<u>Group exercise program using large amplitude movements and functional activity training in</u>

<u>older adults with Parkinson's disease.</u>

by

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BScPT, University of British Columbia, 2004

MASTER OF SCIENCE

in the Department of Exercise Science, Physical and Health Education

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Supervisory Committee

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Abstract

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The purpose of this study was to determine if a ten week, twice weekly group exercise program using large amplitude movement and functional mobility training was effective at improving mobility and quality of life in old, older adults (i.e. average age 80 years) with Parkinson's disease (PD). This exercise program builds on existing large amplitude movement training programs, but differs in that it is delivered in a group format, in an older cohort and incorporates functional training related to the tasks of daily living. To determine the long term training effects of the program, a follow up assessment was conducted at four months post intervention. Sixteen participants with PD with an average age of 80 years (range 69-91years) were recruited through a hospital-based Seniors Outpatient Clinic. Participants were assessed before starting (PRE) and upon completion (POST) of the intervention. To decrease the likelihood that the results would be affected by day-to-day fluctuations in mobility that are often seen with PD, 3 measures were gathered at both PRE and POST and then averaged to provide a single PRE and POST score. A single follow-up assessment was conducted four months after completion. Outcome measures included: Movement Disorder Society-Unified Parkinson's Disease Rating Scale-Part III, Timed Up and Go, Berg Balance Scale, Sit-to-stand Test, gait characteristics (GaitRite system), Parkinson's Disease Questionnaire – 39 and Goal Attainment Scale. Results indicate significant improvements from PRE to POST ($p \leq 0.05$) in all measures of physical function (effect sizes

(ES) ranging from 0.35-0.87), Quality of Life (QOL) (mobility dimension, ES=0.34) and personal goal achievement (ES=2.12). Therefore this group exercise program was effective in improving mobility and QOL for an older adult population with PD. The program frequency and duration was adequate to achieve the desired training effects while being manageable for an old, older population to attend. Further, in those participants who continued to engage in ongoing physical activity, improvements were maintained at 4 months after completion of the program for MDS-UPDRS, TUG, gait velocity, QOL (bodily discomfort dimension) and GAS.

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Chapter 1 –Review of Literature

Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disease. The symptoms were first described by James Parkinson in 1817 when he published 'An Essay on the Shaking Palsy' and described patients with resting tremor, rigidity, and postural instability. Fifty years later, Jean-Martin Charcot defined the condition in more detail and differentiated bradykinesia from rigidity, described the association of PD with pain and dysautonomia and was the first to suggest the term 'Parkinson's disease' (Pagonabarraga, 2010). Since these initial descriptions of the disease there has been a lot of research done to determine the cause and pathology of PD. This literature review will examine the current information available on the etiology, incidence and prevalence, pathology, signs and symptoms and available treatments for PD. In this literature review I will analyze the latest research on neuroplasticity and neuroprotective treatments, the benefits of exercise and specifically the types of components of exercise needed for neuroplastic and functional change, the advantages of group training programs and the importance of ongoing community programs for people with PD. The review will conclude by summarizing the literature findings as they relate to the proposed research project.

Etiology

The cause of PD remains unknown. There is evidence to suggest that environmental and genetic factors contribute to the risk of developing PD (Scharpira & Jenner, 2011). The environmental and lifestyle factors that have been linked to PD are exposure to toxins including pesticides and heavy metals, rural living, diet and lifestyle (Khandhar & Marks, 2007). The toxin exposure theory has been strengthened by the discovery that certain toxins induce parkinsonism in animals (Dunnett & Bjorkland, 1999). This discovery has been the base for creating an animal model for research studies. Interestingly, smoking and caffeine consumption have been negatively

correlated with developing PD (Pagonabarraga, 2010; Prediger, 2010). The factor that most strongly correlates onset of PD is increasing age (Scharpira & Jenner, 2011).

There are numerous genes that have been linked to PD (Pagonabarraga, 2010). There is convincing evidence from epidemiological studies, twin studies and analysis of familial inheritance that genetics play a role in a subset of people with PD (Gasser, 1998). Genetic PD accounts for a very small number of PD cases, but it has been helpful for determining the pathological changes associated with PD. The goal is to discover how protein and gene alterations cause neurodegeneration and how to analyze these changes as potential biomarkers of future PD (Stern, Lang & Poewe, 2012).

According to the Parkinson's Society of BC (2009) there are approximately 11,000 people in British Columbia and 100,000 people in Canada living with PD. Health Canada (2003) has estimated that the prevalence rate in Canada is 100-200 per 100,000 people and the estimated incidence is 10-20 per 100,000 people. Males appear to have a higher incidence and prevalence rates (de Lau & Breteler, 2006). A recent review showed worldwide prevalence rates of PD between 100 and 300 per 100, 000 and that prevalence increases with increasing age (Wirdefeldt, Adami, Cole,Trichopoulos, & Mandel, 2011). A review found that older adults, greater 65 years, showed prevalence rates at 950/100,000 and incidence rates of 160/100,000 (Hirtz et al., 2007).

The available evidence suggests that PD is likely due to a multifactorial etiology. However, the research has only determined correlative data and no causative determinants to have been discovered to date. Despite the fact that the etiology is far from being elucidated there have been great advances in the pathomechanics of PD.

Pathology

There have been significant advances in establishing the pathological changes that occur in Parkinson's disease. Originally it was thought that the pathological changes were confined to the substantia nigra (SN) in the basal ganglia and the loss of neurons that produce the neurotransmitter dopamine. The proposed mechanisms that might account for the cell death and loss of dopaminergic neurons associated with PD are oxidative stress, mitochondrial dysfunction, abnormal protein aggregation and inflammatory changes (Schapira & Jenner, 2011; Jellinger, 2012). This resulting loss of dopamine causes the classic motor symptoms that are associated with PD. Thus the hallmark pathological changes in PD are degeneration of the dopaminergic neurons and presence of intracytoplasmic inclusions in the SN. The inclusions are known as Lewy bodies which contain the protein α-synuclein (Jellinger, 2012; Stern et al., 2012). However, recent research has determined that the neurodegeneration is not confined to the SN and is widespread throughout the central and peripheral nervous systems (Stern et al., 2012). This new understanding of the degenerative changes can help explain many of the motor and non-motor symptoms in PD. The Braak hypothesis first proposed that degenerative changes progress in a systematic way from the medulla oblongata to the neocortex (Braak et al., 2003). This staging scheme has six sequential stages based on the neuroanatomical changes caused by the presence of Lewy body pathology in the brain (Hawkes, Tredici & Braak, 2010). The widespread microstructural degeneration in brains affected by PD is in areas consistent with the known neuroanatomy of the movement control system. There is also consistently degeneration of the somatosensory cortex and post central gyrus that indicates an abnormality of the sensory response system (Zhan et al., 2012). Interestingly, the degree of sensory changes is negatively correlated with clinical motor presentation of disease severity and is proposed to be due to the sensory system compensating of the motor impairments (Zhan et al. 2012). The proposed

degenerative changes are supported by post mortem studies and neuroimaging. Positron emission tomography (PET) and single-photon emission computed tomography (SPECT) scans show decline of striatal dopamine levels and that dopamine levels are correlated with motor scores (Dunnet & Bjorklund, 1999; Stern et al. 2012). Diffuse tensor imaging is also able to detect the microstructural degeneration that correlates with PD severity (Zhan et al. 2012). The Braak staging scheme has gained acceptance but is the subject of debate (Hawkes et al., 2010). An in vivo imaging study concluded that the cortical dysfunction in PD does not follow the topographical Lewy body pathology sequencing outlined in the Braak hypothesis (Brooks, 2010).

Based on the emerging evidence about the pathological changes that are involved in PD, Stern et al. (2012) have proposed a new way of staging PD. The first stage is a hypothesised preclinical stage that exists before any recognizable clinical features appear but PD specific pathology is assumed to be present. The goal for this stage is to determine molecular and imaging markers to determine a biomarker that will predict progression to PD. The second stage is classified premotor and there is extranigral pathology and the presence of non-motor symptoms. The common non-motor symptoms seen at this stage are: abnormal olfaction, constipation and REM sleep behavior disorder (RBD). Frequently neurobehavioral features are also seen at this stage. The features in this stage are non-specific, especially in the elderly population, and they have a low prediction of subsequent PD. The final proposed stage represents the onset of the classic motor symptoms associated with PD. Dysautonmia, sensory symptoms and cognitive decline are also present at this stage. (Stern et al., 2012)

The first sign of symptoms of motor dysfunction was previously thought to be the onset of PD and starting treatment at this stage was considering to be catching the disease early. It is now

known that the amount of dopamine in the brain falls below 30 percent of normal levels before motor symptoms will appear (Lezak, 2004). This supports the proposed model by Stern et al (2012) that indicates that motor symptoms actually indicate an advanced disease process.

The current goal of researchers is to determine which biomarkers and premotor symptoms are actually precursors to motor PD (Tolosa & Pont-Sunyer, 2011). This information will provide the best targets for neuroprotective treatments. The pathological changes that occur throughout the central nervous system create the symptoms that are associated with PD.

Signs and symptoms of PD

The signs and symptoms that are associated with PD are described in the categories of motor symptoms and non-motor symptoms. The motor symptoms considered the cardinal features of PD are resting tremor, bradykinesia, rigidity, and postural instability (Lezak, 2004). The pathological changes in the basal ganglia cause impairment in the automatic performance of motor skills. Motor symptoms usually begin unilaterally and gradually spread to the contralateral side, but there is always an asymmetry of symptoms throughout the disease (Morris, 2000). To date researchers have been unable to demonstrate pathological asymmetry to correlate with the asymmetry of motor signs (Stern et al., 2012).

The motor symptoms of PD affect mobility and function and are usually very obvious. The non-motor symptoms of PD are not as apparent as the classic motor symptoms but they can have a significant impact on function and quality of life. Common non-motor symptoms include olfactory dysfunction, sleep problems, dysautonomia, cognitive impairment, visual disturbances, and neuropsychiatric disturbances (Pagonabarraga, 2010). A solid knowledge of the pathological changes associated with PD and the resulting symptoms forms the basis for understanding the treatments for PD.

Treatment in PD

The majority of treatment for PD is aimed at treating the symptoms of the disease. The largest advance in symptomatic management was the development of levodopa, a pharmaceutical that replaces the lost dopamine in the brain (Dunnett and Bjorklund, 1999). By replacing the depleted dopamine stores it allows for the execution of voluntary movements. The positive benefits of this treatment are that it has increased the ability to move for people PD and this has resulted in increased quality of life and increased life span (Ahlskog, 2011). The negative aspects of this treatment are that optimal effectiveness is only achieved for about 5 years and there are complications of dyskinesias and 'on' and 'off' times (Dunnett & Bjorklund, 1999). When the levodopa is at a high level the person will be in an 'on' state and have improved mobility. When the levodopa is at lower levels the person will be in an 'off' state and will have more difficulty moving. Levodopa is often combined with carbidopa, which slows the breakdown of levodopa (Ahlskog, 2011). There are continually new advances in pharmacological treatment of PD. An evidence based medicine review by the Movement Disorder Society in 2011 found that several other medications are efficacious in the treatment of PD (Fox et al., 2011).

Neurosurgical treatment is a technique used in late stage PD. The implantation of a deep brain stimulator into the thalamus, globus pallidus or subthalmic nucleus can help alleviate tremor and motor symptoms (Dunnett & Bjorklund, 1999; Fox et al., 2011). The parameters of the stimulator can be adjusted to create an optimal response.

Finally, non-invasive therapy treatments are a large part of the management of PD. Speech therapy, occupational therapy and physiotherapy all provide essential treatments that help improve function and quality of life. The evidence based medicine review for the treatment of

motor symptoms in PD found that physical therapy is likely effective as a symptomatic adjunct therapy (Fox et al., 2011). A systematic review in 2012, found evidence for positive short term benefits with physiotherapy treatment (Tomlinson et al., 2012).   Despite the prominent role that physiotherapy plays in the treatment and management of PD, there is a lack of evidence for what is the best practice for treating PD (Keus, Bloem, Hendriks, Bredero-Cohen & Munneke, 2007; Tomlinson et al., 2012).

The first randomized control trial involving physiotherapy treatment for PD was published in 1981 (Gibberd, Page, Spencer, Kinnear, & Hawksworth). Since that time the quality of clinical trials evaluating efficacy of physiotherapy in the treatment of PD has evolved rapidly. Despite the increasing number of studies evaluating physiotherapy treatment, the evidence about the effectiveness of physiotherapy remains inconclusive (Keus et al., 2007). This is partially due to small sample numbers in trials, methodological flaws and wide variety of interventions and outcome measures (Keus et al., 2007). It is generally assumed that physiotherapy treatment is unlikely to change disease process but that it can help to optimize daily function and secondary health problems and teach strategies for coping with impairments and disabilities (Morris, 2000).

