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Standing Posterior Trunk Rotation with Adaptive Proprioceptive Toss

Jennifer Elvir
jne21a@acu.edu

ABSTRACT

Parkinson's disease (PD) is a remarkably individualized disease. Nearly every person's trajectory is unique. One person may experience tremor at an early stage of the disease, while another may experience tremor at a later stage or even not at all. For all PD patients, for certain can expect increasing difficulty as the disease progresses. Parkinson's disease is responsible for the loss of dopamine which displays itself most notably through motor and cognitive symptom disruption. Although Parkinson's is a chronic and progressive condition that is irremediable, significant strides have been facilitated to help control and manage the trajectory of the disease. Interventions such as medicine and physical exercise are the leading alternatives to coping with the advancements of PD. Early motor signs of PD include smaller hand tremors, changes in walking, reduced facial expressions, slowness of movement, and posture. A person will often display at least two of the four cardinal symptoms of tremor rigidity, bradykinesia, and postural instability. The present study was conducted to investigate the relationships between standing posture, trunk stability, recent falls with balance, gait, and trunk rotation among people. It was predicted that consistent, multiple events per week exercise procedures, including exposure to an accuracy-task procedure (ring-toss) will be associated with a reduced rate of motor symptoms progression. The investigation was determined to potentially reverse some of the well-known cardinal symptoms of PD. Participants (N= 10) completed pre-and-post balancing assessments (MiniBESTest and Force Plate) and a weekly balancing protocol (ring-toss). The current study examined the role of exercise in movement

control, which demonstrated that consistent exercise regimens provided long-term bilateral and unilateral motor benefits. The implications of the findings, limitations, and future directions for research will be addressed.

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Thesis Committee

T. Scott Perkins, Ph.D., Chair

David McAnulty, Ph.D

Richard Beck. Ph.D

To those individuals who live with Parkinson's disease and to those who devote their careers to the topic. Thank you for your pursuit of hope.

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CHAPTER I

INTRODUCTION

Parkinson's disease (PD) falls into a group of conditions called *movement disorders*, which result from a loss of the brain's control over voluntary function. PD is a neurogenerative disorder that ordinarily affects dopamine-producing neurons in the subcortical structures. In neurogenerative diseases, neurons die sooner than normal, both inside and outside the brain. All humans are born with an immense number of neurons, and as aging progresses, these cells naturally decrease in number. Fortunately, healthy brains have plenty of additional nerve cells to keep the body and mind working despite the losses. Dopamine neurons help to control multiple brain functions such as movement and an array of behavioral processes. For Parkinson's patients the production and regeneration of dopamine is limited. Consequently, the loss of critical mass dopamine receptors in subcortical structures results in the imbalance of muscle tone, seen in the reduction in walking, talking, swallowing, and writing. These neurons live in part of the brainstem, commonly known as the substantia nigra, whose essential role is to send chemical signaling to your brain to control the bodily movement. As stated previously, PD is visibly seen by full and rigid movements due to the lack of fine-motor control. When the brain's striatum is negatively affected, a person can no longer manage or predict the force in movement.

Surprisingly there is no exact clear understanding on why nerve cells significantly degenerate in PD. The vulnerability of these cells is alarming due to the extensive

branching and reduction of energy. In Parkinson's, the substantia nigra is one of the key regions in the brain where cells die. The cause of the "black substance" in the brain is thought to be caused by clogged clumps of dopamine proteins known as Lewy bodies. Furthermore, alpha-synuclein, a protein that is misfolded, or altered, in people who have PD forms clumps in nerve cells and likely accelerate to nerve cell death.

In turns out, Parkinson's affects more than just dopamine-producing nerve cells in the substantia nigra. Other regions of the brain producing different neurotransmitters also suffer cell loss. The additional damage is responsible for many of the symptoms of PD that are not related to movement function, such sleep disturbance, loss of smell, constipation, loss of gut mobility, and increased pain perception. Sleep disorders associated with PD include REM Behavior Disorder (RBD), restless leg syndrome (RLS), insomnia, and hypersomnolence. RBM is a parasomnia characterized by dream-enactment behavior thar emerges during a loss of REM sleep atonia that manifests in forceful or violent motor behavior, unlike sleep paralysis (Mahmood et al., 2020). Sleeping disturbances are often found to precede PD diagnosis and have been associated with 65% increase in symptom severity during the first five years of PD (Berg et al., 2015; Mahmood et al., 2020). Anosmia is another prevalent non-motor system that occurs prior to diagnosis. Anosmia is the loss of voluntary smell. The loss or reduction of smell is common in early stages of PD and occurs for more than 95% of the population diagnosed (Haehner et al., 2011). Most people report experiencing loss of smell before experiencing difficulties with motor control.

Regardless of how a person obtains PD—through genetics, environmental causes, or a combination of both—every person experiences a loss of functioning that is unique

to them. The length of the stages varies (Marras et al., 2018). Due to age and other genetic factors, early stages of PD are frequently overlooked and misdiagnosed. Symptoms in early development may appear as lack of motivation due to fatigue or lack of energy, chronic pain, or immobility causing bodily changes in postural alternations. People with PD who have symptoms on one side of their body, such as rigidity or tremors, are often in the first stage of PD (Goetz et al., 2004; Hoehn & Yahr, 1967). In this stage, it is common for people to experience slowness of movement either in one arm or leg on either side of their body. In stage two, symptoms are apparent on both left and right sides of the body, in some cases in the midline. It is evident in emotional regulation and facial expressions the lack of cognitive acuity. Some of these include drooling or stooping. In some cases, people in stage two experience mild balancing disturbances whether that be through shuffling of the feet or coordination. However, throughout the third stage, body movement significantly decreases. People experience mild to moderate difficulties in walking (but do not require assistance). Unfortunately, during the fourth stage, a person with PD experiences the cardinal symptoms most invasive in the disease. A person exhibits bradykinesia, rigidity, postural instability, and tremors. Often enough, individuals are becoming less independent and more dependent on others for assistance. The most invasive stage of PD is experienced at stage five, in which a person is unable to mobilize themselves and requires high levels of assistance due to the invasiveness of the disease.

The seminal description of PD came in the early 1800s at the height of the industrial revolution. PD was observed by the thousands of people who walked with an unusual gait and shaking limbs. Most, if not all, of these symptoms were attributed to the

overwhelming rise of industrialization (e.g., air pollution, pesticides, other chemicals). In more recent years, age, genetics, and environmental exposures are known to contribute to the onset of the disease to some degree. For example, age itself is not an indication of the cause of the disease. Rather, longevity is what makes a person be overtaken by the diagnosis because a significant loss of nerve cells is lost as age progresses (Levy, 2007). Environmental and genetic factors contribute to PD progress. The onset of the diagnosis (e.g., nerve damage) likely begins years in advance prior to bodily symptoms. Quite often, nerve damage has significantly increased, causing difficulty to manage when diagnosed. Unfortunately, a person's risk rises with age. The average onset age of PD is 60; however, people as early as 50 have been diagnosed with the condition. According to recent headlines, it is projected that by 2030, there will be a 10% higher risk of early onset developing PD (Wanneveich et al., 2018). Additional research has suggested the risk of prevalence beginning in a person's forties, the risk roughly triples with each passing decade (Van Den Eeden et al., 2003). Gender identification also plays a vital role in the development of PD. Research has shown that men are almost twice as likely to be diagnosed with PD than are to women (Cerri et al., 2019; Jurado-Coronel et al., 2017). One theory suggested that the production of estrogen in women acts as a protective barrier to decreasing the progression of PD (Shulman, 2002). An additional chief risk factor is the influence of genetics. The Parkinson's Foundation and other astute research have highlighted that genetic causes are responsible for 10% to 15% of all PD (Bandres-Ciga et al., 2020; Deng et al., 2018). Genetic mutations and environmental influences can interfere with such development. Fortunately, advancements in technology and genetic testing have helped people and families retrain more information about the predisposition

of PD and early diagnosis. Ultimately, leading research has aided the discovery of improving care and speed the development of new treatments.

The comprehension of PD treatment took centuries to develop. People paid attention to the invasiveness of the condition, especially as it became comorbid with other diseases. Thus far, medication has been the most effective treatment plan to stabilize symptoms. A major shortcoming of medication is its inability to cure the disease altogether. Pharmaceuticals such as Levodopa have been agents to ignite the loss of dopaminergic neurons. The medication helps to transform itself into dopamine after passing through the blood-brain barrier, reaching the brainstem. Such medication is intended to alleviate the motor symptoms, mainly the reduction of tremors and stiffness. Levodopa has not only proven to be an effective agent for movement but has also supplied evidence to the longevity of life-expectancy among people experiencing PD (Morgan et al., 2014). Although medication can minimize severity of the condition, the diagnosis continues to spread affecting neurons. The usage of medication is different for every person with Parkinson's and requires careful consideration of potential risks. Despite the tremendous impact medication has on relieving many of the symptoms of PD, researchers have become increasingly aware of the side effects produced by orally administered medication. Given the impact of orally prescribed medication, researchers continue to investigate the influence of Levodopa and alternative formulations of dopamine replacement interventions.

CHAPTER II

LITERATURE REVIEW

Pharmaceutical Interventions

Dopamine is a naturally occurring substance in the brain that provides specific rewards throughout the body, including the role of controlling memory, mood, and movement. In people with PD, there is little to no production of dopamine, evidenced by the reduction of body control. As discussed previously, Levodopa is the primary oral medication that has been used to decrease the intensity of the motor symptoms of PD. Levodopa, or "L-dopa," is a neurotransmitter precursor of dopamine and interventions utilizing its properties to help replace missing dopamine. Research on pharmaceuticals has focused on optimizing levels of dopamine, but most importantly, increase lifespan and quality of life. These dopamine agonists are intended to supply the brain with dopamine chemistry and the right amount of synthetic chemicals. Levodopa is most typically bundled with Carbidopa and drugs such as Rytary, Sinemet, and a number of others, all of which are dopamine precursors. These have provided the primary point of intervention and are best known to reduce movement deficiencies. However, medication is not a long-term solution. These agents come with a number of side effects with prolonged usage. It is possible that pharmaceuticals have minimized bradykinesia and rigidity but have also exposed a number of cognitive fluctuations.

Although medication is an effective mechanism in controlling motor symptoms, there are several undesirable side effects. Over time, high doses can trigger involuntary

movements. Similar drugs can also cause debilitating impulse behaviors. Some of these oral prescriptions may cause side effects that include respiratory tract infections, cough, discolored sputum, hallucinations, and nausea. L-dopa may lean into some cognitive side-effects of confusion, insomnia, or paranoia (Kuzuhara, 2001; Moskovitz, et al., 1978). Only 2% of people on high dosages report severe side effects. Other complications may include changes in heart rate (e.g., irregular heartbeat, dizziness chest pain), low blood pressure (e.g., hypotension, fainting, blurry vision), and mood dysregulation (e.g., anxiety, nervousness, irritability). It is vital for patients who take pharmaceutical medications whether they be Levodopa-Carbidopa, or any related dopamine agonist, to check with their physicians to minimize the harm of side effects.

Medication is personalized to each patient and should be delivered at unique intervals. L-dopa is taken orally accompanied by water and the presence or absence of food. As the disease progresses, alterations of dosage count may fluctuate based on symptomatology. Notably, it was found that the duration of taking L-dopa or related substances may "wear off" (DeMaagd & Philip, 2015). According to recent studies, after just five years of use, nearly 50% of patients taking dopamine-related medications had changes in their prescriptions (Marsden, 1994; Mizuno et al., 2018). After ten years of usage, two-thirds of people detected a disconnect of control while on L-dopa (Mizuno et al., 2018. In special cases, patients might experience the "wearing off" effects especially when taking L-dopa for an extended period. As the wearing off becomes more frequent, it may result in ab increase of discomfort, specifically when it becomes harder to control movement. The "on-and-off" phenomenon is a term used to describe these inconsistencies of motor fluctuations. When oral medication is working properly, and

symptoms are controlled they are “on” time. However, sudden or inconsistent symptoms occurring (e.g., tremors, rigidity, slow movement) is referred to as “off” time in which medication is beginning to wear off. Managing motor fluctuations and wearing off after a point can be associated with the disease’s perversity.

Levodopa has been amongst the most effective drug to treat symptoms of PD (Obeso et al., 2000). As a precursor in attempts to replace dopamine and dopamine-dependent activities. The intent was to supplement the brain with an appropriate amount of dopamine and dopaminergic and dopamine agonists to help relieve symptoms. L-dopa is a class of medication that is central to the nervous system. It absorbs into the blood stream and travels through the blood from small intestines to the brain. As it travels through, it has the potential to breakdown, thus Carbidopa is a drug that temporarily blocks conversion of levodopa, thus assisting levodopa from becoming dopamine too soon (Zhu et al., 2017).

Some argue that levodopa and other similar pharmaceuticals are the most effective in the reduction of symptoms, however, in most recent studies other experts argue that the decreased functionality of the supplement after long-term use (Cotzias et al., 1967; Pandey & Srivanitchampoom, 2017). As a result, the chance of developing increased dyskinesia effects in early diagnosis is minimal. Researchers have identified that after only five years or more, an increase in motor complications have been reported in more than half of patients on dopamine precursors (Marsden, 1994; Obeso et al., 2000; Thanvi & Lo, 2004; Verhagen, 2002). The clinical phenomenology has conceptually divided motor fluctuations into three types of Levodopa-induced dyskinesia, including peak-dose dyskinesia, wearing off or off-period dyskinesia, and diphasic dyskinesia

(Pandey & Srivanitchampoom, 2017). Given the influence of levodopa, supplementary agents have been created to provide similar synthetic chemicals that help with the bypass of dopamine receptors.

Dopamine agonists are supplements that activate specific types of cells in the brain, more commonly acting as stimulant to influence the brain in thinking it has received dopamine. Unlike its counterparts, dopamine agonists do not convert itself into dopamine, rather takes the place of serotonin. The use of agonists is a less invasive supplement compared to L-dopa. Similar to carbidopa and levodopa, these agents are used to target PD and other related parkinsonism conditions, including restless leg syndrome, neuroleptic malignant syndrome, and type-2 diabetes (Choi & Horner, 2023). Dopamine agonists are now typically prescribed in early treatment for PD or when symptoms appear to be mild. These supplements are often taken in pill form, skin patches, and injections. Some of the risks and benefits of taking the prescription is similar to L-dopa, in which a patient may experience dizziness, constipation, low BP, compulsive behaviors, and orthostatic hypotension (Brooks, 2008; Obeso et al., 2000). Some may be alarmed by side effects that cause people to develop impulsive behaviors (commonly referred to as impulse control disorder), as seen through uncontrolled gambling, sexual activity, excessive eating, or shopping. It is also worth noting that dopamine agonists withdrawal syndrome, also known as DAWS, may occur when there are alterations or suspensions, affecting more than 19% of patients who taper with medication (Garcia et al., 2022).

