postural instabilities. Possibly the reduced time for a corrective response results in the exaggerated destabilization response by the gastrocnemius to try and pull an individuals center of gravity back before it passes one's base of support. The fourth abnormal reflexive response to postural instabilities among individuals with PD is the anticipatory postural reflexes. During stance our body continuously makes minor postural adjustments based on our previous experiences and feed forward control system. These minor adjustments are our anticipatory postural reflexes. Among PD, it appears they lack this feed forward mechanism to maintain appropriate stance through continuous and involuntary adjustments. This inability may lead to more falls because of a reduced spatial awareness of the body.

Investigations of non-reflexive properties of postural stability indicate that individuals with PD may have increased trunk sway resulting in greater hip strategy adaptations (Adkin, Bloem, & Allum, 2005). However, a decreased trunk sway resulting in a stiffening response depending on the type and degree of perturbation has also been observed (Carpenter, Allum, Honegger, Adkin, & Bloem, 2004). Carpenter et al. (2004) also indicated individuals with PD have greater lower leg and hip muscle activation resulting in a stiffening response. Individuals with PD tend to activate their deltoids sooner during perturbations, possibly as an anticipatory fall response, but their directional control of their arms is inconsistent and therefore may not be as beneficial in breaking a fall (Carpenter, et al., 2004). Other investigations indicate that individuals with PD are less capable in processing visual, vestibular, and somatosensory information (Nallegowda, Singh, Handa, Khanna, Wadhwa, Yadav, Kumar, et al., 2004).

In summary, individuals with PD are predisposed to falls due to impaired reflexive movements and inappropriate motor utilization and sensory processing. It is still unknown how and when the reflexive adaptations occur among this population. Yet these changes may be the cause of observed differences in higher motor control functioning, such as trunk sway and arm movements. In addition, it is relatively unknown the impact diminished sensory information utilization has on reflexive and higher motor responses. Do changes in the reflexive response to perturbations result in inadequate sensory processing or is the inaccurate sensory utilization causing changes in reflexive postural control? And how do these changes impact higher motor movement selection and control? Answering these questions may provide the basis for successful intervention strategies to assist individuals with PD reduce their falls.

Parkinson's Disease and Gait

A basic characteristic of Parkinson's disease (PD) is an inability to initiate and control gait. This is apparent in restricted stride lengths as well as reduced walking velocity and the inability to stop and start a movement (Morris, Iansek, Matyas, & Summers, 1994; Morris, Iansek, Matyas, & Summers, 1994; Sofuwa, Niewboer, Desloovere, Willems, Chavret, & Jonkers, 2005; Frankel-Toledo, Giladi, Peretz, Herman, Gruendlinger, & Hausdorff, 2005). However, Canning, Ada, Johnson, and McWhirter (2006) identified that reduced stride lengths and velocities may be dependent on walking distance, in that they found those with PD were able to perform similar spatiotemporal characteristics of walking over short distances but not over longer distances. Increased cadence and increased time of double-support phase are also listed but additional findings on cadence (Morris, et al., 1994) and double support (Sofuwa, et al.2005) have reported conflicting results.

From a biomechanical perspective, Rogers (1996) highlighted additional variations including, discrepancies in hip and knee extension, rotation of the hips and torso, and reduced ground reaction forces between individuals with and without PD. Additionally, it has been found that individuals with PD have reduced ankle plantarflexion, ankle push-off power, and hip pull-off power (Sofuwa, Nieuwboer, Desloovere, Willems, Chavret, & Jonkers, 2005) and their gait is characterized by flat footedness (Pedersen, Oberg, Larsson, & Lindval, 1997).

Of recent interest is identifying changes in gait while performing an additional task. Investigations about how the addition of another task may impact gait among individuals with PD are limited and in those that do exist the methodologies are not consistent across studies. In addition, the dual tasks vary in the amount of cognitive or motor engagement required to perform the task. For example, participants in the Morris et al. (1996) study walked 10 m 4 times while performing one cognitive task (reciting a sentence) with visual cues for the first investigation, and subsequently used 4 separate cognitive tasks with attentional strategies of increasing difficulty (reciting sentences increasing in complexity and length and naming the days of the week in reverse order). In both studies, decreased gait performance was observed as evidenced by reduced velocity, cadence, and stride length with more time needed for double support across the 4 trials.

In another study, Camicioli, Oken, Sexton, Kaye, & Nutt (1998) reported that individuals with PD who concomitantly experienced freezing of gait took a greater number of steps to complete a walking task while simultaneously cognitively engaged in a verbal fluency task. Likewise, Bond and Morris (2000) reported significant decreases in gait speed and stride length when individuals with PD carried a tray with glasses as opposed to a preferred walk. In contrast, carrying a tray with no cups did not significantly impact gait but decreased velocity and stride

length. In addition, Bloem, Grimbergen, Cramer, and Valkenburg (2000) found that 100% of their sample (38 individuals with PD) were able to complete the stops walking when talking (SWWT) assessment utilizing open ended questions and responses by participants without stopping their speech indicating that cognitive engagement does not cease or override the walking command from the motor cortex.

In some of the more specific work on dual task methodologies, Bloem, Valkenburg, Slabbekoorn, and van Djik (2001) observed the Multiple Tasks Test (Bloem, Valkenburg, Slabbekoorn, & Willemsen, 2001) which includes answering questions, carrying an empty tray, and carrying a tray with cups, among individuals with PD and two control groups. Individuals with PD performed the test slower, and displayed more motor errors and hesitations, while the control group demonstrated more cognitive errors. O'Shea, Morris, and Iansek (2002) observed the impact of transferring coins from one side of the body to the other while walking, and digit subtraction while walking as compared to a free preferred walk among individuals with PD and a control group. Both groups demonstrated declines in walking speed, stride length, and cadence between both dual-task conditions and the free preferred walk, with individuals with PD having greater declines than individuals without. In addition, time in double support was significantly higher for the PD group during both dual-tasking events, with no change for the non-PD group. Rochester, Hetherington, Jones, Niewboer, Willems, Kwakkel, and Van Wegen (2004) examined the impact of carrying a tray with cups, answering questions, and performing both activities together while walking. They observed that walking speed and step length were significantly different than a control group and that individuals with PD demonstrated decreased performance from preferred walk alone and each of the dual tasking activities. Finally, Hausdorff, Balash, and Giladi (2003) and Yogev, Giladi, Peretz, Springer, Simon, and Hausdorff (2005) observed

that individuals with PD who performed a cognitively challenging task while walking demonstrated increased gait variability. Taken together, these investigations suggest that walking speed and step length decrease as either cognitive or motor based dual-tasks are added to the gait requirements among individuals with Parkinson's disease.

In summary, individuals with Parkinson's disease tend to walk slower with shorter steps either independently or while performing an additional task. The basis for these ambulatory adaptations may reside in biomechanical changes, such as reduced lift off power in the hips and ankles, and/or as a result of postural instabilities. Identifying how PD impacts gait while performing a variety of tasks is still a novel avenue of research, however. Many studies perform limited dual tasking activities and these activities may not adequately challenge the attentional and motor resources necessary for successful performance. In addition, few spatial and temporal are analyzed. It may be that more complex tasks which require more processing and response demands may illicit significant changes in gait across a wide range of spatial and temporal variables. Identifying how complex tasks impact gait among individuals with PD could establish intervention strategies to assist this population in maintaining mobility and independence.

Parkinson's Disease and Cognition

As mentioned previously, there is a growing interest in the non-motor symptoms (NMS) in PD. One area of NMS beginning to emerge is the cognitive changes that occur among individuals with PD. Early assessments of cognitive deficits in PD indicated that the prevalence of overt dementia at 39.9% among individuals with PD with a range of 30.2% - 69.9% (Cummings, 1998). Bubois and Pillon (1992) contended that cognitive deficits could be as high as 93% but more recent research suggests that cognitive impairment among individuals with PD occurs in 17.5% - 43.6% of the population depending on the specific instrument used (Riedel,

Klotsche, Spottke, Deuschl, Förstl, Henn, Heuser, et al., 2008) . In addition, it has been repeatedly shown that cognitive impairment increases as disease severity increases (Cummings 1988; Muslimović, Post, Speelman, & Schmand, 2005; Verbaan, Marinus, Visser, van Rooden, Stiggelbout, Middelkoop, & van Hilten, 2007; Riedel, et al., 2008).

In one of the earliest and most comprehensive cross-sectional evaluations of cognitive performance between individuals with and without PD was conducted by Owen, James, Summers, Marsden, Quinn, Lange, and Robbins (1992). The primary findings from Owen et al. (1992) indicated that individuals with PD performed worse on: 1) short term memory tasks; 2) spatial working memory tasks; 3) motor initiation and motor execution times while performing a series of computer generated tasks; and 4) attentional set-shifting. Individuals with PD also spent more time planning their movements and responses. More recent cross-sectional studies on the cognitive impairment in PD have shown similar results. For example, Muslimović, et al. (2005) showed that individuals with PD performed worse on measures of immediate and long term memory, executive functioning, and psychomotor speed. Supportive evidence for reduced executive functioning and memory capabilities for individuals with PD has been found (Verbaan, et al., 2007) These declines in the cognitive capabilities of individuals with PD may be due to impaired frontostriatal circuitry (Lewis, Dove, Robbins, Barker, and Owen, 2003; Owen, 2004; Owen, James, Leigh, Summers, Marsden, Quinn, Lange, et al., 1992; Sawamoto, Piccini, Hotton, Pavese, Thielemans, & Brooks, 2008; Zgaljardic, et al., 2003).

It appears that cognitive impairments are not linked nor haves a relationship to the motor deficits of Parkinson's disease (Cooper, et al., 1991). In addition, Owen et al. (1992) indicated that non-medicated individuals tended to perform better on test of cognition than medicated and heavily medicated individuals, which suggests that cognitive deficits may be attributable to

levedopa and other medications. However, Cools, Barker, Sahakian, and Robbins (2001) indicated that the type of cognitive assessment and the underlying cortico-striatal circuitry being activated by the task influences the medication effect. (Cools, et al. (2001) showed that medication positively effects cognitive assessments that utilize the prefrontal cortex and posterior parietal cortex, while medication negatively effects cognitive assessments that utilize orbitofrontal cortex – ventral striatl cirduitry.)

It is apparent that individuals with PD experience cognitive impairments, particularly in executive function and memory than their non-diseased peers. How and when these declines begin to occur are still unknown and raises many questions. For example, do declines in cognition occur simultaneously with initial dopamine loss at very early stages of the disease? And if so are these declines due to the disease or normal aging? It is thought that the reduction in frontostriatal circuitry is the main culprit for such declines, and medication use may negatively impact some cognitive functions while enhancing others. It is also well established that cognitive declines increase with disease progression. Yet there are no cognitive intervention studies which attempt to delay or reverse the cognitive decline in this population. What is still unknown is how these changes in cognition impact the individual. Do individuals with PD recognize their cognitive declines? If so, how does this impact their mood and quality of life?

Parkinson's Disease and Mood

The psychiatric domain of NMS typically refers to the pervasiveness of depression and anxiety (Adler, 2000; Chaudhuri, Healy, & Schapira. 2006; Ziemssen & Reichmann, 2007; Powe, 2008). Depression has been reported in 4 – 70% (Lieberman, 2006) of the PD population with most studies suggesting between 30 – 50% of the PD population having depression (Lieberman, 2006; Poewe, 2007). Despite a high rate of depression among PD, a weak

correlation between depression and disease severity exists (Lieberman, 2006). Anxiety has shown similar prevalence rates at 25 – 40% of the PD population (Lieberman, 2006; Walsh and Bennett; 2001). It has also been recognized that mood changes (depression and anxiety) depending on whether the individual is experiencing "on" or "off" aspects of their medication cycles (Menza, Sage, Marshall, Cody, and Duvoisin, 1990; Walsh and Bennett; 2001), time of day (Maricle, Nutt, and Carter, 1995), and may have a dose-response with levodopa (Maricle, Nutt, Valentine, and Carter, 1995).

It is well established that depression and anxiety have a definitive impact on individuals with PD (Lieberman, 2006), although additional psychiatric traits such as vigor and confusion and their impact on overall mood has not been thoroughly investigated. Investigating additional mood states among individuals with PD appears limited, especially in the respect of positive affects. How does mood impact the lives of individuals with PD? Do individuals with a greater positive mood live better and longer? Does negative mood accelerate PD progression and/or early death? How does mood change over the course of disease progression? What physical and cognitive consequences of PD impact mood the most? These are a just a few questions that should be addressed to identify how future intervention strategies could be designed to help illicit mood changes that may impact disease progression, quality of life, and life expectancy.

Parkinson's Disease and Quality of Life

Numerous studies have shown individuals with PD have lower quality of life than their non-diseased peers and that females with PD have lower quality of life than males with PD (Behari, Srivastava, & Pandey, 2005; Koplas, Gans, Wisely, Kuchibhatla, Cutson, Gold, Taylor, et al., 1999; Kupio, Marttila, Helenius, Toivonen, & Rinne, 2000; Reuther, Spottke, Klotsche, Riedel, Peter, Berger, Athen, et al., 2007; Schragg, Jahanshahi, & Quinn, 2000;). These findings

are consistent using non-disease specific quality of life scales, such as the Medical Outcomes Study 36 – Item Short Form (SF – 36), and disease specific quality of life scales such as the Parkinson's Disease Quality of Life Questionnaire (PDQL) and the 39 – Item Parkinson's Disease Questionnaire (PDQ – 39). In addition, these studies indicate that depression is the primary factor for the lower quality of life among PD. Other studies indicate that reduced motor functioning is also significantly linked to the reduced quality of life (Chapuis, Oochchane, Metz, Gerbaud, & Durif, 2005; Gómez-Esteban, Zarranz, Lezcano, Tijero, Luna, Velasco, Rouco, et al., 2007).

It is well established that individuals with PD have lower quality of life, and depression is considered the primary reason. As mentioned before, however, it is not known how aspects of cognition, such as memory and executive function, which are also decreased in this population, impact one's quality of life. In addition, few studies have examined a wide range of mood states in relation to quality of life. Relationships between mood states, cognition, and quality of life need to be made to identify how changes in these areas may impact each other. Do those who have more cognitive functioning have a better quality of life? How about positive mood states? Can changes in mood, cognition, balance, and gait improve quality of life? How does quality of life impact life expectancy among individuals with PD? These are just a few of the questions that have yet to be answered.

Parkinson's Disease: A Synopsis and Direction for Future Research

Parkinson's disease is a progressive neurodegenerative disease of the basal ganglia. The reduction of the dopamine neurons of the substantia nigra results in tremors, akinesia, bradykinesia, postural instability, and rigidity. In addition, balance and gait are severely affected and the result is a higher rate of falls. The reduction in dopamine may also result in cognitive

impairments and mood disorders, such as depression. Primary treatment remains to be levedopa, with additional medications facilitating the transport and uptake of dopamine. These medications reduce the physical manifestations of PD and may help delay disease progression, but they also may account for some cognitive declines and changes in mood. These physical, cognitive, and emotional changes may lead to reductions in quality of life that are frequent among PD.

This review has identified many gaps in the literature. First, it is relatively unknown when changes in postural control of balance occur and how these changes relate to changes in higher levels of motor control in balance and the use of sensory information in maintaining an upright position. Second, it is well known that PD causes gait adaptations, which may or may not be related to changes in postural control. However, it is not well known how PD impacts the spatial and temporal aspects of walking while performing a simultaneous motor or cognitive based task. Third, while it is recognized that individuals with PD have cognitive impairments, high rates of depression, and lower quality of life, it is not well known how reductions in cognitive performance and a variety of mood states relate to quality of life. The purpose of this dissertation is to answer some the questions posed and help complete our understanding and impact of PD.

CHAPTER 3

COGNITION, MOOD, AND QUALITY OF LIFE IN EARLY PARKINSON'S DISEASE

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Abstract

Introduction. Parkinson's disease (PD) is characterized by many physical manifestations, including akinesia, bradykinesia, postural instability, rigidity, and tremors or uncontrolled shaking, however there has been a growing interest in the non-motor symptoms of PD, such as cognitive function and aspects of mood. The purpose of this study was to identify the relationships between cognition and psychiatric mood with quality of life measures. **Methods.** Twenty individuals (mean age = 70.42 ± 7.07) with stage 2 (Hoehn – Yahr scale) PD completed a series of cognitive (SCOPA – COG), mood (POMS), and quality of life questionnaires (SF – 36, PDQL, and PDQ – 39) and were compared to 20 matched non-diseased peers (mean age = 69.53 ± 9.30). **Results.** Multivariate analysis indicated significant group differences for cognition ($\Lambda = 0.70$, $F_{4, 35} = 3.79$, $p < 0.05$, $\eta^2_{partial} = 0.62$), mood ($\Lambda = 0.39$, $F_{7, 32} = 7.53$, $p < 0.01$), and quality of life ($\Lambda = 0.41$, $F_{10, 29} = 4.12$, $p < 0.01$). Pearson product correlations indicated positive correlations for cognitive capabilities and negative correlations for mood states with quality of life measures. The PDQ – 39 had more significant correlations with cognition while the PDQL had more significant correlations with mood. **Discussion.** Individuals with PD have lower cognitive capabilities, different mood states, and diverse reported quality of life compared to their non-diseased peers. Cognitive performance in the PD group is associated with the type, amount, and care they put into their activities while mood was negatively associated with the mental health of both diseased and non-diseased individuals. In PD, mood may have more impact on quality of life than on cognition. It is recommended that future research examine how natural disease progression and cognitive and mood intervention strategies impact the quality of life among individuals with PD.

Key Words: Parkinson's disease, Cognition, Mood, Quality of life

Introduction.

Parkinson's disease (PD) is a progressive neurodegenerative disorder of the basal ganglia which affects the motor control of planned and unplanned movements (Rosenbaum, 2006). Neurological changes resulting from PD include variable neuron loss in the midbrain, particularly in the substantia nigra pars compacta and the locus ceruleus, depletion of melanized neurons by up to 45 – 66%, and up to 60 – 85 % depletion of the total number of dopamenergic neurons which project to the striatum (Jellinger, 2003). These disease related consequences result in akinesia, bradykinesia, postural instability, rigidity, and tremors or uncontrolled shaking (Lang and Lozano, 1998; Marsden, 1990; Rosenbaum, 2006; Sohn and Hallett, 2005). Because of the physical manifestations of PD, a primary focus of treatment has often been on physical function and motor control.

Of growing interest, however, are those aspects of the disease which do not outwardly impact motor control and function: the non-motor symptoms (NMS) of Parkinson's disease. NMS are often classified into 5 distinct categories: 1) autonomic dysfunctions; 2) cognition; 3) psychiatric; 4) sensory disorders/olfactory dysfunction; and 5) sleep disorders (Adler, 2000; Chaudhuri, Healy, & Schapira. 2006; Ziemssen & Reichmann, 2007; and Powe, 2008). Recent research has provided evidence to suggest certain NMS are strong precursors to PD, such as constipation, olfactory deficit, REM sleep behavior disorder, and depression (Chaudhuri, Healy, & Schapira. 2006). In addition, Ziemssen and Reichmann (2007) suggested NMS should be used as early identifiers for probable PD candidates. Of the 5 categories of NMS, two have been extensively studied: cognition and psychiatric.

Cognitive deficits are often associated with PD. Cummings (1988) reported the prevalence of overt dementia at 39.9% among individuals with PD with a range of 30.2% -

69.9% while Riedel and colleagues (2008) indicated that cognitive impairment was evident in 17.5% - 43.6% depending on the specific instrument used. Results from cross sectional studies indicate that individuals with PD differ from their non-diseased peers (Muslimović, et al., 2005; Verbaan, et al., 2007) and it has been repeatedly shown that cognitive impairment increases as disease severity increases (Cummings, 1988; Muslimović, et al., 2005; Verbaan, et al., 2007; Riedel, et al., 2008).

It appears that cognitive impairments are not linked nor haves a relationship to the motor deficits of Parkinson's disease (Cooper, et al., 1991) while more recent research has indicated that cognitive declines among PD are due to impaired frontostriatal circuitry (Owen, et al., 1992; Lewis, et al., 2003; Zgaljardic, et al., 2003; Owen, 2004). Although compromised motor and cognitive function may coexist in PD, they are not necessarily linked. Likewise, the impact of cognitive deficits on physical function and independence remains unclear.

The psychiatric domain of NMS typically refers to the pervasiveness of depression and anxiety (Adler, 2000; Chaudhuri, Healy, & Schapira. 2006; Ziemssen & Reichmann, 2007; and Powe, 2008). Depression has been reported in 4 – 70% (Lieberman, 2006) of the PD population with most studies suggesting between 30 – 50% of the PD population having depression (Lieberman, 2006; Poewe, 2007). Despite a high rate of depression among PD, a weak correlation between depression and disease severity exists (Lieberman, 2006). Anxiety has shown similar prevalence rates at 25 – 40% of the PD population (Lieberman, 2006; Walsh and Bennett; 2001). It has also been recognized that mood changes (depression and anxiety) depending on whether the individual is experiencing "on" or "off" aspects of their medication cycles (Menza, Sage, Marshall, Cody, and Duvoisin, 1990; Walsh and Bennett; 2001), time of day (Maricle, Nutt, and Carter, 1995), and may have a dose-response with levodopa (Maricle,

Nutt, Valentine, and Carter, 1995). Depression and anxiety have a definitive impact on individuals with PD (Lieberman, 2006), although additional psychiatric traits such as vigor and confusion and their impact on overall mood has not been thoroughly investigated.

Although the physical manifestation and loss of mobility are prominent, Hely, Morris, Reid, and Trafficante (2005) concluded that NMS were the most disabling long-term problems associated with PD. It has also been reported that NMS, especially cognition and psychiatric (depression), contribute significantly to disability among individuals with PD (Weintraub, Moberg, Duda, Katz, et al., 2004). The complications associated with NMS provide evidence that individuals with PD have a lower quality of life (Behari, Srivastava, & Pandey, 2005; Kupio, Marttila, Helenius, Toivonen, & Rinne, 2000; Schragg, Jahanashahi, & Quinn, 2000), that is largely attributed to depression and degree of disability (Koplas, Gans, Wisely et al., 1999; Schrag, Jahanshahi, Quinn, 2000). The importance of NMS are not fully understood, but are indicated to have a large impact on quality of life. This study was undertaken with the purpose to identify the relationships between two well established NMS, cognition and psychiatric, and quality of life between individuals with and without PD.

Methods.