 A problem with physiotherapy treatment for PD is often a lack of PD specific expertise in the treating therapist. Morris (2000) provided a theoretical framework to support physiotherapy treatment in PD.   The theory is based on pathophysiology of basal ganglia disease, scientific evidence and personal observations. The model is based on the assumption that normal movement can be obtained by bypassing the defective basal ganglia circuitry. Morris provides recommendations to enhance performance of common functional motor tasks that include external cues and cognitive movement strategies. The proposed model promotes treating movement impairments within the contexts of everyday tasks, adjusting treatment regularly to

reflect patients changing needs and goals, optimizing overall physical health, addressing issues relating fall prevention and involving the caregiver in treatment process. (Morris, 2000)

Following up on the work of Morris, the first clinical practice guidelines for Physical Therapists were published by the Royal Dutch Society for Physiotherapy (Keus et al., 2007). These guidelines were created by an evidence-based literature review, expert opinions and incorporating patient values. The four specific recommendations from these practice guidelines were: cueing to improve gait, cognitive strategies to improve transfers, exercises to improve balance and training for range of motion and muscular power to improve physical capacity. Cueing involves using external or internally generated auditory, visual, tactile or cognitive cues and cognitive movement strategies involve putting the movement under conscious control to bypass the defective basal ganglia. A concern with using cues and strategies is that these techniques are not as effective if people have cognitive impairment or need to divide their attention (Kues et al., 2007).

Both Morris (2000) and Keus et al. (2007) have developed broad physiotherapy goals and treatment recommendations to correlate with each Hahn and Yager stage of the disease. These guidelines provide evidence and rationale for specific treatments. There are a large variety of treatment options available to physiotherapists when treating a person with PD. Physiotherapy treatment likely needs to be multifaceted because there are a variety of symptoms and severity associated with the disease and different treatments will be needed at different stages of the disease. Treatments need to be client-focused and take into account the goals and expectations of each individual client (Morris, 2006). There is still a need for further research to investigate the optimal intensity, frequency and duration of treatment (Keus, Munneke, Nijkrake, Kwakkel, & Bloem, 2009).

There are effective medications, surgical and therapy treatments for the management of the symptoms of PD, however there are currently no treatments available that slow, stop or reverse the neurodegenerative changes associated with PD. Research is now looking seriously into neuroprotective treatments. The goal is to discover a treatment that can protect against the progressive neurodegeneration that is involved in this disease.

Neuroprotection and neuroplasticity associated with Exercise in Parkinson's Disease

The discovery of the underlying pathology and mechanisms of cell death involved in PD have provided the opportunity for research into neuroprotective therapies that are intended to slow and/or reverse the disease process (Dunnet & Bjorklund, 1999). One area that has a lot of potential is physical activity. There is evidence to suggest that physical activity creates neuroplastic changes and has a potential neuroprotective effect on brain cells (Kramer & Erickson, 2007). Neuroplasticity refers to the intrinsic ability of the nervous system to modify its structure and function in response to environmental demands (Pascual-Leone et al., 2011). Exercise induces changes in the structure of the brain by developing more neurons and more connections between neurons (Christie et al., 2008). A review found that increases in hippocampus and cortical volumes in the brains of older adults with physical exercise were shown in several studies (Ahslkog, Geda, Graff-Radford & Petersen, 2011). Aerobic exercise has been shown to increase hippocampus volume by about two percent over one year (Erickson et al., 2011). A control group doing stretching exercises showed decline of about one and a half percent over the same time period, which is equal to the normal rate of decline of one to two percent per year in older adults. The increased volume was in the anterior hippocampus in the dendate gyrus where cell proliferation takes place and the increase in hippocampus volume was directly related to increases in memory performance (Erickson et al., 2011)

Neurogenesis is the process involving the creation and development of neurons in the brain (Harry, 2008). Brain derived neurotropic factor (BDNF) is a neurotrophin that is involved in neurogenesis, synaptic transmission and learning and memory (Cotman & Berchtold, 2007). Exercise has been shown to increase levels of BDNF (Kramer & Erickson, 2007; Ahslkog et al., 2011).

The structural changes that occur in the brain also result in improved function. Studies have shown the cognitive scores improve after exercise training (Colcombe & Kramer, 2003). A meta-analytic review of randomized controlled trials found that aerobic exercise was associated with modest improvements in cognition (Smith et al., 2010). The changes in cognitive function with physical activity are widespread and almost every type of cognition is affected with some of the most pronounced changes in executive function (Kramer & Erickson, 2007). Executive function is the aspect of cognition involved in the ability to plan, organize and regulate goal directed behavior (Lezak, 2004).

Though there are several proposed mechanisms that to account for the structural and functional changes that are induced in the brain with physical activity, the exact mechanism is not yet determined. However it appears to be multifactorial. Some of the positive factors associated with exercise are increased cerebral blood flow, increased neurotrophin levels and protection against the negative effects of stress (Christie et al., 2008). A moderate amount of exercise appears to be all that is needed to create these changes (Ahslkog et al., 2011). For the older adult population, Health Canada recommends 30-60mins of moderate intensity activity most days of the week (Health Canada, 2012).

The benefits of exercise on brain function are well established in the older adult population. Research has been conducted to determine if exercise produces the same positive effects in brains affected by PD.

Animal studies have provided a lot of support for the neuroplastic changes that are associated with exercise in PD. Studies that examined the effect of vigorous exercise in parkinsonian animals found that vigorous exercise caused increased levels of BDNF and glial derived neurotrophic factors (GDNF) (Ahslkog, 2011). The release of endogenous neurotrophic factors has been associated with increased cognition and BDNF has been shown to protect dopaminergic cells in vitro (Ahslkog, 2011; Ahslkog et al., 2011). Tillerson et al (2002) showed intensive motor therapy via casting to force the use of affected limbs is beneficial for improving movement and attenuating the loss of striatal dopamine in rodents with induced Parkinson symptoms. The hypothesis is that forced exercise can protect the dopaminergic neurons by increasing the GDNF (Smith & Zigmond, 2003). Petzinger et al. (2010) found that high intensity exercise in animals with PD led to changes in the dopaminergic and glutamatergic neurotransmission processes in the basal ganglia.

Measuring the effect of exercise on neurodegeneration in people with PD is difficult because there are no reliable biomarkers for PD progression. The effect of exercise on neurodegeneration can only be measured by indirect means such as measurements of cortical excitability and cognitive testing (Ahslkog, 2011). Following up on the results of their animal study, Petzinger et al (2010) studied the effects of high intensity exercise in humans using body weight support treadmill training (BWSTT). The results of the study were improved physical motor performance and improvements in measures of cortical excitability (Petzinger et al., 2010).

Another study found that high intensity exercise had more positive benefits for motor function and corticomotor excitability in people with early PD (Fisher et al., 2008).

Another mode of high intensity exercise is forced exercise, which is defined as, "aerobic exercise in which exercise rate is augmented mechanically to assist the participant in achieving and maintaining an exercise rate that is greater than their preferred voluntary rate of exercise" (Alberts et al., 2011, p. 177). Alberts et al (2011) studied forced exercise using a stationary tandem bike versus a control group riding stationary bikes at a voluntary rate and found that forced exercise improved motor function and increased cortical and subcortical activity more than voluntary exercise.

Another indirect way to measure the effect of exercise on neurodegeneration is by measuring change in cognitive functioning. Cognitive decline in people with PD is common non- motor symptom. The rate of dementia in PD is 4-6 times greater than in controls and the prevalence of dementia in people with PD is 30 percent (Aarsland & Kurz, 2010). Exercise has shown benefits for cognition and specifically executive function in people with PD. Tanaka et al. (2009) found that generalized physical training three times per week for six months significantly improved performance on a test for executive function more than a control group and the authors concluded that people with PD benefit from exercise for executive function similarly to older adults without PD. Cruise et al (2011) examined the effect of aerobic exercise on executive function and found that three months of exercise improved test scores significantly more than a control group.

The above mentioned literature has demonstrated that exercise has the ability to create neuroplastic changes, but is it neuroprotective? In older adults without PD, increased fitness at

baseline was associated with less hippocampus volume loss and increased performance on spatial memory tasks, indicating a potential neuroprotective effect (Erickson et al. 2011). A review article on vigorous exercise found that it was biologically plausible that exercise could induce a neuroprotective effect in PD (Ahlskog, 2011). Prospective studies provide further evidence that exercise might be neuroprotective. A large cohort study on older adults determined that higher levels of moderate to vigorous activity in mid or later life was associated with lower future risk of PD (Xu et al., 2010).   Other prospective studies determined that strenuous exercise in early adulthood and moderate to vigorous recreational activity was associated with lower risk of PD (Chen, Zhang, Schwarzschild, Hernan & Ascherio, 2005; Thacker et al., 2008). Chen et al. (2005) also found that exercise amounts decreased several years before diagnoses. The findings of these prospective studies need to be interpreted with the consideration of the possibility of reverse causation, where the unrecognizable pathological changes of pre-clinical PD may affect ability to participate in vigorous activities.

The beneficial effects of exercise on the brain in those with Parkinson's disease has been established but further research needs to determine if exercise has a neuroprotective effect. The benefits of exercise in PD also extend to the body.

Benefits of Different Exercise treatments in Parkinson's Disease
Physical mobility is an important factor for maintaining independence and functional abilities. A longitudinal study of ambulatory activity found that people with PD had a significant decrease in the number of steps and amount of moderate intensity steps over a one year period (Cavanaugh et al., 2012). Another study found that people with PD were about one third less active than matched controls and that physical inactivity was associated with decreased walking abilities and increased disability in daily life in people with PD (Van Nimwegen et al., 2011).

Exercise has been shown to be beneficial for general health in older adults. Health Canada (2012) recommends older adults partake in at least 150 minutes of moderate to vigorous exercise each week, strength training two times per week and balance exercises for those with poor mobility. Health Canada (2012) states that 50 percent of functional decline with aging is due to inactivity. This suggests that exercise could be especially beneficial for older adults with PD. Many studies have looked at the specific benefits of exercise in people with PD for balance, gait, strength and quality of life (QOL).

Balance and Falls

Balance is the ability to maintain an upright posture when stationary and during movement (Howe, Rochester, Neil, Skelton & Ballinger, 2011). The balance and postural control changes that are associated with PD have large impacts on mobility, confidence and fall risk. Postural instability and decreased postural reaction is a cardinal feature of PD and distinguishes mild PD from moderate PD (Jacobs, Horak, Tran & Nutt, 2006). A large concern associated with decrease balance is the increased risk for falls. 68 percent of people with PD fall each year and greater 50 percent have multiple falls per year (Wood, Bilclough, Bowron & Walker, 2002). People with PD who were classified as fallers had lower self-perceived balance confidence, decreased single leg stance and decreased mobility (Mak & Pang, 2008).

A systematic review of exercise interventions for improving balance in older adults concluded that there was weak evidence that some types of exercise were moderately effective in improving balance (Howe et al., 2011). Exercise programs that were successful at improving balance generally ran three times per week for three months (Howe et al., 2011). Specific studies in people with PD have showed that exercise is effective to improve balance. Gobbi et al. (2009) showed that long term exercise programs are effective at improving balance in people with PD.

Smania et al (2010) specifically studied the effect of balance training on postural instability and found that balance training was superior to general exercise for improving balance, balance confidence and number of falls. A randomized controlled trial that examined the effects of a home exercise program on fall risk factors in people with PD did not find significant improvements in most balance outcomes (Allen et al., 2010). The authors felt that the lack of improvement may have been attributed to an unsupervised environment and exercises not been challenging enough (Allen et al., 2010). A meta-analysis involving people with PD found that exercise and motor training were effective to improve performance on balance activities but had no effect on the proportion of participants that were fallers (Allen, Sherrington, Paul & Canning, 2011). A Cochrane review also found a significant improvement in balance with physiotherapy treatment but no effect for physiotherapy treatment in decreasing number of falls compared to no treatment (Tomlinson et al., 2012). Further research is needed to determine what type of exercise and physiotherapy treatment that improves balance can best be translated into decreasing risk of falling.

Gait

The pathological decrease of dopamine neurons in PD leads to decreased stride length and gait disturbances (Herman, Giladi & Hausdorff, 2009). A person with PD has a very characteristic gait pattern. The velocity is slower, step and stride length are decreased, there is a lack of heel strike, posture is forward flexed, and there is decreased arm swing (Ahsklog, 2001). There are often difficulties with turning, initiating movement (akinesia) and freezing episodes (Morris, 2000). Gait training has been area extensively studied in PD rehabilitation. Morris et al. (2010) discussed how compensation strategies, motor skill learning, management of secondary sequelae and education can be used for the treatment of gait dysfunction relative to stage of disease progression.