To minimize negative side effects from all dopaminergic supplements, oral prescriptions have been developed to help breakdown levodopa to enhance dopamine

function. Two extenders that help the disintegrate L-dopa are MAO-B and COMT enzymes (Holm & Spencer, 1999). Monoamine oxidase type b (MAO-B) is used to slow the progress of PD. MAO-B inhibitors are commonly referred to as neuroprotectors due to its effective ability to inhibit enzymes from breaking down neurotransmitters. The three most common name brand medications for such enzymes are Selegiline, Azilect, and Xadago (Moore & Saadabadi, 2023). These prescriptions authorized by the FDA cannibalize neurotransmitters (i.e., serotonin, dopamine) to manage early PD symptoms and are known to treat ADHD (Moore & Saadabadi, 2023). COMT inhibitors work to heighten dopamine receptors and prolong the effects of Levodopa medication (i.e., elongate "on" periods) (Holm & Spencer, 1999). The COMT inhibitors increase the benefits of L-dopa, while also decreasing 'off' period that make the prescription unworkable and increase 'on' times. Entacapone (Comtan) and Tolcapone (Tasmar) are two of the most common name brand prescription pills associated with the inhibitors (Lees, 2008).

The most standard and universal delivery of levodopa has been through oral intake. In most recent research, advancements to alternative routes of delivery have been developed, routes such as inhalation and continuous administration via intestinal routes (Thirunavukarasu et al., 2023). The most effective delivery has always been dependent on metabolism to dopamine in the brain, successfully crossing the blood-brain barrier (Bandopadhyay et al., 2022). Unfortunately, not all patients have successful experiences when introduced to medication, as seen through side effects and duration of medication (e.g., nausea, imbalance, hypotension). For patients who have these adverse challenges or for patients who show poor response, now have the option to receive levodopa through

inhalation, intestinal, and subcutaneous delivery (Thirunavukarasu et al., 2023). As of late, a heavily studied remediation of dopamine delivery has been through subcutaneous pump delivery. Researchers at the University of Cincinnati have made a significant stride to the administration of levodopa through an infusion pump, to better manage involuntary movement. They have found favorable results in the insertion of the pump in combination with oral medication (Espay et al., 2024). Such interests have also expanded to alternative therapies, such as intrajejunal delivery of levodopa-carbidopa intestinal gel (LCIG) or continuous apomorphine infusion (Laar et al., 2023). The evidence of the study supported the efficacy of clinical trials, in which alleviated partial symptoms of PD. However, many of these alternative approaches heavily depend on the severity of the patient, the need for advanced instruments, and the dependency of caregivers. In addition to subcutaneous inserts, many have looked to cell replacement for a cure in PD. Cell replacement therapies date back to the early 1980s, in which hoped to replace damaged neurons with new dopamine producing cells. Cell replacement therapy (CRT) has been a promising field that has eased some of the symptoms found in PD (e.g., motor dysregulation) and even slowing down progression (Guo et al., 2021). In a most recent meta-analysis, the data amongst studies revealed the positive changes on post- and-pre-treatment function, as well as the beneficial effect of homogenous cell therapy on movement, providing evidence of postural control (Wang et al., 2023). Despite the significant advancements in infusion pumps and cell replacement therapies there are an array of unknown effects. It remains unclear the longevity of alternative devices, insertions, and replacements. Scientists continue to search for appropriate measures to ensure effectiveness. Alternative solutions such as pharmacological therapy and surgical interventions (e.g., deep brain

stimulation) may be the forerunners of treatment, while researchers continue to design interventions to prevent deterioration.

Surgical Interventions

Deep brain stimulation (DBS) has been the most common surgical intervention when treating for PD. DBS is a treatment involving an implanted device that delivers electrical charges to the brain to better improve unwelcomed involuntary movements in a person with PD. The device involves implanted electrodes on the two hemispheres of the brain, triggering pulse generation. Although most candidates have electrodes connected to both the left and right hemispheres, some patients may only need unilateral placement to target a key region. Like cardiac management, a small pulse generator is implanted below a person's collarbone. These pulse generators are battery operated and rechargeable lasting about six to seven years. The non-invasive transmitter will send electricity to the brain as needed and will alert medical teams directly. New advances enable physicians to make adjustments remotely to minimize travel complications. Stimulation by the device will activate the subthalamic nucleus to help monitor and alleviate motor dysfunction (e.g., excessive tremors, dyskinesia, and balance). Rather than irreversibly destroying the nerve cells, DBS is designed to be modified based on a patient's symptoms. Over time, PD progresses, and having this surgical intervention is required. Most individuals are candidates for DBS when oral medication seems to stop working, or when dopamine supplements (e.g., levodopa-carbidopa) seem to respond negatively to a person.

The subthalamic nucleus (STN) and DBS interact to alter dopaminergic transmission in the basal ganglia, effectively targeting treatment motor dysregulation in

PD (Vachez & Creed, 2020). The subthalamic nucleus of the hypothalamus is located between the thalamus and hypothalamus targeting the basal ganglia (VandenBos, 2015). The function of the STN plays a significant role in movement control, behavioral performance, and motivational processing (Yashoshima et al., 2005). As supported by research, the pathology associated with PD is found directly in the basal ganglia which are subcortical structures (e.g., the deep gray and white matter) (Cordoso et al., 2006; O'Sullivan et al., 2006). The basal ganglia are the uttermost interconnected gray matter located deep within the brain, responsible for macro and micro movement control. STN is divided into sensorimotor (dorsolateral), limbic (medial), and cognitive associative (ventromedial) areas, all in which encompasses a portion of the basal ganglia. Thus, the subthalamic nucleus is a vital structure to decrease motor inhibition found in PD.

According to Kalampokini et al., STN-DBS is a positive surgical alternative in the minimization of involuntary movements such as tremors, levodopa-induced dyskinesia, and rigidity (2020). Significant interest has been generated by the effects of DBS, not only for its impact on motor control, but for positively contributing to better emotional processing. According to a recent article published by the NIH, clinical discovery shows that DBS can be used as a safe and effective tool to treat depression (referred to as treatment-resistant depression) (Alagapan et al., 2023). It can be interpreted that the STN-DBS can heavily influence neuropsychiatric effects that involve cognitive deficits. In addition, the STN-DBS's interplay with mood induction and emotion recognition have been studied (Gray & Tickle-Degnen, 2010; Schneider et al., 2003). Generally, these studies agreed on the significant influence of the stimulator. However, some studies have depicted the adverse effects that come from DBS and have argued its lack of

effectiveness. In a recent study, patients complained about ineffective stimulation, inappropriate pain shocks, and battery related issues (Ward et al., 2021). There are risks, including bleeding, infections, and misplacements of electrodes.

CHAPTER III

PHYSICAL INTERVENTIONS

Motor Symptoms

The four initial presentations of Parkinson's disease were described by Dr. James Parkinson, witnessing the multifaceted attributions of tremors, rigidity, and bradykinesia (Parkinsons, 1817). Balance instability was later introduced to the criteria of PD. Dystonia is another attribution to the diagnosis of PD when a person experiences abnormal muscle contractions occurring involuntarily or unexpectedly. A person diagnosed with PD must meet criteria for at least three of the four cardinal symptoms (Marsili et al., 2018).

Tremors, like PD, are unique to everyone. Tremors are universally understood as an untended or uncontrollable bodily movement, which include shaking, stiffness, and difficulty coordinating. Tremors do not occur to each individual diagnoses, however it is amongst the highest pervasive and observable feature (Jankovic, 2008). Originally, tremors in PD were often labeled "shaking palsy," especially for full-body tremors. Tremors most often occur during resting periods causing a portion of a limb (e.g., arm or leg) to involuntarily shake, heightened often by signs of stress, fatigue, fear, or intensive emotional situations. Tremors are not only reserved to larger limbs, but also minor areas such as lower lip or jaw. Some individuals may be progressively more susceptible to new tremors, while others may only exhibit shaking in one area of their body. Interestingly, tremors may manifest in changes in posture. People become more sensitive to the risk

factors of falling, instability, and rigidity due to the unexpectedness of bodily shaking (Pelicioni et al., 2019). Tremors have been reported by the Parkinson's Foundation as starting asymmetrically, but as the diagnosis progresses, both sides may be compromised. Tremors can limit a person's mobility not only physically, but also socially. Often, people are predisposed to feeling intense emotions of stress, or fatigue as tremors worsen. The pervasiveness of tremors may fluctuate or change over time. Some people may respond well to medication, while others respond poorly to changes in their body.

Rigidity is correlated with muscle stiffness. Some may refer to rigidity as a tightness in limbs. A person experiences intense muscle contractions that cause tightness and muscle cramping. These muscle contortions often lead to serios damages that negatively affect movement. It often gets misdiagnosed or ignored at early stages of disease development, due to most patients referring to their rigidity as pinches (Beach & Adler, 2018). Some providers may even identify this symptomology as early onset arthritis or normal process of aging. These misappropriated complaints can consequently lead to inflammation and instability (e.g., decreased range of motion). Rigidity and tremors are two markers that alone can cause severe impairment or slow movement. In advanced states of PD, rigidity may cause uncomfortable internal consequences (e.g., chest pain, abdominal discomfort). As rigidity prolongs, people with the condition find daily functioning increasingly challenging, seen in changes on walking, turning, or change in direction (Chong et al., 2000).

Much like tremors, rigidity may cause a person to have a stooped posture by leaning or curvature in body composition. Rigidity is often described to be the excessive, inflexible axial postural tone that negatively affects alignment (Artusi et al., 2023).

Likewise, this stooped posture that is due to excessive, static muscle activity contributes to the increased velocity or jerk-like motions of postural sway (Park et al., 2005). Impairment of postural reflexes significantly reduces stability due to the unexpected perturbations. Postural sway due to rigidity is significantly greater in PD patients than in healthy control groups and positively correlates with the duration and severity of the disease (Matinolli et al., 2007).

Slowness of movement or progressive speed halts or hesitations is referred to as *bradykinesia*. To properly diagnose PD, a person must present bradykinesia with either tremors or rigidity. Slowness can often look in the reduction of automatic movements (e.g., evidenced when arms swing side-to-side), difficulty initiating movements, and abnormal stillness (e.g., inability to control micro or macro moves) (Berardelli et al., 2001). Bradykinesia not only affects large bodily control, but also difficulty when writing (e.g., odd handwriting), speech impediments, and facial expressions (e.g., delays or absence). Reaction time may be also attributed to bradykinesia. For example, if a person is having difficulty balancing and leads to a fall, a person with severe bradykinesia may run the risk of being unable to catch or react on time to prevent the event from happening (Berardelli et al., 2001). Bradykinesia is often seen when having difficulty mobilizing themselves (e.g., standing up from a chair, pivoting directions). The presentation of the symptoms begins in one area of the body and may extend to other portions. Bradykinesia can be an unpredictable symptom.

The most challenging symptomology that is greatly affected in PD is postural instability. Tremors, rigidity, and bradykinesia can fluctuate in the course of time; however, the inclusion of postural instability increases the risk of severe outcomes (e.g.,

falls). Problems with balance may result in serious long-term injuries (e.g., head injuries, hip fractures, broken limbs). Balancing instability can be managed by proper medication management and physical exercise. Balancing interferences may be due to the unpredictability of muscle tension, freezing, and lack of motor rotation. People are often seen swaying, shuffling, and leaning to regain postural control (Morris et al., 2001). Postural instability can most likely be pointed to freezing of joint and muscle groups. Common abnormalities seen while observing gait in patients with PD include reduction of arm swinging, reduction in stride and step length, lack of pelvic and thoracic movement coordination, marked rigidity, and freezing of gait (Baron et al., 2017). Sofuwa et al. (2006) discovered that gait pattern is characterized by sub-maximal movements. This observation concluded that there is a significant reduction in the mobility of the hip, knee, ankles, and lack of extension in all joints. Similarly, trunk and pelvic movements are reduced, resulting in a decrease in movement patterns such as arm swings and strides (Van Emmerik et al., 1999).

According to researchers, falls occur three times more frequently in people with PD than in healthy individuals of similar age (Pickering et al., 2007), and approximately 46% of those affected individuals experience more than one fall within three months (Rudziska et al., 2013). Additional investigations suggest that 35–70% of those with PD are nine times higher risk for falls than age-matched healthy individuals (Harro et al., 2018). Researchers have also discovered that nearly 75% of those falls and fractures occur in hospitals (Chou et al., 2011). Falls can not only lead to serious injuries but also contribute to the negative impact on mobility, daily activities, and emotional well-being.

In more recent studies, it was estimated that those living with PD accumulated over $14 billion in medical expenses (Harro et al., 2018).

Freezing of gait (FOG) is characterized by sudden, relatively brief episodes of instability of effective movement. It is also described as muscle stiffness as seen in walking, pivoting, and turning (Spildooren et al., 2019). It is often referred to as "heterogeneous" with other side effects such as trembling and shuffling. FOG is most evident when changes in environment or transitions are placed. For example, some may hesitate or freeze when attempting to step over hurdles or unbalanced surfaces (e.g., doorways, stairs). People who have pervasive freezing have difficulty with compensatory stepping response to recover equilibrium (Park et al., 2005). Such discovery alludes to the common pathological pathways of falls. FOG is also linked to the reduction of dual tasking, in which shifting attention between motor, limbic, sensory, and cognitive networks become challenging (Kwok et al., 2022). Likewise, people find it difficult to accomplish normal gait and many unconsciously walk sideways or inability to initiate movement.

Impairments in rigidity, balance, and gait contribute to high risk of falls. Unfortunately, people with PD are significantly more likely to fall within a couple of years after being diagnosed. According to many studies, up to 70% of persons with PD fall each year, with 13% falling more than once a week (e.g., O'Sullivan et al., 2006). Standing-related changes in postural control methods have been recorded, and they become more apparent when responding to an unanticipated destabilizing disturbance or completing voluntary tasks (Adkin et al., 2005; Morris et al., 2000). Many studies have shown that fear of falling relates to postural instability (Adkin et al., 2003), but the main

issue is that balance systems in the central nervous system are compromised, resulting in impaired postural reactions, and altered gait patterns (O'Sullivan et al., 2006). Postural responses to standing perturbations often comprise a coordinated series of muscle activations in the hip, knee, spine, and ankle (Cholewicki et al., 2000). Postural reactions in sitting primarily entail the activation of muscles regulating the pelvis and spine (i.e., trunk) (Cholewicki et al., 2000). Individuals with PD respond to changed balance demands with an aberrant pattern of postural muscle co-activation. They exhibit decreased muscle torque output, decreased torque production rate, and impaired trunk motions (O'Sullivan et al., 2006). Similarly, adequate trunk stability and control of trunk motions are required for stability and appropriate gait because the upper body accounts for two-thirds of total body weight. The bulk of falls in people with PD and the elderly are caused by an inability to control body weight during daily actions like turning around, standing up, spinning, and bending over forwards. All these activities require core or trunk postural control.

Walking automaticity deteriorates over time in PD patients, requiring more cognitive resources to maintain balance and walking than in healthy individuals. When one loses their ability to automate, they have fewer cognitive resources for other tasks, and walking and maintaining balance become more sensitive to stressors. To maintain equilibrium, the brain and spine structures work together to maintain balance. The basal ganglia are important compensatory mechanisms that keep the motor cortex ready to act so that postural muscles can regulate gravity within the base of support, regulate muscle control, motor control flexibility and adaptivity, and modulate the impact of cognitive factors on balance and gait (i.e., dual task performances; Visser & Bloem, 2005). Due to

dysfunction in the basal ganglia, postural instability is common in PD, ultimately compromising the ability to maintain balance during day-to-day activities (i.e., walking, standing, and sitting). Smithson et al. (1998) state that the timing of muscle activation becomes increasingly slower than usual particularly when the lower limbs and trunk muscles respond to unexpected perturbations. Patterns of co-activation cause rigidity in the body and decrease range of motion and falls. It is also understood that individuals with PD also experience reduced reactive postural responses, which result in insufficient balance strategies in response perturbations and increased fall risk (Harro et al., 2018).