Participants. Individuals diagnosed with early stage idiopathic PD (Hoehn-Yahr stage of 1 or 2) by their neurologist were referred for the study. Eligibility criteria for inclusion were: 1) being diagnosed by a neurologist with PD in the last 5 years; 2) participant report of first PD-like symptom no more than 7 years ago; and 3) age between 55 – 85 years. Individuals with fluctuating responses to medication and/or who unable to independently ambulate for 30 feet were excluded from the study. Participants with PD were matched with non-PD peers based on age, highest educational attainment, employment status, gender, marital status, and physical

activity level as measured by the CHAMPS Activities Questionnaire for Older Adults (Stewart, Mills, King, Haskell, Gills, & Ritter, 2000). The control participants were recruited from the local community. In addition to the CHAMPS, health and demographic questionnaires, each participant completed cognitive, psychiatric (mood), and quality of life assessments. All participants signed an informed consent that was approved by the University Institutional Review Board.

This study was performed as part of a larger cross-sectional study examining the physical, mental, and emotional health of individuals with early PD. Participants completed a battery of assessments across three days of testing for each individual with 24 – 72 hours between each testing day. As part of the larger study, participants completed a cognition examination and questionnaires on mood and quality of life. The cognitive assessment (SCOPA – COG), psychiatric questionnaire (POMS), and first quality of life questionnaire (SF – 36) were completed on the first day of testing while individuals with Parkinson's disease completed two additional quality of life questionnaires (PDQ- 39 and PDQL) on the second day of testing. Each PD participant performed the assessment or questionnaire 1.5 – 2.0 hours post ingestion of their normal medication regimen to maximize the "on" phase capabilities to process information. Explanations of the instruments utilized for the present investigation are presented in the next section.

Testing Instruments and Assessments.

Cognitive Function Assessment. The SCales for Outcomes of PArkinson's disease – cognition (SCOPA – COG) was used to identify the cognitive function of each participant. The SCOPA – COG was developed by Marinus, et al. (2003) to assess the cognitive deficits associated with Parkinson's disease and consists of ten items with a maximum score of 43 with

higher score reflecting better cognitive performance. The SCOPA – COG is a 10- item assessment with four sub-scales: 1) Memory; 2) Attention; 3) Executive Functions; and 4) Visuo-spatial Functions. A total score as well as each sub-scale can be calculated. The ten items included 1) verbal recall of ten words; 2) repeating a series of numbers backwards; 3) repeating a pointing task; 4) counting backwards by 3's from 30; 5) naming the months of the year in a backwards order starting with December and ending with January; 6) fist-edge-palm movements (The participant makes a fist with palm facing up, then stretches his / her hand, turns over hand and places palm on table. This series is repeated ten times.); 7) naming as many animals as possible in one minute; 8) looking at dice and identifying whether the dice are even-odd or higher-lower; 9) assembling patterns with shapes; and 10) delayed recall in which the participant is asked to recall as many of the ten words from item 1 as he/she can. The Memory sub-scale includes items 1, 2, 3, and 10; the Attention sub-scale is composed of items 4 and 5; the Executive Functions sub-scale includes items 6, 7, and 8; and the Visuo-spatial Functions is identified by item 9. The SCOPA – COG has been shown to be a valid (known groups see Marinus, et al., 2003) and reliable (test-retest and internal consistency see Marinus, et al. 2003) method of testing cognitive performance and has also been shown to be more sensitive than other cognitive measures (the Cambridge Cognitive Examination or the Mini Mental State Examination, for example) among Parkinson's disease populations (Marinus, et al., 2003).

Psychiatric Assessment. The NMS domain of psychiatric typically refers to the presence of depression and/or anxiety; essentially identifying mood. Therefore, for the purposes of this study, a wide range of mood states was assessed via the Profile of Mood States (POMS) McNair and Heuchert (2005) an updated version of the original POMS (McNair D. M., Lorr, M., & Droppleman, L.F., 1971). The POMS measures six identifiable mood or affective states:

Tension-Anxiety; Depression-Dejection; Anger-Hostility; Vigor-Activity; Fatigue-Inertia; Confusion-Bewilderment across 65 items on a 5 point likert scale (0 = not at all to 4 = extremely). The six mood states sub-scales are obtained by summing the responses used to define each state. In addition a Total Mood Disturbance score is obtained by summing the Tension-Anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, and Confusion-Bewilderment factors and subtracting the Vigor-Activity composite. Each participant completed the POMS by answering each item in relation to the past week. Assistance to participants who did not understand a word/phase were provided additional substitutes under the recommendations of Albrecht and Ewing (1989). The test-retest reliability and internal consistency (O'Connor, 2004; McNair D. M., Lorr, M., & Droppleman, L.F., 1971) as well as the factorial and content validity (McNair D. M., Lorr, M., & Droppleman, L.F., 1971) of the POMS has been well established. In addition, the POMS has been utilized in previous Parkinson's disease investigations (see Menza et al., 1990; Lou et al., 2001; Weintraub, et al., 2005; & Berney, et al., 2007 for examples). All individuals completed the assessment between 1030 and 1130 hours.

Quality of Life Assessments. Each participant completed three quality of life assessments: the SF-36 version 2, the PDQ – 39, and the PDQL.

SF – 36. The 36 – Item Short – Form Health Survey (SF – 36) version 2 is a five choice self-administered questionnaire which identifies eight health scales among two dimensions. The Physical Functioning, Role-Physical, Bodily Pain, and General Health scales identify the physical dimension of the SF – 36. The mental dimension is composed of the Mental Health, Role – Emotional, Social Functioning, and Vitality scales. The internal consistency, alternate forms, and test-retest reliability and construct (including factor analyses, convergent and

discriminant validity, and known groups), criterion (concurrent and predictive), and content validity of the SF – 36 has been widely examined (Ware, Snow, Kosinski, et al., 1993). In addition, the SF – 36 has been used in over 1000 studies (Ware, 2000) and is frequently used in studies examining the quality of life in PD (Schragg, Jahanhahi, & Quinn (2000); Kuopio, Marttila, Helenius, Toivonen, & Rinne (2000)).

The SF – 36 has been shown to be limited in adequately measuring the functioning and well-being among those with PD; however (Jenkinson, Peto, Fitapatrick, & Hyman, 1995). Jenkins et al. (1995) reported that while the SF – 36 is able to distinguish general quality of life between individuals with and without PD, it is not able to identify disease specific and potentially important factors of quality of life that impact individuals with PD. Therefore, two additional measures specific to quality of life in PD, the PDQ – 39 and the PDQL, were used in conjunction with the SF – 36.

PDQ – 39. The 39-item Parkinson's disease questionnaire (PDQ-39) developed by Peto, Jenkinson, Fitzpatrick, and Greenhall (1995) is a self-administered measure of quality of life measure that assess QOL in eight dimensions: 1) mobility (10 items); 2) activities of daily living (6 items); 3) emotional well-being (6 items); 4) stigma (4 items); 5) social support (3 items); 6) cognition (4 items); 7) communications (3 items); and 8) bodily discomfort (3 items). Each dimension is evaluated on a 100 point scale with 0 indicating "no problem at all" for that particular dimension. Items are answered in relation to how often, during the previous month, an individual has had difficulties or problems with specific tasks and feelings. The PDQ-39 has been shown to have acceptable internal consistency and test-retest reliability (Hagell & Nygren, 2007; Jenkinson, Fitzpatrick, Peto, Greenhall, & Hyman, 1997) and construct (Hagell & Nygren, 2007; Jenkinson, Fitzpatrick, Peto, Greenhall, & Hyman, 1997), content (Kim, Dahlberg, &

Hagell, 2006) validity (Hagell & Nygren, 2007; Jenkinson, Fitzpatrick, Peto, Greenhall, & Hyman, 1997) for identifying the quality of life among individuals with Parkinson's disease.

PDQL. The Parkinson's disease quality of life questionnaire (PDQL) developed by de Boer, Wijker, Speelman, and de Haes (1996) is a 37 – item self-administered measure with four sub-scales: parkinsonian symptoms (13 items); systemic symptoms (7 items); social functioning (7 items); and emotional functioning (9 items). A total composite score can be obtained by summing the four sub-scale scores. High composite scores indicate a higher perceived quality of life. Each item is answered in terms of how much of a problem each item has been in the previous 3 months. The PDQL has been shown to have good - excellent internal consistency (de Boer, Wijker, Speelman, & de Haes, 1996; Martinez-Martin, Serrano – Dueñas, Forjaz, & Serrano, 2007) and discriminant and convergent (de Boer, Wijker, Speelman, & de Haes, 1996; Hobson, Holden, Meara, 1999; Martinez-Martin, Serrano – Dueñas, Forjaz, & Serrano, 2007), validity

Based on the findings of Marinus, Ramaker, van Hilten, and Stiggelbout (2002) both PD specific quality of life questionnaires were utilized based on the observations that the PDQL captured aspects of walking, transfer, motor features (slowness, rigidity, dexterity, shaking/tremors), and other disease features (sleeping, drooling, constipation) while the PDQ-39 highlights aspects of self – care (washing, dressing), daily activities (carrying bags, moving around in public), anxiety, and social and role functioning (embarrassment, relationships). While both instruments were developed to assess quality of life indices, each targets different aspects of the construct. Since the purpose of this study was to identify any relationships between cognition, psychiatric, and quality of life, and the amount of time and effort to complete the

questionnaires is minimal (completion time of each questionnaire takes about 5 minutes), both measures were included to try and get a more accurate indication of these relationships.

Study Design and Analysis. A cross-sectional design was used to identify differences in cognitive function, mood, and quality of life between a group of individuals with and without PD. One-way ANOVAS and Pearson's chi-square tests were used to identify demographic differences between groups. Differences in cognition scores were analyzed by multivariate analysis of the SCOPA – COG sub-scales with Disease State (PD vs Non-PD) and further analyzed with post hoc ANOVA's with Bonferroni adjustments. Similar analyses were performed for mood (POMS Total and its sub-scales) and the SF – 36 quality of life assessment independently (SF – 36 Total Score and its sub-scales). A multivariate analysis between PD genders was performed for each disease specific quality of life assessment (the PDQ – 39 Total Score and its subscales; and the PDQL Total Score and its sub-scales). In addition, Pearson product correlations were used to identify relationships between cognition and quality of life measures, and mood and quality of life measures. All analyses were performed using SPSS 18 (Chicago, IL) with alpha set at 0.05.

Results.

Twenty individuals with early PD (14 males and 6 females) who met the inclusion criteria were matched with 20 non-PD peers based on age, highest educational attainment, employment status, gender, marital status, and physical activity level. Participant demographics can be found in Table 1. No significant differences between genders or groups for any of the matching variables were found.

Cognitive Assessment. Means and standard deviations of cognitive performance are presented in Table 2. A multivariate analysis of the SCOPA - COG four subset scores, Memory,

Attention, Executive Function, and Visuo-Spatial, yielded a significant group effect ($\Lambda = 0.70$, $F_{4, 35} = 3.79$, $p < 0.05$, $\eta^2_{partial} = 0.30$) indicating significant cognitive functioning differences between individuals with and without PD. Further analyses indicated that individuals with PD had significantly lower cognitive function as indicated by group differences on Memory ($F_{1, 38} = 14.03$, $p < 0.01$, $\eta^2_{partial} = 0.27$); Attention ($F_{1, 38} = 7.47$, $p < 0.01$, $\eta^2_{partial} = 0.16$); and Executive Function ($F_{1, 38} = 11.14$, $p < 0.01$, $\eta^2_{partial} = 0.23$). In addition, an analysis of variance (ANOVA) indicated a group difference on Total Scores ($F_{1, 38} = 16.33$, $p < 0.01$, $\eta^2_{partial} = 0.30$)

Psychiatric Assessment. Table 3 contains POMS T-Score means and standard deviations. A multivariate analysis on the psychiatric state of the participants as measured by the POMS, and scored as T-scores, indicated a significant group difference ($\Lambda = 0.38$, $F_{7, 32} = 7.53$, $p < 0.01$, $\eta^2_{partial} = 0.62$). These results suggest that individuals with PD have abnormal mood states which may be explained by significantly higher Total Scores ($F_{1, 38} = 29.78$, $p < 0.01$, $\eta^2_{partial} = 0.44$) and differences on 3 of the 6 mood states measured by the POMS. Individuals with PD reported significantly higher on Tension-Anxiety ($F_{1, 38} = 11.27$, $p < 0.01$, $\eta^2_{partial} = 0.23$) and Confusion-Bewilderment ($F_{1, 38} = 14.52$, $p < 0.01$, $\eta^2_{partial} = 0.28$), and reported lower on Vigor-Activity ($F_{1, 38} = 25.32$, $p < 0.01$, $\eta^2_{partial} = 0.40$).

Quality of Life Assessments. *SF – 36.* Normative means and standard deviations of reported quality of life as measured by the SF – 36 are reported in Table 4. Analyses indicated a significant difference in quality of life between individuals with and without PD ($\Lambda = 0.41$, $F_{10, 29} = 4.12$, $p < 0.01$, $\eta^2_{partial} = 0.99$). Additional analysis identifying specific differences between individuals with and without PD indicated individuals with PD reported significantly lower on Physical Health ($F_{1, 38} = 18.98$, $p < 0.01$, $\eta^2_{partial} = 0.33$) and Mental Health ($F_{1, 38} = 11.60$, $p < 0.01$, $\eta^2_{partial} = 0.23$) dimensions. In addition, the health scales Physical Functioning ($F_{1, 38} =$

23.03, $p < 0.01$, $\eta^2_{partial} = 0.38$), Role-Physical ($F_{1, 38} = 27.07$, $p < 0.01$, $\eta^2_{partial} = 0.42$), General Health, ($F_{1, 38} = 40.44$, $p < 0.01$, $\eta^2_{partial} = 0.52$), Vitality ($F_{1, 38} = 24.40$, $p < 0.01$, $\eta^2_{partial} = 0.39$), Social Functioning ($F_{1, 38} = 27.56$, $p < 0.01$, $\eta^2_{partial} = 0.42$), Role-Emotional ($F_{1, 38} = 10.57$, $p < 0.01$, $\eta^2_{partial} = 0.22$), and Mental Health ($F_{1, 38} = 9.41$, $p < 0.01$, $\eta^2_{partial} = 0.20$) were found to be significantly different between groups. Bodily Pain ($F_{1, 38} = 3.65$, $p = 0.09$) was the only component that was not significantly different.

PDQL and PDQ – 39. Means and standard deviations for the PDQL and PDQ – 39 can be found in Table 5. Analyses of the reported quality of life among individuals with PD as measured by the PDQL and PDQ – 39 indicated no significant differences between genders on either measure ($\Lambda = 0.80$, $F_{4, 15} = 0.94$, $p = 0.47$ and $\Lambda = 0.53$, $F_{9, 10} = 98$, $p = 0.51$, respectively).

Correlations. Pearson product correlations between the Cognition Assessment and SF – 36 and the Psychiatric Assessment and SF – 36 for individuals with and without PD are presented in Tables 6 and 7. Individuals with PD had 6 significant relationships between Cognition and Quality of Life as measured by the SF – 36 and 14 significant correlations occurred between Psychiatric and Quality of Life. Individuals without PD had 0 significant relationships between Cognition and Quality of as measured by the SF – 36 and 27 significant correlations between Psychiatric and Quality of Life. Table 8 displays Pearson product correlations between the Cognition Assessment and Psychiatric Assessment, with the PDQL and PDQ – 39 for PD individuals. Cognitive scores had no significant relationships with the PDQL but 15 significant relationships with the PDQ – 39 were observed. On the Psychiatric measure, the PDQL had 19 significant correlations but only 2 with the PDQ – 39.

Discussion.

This investigation has provided evidence that cognitive deficits exist in individuals with Parkinson's disease, even at early-moderate stages of disease progression. Individuals with PD exhibit lower cognitive functioning attributed to difficulties in memory, executive functioning, and attention. These results are similar to previous investigations that demonstrated low levels of cognitive functioning among individuals with PD (Muslimović, Post, Speelman, et al., 2005; Verbaan, Marinus, Visser et al, 2007). Furthermore, these results parallel those reported by Marinus, Visser, Verwey, et al. (2003) for the Total score and Memory, Attention, Executive Function, and Visuo-spatial subsets who also used the SCOPA – COG their cognitive assessment.

However, it should be noted that our sample of individuals with early-moderate PD (Hoehn-Yahr stage 2) demonstrated similar cognitive functioning scores to Marinus, et al. (2003) sample of severe PD (Hoehn – Yahr stages 4 and 5). The differences in cognitive performance between Marinus et al. (2003) and participants in this study could be attributed to the later age of onset of PD for our sample or an indication that cognition is affected in the early stages of PD. Katzen, Levin, and Llabre (1998) observed that older age onset of PD is linked to an increased cognitive decline. Since our sample had a later disease onset and was slightly older, this may account for these differences. Despite these differences, large variations in cognitive functioning exist between diseased and non-diseased populations and should be addressed in rehabilitative protocols.

Depression and anxiety are commonly associated with Parkinson's disease and occur at higher rates than non-diseased populations (Liebermann, 2006; Poewe, 2007; Walsh & Bennett, 2001). Other mood states associated with PD are not well characterized. Findings from this

study indicate that individuals with PD have differing mood states compared to their non-PD peers based on significantly higher mood states of tension and confusion; and lower rates of vigor. Our results are similar to the findings of Lou, Kearns, Oken, et al. (2001) who utilized the POMS to evaluate fatigue in PD. These results indicate that the psychological state of individuals with PD is multidimensional and not solely based on changes in depression and anxiety. Future studies should address multiple mood states and assess how their impact affects disease progression and quality of life.

In contrast to the large amount of evidence suggesting a strong link and possible precursor with PD, our sample did not report significantly higher levels of depression when the data were analyzed as T-scores. Because of this finding, a *post hoc* analysis of the POMS point scores was performed and a significant difference in reported depression/dejection mood state was then found. Normative values of mood were used for comparison to identify how close the mood states of individuals with PD are to being considered potential concerns to an individual's psychological or emotional state. For example, vigor and confusion are close to being immediate concerns to their psychological or emotional health.

The results on the self-reported quality of life in individuals with Parkinson's disease indicate that these individuals have a poorer quality of life than their non-diseased peers across several dimensions and scales. These findings support previous quality of life investigations which have reported similar results for generic measures of quality of life, the SF – 36, and disease specific assessments such as the PDQL and PDQ 36 (Schrag, Jahanshahi, Quinn, 2000; Kupio, Marttila, Helenius, et al. 2000; Fitzpatrick, Peto, Jenkinson, et al, 1997; Rubenstein, Voelker, Chrischilles, et al., 1998; Reuther, Spottke, Klotsche, et al, 2007). Minor differences between our observations and others did occur, however. For example, Behari, Srivastava, and

Pandey (2005) found significant gender differences for the Total score and each subscale of the PDQL. While we did not find such a result, the differences in sample size may attribute to our capability to find such an effect.

While our observations support the existing literature related to cognitive function, mood, and quality of life among individuals with Parkinson's disease, the primary goal of this investigation was to identify the relationships between cognition and psychiatric status, two well established NMS, and quality of life. This study indicates interesting associations between cognition and quality of life. General quality of life (SF – 36) indicated 6 significant correlations with 3 significant correlations occurring between Cognition and Role-Emotional and all 6 were observed for those with Parkinson's disease. The disease specific quality of life questionnaires yielded mixed results: the PDQL indicated no significant relationships with Cognition, while the PDQ – 39 indicated 4 significant correlations with the Total score and 11 additional others. Interestingly, 8 of these 11 correlations were in the areas of Mobility and Activities of Daily Living. These findings suggest that the cognitive capabilities of individuals with PD and the type, amount, and care they put into their activities are positively related. Individuals with higher cognition scores tend to perform and accomplish more tasks with efficiency and with regularity. Possibly, the additional cognitive effort individuals with PD may need to allocate to specific tasks may explain this relationship.

Findings from this study indicate cognitive performance is lower in individuals with PD when compared to matched non-PD controls. This observation may indicate a need for individuals with PD to take more time, gravitate towards specific tasks, and/or use more cognitive engagement (for example, on attention, memory, and executive functioning) to be successful in task performance. In turn, the need to spend more resources on cognitive processes

may hinder the capability to perform activities in timely and/or effective ways. Failure to complete activities efficiently may lead to a reduction in future task involvement. This, in turn, could begin a cycle of continued decline in cognition and diminished capability for successful activity participation and performance. Conversely, those who can cognitively engage in activities successfully and with minimal effort tend to report more ease and willingness to perform movement and activities of daily living. Continued successful task performance may help initiate pride in what they have accomplished (improved role-emotional state), and reinforce willingness to participate in activities both physically and cognitively. This positive cycle of engagement may reduce the cognitive decline that is often observed among individuals with PD. Future research should be conducted to investigate how changes in cognition, through disease progression and through cognitive exercises, impacts quality of life.

Identified relationships between psychiatric functioning and quality of life measures may indicate that mood may impact quality of life more so than cognition. More significant correlations were observed for both groups and for all measures of quality of life. One finding is the greater number of significant relationships for the non-diseased population; nearly double that of those with PD. It appears the Mental Health of these individuals is impacted by many components of mood states.

Results from individuals with PD, indicated that mood negatively correlates with the Mental Health dimension and scales identified by the generic quality of life assessment. Individuals with higher levels of tension, depression, and confusion reported lower quality of life, mainly through aspects of mental health. The disease specific quality of life questionnaires provided interesting results in that the PDQL had many significant correlations with the psychiatric assessment while the PDQ – 39 only had 2. Findings from the disease specific

instruments indicate that increased tension, fatigue, confusion, and anger are significantly related to decreased quality of life. A positive association was found between vigor and quality of life, however. These results suggest that individuals with PD may be limiting their quality of life by having reduced mental health across a wide range of mood states. The Physical Health dimension of the SF – 36 did not have any significant relationships with this population, perhaps indicating that they are not limited in their desire or willingness to perform physical activities because of their mood states. Future research should investigate the impact mood has on PD progression and how changes in mood impact both disease symptoms and quality of life.

Although a confounding problem of this study was the small sample size and the variation of age of PD onset, our study provides some noteworthy findings. As previously discussed, participants with PD performed significantly worse than their peers on the cognitive assessment, but when compared to other studies, our group matched individuals with Hoehn-Yahr stage 3, 4, or 5 while ours were classified as stage 2 indicating that the age of onset needs to be a component of treatment and intervention strategies.

In conclusion the major findings of this study are: 1) individuals with PD have lower cognitive function, different mood states, and differences in reported quality of life than their non-diseased peers; 2) that cognitive performance among individuals with PD is associated with the type, amount, and care they put into their activities; 3) mood is negatively associated with the mental health of both diseased and non-diseased individuals; and 4) for individuals with PD, mood may play a greater role on quality of life than cognition. Secondarily, we identified additional differences in the disease specific quality of life questionnaires, in that the PDQL may have a stronger relationship to mood while the PDQ – 39 may have a stronger relationship with cognition. We highlight the importance of future research focusing on how changes in cognition

and psychiatric impact the quality of life among individuals with PD. More experimental studies involving mental exercise and mood interventions are needed to identify how changes in both cognition and mood impact disease progression.