Treadmill training is commonly used in the treatment of gait disorders. Intensive treadmill training over six weeks caused improvements in disease severity, gait speed and QOL and long term benefits at four to five months post training were found for disease severity, gait speed and stride length (Herman, Giladi, Gruendlinger & Hausdorff, 2007). A systematic review by Herman et al. (2009) found evidence to support treadmill training for increasing gait speed, mobility and QOL. Mehrholz et al. (2010) found similar results with a systematic review of eight randomized controlled trials and concluded that treadmill training results in improvements in gait speed, stride length and walking distance. Treadmill training was also found to be a safe and feasible rehabilitation option (Herman et al, 2009).   A recent randomized controlled trial found that low intensity treadmill training was more effective than high intensity treadmill training for increasing walking capacity (Shulman et al., 2013).

The possible mechanisms by which treadmill training improves mobility is by stimulating motor learning through progressively increasing the demands or acting as an external cue and bypassing the basal ganglia and putting the task under conscious control (Herman et al., 2009). Fisher et al (2008) found that treadmill training increased corticoexcitability, indicating there is potential for neuroplastic changes with this training. The optimal training program is unclear due to methodological differences in past studies in duration, frequency and type of treatment (Mehrholz et al., 2010).

Another treatment gaining interest in people with PD is the use of Nordic walking. Nordic walking has benefits for promoting upright posture, using upper body muscles and providing balance support. A six week Nordic walking program showed significant improvements in walking tests and QOL; these effects persisted at five months post intervention (van Eijkeren et al., 2008). Nordic walking and regular walking both showed significant improvements in gait

parameters and disease severity compared to an exercise program of flexibility, balance and relaxation exercises (Reuter et al., 2011). The improvements with Nordic walking might be similar to treadmill training in that it creates a mindful way of walking and thus might put the movement under conscious control effectively bypassing the defective basal ganglia (van Eijkeren et al., 2008).

Strength

The lack of the neurotransmitter dopamine causes impaired motor function which contributes to muscle and bone weakness (Falvo, Schilling & Earhart, 2008). This lack of strength can also cause difficulties with functional activities. A Cochrane review found evidence to support the effects of progressive resistance training on increasing strength and performance of functional activities in older adults (Liu & Latham, 2009). There is positive support for strength training in people with PD. A study that investigated high intensity eccentric exercise in people with PD showed greater improvements in muscle force, bradykinesia and quality of life compared to a control group doing traditional lower extremity strengthening exercises but no differences in measures of disease severity (Dibble, Hale, Marcus, Gerber & LaStayo, 2009). A systematic review in people with PD also found positive benefits to resistance training (Goodwin et al., 2008). A recent study showed that people with PD positively benefitted from long term progressive resistive training (Corcos et al., 2013). A study providing rationale and recommendations for strength training in PD concluded that people with PD likely respond to strength training similarly to neurologically normal adults and recommended further research in this area (Falvo et al., 2008). Thus, the general older adult recommendations of strength training two times per week are probably applicable to older adults with PD.

Quality of Life

The mobility changes associated with PD can have a profound effect a person's quality of life.

There is also mounting research that the non-motor symptoms of PD contribute significantly to

QOL (Chaudhuri, Odin, Antonini & Martinez-Martin, 2011). Many exercise programs in people

with PD have demonstrated an improvement in QOL (Hackney & Earhart, 2009; Herman,

Giladi, Gruendlinger & Hausdorff, 2007; Morris, Iansek & Kirkwood, 2009; Reuter et al., 2011;

Van Eijkeren et al., 2008). To the contrary, a review in 2009 (Dibble et al.) found limited

evidence for the impact of exercise on QOL and a systematic review found no significant effect

for physiotherapy/exercise treatment for the summary index or mobility dimension of a QOL

measure (Tominson et al., 2012).   Cruise et al. (2011) found that exercise did not affect mood or

quality of life in a study where the majority of the sample did not have depressive symptoms or

poor quality of life ratings at baseline. This might suggest that exercise may not have the ability

to improve symptoms beyond the normal range. Ellis et al (2011) found that physical function

was predictive of QOL and suggest targeting mobility limitations to improve QOL.

The above sections have provided rationale and support for the benefit of exercise in people with

PD, however, the best type and dosage of exercise has not been established for this population.

Benefits of exercise in old, older adults with PD

Despite the evidence that has been outlined about the potential impact of exercise on brain

neuroplasticity and the positive physical benefits associated with exercise and the need for

ongoing exercise in people with PD, there is a lack of knowledge about the benefits of exercise

in old, older adults (ie. average age 80 years old) with PD. Old, older adults with PD are

specifically at risk for functional decline due to the symptoms and physical impairments

associated with the disease, the negative mobility changes associated with aging and negative

effects associated low levels of physical activity (van Nimwegen et al., 2011; Health Canada,

2012). Due to the increased risk factors affecting this population, exercise could be an advantageous treatment for old, older adults with PD.

Studies in the older adult population that have found beneficial effects of exercise in the 80 years and older age range. In frail older adults, a systematic review on found strong evidence for training effects on physical fitness, function and QOL (Weening-Dijksterhuis et al., 2011) and a meta-analysis found exercise was beneficial for improving gait, balance and function (Chou, Hwang & Wu, 2012). A systematic review on progressive resistance training found it was effective to increase physical function and strength in this older age range (Liu & Latham, 2009). There is evidence that exercise is beneficial in older adults with PD and in old, older adults without PD. An area that needs further investigation is whether old, older adults with PD can attain similar benefits with an exercise intervention.

Benefits of group exercise

An effective mode to deliver an exercise intervention is via a group program.   A group delivery format significantly reduces the cost to implement and run the program making it more economically viable to be delivered in hospital and community programs than individualized programs (Rodrigue de Paula, Teixeira-Salmela, Coelho de Morais Faria, Rocha de Brito & Cardoso, 2006). There are several benefits of a small group format for an exercise intervention. People have a predisposition to exercise with other people and gather together to participate in physical activity (Estabrooks, Harden, & Burke, 2012). Studies of exercise groups using team building strategies in older adults have shown that these interventions increase cohesiveness and increase adherence as measured by attendance (Estabrooks & Carron, 1999; Watson et al., 2012). Group exercise studies in people with PD have also shown high attendance rates to group-based interventions (Sage & Almeida, 2009; Reuter et al., 2011; States, Spierer & Salem, 2011).

The positives to group exercise programs are supported by intervention studies. Group exercise

programs have shown positive improvements to functional mobility and QOL (Ellis et al., 2005;

Reuter et al., 2011; Sage & Almeida, 2009). Participants in a long term community based group

exercise program found the group atmosphere provided benefits for social support, camaraderie,

sense of community and QOL (Rodrigues de Paula et al., 2006; States, Spierer & Salem, 2011).

A randomized controlled trial comparing a home-based exercise intervention to a combined

home and group exercise program over 12 weeks found that both groups improved their motor

function and health related QOL but that the combined group had significantly greater

improvements, especially in mental health benefits (Helbostad, Sletvold & Moe-Nilssen, 2004).

The positives from group programs may be due to the physical exercise, the social interactions,

motivation of the group environment or a combination of these factors. A negative about group

programs is that intervention may not be as specific to the needs of the individual participant and

attention from the instructor is reduced compared to individual therapy. One key benefit of group

exercise programs is that they resemble the types of ongoing community programs that clients

will likely participate in after completing a hospital-based program.

Importance of community integration

Since PD is a progressive disease exercise needs to be ongoing for the benefits of the exercise to

be enduring. Alberts et al (2011) found that outcome measures returned to baseline just four

weeks after the intervention had finished. This suggests that there needs to be appropriate

ongoing community programs available for clients to continue exercise at after they finish an

outpatient-based program.

Long term exercise programs for people with PD have shown positive benefits for physical

function (Gobbi et al., 2009; States et al., 2011). Stability of function over an extended period of

time can be seen as a positive result in a progressive degenerative condition such as PD. A study that looked at the relationship between mobility, quality of life and participation in life activities in people with PD found that decreased QOL and decreased mobility were associated with decreased participation in variety of activities (Duncan & Earhart, 2011).

Unfortunately there are many barriers that prevent people with PD from participating in regular exercise programs. In a qualitative study, researchers found that the majority of respondents had decreased their physical activity levels since the end of their exercise intervention. To encourage ongoing participation in exercise the study participants wanted evidence supporting the benefits of exercise, a greater availability of community programs and guidance from their medical practitioner (Ene, McRae & Schenkman, 2011). A study through the National Parkinson's Disease foundation in 2008 found that less than one percent of respondents were exercising at community based facilities and that respondents would be more likely to exercise if they had access to PD specific community based exercise programs.

However there is no consensus on the best exercise intervention for people with PD and the lack of PD specific expertise in community exercise instructors produces difficulties in creating evidence based community exercise programs (Hirsch, 2009). Ideally an ongoing community exercise program could be an economically feasible group-based program that contains the components necessary for positive physical function and neuroplastic changes.

Exercise intervention components needed for neuroplastic change and global functional improvements.

The positive benefits of exercise for people with PD have been established and researchers are continually trying to determine the optimal exercise treatment.

Many exercise programs for treatment in PD are geared to facilitate neuroplastic changes resulting in long term effect on functional ability. The components of saliency, repetition, progressive level of challenge and complexity, intensity and specificity have been shown to induce neuroplasticity (Farley, Fox, Ramig & McFarland, 2008; Petzinger et al., 2010; Kleim & Jones, 2008). A review article suggests that no specific treatment for neuroplasticity is superior as long as treatment reaches a critical threshold of high effort over sufficient time (Farley et al., 2008).

The area of intensity has gained a lot of attention in recent research. Interventions using high intensity exercises in PD have shown positive improvements for functional mobility and neuroplastic changes (Alberts et al., 2011; Fisher et al., 2008; Frazzitta et al., 2013; Ridgel, Vitek & Alberts, 2009). A review on intensive exercise training in people with PD found positive improvements to motor function and a potential impact on disease progression and neuroplasticity (Frazzitta et al., 2013). This review considered exercise interventions intensive if they were 2-3x/week over 6-14 weeks for a total of 12-42 hours (Frazzitta et al., 2013).

Another treatment area that been investigated is exercises that are designed to increase attention to sensory feedback. The sensorimotor system is impaired in PD (Jacobs et al., 2006). A study by Sage and Almeida (2009) found that sensory attention exercises improved PD symptoms and mobility more an aerobic exercise group and a follow-up study found that the attention to sensory feedback component of the program was the key factor in the improvements (Sage & Almeida, 2010).

A recent review concluded that exercise involving both goal-based learning and aerobic activity was beneficial in PD for improving motor function and facilitating neuroplasticity (Petzinger et

al., 2013). This review also discussed the neuroprotective and neurostorative potential of intensive exercise from animal model data and the potential role of exercise in overall brain health that might impact the structural and physiological properties of the brain (Petzinger et al., 2013).

A treatment that uses training of amplitude as the primary focus incorporates many of the above principles and is designed to promote neuroplasticity (Fox, Ebersback, Ramig & Sapir, 2012). Amplitude-focused treatment includes intensive large amplitude movements, sensory recalibration, functional mobility training and patient specific salient goals (Farley et al., 2008). One delivery model for this treatment is in individual treatment sessions 4x/week for four weeks and (Farley et al., 2008). Two intervention studies using this delivery model have shown evidence of functional improvements (Farley & Koshland, 2005; Ebersbach et al., 2010). The focus of training of amplitude provides a compensatory strategy to increase conscious awareness of movement and participants are encouraged to self- monitor their movements. A single focus on training amplitude decreases the cognitive load for the participant making it easier for older adults with PD (Fox et al., 2012).

Despite the positive benefits of this type of treatment, the format of this intervention is very labour and time intensive to the center delivering the program and is a potential a barrier to participation of old, older adults. Further, there are studies that suggest at least eight weeks of training is needed for neuroplastic and physical function changes (Alberts, Linder, Penko, Lowe & Phillips, 2011; Petzinger et al., 2010). A study using the large amplitude speech therapy treatment found treatment 2x/week for 8 weeks produced similar results to the standard delivery 4x/week for 4 weeks (Spielman, Ramig, Mahler, Halpern & Gavin, 2007). This provides support

that the positive effects from this type of exercise intervention may extend to another program with a different delivery mode and model**.**

Building on these findings the goal of this research study is to design and evaluate a group delivery format of a large amplitude movement and functional mobility training program that is designed to meet the needs of the old, older adult population while still maintaining the components necessary for neuroplastic and functional mobility changes. To determine the effectiveness of the designed program, various outcome measures will be assessed.