Horak et al. (2009) suggested a framework that includes six aspects of balance: biomechanical constraints, stability limits, anticipatory postural adjustments, postural responses, sensory orientation, and gait stability. Each of these neurophysiological impairments contribute to the aspect of postural control. Biomechanical constraints account for the stropped posture often found in people with PD evidenced by weak ankles and hips that impact overall balance, which in-turn affects a person's stability limiting the body's center of mass often leading to poor alignment. The model designed by Horak et al. (2009) helps assess balance (MiniBESTest) by providing a variety of measurements. Balance is often described as control of the body's center of mass over its base support to achieve equilibrium and orientation. A large body of literature supports the negative impact of having balance instability (postural deficits).

Trunk control is important for maintaining balance. Individuals with PD have impaired trunk stability. Individuals have abnormal muscle coactivation patterns, resulting in a rigid body and inability to use normal posture (Bridgewater,1998; Emmerik et al., 2009; O'Sullivan et al., 2006). As the body deteriorates, axial rigidity increases.

Symptoms of axial rigidity include impaired lateral balance control, which causes the body to require more input from the trunk and hip muscles than those from an anterior posterior direction (Hong et al., 2009; Hubble et al., 2019). As a result, people with PD who experience these symptoms have greater difficulties timing and coordinating effective movements, which increases the risk of overbalancing and falling. Postural control while standing can be achieved through a variety of responses at the ankle, hip, and trunk joints, either independently or in combination (Hubble et al.,2019; Krishnamoorthy et al., 2005). As a response, researchers have suggested that "hip" strategies, controlled primarily with the pelvic, hip, and trunk, have been ineffective in control of the muscles (Horak et al., 1986). Side effects that are caused by loss of postural control include decreased muscle force production, loss of available range of motion, and muscle weakness. Studies comparing postural control of the trunk during unstable sitting activities found significant differences in balance performance between people with PD and healthy controls (Van Wegan et al., 2006).

Other motor symptoms that a person may experience are muscle weakness, dystonia, and akinesia. When muscles contract involuntarily or activate at spontaneous moments is referred to as dystonia. When this occurs, muscles tense up, commonly contracting in the arms, legs, trunk, face or neck, causing a long-lasting painful experience. Dystonia can be diagnosed separately from Parkinson's; however, most experience symptoms of dystonia throughout their progression with the disease. Sudden involuntary movements that cause people to drop things or lose their balance may occur and are referred to as *myoclonus* (Akarsu et al., 2014). Akinesia may also occur in PD, in which there is a sudden decline in movement. Like bradykinesia, this symptomatology is

the absence of motor control. People experiencing this may not be able to regain control of motor functioning for a short period of time.

An additional concerning motor impairment that occurs in PD involves fluctuation in speech, voice, and swallowing. For some, their fine motor skills become weaker. For example, some individuals begin to slur their words. Speed is either involuntarily accelerated or the loss of expressiveness occurs. These side effects cause people to often be frustrated due to the limited communication that occurs. Speech impairments, for example, have a prevalence rate of up to 89% and can be caused by motor and cognitive interferences that begin in the early stages (Dashtipour et al., 2018). Long pauses ("periods of silence"), aberrant sounds, stuttering, or word slurring are some of the speech disorders observed in PD patients (Ahn et al., 2014). Despite its high incidence, only 3% of persons with PD and speech loss pursue and receive treatment from a speech professional (Dashtipour et al., 2018). Breathing and swallowing may become a difficult task in later stages resulting in drooling or aspiration risks. It is important to recognize that although these motor symptoms are invasive to the human body, they may fluctuate depending on treatment care and assistance.

Non-Motor Symptoms

Most symptoms of Parkinson's disease are detected by the motor deficits; however, the disease can cause an array of non-motor symptoms. These limitations occur in the sensory, cognitive, emotional, and alternations of the brain and body. Sensory symptoms that are affected at diagnosis include smell, touch, hearing, taste, and/or vison. Before being diagnosed with PD, individuals may experience the loss of smell and may experience fluctuations which can affect the sense of taste causing a significant decrease

in appetite. The loss of vision may also occur when experiencing double vision or a blurred perspective. Additionally, they are predisposed to light sensitivity or losing depth perception due to the malfunctioning retina and damages in the inner lining of their eyes. Lastly, individuals may experience sudden unusual sensations in their ability to feel. The sense of touch may appear in sudden tingling in their legs or feet, which can cause muscle contractions or restless leg syndrome.

A secondary category in non-motor symptoms of PD is cognitive alternations. Many people with neurological condition experience changes in attention, concentration, memory, judgment, communication, processing skills, retaining new knowledge, and problem-solving. The cognitive function that is most affected by early diagnosis of PD is executive functioning. It is responsible for making decisions, solving problems, and multitasking. The most concerning function is memory and the ability to perform innate tasks. Some providers may diagnose patients with mild cognitive impairments (MCI) to compensate cognitive deficits. An individual often experiences losses in short-term memory, difficulty understanding simple statements or commands. MCI is followed by progressive cognitive decline often affecting a persons' executive functioning skills. The diagnosis is represented by a significant decline in functioning that persists for more than six months.

More than 30% of people with PD may experience some degree of cognitive impairment. The process can lead to dementia, in which biological changes occur in the brain including psychological, behavioral, and cognitive alterations occur due to cognitive decline. Dementia with Lewy bodies (DLB) is a typical diagnosis in early PD because of its three primary symptoms, such as loss of thinking, reasoning, and

independent function. Some of these specific diagnoses in early stages are also considered as Parkinson's disease dementia (PDD). These symptoms in PDD have been reported to affect 20–40% of individuals living with PD in several population-based epidemiologic studies (Astrom et al, 2022). Some longitudinal studies have reported that over half of persons with Parkinson's disease develop PDD within 10 years of PD diagnosis (Cosgrove et al, 2015), and after twenty years, that figure may rise as high as 80% of PD patients (Aarsland & Kurz, 2009). This diagnosis is the decline of the cortex responsible for higher functions of thinking understanding, learning, remembering, and processing. Many of the same symptoms are often found in Alzheimer's disease (AD). After Alzheimer's disease, subcortical disease is the second most common neurodegenerative disorder. Not surprisingly, research has indicated that patients with MCI are more likely to develop dementia (Aarsland & Kurz, 2009).

Emotional and psychiatric symptoms can be experienced in PD. Depression, apathy, and anxiety can all act as comorbidity agents in the diagnosis. Depression, amongst many other mood disorders, has a significant effect on a person's quality of life. Individuals experience high levels of sadness, hopelessness, and a reduction of energy. Apathy occurs when individuals' loss sudden interests or minimize social interactions caused by the depressive episodes. Unfortunately, more than half are affected by anxiety. Most people are diagnosed with generalized anxiety disorders (GAD) or unspecified anxiety. Many of these anxious feelings are derivative phobias or panic disorders. Individuals may experience fear of falling, social phobia, or agoraphobia. A common psychiatric dysfunction that may present in PD is distorted sense of reality caused by psychosis. People may be more susceptible to hallucinations, delusions, illusions, and

paranoia. These symptoms proposed by psychosis are significant due to the lack of dopamine receptors and can be triggered by medication.

According to Ruffman et al. (2008), emotion recognition is defined as a central component of non-verbal communication of emotion, often expressed through changes in facial expression, eye contact, body posture, and movement. These authors state that difficulties in emotion recognition may be a critical factor in poor communication and are often associated with interpersonal problems and the maintenance of psychopathology (Ruffman et. al., 2008). Facial expressions are complex. Recognizing facial expressions for an individual suffering from PD may be even more complicated. For a person with PD, emotions can often blend. Many people with PD tend to suffer from tremors and slurred speech, which also appears to impair a person's ability to accurately read the emotions of others. Many researchers speculate that PD may take a bigger role on central neural circuits that involve recognizing negative emotions. From previous studies, it can be seen that PD occurs when nerve cells that produce dopamine are impaired and deficient (Chinta & Andersen, 2005). This insufficiency of dopamine production strengthens the susceptibility of a person with PD to experience tremors, balance problems, and other severe symptoms. Recent meta-analyses have suggested that emotion recognition deficits in PD are heavily associated with influences of dopaminergic medication (Gray & Tickle-Degnen, 2010), highlighting that emotion recognition impairment of PD patients was greater in the hypodopaminergic state compared to the medicated state.

Sleep disruptions, excessive sleepiness, and specific sleep disorders may be present in PD. Sleep is negatively affected in more than 75% of people with PD; sleep

disorders are often considered the most disabling non-motor symptom (Parkinson's Foundation, 2024). It has been seen that many individuals suffer with insomnia, commonly resulting in the trouble of falling asleep or staying asleep throughout the night. Sleeping may be a difficult task due to motor symptoms experienced (i.e., tremors, muscle stiffness). Some individuals may also struggle with rapid eye movement (REM) sleep behavior disorder (RBD), conditions that involve a combination of sleepwalking, punching or sleep taking.

These involuntary responses can interfere with sleep quality and even affect a person's automatic nervous system. The nervous system is responsible for controlling systolic and diastolic blood pressure (SBP; DBP), body temperature, HR, gastrointestinal, respiration, bladder movements, and much more. Unfortunately, individuals experience several limitations in one or more automatic controls. For example, a person may experience dramatic drops in their BP caused by standing up to quicky or external stressors, similarly, some individuals lose bladder control (i.e., neurogenic bladder) or experience slowness of bowel motions (i.e., constipation). One study suggested the increase mechanism of slow wave sleep correlates with better performance in executive function, language, and processing speed (Wood et al., 2021). Thus, it is supported that the idea that good deep sleep can significantly affect physical health also positively impact mental and cognitive wellbeing.

Physical Activity

Exercise is an important part of healthy living for all individuals. For those living with Parkinson's disease, exercise is crucial. Exercise enhances muscle strength, body composition, and quality of health. Physical activity has been shown to improve mobility,

flexibility, and balance, but can also impact cognition. Establishing exercise habits is a vital component to the overall success and management of PD. According to the Parkinson's Outcome Project, people who begin to exercise earlier onto their diagnosis for a minimum of 2.5 hours per week, have seen a relatively positive outcome. Loss of mobility is common amongst older adults which may cause profound consequences (e.g., social, physical, and cognitive results). The loss of mobility, such as older age, low physical activity, impaired strength and balance, elicited other concerning health impairments (e.g., diabetes, arthritis) (Brown & Flood, 2013).

There is evidence that incorporating physical training improves functional capacity and mobility amongst people with PD (Goodwin et al., 2008). Physical exercise is generally recommended with the presence of pharmacological supplements. Evidence has pointed toward positive reports that aerobic exercise with medication can significantly impact the risk or intensity of PD (Alberts & Rosenfeldt, 2020; Lauze et al., 2016). Other findings have also supported the thought that exercise may be equally effective in controlling symptoms compared to pharmaceuticals. A variety of medications used in PD can also become ineffective and may lead to some undesirable side effects (Rinne, 1983). Thus, exercise has been sought by mechanisms that stimulate motor and cognitive functioning.

When it comes to exercise, there are a variety of modalities. Medical teams continue to wonder which physical mechanisms provide the most benefit to people with chronic immobility. The latest research suggests endurance (e.g., cardio, aerobics), strength training, and balancing protocols (e.g., yoga, tai chi) are amongst the most helpful interventions for management. According to a meta-analysis, it was found that

men particularly benefit from moderate resistance and aerobic exercises as a prophylactic strategy to lessen symptoms, reduce inflammation, and sustain dopaminergic function (Fang et al., 2018). Multiple factors contribute to the efficacy of exercise in frequency, intensity, and complexity. It is still unclear which mode of exercise is most constructive, especially due to the disease's individuality in each person. Gait dysfunction in PD can affect all if not most people with PD. Gait dysfunction can cause other severity of symptoms to cover such as the rise of falls, rigidity, and freezing of muscles. An array of studies has shown the importance of physical exercise to improve the range of walking parameters. Physical and occupational therapies have been seen as positive interventions.

Physical therapy has considerable benefits, including reduction of falls, improvement in mobility, and noticeable differences in non-motor impairments, as well as being a cost-effective and low-risk intervention (Lauze et al., 2016). It can be inferred that the use of medication and the influence of physical activity have a significant effect of improving symptoms (i.e., balance, and gait). Physical therapy includes the use of stretching and strengthening exercises and machines to help people with Parkinson's maintain strength, coordination, flexibility, and endurance and regain function (i.e., level of independence), whereas occupational therapy is the use of rehabilitation techniques that help people with neurological conditions better perform routine tasks to minimize distress and to maximize those adaptations. Literature encourages people with impairments to incorporate repeated learning, motor tasks, and physical activity (Liu & Latham, 2009; Ramazzina et al., 2017). A variety of behavioral modalities, such as physiotherapy, external cueing, attentional exercises, and cognitive training, have been

designed and implemented in clinic and research settings to target various PD triggers and determinants. Exercise must be done on a regular basis. Physical therapy is thought to reduce the risk of physical and psychological symptoms, hence improving general well-being.

Studies have supported progressive resistance training, Nordic walking, and daily treadmill exercises to significantly improve gait (Frenkel-Toledo et al., 2005; Goodwin et al., 2008; Kwok et al., 2022; Rafferty et al., 2017). Most importantly, the integration of exercise has minimized the number of falls (Allen et al., 2010; Shen et al., 2016). Using a treadmill may act as an external cue, reinforcing neuronal circuits and walking patterns. This finding further suggests that treadmill training with external cueing is more effective in reducing rigidity and FOG symptoms. Treadmill training is the most studied form of aerobic training in PD (Lamotte et al., 2015). These exercises empirically support the important factor in achieving physiological adaptations from aerobic training, due to significant improvements in gait speed and stride (Mehrholz et al., 2015; Ridgel et al., 2015; Schenkman et al., 2018). Following a progressive and repeated motor-cognitive training process aids in skill acquisition.

Other interventions such as repetitive training of compensatory steps have significantly shown to improve balance in patients with PD. Mak and Hui-Chan (2008) reported that a patient's ability to perform sit and stand performances improve task-specific training and mass velocity. Controlling posture and balance is difficult and negatively impacts gait and safety, especially when turning or changing directions becomes extremely difficult and must be accomplished in micro steps (Crenna et al., 2007). Thus, training concentrates heavily on musculoskeletal limitations. Limitations in

ankle knee flexion/extension, stride length, hip extension, and hip rotations are common in Parkinson's disease patients. Joint mobilization and soft tissue stretching can help to improve range of motion (ROM) and gait. A comprehensive gait training program for Parkinson's disease patients must include trunk mobility (rotation) and upper extremity ROM (large, reciprocal arm swings). This suggests that exercise-based interventions may be associated with mobility, strength, and balance in people with PD who exhibit mild to moderate symptoms of severity.

There is clear and compelling evidence that the increase of exercise appears to increase in brain connectivity. For example, high intensity training elevates the body's heart rate (HR) which results in the vascularization of the brain which improves as the blood vessels in the brain become healthier. As those blood vessels strengthen, it can take in more oxygen to different parts of the brain and results in higher levels of brain function. It is evidenced that when a person exerts large forces (i.e., HIRT workouts), the basal ganglia and the cluster of brain nuclei get activated. Exercise is commonly known not only to improve physical strength, but also to improve mental functioning. It is strongly suggested that physical activity become an integral part of people's lifestyle to maintain and reduce symptoms.