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Table 3.1: Demographics

Disease State	N	Age	Education[1]	Employment[2]	Marital Status[3]	Physical Activity[4]	
MALES						Total Frequency	Total Calories
PD	14	71.47 (6.20)	6.50 (1.35)	2.86 (0.54)	2.07 (0.27)	26.21 (17.27)	4824.62 (3748.27)
Non-PD	14	71.51 (9.93)	7.50 (1.02)	2.71 (0.61)	2.14 (0.54)	26.07 (11.19)	4751.43 (2923.16)
FEMALES							
PD	6	67.95 (8.92)	5.50 (1.05)	2.83 (0.41)	1.83 (0.41)	17.17 (10.23)	3074.16 (2340.68)
Non-PD	6	64.90 (5.99)	5.50 (1.05)	2.83 (0.41)	2.00 (0.00)	16.83 (8.95)	2362.71 (1523.37)
TOTAL							
PD	20	70.42 (7.07)	6.55 (1.38)	2.85 (0.49)	2.00 (0.32)	23.50 (15.80)	4299.48 (3425.19)
Non-PD	20	69.53 (9.30)	6.90 (1.37)	2.75 (0.55)	2.10 (0.45)	23.30 (11.21)	4034.82 (2778.22)

[1]Education: 1 = None, 2 = Less than 8th Grade, 3 = High School Incomplete, 4 = High School Complete, 5 = College/Trade School Incomplete, 6 = College/Trade School Complete, 7 = Masters, 8 = Ph.D./M.D./D.V.M., 9 = Other
[2]Employment: 1 = Full-time, 2 = Part-time, 3 = Retired, 4 = Not Working
[3]Marital Status: 1 = Single/Never Married, 2= Married, 3 = Separated/Divorced, 4 = Widowed, 5 Other
[4]Physical Activity: Frequency and Calorie estimates calculated from CHAMPS Physical Activity Questionnaire for Older Adults

Table 3.2: Cognitive Performance as Measured by the SCales for Outcomes of PArkinson's disease – COGnition (SCOPA-COG[1])

Disease State	N	Total Score*	Memory*	Attention*	Executive Function*	Visuo-Spatial
PD	20	22.40 (7.45)	8.75 (3.52)	2.85 (1.31)	7.10 (2.85)	3.70 (1.22)
Non-PD	20	30.70 (5.37)	13.05 (3.73)	3.70 (0.47)	9.75 (2.12)	4.20 (0.89)

[1]Higher scores indicate better performance. Total Range = 0 – 43; Memory Range = 0 – 22; Attention Range = 0 – 4; Executive Function Range = 0 – 12; Visuo-Spatial = 0 – 5.

*$p < 0.05$

Table 3.3: Psychiatric Assessment as measured by the Profile of Mood States (POMS)[1] T-Scores.

Disease State	N	Total Score*	Tension-Anxiety*	Depression-Dejection	Anger-Hostility	Vigor-Activity*	Fatigue-Inertia	Confusion-Bewilderment*
PD	20	62.85 (10.73)	61.70 (17.92)	55.85 (17.81)	51.45 (14.95)	35.95 (8.23)	58.00 (16.20)	63.15 (17.91)
Non-PD	20	47.55 (6.49)	47.30 (6.84)	47.70 (4.81)	48.20 (7.78)	49.70 (9.03)	47.80 (7.61)	46.95 (6.38)

[1] A score above 65 or below 35 may indicate a concern about an individual's psychological/emotional state or condition.

*$p < 0.05$

Table 3.4: Quality of Life as measured by SF-36 v 2 Normative Values[1]

	PD	Non-PD
Physical Health*	40.04 (9.51)	51.63 (7.19)
Mental Health*	46.21 (11.33)	55.61 (4.89)
Physical Functioning*	38.83 (9.85)	51.03 (5.68)
Role-Physical*	36.77 (8.13)	49.87 (7.80)
Bodily Pain	47.41 (9.63)	52.78 (8.07)
General Health*	41.64 (8.35)	56.34 (6.11)
Vitality*	45.69 (8.68)	56.93 (5.31)
Social Functioning*	42.67 (9.09)	54.40 (4.14)
Role Emotional*	39.94 (14.59)	51.60 (6.66)
Mental Health*	47.90 (9.89)	55.36 (4.56)

[1] Scores low (below 45) on the scale may indicate limitations, such as high amounts of pain, limits in participating in physical activity, frequent psychological distress, and poor general health. High scores (above 55) indicate little or no physical limitations, high energy levels, positive affect, and good general health.

* $p < 0.05$

Table 3.5: Mean Parkinson Disease Quality of Life Assessment (PDQL)[1,2] and 39 Item Parkinson's Disease Questionnaire (PDQ – 39)[1,2]

PDQL

	Total	Parkinsonian Symptoms	Systemic Symptoms	Social Functioning	Emotional Functioning
Males (n = 14)	125.93 (21.10)	45.57 (7.40)	24.14 (4.17)	24.93 (5.73)	31.29 (5.68)
Females (n = 6)	127.67 (14.51)	47.833 (6.62)	23.67 (2.50)	25.00 (4.29)	31.17 (4.26)
Total (n = 20)	126.45 (18.99)	46.25 (7.08)	24.00 (3.68)	24.95 (5.23)	31.25 (5.18)

[1] Higher the score indicates the better quality of life. Total Range = 0 – 185; Parkinsonian Symptoms Range = 0 – 70; Systemic Symptoms Range = 0 – 35; Social Functioning Range = 0 – 35; Emotional Functioning Range = 0 - 45

[2]Only individuals with PD completed this questionnaire

PDQ – 39

	Total	Mobility	Activities of Daily Living	Emotional Well Being	Stigma	Social Support	Cognitive Impairment	Communication	Bodily Discomfort
Males (n = 14)	40.79 (15.95)	27.86 (20.68)	29.17 (16.98)	26.79 (21.29)	12.95 (13.08)	15.67 (19.60)	39.29 (20.86)	31.15 (17.68)	23.02 (17.55)
Females (n = 6)	45.33 (14.57)	38.75 (27.96)	30.56 (17.01)	29.86 (8.09)	14.58 (13.50)	5.56 (6.80)	31.95 (13.61)	26.39 (11.08)	36.11 (22.15)
Total (n = 20)	42.15 (15.32)	31.13 (22.91)	29.58 (16.55)	27.71 (18.15)	13.44 (12.87)	12.64 (17.25)	37.08 (18.93)	29.72 (15.85)	26.94 (19.44)

[1] Lower the score indicates the better quality of life. Total Score Range = 0 – 156; Mobility Range = 0 – 40; Activities of Daily Living Range = 0 – 24; Emotional Well Being Range = 0 – 24; Stigma Range = 0 – 16; Social Support Range = 0 – 12; Cognitive Impairment Range = 0 – 16; Communication Range = 0 – 12; Bodily Discomfort Range = 0 – 12

[2] Only individuals with PD completed this questionnaire

Table 3.6: Cognition and Quality of Life Pearson Product Correlation's for Individuals with and without PD

	SF – 36 v 2										
	PH	MH	PF	RP	BP	GH	V	SF	RE	M	
Cognition											
Total	0.156	0.294	0.376	0.146	0.278	0.054	0.151	0.389	0.523*	0.006	PD
	0.045	-0.127	0.116	-0.062	0.006	0.109	-0.016	0.043	-0.129	-0.002	NON-PD
Memory	0.305	0.239	0.494*	0.180	0.455*	0.147	0.149	0.412	0.507*	-0.016	
	0.001	-0.024	0.083	-0.014	-0.019	0.128	-0.029	-0.047	-0.032	0.140	
Attention	0.008	0.167	-0.007	0.206	-0.051	-0.051	0.085	0.174	0.190	0.089	
	0.105	-0.029	-0.004	0.032	0.043	0.235	0.086	0.044	-0.170	0.097	
Executive	0.185	0.308	0.400	0.270	0.219	0.089	0.127	0.468*	0.582*	-0.045	
	0.033	-0.137	0.108	-0.134	-0.060	0.069	0.069	0.188	-0.210	-0.161	
Visuo-spatial	-0.368	0.212	-0.137	-0.250	-0.347	-0.250	0.104	-0.093	0.166	0.092	
	0.133	-0.319	0.096	-0.011	0.238	-0.168	-0.180	-0.016	-0.055	-0.385	

PH = Physical Health Dimension; MH = Mental Health Dimension; PF = Physical Functioning; RP = Role – Physical; BP = Bodily Pain; GH = General Health; V = Vitality; SF = Social Functioning; RE = Role – Emotional; M = Mental Health

* $p < 0.05$

Table 3.7: Psychiatric and Quality of Life Pearson Product Correlation's for Individuals with and without PD

	SF – 36 v 2										
	PH	MH	PF	RP	BP	GH	V	SF	RE	M	
Psychiatric											
Total	0.204	-0.804*	-0.030	-0.199	-0.066	-0.179	-0.369	-0.591*	-0.541*	-0.799*	PD
	-0.518*	-0.476*	-0.584*	-0.488*	-0.302	-0.662*	-0.739*	-0.363	-0.302	-0.685*	NON-PD
Tension-Anxiety	0.161	-0.611*	-0.026	-0.180	-0.005	-0.181	-0.290	-0.341	-0.336	-0.758*	
	-0.263	-0.660*	-0.203	-0.466*	-0.186	-0.439	-0.517*	-0.327	-0.549*	-0.705*	
Depression-Dejection	0.245	-0.620*	0.084	-0.139	0.008	-0.139	-0.099	-0.372	-0.394	-0.703*	
	-0.323	-0.540*	-0.300	-0.378	-0.316	-0.416	-0.602*	-0.255	-0.355	-0.673*	
Anger-Hostility	-0.003	-0.357	-0.014	-0.294	-0.133	-0.187	-0.042	-0.307	-0.307	-0.362	
	-0.399	0.007	-0.360	-0.146	-0.457*	-0.275	-0.498*	-0.055	-0.046	-0.048	
Vigor-Activity	0.012	0.545*	0.212	0.283	0.025	0.152	0.490*	0.562*	0.444*	0.374	
	0.332	0.530*	0.395	0.381	0.018	0.811*	0.536*	0.286	0.287	0.736*	
Fatigue-Inertia	-0.099	-0.407	-0.150	-0.348	-0.036	-0.405	-0.365	-0.353	-0.234	-0.480*	
	-0.665*	0.090	-0.697*	-0.413	-0.471*	-0.364	-0.609*	-0.353	0.067	-0.091	
Confusion-Bewilderment	-0.039	-0.504*	-0.212	-0.419	0.003	-0.337	-0.137	-0.406	-0.440	-0.540	
	-0.376	-0.429	-0.342	-0.285	-0.166	-0.766*	-0.686*	-0.277	-0.082	-0.663	

PH = Physical Health Dimension; MH = Mental Health Dimension; PF = Physical Functioning; RP = Role – Physical; BP = Bodily Pain; GH = General Health; V = Vitality; SF = Social Functioning; RE = Role – Emotional; M = Mental Health

* $p < 0.05$

Table 3.8: Cognition, Psychiatric, and Disease Specific Quality of Life Pearson Product Correlation's for Individuals with PD

	PDQL					PDQ - 39								
	Total	PS	SS	SF	EF	Total	M	ADL	EWB	S	SS	CI	C	BD
Cognition														
Total	0.400	0.405	0.312	0.440	0.248	**-0.581***	**-0.453***	**-0.610***	-0.104	0.174	-0.053	**-0.506***	-0.408	-0.232
Memory	0.355	0.395	0.223	0.340	0.260	**-0.577***	**-0.504***	**-0.521***	-0.068	0.317	-0.109	**-0.602***	-0.305	-0.180
Attention	0.335	0.311	0.207	0.384	0.270	**-0.464***	-0.117	**-0.483***	-0.305	-0.030	-0.358	-0.365	**-0.556***	-0.247
Executive	0.374	0.338	0.356	0.425	0.227	**-0.503***	**-0.486***	**-0.527***	0.045	0.168	0.101	-0.427	-0.416	-0.260
Visuo-Spatial	0.188	0.211	0.211	0.303	-0.054	-0.215	-0.053	**-0.472***	-0.219	-0.212	0.141	0.037	-0.044	-0.023
Psychiatric														
Total	**-0.608***	**-0.580***	**-0.522***	**-0.590***	**-0.471***	0.320	0.057	0.128	0.410	0.263	0.192	-0.054	0.293	0.436
Ten-Anxiety	**-0.540***	**-0.553***	**-0.445***	**-0.460***	-0.441	0.230	-0.054	0.140	0.295	0.421	0.209	-0.067	0.148	0.408
Depression-Dejection	-0.432	-0.413	-0.339	-0.424	-0.350	0.109	-0.165	0.202	0.290	0.378	0.385	-0.254	0.334	0.310
Anger-Hostility	-0.252	-0.235	-0.302	-0.188	-0.200	0.082	-0.066	-0.131	0.095	0.083	0.308	-0.152	**0.468***	**0.478***
Vigor-Activity	**0.534***	0.**432**	**0.482***	**0.557***	**0.462***	-0.426	-0.432	-0.389	-0.155	-0.034	-0.380	-0.311	-0.003	-0.102
Fatigue-Inertia	**-0.518***	**-0.535***	**-0.623***	-0.379	-0.343	0.144	0.000	0.061	0.020	0.248	0.030	-0.031	0.183	0.392
Confusion-Bewilderment	**-0.548***	**-0.512***	**-0.479***	-0.429	**-0.534***	0.300	0.114	0.074	0.210	0.149	0.354	0.092	0.343	0.317

PDQL: Total = Total Composite Score; PS = Parkinsonian Symptoms; SS = Systemic Symptoms; SF = Social Functioning; EF = Emotional Functioning

PDQ – 39: Total = Total Composite Score; M = Mobility; ADL = Activities of Daily Living; EWB = Emotional Well-Being; S = Stigma; SS = Social Support; CI = Cognition; C = Communications; BD = Bodily Discomfort

*** p < 0.0**

CHAPTER 4

DUAL – TASKING IN PARKINSON'S DISEASE:

SPATIAL AND TEMPORAL CHANGES IN GAIT

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Abstract

Introduction. A basic characteristic of Parkinson's disease (PD) is an inability to initiate and control gait. However, understanding the impact a simultaneous task has on the spatial and temporal characteristics of gait are relatively unknown. Therefore, the purpose of this study was to compare 14 spatial and temporal characteristics of gait between individuals with and without stage 2 PD while performing cognitive and motor dual tasking activities, in addition to walking a preferred gait. **Methods.** Twenty individuals (mean age = 70.42 ± 7.07) with stage 2 (Hoehn – Yahr scale) PD completed a series of tasks while walking and were compared to 20 non-diseased peers (69.53 ± 9.30). Participants walked and carried a plate and a cup, walked and carried a tray with cups on it, walked and talked on a cell phone, and walked and buttoned a shirt. **Results.** Multiple analyses of variance (MANOVA's) indicated significant spatial group differences while walking and carrying a tray with cups ($\Lambda = 0.63$, $F_{7, 32} = 2.67$, $p < 0.05$, $\eta^2_{partial} = 0.37$), walking and talking on a cell phone ($\Lambda = 0.65$, $F_{7, 32} = 2.47$, $p < 0.05$, $\eta^2_{partial} = 0.35$), and walking and buttoning a shirt ($\Lambda = 0.62$, $F_{7, 32} = 2.77$, $p < 0.05$, $\eta^2_{partial} = 0.38$). **Discussion.** These findings may indicate that individuals with early stage PD have diminished walking performance but they are still able to allocate the necessary resources to perform, control, and maintain gait similar to that of their preferred walk while simultaneously performing another task. From a motor control perspective, these findings indicate that individuals with early to moderate PD: 1) have intact generalized motor programs for walking that are able to make the appropriate modifications for successful ambulation to occur; 2) maintain the relative timing of the movements necessary for appropriate gait functioning; 3) have difficulty in the refinement of their walking generalized motor program which may begin with an inappropriate base of support; 4) use similar strategies

as non-diseased peers to maintain gait while simultaneously performing another task; and 5) task complexity may play an important role in identifying dual tasking and gait relationships.

KEY WORDS: Parkinson's disease, Dual-tasking, Ambulation.

Introduction.

A basic characteristic of Parkinson's disease (PD) is an inability to initiate and control gait. This is apparent in restricted stride lengths as well as reduced walking velocity and the inability to stop and start a movement (Morris, Iansek, Matyas, & Summers, 1994; Morris, Iansek, Matyas, & Summers, 1994; Sofuwa, Niewboer, Desloovere, Willems, Chavret, & Jonkers, 2005; Frankel-Toledo, Giladi, Peretz, Herman, Gruendlinger, & Hausdorff, 2005). From a biomechanical perspective, Rogers (1996) highlighted additional variations including, discrepancies in hip and knee extension, rotation of the hips and torso, and reduced ground reaction forces. Increased cadence and increased time of double-support phase are also listed but additional findings on cadence (Morris, et al., 1994) and double support (Sofuwa, et al.2005) have reported conflicting results.

In addition to the deficiencies that are evident while performing a preferred gait is the difficulty in allocating resources to perform a simultaneous task. Investigations about how the addition of another task may impact gait among individuals with PD are limited and in those that do exist the methodologies are not consistent across studies. In addition, the dual tasks vary in the amount of cognitive or motor engagement required to perform the task. For example, participants in the Morris et al. (1996) study walked 10 m 4 times while performing one cognitive task (reciting a sentence) with visual cues for the first investigation, and subsequently used 4 separate cognitive tasks with attentional strategies of increasing difficulty (reciting sentences increasing in complexity and length and naming the days of the week in reverse order). In both studies, decreased gait performance was observed as evidenced by reduced velocity, cadence, and stride length with more time needed for double support across the 4 trials.

In another study, Camicioli, Oken, Sexton, Kaye, & Nutt (1998) reported that individuals with PD who concomitantly experienced freezing of gait took a greater number of steps to complete a walking task while simultaneously cognitively engaged in a verbal fluency task. Likewise, Bond and Morris (2000) reported significant decreases in gait speed and stride length when individuals with PD carried a tray with glasses as opposed to a preferred walk. In contrast, carrying a tray with no cups did not significantly impact gait but decreased velocity and stride length. In addition, Bloem, Grimbergen, Cramer, and Valkenburg (2000) found that 100% of their sample (38 individuals with PD) were able to complete the stops walking when talking (SWWT) assessment utilizing open ended questions and responses by participants without stopping their speech indicating that cognitive engagement does not cease or override the walking command from the motor cortex.

In some of the more specific work on dual task methodologies, Bloem, Valkenburg, Slabbekoorn, and van Djik (2001) observed the Multiple Tasks Test (Bloem, Valkenburg, Slabbekoorn, & Willemsen, 2001) which includes answering questions, carrying an empty tray, and carrying a tray with cups, among individuals with PD and two control groups. Individuals with PD performed the test slower, and displayed more motor errors and hesitations, while the control group demonstrated more cognitive errors. O'Shea, Morris, and Iansek (2002) observed the impact of transferring coins from one side of the body to the other while walking, and digit subtraction while walking as compared to a free preferred walk among individuals with PD and a control group. Both groups demonstrated declines in walking speed, stride length, and cadence between both dual-task conditions and the free preferred walk, with individuals with PD having greater declines than individuals without. In addition, time in double support was significantly higher for the PD group during both dual-tasking events, with no change for the non-PD group.

Rochester, Hetherington, Jones, Niewboer, Willems, Kwakkel, and Van Wegen (2004) examined the impact of carrying a tray with cups, answering questions, and performing both activities together while walking. They observed that walking speed and step length were significantly different than a control group and that individuals with PD demonstrated decreased performance from preferred walk alone and each of the dual tasking activities. Finally, Hausdorff, Balash, and Giladi (2003) and Yogev, Giladi, Peretz, Springer, Simon, and Hausdorff (2005) observed that individuals with PD who performed a cognitively challenging task while walking demonstrated increased gait variability. Taken together, these investigations suggest that walking speed and step length decrease as either cognitive or motor based dual-tasks are added to the gait requirements among individuals with Parkinson's disease.

Although the literature is consistent in showing reduced performance between individuals with and without PD, however, less is known about the influence of dual-tasking on gait, especially on the threshold of the disease becoming a disability. Investigating the impact of dual-tasking on gait is important because the overall function and performance of activities of daily living (ADL's) and instrumental activities of daily living (IADL's) frequently involve the capability to ambulate while simultaneously performing another task. A loss of independent mobility has been identified as a primary determinant of disability in Parkinson's disease (Schenkman, Cutson, Zhu, & Whetten-Goldstein, 2002) and the transition of PD from a limitation to a disability has shown to occur between Hoehn-Yahr stages 2 and 3 (Shulman, Gruber-Baldini, Anderson, Vaughan, Reich, Fishman, & Weiner, 2008). Further, minimal information is available with respect to the spatial and temporal components of gait as well as dual-tasking conditions that require cognitive and motor engagement. Therefore, the purpose of this study was to compare 14 spatial and temporal characteristics of gait between individuals

with and without stage 2 PD while performing cognitive and motor dual tasking activities, in addition to walking a preferred gait.

Methods.

The assessment of gait parameters was completed as part of a larger cross-sectional study that was designed to examine the physical, mental, and emotional health of individuals with early-moderate PD. The entire study involved three days of testing for each individual with 24 – 72 hours between each testing day. Each PD participant performed the gait assessment 1.5 – 2.0 hours post ingestion of their normal medication regimen to maximize the "on" phase capabilities to process information and to achieve optimal performance. The gait assessment occurred on the second day of testing following a familiarization period on the first day of testing. During the familiarization period, participants were introduced to the gait assessment and allowed to practice each activity 3 times.

Participants. Individuals identified with early stage idiopathic PD (Hoehn-Yahr stage of 1 or 2) by their neurologist were referred for the study. Potential participants were then screened and were selected for participation based on: 1) being diagnosed by a neurologist with PD in the last 5 years; 2) participant report of first PD-like symptom no more than 7 years ago; and 3) age range between 55 – 85. Individuals with fluctuating responses to medication and/or who unable to ambulate on their own for 30 feet were excluded from this study. Individuals with early - moderate PD who met the inclusion criteria were matched with non-PD peers based on age, height, weight, and gender. The controls were recruited individuals from community agencies, such as the local Community Council on Aging. All participants signed an informed consent that was approved by the University Institutional Review Board.