Review of Outcome Measures

The outcome measures that will be used in the research study are outlined with a description of the measure and validity and reliability of the measure. These outcome measures were chosen to assess the effectiveness of the exercise intervention on the multiple areas of physical function, quality of life and attainment of personal goals.

Hoehn and Yahr Staging Scale

The Hoehn and Yahr Staging Scale is a simplistic scale that provides a general estimate of motor impairment with PD. Severity is rated on a scale of 1-5 based on motor involvement and degree of compromised balance and gait (Hoehn & Yahr, 1967). On this scale, postural instability differentiates mild from moderate severity (Jacobs, Horak, Tran & Nutt, 2006). A positive of the scale is that it is widely used and well accepted in clinical settings. The scale has been shown to have a moderate to significant level of inter-rater reliability (Kappa scores between 0.44 and 0.71) as well as adequate convergent validity when compared to other measures of PD severity (Goetz et al., 2004).

Mini Mental Status Exam

The Mini Mental Status Exam is used to index global cognitive functioning. The maximum score on the exam is 30. Participants' who receive a score of 24 or higher are considered to be in the "normal" range. The exam has been found to be reliable and valid in an elderly population. High test retest reliability ($r = 0.887$) and inter rater reliability ($r = 0.827$) have been shown (Folstein, Folstein & McHugh, 1975). Concurrent validity has been found when the MMSE is compared with the Wechler Adult Intelligence scale ($r = 0.776$) and construct validity has been determined by its ability to separate patients with cognitive deficits from those without (Folstein, Folstein & McHugh, 1975).

The Movement Disorder Society – Unified Parkinson's Disease Rating Scale Part III

The Movement Disorder Society – Unified Parkinson's Disease Rating Scale – Part III (MDS-UPDRS-III) was used to assess severity of motor symptoms. The motor examination consists of 18 distinct tasks rated by the examiner on a 5 point scale from 0 (normal) to 4 (severe) out of a total score of 132, with higher scores reflecting increased disease severity(Goetz et al. 2008). The MDS-UPDRS III has been shown to have high internal consistency ($\alpha = 0.93$) and strong concurrent validity based on high correlation ($r = 0.96$) with the original UPDRS III (Goetz et al., 2008). Specifically, the motor section of the MDS-UPDRS has been shown to correlate highly ($r = 0.97$) with the UPDRS motor section in detecting change in PD symptoms during acute levodopa changes (Merello, Gerschcovich, Ballesteros & Cerquetti, 2011).

A benefit of a scale that is comparable to the UPDRS is that the UPDRS has been widely used in research involving exercise interventions in people with PD. The original UPDRS has been used and tested extensively since its origin in the 1980's (Fahn et al., 1987). The UPDRS III has been shown to have high test retest reliability (ICC 0.90) in early (Siderowf et al., 2002) and advanced stages of PD (Metman et al., 2004).

Timed Up and Go

The Timed Up and Go (TUG) test is used to assess functional mobility and risk for falls. Participants are instructed to stand up from a chair, walk 3 metres at their preferred, normal walking pace, turn around, walk back to the chair and sit down. The participants can use any assistive device that they usually use for walking. The TUG has been shown to be a valid measure for screening both level of functional mobility and risk for falls in elderly people (sensitivity and specificity = 87%) (Shumway-Cook & Brauer, 2000). In people with PD, the TUG has been shown to have high test retest reliability during the "off" phase (r = 0.80 – 0.98) and "on" phase (r = 0.73 – 0.99) of levodopa medication and high inter rater reliability (ICC = 0.87-0.99) (Morris, Morris, & Iansek, 2001). More recent studies found comparable test-retest reliability (ICC = 0.97) (Paul, Canning, Sherrington & Fund, 2012) and high intra and inter rater reliability (ICC = 0.85-0.88) (Lim et al., 2005). Construct validity is supported by the TUG's ability to reflect changes in performance according to levodopa use (Morris, Morris, & Iansek, 2001).

Berg Balance Scale

The Berg Balance Scale (BBS) is used as a measure of balance and of overall function (Qutubuddin et al., 2005, Brusse, Zimdars, Zalewski & Steffen, 2005). The BBS rates performance of 14 functional balance tasks on a continuum from 0 to 4 with a total score out of 56 (Berg, 1998). A lower score indicates increased impairment of balance.

The BBS has been shown to have strong inter rater reliability (r = 0.88) with older adults (Bogle & Newton, 1996) as well as criterion related validity for use with people with PD (Qutubudden et al., 2005). Due to its correlation with many other functional tests, including the UPDRS, Brusse et al. (2005) consider it to be good overall measure of function in the PD population.

Sit-to-Stand Test

The sit-to-stand test (STS) is used as a measure of functional performance and leg strength (Bohannon, 1995; Lord, Murray, Chapman, Munro & Tiedemann, 2002). A score is calculated by counting the number of repetitions of rising out of a chair without using their hands to a standing position that a participant can complete in 30 seconds (Jones, Rikli, & Beam, 1999.) This test has been shown to have high test-retest reliability (ICC = 0.84-0.92), as well as criterion related validity as a measure of leg strength when compared to weight-adjusted leg press performance (r = 0.71 − 0.78) (Jones, Rikli, & Beam, 1999). A recent study in diabetic older adults provides further support of the reliability (ICC = 0.92) of this measure (Alfonso-Rosa, Pozo-Cruz, Pozo-Cruz, Sanudo & Rogers, 2013). Construct validity is shown by its ability to discriminate between varying age and physical activity level groups (Jones, Rikli, & Beam, 1999).

GAITRite

The GAITRite is a pressure sensing walkway system that measures spatiotemporal gait parameters including velocity, cadence, step length and stride length. Many studies have shown the GAITRite system to be a valid and reliable measure when tested with a healthy population. Inter trial reliability has been shown for speed, cadence and stride length (ICC = 0.93-0.97) at all walking speeds (Bilney, Morris, & Webster, 2003). GAITRite has also been shown to have high test-retest reliability for spatial and temporal gait parameters at preferred and fast walking speeds (ICC ≥ 0.92) (van Uden & Besser, 2004). Strong concurrent validity has been determined by comparing the GAITRite system to criterion measures such as the Clinical Stride Analyzer. This comparison showed excellent agreement for speed, cadence and stride length (ICC = 0.99) (Bilney et al., 2003). Strong concurrent validity has also been shown when comparing spatial

measures to a paper-and-pencil method (ICC ≥ 0.95) and when comparing temporal measures to a video method (ICC ≥ 0.93) (McDonough et al., 2001).

A study using GAITRite with people with PD, the system showed significant correlation with timed tests and UPDRS III scores when comparing the difference between "ON" and "OFF" states of levodopa medication (Chien et al., 2006). GAITRite has also shown high correlation with non-instrumented walk test in people with PD (Bryant, Rintala, Hou & Protas, 2013).

Incidence of Falls

A fall is defined as unintentionally coming to rest on the ground or other lower level (Protas et al., 2005). Monitoring falls has been shown to be an effective tool to measure the efficacy of interventions that may influence the incidence of falls (Rubenstein, Josephson, & Robins, 1994). Retrospectively report of the number of falls that have occurred in a given timeframe is a method to monitor incidence of falls.

Parkinson's Disease Questionnaire – 39

The Parkinson's Disease Questionnaire – 39 (PDQ-39), is a health-related quality of life questionnaire, that is used to evaluate the aspects of function and well-being that can be adversely affected by Parkinson's disease. The questionnaire includes 39 questions and involves 8 different dimensions. The dimensions include Mobility (10 items), Activities of daily living (6 items), Emotional well-being (6 items), Stigma (4 items), Social support (3 items), Cognitions (4 items), Communication (3 items) and Bodily discomfort (3 items). The Single Index score (SI) indicates a global impact of PD symptoms on QOL. A higher score indicates an increased impact of PD symptoms. The questionnaire is intended to be a self-completion instrument (Jenkinson et al., 2008).

The PDQ-39 has been shown to have satisfactory internal consistency reliability of the eight dimensions (Cronbach's $\alpha = 0.69 - 0.94$) and test retest reliability ($r = 0.68 - 0.94$) (Peto et al., 1995). The questionnaire has also been shown to have good construct validity when correlated to other measures, such as the Short Form Health Survey (Jenkinson et al., 1995; Peto et al., 1995). Jenkinson et al. (1997) showed that internal consistency reliability remains high (Cronbach's $\alpha = 0.84 - 0.89$) when using a summary index score to evaluate the overall effect of Parkinson's disease on well-being and function.

Goal Attainment Scale

The Goal Attainment Scale (GAS) is used to assess the achievement of participants' personalized goals. Participants individually set goals at levels appropriate to their current and expected levels of performance. In a standardized way the GAS provides a numerical score assigned to the extent that the individualized goal was attained to allow for statistical analysis across participants. The GAS has been shown to have excellent inter-rater reliability of the follow-up score (ICC = 0.93) and acceptable inter-rater reliability for rating of individual goal attainment levels (ICC = 0.89) (Stolee et al. 1999; Rockwood, Stolee, & Fox 1993). The GAS tool has also been shown to have construct validity when compared to other clinical rating scales and high responsiveness in a geriatric setting. This increased responsiveness, in comparison to other standardized measures, is a major benefit of the GAS (Stolee et al. 1999; Rockwood, Stolee, & Fox 1993).

Conclusion

Current research is focused on finding neuroprotective treatments that can slow, stop or reverse the disease process. Physical activity is known to create neuroplastic changes, could potentially be neuroprotective, and can produce positive changes in mobility and quality of life in people with PD. Despite the increased prevalence of the disease with increasing age and the known

benefits of exercise in old, older adults there are limited studies that have assessed the merit of exercise interventions in old, older adults with PD.

This research study will evaluate the effectiveness of a group exercise program that is designed to meet the needs of the old, older adult population while still maintaining the components necessary for neuroplastic changes. The first aim of this study is to investigate if a group exercise intervention involving large amplitude movement and functional mobility training can produce clinical and functional improvements in old, older adults with PD. The second aim is to assess if this exercise intervention can improve participants' quality of life and achievement personal goals. The final aim of the study is to assess if there are long term benefits to the exercise intervention.

Chapter 2: Manuscript

Introduction

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that has a significant impact on functional mobility and quality of life. PD has an increased prevalence with increasing age. A recent review showed worldwide prevalence rates of PD between 100 and 300 per 100,000 (Wirdefeldt, Adami, Cole,Trichopoulos, & Mandel, 2011) and 950 per 100,000 in adults 65 years and older (Hirtz et al., 2007). The symptoms and physical impairments associated with PD, make those with PD about 30 percent less active than older adults without PD (Van Nimwegen et al., 2011). Further, fifty percent of functional decline in mobility seen in older adults is due to inactivity (Health Canada, 2012) .Thus older adults with PD have a compounded risk of functional decline in mobility due to the low activity level associated with age and the disease.

Animal studies have shown that reduced physical activity may contribute to neuro-degeneration (Tillerson et al., 2002) while exercise is neuroprotective (Fisher et al, 2004; Lau, Patki, Das-Panja, Le & Ahmad, 2011). Physical activity in humans is known to create neuroplastic changes and could potentially be neuroprotective (Fisher et al., 2008; Kramer & Erickson, 2007; Xu, 2010). Positive benefits from physical exercise have been demonstrated in old, older adults (i.e. average of 80 years) (Weening-Dijksterhuis, de Greef, Scherder, Slaets & van der Schans, 2011; Liu & Latham, 2009; Chou, Hwang & Wu, 2012). Exercise-based physiotherapy interventions have been shown to improve functional mobility in people with PD (Kwakkel, de Goede & van Wegen, 2007; Tomlinson et al., 2012). A review on intensive exercise training in people with PD found positive improvements to motor function and a potential impact on disease progression and neuroplasticity (Frazzitta et al., 2013). Another review concluded that exercise involving

both goal based learning and aerobic activity is beneficial in PD for improving motor function and facilitating neuroplasticity (Petzinger et al., 2013). Despite the positive benefits of exercise in people with PD, it is currently not clear which physiotherapy exercise interventions are most beneficial (Deane et al., 2009; Tomlinson et al., 2012; Dibble, Addison & Papa, 2009).