The Present Study

The altered motor symptoms of Parkinson's disease have a detrimental impact on quality of life, disrupt daily activities, and raise the risk of falling and disability. As a result, identifying the association between standing posture and trunk stability and the balance, gait, and rotation found in high-functioning persons with Parkinson's disease, who are at a higher risk of falling, is of special interest. Previous research has revealed

therapeutic interventions connected with maintaining balance through medication and surgical interventions. Additionally, a positive association between trunk control measurements and clinical tests of standing posterior trunk rotation performance could lead to new therapeutic treatments that increase trunk stability in the treatment of gait, balance, and freezing in people with Parkinson's disease and the elderly.

This proposal focuses on the efficacy of a complex exercise regimen, specifically targeting increased stability, mobility, and flexibility. It is also anticipated that consistent exposure to this routine will improve stability and reduce both fear of falling and experienced falls. Specific hypotheses in these areas are as follows:

Hypothesis I: It is hypothesized that a consistent workout regimen will increase a person's ability to successfully perform a ring-toss procedure for the duration of five-weeks. It is also hypothesized that more than 50% of participants will successfully accomplish the intervention (ring toss) by displaying low levels of imbalance and rigidity.

Hypothesis II: It is hypothesized that regular exercise and the intervention of the ring-toss will demonstrate significant improvement in balance and a positive change in motor functioning. It is further hypothesized that there will be a reduction in pace of any motor deterioration determined by the MiniBESTests balance measurement.

Hypothesis III: It is presumed that the Force Plate will demonstrate postural stability for people who advance in the ring-toss protocol. It is hypothesized that there will be significant correlations across pre-and-post assessments in people with Parkinson's disease. It is predicted that there will be significant improvements in stability and mobility after five weeks of assessment.

CHAPTER IV

METHODOLOGY

Participants

Ten ($N = 10$) volunteers aged 50 years or older participated in this study during February, March, and April 2023. Subjects were selected and assessed for PD symptom severity. The study was designed as a pre-test, post-test design with subjects providing their own point of comparison based on pre-test scores. The subject's routine involving low-to-high intensity workouts was not changed for the duration of the study (five weeks), and subjects additionally, added a balancing protocol (i.e., twist-and-turn). Pre- and post-assessments were administered to further investigate the prevalence of falls and imbalance through a series of balance protocols. The assessment instruments that were included involve the incorporation of the MiniBESTest and the Force Plate measures.

Subject demographics (mean age, gender, race) and PD diagnostic classification (mild or moderate levels) are found in Table 1. The modified Hoehn and Yahr (mHY) was utilized as a marker to assess participant's progression with PD. The participants who properly met stage three or higher classification, included having observable mild to moderate bilateral disease with some postural instability and physical independence were invited to participate. Participants in the study pool who exhibited severe disability (i.e., wheelchair bound, needed walking aid, severe assistance with balance) were identified and included in the study, with necessary adjustments. The majority of individuals has been diagnosed with PD based on observable symptoms such as bodily tremors,

bradykinesia, unilateral disease, axial restrictions, bilateral instability, decreased balance, and freezing of gait (evidenced by stiffness and shuffling).

Preliminary Screening

Individuals were recruited for the study from Human Performance Laboratory (HPL) PD exercise members who were active members of the Big Country Parkinson's Support Group in Abilene, Texas. The Human Performance Lab was a facility on the main campus of Abilene Christian University (ACU) for faculty, students, and staff who want to evaluate health technology (for example, DEXA, Parvo metabolic monitoring system) or study body composition, muscle strength, or cardiovascular equipment. HPL facilities were made available at no cost to PD patients in the Big Country area, regardless of ACU employment status. Participants were originally recruited by word of mouth, flyers, churches, and therapy centers. Participants were active exercisers at the HPL at ACU, working out multiple times a week, during the working hours of 8 am to 5pm. Each individual routine was standardized by Dr. Anne Bane, Kinesiologist at ACU. During the initial visits, review of the experimental procedure was administered (see Appendix B). All participants were provided with a copy of the Informed Consent form (see Appendix B), with all questions answered about further involvement in the proposed study.

A series of questions were presented of all active HPL members to ensure all criteria were met for the study. Participants who met the following criteria were admitted to the study: (1) Participant had an existing diagnoses of mild to moderate PD (modified Hoehn and Yahr (mHY) stages $\leq$3), (2) was over 50 years of age, (3) was on oral medication (e.g., levodopa therapy), (4) patient participation in resistance training or

high-intensity exercises (i.e., dynamic exercises, upper extremity and lower body exercises), and (5) completion of five weeks of balance training intervals.

Participants not meeting study criteria included those (1) who had not signed a consent form, (2) those who had not been diagnosed with Parkinson's disease, and any who rated at stages below the requirement of the mHY scale, (3) were not on medication, (4) had extreme bodily limitations that inhibited participation in exercises (i.e., the inability to walk, or cardiovascular risk factors), and (5) any others who were unable to complete exercise more than two days a week for five consecutive weeks.

Experimental Procedure

Participants visiting the laboratory for pre-assessments (before the 5-week exercise intervention) received the following program: *visit one* = entry/familiarization, medical history form, *visit two* = pre-assessment of the MiniBESTest balance evaluation, and *visit three* = force plate analysis. After the 5-week intervention (ring-toss), participants returned to the laboratory for post-assessment, *visit five* = post-assessment of the MiniBESTest balance evaluation and the force plate analysis.

Prior to the study, each of the procedures was explained to participants. All questions or concerns were addressed regarding the investigation. All procedures and participation criteria were approved by the ACU's Institutional Review Board (IRB) (see Appendix A). When the participant's questions had all been addressed, the informed consent document was signed, and participants completed a health history questionnaire, including dates of first diagnosis with PD, medication list, and additional health risk factors (see Appendix C). The questionnaire was analyzed by the research team to ensure that eligibility requirements. Preliminary screening and balance protocols were then

conducted in the Human Performance Laboratory (HPL) at Abilene Christian University.

Assessments (pre- and post-) were administered in weeks one and five. All participants reported to HPL working alongside a student worker and research assistant. The first administration reported at ACU was the MiniBESTest balance evaluation. The test administered assessed dynamic balance through a series of unidimensional construct movements. Participants completed all mini assessments and exercises within 15–20 minutes. The second assessment conducted at pre-and-post observations was the force plate measure. The test was administered at Hardin Simmons University (HSU) in Abilene, Texas, due to equipment placement. Participants completed all assessments on the platform within a one-hour timeframe. The force plate had been specifically tailored to calculate gait, balance, and static analysis. These instruments (MiniBESTest & Force Plate) (see Appendix D and G) to calculate each participant's progression with balance and stability. An overview of the trunk exercise program is provided in Table 2.

Participants had an existing exercise regimen prior to the study. Most of the exercise protocols were low to medium intensity training. Intensities and general protocol were unique to each individual. Exercise was performed two-to-three times a week, with two days of rest between each session. All participants were accompanied by a student worker, guiding them through the exercises. Student workers adjusted weights per request or level of endurance based upon how the participant felt. Participants performed a variety of exercises. Some of these exercises included leg extensions, seated leg curls, calf raises, seated abductions, seated triceps extensions, rope pull-downs, and anti-gravity treadmill (alterG) (see Appendix E). Participants were able to take two-to-three-minute

rests between sets. Most participants were able to complete three sets of twelve repetitions on average (i.e., weight was subjective to the participant). Most participants had neurological exercises incorporated into their regimen. These cognitive exercises administered included warm-ups (i.e., walking marches, fingertip touches, pickups), balance (i.e., standing touches, backwards walking), posture (i.e., standing roll, neck and back extensions), and neuromuscular exercises (i.e., seated medicine drop-and-catch).

The researchers and student workers measured and recorded each participant's blood pressure and heart rate before and after the volunteer exercise. On some occasions, student researchers read BP multiple times at one given point to accurately assess the participant. Several participants disclosed a history of increased blood pressure or an unstable blood pressure; given these circumstances, these individuals were closely watched, particularly when balancing procedures were added to their exercise regimen. Manual BP was administered (1) prior to exercise regimen, (2) immediately after the exercises, (3) after the ring-toss activity, or (4) during one of the participant's low-intensity workout.

To determine the efficacy of the five-week interventions, each analysis was modified individually to ensure standardization. In accordance with this approach, two participants were unable to adequately participate in the balancing protocols, due to the restraint of gait restrictions. When a participant was unable to accomplish the task or adequately perform, they were asked to come back another day or were considered absent. Even with unfavorable gait problems, each participant was able to contribute significantly to the data, by modifying the balance protocol. Throughout the duration of the study, the variables were consistent. The balancing protocol had been the independent

variable, while the pre-and-post assessments force plate and the MiniBESTest remained dependent variables. Descriptive statistics, paired-sample *t* tests, and one-sample *t* tests were utilized to measure results. All data analyses were conducted using Statistical Product and Service Solutions (SPSS v. 21, New York, USA) with significance set at $p < 0.05$.

Measurements

MiniBESTest Balance Evaluation

Balance was measured using the MiniBESTest (Franchignoni et al., 2010; Oregon Health & Science, 2013) (see Appendix D). The clinical test measured four components of balance: anticipatory postural adjustments, reactive postural control, sensory integration, and dynamic gait. The MiniBESTest is a 14-item test scored on a three-level ordinal scale. It ranges from 0 to 28 with higher scores indicating positively attributed balance performance. Psychometric evaluation has shown it to be a reliable tool with strong test reliability (Franchignoni et al., 2010). Evaluations of the assessment have found large measurement errors in previous trials, especially in the evaluation of the reactive postural control subsection components (Lofgren et al., 2014). However, additional studies have found a significance in correlation between MiniBESTest and BESTest total score ($r = 0.955$) (Leddy et al., 2011). Within a 15–20-minute timeframe, participants were asked to test a range of dynamic balance controls (e.g., sit-to-stand, standing on one leg, platform stance, etc.).

Force Plate

A Force Plate assessment was administered to evaluate gait, balance, and other static and dynamic analysis mainly utilized in sports medicine. The plates are known for

calculating small and large body deviations, generating a pattern known as spontaneous sway. Postural evaluations were performed based on body segment displacement, muscle activity and displacement, and motion patterns. A typical force plate measures force, in three dimensions at each of its four corners. The three prominent measurements used for this study included the center of ellipse area (CEA), center of pressure accounting for length (COP-L), and center of pressure accounting for velocity (COP-V).

The center of pressure (COP) is recorded using the force platforms, which track the point of ground reaction forces, and which is frequently analyzed using one-dimensional variations in mediolateral or anteroposterior direction (Jamshidi et al., 2010; Jeon & Cho, 2020). The computerized assessment also acquired data on the location of the ground reaction force in the anterior-posterior and medial-lateral directions. For this study, only the vertical components of force are needed for the COP calculation. When vertical forces at each corner are equal, the COP is at the exact center of the plate.

Subjects utilized their upright stance on the plate and were asked to follow six balance tests. The positioning of the stance varied based on each individual, however the force plate is standardized. Participants were administered six protocols which include: 1) a two-legged stance with eyes open, 2) two-legged stance with eyes closed, 3) semi-tandem with eyes open, 4) semi-tandem with eyes closed, 5) one-legged stance (preferred leg), and 6) twist and turn taps. The variables accounted for included: confidence ellipse area of center of pressure (A-COP), COP velocity (VEL), Frequency (MF), frequency in the anterior-posterior direction, and the frequency of the mediolateral direction (Da Silva et al., 2017). Similar to previous studies, the position of feet was standardized, using tape markers on the force platform. The participants performed three 60-second trials for the

first four tasks, three 30-second trials for task five (one-leg stance), while the twist-and-turn tasks lasted for 30 seconds; however, duration of intervals were subjected based on the individual; 30 seconds of rest was granted between each trial (Da Silva et al., 2017).

Y-Balance Test

The Y-Balance Test (YBT) quantitatively measured stability, lower body strength, and flexibility (Pacheco et al., 2014). The test was performed at the intersection of three lines which included an anterior line, and two posterior diagonal lines with a 90-degree angle between them and a 135-degree angle in relationship to the anterior line (Pacheco et al., 2014). For the use of the present study, the YBT was utilized as a standardization for participant's stance. Each volunteer was asked to place their heels on the intersection of the two posterior (lateral and medial) lines facing towards the anterior direction. The YBT measurement was tapped on the floor of the HPL and labeled based on each participant's arm length (in cm). The quantitative measure allowed for the researchers to place the foam pillars on the assigned measurement in which the participants can proceed with the ring-toss procedure.

Ring Toss

The Twist-and-Toss measured balance, dual tasking, and dexterity. The procedure incorporated five critical steps for the succession of the postural control evaluation. The protocol was administered pre-and-post the participant's normal exercise regimen, allowing time to perform two sets of ten ('pre') and three sets ('post') workout (see Appendix F). Participants were instructed to stand in the medial line of the YBT, forward facing. Participants were then instructed to hold exercise rings with palms facing upwards, adopting a slight bend in the arms and knees. Researchers asked their

volunteers to rotate their upper body while their lower body remained stable towards the fixed posts, then instructed to hover over the posts after exhibiting posterior trunk rotation, while in a stable position, participants released the ring into the posts and returned to a forward position.

Each participant began the assessment leveled to the floor–the participant was challenged to stand on a variety of platforms based on their level of succession (i.e., observable balance/stability and ability to not knock over fixed poles. The three progression markers included: floor-level stance (*score of 1*), one foam mat (*score of 2*), and balancing disks (*score of 3*). Participants progressed after achieving 90% success rates following the performance of the ring-toss intervention (see Table 2 and 3 in results). Furthermore, as the participants progressed with the intervention, standing on a foam mat and air-filled disk was introduced into the exercises to create an unstable surface and balancing challenge. The fixed posts were measured based on the subject's arm length and were labeled on the YBT for adequate length. The scores for each trial were calculated based on balance (success) and drop (failure), which were calculated by averaging the scores for each set of five trials for the consecutive five weeks. The goal of the rehabilitation instrument was to assess balance, improve how participants turn in daily life, and to reduce falls.

CHAPTER V

RESULTS

The investigation included ten ($N = 10$) well-functioning people with Parkinson's disease. Ages ranged from 54 to 84 years with a mean of 68.5 $\pm$ 9 years. Limited racial diversity was reported among participants (90% Caucasian and 10% Hispanic/Latino). All participants had been previously diagnosed with PD, with a range of 2 to 17 years reported since diagnosis. All participants were on medication (i.e., carbidopa-levodopa) for a duration of 2 to 15 years. The wide range of age and severity of PD is consistent with the interindividual nature of the disease. Many of the participants maintained their motor functioning until intervention, while some had a rapid physical and cognitive decline in their functioning. The progression of the disease is respectfully individualized, however many of the related factors are due to early-or-late onset, in which most of the participants in this study reported having middle-to-late onset. Baseline physiologic and anthropometric characteristics are presented in Table 1.

Table 1

Sample Demographics Questionnaire (N = 10)

		Frequency	Percent
Gender			
	Male	8	80.0
	Female	2	20.0
Ethnicity			
	Caucasian	9	90.0
	Hispanic/Latino	1	10.0
Affected side			
	Right	5	50.0
	Left	5	50.0
Recent Falls (<1 year)			
	Fall(s)	8	80.0
	No fall(s)	2	2.0

Three measurements were utilized for balance protocols: twist-and-turn (ring-toss), MiniBESTest, and a Force Plate (pre-and-post assessments) as described in Table 2. The intent for this study was to focus on the effectiveness of a comprehensive workout regimen aimed at increasing stability, mobility, and functional balance. Consistent with a dual-tasking approach of a trunk rotational exercise.