Gait. Temporal and spatial gait parameters of each participant were measured via GAITRite computerized electronic walkway. The GAITRite walkway consists of 6.96 meters of linear ambulatory space with 16,128 sensors arranged in a grid-like pattern. As an individual ambulates across the walkway, activated sensors identify spatial and temporal parameters which are transformed into a Functional Ambulation Profile (FAP). The FAP was developed by Nelson (1974) and is a numerical representation of adult gait and is comprised of the linear relationship of step length/leg length ratio to step time when the velocity is "normalized" to leg length in healthy adults. In healthy adult populations FAP scores range from 95 – 100 points (Nelson, 1974). FAP scores have been shown to be a reliable and valid method of measuring adult gait parameters (Nelson, 1974). In addition to the FAP score, GAITRite records a large number of ambulatory components for each footfall including: step length, step width, stride length, stride width, number of steps, gait speed, and cadence, single support time, double support time, swing time, stance time, toe in / toe out, heel on, heel off, mid-foot on, mid-foot off, toe on, toe off. The criterion (concurrent) validity and internal consistency and test-retest reliability of GAITRite has been documented for healthy adults (McDonough, Batavia, Chen, Kwon, & Ziai, 2001; Bilney, Morris, & Webster, 2003), and the internal consistency,test-retest reliability, and construct validity of the GAITRite and use of the FAP (for preferred gait) in Parkinson's disease has been established (Nelson, et al., 2002).

For the present study on gait, a gait battery consisting of 5 tasks: 1) preferred walk; 2) buttoning a shirt while walking; 3) walking and carrying a tray with 6 cups; 4) walking and talking on a cell phone; and 5) carrying a plate with one hand and a coffee mug by the handle with the other was developed based on the recommendations for future research in a review of gait in Parkinson's disease (Morris, Huxham, McGinley, Dodd, & Iansek, 2001), to attempt to

mimic community ambulation or tasks individuals perform frequently while walking. In addition, these tasks were chosen based on the level and types of dual-tasking involvement. It was hypothesized that walking and carrying a plate and cup would be a minimal dual-tasking activity while carrying a tray and cup would be slightly more demanding, but both tasks would be predominantly motor dual-tasking. Walking and talking on a cell phone would be mainly a cognitive dual-task and more challenging then carrying a tray and cups. Finally, buttoning a shirt and walking was selected because it requires both motor and cognitive functioning to perform the task, and thus was thought would be the more difficult dual-task activity.

The tray was carried with elbows at approximately 90° flexion with hands around the handles of the tray and the cups were equally spaced (3.18 cm apart) across two rows with 3 cups to each row. The plate and the cup were carried in the same hand depending on preference of the participant (if a participant carried the plate in the right hand for the first trial then he/she carried it in the right hand for trials 2 and 3 and the cup in the left for all three trials) with elbows approximately 90° flexion. A 3.05 meter pre- and post- walkway was included. Participants began each activity as soon as he/she began walking following a go signal and continued the activity until he/she reached the end of the post-walkway. Each participant performed each task three times in a randomized order, 24 – 48 hours after the familiarization period.

Gait Variables. Seven spatial and 7 temporal variables identified by GAITRite were selected for analysis. The selected spatial variables are: 1) step length; 2) stride length; 3) step/extremity ratio; 4) toe in/toe out; 5) step width; 6) stride width and 7) base of support. The selected temporal variables are: 1) step time; 2) ambulation time; 3) velocity (normalized); 4) single support time; 5) double support time; 6) stance time; and 7) swing time. Definitions of each variable as defined by GAITRite are provided in Appendix A.

Study Design and Analysis. A cross-sectional study utilizing multiple one-way ANOVAS to identify demographic differences, and multiple Spatial (7) and Temporal (7) by Disease State (PD vs Non-PD) multivariate analyses to identify group differences were utilized. In addition, multiple one-way repeated measures ANOVAs with planned simple contrasts with Preferred Walk as the comparison variable were performed to identify within group differences while performing the gait tasks. All analyses were performed using SPSS 18 (Chicago, IL) with alpha set at 0.05.

Results.

Twenty individuals with early PD (14 males and 6 females) who met the inclusion criteria were matched with 20 non-PD peers based on age, height, weight, and gender. Participant demographics can be found in Table 1. No significant differences between genders or disease state were found for age. Males did however weigh more than females ($F_{1, 36} = 4.85$, $p = 0.03$) but there was no significant Disease State factor ($F_{1, 36} = 0.04$, $p = 0.84$), indicating that there was no significant difference between the means of the two groups (individuals with and without PD). The same was found for height and left and right leg length. Males were taller than females ($F_{1, 36} = 18.07$, $p < 0.01$) and had longer leg lengths ($F_{1, 36} = 13.94$, $p < 0.01$; $F_{1, 36} = 14.41$, $p < 0.01$ for left and right legs, respectively) but did not differ across groups ($F_{1, 36} = 0.40$, $p = 0.53$; $F_{1, 36} = 1.00$, $p = 0.32$; $F_{1, 36} = 1.07$, $p = 0.31$ for height and left and right leg lengths respectively). Because there were no significant differences in groups, despite gender specific differences, and group means were compared in the remaining analyses height and leg length were not used as covariates. Post hoc analysis using height and leg length as covariates to identify possible gender differences revealed identical results with no significant gender specific

results. The reported analyses and reported data are from the initial analyses examining males and females together in their respective disease state groups.

FAP Scores. FAP scores for the gait activities can be found in Table 2. The reader is cautioned that using FAP scores as a predictor of gait capabilities may not be appropriate outside the Preferred Walk setting; however one can use the FAP scores as an indicator of possible differences between the groups. ANOVA's indicated that groups differed in FAP scores for the Preferred Walk ($F_{1, 38} = 6.48$, $p = 0.02$), Plate and Cup ($F_{1, 38} = 5.04$, $p = 0.03$), Tray and Cup ($F_{1, 38} = 6.79$, $p = 0.01$), Phone ($F_{1, 38} = 5.54$, $p = 0.02$), and Shirt ($F_{1, 38} = 6.03$, $p = 0.02$). These differences may indicate that individuals with early stage PD, in general, are transitioning from a normal walking pattern and that further analyses into the spatial and temporal characteristics of both groups are warranted to identify where these differences occur.

Spatial and Temporal Disease State Differences. Table 3 contains the means and standard deviations for individuals with and without PD for each Spatial and Temporal variable of interest. Multivariate tests indicated that the groups significantly were different for Tray and Cups ($\Lambda = 0.63$, $F_{7, 32} = 2.67$, $p < 0.05$, $\eta^2_{partial} = 0.37$), Phone ($\Lambda = 0.65$, $F_{7, 32} = 2.47$, $p < 0.05$, $\eta^2_{partial} = 0.35$), and Shirt ($\Lambda = 0.62$, $F_{7, 32} = 2.77$, $p < 0.05$, $\eta^2_{partial} = 0.38$) with respect to the spatial dependent variables only. Groups were not significantly different for the spatial and temporal variables while individuals performed the Preferred Walk ($\Lambda = 0.74$, $F_{7, 32} = 1.61$, $p = 0.17$; $\Lambda = 0.80$, $F_{7, 32} = 1.17$, $p = 0.35$) and Plate and Cup ($\Lambda = 0.78$, $F_{7, 32} = 0.78$, $p = 0.29$; $\Lambda = 0.71$, $F_{7, 32} = 1.91$, $p = 0.10$). In addition, groups were not significantly different in respect to the temporal aspects of gait while performing the Tray and Cups ($\Lambda = 0.78$, $F_{7, 32} = 1.55$, $p = 0.19$), Phone ($\Lambda = 0.73$, $F_{7, 32} = 1.68$, $p = 0.15$), and Shirt ($\Lambda = 0.72$, $F_{7, 32} = 1.82$, $p = 0.12$). Put another way, the two groups do not differ significantly with respect to the combination of all the Spatial

and Temporal variables except for three of the dual tasking conditions and only for the spatial variables. So, it appears the combination of all the Spatial or Temporal variables on impacting gait while dual tasking was minimal and may indicate that the impact of several variables on gait may only become a factor as task complexity increases.

Post hoc ANOVAS with Bonferroni adjustments indicated statistically significant differences between individuals with PD and non-disease peers in step length, stride length, and step width for Phone and Shirt. Individuals with PD took shorter steps ($F_{1, 38} = 8.04$, $p < 0.007$, $\eta^2_{partial} = 0.18$) and strides ($F_{1, 38} = 8.45$, $p < 0.007$, $\eta^2_{partial} = 0.19$), and narrower steps ($F_{1, 38} = 8.16$, $p < 0.007$, $\eta^2_{partial} = 0.18$) while walking and talking on a cell phone. Similar results were found for PD individuals while walking and buttoning a shirt; they demonstrated significantly shorter step lengths ($F_{1, 38} = 9.24$, $p < 0.007$, $\eta^2_{partial} = 0.20$) and stride lengths ($F_{1, 38} = 10.45$, $p < 0.007$, $\eta^2_{partial} = 0.22$) with a narrower step width ($F_{1, 38} = 8.10$, $p < 0.007$, $\eta^2_{partial} = 0.18$). While the multivariate analysis of Tray and Cup indicated significant group differences on the spatial variables, the *post hoc* Bonferroni adjusted ANOVAs did not identify any individually significant spatial variables.

Dual-Tasking Compared to Preferred Walk. Table 4 contains percent differences in the Temporal and Spatial variables for each gait condition as compared to Preferred Walk for each disease state. Results of the repeated measures ANOVA's with Greenhouse-Geisser corrections indicated significant differences existed between the walking tasks and for each of the 14 gait variables of interest for those with PD. Individuals with PD demonstrated significant variations in base of support ($F_{4, 76} = 4.62$, $p < 0.05$), step length ($F_{2.69, 51.12} = 22.28$, $p < 0.01$), step width ($F_{2.94, 55.92} = 64.80$, $p < 0.01$), stride length ($F_{2.72, 51.59} = 17.34$, $p < 0.01$), stride width ($F_{2.31, 43.80} = 5.01$, $p < 0.01$), toeing in and out ($F_{2.81, 53.40} = 8.49$, $p < 0.01$), step extremity ratio ($F_{2.73, 51.89} =$

23.84, $p < 0.01$), ambulation time ($F_{1.58, 30.04} = 11.68$, $p < 0.01$), velocity ($F_{4, 76} = 25.18$, $p < 0.01$), single support time ($F_{2.84, 54.02} = 3.42$, $p < 0.05$), double support time ($F_{1.74, 33.06} = 13.64$, $p < 0.01$), stance time ($F_{2.18, 41.41} = 8.40$, $p < 0.01$), step time ($F_{2.22, 42.17} = 11.95$, $p < 0.01$), and swing time ($F_{2.80, 53.20} = 3.24$, $p < 0.01$). Individuals without PD demonstrated significant variations in step length ($F_{2.54, 48.26} = 106.86$, $p < 0.01$), step width ($F_{2.46, 46.69} = 18.93$, $p < 0.01$), stride length ($F_{2.47, 46.84} = 100.88$, $p < 0.01$), stride width ($F_{4, 76} = 3.32$, $p < 0.05$), toeing in and out ($F_{2.22, 42.09} = 5.52$, $p < 0.01$), step extremity ratio ($F_{2.38, 45.19} = 19.83$, $p < 0.01$), ambulation time ($F_{1.72, 32.63} = 7.88$, $p < 0.01$), velocity ($F_{2.59, 49.12} = 16.01$, $p < 0.01$), single support time ($F_{2.68, 50.84} = 13.17$, $p < 0.01$), double support time ($F_{2.46, 46.79} = 9.37$, $p < 0.01$), stance time ($F_{4, 76} = 11.20$, $p < 0.01$), step time ($F_{2.28, 43.28} = 70.05$, $p < 0.01$), and swing time ($F_{2.67, 50.63} = 15.72$, $p < 0.01$) but not in base of support ($F_{4, 76} = 3.32$, $p = 0.07$),

Post hoc simple contrasts with Bonferroni adjustments ($p < 0.0083$) indicated several significant Spatial and Temporal differences between Preferred Walk and the other walking conditions for individuals with PD. Statistics of each test can be found in table 5. During the Plate and Cup condition, individuals with PD had significantly narrower step width, smaller base of support, and had a higher walking velocity than their Preferred Walk. While performing the Tray and Cups the PD group demonstrated significantly smaller step extremity ratio, narrower step width, smaller base of support, had less time in single support, reduced stance time, and slower step and swing times than their Preferred Walk. The Phone condition was significantly different than the Preferred Walk on all of the Spatial parameters except base of support and stride width indicating they took smaller steps, had a shorter stride, smaller step extremity ratio, more toeing out, and with a narrower step width. They also had significantly slower velocity, and spent more time in double support while walking and talking on a cell phone. While,

walking and buttoning a shirt, individuals with PD demonstrated significantly shorter step lengths and stride lengths, a smaller step extremity ratio, more toeing out, a narrower step width, had a longer ambulation time, a slower velocity, and spent more time spent in double support than their Preferred Walk.

Individuals without PD during the Plate and Cup condition demonstrated significantly shorter step length and stride lengths, reduced step time, spent less time in single support, and a shorter stance time and swing time than their Preferred Walk. While performing the Tray and Cups the non – PD group demonstrated significantly shorter step length, smaller step extremity ratio, narrower step width, a shorter stride length, shorter step time, had less time in single and double support, shorter stance time, and faster swing time than their Preferred Walk. Individuals without PD took smaller steps, had a shorter stride, smaller step extremity ratio, more toeing out, with a narrower step width while slowing their velocity when talking on a cell phone than their Preferred Walk. While walking and buttoning a shirt, individuals without PD, demonstrated significantly shorter step lengths and stride lengths, a smaller step extremity ratio, a narrower step width, and slower velocity and reduced step time than their Preferred Walk.

Discussion.

The purpose of this study was to identify gait discrepancies between individuals with and without Parkinson's disease. Initial findings based on FAP scores indicated that individuals with PD demonstrated decreased walking capabilities as compared to individuals without PD. An examination of the FAP score indicates that both groups were relatively consistent in their walking capabilities across the walking tasks as indicated by similar and limited shifts in FAP scores across the dual-tasking activities. This finding may indicate that the motor program for walking among individuals with early – moderate PD may be relatively unimpaired and supports

previous findings by Behrman, Teitlbaum, and Cauraugh (1998) and Morris, Iansek, Matyas, and Summers (1996) who suggested that PD individuals can still generate the motor program to walk and facilitate gait parameters that are similar to non-diseased individuals by using compensatory strategies that include verbal, visual, and attentional cues. For example, using markers for foot placement to initiate and maintain gait or snapping one's fingers to overcome freezing of gait.

Further investigation of the gait differences between individuals with and without PD indicated spatial changes in gait while ambulating and talking on a cell phone, and walking and buttoning a shirt. For both of these tasks, individuals with PD significantly reduced their step length, stride length, and narrowed their step width. Similar results, though non-significant, were observed for the other tasks. These results are similar to previous findings (Bond, et al.,2000; O'Shea, et al., 2002; Rochester et al., 2004) and demonstrate that early stages of the disease begins to affect aspects of pre-programmed motor movements. Individuals with PD demonstrated more toeing out for each task, possibly as a consequence of a narrower step width. As dual task complexity increased, individuals with PD increased their toeing out, where as non-PD individuals demonstrated minor variations to toeing out across tasks, possibly as an internal (but incorrect) response to try an increase their base of support. Additional research should be conducted to identify if this observation and its impact on base of support among individuals with PD is correct.

Additionally important, but non-significant, observations about the spatial results need to be addressed. For three of the four dual tasking activities, PD individuals demonstrated narrower bases of support than their peers. In contrast, during the preferred walk and carrying a plate and cup while walking, these individuals demonstrated a wider base of support. While this observation supports, and may partially explain, the significantly narrower step widths, it raises a

possible explanation about potential postural instabilities that commonly exist in PD, especially as disease progression occurs. Individuals with PD are predisposed to falls (Grimbergen, Munneke, & Bloem, 2004) and the finding that these individuals have narrower bases of support while walking and performing potentially complex motor and cognitive tasks may contribute to their high fall rates. A narrow base of support results in a reduced range for positioning one's center of gravity to maintain an upright position. Other disease manifestations, such as shuffling or freezing, may result in one's center of gravity more easily and frequently getting outside ones base of support, resulting in more falls. Future PD gait research should examine base of support during gait and multitasking to confirm this observation.

In contrast, the temporal aspects of gait demonstrated no significant differences between individuals with PD and those without. Individuals with PD took more time and had slower walking speeds while walking with or without secondary tasks than their non-diseased peers, however, which supports previous findings (Morris et al.,1996; O'Shea et al, 2002; Rochester, et al., 2004). This is apparent as individuals with PD tend to be more cautious as they walk. Interestingly, both groups spent nearly identical amounts of time in single support, double support, stance time, step time, and swing time. This is in contrast to other published reports which indicate individuals with PD spend more time in double support (O'Shea, et al., 2002). A closer look at the data reveals that this is true in our sample as well, but significant differences were not achieved, similar to the findings of Bond and Morris (2000).

These temporal findings indicate that individuals with PD, while they take longer to ambulate, are still capable of performing essential aspects of gait at the appropriate time. From a motor behavior perspective, this indicates that the relative timing and the necessary structures to accomplish the timing of the tasks do not appear to be largely impacted by early – moderate

Parkinson's disease. In essence, the relative timing of the movements required remained apparently "normal". This finding is different than Schaafsma et al. (2003) who found that reported PD fallers had impaired stride-to-stride variability when compared to non-fallers with PD, although it is difficult to compare studies without a non-PD control group. It is quite probable that by the time individuals with PD begin to experience falls, changes in the temporal sequence of gait and posture have already occurred. Since this sample was in stage 2 of PD and they may not have regressed to the point where temporal factors are affected. Further research should examine the temporal requirements of gait, under preferred gait only and dual tasking conditions, across PD fallers, PD non-fallers, and non-PD control groups (both fallers and non-fallers) to enhance our understanding the timing sequences of gait and the transition that occurs during the progression of the disease. By isolating these differences, intervention strategies could be developed to help individuals with PD develop and maintain the timing of their movements, as disease progression occurs, to reduce falls and promote the maintenance of independence.

Within group variations between dual tasking conditions and walking alone indicated surprising results. In general, both groups experienced similar changes in their walking pattern while simultaneously completing another task. Both groups had 15 significantly different spatial changes from a dual tasking condition when compared to preferred walk. In addition, individuals with PD had 10 significantly different temporal changes while dual tasking from normal gait and non-PD individuals had 12. This finding suggests that individuals with early – moderate PD employ similar strategies in order to complete dual-tasking tasks and are able to successfully adapt these strategies to properly perform the skills.

The current study was designed to characterize gait patterns in individuals with PD while performing a variety of functional tasks of increasing difficulty. Our findings suggest that individuals with early stage PD have diminished walking performance but appear able to successfully (i.e., similar to non-diseased individuals) allocate the necessary resources to perform, control, and maintain gait similar to that of their preferred walk while simultaneously performing another task. From a motor control perspective, these findings indicate that individuals with early to moderate PD: 1) have intact generalized motor programs for walking that are able to make modifications for successful ambulation to occur; 2) maintain the relative timing of the movements necessary for proper gait functioning; 3) have difficulty in the refinement of their walking generalized motor program which may begin with an inappropriate base of support; 4) use similar strategies as non-diseased peers to maintain gait while simultaneously performing another task; and 5) that task complexity may play an important role in identifying dual tasking and gait relationships.

Appendix A

Spatial and Temporal gait variable definitions*.

Spatial Variables

Base of Support – The perpendicular distance from heel point of one footfall to the line of progression of the opposite foot.

Step Length – Horizontal distance between the heel point of the current footfall to the heel point of the previous footfall on the opposite foot.

Step Width – Distance from the midline midpoint of the current footprint to the midline midpoint of the previous footprint on the opposite foot.

Stride Length – Distance between the heel points of two consecutive footfalls of the same foot.

Stride Width – The vertical distance from midline midpoint of one footprint to the line formed by midline midpoints of two footprints of the opposite foot.

Toe In / Toe Out – The angle between the line of progression and the line connecting the heel point to the forward point of the footfall. A positive angle represents toe out.

Step – Extremity Ratio – Step length divided by leg length of the same leg.

Temporal Variables

Ambulation Time – Time elapsed between the first contacts of the first and last footfalls.

Velocity – Distance travelled divided by Ambulation Time.

Single Support Time – Time elapsed between the last contact of the current footfall to the first contact of the next footfall of the same foot.

Double Support Time – Time elapsed between first contact of the current footfall and the last contact of the previous footfall, added to the time elapsed between the last contact of the current footfall and the first contact of the next footfall.

Stance Time – Time elapsed between the first contact and the last contact of two consecutive footfalls on the same foot.

Step Time – Time elapsed from the first contact of one foot to the first contact of the opposite foot.

Swing Time – Time elapsed between the last contact of the current footfall to the first contact of the next footfall on the same foot.