Exercise interventions using a goal of intensive large amplitude movement training combined with functional mobility training delivered in individual treatment sessions 4x/week for four weeks showed noteworthy functional improvements (Farley & Koshland, 2005; Ebersbach et al., 2010). However, other studies suggest at least eight weeks of training is needed for measurable cortical neuroplastic changes as well as improvements in physical function (Alberts, Linder, Penko, Lowe & Phillips, 2011; Petzinger et al., 2010). Further, the 4x/week training schedule could be a barrier for adherence in the older adult population and individual treatment sessions would be costly for the health care system to administer. A group delivery format significantly reduces the cost to implement and run an exercise program making it more economically viable to deliver compared to individually delivered programs. Group exercises programs have shown positive improvements to functional mobility and quality of life (QOL) in people with PD (Sage & Almeida, 2009; States, Spierer & Salem, 2011). The benefits from group exercise programs may be due to a combination of the physical intervention, social interactions and motivation of the group environment. The efficacy of group delivery format of a large amplitude movement and functional mobility training program administered with fewer sessions per week, but over greater number of weeks has not yet been evaluated in those with PD.

Despite the well-known known benefits of physical activity, facilitating exercise adherence in older adults remains an issue (Rhodes et al., 1999). Goal setting has been shown to be a motivating factor for exercise adherence in people with PD (Ene, McRae & Schenkman, 2011).

In addition, individualized goal setting can help tailor an exercise program to the specific needs of each participant. We are not aware of previous research with people with PD that has evaluated the efficacy of an exercise intervention by using a goal attainment outcome measure to quantify the achievement of individualized participant goals.

In spite of the increased prevalence of PD with increasing age and known benefits of exercise in old, older adults and in people with PD there are limited studies that have assessed the merit of exercise interventions in old, older adults with PD. Thus the goal of this study was to evaluate a group delivery format of a large amplitude movement and functional mobility training program that was designed to meet the needs of the old, older adult population while still maintaining the components necessary for neuroplastic changes. The first aim of this study was to investigate if this exercise intervention using a group exercise delivery model with a frequency of 2x/week for ten weeks could produce clinically relevant and functional improvements in mobility in old, older adults with PD. The second aim was to assess if the exercise intervention improved participants' quality of life and allowed participants to achieve self-selected mobility related goals. The final aim was to determine if there were long term benefits to the exercise intervention.

Methods

Participants:

Twenty participants with PD were recruited through a Seniors Outpatient Clinic (SOPC) at a local hospital and participated in the study with informed consent. Participants had a physician confirmed diagnosis of PD and had no medical conditions that would preclude their participation in an exercise program. The study was approved by the University of Victoria and Vancouver Island Health Authority Joint Research Ethics Sub-Committee. At the onset of the study the

Hoehn and Yahr scale and the Mini Mental Status Exam was conducted with each participant to determine PD disease severity (Goetz et al., 2004) and global cognitive status (Folstein, Folstein & McHugh, 1975) respectively.

Anti-Parkinson medications were stabilized prior to participation in the study and participants were instructed to continue with this medication regime over the duration of the study. Testing and interventions were done at the same time of day at the SOPC and participants were instructed to take their medication 1-2 hours before testing. Timing of last dose prior to testing was recorded. Participants were also instructed to not engage in other new exercise programs during the course of the study.

Intervention:
The exercise program included a one hour class, instructed by a physiotherapist, twice weekly for 10 weeks. There were 6 participants in each class instructed by a physiotherapist and assisted by a rehabilitation assistant. The exercise intervention consisted of dynamic exercises of repetitive, large amplitude exercises for the first half of the class and goal-directed functional activities in the second half of the class. These exercises contained the necessary components of saliency, repetition, difficulty, intensity and specificity to induce neuroplasticity (Farley, Fox, Ramig & McFarland, 2008; Petzinger et al., 2010; Kleim & Jones, 2008)

These dynamic exercises of repetitive large amplitude movements in the first half of the class focused on balance, strength and range of movement tailored to the appropriate level of challenge for each participant. The repetitive and large amplitude nature of the movements was designed to improve attention to and awareness of sensory feedback and effort related to movement (Farley & Koshland, 2005; Farley et al., 2008). People with PD have sensory deficits and sensory feedback exercise interventions have shown positive results for PD symptoms (Sage

& Almeida, 2009; Sage & Almeida, 2010). The second half of each class incorporated the large

amplitude movement into functional activity training, such as transfers, gait, balance training,

turning, reaching and fine motor skills. Specific functional mobility training activities were

guided by and tailored to patient-identified specific goals. Interaction between group participants

was encouraged. Support was provided to assist participants with arranging transportation.

Participants were instructed to complete a prescribed home exercise program six days per week.

The participants were given a booklet with pictures of the home exercise, and a calendar to

record their adherence to the prescribed exercises, incidence of falls and other physical activities.

On completion of the exercise intervention efforts were made to link the participant to an

ongoing community program or provide a home exercise program. The majority of ongoing

local community programs for people with PD or older adults ran twice a week. We classified

adherence to ongoing physical activity as participation in community or home program equal to

or greater than twice a week.

Assessment Procedures:
The assessments were conducted by a physiotherapist who is trained and certified in all testing

procedures. All participants were assessed before starting the intervention (PRE), upon

completion of the intervention (POST) and four months after completion of the intervention

(4monthPOST) by the same physiotherapist. To decrease the likelihood that the results would be

affected by day-to-day fluctuations commonly seen in PD (Greenberg, Aminoff & Simon, 2012),

mobility outcome measures (see below) were gathered on 3 different days during a two week

time period at both PRE and POST and then averaged to provide a single PRE and POST score.

Demonstrating stability of the assessment scores over a 2 week period both PRE and POST (i.e.

a time series design) helps ensure that the changes in the participant's mobility were due to the

intervention. Non-mobility measures (see below) were scored once PRE and POST. All 4monthPOST measures were conducted once.

Outcome Measures:

Mobility Outcomes:

The Movement Disorder Society – Unified Parkinson's Disease Rating Scale Part III (MDS-UPDRS III) was used to assess severity of motor symptoms. The motor examination consists of 33 items rated by the examiner on a 5 point scale from 0 (normal) to 4 (severe) (Goetz et al. 2008). The total score is out of 132 with higher scores reflecting increased disease severity.

The Timed Up and Go (TUG) test was used to assess functional mobility (Shumway-Cook, Brauer & Woollacott, 2000). Participants were instructed to walk at their preferred, normal walking pace. Each participant did two trials and the best time was used.

The Berg Balance Scale (BBS) was used as a measure of balance and of overall function (Qutubuddin et al., 2005). The BBS rates performance on 14 functional tasks, on a scale from 0 to 4 points out of a total score out of 56 (Berg, 1998). A lower score indicates increased impairment of balance.

The Sit-to-stand test (STS) was used as a measure of functional performance and leg strength (Bohannon, 1995). A score was calculated by counting the number of repetitions of rising out of a chair without using their hands to a standing position that a participant could complete in 30 seconds (Jones, Rikli, & Beam, 1999.)

Spatiotemporal gait parameters including velocity, cadence, step length and stride length, were assessed using a GAITRite system. The GAITRite is a pressure sensing walkway system

that has been shown to be effective in measuring these specific gait parameters in people with PD (Hundza et al., in press; Chien et al., 2006). Participants were instructed to walk across the mat two times at a self-selected preferred, normal walking speed. They wore shoes and used an assistive device if one was typically used on a daily basis. The participants walked 1.5 meters prior to and after the mat ended in order to account for acceleration and deceleration in gait velocity with a total recorded walking distance of approximately 6.10 metres. The physiotherapist consistently walked to the side and behind each participant for safety during testing. Prior to the assessment trial, participants performed a practice, familiarization walking trial.

Additional Measures:

The Parkinson's Disease Questionnaire – 39 (PDQ-39), a health-related quality of life questionnaire, was used to evaluate the aspects of function and well-being that can be adversely affected by Parkinson's disease (Jenkinson, Peto, Fitzpatrick, Greenhall & Hyman, 1995). The questionnaire has 39 questions and involves eight different dimensions including: Mobility (10 items), Activities of daily living (6 items), Emotional well-being (6 items), Stigma (4 items), Social support (3 items), Cognitions (4 items), Communication (3 items) and Bodily discomfort (3 items). The Single Index score (SI) indicates a global impact of PD symptoms on QOL with a score rated out of 100. A higher score indicates an increased impact of PD symptoms on QOL. Though the questionnaire is intended as a self-completion instrument, in some instances, participants were assisted by a spouse, family member or research assistant if they were not able to read or comprehend questions. The level and type of assistance provided was kept consistent each time the questionnaire was administered.

The Goal Attainment Scale (GAS) was used to assess the achievement of participants' personalized goals. A priori the participants individually set three movement-related goals at levels appropriate to their current and expected levels of performance. The GAS rates goal attainment on a scale from -2 to 2 and an improvement in score indicates surpassing set goal. In a standardized way the GAS provides a numerical score assigned to the extent that the individualized goal was attained to allow for statistical analysis across participants. The GAS has been shown to have high inter-rater reliability, content and construct validity and is a sensitive measure for assessing goal attainment in older adults (Hurn et al. 2006).

Fall rates were recorded using subjective recall for the four month period prior to the intervention and the four month period after completion of the program. Caregivers provided assistance in recall as needed.

Data Analysis:

IBM SPSS Version 21 was used to conduct separate repeated measures analysis of variance (RMANOVA) for each outcome measures across PRE, POST and 4monthPOST to determine the effect of the intervention. Planned comparisons were conducted for apriori defined questions for finding significant differences between PRE vs. POST and PRE vs. 4 months POST. An additional RMANOVA was done for the subgroup of participants that continued with regular physical activity after discharge. Student paired t-tests were used to compared incidence of falls. Separate repeated measure analyses were also conducted on the 3 PRE and POST measures to evaluate day-to-day variability. An interclass correlation coefficient (ICC) was done for all measures within the PRE and POST separately to determine reliability of the measures. Pearson's correlation was conducted to evaluate the relationship between time from medication

dose to mobility assessment and the score on the mobility assessment. Significance level was set at p≤0.05.

Results

Of the 20 participants, 16 participants completed the exercise study and their demographic and clinical characteristics are described in Table 1. Four individuals dropped out of the study for the following reasons: fall and subsequent hip fracture, transportation issues, diagnosed with progressive supranuclear palsy and moved to a care facility. Fifteen of the 16 participants completed the final four month assessment after completion of the program (4monthPOST) and 12 participants continued with regular physical activity. On average participants attended 92% of available classes and the average hours of participation was 19.7 (SD 2.4). Ninety-four percent of the participants did additional physical activity at home and 63% of the participants completed the prescribed home exercises.

Table 1. Characteristics of the study participants

Characteristics	Mean	Range
Age (y)	80.3 ± 7.4	69-91
Hoehn and Yahr Stage	2.8 ± 0.7	1-4
Disease Duration (y)	5.6 ± 4.9	0-16
MMSE Score	26.3 ± 2.9	20-29

(Data represent values for 16 subjects. 4 males and 12 females)

No clinically relevant medication changes occurred during the study. No significant relationship was found between scores on clinical outcome measures and time duration from medication dose to testing (r=0.14-0.45, critical r=0.5, df=13).

No significant differences were found for any outcome measures across the 3 PRE or the 3 POST measures (RMANOVA (p>0.05)) demonstrating that there was limited variability across days for all the mobility measures. An ICC was done for all measures within the PRE and POST

separately and ranged from 0.75-0.98, indicating a high reliability of the measures. An average

of these measures created a single PRE and POST value for each subject. Group averages and

means for all outcome measures at PRE, POST and 4monthPOST are summarized in Table 2.

 PRE vs POST

With the exception of cadence, all mobility outcome measures showed significant improvement

from PRE to POST (planned comparison, p≤0.05- see Table 2 for specific p values). The MDS-

UPDRS III showed an improvement of 5.9 points (38.7 to 32.8) with an Effect Size(ES) of 0.76.

This study found a decrease of 1.7 sec on the TUG times (17.1 sec to 15.4sec) with an ES of

0.35. The BBS scores improved 4.3 points (43.6to 47.9) with an ES of 0.87. On the STS test an

improvement of 1.25 was obtained (6.1to 7.4) with an ES of 0.38. Gait velocity improved 10

cm/s (74.2cm/s to 84.1cm/s) with an ES of 0.62. Step length improved 4cm (44.1 cm to 48.1

cm) with an ES of 0.51. Stride length improved 8.1 cm (88.4cm to 96.5cm) with an ES of 0.51.

The mobility dimension of the PDQ-39 also showed a significant improvement of 7 points

(49.7to 42.7) with an ES=0.34. Meanwhile the other components of the PDQ-39 did not show

any significant change. The GAS showed a significant improvement (-1.0 to 0.2) with an ES of

2.12.