Table 2

Description of the Core Components and the Progression of the Ring-Toss Program

Task	Sets	Duration/ Progress	Core Components	Rationale
Intervention Exercise				
Ring-Toss	2 sets each visit (conducted pre-and-post exercise regimen)	5 weeks 90% successful ring-tosses progresses to stabilization platforms: floor level, one foam mat, & balancing disks	Assesses stability, mobility, rotation, & sensory integration,	During dynamic tasks, the coordination of pelvic and trunk movements is vital to maintain stability. PT's are required to toss ring through post while standing on an unstable surface.
Pre-and-Post measurements				
The Mini-BESTest		5 weeks Conducted week one and week five	Area of assessment in balance, functional mobility, gait, and vestibular The four domains included are antifactory postural adjustment, reactive postural control, sensory orientation, & dynamic gait	Clinical balance assessment tool aims to target and identify 6 balance control systems designed for balance deficits.
Force Plate		5 weeks Conducted week one and week five	Area of assessment center of ellipse area (CEA) and center of pressure in length and velocity (COP-L, COP-V) 6 balancing intervals were conducted	Administered to assess gait, balance, and other static and dynamic analysis. The plates calculate small and large body deviations, generating a pattern known as spontaneous sway.

Descriptive statistics were utilized to measure the mean and standard deviation for the balancing intervention of the ring-toss, seen in Table 3.

Table 3

Descriptive Statistics of Ring Toss

	M	*SD*
Week 1 success percentage	100.0	.000
Week 2 success percentage	88.8	21.64
Week 3 success percentage	78.3	25.05
Week 4 success percentage	85.7	20.76
Week 5 success percentage	91.9	16.75

My first hypothesis stated that the introduction of a consistent training plan would be associated with observation of an improved capacity to correctly perform the ring-toss procedure over the course of five weeks. This hypothesis was supported. The progression of the ring-toss was evidenced by the percentages of the totaled success rates per week. As seen in Table 2, all participants were able to adequately perform the balancing procedure (M = 100.0, SD = .000). Throughout the duration of the five-week balancing protocol participants maintained significant levels of balance, evidenced by maintaining stability and trunk rotation (i.e., week two, M = 88.8; week five, M = 91.9). It was further supported by the original hypothesis that more than half of the participants completed the intervention (ring-toss) by demonstrating lower levels of imbalance and rigidity than they displayed at pretest assessment. The direction of this supported predictions and suggested that participants who were able to progress intervals had less difficulty adjusting to new interventions (i.e., mat, balancing disks).

A one-sample (dependent groups) t test was conducted to assess the impact of the balance training protocol and the effectiveness of improvements in stability and mobility and maintaining stability as well as mobility. These analyses are presented in Table 4.

Table 4

One-Sample T *Test of Ring Toss*

	People able to Progress	*M*	*SD*
Floor Average	10	92.17	12.67
Mat Average	4	80.50	12.34
Disk Average	4	98.50	1.73

The original prediction of the first hypothesis maintained that a consistent fitness routine and the integration of a ring-toss technique would improve a person's capacity to successfully perform balancing protocols over the course of five weeks by actively progressing levels of stability. The hypothesis was somewhat supported. The progression of stability baseline significantly increased for more than four participants (mat average $M = 80.50$, $SD = 12.34$; Disk average $M = 98.50$, $SD = 1.73$). The level of success was high (at floor level) despite introducing the mat and balancing disk. Not all participants were able to progress challenging stability platforms; however, statistical significance was achieved. Table 3 depicts that 40% of participants were able to progress beyond the baseline level to a mat, while the same four participants (accounting for 40%) progressed to a balancing disk. Although 50% of the participants remained at a baseline level, these individuals maintained 78% or higher of successful ring-toss completion. The direction of this observation suggests that the relatively good level of function exhibited by participants at baseline suggests that participants had a limited capacity to improve on these specific outcomes following the interventions.

A paired-sample *t* test was conducted to test the interaction between pre-and-post intervention of the MiniBESTest balancing protocol as demonstrated in Table 5.

Table 5

Paired-Sample T *Test on the MiniBESTest*

	Pre-Test	Post-Test	*p*
Overall	20.70 ± 5.5	22.0 ± 7.3	0.404
Anticipatory	3.50 ± 1.90	4.10 ± 1.79	0.357
Reactive Posture	4.10 ± 2.18	4.40 ± 2.63	0.697
Sensory	4.50 ± 1.71	5.10 ± 1.37	0.297
Dynamic	8.80 ± 2.14	8.80 ± 3.15	1.00

$p < 0.05$*; $p < 0.01$**

It was hypothesized that regular exercise and the implementation of the ring-toss would result in considerable improvements in balance and a benefit shift in motor functioning. Although this hypothesis was proven to be observable throughout the study, it was further predicted that any motor degeneration shown by the MiniBESTest balance measurement would be slowed. While balance, dynamic posture, and sensory interventions were assessed, the overall measure was not significant, thus, the overall hypothesis was not supported. Participants reported low levels across the pre-and-post assessment. Scores were not found to be statistically significant as seen in Table 4. It is interesting to note that there were no improvements and no significance seen throughout the evaluation between weeks of the balancing evaluation. It could be inferred that there were individualistic improvements; however, the overall account implied some deterioration, instead.

A paired-sample *t* test was conducted to measure pre-and-post intervention of the Force Plate as seen in Tables 6–15. The overall hypothesis in utilizing the Force Plate as an additive measure to demonstrate postural stability for person's who progress through the ring-toss procedure. It was predicted that after five weeks, there would be significant changes in stability and mobility, with high correlations found between pre-and-post

assessments. This hypothesis was tested using a paired-samples *t* test with tolerance toward balancing protocols (i.e., feet together, semi-tandem, one-legged stances) as the variables. The hypothesis was both supported and not supported. Participants' data shows scattered levels of significance on the eight balancing protocol components of the Force Plate measures. Postural sway, balance, twist, 30-second one-legged stance, and number of taps all showed some effects as is shown in the following tables (see Tables 6–15).

Table 6

Paired-Sample T *Test on Force Plate Data: Postural Sway*

		Pre	Post	*p*
Feet Together	CEA_cm^2	11.92 + 9.80	7.40 + 5.03	0.179
	COP_L cm	14.50 + 9.49	11.18 + 7.56	0.302
	COP_V cm/s	2.3 + 1.45	1.83 + 1.25	0.303

p <0.05*; p <0.01**

Table 7

Paired-Sample T *Test on Force Plate Data: Postural Sway*

		Pre	Post	*p*
Feet Together Eyes Closed	CEA_cm^2	11.58 + 12.40	9.12 + 6.98	0.597
	COP_L cm	19.72 + 14.25	15.79 + 9.95	0.463
	COP_V cm/s	3.22 + 2.35	2.56 + 1.63	0.452

p <0.05*; p <0.01**

Table 8

Paired-Sample T *Test on Force Plate Data: Postural Sway*

		Pre	Post	*p*
Semi Tandem	CEA_cm^2	11.36 + 5.73	8.78 + 6.53	0.317
	COP_L cm	15.75 + 7.17	15.60 + 8.43	0.963
	COP_V cm/s	2.57 + 1.17	2.55 + 1.39	0.972

p <0.05*; p <0.01**

Table 9

Paired-Sample T *Test on Force Plate Data: Postural Sway*

		Pre	Post	*p*
Semi Tandem Eyes Closed	CEA_cm^2	17.11 + 13.76	11.33 + 7.24	0.244
	COP_L cm	24.76 + 13.59	23.21 + 14.88	0.784
	COP_V cm/s	4.01 + 2.20	3.74 + 2.45	0.774

p <0.05*; p <0.01**

No significant difference was observed between the postural sway after the 5-week twist and toss intervention for the measurements accounting for feet together, feet together eyes closed, semi tandem, and semi-tandem eyes closed as seen in Tables 6–9. Although increased strength and decreased sway were observed over time, there was no significance within individuals. For significant differences to be observed, data analysis would have detected a decrease in center of ellipse area (CEA) and center of pressure (COP) favoring a stable non-swaying posture.

Significant improvements were observed in balance assessments Tables 10–11. This hypothesis was supported. Pre-and-post significance was found with the center of ellipse area (CEA) for the one-legged assessment on the right side (*pre M = 38.92 $\pm$ 28.77; post M = 19.63 $\pm$ 16.78; p<0.050*). There was no significant data accounting for pre-and-post one-legged balance assessment on the left side. The center of pressure average length (COP-L) was significantly lower in post-assessments compared to pre-assessments in the one-legged right balance as seen in Tables 10–11 (*p<0.017*).

Table 10

Paired-Sample T *Test on Force Plate Data: Balance*

		Pre	Post	*p*
One Legged Left	CEA_cm^2	61.35 + 94.79	34.95 + 94.79	0.443
	COP_L cm	23.41 + 17.31	16.49 + 14.79	0.262
	COP_V cm/s	7.22 + 5.34	5.12 + 4.60	0.270

p <0.05*; *p* <0.01**

Table 11

Paired-Sample T *Test on Force Plate Data: Balance*

		Pre	Post	*p*
One Legged Right	CEA_cm^2	38.92 + 28.77	19.63 + 16.78	0.050
	COP_L cm	21.01 + 10.61	13.63 + 8.23	0.017
	COP_V cm/s	6.55 + 3.26	4.27 + 2.62	0.017

p <0.05*; *p* <0.01**

Significant differences were found for rotational twist on the force plate. The center of pressure average length (COP-L) was significantly lower in post-assessment compared to pre-assessments in the twist and toss procedure as seen in Tables 12–13 (*p<0.002; p<0.004*). Additionally, it was found that there was a positive trend when participants were able to complete a 30-second one-legged interval held as seen in Table 14.

Table 12

Paired-Sample T *Test on Force Plate Data: Twist*

		Pre	Post	*p*
Twist Left	CEA_cm^2	105.64 + 83.61	62.03 + 29.82	0.185
	COP_L cm	57.43 +22.33	25.76 + 11.64	0.002
	COP_V cm/s	9.11 + 3.63	7.61 +3.40	0.344

p <0.05*; *p* <0.01**

Table 13

Paired-Sample T *Test on Force Plate Data: Twist*

		Pre	Post	*p*
Twist Right	CEA_cm^2	86.61 + 77.18	51.05 + 22.91	0.229
	COP_L cm	55.55 + 24.81	25.31 + 10.35	0.004
	COP_V cm/s	8.96 + 4.07	7.73 + 3.25	0.422

p <0.05*; *p* <0.01**

Table 14

Paired-Sample T *Test on Force Plate Data: 30 Second One-Legged Hold*

	Pre	Post	*p*
OL hold left	0.14 + 00.5	0.16 + 00.5	0.343
OL hold right	0.14 + 00.5	0.16 + 00.5	0.343

OL = one-legged; p <0.05*; *p* <0.01**

Participants were asked to perform a modified ring-toss intervention while on the Force Plate. The balancing protocol was altered based on the individual's need and adjustment to the balance plates. A paired-samples *t* test was conducted to compare the number of unilateral twist and taps improvements at pre-and-post assessments in the Force Plate. It was originally hypothesized that within individuals would indicate positively significant alterations in mobility and stability. Such a hypothesis was significant. As seen in Table 15, the number of taps to the unilateral left and right side were significantly strong, positive, and significant despite limitations The number of taps performed on the right-side post-assessment significantly improved compared to pre-assessment (pre $M = 1.38 \pm 0.46$, post 0.91 ± 0.23; $p<0.004$).

Table 15

Paired-Sample T *Test on Force Plate Data: Number of Taps*

	Pre	Post	*p*
Number of taps Left	1.47 + 0.58	1.01 + 0.41	0.009
Number of taps Right	1.38 + 0.46	0.91 + 0.23	0.004

$p < 0.05$*; $p < 0.01$**

CHAPTER VI

DISCUSSION

Results Discussion

The purpose of this study was to integrate increased attention on stability, strength, and stamina into the regular exercise routines of patients. Specifically, I intended to introduce a balancing exercise in order to reduce both the fear of falling and the experienced of falls. The study took keen interest in the correlation between motor impairments in persons with Parkinson's disease and trunk stability. After five weeks of exercise, participants successfully accomplished the ring-toss intervention. Four out of ten participants completed all three progressions introduced in the balancing protocol, while the others remained at baseline levels. Although some participants did not progress across the stability platforms, they maintained significant trunk rotation and successful ring-tosses. Additionally, a positive relationship between the balancing intervention and the Force Plate was observed. The ring-toss evidently improved markers of fragility, FOG, and balance. Improvements in automatic symptoms and severity were individual, but significantly improved throughout the five-week intervention.

There was no statistically significant result for the MiniBESTest balancing measurement. The test revealed minimal and low-level differences between pre-and-post assessments. The balance evaluation systems test is a predicted tool that calculates likelihood of falls, due to lack of balance. Participants across the board scored significantly high on dynamic balance (i.e., TUG, change in speed, pivot turns,

obstacles), and sensory orientation exercises (i.e., inclined stance, feet together). However, participants had worsening autonomic symptoms and severity that impaired their performance with balancing protocols, such as their presentation on anticipatory exercises (e.g., rising on toes, standing on one leg) and on reactive postural control (i.e., compensatory stepping corrections forward falling, backward falling, and unilateral leaning. Unfortunately, no significant differences were detected after post-assessment.

Notable findings were indicated by the Force Plate measurements. According to the findings, participants with PD exhibited postural instability while having their feet together, semi-tandem, and their eyes closed. There was no significant improvement in these measurements. It is noteworthy that participants decreased severity of swings in post-analysis, but not strong enough to reach significance. Despite insufficient stability, participants demonstrated significant improvement in balance when asked to stand on one-leg and when performing a modified ring-toss protocol on the Force Plate.

Ring Toss Results

Despite the inconsistent statistical significance found in the Ring Toss results, there were observable differences after the short five-week intervention resulting in strength, balance, and mobility improvements. Although four patients advanced to the highest level of progression interval, it was evident that most all participants were able to maintain high levels of successful ring-tosses. Accepting 90% of the ring-toss meant that the progression of levels became increasingly more difficult. However, individuals kept high percentages of successful ring-tosses without losing their balance and without knocking over additive posts. Despite insignificant findings, participants who were able to maintain high levels of progression had the ability to sustain rapid mobility when faced

with new and advanced balancing protocols. It can be inferred that the ring-toss balancing protocol was a precursor to a patient's overall success during the five-week intervention. The intervention is a feasible exercise that may have substantially improved balance and other symptoms of PD, even without demonstrating statistical significance in these analyses.

Individuals were asked to perform the ring-toss intervention before and after their workout regimen. These strength training exercises included (but were not limited to) chest press, seated rows, and leg extensions. Participants typically exercised for thirty minutes to an hour before proceeding to the ring toss. A compelling observation was made that elicited some distinction between pre-and-post assessment ring-toss success. It is noteworthy to state that all failed attempts (i.e., inability to rotate or drop ring into posts) and successful attempts were documented. There was a negative trend of failed or missed ring-tosses performed by most all participants during pre-ring-toss assessments. While post-ring-toss assessments positively resulted in higher levels of success. Scores across the board were progressively significant when comparing them to pre-assessment.