* Definitions were provided by GAITRite in the GAITRite Manual Version 3.9 and online at: http://www.gaitrite.com/Downloads/GAITRite_Measurement_Definitions.pdf

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Table 4.1: Demographics

Disease State	N	Age (yrs)	Weight (kg)[1]	Height (cm)[1]	Leg Length (cm)[2]	
					Left	Right
MALES						
PD	14	71.47 (6.20)	82.39 (17.96)	176.08 (7.61)	98.37 (7.73)	97.83 (6.25)
Non-PD	14	71.51 (9.93)	82.43 (15.87)	175.08 (12.69)	100.00 (7.00)	100.00 (7.53)
FEMALES						
PD	6	67.95 (8.92)	68.95 (17.91)	163.20 (7.26)	88.48 (6.66)	88.90 (6.17)
Non-PD	6	64.90 (5.99)	71.21 (8.94)	160.02 (5.56)	91.72 (5.61)	91.49 (5.69)
TOTAL						
PD	20	70.42 (7.07)	78.36 (18.58)	172.21 (9.50)	95.41 (8.61)	95.15 (7.37)
Non-PD	20	69.53 (9.30)	79.06 (14.87)	170.56 (12.98)	97.52 (7.55)	97.45 (7.96)

[1] = Significant ($p < 0.05$) gender difference

[2] = Significant ($p < 0.05$) gender difference for the left and right leg

Table 4.2: FAP scores

	PD	Non - PD
Preferred Walk*	87	94
Plate and Cup*	87	94
Tray and Cup*	85	93
Phone*	84	92
Shirt*	82	90

* $p < 0.05$

Table 4.3: Mean (SD) Spatial and Temporal Gait Outcomes between Disease States

	Preferred Walk		Plate and Cup		Tray and Cups	
	PD	Non – PD	PD	Non – PD	PD	Non – PD
Spatial						
Base of Support (cm)	9.81 (2.70)	9.40 (2.40)	9.09 (2.73)	9.03 (2.39)	9.03 (2.75)	9.37 (2.26)
Step Length (cm)	54.05 (10.70)	62.18 (7.36)	54.89 (11.45)	62.27 (7.84)	52.42 (11.37)	60.99 (7.82)
Step Width (cm)	55.65 (10.23)	63.36 (7.18)	56.33 (9.98)	63.34 (7.68)	54.00 (10.75)	62.15 (7.67)
Stride Length (cm)	107.71 (21.71)	124.52 (14.71)	109.45 (22.83)	124.57 (15.71)	104.97 (22.75)	121.92 (15.88)
Stride Width (cm)	12.14 (3.01)	11.22 (2.74)	11.48 (3.11)	10.76 (2.71)	11.63 (3.23)	11.22 (2.47)
Toe In/Toe Out (°)	6.73 (4.35)	4.82 (3.81)	6.45 (4.53)	4.53 (4.33)	7.14 (4.76)	4.87 (4.26)
Step Extremity Ratio	0.57 (0.10)	0.64 (0.07)	0.57 (0.11)	0.64 (0.08)	0.55 (0.11)*	0.63 (0.08)
Temporal						
Ambulation Time (sec)	5.42 (1.65)	4.48 (0.78)	5 .32 (1.86)	4.34 (0.82)	5.42 (2.04)	4.39 (0.83)
Velocity (cm/sec)	104.38 (22.94)	119.63 (17.19)	109.72 (27.40)	123.08 (19.59)	106.69 (26.91)	122.13 (18.90)
Single Support Time (sec)	0.37 (0.05)	0.39 (0.03)	0.37 (0.04)	0.38 (0.03)	0.36 (0.04)	0.37 (0.03)
Double Support Time (sec)	0.30 (0.06)	0.27 (0.04)	0.29 (0.07)	0.26 (0.04)	0.29 (0.07)	0.26 (0.04)
Stance Time (sec)	0.67 (0.08)	0.66 (0.05)	0.65 (0.09)	0.64 (0.06)	0.64 (0.09)	0.63 (0.06)
Step Time (sec)	0.52 (0.05)	0.52 (0.04)	0.51 (0.06)	0.51 (0.04)	0.50 (0.06)	0.50 (0.04)
Swing Time (sec)	0.37 (0.05)	0.39 (0.03)	0.37 (0.05)	0.38 (0.03)	0.36 (0.04)	0.37 (0.03)

* $p < 0.05$

	Phone		Shirt	
	PD	Non – PD	PD	Non – PD
Spatial				
Base of Support (cm)	9.18 (2.92)	9.57 (2.82)	9.60 (3.04)	9.72 (2.62)
Step Length (cm)	50.68 (11.38)*	59.20 (7.16)	48.48 (10.98)*	58.00 (8.68)
Step Width (cm)	52.45 (10.53)*	60.50 (6.93)	50.76 (10.53)*	59.35 (8.46)
Stride Length (cm)	100.98 (22.95)*	118.54 (14.25)	96.16 (21.44)*	116.10 (17.34)
Stride Width (cm)	11.81 (3.54)	11.56 (2.93)	12.36 (3.61)	11.54 (2.88)
Toe In/Toe Out (°)	7.46 (4.87)	5.29 (4.10)	7.74 (5.23)	4.94 (4.30)
Step Extremity Ratio	0.54 (0.11)	0.61 (0.08)	0.51 (0.11)	0.60 (0.09)
Temporal				
Ambulation Time (sec)	6.03 (2.47)	4.76 (0.82)	6.53 (2.96)	4.96 (1.40)
Velocity (cm/sec)	98.03 (24.65)	113.21 (17.79)	92.24 (25.72)	111.75 (21.89)
Single Support Time (sec)	0.37 (0.05)	0.39 (0.03)	0.37 (0.05)	0.39 (0.03)
Double Support Time (sec)	0.32 (0.08)	0.28 (0.05)	0.34 (0.11)	0.29 (0.06)
Stance Time (sec)	0.68 (0.10)	0.67 (0.07)	0.71 (0.14)	0.67 (0.07)
Step Time (sec)	0.53 (0.06)	0.53 (0.05)	0.54 (0.08)	0.53 (0.05)
Swing Time (sec)	0.37 (0.05)	0.39 (0.03)	0.37 (0.05)	0.39 (0.03)

* $p < 0.05$

Table 4.4: Percent Changes from Preferred Walk

	Plate and Cup		Tray and Cup		Phone		Shirt	
Spatial	PD	Non – PD	PD	Non – PD	PD	Non – PD	PD	Non – PD
Base of Support	-7.34*	-3.94	-7.95*	-0.32	-6.42	1.81	-1.12	3.40
Step Length	1.55	-13.39*	-3.02	-15.17*	-6.32*	-17.66*	-10.31*	-19.33*
Step Width	-11.40*	-0.03	-15.07*	-1.91*	-17.52*	-4.51*	-20.16*	-6.33*
Stride Length	1.62	-13.38*	-2.54	-15.22*	-6.25*	-17.57*	-10.72*	-19.27*
Stride Width	2.50	-4.01	3.84	0.00	5.45	3.03	10.36	2.85
Toe In/Toe Out	-4.16	9.95	6.09	18.20	10.85*	28.40*	15.01*	19.90
Step Extremity Ratio	0.00	0.00	-3.51*	-2.03*	-5.26*	-4.84*	-10.53*	-6.71*
Temporal								
Ambulation Time	-1.85	-3.13	0.00	-2.01	11.25	6.25	20.48*	10.71
Velocity	5.12*	2.88	2.21	2.09	-6.08*	-5.37*	-11.63*	-6.59*
Single Support Time	-2.41	-2.06*	-4.55*	-3.86*	-1.87	0.00	-1.34	-1.03
Double Support Time	28.70	-3.70	25.65	-3.70*	38.70*	4.07	48.26*	5.56
Stance Time	-2.55	-3.19*	-3.75*	-5.01*	2.55	1.37	5.70	1.21
Step Time	-2.68	-2.86*	-4.59*	-4.19*	0.96	0.76	3.25	-13.14*
Swing Time	-2.14	-2.31*	-4.81*	-4.10*	-1.87	-0.26	-1.60	-1.28

* Mean was significantly ($p < 0.01$) different than Preferred Walk

Table 4.5: Test Statistics for Repeated Measures ANOVA's with Bonferroni Adjustments Comparing Preferred Walk to Plate and Cup, Tray and Cups, Phone, and Shirt

	Plate and Cup	Tray and Cup	Phone	Shirt	
Spatial					
Base of Support	**$F_{1, 19} = 10.10$** $F_{1, 19} = 2.50$	**$F_{1, 19} = 8.49$** $F_{1, 19} = 0.02$	$F_{1, 19} = 5.49$ $F_{1, 19} = 0.30$	$F_{1, 19} = 0.55$ $F_{1, 19} = 1.32$	PD Non - PD
Step Length	$F_{1, 19} = 2.63$ **$F_{1, 19} = 118.70$**	$F_{1, 19} = 7.31$ **$F_{1, 19} = 165.87$**	**$F_{1, 19} = 15.46$** **$F_{1, 19} = 144.88$**	**$F_{1, 19} = 36.42$** **$F_{1, 19} = 252.24$**	
Step Width	**$F_{1, 19} = 55.34$** $F_{1, 19} = 0.00$	**$F_{1, 19} = 81.93$** **$F_{1, 19} = 9.49$**	**$F_{1, 19} = 118.40$** **$F_{1, 19} = 36.11$**	**$F_{1, 19} = 142.26$** **$F_{1, 19} = 26.74$**	
Stride Length	$F_{1, 19} = 1.78$ **$F_{1, 19} = 109.52$**	$F_{1, 19} = 3.25$ **$F_{1, 19} = 163.45$**	**$F_{1, 19} = 10.90$** **$F_{1, 19} = 131.20$**	**$F_{1, 19} = 23.39$** **$F_{1, 19} = 229.03$**	
Stride Width	$F_{1, 19} = 0.94$ $F_{1, 19} = 3.94$	$F_{1, 19} = 2.34$ $F_{1, 19} = 0.00$	$F_{1, 19} = 3.75$ $F_{1, 19} = 1.21$	$F_{1, 19} = 7.52$ $F_{1, 19} = 1.28$	
Toe In/Toe Out	$F_{1, 19} = 1.50$ $F_{1, 19} = 1.38$	$F_{1, 19} = 3.52$ $F_{1, 19} = 4.26$	**$F_{1, 19} = 15.13$** **$F_{1, 19} = 27.62$**	**$F_{1, 19} = 10.30$** $F_{1, 19} = 4.83$	
Step Extremity Ratio	$F_{1, 19} = 1.07$ $F_{1, 19} = 0.00$	**$F_{1, 19} = 14.30$** **$F_{1, 19} = 8.79$**	**$F_{1, 19} = 17.26$** **$F_{1, 19} = 37.59$**	**$F_{1, 19} = 48.10$** **$F_{1, 19} = 26.04$**	

	Plate and Cup	Tray and Cup	Phone	Shirt	
Temporal					
Ambulation Time	$F_{1, 19} = 0.72$ $F_{1, 19} = 6.12$	$F_{1, 19} = 0.00$ $F_{1, 19} = 2.50$	$F_{1, 19} = 7.26$ $F_{1, 19} = 7.86$	**$F_{1, 19} = 10.38$** $F_{1, 19} = 6.60$	PD Non - PD
Velocity	**$F_{1, 19} = 9.03$** $F_{1, 19} = 4.56$	$F_{1, 19} = 2.24$ $F_{1, 19} = 3.71$	**$F_{1, 19} = 11.56$** **$F_{1, 19} = 14.24$**	**$F_{1, 19} = 43.53$** **$F_{1, 19} = 11.62$**	
Single Support Time	$F_{1, 19} = 3.69$ **$F_{1, 19} = 15.23$**	**$F_{1, 19} = 13.92$** **$F_{1, 19} = 59.69$**	$F_{1, 19} = 0.98$ $F_{1, 19} = 0.03$	$F_{1, 19} = 0.55$ $F_{1, 19} = 1.98$	
Double Support Time	$F_{1, 19} = 2.86$ $F_{1, 19} = 7.59$	$F_{1, 19} = 2.25$ **$F_{1, 19} = 8.62$**	**$F_{1, 19} = 10.62$** $F_{1, 19} = 3.58$	**$F_{1, 19} = 10.66$** $F_{1, 19} = 5.44$	
Stance Time	$F_{1, 19} = 3.28$ **$F_{1, 19} = 16.80$**	**$F_{1, 19} = 8.11$** **$F_{1, 19} = 17.39$**	$F_{1, 19} = 1.91$ $F_{1, 19} = 1.20$	$F_{1, 19} = 4.51$ $F_{1, 19} = 1.11$	
Step Time	$F_{1, 19} = 7.41$ **$F_{1, 19} = 19.30$**	**$F_{1, 19} = 23.05$** **$F_{1, 19} = 64.87$**	$F_{1, 19} = 0.52$ $F_{1, 19} = 0.55$	$F_{1, 19} = 3.25$ **$F_{1, 19} = 155.74$**	
Swing Time	$F_{1, 19} = 3.12$ **$F_{1, 19} = 24.58$**	**$F_{1, 19} = 13.95$** **$F_{1, 19} = 103.70$**	$F_{1, 19} = 0.98$ $F_{1, 19} = 0.20$	$F_{1, 19} = 0.59$ $F_{1, 19} = 3.80$	

$P < 0.01$

CHAPTER 5

LIMITS OF STABILITY IN PARKINSON'S DISEASE

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Abstract

Introduction. Individuals with Parkinson's disease (PD) have difficulty with mobility and balance and are predisposed to falls. The ability to control one's center of gravity (COG) is imperative in maintaining balance during static and dynamic activities necessary for independence and avoiding falls. The purpose of this study was to compare individuals with and without PD on the ability to control their center of gravity. **Methods.** Twelve individuals (mean age = 68.98 ± 8.33) with stage 2 (Hoehn – Yahr scale) Parkinson's disease completed the Limits of Stability (LOS) test (NeuroCom Balance Master) and were compared to 12 non-diseased peers (mean age = 68.29 ± 7.51). **Results.** Multivariate analysis of the LOS overall composite scores indicated individuals with early – moderate PD do not significantly differ from controls on limits of stability ($\Lambda = 0.622$, $F_{5, 18} = 2.19$, $p > 0.05$). Independent Bonferroni adjusted ANOVAs indicated significant group differences on movement velocity ($F_{1, 22} = 10.95$, $p < 0.01$), however. **Discussion.** Individuals with PD display deficient dynamic balance reflected by reduced capabilities to control one's center of gravity. Changes in center of gravity control associated with PD may result in modifications of one's base of support and negatively impact performance of dynamic and complex movements, such as walking while simultaneously performing another task. Future research should identify strategies to maintain and improve PD individuals' center of gravity control and investigate the impact changes on center of gravity control have on balance and gait.

Key Words: Parkinson's disease, Center of gravity, Limits of stability

Introduction.

Individuals with Parkinson's disease (PD) are predisposed to falls (Klawans et al., 1974; Aita, 1982). Recent studies have identified falling rates from 46 – 68% for at least 1 fall and 25 – 50% for multiple (2 or more) falls among this population (Bloem et al., 2001; Wood et al., 2002; Balash, et al., 2005; and Dibble; et al., 2006). This contrasts to 15% single falls and 4% for multiple falls among reported non-diseased control groups (Bloem et al, 2001). Pickering et al. (2007) found a 46% 3 – month fall rate, 57% 1 year fall rate, and a 40% 1 year multiple fall rate based on a meta-analytical review of 6 additional reports on PD falling. In addition, falls in individuals with PD exacerbate the potential for and fear of future falls more than their non-diseased peers (Adkin, et al., 2003; Bloem, et al., 2001). Consequently, a reduction in daily activities may occur because of not only their higher rates of falling but also the fear of future falls (Bloem, et al, 2001).

Horak (2006) discussed 6 areas of resource allocation necessary for postural stability: 1) biomechanical constraints such as degrees of freedom, strength, and limits of stability; 2) movement strategies to return to and maintain equilibrium; 3) sensory information utilization; 4) spatial orientation; 5) control of one's center of mass during dynamic movements; and 6) cognitive processing. Also, it has been previously highlighted that there is a need for proper postural instability analysis among PD populations to identify why such a high fall incidence occurs (Grimbergen et al. 2004). In addition, Zagrodnik (Chapter 4), demonstrated PD individuals had a narrower base of support under various dual-tasking conditions while walking. This finding led the authors to hypothesize that the smaller base of support would provide more opportunities for an individual's center of mass to extend outside his or her base of support

resulting in more falls and recommended future static and dynamic balance investigations should examine this hypothesis. Therefore, this study was designed to investigate the dynamic balance between individuals with and without PD. We hypothesized that individuals with PD would demonstrate reduced limits of stability due in part to adaptations to their base of support.

Methods.

Participants. Individuals identified with early stage idiopathic PD (Hoehn-Yahr stage of 1 or 2) by their neurologist were referred for the study. Potential participants were then screened and were selected for participation based on: 1) being diagnosed by a neurologist with PD in the last 5 years; 2) participant report of first PD-like symptom no more than 7 years ago; and 3) age range between 55 – 85 years. Individuals with fluctuating responses to medication and/or who were unable to ambulate independently for 30 feet were excluded from the study. Individuals with early PD who met the inclusion criteria were matched with non-PD peers based on age, gender, height, and weight. The controls were recruited from the local community. All participants signed an informed consent that was approved by the University Institutional Review Board.

Participants completed a battery of assessments as part of a larger cross-sectional study examining the physical, mental, and emotional health of individuals with early PD that involved three days of testing for each individual with 24 – 72 hours between each testing day. As part of the larger study, participants completed a series of balance assessments, including a limits of stability assessment. Each participant performed a familiarization session on the first day of testing. On day 2 of testing individuals performed the limits of stability assessment with each PD participant performing the assessment 1.5 – 2.0 hours post ingestion of their normal

medication regimen to maximize the "on" phase capabilities to process information and maximize performance capabilities.

Dynamic Balance Assessment. Limits of stability was measured via NeuroCom Balance Master Limits of Stability (Clackamas, OR, USA) assessment. The Limits of Stability (LOS) test utilizes two dual forceplates with force transducers connected to a computer monitor for visual performance. During testing, each participant shifted his/her weight, to move a cursor projected by the computer screen, to one of eight targets surrounding a center starting position: 1) forward; 2) forward-right; 3) right; 4) right-backward; 5) backward; 6) left-backward; 7) left; and 8) forward-left. The participant was instructed to move the cursor as quickly, accurately, and as far as they could for eight seconds to each appropriate target. Each participant was provided a practice session 24 – 72 hours prior to testing and a spotter was present to prevent falls. During testing each participant performed each of the 8 directional movements 1 time to prevent practice effects. If an individual lost balance the trial was repeated 1 additional time.

Reaction time (RT), movement velocity (MV), endpoint excursion (EE), maximum excursion (ME), and directional control (DC) were calculated and composite scores and 4 directional (Forward, Backward, Right, Left) subscores are provided for each variable. Reaction time was defined as the time (in seconds) between the signal to move and the initiation of movement. Smaller reaction times indicate quicker movement initiation and are more desirable then greater reaction times. Movement velocity was defined as the average speed (degrees/second) of the movement of the center of gravity (COG) to the required target. Higher values indicate faster movement of one's COG. Endpoint excursion is the distance traveled by the COG on the initial attempt to reach the desired target, and is expressed as a percentage of

LOS. The initial attempt is identified by the computer when the COG movement speed is zero or the COG moves away from the target. In general, an initial movement occurs to get the COG to the target with multiple and subsequent corrective movements of one's COG to get to the target and stabilize one's COG in the target. Higher values indicate greater distance to the target covered in the initial movement of one's COG. Maximum excursion is the furthest distance travelled by an individual's COG during the attempted trial and is also represented as a percentage of one's LOS. Directional control compares the amount of movement in the intended direction (toward the target) to the amount of extraneous movement (away from the target) and is calculated by the computer by the following equation: [(amount of intended movement – amount of extraneous movement) / amount of intended movement] × 100%. Higher directional control scores indicate better control of movement with a maximum possible score of 100.

Study Design and Data Analysis. A cross-sectional study utilizing multiple one-way ANOVAS to identify demographic differences and a multivariate analysis to identify group differences on limits of stability were utilized. In addition, independent ANOVA's with Bonferroni adjustments were conducted to identify group differences on each outcome. All analyses were performed using SPSS 18 (Chicago, IL) with alpha set at 0.05.

Results.

Twenty individuals with early PD (14 males and 6 females) who met the inclusion criteria were enrolled in the study. Of these, two individuals could not complete the LOS assessment due to excessive amounts of falls, 4 individuals were unable to be tested due to mechanical errors of the force platform, and 2 participants had incomplete data. Therefore, 12 individuals with Parkinson's disease were age, gender, height, and weight matched with 12 non-

diseased controls. Participant demographics can be found in Table 1. No significant differences between genders or groups were found for age or weight. Males were significantly taller than females ($F_{1, 20} = 13.39$; $p < 0.05$) but there was no gender - disease state interaction or significant difference between disease states. All following analyses and reported data are from analyses examining males and females together in their respective disease state groups.

Limits of Stability overall composite scores and composite directional scores can be found in table 2. The multivariate analysis of the RT, MV, EE, ME, and DC composite scores indicated that the groups did not differ in relation to the limits of stability construct ($\Lambda = 0.622$, $F_{5, 18} = 2.19$, $p > 0.05$). Separate independent ANOVA's with Bonferroni adjustments were performed on each variable to identify if group differences existed. Significant group differences on the composite scores of movement velocity ($F_{1, 22} = 10.95$; $p < 0.01$) were found. These results indicate that individuals with PD move their COG significantly slower in space. Bonferroni adjusted ANOVA analyses of the directional composite scores indicated significant differences when moving in the backward and right directions. Individuals with PD had significantly slower movement velocities while going backwards ($F_{1, 22} = 10.22$; $p < 0.01$) and to the right ($F_{1, 22} = 13.09$; $p < 0.01$) than their healthy peers. In addition, individuals with PD demonstrated reduced COG movements as indicated by significantly lower endpoint excursions ($F_{1, 22} = 9.04$; $p < 0.01$) and maximum excursions when moving backward ($F_{1, 22} = 6.26$; $p = 0.01$).

Discussion.

Significant reductions in the speed and distance with which individuals with PD move their COG were evident. Additionally, non-significant results indicate that this population reacts

slower to a visual cue and responds with more unnecessary movements, as indicated by longer reaction times and lower directional control. Overall the findings from this study indicate that individuals with PD have a reduced control of their dynamic balance. This finding remained constant when moving in the backward, right, and left directions. It should be noted that in the forward direction both groups were similar in their responses. This result suggest that individuals with early-moderate PD adopt postural adaptations to remain functional as the individual adapts to successfully produce forward movements. However, this compensatory strategy comes at the cost of reducing the capability to move in the right, left, and backward directions.

Our findings are similar to others who have used the same limits of stability assessment measures among this population. For instance, Nallegowda et al. (2004) found significant decreases in movement velocity, endpoint excursion, maximum excursion, and directional control and non-significant reductions in reaction time between those with PD and matched controls. However, our findings are in contrast to Yang and colleagues (2007) who observed a significant decrease in forward movement velocity. Our results are consistent with others who found reduced postural control during dynamic balance while using different measures of dynamic stability. For instance, Ashburn, et al. (2001) showed that PD fallers had shorter functional reach than PD non-fallers and Mancini et al. (2008) found that individuals with PD had reduced maximal forward and backward movements during leaning tests.

Zagrodnik (Chapter 4) indicated that individuals with PD had narrower bases of support while performing various walking tasks and suggested the reduced base of support could be a potential explanation for the high rates of falls observed in people with PD. Our results suggest

that the narrower base of support often adopted in PD may serve as a protective mechanism the body has adapted to try and reduce falling and the reduced capability to move one's center of gravity at an optimal speed may be the foundation for such changes. For example, if a person takes more time to maneuver his/her center of gravity then they have less time to respond to external or internal perturbations. Consequently, they may fall more often because they cannot optimally shift their center of gravity between their base of support to remain stable. By reducing one's base of support, there is less space necessary to control their center of gravity and in turn may supplement the reduction in movement speed providing a corrective adaptation.

This theory is supported by the reductions in endpoint and maximum excursions that were observed. The limits of stability test employed in this investigation, arranges individuals' feet in predetermined positions based on their height. By demonstrating reduced initial movements (endpoint excursion) and total movements (maximum excursion), despite having identical bases of supports as controls, individuals with PD indicated that modifications in successful center of gravity control to maintain upright stance have occurred. Apparently the balance centers of the brain have been reprogrammed to limit how far the individual is able to shift their center of gravity based on the reduction in velocity control and narrower base of support. In turn, this modification could affect ambulatory capabilities.

Bloem et al. (2006) have suggested that individuals with PD adopt a "posture second" strategy whereby when an individual with PD walks while performing a simultaneous task, he/she will allocate equal resources to all the elements he/she is trying to perform. In contrast, young healthy adults, and to a lesser extent older healthy adults, utilize a "posture first" response to ambulatory dual-tasking, where the individual will limit the performance of one task to ensure

proper and successful performance necessary for gait and balance. Results from our study provide evidence that people with PD may be at a greater risk for falls, in part because of their reduced capability to move their center of gravity fast enough to maintain stability. If individuals with PD are not appropriately allocating resources to maintain posture while walking and have difficulty controlling their center of gravity they will encounter more opportunities to fall.