PRE vs 4monthPOST

When looking across all participants the significant improvements gained from the exercise

program were maintained at the 4monthPOST assessment for MDS-UPDRS III and GAS

(planned comparison, p≤0.05- see Table 2 for specific p values). The MDS-UPDRS III showed

an improvement of 5.2 points (38.7 to 33.5) with an ES of 0.68 and the GAS improved (-1.0 to-

.01) with an ES of 1.40. When analysis was conducted for the subgroup of 12 participants that

continued with regular physical activity, there was a significant improvement from PRE to

4monthPOST for MDS-UPDRS III, TUG, gait velocity, PDQ-39-bodily discomfort dimension

and GAS (planned comparison, p≤0.05- see Table 2 for specific p values). The MDS-UPDRS

improved from 40.7 to 34.3 with an ES of 0.84. The TUG improved 2 sec (18.1 to 16.1) with an

ES of 0.40. Gait velocity improved 12.2 cm/s (68.8 cm/s to 81.0 cm/s) with an ES of 0.74. The

PDQ-39-bodily discomfort dimension improved from 50.0 to 36.1 with an ES of 0.60. The GAS

improved (-1.0 to 0.3) with an ES of 2.2. Incidence of falls decreased significantly from the four

months preceding the intervention (average 2.9 falls) to the four months following the

intervention (average 1.0 falls) (p=0.04) ES of 0.72.

Table 2. Outcome measures PRE, POST and 4-month POST exercise intervention

Measures	PRE Mean ± SD	POST Mean ± SD	4month POST Mean ± SD	PRE vs. POST p value	PRE vs. 4month POST p value	PRE vs. 4monthPOST - cont. physical activity p value (n=12)
MDS-UPDRS III	38.7 ± 7.9	32.8 ± 7.6	33.5 ± 7.5	0.001*	0.01*	0.01*
TUG (sec)	17.1 ± 4.7	15.4 ± 5.1	16.4 ± 4.7	0.01*	0.44	0.03*
BBS	43.6 ± 5.1	47.9 ± 4.8	46.6 ± 5.7	0.001*	0.06	0.07
STS	6.1 ± 3.2	7.4 ± 3.6	6.6 ± 3.6	0.01*	0.36	0.26
Gait Measures						
Velocity (cm/s)	74.2 ± 17.2	84.1 ± 14.5	81.2 ± 16.2	0.04*	0.22	0.05*
Cadence (steps/min)	100.9 ± 11.3	104.7 ± 9.5	103.9 ± 3.3	0.25	0.53	0.26
Step Length (cm)	44.1 ± 8.9	48.1 ± 6.8	46.8± 7.6	0.02*	0.97	0.07
Stride Length Right (cm)	88.4± 17.9	96.5± 13.4	93.8± 15.1	0.02*	0.18	0.07
PDQ-39 (% disability)						
Single Index Score	31.4 ± 14.7	29.1 ± 12.8	27.7 ± 13.3	0.39	0.51	0.09
Mobility	49.7 ± 21.5	42.7 ± 19.5	41.5 ± 24.3	0.02*	0.14	0.09
Activities of daily living	35.7 ± 19.2	33.3 ± 25.9	33.6 ± 21.9	0.72	0.78	0.34
Emotional well-being	29.9 ± 21.7	27.9 ± 19.9	27.8 ± 21.1	0.64	0.89	0.75
Stigma	16.0 ± 17.7	15.6 ± 16.5	16.0 ± 17.8	0.85	0.69	0.90
Social Support	14.6 ± 22.1	11.5 ±18.0	11.1 ± 16.0	0.74	0.66	0.42
Cognitions	30.5 ± 21.0	29.3 ± 16.4	30.9 ± 17.6	0.84	0.75	0.93
Communication	29.2 ± 26.5	22.9 ± 19.6	22.2 ± 19.6	0.27	0.68	0.38
Bodily Discomfort	45.8 ± 22.4	49.5 ± 21.0	38.9 ± 24.1	0.67	0.27	0.02*
GAS	-1.0 ± 0.0	0.2 ± 0.8	-0.01 ± 1.0	0.000*	0.002*	0.000*

* denotes p≤0.05

Discussion

The main finding of this study was that our 10 week twice weekly group exercise program involving large amplitude movements and functional mobility training was effective in making clinical improvements in many areas of physical function for old, older adults with PD. Additionally, the program conferred benefits to QOL (mobility dimension) and personal goal achievement. In those who continued to engage in regular physical activity after the completion of the exercise intervention, more of the outcome measures continued to show improvements at four months.

PRE vs POST

A unique feature of this study was the older average age of the participants (80.3 +/-7.4). In other studies investigating the benefits of exercise interventions in those with PD the average participant's age is in the sixties (Ebersbach et al., 2010; Farley & Koshland, 2005; Sage & Almeida, 2009). The older age range of our participants comes with additional multiple comorbidities which could be expected to reduce the relative efficacy of an exercise intervention. Despite this, the quantitative gains in mobility and QOL resulting from our intervention appear to be either equivalent to or greater than those noted in studies with comparable interventions, but younger age groups (Ebersbach et al., 2010; Farley & Koshland, 2005; Sage & Almeida, 2009). This adds to the evidence that age does not limit the ability to significantly benefit from exercise (Chou, Hwang & Wu, 2012; Chin A Paw, Van Uffelen, Riphagen & van Mechelen, 2008).

The time series design showed stability of scores within the 2 week PRE and POST assessment time frames for each outcome measures helping to ensure that the improvements in the participant's mobility were due to the intervention. Significant improvements were demonstrated

across many functional areas of mobility and QOL that are meaningful to the old, older adult population. Previous research has determined that TUG scores greater than 16 seconds are correlated with an increased fall risk in people with PD (Mak & Pang, 2009). The current exercise intervention was effective at decreasing the average TUG score to below this threshold and reducing the number of participants at increased risk for falls from 50 percent to 31percent. This improvement is important given that 68 percent of people with PD fall each year and greater than 50 percent have multiple falls per year (Wood, Bilclough, Bowron & Walker, 2002). The 1.7 sec TUG improvement is greater than the mean 0.61 second improvement conferred with other physiotherapy treatments reported in the Cochrane review (Tomlinson et al., 2012) and the 0.75 sec improvement noted in another study using large amplitude training with a one: one treatment format (Ebersbach et al., 2010).

This intervention was effective at improving balance which is also a key factor for fall risk. The average BBS improved to above the 44 point cut-off recommended for determining fall risk in PD and decreased the number of participants at increased risk for falls by 27 percent (Landers, Backlund, Davenport, Fortune & Schuerman, 2008).   The 4.3 point improvement seen in the current study exceeds significant mean improvement of 3 points with physiotherapy treatment found in the Cochrane review (Tomlinson et al., 2012) and falls within the previously determined minimal detectable change of 2.8 to 5 point improvement (Lim et al., 2005; Steffen & Seney, 2008). In addition to reducing fall risk the intervention was also effective at reducing incidence of falls.

The 6 point improvement seen on the MDS-UPDRS motor section has been suggested to indicate a moderate, clinically important change in motor symptom severity based on the UPDRS (Shulman et al 2010).   The high correlation between the motor section of the UPDRS and the

MDS-UPDRS (Goetz et al., 2008; Merello, Gerschcovich, Ballesteros & Cerquetti, 2011) suggests they can be directly compared as done in a recent Cochrane review (Tomlinson et al., 2012). The improvement in motor symptoms found in the current study exceeds the improvement of 4.1 points found with physiotherapy treatment in the Cochrane review (Tomlinson et al., 2012) and is similar to other studies whose intervention also focused on sensory awareness (Sage & Almeida, 2009; Sage & Almeida, 2010) or investigated large amplitude movements, delivered in a one:one model (Ebersbach et al., 2010).

There was an increase in lower extremity strength as indicated by improvements in the average STS score. Studies have shown that improvements in lower extremity strength are associated with improvements in functional mobility (Dibble et al., 2006). However there are no MDC for the STS in people with PD for direct comparison

Our noted improvement in gait velocity has been shown to be a meaningful change in older adults (Perera, Mody, Woodman & Studenski, 2006) and predictive of increased survival rates (Studenski et al., 2011). Gait velocity of 0.88m/s has been found to predict the ability to be a community walker in PD (Elbers, van Wegen, Verhoef & Kwakkel, 2013). Based on this standard the number of participants classified as community walkers increased by 31 percent. The improvement of velocity in this study using a group delivery method was 13%, which is comparable to the 12% improvement found in another study using large amplitude training protocols in a one to one delivery format (Farley & Koshland, 2005).

Consistent with the findings of previous studies the participants increased their gait velocity by increasing stride length but not increasing cadence (Farley & Koshland, 2005; Morris, Iansek, Matyas & Summers, 1996). Our step length improvements of 4cm surpass the 3 cm increases

found in reviews of other exercise/physiotherapy treatments (Tomlinson et al., 2012; Allen, Sherrington, Paul & Canning, 2011). Our results along with others show that despite deficits in in the ability to regulate stride length, those with PD are able to improve stride length with attention strategies (Morris, Iansek, Matyas & Summers, 1994; Morris, Iansek, Matyas & Summers, 1996).

Physical function has been shown to be predictive of QOL which suggests that enhancing mobility will improve QOL in people with PD (Ellis et al. 2011). In this study, the mobility dimension of the PDQ-39 significantly increased and the associated ES indicates this change is subjectively meaningful to participants (Peto, Jenkinson & Fitzpatrick, 2001). Despite non-significant changes in the single index score, the ES exceeds that necessary to suggest a meaningful change (Peto, Jenkinson & Fitzpatrick, 2001).

To our knowledge, the GAS has not previously been used to evaluate the efficacy of PD exercise interventions. Evidence supports that the GAS is effective in detecting clinically meaningful change (Stolee et al., 2012; Rockwood et al., 2003) and is more responsive to change than other commonly used outcome measures (Rockwood et al., 2003; Hurn, Kneebone & Cropley, 2006). Significant improvements on the GAS were similar in magnitude to other studies (Stolee et al., 2012; Rockwood et al., 2003). The GAS instrument played an important secondary function in addition to its role as an outcome measure. The process of determining participant specific goals was instrumental in designing salient activities for the functional mobility training. Goal setting was identified by 67% of respondents as beneficial in a study exploring the motivators and barriers following an exercise intervention in people with PD (Ene, McRae & Schenkman, 2011).

Intervention Design and Delivery

The 2 times a week, 10 week delivery format of the intervention program was manageable for this old, older adult population as suggested by the 92% attendance rate. Further this format still maintained the components necessary for neuroplastic change and global functional improvements (Alberts et al., 2011; Petzinger et al., 2010). Further the global/comprehensive nature of the exercise program (addressing many areas of physical function) translated into improvements in balance, strength, functional mobility, and gait parameters. The current program produced results similar to programs using large amplitude movements and functional mobility training delivered in a one:one format (Farley & Koshland, 2005; Ebersbach et al., 2010), demonstrating that a group-based delivery format can confer similar benefits for this type of exercise intervention in this age group.

In addition to a group-based delivery model being more cost effective and economically viable for hospital and community programs (Rodrigue de Paula, Teixeira-Salmela, Coelho de Morais Faria, Rocha de Brito & Cardoso, 2006), it can also engender social support, camaraderie, sense of community and improve QOL (States, Spierer & Salem, 2011; Rodrigue de Paula et al., 2006). Encouraging interactions between participants is a team building strategies known to increase adherence among elder exercisers (Watson et al., 2012). These group factors may have contributed to the high class attendance rates, good rates of adherence to home exercises and positive gains in physical function seen in this study. Another advantage of group exercise physiotherapy programs is that they better resemble ongoing community programs that clients will likely participate in after completing a hospital based program which may assist with this transition.

Long term benefits - 4monthPOST

This study also sought to investigate if the benefits achieved through the exercise program would be maintained four months after the completion of the intervention. Similar to previous studies we found that more significant improvements in functional mobility, QOL scores and achieving self-identified goals were maintained among those who adhered to ongoing regular physical activity (States, Spierer & Salem, 2011; Steffen, Petersen & Dvorak, 2008). It is not clear if further gains would be made if physiotherapy intervention had been maintained long term, but it is clear that ongoing regular physical activity was able to maintain many of the gains achieved with the physiotherapy intervention.

Limitations

One limitation of the study was that the design did not clearly differentiate if the improvements were a result of the physical exercise, the influence of the dynamics of the group program format, a combination or another factor. It was not feasible to have a randomized control group due to limited availability of participants with PD. However a time series design was used at PRE and POST to reduce the potential of confounding biases. The small sample size was an additional limitation.