A possible explanation for this occurrence may be due to immediate acute stiffness and freezing prior to exercise. Almost half of the participants exhibited some degree of rigidity and inflexibility. Another probability may be due to time. It was observed that participants performed significantly better after their exercise, which could be attributed to strength, energy, and endurance. Participants may have found it more difficult to perform the ring-toss due to the lack of energy and momentum. The most readily perceived explanation for this pattern is the fact that participants had better upper

body rotation and arm extension provided by their exercise. Furthermore, there was a positive association between regular exercise and the ring-toss intervention. The capacity to recover following exercise serves as more evidence of the significant of therapeutic interventions that can enhance trunk stability. This observation is a promising intervention that may help attenuate and possibly allude to the influence of time, exercise, and duration of an intervention, such as a balancing protocol.

MiniBESTest Balance Protocol Results

No statistical effect for the secondary outcome MiniBESTest. The results of the model analyses revealed that the intervention led to no change in mobility, balance, or improved motor symptoms (i.e., rigidity). There were no significant differences favoring the ring-toss balancing program for primary outcomes. There was no statistical significance between the pre-and-post measurements. The study cannot provide full support for the beneficial effects of the MiniBESTest measurement when working with people with mild to moderate PD. It can be further understood that the original hypothesis two could not lend support that the MiniBESTest would have beneficial effects for such population due to the duration of the study. Although the measurement is used to assess balance, it can be concluded that it served as an observational tool in this study more than a contributing measurement. The assessment did not account for patterns that enhanced balance.

However, the MiniBESTest measurement helped researchers identify individuals' capabilities and accuracy while performing balancing protocols. Unfortunately, it is evident that the protocol did not account for better balance, stability, or mobility for this study. Progression was only witnessed when administering tests. It may be more

favorable to administer the measure over a longer period of time (e.g., years) to observe significant changes. Limited capacity to improve may have been a major limitation on specific outcomes. Adopting more challenging intervals of the MiniBEST (balance, mobility, and physical function) may help to identify underlying deficits and the efficacy of specific interventions throughout future investigations. More research is needed to determine the protocol's effectiveness for the current research proposal in persons with PD to improve balance.

Force Plate Results

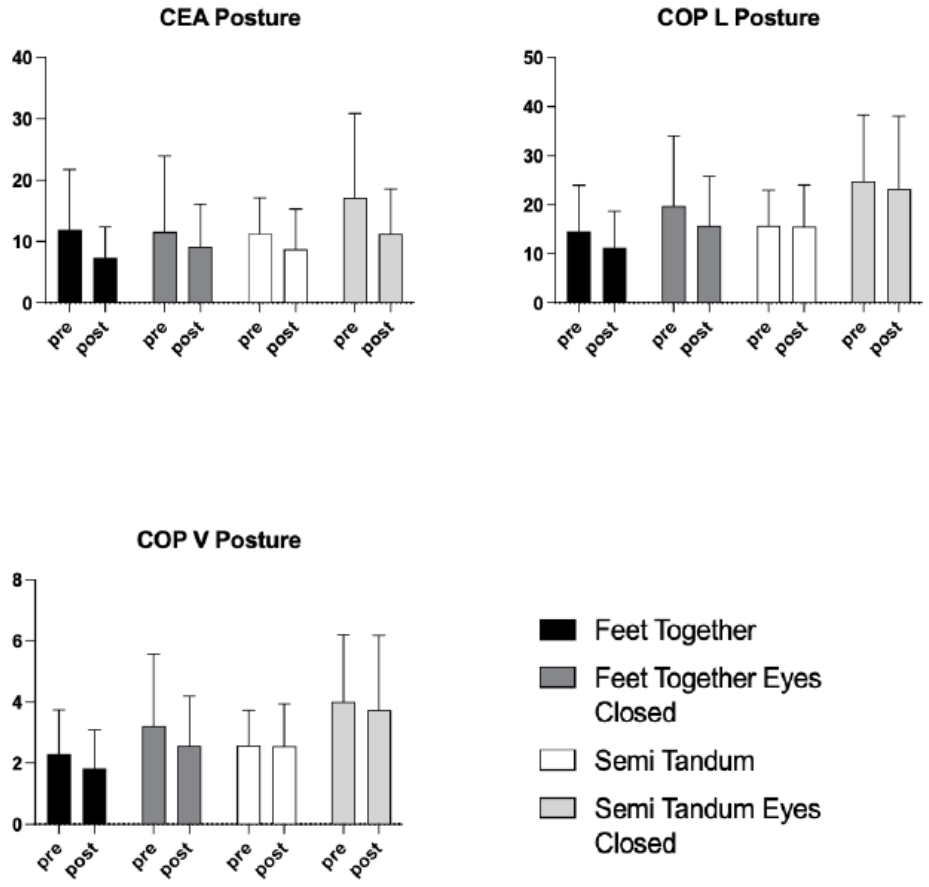
The Force Plate data analysis revealed a variety of significance amongst tests. Frequency, magnitude, velocity, and direction were all accounted for by the Force Plate (see Appendix G; Figures 1 and 2). Two of the parameters that were addressed when assessing balance were the individual's center of mass (CoM) and center of pressure (COP). The center of pressure analyzed three contributing factors including a person's center of ellipse area, center of pressure in length, and center of pressure in velocity. These three factors were further analyzed through each balancing assessment (i.e., feet together, semi-tandem, one-legged stance, twisting procedure).

There were no significant pre-and-post differences after the five-week twist and toss intervention. Specifically, no differences were evidenced for feet together, feet together eyes closed, semi-tandem, and semi-tandem eyes closed for the postural sway. It is further inferred that the less movement occurred, the less a person swayed while standing on the Force Plate platform. It is interesting to note that there was no significant change in anterior-posterior sway variability at the five-week point. A possible explanation for this finding could be the relative importance of the trunk muscles that are

mostly related to corrective movements and posture. It was further reported that the center of ellipse area (CEA) and the center of pressure (COP) measurements are favorable for a stable, non-swaying posture.

Figure 1

Force Plate Postural Measurements

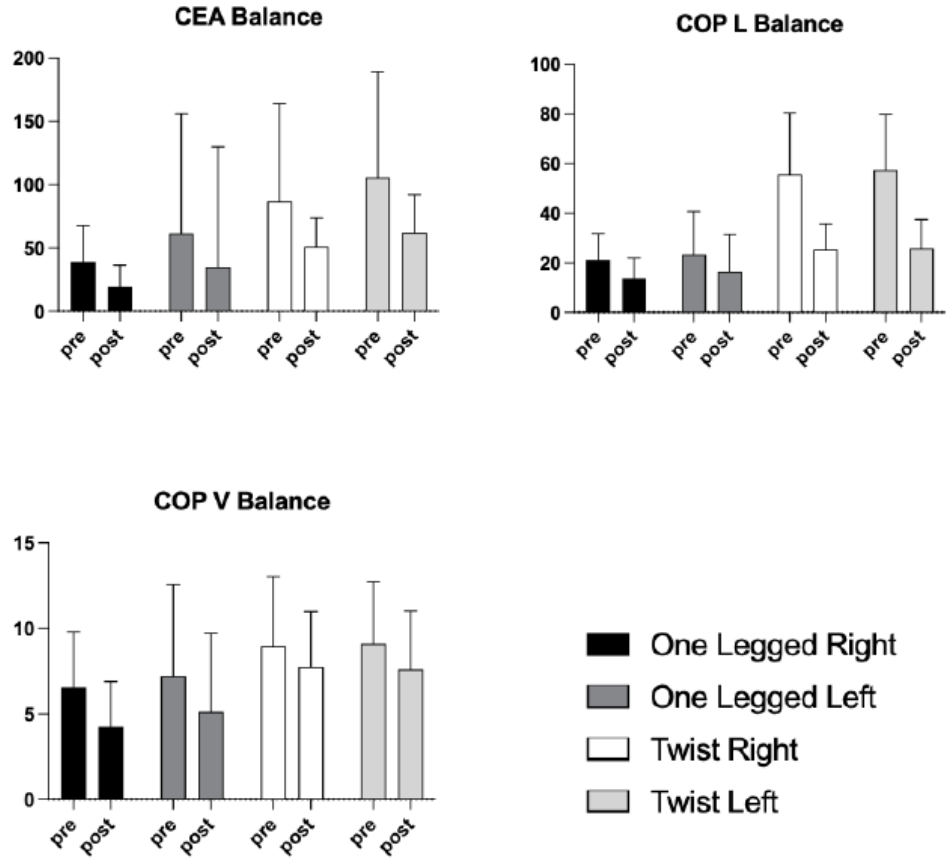


Interestingly, pre-to-post significance was found in the one-legged stances. The analysis was found to be positive, strong, and significant. The center of ellipse area for the one-legged balance assessment on the right side was significantly proven, however, not for the left-side. The center of pressure average length (COP-L) was significantly lower during post assessments compared to the pre-assessment trials for the one-legged

stance on the right side. Data analysis also demonstrated significance for the ring-toss balance assessment on both sides (right and left). The third finding also revealed the center of pressure velocity was significantly less in the one-legged balance on the right side. It is concluded that the velocity of movement performed by most participants was less evident on their right affected side. Interestingly, participants reported their most immediate affected side to be on the right side. This finding contributes to the overall stability and significance of the study demonstrated in overwhelming improvements to unilateral and bilateral balance.

Figure 2

Force Plate Balance Measurements



The participants were individuals diagnosed with PD two to seventeen years ago. Participants' ages ranged from 54–84 years, and the severity of their disease was mild to moderate. Age was consistent with the progression of the diagnosis. Blood pressure readings were also conducted and accounted for the study. While there were no significant differences between BP, strength, years on medication, or affected side, the significance in age was apparent throughout the study. Despite the individuals' age, two younger (age 58) participants demonstrated significant challenges when performing balancing protocols and exercise regimens. These participants significantly decline over the duration of the study, both neurologically and physiologically. Most exercises were modified based on the individual's limitations and physical comfort. It was therefore concluded and accepted that PD manifests differently and subjectively due to the progression and severity of the diagnosis. Thus, balance interventions were significantly distinguishable between most of the participants.

Medication is prescribed early in the diagnosis of PD. Prescription medication, such as Levodopa, is encouraged and often one of the first lines of defense against motor symptoms. As stated in the literature, Levodopa is a natural precursor for dopamine. The participants were asked to maintain regular intake of medication for the progression of the study. Although Levodopa dosage was not analyzed in the study, it was anecdotally the impact medication has on a persons' balance and overall stability. It was evident that participants failing to take medications on time or prior to exercising had more trouble than usual with the balance regimen. Participants potentially "off" were also observed to exhibit higher levels of bradykinesia, FOG, or simply experiencing freezing joints. The contribution of PD medication helped participants regulate and generate dopamine, which

plays a pivotal role in the progression of PD. Additionally, nutrition was not a primary intervention for this study, however, food intake played an important role in the success of the patient's balance like medication.

Strength improved significantly over time. In the study, participants were asked to continue with regular exercise throughout the progression of the study. Although regimens were administered based on the person's needs, most participants were able to perform high intensity workouts using strength training machinery (i.e., leg extension, chest press). Individuals could maintain and perform 3–4 sets of 12 repetitions with 30 seconds of rest in between and constant occlusion for all body exercises for 5 weeks. In the current study, blood pressure was administered consistently prior and post exercise. Most participants maintained steady blood readings, while some participants' BP significantly fluctuated. It was in some rare occasions in which the participant did not follow through with exercise or balance intervention due to a high BP reading. However, only two participants maintained elevated or low BP.

Limitations of the Current Study

This study had an aim to investigate motor deficits and the effects of introducing a balancing protocol in people with mild to moderate PD. The balancing approach helped to maintain the advancements in mobility and stability. It is hoped that publishing the results of the feasibility study can help other researchers in their study design and thereby decrease the efforts for study participants as well as valuable research investments. Importantly, it was noted that numerous elements needed improving while conducting the study.

The first limitation of the study was the absence of a control group. It was predicted that the lack of control condition was due to the small sample size of the study. There was a small sample size of people with mild to moderate PD in the surrounding area. To increase the number of direct replications, further research should consider characteristics such as high statistical power. Due to this difficulty experienced with participant recruitment, it was not feasible to determine the potential efficacy of an exercise-based intervention. The second limitation in the study was having to standardize the balancing protocol. There are limited literature reviews on the efficacy of the trunk rotation protocol. As such, despite the encouraging outcomes reported in this study, there is a need for further research aimed at establishing whether the frequency of this ring-toss program offers greater improvements in balance and/or has the potential to reduce the rate of falls in people with PD.

As stated above, a major concern for this investigation was the lack of a control group. Indeed, the small sample size was prohibitive as far as conducting any type of randomized controlled trial. Without a control group, it was difficult to rule out as history, instrumentation, testing effects or other threats to internal validity. Fourth, while every effort was made to ensure that participants were assessed at a similar time of day for each testing session, logistical constraints meant that some participants had to be tested at a different time of day or in follow-up sessions. A similar limitation occurred with medication. The fifth major concern was the inconsistency of intake medication. Due to the lack of medication intervention, participants' performance was highly impacted by their scheduled dose. More care should be taken to ensure the participants take their prescribed medication prior to exercising. Medication seems to both hinder

performance when not taken, and/or positively minimize the influence of motor fluctuations that patients experienced throughout the protocols. Overall, the potential impact of any changes in participants' medication should be considered.

Despite participants' requirement to perform the exercise program for a duration of five weeks, their additional involvement in external exercise-based activities should be considered. As such, it should be noted that all exercises beyond the balancing protocol were accounted for, it could be of greater benefit to report and measure improvement throughout external physical programs to further highlight a person's stability progression. Most of the participants in the study had been active members in the HPL laboratory prior to this investigation. Their earlier participation may have resulted in a more active lifestyle during this time. The most salient limitation is the duration of the intervention. Although statistical significance was reported during the short five-week intervention, a longitudinal study could allow for more significant improvements and better outcomes. Lastly, although having substantial value, the measures (e.g., MiniBEST) in the study lacked significance when used amongst participants. Further investigators should learn from the study the impact of utilizing the balance intervention, by enhancing its use more than twice during a short interval. For example, the MiniBESTest could have been deemed to be clinically significant, however due to low power, results for this measure were not found to be statistically significant. In light of this, the most correct interpretation of the non-significant results is that it is unlikely due to the validity of the measure, but more so the lack of use of the balancing intervention measure.

Implications of the Current Study

The current study findings should be used to guide future research into balancing methods for patients with Parkinson's disease. Recent literature has provided multiple studies viewing motor tasks and physical therapy as a positive contributor towards regulating symptoms. However, there is minimal research about the efficacy of balance protocols, such as proprioceptive trunk rotation exercises. This design was particularly interested in determining the relationship between standing balance and trunk stability exhibited in balance, gait, and rotation. Specifically, targeting high functional persons with higher risk of falling and freezing of gait. The overall hypotheses were proven to be both correct and incorrect. First, as far as trunk rotational exercises, the ring-toss accounted for high levels of success and progression among participants. Secondly, the MiniBESTest revealed no significant interaction between balance and stabilization. Although the MiniBESTest measures accurate data, it was not a reliable source of measurement for this study. The tool did not account for micro-deviations and management when calculating for balance. Third, improvements were readily apparent utilizing the Force Plate measurements, depicting positive trends of significance in balancing protocols throughout the five-week intervention and inclusion of the ring-toss. The Force Plate statistically calibrated changes in postural sway, balance, and twist. The Force Plate measurement also identified high statistical significance in a person's center of pressure both in length and velocity.