From a therapeutic or rehabilitation perspective, it is imperative to develop corrective strategies that will improve the speed of one's center of gravity. This study provides evidence that changes among PD individuals' dynamic balance begins with changes in COG control, which may impact comfort in spatial COG movement and changes in base of support. If strategies are developed to maintain and improve COG control among this population, then reductions in falls may occur in both stationary and dynamic movements and may facilitate a resetting to a "posture first" strategy while performing life activities.

In summary, individuals with PD have deficient dynamic balance due to reduced capabilities to control one's center of gravity. Changes in center of gravity control may result in modifications of one's base of support and negatively impact an individual while undergoing dynamic and complex movements, such as walking and simultaneously performing another task. Future research should identify strategies to maintain and improve PD individuals' center of gravity control and investigate the impact these changes have on balance and gait.

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Table 5.1: Demographics

Disease State	N	Age (yrs)	Weight (kg)	Height (cm)[1]
TOTAL				
PD	12	68.98 (8.33)	82.90 (19.91)	175.47 (9.24)
Non-PD	12	68.29 (7.51)	79.76 (11.57)	170.18 (12.15)
MALES				
PD	9	71.07 (7.65)	87.90 (19.02)	179.07 (6.66)
Non-PD	9	68.88 (7.87)	81.40 (11.57)	174.13 (11.06)
FEMALES				
PD	3	62.90 (8.57)	67.90 (16.82)	164.68 (7.66)
Non-PD	3	66.50 (7.50)	74.84 (12.35)	158.33 (6.39)

[1] = Significant ($p < 0.05$) gender difference

Table 5.2: Limits of Stability Composite and Directional Scores

	Reaction Time	Movement Velocity	Endpoint Excursion	Maximum Excursion	Directional Control
Composite					
PD	1.07 (0.34)	**2.53 (0.80)***	56.92 (11.89)	74.00 (15.81)	67.67 (13.01)
Non – PD	0.88 (0.27)	3.68 (0.90)	69.25 (12.14)	85.92 (11.62)	71.08 (8.50)
Forward					
PD	1.19 (0.51)	2.44 (1.20)	50.58 (20.54)	67.50 (21.91)	73.83 (18.67)
Non – PD	1.09 (0.41)	3.06 (1.02)	59.83 (17.67)	77.42 (15.01)	77.08 (9.37)
Backward					
PD	0.90 (0.49)	**1.67 (0.65)***	**42.92 (13.73)***	**58.33 (17.95)***	59.33 (14.16)
Non – PD	0.72 (0.28)	2.69 (0.90)	64.08 (20.16)	75.50 (15.59)	63.50 (12.55)
Right					
PD	1.20 (0.44)	**2.93 (1.04)***	66.17 (17.71)	86.08 (24.19)	67.33 (10.43)
Non – PD	0.83 (0.44)	4.48 (1.06)	70.75 (22.79)	95.92 (18.70)	71.25 (11.54)
Left					
PD	0.97 (0.39)	3.03 (1.51)	67.58 (26.38)	84.08 (25.85)	70.08 (13.27)
Non – PD	0.87 (0.34)	4.43 (1.53)	80.25 (20.62)	92.67 (24.10)	72.00 (11.69)

*** P < 0.05**

CHAPTER 6

CONCLUSIONS

Parkinson's disease is a progressive neurodegenerative disease of the basal ganglia. The reduction of the dopamine neurons of the substantia nigra results in tremors, akinesia, bradykinesia, postural instability, and rigidity. In addition, balance and gait are severely affected and the result is a higher rate of falls. The reduction in dopamine may also result in cognitive impairments and mood disorders, such as depression. Primary treatment remains to be levedopa, with additional medications facilitating the transport and uptake of dopamine. These medications reduce the physical manifestations of PD and may help delay disease progression, but they also may account for some cognitive declines and changes in mood. The physical, cognitive, and emotional changes associated with PD may lead to reductions in quality of life. Therefore a series of studies were designed to assess the overall function, health, and quality of life among individuals with PD. The purposes of these investigations were to: 1) compare the cognitive functioning of individuals with and without PD and identify the relationships between cognition and quality of life; 2) compare spatial and temporal aspects of gait between individuals with and without PD while performing several dual-tasking activities; and 3) to compare the control of individuals with PD's center of gravity to healthy peers.

In the first study, individuals with early – moderate Parkinson's disease completed cognitive, mood, and quality of life assessments and were matched to non-diseased peers. The major findings from this study indicated: 1) individuals with PD have lower cognitive function,

different mood states, and differences in reported quality of life than their non-diseased peers; 2) that cognitive performance among individuals with PD is associated with the type, amount, and care they put into their activities; 3) mood is negatively associated with the mental health of both diseased and non-diseased individuals; and 4) for individuals with PD, mood may play a greater role on quality of life than cognition. In addition, the importance of future research focusing on how changes in cognition and psychiatric impact the quality of life among individuals with PD were highlighted. It was also suggested that intervention strategies aimed at improving cognitive capabilities and enhancing more positive mood states should be conducted to identify how these changes impact quality of life and life expectancy.

In the second study, individuals with early – moderate Parkinson's disease and matched controls performed a series of walking tasks while performing motor or cognitive based activities. It was found that individuals with early stage PD have diminished walking performance but appear able to successfully (i.e., similar to non-diseased individuals) allocate the necessary resources to perform, control, and maintain gait similar to that of their preferred walk while simultaneously performing another task. From a motor control perspective, the findings from this study indicated that individuals with early to moderate PD: 1) have intact generalized motor programs for walking that are able to make the appropriate modifications for successful ambulation to occur; 2) maintain the relative timing of the movements necessary for proper gait functioning is not impacted by the disease; 3) have difficulty in the refinement of their walking generalized motor program which may begin with an inappropriate base of support; 4) use similar strategies as non-diseased peers to maintain gait while simultaneously performing another task; and 5) task complexity may play an important role in identifying dual tasking and gait relationships. Future research should continue to focus on dual-tasking activities

and should modify task complexity and degree of cognitive and motor engagement to identify how these changes impact gait. Results from such studies may indicate how dopamine reduction impacts gait, through motor deficits or through processing deficits. Such knowledge would enable intervention strategies to be developed that may help delay disease progression by maintaining function and independence.

In the third study, individuals with early – moderate Parkinson's disease performed a dynamic stability test to assess their capability to control their center of gravity. It was found that individuals with PD have deficient dynamic balance due to reduced capabilities to control one's center of gravity. And it was suggested that changes in center of gravity control may result in modifications of one's base of support and negatively impact an individual while undergoing dynamic and complex movements, such as walking and simultaneously performing another task. Future research should identify strategies to maintain and improve PD individuals' center of gravity control and investigate the impact these changes have on balance and gait.

The combined results from these studies indicate that individuals with early – moderate Parkinson's disease have reduced functional status and quality of life but they are still able to perform many tasks successfully. Future research should develop specific intervention strategies that challenge the physical and cognitive capabilities of this population at this stage of the disease. Activities that challenge the individual on both the physical and cognitive levels may help reduce disease progression and promote improved mood and therefore improved quality of life. Improved functional status, both physically and mentally, improved mood, and improved quality of life may result in prolonged life.

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APPENDIX A

DESCRIPTION OF THE LARGER STUDY

DESCRIPTION OF THE LARGER STUDY

Participants

Thirty older adults (50 – 80 years) with idiopathic Parkinson's disease will be recruited through the Athens Community Council on Aging Parkinson's Support Group and Athens Neurological Associates. Thirty older adults without Parkinson's disease will be recruited and matched based on age, gender, and level of physical activity. Non-Parkinson's diseased participants will be recruited from a pool of spouses / caretakers of individuals with Parkinson's disease, from the Athens Community Council on Aging, and from participants in the University of Georgia's adult fitness clinic.

Protocol and Testing Procedures

During three separate testing sessions, each participant will complete a battery of questionnaires, blood analyses, and physical performance examinations designed to assess overall function, health, and quality of life. Three testing sessions will be used to reduce any effects of physical and mental fatigue which may result from participation. The first session will involve review and signature of the informed consent form and DEXA waiver, a cardiovascular risk assessment, a cognitive function assessment, a body composition assessment, familiarization of the gait, strength, and balance assessments, and a variety of questionnaires: 1) demographic and medical history questionnaire; 2) CHAMPS physical activity questionnaire; and 3) the SF – 36 quality of life questionnaire. The second session will take place 24 – 72 hours after the completion of session 1 and will a gait assessment, a balance assessment, and a fall risk assessment. In addition three more questionnaires will be completed: 1) Profile of Mood States; 2) the Parkinson's Disease Quality of Life questionnaire; and 3) the 39-item Parkinson's disease

questionnaire. The third, and final, session will occur 24 – 72 hours after the completion of session 2 and will involve a strength assessment.

All sessions will be performed after one hour of ingestion of any Parkinson's disease medications in order to ensure activation of the drugs, particularly L-dopa, and will increase the chances the participant is "on" and at peak motor performance for the motor functioning portions of this study (1 – 4 hours after drug ingestion) (Rosenbaum, 2006). Each participant will be monitored for signs of fatigue and be given 5 minutes of rest time between each assessment. Upon completion of the balance assessment during session 2, each participant will rest in a seated position for 10 minutes. Estimated time to complete the study is 330 - 445 minutes per participant with session 1 taking 150 - 200 minutes, session 2 taking 150 - 200 minutes, and session 3 taking 30 – 45 minutes.

Session 1.

Cardiovascular Risk. Systolic and diastolic blood pressure will be measured with a One Step Auto-Inflation automatic blood pressure monitor (A & D Medical, Model: UA – 767V, Milpita, CA). Blood pressure will be obtained according to the guidelines of the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (Chobanian, et al., 2003): patients will be seated quietly for 5 minutes, with feet flat on the floor, and the arm suspended at heart level.

A fasted blood profile consisting of total cholesterol, high density lipoprotein cholesterol, triglycerides, glucose, total cholesterol / high density lipoprotein cholesterol ratio, non-high density lipoprotein cholesterol, and estimates of low density lipoprotein cholesterol will be measured (Cholestech, Haywood, CA). A blood sample (35 μL) will be taken via pin prick of

the distal segment of the non-dominant hand middle or index fingers. Blood profile sample collection and analysis will be conducted by a trained phlebotomist.

Breakfast. Each participant will be provided a breakfast of apple and orange juice, coffee, and muffins. During the breakfast time, individuals who have not taken their Parkinson's medications will be instructed to do so. A one hour period will follow in which the participant will complete two questionnaires: a demographic and medical history questionnaire and physical activity questionnaire.

Demographic and medical history questionnaire. The demographic and medical history questionnaire (Appendix B) will identify the gender, age, height, weight, living status (alone, with spouse, with family), employment status (working, retired, not working), dwelling status, and the general health of each participant. The general health portion of the questionnaire will identify if the participant has fallen in the past 12 months, how many times in the past 12 months, and the number and type of fractures which may have occurred. In addition, the participant will be asked if, (and if so, when) he or she has been diagnosed or had osteoporosis, diabetes, a heart condition, stoke, arthritis, and/or depression. Finally, the participant will be asked to list any medications he or she is currently taking or has taken in the past 30 days and if a "special" diet has been prescribed by a doctor or attempted by the participant in the last 30 days. A "special" diet could be any diet intended to improve the function or health of an individual that the participant would not normally consume on his/her own. For instance, some individual's with Parkinson's disease may consume a diet high in fish oils in order to avoid taking cholesterol controlling drugs (i.e. Lipitor) which may have negative side effects with their prescribed medications for Parkinson's disease. Individuals with Parkinson's disease will complete a

section identifying the year of disease diagnosis and the major physical deficits he/she experiences (i.e. hand tremors, freezing, etc.).

Community Health Activities Model Program for Seniors (CHAMPS) Activities Questionnaire for Older Adults. The CHAMPS Activities Questionnaire (Stewart, Mills, King, Haskell, Gills, & Ritter, 2000) (Appendix C) contains 41 items in which an older adult is asked for the frequency and total hours per week an individual performs each item. Items include social activities (i.e. visiting friends), golfing, tennis, swimming, gardening, and housework. MET's and caloric expenditure per week can be calculated for all exercise-related activities and for moderate-intensity exercise-related activities. The CHAMPS Activities Questionnaire has been shown to have acceptable reliability and validity (Stewart, et al., 2000, Harada, Chiu, King, Stewart, 2000, & Resnick, King, Riebe, Ory, 2008). The CHAMPS Activities Questionnaire will be completed independently but for individuals who need assistance an interview format will take place. The CHAMPS Activities Questionnaire was selected over other older adult physical activity questionnaires (the Physical Activity Survey for the Elderly (PASE) and the Yale Physical Activity Survey (YPAS)) based on: 1) the findings of Harada, Chiu, King, and Stewart (2000) who found that all three questionnaires have acceptable validity and reliability and that the authors did not find any evidence to support one measure over the others; 2) the findings of Resnick, King, Riebe, and Ory (2008) who found that the CHAMPS Activities Questionnaire was more likely to identify information about moderate-intensity physical activities and was more related to vitality than the YPAS; and 3) the CHAMPS Activities Questionnaire is the only questionnaire of the three which can be administered independently and via interview. That the CHAMPS Activity Questionnaire is similar to other older adult physical activity questionnaires

in obtaining information about physical activity levels and its adaptability were the deciding factors in its selection for this study.

Cognitive Function. The SCales for Outcomes of PArkinson's disease – cognition (SCOPA – COG) will be used to identify the cognitive function of each participant. The SCOPA – COG (Appendix D) was developed by Marinus, et al. (2003) to assess the cognitive deficits associated with Parkinson's disease and consists of ten items with a maximum score of 43 with a higher score reflecting better cognitive performance. The ten items are 1) verbal recall of ten words; 2) repeating a series of numbers backwards; 3) repeating a pointing task; 4) counting backwards by 3's from 30; 5) naming the months of the year in a backwards order starting with December and ending with January; 6) fist-edge-palm movements (The participant makes a fist with palm facing up, then stretches his / her hand, turns over hand and places palm on table. This series is repeated ten times.); 7) naming as many animals as possible in one minute; 8) looking at dice and identifying if the dice are even-odd or higher-lower; 9) assembling patterns with shapes; and 10) delayed recall in which the participant is asked to recall as many of the ten words from item 1 as he/she can. These ten items are distributed between four sub-scales: 1) Memory; 2) Attention; 3) Executive Functions; and 4) Visuospatial Functions. A total score and four sub-scale totals can be calculated. The SCOPA – COG has been shown to be a valid and reliable method of testing cognitive performance and has also been shown to be more sensitive than other cognitive measures (the Cambridge Cognitive Examination or the Mini Mental State Examination, for example) among Parkinson's disease populations (Marinus, 2003).

Body Composition and Bone Mineral Density. Dual energy X-ray (DEXA) will measure the lean and fat tissue (grams) and bone mineral density (grams/centimeters^2) of each participant. Multiple scans will be performed: 1) one total body scan; 2) two hip, trochanter, and femoral

neck scans; 3) one lumbar scan and 4) two wrist scans. The total body scan will identify total lean, fat, and bone content for each individual. The two wrist scans will be used to measure the bone mineral density of the 2nd metacarpal in the left and right wrist. T-scores for the total body scan will be recorded in addition to the total bone mineral density and the bone mineral density for each site.

36 – Item Short – Form Health Survey (SF – 36) Version 2. The SF – 36 (Appendix E) is a five choice self-administered questionnaire which identifies eight health scales among two dimensions. The Physical Functioning, Role-Physical, Bodily Pain, and General Health scales identify the physical dimension of the SF – 36. The mental dimension is composed of the Mental Health, Role – Emotional, Social Functioning, and Vitality scales. The validity and reliability of the SF – 36 has been established (Ware, Snow, Kosinski, et al., 1993) and it has been used in over 1000 studies (Ware, 2000). In addition, a prediction equation has been developed using the 8 SF – 36 scales to estimate quality-adjusted life-years (QALY's). QALY's can be used to express health status in terms of equivalents of well-years of life.

Session 2.

Profile of Mood States. The Profile of Mood States (POMS) which was developed by Mcnair, Loor, and Droppleman (1971) (Appendix F) and will be used to assess the psychological function of each participant. The profile of mood states measures six identifiable mood or affective states: Tension-Anxiety; Depression-Dejection; Anger-Hostility; Vigor-Activity; Fatigue-Inertia; Confusion-Bewilderment across 65 items on a 5 point likert scale (0 = not at all to 4 = extremely). The reliability and validity of the POMS has been well established (Mcnair, Loor,& Droppleman, 1971). Assistance to participants not understanding a word will be provided under the recommendations of Albrecht and Ewing (1989). Six composite scores are

obtained by summing the responses used to define each state as well as a Total Mood Disturbance score which is obtained by summing Tension-Anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, and Confusion-Bewilderment factors and subtracting the Vigor-Activity composite.

Fall Risk Assessment. The fall risk of each participant will be assessed by performance on the Performance Oriented Mobility Assessment (Appendix G) which is also known as the Tinetti Balance and Gait Assessment (Tinetti, Williams, Mayewski, 1986; Tinetti, 1986). The Tinetti Balance Assessment Tool is comprised of two sections: 1) a balance section; and 2) a gait section. The balance section will assess each participant's: 1) sitting balance; 2) rising from a chair; 3) balance while rising; 4) immediate standing balance; 5) standing balance; 6) nudge on sternum; 7) standing with eyes closed; 8) turning 360°; and 9) balance while sitting down. The scores from each balance assessment are summed to develop a composite balance score. The gait section of the Tinettit Balance Assessment Tool involves the assessment of: 1) the initiation of gait; 2) step length and height; 3) foot clearance; 4) step symmetry; 5) step continuity; 6) path deviation; 7) trunk stability; and 8) walking stance. The scores from each gait assessment are summed to develop a composite gait score. The composite balance and composite gait score are then summed to identify the risk of falls. A score of 18 or lower indicates a high risk of falls, a total score of 19 – 23 indicates a moderate risk of falls, and a total score of 24 or greater indicates a low risk of falls. The Tinetti Balance Assessment Tool is considered the "gold standard" for fall assessment in older individuals (Köpke & Meyer, 2006).

Gait. Temporal and spatial gait parameters of each participant will be measured via GAITRite computerized electronic walkway. The GAITRite walkway consists of 6.96 meters of linear ambulatory space with 16,128 sensors arranged in a grid-like pattern. As an individual

ambulates across the walkway activated sensors identify temporal and spatial parameters which are transformed into a Functional Ambulation Profile (FAP). The FAP was developed by Nelson (1974) and is a numerical representation of adult gait and is comprised of the linear relationship of step length/leg length ratio to step time when the velocity is "normalized" to leg length in healthy adults. In healthy adult populations FAP scores range from 95 – 100 points (Nelson, 1974). FAP scores have been shown to be a reliable and valid method of measuring adult gait parameters (Nelson, 1974). In addition to the FAP score, GAITRite records a large number of ambulatory components for each footfall including: step length, step width, stride length, stride width, number of steps, gait speed, and cadence, single support time, double support time, swing time, stance time, toe in / toe out, heel on, heel off, mid-foot on, mid-foot off, toe on, toe off. The validity and reliability of GAITRRite has been documented for health adults (McDonough, Batavia, Chen, Kwon, & Ziai, 2001; Bilney, Morris, & Webster, 2003). The validity of the GAITRite and use of the FAP (for preferred gait) in Parkinson's disease has been established (Nelson, et al., 2002).

For the present study a gait battery was developed, based on the recommendations for future research in a review of gait in Parkinson's disease (Morris, Huxham, McGinley, Dodd, & Iansek, 2001), to attempt to mimic community ambulation or tasks individuals perform frequently while walking. The gait battery consists of 7 tasks: 1) preferred gait; 2) fast gait; 3) buttoning a shirt while walking; 4) walking and carrying a tray with 6 cups; 5) walking and stepping over two hurdles 17.8 centimeters high, spaced 1.83 meters; 6) walking and talking on a cell phone; and 7) an obstacle course in which the participant will weave around four cones placed 1.22 meters apart. Each participant will perform each task three times in a randomized order.

Parkinson's disease quality of life questionnaire. The Parkinson's disease quality of life questionnaire (PDQL) (Appendix H) developed by de Boer, Wijker, Speelman, and de Haes (1996) is a 37 item self-administered measure across four sub-scales: parkinsonian symptoms (13 items); systemic symptoms (7 items); social functioning (7 items); and emotional functioning (9 items). A total composite score can be obtained by adding up the four sub-scale scores. High composite scores indicate a higher perceived quality of life. Each item is answered in terms of how much of a problem each item has been in the past 3 months. The PDQL has been shown to be a valid measure of quality of life for individuals with Parkinson's disease (de Boer, Wijker, Speelman, & de Haes, 1996; Hobson, Holden, Meara, 1999).

Balance. Balance will be assessed by computerized dynamic posturography performed during the Sensory Organization Test on the NeuroCom Equitest System (NeuroCom International, Clackamas, OR). The NeuroCom Equitest System utilizes transducers located in a force platform which measure vertical and horizontal forces that are produced by the body's movement around a fixed base of support (Guskiewicz 2001; Guskiewicz, Riemann, Perrin & Nashner 2001). In addition to the force platform the NeuroCom Equitest System involves a moveable visual surround. Sway referencing of the force plate and / or the visual surround to the body movements of the participant results in inaccurate information being received by the sensory systems. Sway referencing refers to the tilting of the force plat and / or visual surround in relation to the sway of the center of gravity of an individual (Guskiewicz, 2001). Therefore, when the force platform and / or visual surround are being sway referenced they will move in relation an individual's movement of his / her center of gravity. This is in contrast to having a fixed force platform and / or visual surround in which the force platform and / or visual surround will not move in relation to the displacement of an individual's center of gravity. The

NeuroCom Equitest System has proven to be a valid instrument for balance assessment (Guskiewicz, Riemann, Perrin & Nashner 2001).

The NeuroCom Equitest System contains 5 standardized balance assessment protocols including the Sensory Organization Test. The Sensory Organization Test (SOT) assesses the somatosensory, visual, and vestibular information utilized by an individual to maintain balance through 6 conditions. Condition 1 involves the participant standing on a fixed force platform with his / her eyes open and the visual surround in a fixed position. Condition 2 involves the participant standing on a fixed force platform with a fixed visual surround with his/her eyes closed. Condition 3 involves an individual standing on a fixed force platform with a sway referenced visual surround with his / her eyes open. Condition 4 involves the participant standing on a sway referenced force platform with a fixed visual surround with his / her eyes open. Condition 5 involves the participant standing on a sway referenced force platform with a fixed visual surround with his / her eyes closed. Condition 6 involves an individual standing on a sway referenced force platform and a sway referenced visual surround with his / her eyes open. Each condition is performed three times each and each trial lasts 20 seconds. The reliability of the SOT in older adults has been demonstrated (Ford-Smith, Wyman, Eslwick, Fernandez, & Newton, 1995).