Implications

For old, older adults with PD, a group exercise program using large amplitude movements and functional mobility training, 2 times a week for 10 weeks, was manageable and was effective in improving multiple areas of physical function and quality of life. Ongoing physical activity in the community helped maintain these improvements providing additional support for the need for more community based exercise interventions for those with PD (Hirsch, 2009).

Determining whether or not sustained physical therapy intervention would confer continued

improvements requires further research.

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Appendices

Appendix A

Hoehn and Yahr Staging of Parkinson's Disease

1. Stage One
   1. Signs and symptoms on one side only
   2. Symptoms mild
   3. Symptoms inconvenient but not disabling
   4. Usually presents with tremor of one limb
   5. Friends have noticed changes in posture, locomotion and facial expression
2. Stage Two
   1. Symptoms are bilateral
   2. Minimal disability
   3. Posture and gait affected
3. Stage Three
   1. Significant slowing of body movements
   2. Early impairment of equilibrium on walking or standing
   3. Generalized dysfunction that is moderately severe
4. Stage Four
   1. Severe symptoms
   2. Can still walk to a limited extent
   3. Rigidity and bradykinesia
   4. No longer able to live alone
   5. Tremor may be less than earlier stages
5. Stage Five
   1. Cachectic stage
   2. Invalidism complete
   3. Cannot stand or walk
   4. Requires constant nursing care

Appendix B - Mini Mental State Examination

MINI MENTAL STATE EXAMINATION

Client Name _____ Assessor _____ Date _____

Maximum Score
Score: Achieved: Record client's answers in the spaces provided

Maximum Score	Score Achieved		
5	( )	Q1	**ORIENTATION:** **What is the -** Year_____ Season_____ Month_____ Day_____ Date_____
5	( )	Q2	**Where are we -** Country _____ State _____ Town/City_____ Hospital/Street_____ Ward/House no. _____
3	( )	Q3	**REGISTRATION:** Name these 3 objects - **apple, penny, table.** 1 second to say each. Then ask the person to repeat all three after you have said them. Score 1 point for each one correct on the first attempt. Repeat them (maximum 5 times) until he/she learns them. Count trials and record. Trials: ____
5	( )	Q4	**ATTENTION AND CALCULATION:** Serial 7's: Count backwards from 100 by subtracting 7 (**93 86 79 72 65**) Score 1 point for each correct. (A correct response is one that is 7 less than the previous response even if the previous response is incorrect) Stop at 5 responses. - **OR** - Ask the person to spell the word "WORLD" forward and then backwards. Score 1 point for each letter in correct order. e.g. DLROW = 5, DLORW = 3
3	( )	Q5	**RECALL:** Ask for the names of the three objects given to remember in Q3. Score 1 point for each correct answer irrespective of the order they are recalled in. **apple penny table**
2	( )	Q6	**LANGUAGE:** Show the person a "PENCIL" and a "WATCH". Have the person name them as you point. Score 1 point for each correct answer.
1	( )	Q7	Have the person repeat the phrase - "NO IFS, ANDS, OR BUTS". Score 1 point for a correct repetition.
3	( )	Q8	Have the person follow a 3 stage command. Take the paper in your right/left hand. Fold it in half once with both hands. Put it on the floor. Score 1 point for each part correctly executed.
1	( )	Q9	Read and obey the message. **CLOSE YOUR EYES** Score 1 point if the person closes their eyes. They do not have to read aloud.
1	( )	Q10	Ask the person to write a sentence of his/her own choice. The sentence should contain a subject and an object and make sense. Ignore spelling errors.
1	( )	Q11	Ask the person to copy the design. Score 1 point if all sides and angles are preserved and the intersecting sides form a quadrangle.
30	( )	**TOTAL SCORE**	

References: 1. Derived from: Folstein MF. et al "Mini-Mental State" : a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975: 12:189. 2. Derived from: Cockrell JR et al Mini Mental State Examination (MMSE). Psychopharm Bull. 1988;24:689-692

Appendix C

Movement Disorders Society - Unified Parkinson's Disease Rating Scale – Section III

III. MOTOR EXAMINATION

Overview: This portion of the scale assesses the motor signs of PD. In administering Part III of the MDS-UPDRS the examiner should comply with the following guidelines:

At the top of the form, mark whether the patient is on medication for treating the symptoms of Parkinson's disease and, if on levodopa, the time since the last dose.
Also, if the patient is receiving medication for treating the symptoms of Parkinson's Disease, mark the patient's clinical state using the following definitions:

ON is the typical functional state when patients are receiving medication and have a good response.
OFF is the typical functional state when patients have a poor response in spite of taking medications.

The investigator should "rate what you see". Admittedly, concurrent medical problems such as stroke, paralysis, arthritis, contracture, and orthopedic problems such as hip or knee replacement and scoliosis may interfere with individual items in the motor examination. In situations where it is absolutely impossible to test (e.g., amputations, plegia, limb in a cast), use the notation "UR" for Unable to Rate. Otherwise, rate the performance of each task as the patient performs in the context of co-morbidities.

All items must have an integer rating (no half points, no missing ratings).

Specific instructions are provided for the testing of each item. These should be followed in all instances. The investigator demonstrates while describing tasks the patient is to perform and rates function immediately thereafter. For Global Spontaneous Movement and Rest Tremor items (3.14 and 3.17), these items have been placed purposefully at the end of the scale because clinical information pertinent to the score will be obtained throughout the entire examination.

At the end of the rating, indicate if dyskinesia (chorea or dystonia) was present at the time of the examination, and if so, whether these movements interfered with the motor examination.

3a Is the patient on medication for treating the symptoms of Parkinson's Disease?   No   Yes

3b   If the patient is receiving medication for treating the symptoms of Parkinson's Disease, mark the patient's clinical state using the following definitions:

3c Is the patient on Levodopa ?   No   Yes

3.C1 If yes, minutes since last levodopa dose:

ON: On is the typical functional state when patients are receiving medication and have a good response.

OFF: Off is the typical functional state when patients have a poor response in spite of taking medications.

3.1 SPEECH
Instructions to examiner: Listen to the patient's free-flowing speech and engage in conversation if necessary. Suggested topics: ask about the patient's work, hobbies, exercise, or how he got to the doctor's office. Evaluate volume, modulation (prosody) and clarity, including slurring, palilalia (repetition of syllables) and tachyphemia (rapid speech, running syllables together).

0: Normal: No speech problems.
1: Slight: Loss of modulation, diction or volume, but still all words easy to understand.
2: Mild: Loss of modulation, diction, or volume, with a few words unclear, but the overall sentences easy to follow.
3: Moderate: Speech is difficult to understand to the point that some, but not most, sentences are poorly understood.
4: Severe: Most speech is difficult to understand or unintelligible.

3.2 FACIAL EXPRESSION
Instructions to examiner: Observe the patient sitting at rest for 10 seconds, without talking and also while talking. Observe eye-blink frequency, masked facies or loss of facial expression, spontaneous smiling and parting of lips.

0: Normal: Normal facial expression.
1: Slight: Minimal masked facies manifested only by decreased frequency of blinking.
2: Mild: In addition to decreased eye-blink frequency, Masked facies present in the lower face as well, namely fewer movements around the mouth, such as less spontaneous smiling, but lips not parted.
3: Moderate: Masked facies with lips parted some of the time when the mouth is at rest.
4: Severe: Masked facies with lips parted most of the time when the mouth is at rest.

3.3 RIGIDITY
Instructions to examiner: Rigidity is judged on slow passive movement of major joints with the patient in a relaxed position and the examiner manipulating the limbs and neck. First, test without an activation maneuver. Test and rate neck and each limb separately. For arms, test the wrist and elbow joints simultaneously. For legs, test the hip and knee joints simultaneously. If no rigidity is detected, use an activation maneuver such as tapping fingers, fist opening/closing, or heel tapping in a limb not being tested. Explain to the patient to go as limp as possible as you test for rigidity.

0: Normal: No rigidity.
1: Slight: Rigidity only detected with activation maneuver.

2: Mild: Rigidity detected without the activation maneuver, but full range of motion is easily achieved.
3: Moderate: Rigidity detected without the activation maneuver; full range of motion is achieved with effort.
4: Severe: Rigidity detected without the activation maneuver and full range of motion not achieved.

3.4 FINGER TAPPING

Instructions to examiner: Each hand is tested separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to tap the index finger on the thumb 10 times as quickly AND as big as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude.

0: Normal: No problems.
1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or
hesitations of the tapping movement; b) slight slowing; c) the amplitude decrements near the end of the 10 taps.
2: Mild: Any of the following: a) 3 to 5 interruptions during tapping; b) mild slowing; c) the amplitude decrements midway in the 10-tap sequence.
3: Moderate: Any of the following: a) more than 5 interruptions during tapping or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing; c) the amplitude decrements starting after the 1st tap.
4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.

3.5 HAND MOVEMENTS

Instructions to examiner: Test each hand separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to make a tight fist with the arm bent at the elbow so that the palm faces the examiner. Have the patient open the hand 10 times as fully AND as quickly as possible. If the patient fails to make a tight fist or to open the hand fully, remind him/ her to do so. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude.

0: Normal: No problem.
1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the movement; b) slight slowing; c) the amplitude decrements near the end of the task.
2: Mild: Any of the following: a) 3 to 5 interruptions during the movements; b) mild slowing;
c) the amplitude decrements midway in the task.
3: Moderate: Any of the following: a) more than 5 interruptions during the movement or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing; c) the amplitude decrements starting after the 1st open-and-close sequence.
4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.

3.6 PRONATION-SUPINATION MOVEMENTS OF HANDS

Instructions to examiner: Test each hand separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to extend the arm out in front of his/her body with the palms down; then to turn the palm up and down alternately 10 times as fast and as fully as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude.

0: Normal: No problems.
1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the movement; b) slight slowing; c) the amplitude decrements near the end of the sequence.
2: Mild: Any of the following: a) 3 to 5 interruptions during the movements; b) mild slowing;
c) the amplitude decrements midway in the sequence.
3: Moderate: Any of the following: a) more than 5 interruptions during the movement or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing c) the amplitude decrements starting after the 1st supination-pronation sequence.
4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.

3.7 TOE TAPPING

Instructions to examiner: Have the patient sit in a straight-backed chair with arms, both feet on the floor. Test each foot separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to place the heel on the ground in a comfortable position and then tap the toes 10 times as big and as fast as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude.
0: Normal: No problem.
1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the tapping movement; b) slight slowing; c) amplitude decrements near the end of the ten taps.
2: Mild: Any of the following: a) 3 to 5 interruptions during the tapping movements; b) mild slowing; c) amplitude decrements midway in the task.or at least one longer arrest (freeze) in ongoing movement;
3: Moderate: Any of the following: a) more than 5 interruptions during the tapping movements b) moderate slowing; c) amplitude decrements after the first tap.
4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.

3.8 LEG AGILITY

Instructions to examiner: Have the patient sit in a straight-backed chair with arms. The patient should have both feet comfortably on the floor. Test each leg separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to place the foot on the ground in a comfortable position and then raise and stomp the foot on the ground 10 times as high and as fast as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude.

0: Normal: No problems.
1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions
or hesitations of the movement; b) slight slowing; c) amplitude decrements near the end of the task.
2: Mild: Any of the following: a) 3 to 5 interruptions during the movements; b) mild slowness; c) amplitude decrements midway in the task.
3: Moderate: Any of the following: a) more than 5 interruptions during the movement or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing in speed; c)amplitude decrements after the first tap.
4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.

3.9 ARISING FROM CHAIR

Instructions to examiner: Have the patient sit in a straight-backed chair with arms, with both feet on the floor and sitting back in the chair (if the patient is not too short). Ask the patient to cross his/her arms across the chest and then to stand up. If the patient is not successful, repeat this attempt a maximum up to two more times. If still unsuccessful, allow the patient to move forward in the chair to arise with arms folded across the chest. Allow only one attempt in this situation. If unsuccessful, allow the patient to push off using his/her hands on the arms of the chair. Allow a maximum of three trials of pushing off. If still not successful, assist the patient to arise. After the patient stands up, observe the posture for item 3.13

0: Normal: No problems. Able to arise quickly without hesitation.
1: Slight: Arising is slower than normal; or may need more than one attempt; or may need to move forward in the chair to arise. No need to use the arms of the chair.
2: Mild: Pushes self up from arms of chair without difficulty.
3: Moderate: Needs to push off, but tends to fall back; or may have to try more than one time using arms of chair, but can get up without help.
4: Severe: Unable to arise without help.