While the measurements in this study aided in assessing balance and stabilization, future research should consider the influence on data analysis. Throughout the study, it was concluded that the MiniBESTest balance evaluation aided as a clinical measure,

while the Force Plate measurement aims for research analysis. Specifically, there was evidence that the MiniBESTest was steadily utilized as an observational measure, whereas the Force Plate served more as a positive contributor to the overall findings.

While this study concerned itself with balance and stabilization, it would be interesting if future researchers explored vestibular and unilateral influences in a person with PD and its potential impact on affected (left or right) sides. The literature points to the fact that most people with Parkinson's disease take on more unilateral deficits, future studies may want to consider the influence of the twist-and-toss protocol on neuromuscular studies.

As stated in previous result discussion, it is strongly encouraged future investigations to increase the use of the MiniBESTest balancing evaluation. In this study, it was found that no significant improvements occurred when utilizing this measurement as a pre-and-post assessment. It is highly encouraged future researchers to implement the balance evaluation more than once a week, in order to observe and collect significant and meaningful data. Many factors can influence the lack of significance, such as variations in the time of day between pre-and-post test, medication adherence, sleep disruption, and fluctuating symptoms (e.g., on/off days).

As mentioned in the limitations, freezing of joints, shuffling gait, and rigidity negatively impacted a person's ability to perform balancing activities. Moreover, future studies may want to investigate the influence of bradykinesia and freezing of gait (FOG) on falls. Clinicians may want to consider patients who are bound to walking devices (i.e., wheelchairs, walkers) and their overall contribution to the data.

As previously stated, the ring-toss was established to assess potential improvements in trunk rotation and stabilization, with a focus on fall reduction. The proposal focused on the efficacy of complex balancing protocols that elicited better stamina and strength. It is suggested to all future studies to investigate the influence of pre and post assessment. Particular attention to the impact of time, medication, nutrition, and patient's symptomatology. It would be of greater significance if future clinicians took interest correlating the ring-toss intervention with brain memory activities, occupying a neuropsychological area of study.

Although this was a short balance intervention, improvements in quality of balance were significantly observed. Future researchers may desire to explore the influence of cognitive impairments on people with PD. The Quality-of-Life questionnaire is a short assessment that is divided into subsections addressing a person's emotion, social support, communication, and bodily discomfort. The measurement has been utilized in healthcare settings to better understand a person's quality of treatment. The implementation of such measurement can effectively assess an individuals' functioning. Using a QoL measurement in a longitudinal study could further add to the understanding of PD and its influence on cognition and neurological feedback.

Conclusion

The study revealed improvements while measuring for balance during a five-week protocol. The study protocols challenge participants exhibiting mild to moderate disease severity with unstable sensory platforms and trunk-rotational exercises. More research may be needed to evaluate whether a similar balancing program of greater intensity can result in changes of involvement and falls risk. More research is needed to also determine

whether improvements are sufficient to reduce falls while allowing for a larger sample size, longitudinal study, and a control group.

This study encourages further research to continue investigating the significance of balance in Parkinson's disease patients. It is favorable to support the growing interest in effective therapeutic strategies to reduce the deficits seen in people with Parkinson's disease. While several balancing measurements did not seem to be significant in this study, future research may aid to improve important findings by increasing evaluation adherence. While drastic changes were not seen with MiniBESTest, strength markers improved overall. Both the ring-toss and Force Plate interventions decreased postural sway and increased momentum and progression. More study is needed to investigate therapies to improve balance and mobility function in people with Parkinson's disease, which can assist minimize the number of falls and improve stability and overall functioning.

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APPENDIX A

Institutional Review Board Approval

The Institutional Review Board at Abilene Christian University states that Jennifer Elvir's project titled "Standing Posterior Trunk Rotation with Adaptive Proprioceptive Toss," which is IRB # 2023-89, is expedited, category 6 under Federal Policy for the Protection of Human Subjects. This approval is dated 4/19/2023. Please contact the ACU Office of Research and Sponsored Programs at orsp@acu.edu with any questions.

APPENDIX B

Informed Consent

Abilene Christian University

Institutional Review Board Informed Consent Form

Thank you for taking the time to read this information and for considering participating in our project. You are aware that you have been identified as an individual with Parkinson's Disease PD) by Dr. Annie Bane of the Department of Kinesiology at Abilene Christian University (ACU). You are also aware that Dr. Bane and her assistants are regularly collecting your personal exercise data during your workouts in the Human Performance Laboratory on the ACU campus. This data is being regularly reviewed by Dr. Bane and her staff and these evaluations are being used to chart exerciese progress, to address new difficulties experienced in movement, gait, and stability, and to determine appropriate timing of revisions to your exercise routine (like increasing weight amounts). Furthermore, you understand that the exercise opportunity offered to Persons With Parkinson's Disease (PWPD) by Dr. Bane in our community is being provided at no cost to participants.

The exercise routines offered in the Human Performance Laboratory under Dr. Bane's supervision primarily target improved management of the motor symptom of PD you may have been experiencing. You may not have been aware that Dr. Bane and her associates have specifically designed some of the exercise routines to directly target PD movement-related symptoms that at this time are not known to have effective exercise-related interventions. Empirical demonstration of the effectiveness of these routines is a prerequisite for presenting these procedures to the scientific community working with PWPD. Further dissemination to physicians (MD/DO), Physical Therapists (PTs), Movement Disorder Specialists (Neurologists), Kinesiologists, and other Rehabilitation professionals or health-care staff, as well as PD patients and their care-givers would be expected to adopt any routines shown through empirical demonstration of effectiveness, to reduce the motor difficulties encountered in PD. These specifically include balance/instability, gait/freezing, turning/flexibility, and the complex combination of simultaneous trunk rotation, postural instability, and an accuracy-task (ring-toss) procedure. It is specifically hypothesized that regular, repeated exposure to this complex training routine will be associated with PD patient data indicating a slowing or even reversals of motor symptoms in the areas of imbalance, bradykinesia, falls, freezing of gait (FOG), difficulties with stopping and turning, and overall a Quality of Life.

Dr. Scott Perkins from the Department of Psychology will be assisting Dr. Bane and in conducting the evaluation of the exercise activities described above. This assessment is an essential component of Dr. Bane's ongoing oversight of your successful management of PD motor symptoms. Dr. Bane and Dr. Perkins have invited Psychology graduate student Jennifer Elvir to assist them with the collection, evaluation, analysis, interpretation of this data.

The following document is intended to provide you with the opportunity to express your desire for your exercise data to be included in the data evaluation described above. As with any research participation, it is important that you read and understand the following information regarding the purposes, benefits, and procedural methodology used in this study, and any potential risks you might encounter by allowing your data to be included in this study.

Title of Study: Standing Posterior Trunk Rotation with Adaptive Proprioceptive Ring Toss

Student Investigator: Jennifer Elvir, B.S., Abilene Christian University (ACU) Department of Psychology

Supervising Investigator: Scott Perkins, Ph.D., & Annie Bane, Ph.D.

You are invited to take part in a research study. This form provides important information about the study, including risks and benefits to you, as a potential participant. Please read this information carefully and ask any questions that you may have regarding the procedures, your involvement, and any risks or benefits you may experience. You may also wish to discuss your participation with other people, such as family members or doctors. Please let the researcher know if you are participating in any other research studies.

Also, please note that your participation is entirely voluntary. You may decline to participate or withdraw from the study at any time or for any reason without penalty or loss of benefits to which you are otherwise entitled.

Please contact the Principal Investigator if you have any questions or concerns regarding this study, or if you wish to withdraw from this study at a later time. Contact information for the Principal Investigator is provided at the end of this form.

Purpose of the Study: The goal of this study is to investigate the implications of step, twist, turning, balance, and rigidity in Parkinson's disease. As a result, this study is particularly interested in determining the relationship between standing posture and trunk stability and the balance, gait, and rotation observed in functioning individuals with Parkinson's disease, who are at a higher risk of falling.

Study Procedures: You will be asked to complete a series of tests and evaluation questionnaires pertaining to balance and stability. The study will ask you to participate

and engage in an exercise regimen with specific activities addressing disturbances in gait due to freezing and difficulty turning, exercises will be encouraged multiple times a week. Some sample items included in the evaluation (assessing balance) will ask participants to "place your hands on your hips. Place your feet together until almost touching. Look straight ahead. Be as stable and still as possible, until I say stop", and "Begin walking at your normal speed, when I tell you 'fast', walk as fast as you can. When I say 'slow', walk very slowly."

After agreeing to participate in this study, all participants will be asked to take a balance evaluation systems tests (*Mini-BESTest*) pre-and-post assessment at the start of the trial and at the end to assess for progression. Secondly, participants will complete two exercise regimens including a force plate and adaptive proprioceptive ring toss. These pre-and-post exercises will take no longer than 15 minutes. These regimens will be encouraged twice a week for four weeks.

No experimental procedures are being utilized in this study. You may withdraw your participation at any point during the study. Researchers deserve the right to terminate your participation if they believe it is no longer in your interest to continue in the study or if you fail to generally follow the instructions provided. Your participation may also end if the study is terminated early for any reason. In the event of termination, you will be contacted by the primary investigator and provide specific information regarding the status of the study and your participation.

Foreseeable Risks: Physical risks may include physical discomfort, pain, or injury brought about by the methods and procedures of the research. A physical risk may result from the involvement of balancing protocols (i.e., standing on unstable foam 3 inches from the ground).

It is possible that you may experience a mild fall, however one of the researchers and a trained student assistant will always be with you as you participate in the data collection procedures. You may experience the possibility of minor imbalance and instability while participating in specific exercises. Every effort will be made to minimize these risks by evaluation of preliminary information related to your health and fitness and by careful observation during testing (i.e., utilizing gait belt, monitorization of shortness of breath, abnormal blood pressure, fast or slow heart rhythm).

A secondary risk is that of Breach of Confidentiality. Participating in this study may result in the loss of privacy and the possibility of a breach of confidentiality. There is a danger of data security breach with any usage of electronic technologies to keep data, however, we have taken measures to minimize the possibility of that occurring. If there is a breach in confidentiality we intend to follow ACU's data storage policies. These policies are as follows: we will securely store the data on campus with the faculty mentor, in this case Dr. Perkins, and all materials will be stored behind closed and locked filing cabinets, and will remain stored for 3 years, following the completion of the investigators. We intend to minimize the risk of breach by properly storing materials in a

secure location, all materials will be kept secure by utilizing a password protected USB to store data, and all information abstained from the study will be unidentified.

No social, legal, or economic risks are anticipated as a result of your participation in this study. In designing this study, the principal investigators have taken steps to minimize the risks associated with your participation. However, if you experience any problems you may contact the principal investigator, Jennifer Elvir through email jne21a@acu.edu, Scott Perkins at perkinss@acu.edu, and Annie Bane at annie.bane@acu.edu.

If you do experience feelings of discomfort, you may contact the supervising investigator, who can refer you to the services for counseling or appropriate physicians. Additionally, you may contact more information and referral service through NAMI (national alliance on mental illness): 800-950-6264 or on their website www.nami.org. Additionally, you may choose to stop participating at any point during the study.

Potential Benefits: This study hopes to continue to advocate for physical health, but may also contribute to the growing body of knowledge surrounding the Parkinson's disease experience. Your contribution to this body of knowledge could lead to an increased understanding about the facets of motor impairments. A positive correlation between trunk control measures and clinical tests of standing posterior trunk rotation performance may yield insight into novel therapeutic interventions that promote trunk stability in the treatment of gait, balance, turning, and freezing in those with Parkinson's disease.

Compensation: No compensation will be awarded for participation in this study.

Confidentiality: Your participation and the information collected for this study will be confidential. The confidentiality of your individual data will be maintained in any publications or presentations regarding this study. Only aggregated data from the questionnaires will be presented publicly or reported in subsequent publications. All research materials will be kept secure by utilizing a password protected USB to store data. Only the investigators will have access to these materials. Confidentiality will be maintained to the degree possible given the technology and practices used by the investigates and participating staff members.

If a breach of confidentiality were to occur, you will be notified within 24hrs of the breach by the primary investigator. Personal information such as Name, Address,Telephone number, Fax number, Email, Social security number, Medical record number, Health plan number, Finger prints, Identifiable photos, or any other elements that could be used to re-identify someone will not be collected.

Questions about the Study: If you have any questions about the study, you may contact Jennifer Elvir through email jne21a@acu.edu, Scott Perkins at perkinss@acu.edu, and Annie Bane at annie.bane@acu.edu.

Review for the Protection of Participants: If you have concerns about this study, believe you may have been injured because of this study, or have general questions about

your rights as a research participant, you may contact ACU's Executive Director of Research, Qi Hang, at qxh22a@acu.edu.

Research Participants' Rights:
You have read or have had read to you all of the above and you confirm all of the following:

- You understand the possible benefits and the potential risks and/or discomforts of the study.
- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant, and you voluntarily consent to participate in this study.

Please sign this form if you voluntarily agree to participate in this study. Sign only after you have read all of the information provided and your questions have been answered to your satisfaction. You should receive a copy of this signed consent form. You do not waive any legal rights by signing this form.

_____ _____

Signature of Participant Date

APPENDIX C

Demographic Questionnaire

Demographic Questionnaire
Assessment Data Collection Sheet

Name:_____

Phone Number: _____ Email:_____

Age:_____ DOB: _____ Gender:_____

Height:_____ Weight:_____ Arm-Length:_____

Ethnicity: caucasian Hispanic/Latino African-American other:_____
(circle one that applies)

On average, blood pressure seems:
- ☐ High
- ☐ Low
- ☐ Inconsistent
- ☐ Normal

Date of Diagnosis with PD:_____

Most affective side:_____

List of current medications:_____

Dosage:_____

Side effects:_____

Number of falls or injuries this past year:_____

How was this injury sustained?:_____

Were you hospitalized for this injury? (if, yes, for how long?):_____

Level of physical activity? (i.e., Health Groups, Gym regimen): _____

Check all that apply, in regards to the participant's gait and balance:

Pace Appears

- ☐ Even
- ☐ Uneven
- ☐ Slow
- ☐ Just right
- ☐ Fast

Postural stability

- ☐ Stable
- ☐ Unstable

Sway

- ☐ Forward
- ☐ Backward
- ☐ Side-to-side

Balance

- ☐ Stable
- ☐ Unstable
- ☐ Need of assistance (i.e., wheel-chair or walker)

Leg Dominance

- ☐ Right Leg
- ☐ Left Leg

Check all that apply

- ☐ Slow, tentative pace(s)
- ☐ Shuffling
- ☐ Steadying self on walls
- ☐ Short strides
- ☐ Frequently loss of balance
- ☐ Arm swings (circle for right arm or left arm or both)

APPENDIX D

MiniBESTest Balance Evaluation Measure

Mini-BESTest: Balance Evaluation Systems Test

ANTICIPATORY ***SUB SCORE:*** /6

1. SIT TO STAND
Instruction: "Cross your arms across your chest. Try not to use your hands unless you must. Do not let your legs lean against the back of the chair when you stand. Please stand up now."
(2) Normal: Comes to stand without use of hands and stabilizes independently.
(1) Moderate: Comes to stand WITH use of hands on first attempt.
(0) Severe: Unable to stand up from chair without assistance, OR needs several attempts with use of hands.