39-item Parkinson's disease questionnaire. The 39-item Parkinson's disease questionnaire (PDQ-39) (Appendix I) developed by Petro, Jenkinson, Fitzpatrick, and Greenhall (1995) is a self-administered measure of quality of life across eight dimensions: 1) mobility (10 items); 2) activities of daily living (6 items); 3) emotional well-being (6 items); 4) stigma (4 items); 5) social support (3 items); 6) cognitions (4 items); 7) communications (3 items); and 8) bodily discomfort (3 items). Each dimension is calculated on a scale from 0 to 100 with a score

of 0 indicating no problem for that particular dimension. Each item is answered in relation to how often during the past month an individual has had difficulties or problems with specific tasks and feelings. The PDQ-39 has been shown to have acceptable reliability and validity (Hagell & Nygren, 2007; Jenkinson, Fitzpatrick, Peto, Greenhall, & Hyman, 1997) for identifying the quality of life among individuals with Parkinson's disease.

The SF – 36 (session 1), PDQL, and PDQ-39 quality of life questionnaires will be administered based on the findings of Jenkinson, Peto, Fitapatrick et al. (1995) that the SF-36 may not be sensitive enough to measure the levels of functioning and well-being among those with Parkinson's disease and that more specific measures, such as the PDQ – 39 should be used in conjunction with the SF – 36 with this population. In addition, Marinus, Ramaker, van Hilten, and Stiggelbout (2002) identified that selection of the PDQL and PDQ-39 depends mainly on the goals of the study and that the PDQL highlights more aspects of walking, transfer, motor features (slowness, rigidity, dexterity, shaking/tremors), other disease features (sleeping, drooling, constipation) while the PDQ-39 highlights more aspects of self-care (washing, dressing), daily activities (carrying bags, moving around in public), anxiety, and social and role functioning (embarrassment, relationships). The decision to use all three quality of life questionnaires (the SF – 36, the PDQL, and the PDQ – 39) was based on: 1) the overall goal of this study is to develop an overall picture of function and health and the questionnaires will be more comprehensive in identifying overall functional status than if only one questionnaire would be used; and 2) each questionnaire will take a minimal amount of time (approximately 5 minutes each) and can be completed in either a self-administered or interview method.

Session 3.

Strength. The upper and lower body strength of each participant will be measured by hand held dynamometry using the Arcon Manual Muscle Tester (Hoggan Health Systems, Draper, Utah). Eleven muscle groups will be assessed: ankle plantarflexors, ankle dorsiflexors, knee flexors, knee extensors, hip flexors, hip extensors, wrist extensors, elbow flexors, elbow extensors, shoulder flexors, and shoulder abductors based on previously recommended procedures by Kendall, McCreary, Provance, Rogers, and Romani (2005). Each muscle group will be identified and marked for consistent placement of the Arcon MMT. A make test procedure will be used and each muscle group will be measured three times with the highest value of the three trials used in analysis. The make test involves the examiner holding the dynamometer stationary while the participant exerts a maximum effort against the device (Horvat, Block, and Kelly, 2007 pg 114) The make test differs from the break test in which the participant attempts to hold his/her limb stationary while the examiner exerts a force until the limb gives or breaks. Bohannon (1988) found that while the break test exerts greater forces, the reliability of both tests is similar. Acceptable test-rest reliability of novice testers on the make test indicates has been shown (Wang, Olson, & Protas, 2002). The overall reliability and validity of hand-held dynamometry has been found sufficient based on a review of over 100 studies in which manual muscle testing was employed (Cuthbert & Goodheart, 2007). Summation of the ankle plantarflexors, ankle dorsiflexors, knee flexors, knee extensors, hip flexors, hip extensors will be used to develop a Lower Body Assessment while summation of the wrist extensors, elbow flexors, elbow extensors, shoulder flexors, and shoulder abductors will be used to develop an Upper Body Assessment.

APPENDIX B

PARTICIPANT MEDICAL HISTORY AND DEMOGRAPHIC QUESTIONNAIRE

PARTICIPANT MEDICAL HISTORY AND DEMOGRAPHIC QUESTIONNAIRE

Name: _____ Date of Birth: _____

Address: _____ Phone number: (w) _____

_____ (h) _____

Email: _____

Blood Pressure:_____/_____ (cell) _____

Height: _____ Weight: _____

Gender (circle): Male Female

Ethnicity (circle): Caucasian African American Hispanic Asian Other

Emergency contact name and number:

_____

Family Physician name and number:

_____

Please answer the following questions:

I. GENERAL HEALTH

1. Have you been diagnosed with diabetes? **Y** **N**
   If "yes", please explain
   _____
2. Have you ever had an oral glucose tolerance test? **Y** **N**
   If "yes", please explain
   _____
3. Have you ever been told by a physician that you have Osteoporosis/Osteopenia?
   Y **N**
4. Have you ever been told by a physician that you have a heart condition? **Y** **N**
5. Have you or anyone in your immediate family had a heart attack, stroke, or **Y** **N**

cardiovascular disease before age 50 yrs? If "yes," please explain.

_____

6. Have you ever been told by a physician that you have high blood pressure? **Y** **N**

7. Have you ever been told by a physician that you have high cholesterol? **Y** **N**

8. Have you ever been told by a physician that you have thyroid problems? **Y** **N**

9. Have you ever been told by a physician that you have kidney disease? **Y** **N**

10. Do you feel angina-like symptoms (pain or pressure in your chest, neck, shoulders, or arms) during or after physical activity? **Y** **N**

11. Do you ever lose your balance because of dizziness? **Y** **N**

12. Have you fallen in the last 12 months? **Y** **N**
    If "yes", how many times have you fallen:_____

13. Do you limit activity due to fear of falling? **Y** **N**

14. Do you ever lose consciousness? **Y** **N**

15. Do you consider most of your days very stressful? **Y** **N**

16. Do you consider your eating habits healthy overall? **Y** **N**
    (Lower in fats and fried foods, higher in fruits, veggies and grains)

17. Have you had any major surgeries? **Y** **N**
    If "yes", please explain: _____

18. Do you consider yourself to be generally healthy? **Y** **N**

19. Do you currently smoke cigarettes or cigars or chew tobacco? **Y** **N**
    If "yes", how often and how much: _____

20. Are you a former smoker? **Y** **N**
    If so, how long has it been since you quit smoking? _____

21. Has your weight changed more than 5 pounds in the last 6 months? **Y** **N**

22. Have you been diagnosed with Parkinson's disease? **Y** **N**
    If "yes", when _____

23. Are there any other health related issues we should know about? **Y** **N**
Please explain _____
_____

24. Have you ever been diagnosed with a depression? **Y** **N**
If "yes", please explain _____

25. Have you ever been diagnosed with any additional mental health condition? **Y** **N**
If "yes", please explain _____

26. In the past 30 days have you participated in any "special" diets such as a diet high in fish oils or any diet out or your normal eating habits? **Y** **N**
If "yes", please explain _____

Please make an "X" next to all that apply.

EARS:
_____ hearing difficulty
_____ ringing
_____ pain
_____ discharge
_____ other

NOSE:
_____ bleeding
_____ difficulty smelling
_____ nasal congestion
_____ sinus problems
_____ other

Please explain
_____

PULMONARY:
_____ shortness of breath
_____ wheezing
_____ asthma
_____ chronic cough
_____ allergies
_____ other

Please explain
_____

II. MEDICATION/SUPPLEMENTS

1. Please list all of the **prescription medication** you are currently taking.

Medicine name	Amount taken per day	Months/years on the Medication	Reason
a. _____	_____	_____	_____

b. _____ _____ _____ _____

c. _____ _____ _____ _____

d. _____ _____ _____ _____

e. _____ _____ _____ _____

f. _____ _____ _____ _____

2. Any known allergies? Explain
_____

3. Have you been on steroid medication in the past? **Y** **N**
If so, please explain in detail _____

4. Please list all of the **over-the-counter medicines or supplements** (including vitamins that you take regularly)

Item name	Amount taken per day	Months/years on Medication	Reason
a. _____	_____	_____	_____
b. _____	_____	_____	_____
c. _____	_____	_____	_____
d. _____	_____	_____	_____
e. _____	_____	_____	_____
f. _____	_____	_____	_____

III. REPRODUCTIVE STATUS

1. Have you reached menopause? (if NO skip to Section III) **Y** **N**

2. How long has it been since you reached menopause? _____ **Y** **N**

3. Do you still have your ovaries? _____ **Y** **N**
   a. If not, how old were you when they were removed? _____.

4. Have you ever been on hormone replacement therapy? **Y** **N**

   a. If so, are you still taking hormone replacement therapy? **Y** **N**

   b. If you have previously taken hormone replacement therapy, but have since stopped, when did you stop taking hormone replacement therapy? _____

5. Have you ever taken osteoporosis medications? **Y** **N**

   Which ones and for how long? _____

IV. OSTEOPOROSIS/FRACTURE/BONE HEALTH SECTION

1. Have you ever had a bone scan? **Y** **N**
   If so, what year _____
   What was the outcome_____

2. Please provide a list of any bone fractures you have had in the past.

Bone	Cause (fall, accident, etc)	Year
_____	_____	
_____	_____	

3. Did either of your parent's experience a bone fracture? **Y** **N**
   ?

   If so, do you know which bone (s)? _____

4. Did a doctor tell you that any of these fractures were due to osteoporosis/osteopenia? **Y** **N**

5. Is your diet low in dairy products? **Y** **N**

6. Do you take calcium supplements? **Y** **N**
   If so, how much per day? _____

7. Do you take systemic corticosteroids? **Y** **N**

8. In a typical day, how many alcoholic drinks do you consume? _____
9. Do you drink coffee, tea, or cola products routinely? **Y** **N**
   About how much coffee, tea, or cola do you drink on an average day? _____

10. Do you have rheumatoid arthritis? **Y** **N**

11. Do you have a heart valve or implant devices such as knee, hip ect.? **Y** **N**

12. Do you get claustrophobic in small spaces? **Y** **N**

V. SUN EXPOSURE

1. How many times a week do you spend more than 10 minutes outside? _____
2. How much time do you spend outdoors (minutes) per week?_____
3. How much of your outdoor time is spent without sunscreen on (minutes)?_____
4. How much of your outdoor time is spent "fully exposed" (minutes)?_____
   ("fully exposed" is defined as uncovered face, arms, and hands)

VI. EXERCISE HABITS

1. How many times per week do you generally exercise?
   _____

   a. What type(s) of exercise do you generally perform? (circle all that apply)

Walking	Running	Bicycling	Swimming
Weight Lifting	Aerobics	Spinning	Tennis
Other			

   _____

   b. In a typical week, how may days do you exercise ? (circle)

0-1 time/week	2-3 times/week	4-6 times/week	daily

   c. How many minutes do you typically exercise per session (circle)

<15 min	15-30 min	30-45	>45

   Other_____

   d. What is the typical level of exertion during your exercise?

Light	Moderate	Moderate/Heavy	Heavy

   e. When you are exercising do you ever feel limited by the following?

	Yes	No	Activity
Breathing	___	___	_____

Chest arm neck pain	___	___	_____
Low back pain	___	___	_____
Side ache	___	___	_____
Leg pain	___	___	_____
Foot drop	___	___	_____

Other? Please explain _____
_____

VII. PARKINSON'S DISEASE STATUS (Please skip to Section IV if you do not have Parkinson's disease)

1. How long have you been diagnosed with Parkinson's Disease?
   _____
2. When did you have your first PD symptom?
   _____
3. Has your physician ever discussed what type of PD you have? **YES NO**

Idiopathic PARK Gene Alpha Syneuclin MPPT OTHER
_____

4. Have you ever performed the United Parkinson's Disease Rating Scale? **YES NO**
   If yes, what is your UPDRS Score? _____
5. Have you ever performed the Hoehn-Yahr Scale? **YES NO**
   If yes, what is your Hoehn-Yahr Score? _____
6. Briefly described your current PD symptoms
   _____
   _____
   ____
7. Does PD affect your legs? **YES NO** Does PD affect your arms? **YES NO**

If yes, which legs is more involved? Right Left Both same
If yes, which arm is more involved? Right Left Both same

8. Do you fatigue easily? **YES NO**
If yes, what causes it to be worse?

_____

_____

_____

9. Do you ever experience worsening of symptoms? **YES NO**

	YES	**NO**	**How often?**
Bath/shower	____	____	_____
Physical activity	____	____	_____
Hot outside	____	____	_____

10. Do you drive yourself independently? **YES** **NO**

11. Do you walk (circle) w/o aid with cane walker wheelchair

12. Has your physician ever recommended that you get a bone scan?_____

13. Has you physician ever recommended that you exercise? _____

IV. CURRENT EMPLOYMENT STATUS

1. Full-time employed ____
2. Part-time employed ____
3. Retired ____
4. Not working ____

X. EDUCATION

What is the highest level of education you have attained?

1. None ____
2. Less than 8th Grade ____
3. High school incomplete ____
4. High school complete ____
5. College / Trade school incomplete ____

6. College / Trade school complete ____

7. Masters ____

8. Ph.D. ____

9. Other ____

Please explain_____

XI. DWELLING AND CO-HABITATION STATUS

In what type of dwelling do you currently reside in?

1. Single – family house ____

2. Apartment , condo, or townhouse ____

3. Mobile home / trailer ____

4. Group home ____

5. Retirement community ____

6. Assisted living facility ____

7. Nursing home ____

What is your marital status?

1. Single, never married ____

2. Married ____

3. Separated or divorced ____

4. Widowed ____

5. Other _____

Who currently resides with you? (Check all that apply)

1. No one (lives alone) ____

2. Spouse ____

3. Child(ren) ____

4. Other relatives ____

5. Friend(s) ____

6. Non-related paid helper ____

I certify that these answers are accurate and complete

_____ _____

YOUR SIGNATURE DATE

APPENDIX C

CHAMPS PHYSICAL ACTIVITY QUESTIONNAIRE

FOR OLDER ADULTS

CHAMPS Activities Questionnaire for Older Adults

CHAMPS: Community Healthy Activities Model Program for Seniors
Institute for Health & Aging, University of California San Francisco
Stanford Center for Research in Disease Prevention, Stanford University

Contact: Anita L. Stewart, Ph.D., UCSF, anitast@itsa.ucsf.edu

Date:_____

This questionnaire is about activities that you may have done in the past 4 weeks. The questions on the following pages are similar to the example shown below.

INSTRUCTIONS

If you DID the activity in the past 4 weeks:
Step #1 Check the YES box.

Step #2 Think about how many TIMES a week you usually did it, and write your response in the space provided.

Step #3 Circle how many TOTAL HOURS in a typical week you did the activity.

Here is an example of how Mrs. Jones would answer question #1: Mrs. Jones usually visits her friends Maria and Olga twice a week. She usually spends one hour on Monday with Maria and two hours on Wednesday with Olga. Therefore, the total hours a week that she visits with friends is 3 hours a week.

In a typical week during the past 4 weeks, did you…							
1. Visit with friends or family (other than those you live with)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

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If you DID NOT do the activity:

- **Check the NO box and move to the next question**

In a typical week during the past 4 weeks, did you …							
1. Visit with friends or family (other than those you live with)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
2. Go to the senior center? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
3. Do volunteer work? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
4. Attend church or take part in church activities? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
5. Attend other club or group meetings? ☐ **YES** How many TIMES a week?____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
6. Use a computer? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
7. Dance (such as square, folk, line, ballroom) (do <u>not</u> count aerobic dance here)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
8. Do woodworking, needlework, drawing, or other arts or crafts? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
9. Play golf, carrying or pulling your equipment (count walking time only)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
10. Play golf, riding a cart (count walking time only)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
11. Attend a concert, movie, lecture, or sport event? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
12. Play cards, bingo, or board games with other people? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
13. Shoot pool or billiards? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
14. Play singles tennis (do not count doubles)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
15. Play doubles tennis (do not count singles)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
16. Skate (ice, roller, in-line)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
17. Play a musical instrument? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
18. Read? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
19. Do heavy work around the house (such as washing windows, cleaning gutters)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
20. Do light work around the house (such as sweeping or vacuuming)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
21. Do heavy gardening (such as spading, raking)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
22. Do light gardening (such as watering plants)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
168 23. Work on your car, truck, lawn mower, or other machinery? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
****Please note: For the following questions about running and walking, include use of a treadmill.**							
24. Jog or run? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
25. Walk uphill or hike uphill (count only uphill part)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
26. Walk fast or briskly for exercise (do not count walking leisurely or uphill)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
27. Walk to do errands (such as to/from a store or to take children to school (count walk time only)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
28. Walk leisurely for exercise or pleasure? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
29. Ride a bicycle or stationary cycle? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
30. Do other aerobic machines such as rowing, or step machines (do not count treadmill or stationary cycle)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
31. Do water exercises (do not count other swimming)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
32. Swim moderately or fast? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
33. Swim gently? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
34. Do stretching or flexibility exercises (do <u>not</u> count yoga or Tai-chi)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
35. Do yoga or Tai-chi? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
36. Do aerobics or aerobic dancing? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL <u>hours a week</u> did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
37. Do moderate to heavy strength training (such as hand-held weights of more than 5 lbs., weight machines, or push-ups)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
38. Do light strength training (such as hand-held weights of 5 lbs. or less or elastic bands)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
39. Do general conditioning exercises, such as light calisthenics or chair exercises (do not count strength training)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

In a typical week during the past 4 weeks, did you …							
40. Play basketball, soccer, or racquetball (do not count time on sidelines)? ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours
41. Do other types of physical activity not previously mentioned (please specify)? _____ ☐ **YES** How many TIMES a week?_____ ➔ ☐ **NO**	How many TOTAL hours a week did you usually do it? ➔	Less than 1 hour	1-2½ hours	3-4½ hours	5-6½ hours	7-8½ hours	9 or more hours

Thank You

APPENDIX D

SCALES FOR OUTCOMES OF PARKINSON'S DISEASE - COGNITION (SCOPA – COG)

SCOPA-COG

Memory and learning

1. *Verbal recall*

Ten words are repeatedly shown for at least 4 seconds, get the patient to read them out loud, the time allowed for recall is unlimited. Underline each word that has been named. When words are named that were not shown, no penalty is given. When a false answer is changed (e.g. king into queen), it is correct.

Instruction: "Read the following 10 words aloud and try to remember as many as possible. After reading them all, name as many words as possible, the order of the words is not important".

10 words: Butter arm shore letter queen cabin pole ticket grass engine

(10 correct = 5, 8-9 correct = 4, 6-7 correct = 3, 5 correct = 2, 4 correct = 1, ≤ 3 correct= 0)

score ……../5

2. *Digit span backward*

Ask the patient to repeat a series of numbers backwards; the numbers are read out separately, 1 second per number; if incorrectly repeated, the alternative in the second column is presented. Continue until both the first and the alternative series are repeated incorrectly. Make sure the time interval between numbers stays the same. Read the numbers calmly and make sure the time between numbers is equal. Record the highest series that is repeated correctly at least once; Give an example: "If I say 2-7-3, than you say (3-7-2)

backwards		score:
2-4	5-8	= 1
6-2-9	4-1-5	= 2
3-2-7-9	4-9-6-8	= 3
1-5-2-8-6	6-1-8-4-3	= 4
5-3-9-4-1-8	7-2-4-8-5-6	= 5
8-1-2-9-3-6-5	4-7-3-9-1-2-8	= 6
9-4-3-7-6-2-5-8	7-2-8-1-9-6-5-3	= 7

score ……../7

SCOPA-COG

3. *Indicate cubes*

Point to the cubes in the order given below; the patient should copy this; do this slowly; the patient decides for himself with which hand he/she prefers. Indicate the cubes in the order as indicated. Observe carefully if the patient copies the order correctly. When a patient wants to correct a mistake, let him/her do the complete order again. This is not counted as a mistake. However, if the patient forgets the order and would like to see the order a second time, the researcher does not repeat the order again but starts with the next order.

1 2 3 4

a. 1-2-4-2
b. 1-2-3-4-3
c. 3-4-2-1-4
d. 1-4-2-3-4-1
e. 1-4-2-3

score ……../5

Attention

4. *Counting backwards (30 to 0)*

Instruction: "Would you subtract three from 30, and subtract three again from the result and continue till zero?".

Mistakes can be: the order, missing or not knowing a number, or not finishing off the series. Record the order of numbers named by the patient. If the patient asks where to start or how much to subtract, the researcher repeats the instructions but counts that as one mistake. If the patient makes a mistake but continues from that point to subtract three, it is only one mistake. If the patient stops the order and starts all over again, it is one mistake.

(0 mistakes = 2, 1 mistake = 1, ≥ 2 mistakes = 0)

score ……../2

5. *Months backwards*

Instruction: "Name the months of the year in reverse order, starting with the last month of the year".

Mistakes are: the order, missing or not knowing the next month, or not finishing off the series. Underline the months that are named correctly. When a month is passed over, this is a mistake, even if the patient corrects it later on. If the patient stops the order and starts all over again, it is one mistake. If the patient starts naming the month forward, repeat the instructions and count it as one mistake.

Dec- Nov-Oct-Sept-Aug-July-June-May-April-March-Feb-Jan.

(0 mistakes = 2, 1 mistake = 1, ≥ 2 mistakes = 0)

score ……../ 2

Executive functions

6. *Fist-edge-palm*

1. fist with ulnar side down, 2. stretched fingers with ulnar side down, 3. stretched fingers with palm down; Practice 5 times together with the patient, the patient chooses which hand he/she prefers. Do it slowly and tell the patient to watch carefully and repeat what you are doing. Practice first 5 rounds, with verbal help, e.g. FIST- STRETCH-PALM. Then tell the patient to make the movements alone.

Instructions: "Now it is your turn to make the three movements, fist-stretch-palm, 10 times in a row. You don't have to count, I will tell you when to stop".

Note the number of correct trios from a total of 10; Count carefully but not out loud. Every time a patient makes a wrong movement, count it as a mistake, even when the patient corrects it halfway.

(10 correct = 3, 9 correct = 2, 8 correct = 1, ≤ 7 correct = 0)

score ……../3

7. *Semantic fluency*

Tell the patient to name as many animal as he/she knows in one minute. Note all answers that are given by the patient. No repetition or variations of words, such as lion-lioness, tiger-tigress; categories are allowed, bird and pigeon are both correct. Count the number of animals correctly named. The purpose is that the patient generates the animals actively, therefore no clues are allowed. When the patient asks whether, for instance, naming different types of birds is allowed, this may be confirmed. When the patient almost immediately says he/she does not know any more animals, try to

stimulate the patient by saying "there is still a lot of time left", but do not give clues. When the patient starts naming other things than animals, do not correct the patient. Naming other things besides animals is not counted as an additional mistake.

(≥ 25 correct = 6, 20-24 = 5, 15-19 = 4, 10-14 = 3, 5-9 = 2, 1-4 = 1 0=0)

number of animals correct: .....

score ...../6

Write down all animals named:

8. *Dice*

Use 2 cards, one with YES = EVEN, NO = ODD; one with YES = HIGHER, NO = LOWER. Put the correct card face up next to the explanation of the test and make sure that the other, irrelevant card is out of sight. The first round (situation 1) is not scored, and the patient is corrected if necessary.

Situation 1: YES = EVEN

Put the card "YES=EVEN, NO=ODD" on the table and leave it there during the test.

Instruction: "Say YES for an even number on a dice and NO for an odd number, when you see a picture of a dice with an EVEN number of pips, I would like you to say YES, and NO when the number of pips is ODD".

Show the first two examples (3 even and 3 odd dices) and ask the patient "If you see one of these dice, do you say yes or no?" Tell the patient if the answer is correct or not. If the answer is not correct, explain why. It is important that the patient says YES or NO and not EVEN or ODD. Show the next two examples (with only one dice) and ask the patient "if you see this dice, do you say yes or no?" Tell the patient if the answer is correct or not. If the answer is not correct, explain why.

Then show the patient the following 10 dices. Correct the patient if the answer is wrong.

Situation 2: YES = HIGHER

With the card "example 1" (dice with 3 pips) the next condition starts. Put the card "YES=HIGHER, NO=LOWER" on the table and remove the former card.

Instruction: "Now, we change the test a little. When you see a picture of a dice that is higher than de dice on the page before, you say YES. When the dice is lower, you say NO".

Tell the patient you have an example (example 1). "Try to remember this dice" (turn the page) "Is this YES or NO?" Tell the patient whether the answer is correct or not. If the answer is not correct, explain why. Continue with example 2 and say "now remember this dice"(turn the page) "Is this YES or NO?" Tell the patient if the answer is correct or not. If the answer is not correct, explain why.

Then start the test and show all 10 dices one after another. The first response counts and corrections are not allowed. Do NOT correct when a wrong answer is given. If a patient corrects a wrong answer, it is still counted as a mistake. If the patient asks for the instruction, the researcher explains but that is counted as one mistake.

(10 correct = 3, 9 correct = 2, 8 correct =1, ≤ 7 correct = 0)

number correct: …./10

score ……../3

Visuo-spatial functions

9. *Assembling patterns*

The patient is shown 5 incomplete patterns and has to choose 2 or 3 shapes out of 4 to 6 possible alternatives in order to complete the pattern. First practice 2 figures.

Show the patient example A and give the instruction to choose the shapes that form the pattern. Tell the patient if the answer is correct or not. If the answer is not correct, explain why and give the correct solution. Repeat this with example B. Then show the 5 patterns. Do not tell the patient whether the answer is correct or not. There is no time limit. If the patient corrects a wrong answer, this is not counted as a mistake.

a. b. c. d. e.

score ……../5

SCOPA-COG

Memory

10. Delayed recall

Instruction: "Can you name as many as possible of the 10 words that you learned during the first test? "

Underline each word that has been named. When words are named that were not shown, no penalty is given. When a false answer is changed (e.g. king into queen), it is correct.

10 words: butter arm shore letter queen cabin pole ticket grass engine

(10 correct = 5, 8-9 correct = 4, 6-7 correct = 3, 5 correct = 2, 4 correct = 1, ≤ 3 correct= 0)

number of correct words: …. /10

score ……../5

Total COG score: … /43

APPENDIX E

36 – Item Short – Form Health Survey (SF – 36)

Your Health and Well-Being

This survey asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities. ***Thank you for completing this survey!***

For each of the following questions, please mark an ☒ in the one box that best describes your answer.

1. In general, would you say your health is:

Excellent	Very good	Good	Fair	Poor
☐1	☐2	☐3	☐4	☐5

2. <u>Compared to one year ago</u>, how would you rate your health in general <u>now</u>?

Much better now than one year ago	Somewhat better now than one year ago	About the same as one year ago	Somewhat worse now than one year ago	Much worse now than one year ago
☐1	☐2	☐3	☐4	☐5

3. The following questions are about activities you might do during a typical day. Does <u>your health now limit you</u> in these activities? If so, how much?

	Yes, limited a lot	Yes, limited a little	No, not limited at all
a Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	☐ 1	☐ 2	☐ 3
b Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	☐ 1	☐ 2	☐ 3
c Lifting or carrying groceries	☐ 1	☐ 2	☐ 3
d Climbing several flights of stairs	☐ 1	☐ 2	☐ 3
e Climbing one flight of stairs	☐ 1	☐ 2	☐ 3
f Bending, kneeling, or stooping	☐ 1	☐ 2	☐ 3
g Walking more than a mile	☐ 1	☐ 2	☐ 3
h Walking several hundred yards	☐ 1	☐ 2	☐ 3
i Walking one hundred yards	☐ 1	☐ 2	☐ 3
j Bathing or dressing yourself	☐ 1	☐ 2	☐ 3

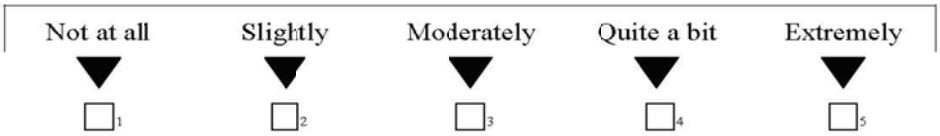
4. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Cut down on the amount of time you spent on work or other activities	☐1	☐2	☐3	☐4	☐5
b Accomplished less than you would like	☐1	☐2	☐3	☐4	☐5
c Were limited in the kind of work or other activities	☐1	☐2	☐3	☐4	☐5
d Had difficulty performing the work or other activities (for example, it took extra effort)	☐1	☐2	☐3	☐4	☐5

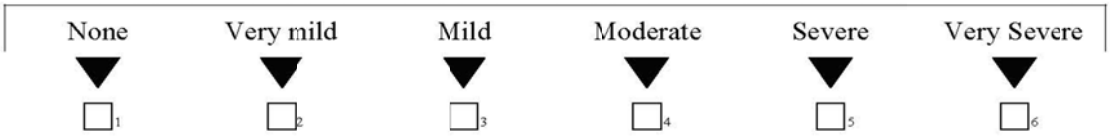
5. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Cut down on the amount of time you spent on work or other activities	☐1	☐2	☐3	☐4	☐5
b Accomplished less than you would like	☐1	☐2	☐3	☐4	☐5
c Did work or other activities less carefully than usual	☐1	☐2	☐3	☐4	☐5

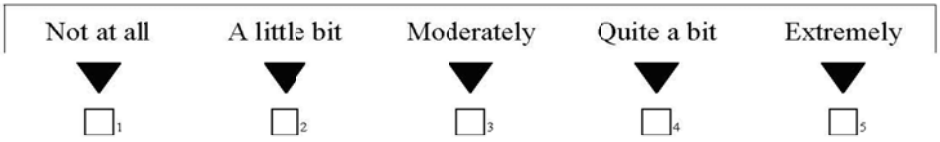
6. **During the <u>past 4 weeks</u>, to what extent has your <u>physical health or emotional problems</u> interfered with your normal social activities with family, friends, neighbors, or groups?**



7. **How much <u>bodily</u> pain have you had during the <u>past 4 weeks</u>?**



8. **During the <u>past 4 weeks</u>, how much did <u>pain</u> interfere with your normal work (including both work outside the home and housework)?**



9. **These questions are about how you feel and how things have been with you <u>during the past 4 weeks</u>. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the <u>past 4 weeks</u>...**

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Did you feel full of life?	☐1	☐2	☐3	☐4	☐5
b Have you been very nervous?	☐1	☐2	☐3	☐4	☐5
c Have you felt so down in the dumps that nothing could cheer you up?	☐1	☐2	☐3	☐4	☐5
d Have you felt calm and peaceful?	☐1	☐2	☐3	☐4	☐5
e Did you have a lot of energy?	☐1	☐2	☐3	☐4	☐5
f Have you felt downhearted and depressed?	☐1	☐2	☐3	☐4	☐5
g Did you feel worn out?	☐1	☐2	☐3	☐4	☐5
h Have you been happy?	☐1	☐2	☐3	☐4	☐5
i Did you feel tired?	☐1	☐2	☐3	☐4	☐5

10. **During the <u>past 4 weeks</u>, how much of the time has your <u>physical health or emotional problems</u> interfered with your social activities (like visiting friends, relatives, etc.)?**

All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐1	☐2	☐3	☐4	☐5

11. How TRUE or FALSE is <u>each</u> of the following statements for you?

	Definitely true	Mostly true	Don't know	Mostly false	Definitely false
a I seem to get sick a little easier than other people	☐1	☐2	☐3	☐4	☐5
b I am as healthy as anybody I know	☐1	☐2	☐3	☐4	☐5
c I expect my health to get worse	☐1	☐2	☐3	☐4	☐5
d My health is excellent	☐1	☐2	☐3	☐4	☐5

THANK YOU FOR COMPLETING THESE QUESTIONS!

APPENDIX F

PROFILE OF MOOD STATES (POMS)

POM180

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

Client ID: _____ **Age:** _____ **Gender:** Male Female (Circle one)

Birth Date: ____/____/____ (Month / Day / Year) **Today's Date:** ____/____/____ (Month / Day / Year)

To the Administrator:

Place a checkmark ✔ in one box to specify the time period of interest.

To the Respondent:

Below is a list of words that describe feelings that people have. Please read each word carefully. Then circle the number that best describes

- ☐ how you have been feeling during the PAST WEEK, INCLUDING TODAY.
- ☐ how you feel RIGHT NOW.
- ☐ other: _____

If no box is marked, please follow the instructions for the first box.

POMS™

		Not at all	A little	Moderately	Quite a bit	Extremely
1.	Friendly	0	1	2	3	4
2.	Tense	0	1	2	3	4
3.	Angry	0	1	2	3	4
4.	Worn out	0	1	2	3	4
5.	Unhappy	0	1	2	3	4
6.	Clear-headed	0	1	2	3	4
7.	Lively	0	1	2	3	4
8.	Confused	0	1	2	3	4
9.	Sorry for things done	0	1	2	3	4
10.	Shaky	0	1	2	3	4
11.	Listless	0	1	2	3	4
12.	Peeved	0	1	2	3	4
13.	Considerate	0	1	2	3	4
14.	Sad	0	1	2	3	4
15.	Active	0	1	2	3	4
16.	On edge	0	1	2	3	4
17.	Grouchy	0	1	2	3	4
18.	Blue	0	1	2	3	4
19.	Energetic	0	1	2	3	4
20.	Panicky	0	1	2	3	4
21.	Hopeless	0	1	2	3	4
22.	Relaxed	0	1	2	3	4
23.	Unworthy	0	1	2	3	4
24.	Spiteful	0	1	2	3	4
25.	Sympathetic	0	1	2	3	4
26.	Uneasy	0	1	2	3	4
27.	Restless	0	1	2	3	4
28.	Unable to concentrate	0	1	2	3	4
29.	Fatigued	0	1	2	3	4
30.	Helpful	0	1	2	3	4

Please flip over.
Items continue on the back page...

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

POMS™

		Not at all	A little	Moderately	Quite a bit	Extremely
31.	Annoyed	0	1	2	3	4
32.	Discouraged	0	1	2	3	4
33.	Resentful	0	1	2	3	4
34.	Nervous	0	1	2	3	4
35.	Lonely	0	1	2	3	4
36.	Miserable	0	1	2	3	4
37.	Muddled	0	1	2	3	4
38.	Cheerful	0	1	2	3	4
39.	Bitter	0	1	2	3	4
40.	Exhausted	0	1	2	3	4
41.	Anxious	0	1	2	3	4
42.	Ready to fight	0	1	2	3	4
43.	Good natured	0	1	2	3	4
44.	Gloomy	0	1	2	3	4
45.	Desperate	0	1	2	3	4
46.	Sluggish	0	1	2	3	4
47.	Rebellious	0	1	2	3	4
48.	Helpless	0	1	2	3	4
49.	Weary	0	1	2	3	4
50.	Bewildered	0	1	2	3	4
51.	Alert	0	1	2	3	4
52.	Deceived	0	1	2	3	4
53.	Furious	0	1	2	3	4
54.	Efficient	0	1	2	3	4
55.	Trusting	0	1	2	3	4
56.	Full of pep	0	1	2	3	4
57.	Bad-tempered	0	1	2	3	4
58.	Worthless	0	1	2	3	4
59.	Forgetful	0	1	2	3	4
60.	Carefree	0	1	2	3	4
61.	Terrified	0	1	2	3	4
62.	Guilty	0	1	2	3	4
63.	Vigorous	0	1	2	3	4
64.	Uncertain about things	0	1	2	3	4
65.	Bushed	0	1	2	3	4

Please ensure you have answered every item.
Thank you for completing this questionnaire.

APPENDIX G

PERFORMANCE ORIENTATED MOBILITY ASSESSMENT

TINETTI BALANCE ASSESSMENT TOOL

Tinetti ME, Williams TF, Mayewski R, Fall Risk Index for elderly patients based on number of chronic disabilities. Am J Med 1986:80:429-434

PATIENTS NAME _____ D.o.b. _____ Ward _____

BALANCE SECTION

Patient is seated in hard, armless chair;

		Date		
Sitting Balance	Leans or slides in chair Steady, safe	= 0 = 1		
Rises from chair	Unable to without help Able, uses arms to help Able without use of arms	= 0 = 1 = 2		
Attempts to rise	Unable to without help Able, requires > 1 attempt Able to rise, 1 attempt	= 0 = 1 = 2		
Immediate standing Balance (first 5 seconds)	Unsteady (staggers, moves feet, trunk sway) Steady but uses walker or other support Steady without walker or other support	= 0 = 1 = 2		
Standing balance	Unsteady Steady but wide stance and uses support Narrow stance without support	= 0 = 1 = 2		
Nudged	Begins to fall Staggers, grabs, catches self Steady	= 0 = 1 = 2		
Eyes closed	Unsteady Steady	= 0 = 1		
Turning 360 degrees	Discontinuous steps Continuous	= 0 = 1		
	Unsteady (grabs, staggers) Steady	= 0 = 1		
Sitting down	Unsafe (misjudged distance, falls into chair) Uses arms or not a smooth motion Safe, smooth motion	= 0 = 1 = 2		
	Balance score		/16	/16

P.T.O.

TINETTI BALANCE ASSESSMENT TOOL

GAIT SECTION

Patient stands with therapist, walks across room (+/- aids), first at usual pace, then at rapid pace.

		Date		
Indication of gait (Immediately after told to 'go'.)	Any hesitancy or multiple attempts No hesitancy	= 0 = 1		
Step length and height	Step to Step through R Step through L	= 0 = 1 = 1		
Foot clearance	Foot drop L foot clears floor R foot clears floor	= 0 = 1 = 1		
Step symmetry	Right and left step length not equal Right and left step length appear equal	= 0 = 1		
Step continuity	Stopping or discontinuity between steps Steps appear continuous	= 0 = 1		
Path	Marked deviation Mild/moderate deviation or uses w. aid Straight without w. aid	= 0 = 1 = 2		
Trunk	Marked sway or uses w. aid No sway but flex. knees or back or uses arms for stability No sway, flex., use of arms or w. aid	= 0 = 1 = 2		
Walking time	Heels apart Heels almost touching while walking	= 0 = 1		
	Gait score		/12	/12
	Balance score carried forward		/16	/16
	Total Score = Balance + Gait score		/28	/28

Risk Indicators:

Tinetti Tool Score	Risk of Falls
≤18	High
19-23	Moderate
≥24	Low

APPENDIX H

PARKINSON'S DISEASE QUALITY OF LIFE QUESTIONNAIRE (PDQL)

THE PARKINSON'S DISEASE QUALITY OF LIFE QUESTIONNAIRE (PDQL)

The following questions are about your health, your feelings and your social activities, mostly in connection with your disease.

We would like to know **how often** you were bothered by the problems mentioned below **during the last 3 months**.

How often during the last 3 months did you have trouble with the following:

	All of the time	Most of the time	Some of the time	A little of the time	Never
1. stiffness?	1	2	3	4	5
2. feeling generally unwell?	1	2	3	4	5
3. you are no longer able to do your hobbies?	1	2	3	4	5
4. being tense?	1	2	3	4	5
5. feeling unsure of yourself due to your physical limitations?	1	2	3	4	5
6. shaking of your hand(s)?	1	2	3	4	5
7. feeling worn out or having no energy?	1	2	3	4	5
8. difficulties in doing sport or leisure activities?	1	2	3	4	5
9. clumsiness?	1	2	3	4	5
10. feeling embarrassed because of your illness?	1	2	3	4	5
11. shuffling?	1	2	3	4	5
12. having to postpone or cancel social activities because of your illness?	1	2	3	4	5
13. a feeling of extreme exhaustion?	1	2	3	4	5
14. difficulties turning round (while walking)?	1	2	3	4	5

How often during the last 3 months did you have trouble with the following:

	All of the time	Most of the time	Some of the time	A little of the time	Never
15. being afraid of possible progression of the illness?	1	2	3	4	5
16. difficulties writing?	1	2	3	4	5
17. being less able to go on holiday than before your illness?	1	2	3	4	5
18. feeling unsure of yourself around others?	1	2	3	4	5
19. difficulties getting a good night's rest?	1	2	3	4	5
20. "on/off" periods?	1	2	3	4	5
21. difficulty accepting your illness?	1	2	3	4	5
22. difficulties talking?	1	2	3	4	5
23. difficulties signing your name in public?	1	2	3	4	5
24. difficulties walking?	1	2	3	4	5
25. drooling?	1	2	3	4	5
26. feeling depressed or discouraged?	1	2	3	4	5
27. difficulty with sitting still (for long periods)?	1	2	3	4	5
28. wetting yourself and /or increased need to urinate?	1	2	3	4	5
29. difficulties with transport (e.g. car, bus, train...)?	1	2	3	4	5
30. sudden uncontrolled movements?	1	2	3	4	5

How often during the last 3 months did you have trouble with the following:

	All of the time	Most of the time	Some of the time	A little of the time	Never
31. difficulties concentrating?	1	2	3	4	5
32. difficulties getting up (e.g. from a chair)?	1	2	3	4	5
33. constipation?	1	2	3	4	5
34. difficulties with your memory?	1	2	3	4	5
35. difficulties turning over in bed?	1	2	3	4	5
36. your illness inhibits your sex life?	1	2	3	4	5
37. feeling worried about (the possible consequences of) an operation in connection with your illness?	1	2	3	4	5

APPENDIX I

39 – ITEM PARKINSON'S DISEASE QUESTIONNAIRE (PDQ – 39)

DUE TO HAVING PARKINSON'S DISEASE, how often have you experienced the following, during the last month?

Due to having Parkinson's disease, how often during the last month have you	*Please tick* ***one box*** *for each question*				
	Never	**Occasionally**	**Sometimes**	**Often**	**Always or cannot do at all**
1. Had difficulty doing the leisure activities which you would like to do?	☐	☐	☐	☐	☐
2. Had difficulty looking after your home, e.g. DIY, housework, cooking?	☐	☐	☐	☐	☐
3. Had difficulty carrying bags of shopping?	☐	☐	☐	☐	☐
4. Had problems walking half a mile?	☐	☐	☐	☐	☐
5. Had problems walking 100 yards?	☐	☐	☐	☐	☐
6. Had problems getting around the house as easily as you would like?	☐	☐	☐	☐	☐
7. Had difficulty getting around in public?	☐	☐	☐	☐	☐
8. Needed someone else to accompany you when you went out?	☐	☐	☐	☐	☐
9. Felt frightened or worried about falling over in public?	☐	☐	☐	☐	☐

Please check that you have ticked ***one box for each question*** *before going on to the next page*

Due to having Parkinson's disease, how often <u>during the last month</u> have you ....

*Please tick **one box** for each question*

	Never	Occasionally	Sometimes	Often	Always
10. Been confined to the house more than you would like?	☐	☐	☐	☐	☐
11. Had difficulty washing yourself?	☐	☐	☐	☐	☐
12. Had difficulty dressing yourself?	☐	☐	☐	☐	☐
13. Had problems doing up buttons or shoe laces?	☐	☐	☐	☐	☐
14. Had problems writing clearly?	☐	☐	☐	☐	☐
15. Had difficulty cutting up your food?	☐	☐	☐	☐	☐
16. Had difficulty holding a drink without spilling it?	☐	☐	☐	☐	☐
17. Felt depressed?	☐	☐	☐	☐	☐
18. Felt isolated and lonely?	☐	☐	☐	☐	☐

*Please check that you have ticked **one box for each question** before going on to the next page*

Due to having Parkinson's disease, how often <u>during the last month</u> have you ....

*Please tick **one box** for each question*

	Never	Occasionally	Sometimes	Often	Always
19. Felt weepy or tearful?	❒	❒	❒	❒	❒
20. Felt angry or bitter?	❒	❒	❒	❒	❒
21. Felt anxious?	❒	❒	❒	❒	❒
22. Felt worried about your future?	❒	❒	❒	❒	❒
23. Felt you had to conceal your Parkinson's from people?	❒	❒	❒	❒	❒
24. Avoided situations which involve eating or drinking in public?	❒	❒	❒	❒	❒
25. Felt embarrassed in public due to having Parkinson's disease?	❒	❒	❒	❒	❒
26. Felt worried by other people's reaction to you?	❒	❒	❒	❒	❒
27. Had problems with your close personal relationships?	❒	❒	❒	❒	❒

*Please check that you have ticked **one box for each question** before going on to the next page*

Due to having Parkinson's disease, how often <u>during the last month</u> have you ....

*Please tick **one box** for each question*

	Never	Occasionally	Sometimes	Often	Always
28. Lacked support in the ways you need from your spouse or partner? *If you do not have a spouse or partner tick here* ☐	❒	❒	❒	❒	❒
29. Lacked support in the ways you need from your family or close friends?	❒	❒	❒	❒	❒
30. Unexpectedly fallen asleep during the day?	❒	❒	❒	❒	❒
31. Had problems with your concentration, e.g. when reading or watching TV?	❒	❒	❒	❒	❒
32. Felt your memory was bad?	❒	❒	❒	❒	❒
33. Had distressing dreams or hallucinations?	❒	❒	❒	❒	❒
34. Had difficulty with your speech?	❒	❒	❒	❒	❒
35. Felt unable to communicate with people properly?	❒	❒	❒	❒	❒
36. Felt ignored by people?	❒	❒	❒	❒	❒

*Please check that you have ticked **one box for each question** before going on to the next page*

Due to having Parkinson's disease, how often <u>during the last month</u> have you	*Please tick **one box** for each question*				
	Never	**Occasionally**	**Sometimes**	**Often**	**Always**
37. Had painful muscle cramps or spasms?	❒	❒	❒	❒	❒
38. Had aches and pains in your joints or body?	❒	❒	❒	❒	❒
39. Felt unpleasantly hot or cold?	❒	❒	❒	❒	❒

Please check that you have ticked one box for each question

Thank you for completing the questionnaire