2. RISE TO TOES
Instruction: "Place your feet shoulder width apart. Place your hands on your hips. Try to rise as high as you can onto your toes. I will count out loud to 3 seconds. Try to hold this pose for at least 3 seconds. Look straight ahead. Rise now."
(2) Normal: Stable for 3 s with maximum height.
(1) Moderate: Heels up, but not full range (smaller than when holding hands), OR noticeable instability for 3 s.
(0) Severe: ≤ 3 s.

3. STAND ON ONE LEG
Instruction: "Look straight ahead. Keep your hands on your hips. Lift your leg off of the ground behind you without touching or resting your raised leg upon your other standing leg. Stay standing on one leg as long as you can. Look straight ahead. Lift now."

Left: *Time in Seconds Trial 1:_____ Trial 2:_____*
(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable.

Right: *Time in Seconds Trial 1:_____Trial 2:_____*
(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable

To score each side separately use the trial with the longest time.
To calculate the sub-score and total score use the side [left or right] with the lowest numerical score [i.e. the worse side].

REACTIVE POSTURAL CONTROL ***SUB SCORE:*** /6

4. COMPENSATORY STEPPING CORRECTION- FORWARD
Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean forward against my hands beyond your forward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."
(2) Normal: Recovers independently with a single, large step (second realignment step is allowed).
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

5. COMPENSATORY STEPPING CORRECTION- BACKWARD
Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean backward against my hands beyond your backward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."
(2) Normal: Recovers independently with a single, large step.
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

6. COMPENSATORY STEPPING CORRECTION- LATERAL
Instruction: "Stand with your feet together, arms down at your sides. Lean into my hand beyond your sideways limit. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

Left
(2) Normal: Recovers independently with 1 step (crossover or lateral OK).
(1) Moderate: Several steps to recover equilibrium.
(0) Severe: Falls, or cannot step.

Right
(2) Normal: Recovers independently with 1 step (crossover or lateral OK).
(1) Moderate: Several steps to recover equilibrium.
(0) Severe: Falls, or cannot step.

Use the side with the lowest score to calculate sub-score and total score.

SENSORY ORIENTATION ***SUB SCORE:*** /6

7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE
Instruction: "Place your hands on your hips. Place your feet together until almost touching. Look straight ahead. Be as stable and still as possible, until I say stop."
Time in seconds:_____
(2) Normal: 30 s.
(1) Moderate: < 30 s.
(0) Severe: Unable.

8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE
Instruction: "Step onto the foam. Place your hands on your hips. Place your feet together until almost touching. Be as stable and still as possible, until I say stop. I will start timing when you close your eyes."

Time in seconds:_____
(2) Normal: 30 s.
(1) Moderate: < 30 s.
(0) Severe: Unable.

9. INCLINE- EYES CLOSED
Instruction: "Step onto the incline ramp. Please stand on the incline ramp with your toes toward the top. Place your feet shoulder width apart and have your arms down at your sides. I will start timing when you close your eyes."

Time in seconds:_____
(2) Normal: Stands independently 30 s and aligns with gravity.
(1) Moderate: Stands independently <30 s OR aligns with surface.
(0) Severe: Unable.

DYNAMIC GAIT ***SUB SCORE:*** **/ 10**

10. CHANGE IN GAIT SPEED
Instruction: "Begin walking at your normal speed, when I tell you 'fast', walk as fast as you can. When I say 'slow', walk very slowly."
(2) Normal: Significantly changes walking speed without imbalance.
(1) Moderate: Unable to change walking speed or signs of imbalance.
(0) Severe: Unable to achieve significant change in walking speed AND signs of imbalance.

11. WALK WITH HEAD TURNS – HORIZONTAL
Instruction: "Begin walking at your normal speed, when I say "right", turn your head and look to the right. When I say "left" turn your head and look to the left. Try to keep yourself walking in a straight line."
(2) Normal: performs head turns with no change in gait speed and good balance.
(1) Moderate: performs head turns with reduction in gait speed.
(0) Severe: performs head turns with imbalance.

12. WALK WITH PIVOT TURNS
Instruction: "Begin walking at your normal speed. When I tell you to 'turn and stop', turn as quickly as you can, face the opposite direction, and stop. After the turn, your feet should be close together."
(2) Normal: Turns with feet close FAST (≤ 3 steps) with good balance.
(1) Moderate: Turns with feet close SLOW (≥4 steps) with good balance.
(0) Severe: Cannot turn with feet close at any speed without imbalance.

13. STEP OVER OBSTACLES
Instruction: "Begin walking at your normal speed. When you get to the box, step over it, not around it and keep walking."
(2) Normal: Able to step over box with minimal change of gait speed and with good balance.
(1) Moderate: Steps over box but touches box OR displays cautious behavior by slowing gait.
(0) Severe: Unable to step over box OR steps around box.

14. TIMED UP & GO WITH DUAL TASK ***[3 METER WALK]***
Instruction TUG: "When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair."
Instruction TUG with Dual Task: "Count backwards by threes starting at ___. When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair. Continue counting backwards the entire time."

TUG: _____seconds; Dual Task TUG: _____seconds
(2) Normal: No noticeable change in sitting, standing or walking while backward counting when compared to TUG without Dual Task.
(1) Moderate: Dual Task affects either counting OR walking (>10%) when compared to the TUG without Dual Task.
(0) Severe: Stops counting while walking OR stops walking while counting.
When scoring item 14, if subject's gait speed slows more than 10% between the TUG without and with a Dual Task the score should be decreased by a point.

TOTAL SCORE: _____ / 28

Mini-BESTest Instructions

Subject Conditions: Subject should be tested with flat-heeled shoes OR shoes and socks off.
Equipment: Tempur® foam (also called T-foam™ 4 inches thick, medium density T41 firmness rating), chair without arm rests or wheels, incline ramp, stopwatch, a box (9" height) and a 3 meter distance measured out and marked on the floor with tape [from chair].
Scoring: The test has a maximum score of **28** points from **14 items** that are each scored from 0-2.
"0" indicates the lowest level of function and "2" the highest level of function.
If a subject must use an assistive device for an item, score that item one category lower.
If a subject requires physical assistance to perform an item, score "0" for that item.
For **Item 3** (stand on one leg) and **Item 6** (compensatory stepping-lateral) only include the score for one side (the worse score).
For **Item 3** (stand on one leg) select the best time of the 2 trials [from a given side] for the score.
For **Item 14** (timed up & go with dual task) if a person's gait slows greater than 10% between the TUG without and with a dual task then the score should be decreased by a point.

1. SIT TO STAND	Note the initiation of the movement, and the use of the subject's hands on the seat of the chair, the thighs, or the thrusting of the arms forward.
2. RISE TO TOES	Allow the subject two attempts. Score the best attempt. (If you suspect that subject is using less than full height, ask the subject to rise up while holding the examiners' hands.) Make sure the subject looks at a non-moving target 4-12 feet away.
3. STAND ON ONE LEG	Allow the subject two attempts and record the times. Record the number of seconds the subject can hold up to a maximum of 20 seconds. Stop timing when the subject moves hands off of hips or puts a foot down. Make sure the subject looks at a non-moving target 4-12 feet ahead. Repeat on other side.
4. COMPENSATORY STEPPING CORRECTION-FORWARD	Stand in front of the subject with one hand on each shoulder and ask the subject to lean forward (Make sure there is room for them to step forward). Require the subject to lean until the subject's shoulders and hips are in front of toes. After you feel the subject's body weight in your hands, very suddenly release your support. The test must elicit a step. NOTE: Be prepared to catch subject.
5. COMPENSATORY STEPPING CORRECTION - BACKWARD	Stand behind the subject with one hand on each scapula and ask the subject to lean backward (Make sure there is room for the subject to step backward.) Require the subject to lean until their shoulders and hips are in back of their heels. After you feel the subject's body weight in your hands, very suddenly release your support. Test must elicit a step. NOTE: Be prepared to catch subject.
6. COMPENSATORY STEPPING CORRECTION- LATERAL	Stand to the side of the subject, place one hand on the side of the subject's pelvis, and have the subject lean their whole body into your hands. Require the subject to lean until the midline of the pelvis is over the right (or left) foot and then suddenly release your hold. NOTE: Be prepared to catch subject.
7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE	Record the time the subject was able to stand with feet together up to a maximum of 30 seconds. Make sure subject looks at a non-moving target 4-12 feet away.
8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE	Use medium density Tempur® foam, 4 inches thick. Assist subject in stepping onto foam. Record the time the subject was able to stand in each condition to a maximum of 30 seconds. Have the subject step off of the foam between trials. Flip the foam over between each trial to ensure the foam has retained its shape.
9. INCLINE EYES CLOSED	Aid the subject onto the ramp. Once the subject closes eyes, begin timing and record time. Note if there is excessive sway.
10. CHANGE IN SPEED	Allow the subject to take 3-5 steps at normal speed, and then say "fast". After 3-5 fast steps, say "slow". Allow 3-5 slow steps before the subject stops walking.
11. WALK WITH HEAD TURNS-HORIZONTAL	Allow the subject to reach normal speed, and give the commands "right, left" every 3-5 steps. Score if you see a problem in either direction. If subject has severe cervical restrictions allow combined head and trunk movements.
12. WALK WITH PIVOT TURNS	Demonstrate a pivot turn. Once the subject is walking at normal speed, say "turn and stop." Count the number of steps from "turn" until the subject is stable. Imbalance may be indicated by wide stance, extra stepping or trunk motion.
13. STEP OVER OBSTACLES	Place the box (9 inches or 23 cm height) 10 feet away from where the subject will begin walking. Two shoeboxes taped together works well to create this apparatus.
14. TIMED UP & GO WITH DUAL TASK	*Use the TUG time to determine the effects of dual tasking. The subject should walk a 3 meter distance. TUG:* Have the subject sitting with the subject's back against the chair. The subject will be timed from the moment you say "Go" until the subject returns to sitting. Stop timing when the subject's buttocks hit the chair bottom and the subject's back is against the chair. The chair should be firm without arms. *TUG With Dual Task*: While sitting determine how fast and accurately the subject can count backwards by threes starting from a number between 100-90. Then, ask the subject to count from a different number and after a few numbers say "Go". Time the subject from the moment you say "Go" until the subject returns to the sitting position. Score dual task as affecting counting or walking if speed slows (>10%) from TUG and or new signs of imbalance.

APPENDIX E

Unidentified HPL Workout Regimen

XXX's workout regimen week 3	Trained By:		Trained By:	
	Date:		Date:	
Starting	BP:	HR:	BP:	HR:
Ending	BP:	HR:	BP:	HR:
Meds:				
Daily Warm Up:	Alter G Treadmill	70%	0 incline	2.5-3mph
	10 minutes			
Exercises	Reps	Weight	Reps	Weight
Chest Press				
weight range: 50-70				
rep range: 10-12				
Leg Press				
weight range: 150-180				
rep range: 10-12				
Seated Row				
weight range: 75-85				
rep range: 10-12				
Leg Extensions (watch R foot)				
weight range: 55-65				
rep range: 10-12				
Shoulder Press (LIGHT-R)				
weight range: 30-40				
rep range: 10-12				
Alt Banded Hamstring Curls				
weight range: Gold/Heavy				
rep range: 10-12				
Rear Delt (SLOW)				
weight range: 30-40				
rep range: 10-12				
Ball Bridges				
weight range: none				
rep range: 10-12				
Opp Arm/Leg on Swiss Ball				
weight range:				
rep range: 3 x 5 sec (each)				
Ankle stability exercises:				
Balance disk circles (both ways)				
2 x 10				
Foam Pad Balance with Rings				
3 x 4				
Consider:	Right shoulder and right plantar flexion with dyskinesia on R foot			

APPENDIX F

Ring Toss Protocol

TWIST & TURN PROTOCOL

TWIST & TURN EXERCISE	
Protocol	Twist and Turn is administered to PT to assess balance. The protocol will be administered before (2 sets of 10) and after (3 sets of 10) PT's normal exercise regimen.
Equipment	• Two (foam) fixed posts • 10 rings • 2 Foam pads • The functional movement screening Y-balance test (YBT) coordinates (lines A-D)
Scoring	Check the box that applies on data sheet Check "balance" if the PT was balanced (indicator of success) Check "drop" if the PT dropped one or both foam pillars (indicator of failure) PT will begin at floor level and progress

APPENDIX G

Unidentified Comparison Report (on Force Plate)

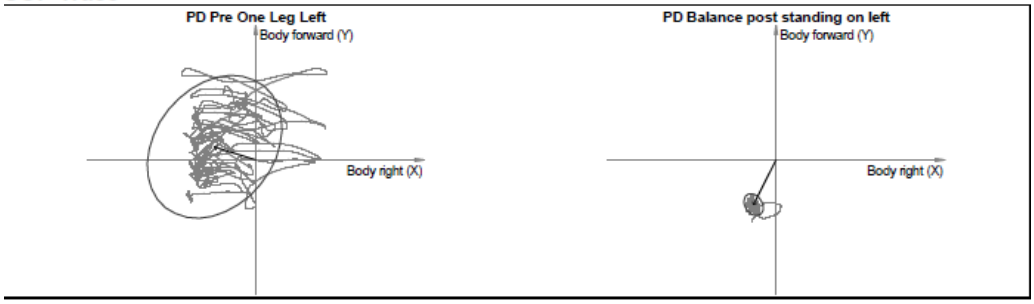
Single Leg Balance Report

NORAXON
MOVEMENT • DATA • PEOPLE

Patient
Project — PD Group-Bane
Notes

Record
Date Measured — 3/9/2023 10:23

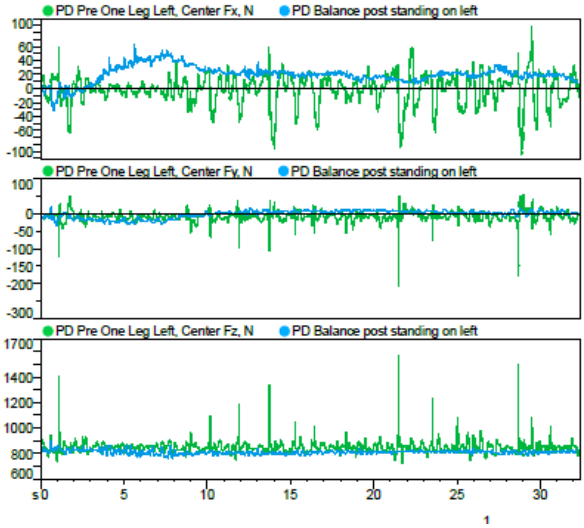
COP Trace



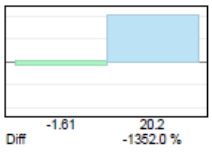
COP Parameters

Analysis time, sec	PD Pre One Leg Left	32.4
	PD Balance post standing on left	32.2
	Diff, %	-0.5
95% confidence ellipse area, mm²	PD Pre One Leg Left	32077
	PD Balance post standing on left	691
	Diff, %	-97.8
COP path length, mm	PD Pre One Leg Left	6061
	PD Balance post standing on left	893
	Diff, %	-85.3
COP average velocity, mm/sec	PD Pre One Leg Left	187
	PD Balance post standing on left	28
	Diff, %	-85.2

Force-Time Curve



Mean



Mean Frequency