3.10 GAIT

Instructions to examiner: Testing gait is best performed by having the patient walking away from and towards the examiner so that both right and left sides of the body can be easily observed simultaneously. The patient should walk at least 10 meters (30 feet), then turn around and return to the examiner. This item measures multiple behaviors: stride amplitude, stride speed, height of foot lift, heel strike during walking, turning, and arm swing, but not freezing. Assess also for "freezing of gait" (next item 3.11) while patient is walking. Observe posture for item 3.13

0: Normal: No problems.
1: Slight: Independent walking with minor gait impairment.
2: Mild: Independent walking but with substantial gait impairment.
3: Moderate: Requires an assistance device for safe walking (walking stick, walker) but not a person.
4: Severe: Cannot walk at all or only with another person's assistance.

3.11 FREEZING OF GAIT

Instructions to examiner: While assessing gait, also assess for the presence of any gait freezing episodes. Observe for start hesitation and stuttering movements especially when turning and reaching the end of the task. To the extent that safety permits, patients may NOT use sensory tricks during the assessment.

0: Normal: No freezing.
1: Slight: Freezes on starting, turning or walking through doorway with a single halt during any of these events, but then continues smoothly without freezing during straight walking.
2: Mild: Freezes on starting, turning or walking through doorway with more than one halt during any of these activities, but continues smoothly without freezing during straight walking.
3: Moderate: Freezes once during straight walking.
4: Severe: Freezes multiple times during straight walking.

3.12 POSTURAL STABILITY

Instructions to examiner: The test examines the response to sudden body displacement produced by a quick, forceful pull on the shoulders while the patient is standing erect with eyes open and feet comfortably apart and parallel to each other. Test retropulsion. Stand behind the patient and instruct the patient on what is about to happen. Explain that s/he is allowed to take a step backwards to avoid falling. There should be a solid wall behind the examiner, at least 1-2 meters away to allow for the observation of the number of retropulsive steps. The first pull is an instructional demonstration and is purposely milder and not rated. The second time the shoulders are pulled briskly and forcefully towards the examiner with enough force to displace the center of gravity so that patient MUST take a step backwards. The examiner needs to be ready to catch the patient, but must stand sufficiently back so as to allow enough room for the patient to take several steps to recover independently. Do not allow the patient to flex the body abnormally forward in anticipation of the pull. Observe for the number of steps backwards or falling. Up to and including two steps for recovery is considered normal, so abnormal ratings begin with three steps. If the patient fails to understand the test, the examiner can repeat the test so that the rating is based on an assessment that the examiner feels reflects the patient's limitations rather than misunderstanding or lack of preparedness. Observe standing posture for item 3.13

0: Normal: No problems: Recovers with one or two steps.
1: Slight: 3-5 steps, but subject recovers unaided.
2: Mild: More than 5 steps, but subject recovers unaided.
3: Moderate: Stands safely, but with absence of postural response; falls if not caught by examiner.
4: Severe: Very unstable, tends to lose balance spontaneously or with just a gentle pull on the shoulders.

3.13 POSTURE

Instructions to examiner: Posture is assessed with the patient standing erect after arising from a chair, during walking , and while being tested for postural reflexes. If you notice poor posture,

tell the patient to stand up straight and see if the posture improves (see option 2 below). Rate the worst posture seen in these three observation points. Observe for flexion and side-to-side leaning.

0: Normal: No problems.
1: Slight: Not quite erect, but posture could be normal for older person.
2: Mild: Definite flexion, scoliosis or leaning to one side, but patient can correct posture to normal posture when asked to do so.
3: Moderate: Stooped posture, scoliosis or leaning to one side that cannot be corrected volitionally to a normal posture by the patient.
4: Severe: Flexion, scoliosis or leaning with extreme abnormality of posture.

3.14 GLOBAL SPONTANEITY OF MOVEMENT (BODY BRADYKINESIA)
Instructions to examiner: This global rating combines all observations on slowness, hesitancy, and small amplitude and poverty of movement in general, including a reduction of gesturing and of crossing the legs. This assessment is based on the examiner's global impression after observing for spontaneous gestures while sitting, and the nature of arising and walking.

0: Normal: No problems.
1: Slight: Slight global slowness and poverty of spontaneous movements.
2: Mild: Mild global slowness and poverty of spontaneous movements.
3: Moderate: Moderate global slowness and poverty of spontaneous movements.
4: Severe: Severe global slowness and poverty of spontaneous movements.

3.15 POSTURAL TREMOR OF THE HANDS
 Instructions to examiner: All tremor, including re-emergent rest tremor, that is present in this posture is to be included in this rating. Rate each hand separately. Rate the highest amplitude seen. Instruct the patient to stretch the arms out in front of the body with palms down. The wrist should be straight and the fingers comfortably separated so that they do not touch each other. Observe this posture for 10 seconds.
0: Normal: No tremor.
R
1: Slight: Tremor is present but less than 1 cm in amplitude.
2: Mild: Tremor is at least 1 but less than 3 cm in amplitude.
3: Moderate: Tremor is at least 3 but less than 10 cm in amplitude.
4: Severe: Tremor is at least 10 cm in amplitude.

3.16 KINETIC TREMOR OF THE HANDS
Instructions to examiner: This is tested by the finger-to-nose maneuver. With the arm starting from the outstretched position, have the patient perform at least three finger-to-nose maneuvers with each hand reaching as far as possible to touch the examiner's finger. The finger-to-nose maneuver should be performed slowly enough not to hide any tremor that could occur with very fast arm movements. Repeat with the other hand, rating each hand separately. The tremor can be present throughout the movement or as the tremor reaches either target (nose or finger). Rate the highest amplitude seen.

0: Normal: No tremor.
1: Slight: Tremor is present but less than 1 cm in amplitude.
2: Mild: Tremor is at least 1 but less than 3 cm in amplitude.
3: Moderate: Tremor is at least 3 but less than 10 cm in amplitude.
4: Severe: Tremor is at least 10 cm in amplitude.

3.17 REST TREMOR AMPLITUDE

Instructions to examiner: This and the next item have been placed purposefully at the end of the examination to allow the rater to gather observations on rest tremor that may appear at any time during the exam, including when quietly sitting, during walking and during activities when some body parts are moving but others are at rest. Score the maximum amplitude that is seen at any time as the final score. Rate only the amplitude and not the persistence or the intermittency of the tremor.

As part of this rating, the patient should sit quietly in a chair with the hands placed on the arms of the chair (not in the lap) and the feet comfortably supported on the floor for 10 seconds with no other directives. Rest tremor is assessed separately for all four limbs and also for the lip/jaw. Rate only the maximum amplitude that is seen at any time as the final rating.

Extremity ratings
0: Normal: No tremor.
1: Slight.:   < 1 cm in maximal amplitude.
2: Mild: > 1 cm but < 3 cm in maximal amplitude.
3: Moderate: 3 - 10 cm in maximal amplitude.
4: Severe: > 10 cm in maximal amplitude.

Lip/Jaw ratings
0: Normal: No tremor.
1: Slight: < 1 cm in maximal amplitude.
2: Mild: > 1 cm but < 2 cm in maximal amplitude.
3: Moderate: > 2 cm but < 3 cm in maximal amplitude.
4: Severe: > 3 cm in maximal amplitude.

3.18 CONSTANCY OF REST TREMOR

Instructions to examiner: This item receives one rating for all rest tremor and focuses on the constancy of rest tremor during the examination period when different body parts are variously at rest. It is rated purposefully at the end of the examination so that several minutes of information can be coalesced into the rating.

0: Normal: No tremor.
1: Slight: Tremor at rest is present < 25% of the entire examination period.
2: Mild: Tremor at rest is present 26-50% of the entire examination period.
3: Moderate: Tremor at rest is present 51-75% of the entire examination period.
4: Severe: Tremor at rest is present > 75% of the entire examination period.

DYSKINESIA IMPACT ON PART III RATINGS

A. Were dyskinesias (chorea or dystonia) present during examination?   No   Yes
B. If yes, did these movements interfere with your ratings?   No   Yes

Appendix D

GAITRite Mat

GAIT PARAMETERS:

Participant: _____

Date: _____

Parameters	
Velocity (cm/sec)	
Cadence (Steps/Min)	
Step Length (cm)	
Stride Length (cm)	

Appendix E

Timed Get Up and Go (Podsiadlo & Richardson, 1991)

Equipment

- straight-backed armchair with a seat height of 46 cm
- one pylon
- stopwatch
- measuring tape
- masking tape
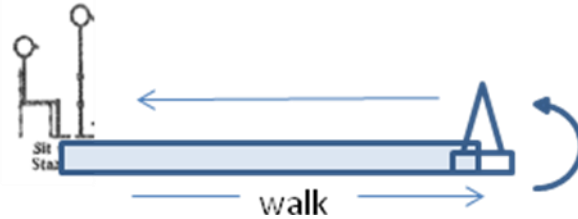
Positioning and preparation

- Place a piece of tape 3 metres from the front of the chair and place the pylon on the middle of the tape.
- Ensure the chair is stable and will not move when the participant moves from sit to stand or sits down
- Participant should be wearing regular footwear, may use usual walking aid if needed, and sitting with their back resting on the back of the chair.

Instructions to the participant

"Sit with your back against the chair and your arms on the arm rests. On the word `go,' stand upright, then walk at your normal pace around the cone, walk back to the chair, and sit down ."

Timing

The stopwatch is started on the word `go' and stopped when the participant has returned to the starting position.

Appendix F

Berg Balance Scale

1. SITTING TO STANDING
INSTRUCTIONS: Please stand up. Try not to use your hands for support.
(4) able to stand without using hands and stabilize independently
(3) able to stand independently using hands
(2) able to stand using hands after several tries
(1) needs minimal aid to stand or to stabilize
(0) needs moderate or maximal assist to stand

2. STANDING UNSUPPORTED
INSTRUCTIONS: Please stand for two minutes without holding.
(4) able to stand safely 2 minutes
(3) able to stand 2 minutes with supervision
(2) able to stand 30 seconds unsupported
(1) needs several tries to stand 30 seconds unsupported
(0) unable to stand 30 seconds unassisted If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

3. SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL
INSTRUCTIONS: Please sit with arms folded for 2 minutes.
(4) able to sit safely and securely 2 minutes
(3) able to sit 2 minutes under supervision
(2) able to sit 30 seconds
(1) able to sit 10 seconds
(0) unable to sit without support 10 seconds

4. STANDING TO SITTING
INSTRUCTIONS: Please sit down.
(4) sits safely with minimal use of hands
(3) controls descent by using hands
(2) uses back of legs against chair to control descent
(1) sits independently but has uncontrolled descent
(0) needs assistance to sit

5. TRANSFERS
INSTRUCTIONS: Arrange chairs(s) for a pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
(4) able to transfer safely with minor use of hands
(3) able to transfer safely definite need of hands
(2) able to transfer with verbal cueing and/or supervision
(1) needs one person to assist

(0) needs two people to assist or supervise to be safe

6. STANDING UNSUPPORTED WITH EYES CLOSED
INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
(4) able to stand 10 seconds safely
(3) able to stand 10 seconds with supervision
(2) able to stand 3 seconds
(1) unable to keep eyes closed 3 seconds but stays steady
(0) needs help to keep from falling

7. STANDING UNSUPPORTED WITH FEET TOGETHER
INSTRUCTIONS: Place your feet together and stand without holding.
(4) able to place feet together independently and stand 1 minute safely
(3) able to place feet together independently and stand for 1 minute with supervision
(2) able to place feet together independently but unable to hold for 30 seconds
(1) needs help to attain position but able to stand 15 seconds feet together
(0) needs help to attain position and unable to hold for 15 seconds

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING
INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the finger reaches while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.).
(4) can reach forward confidently >25 cm (10 inches)
(3) can reach forward >12 cm safely (5 inches)
(2) can reach forward >5 cm safely (2 inches)
(1) reaches forward but needs supervision
(0) loses balance while trying/requires external support

9. PICK UP OBJECT FROM FLOOR FROM A STANDING POSITION
INSTRUCTIONS: Pick up shoe/slipper which is placed in front of your feet.
(4) able to pick up slipper safely and easily
(3) able to pick up slipper but needs supervision
(2) unable to pick up but reaches 2-5cm (1-2 inches) from slipper and keeps balance independently
(1) unable to pick up and needs supervision while trying
(0) unable to try/needs assist to keep from losing balance or falling

10. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward left shoulder. Repeat to the right. Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.

(4) looks behind from both sides and weight shifts well

(3) looks behind one side only other side shows less weight shift

(2) turns sideways only but maintains balance

(1) needs supervision when turning

(0) needs assist to keep from losing balance or falling

11. TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

(4) able to turn 360 degrees safely in 4 seconds or less

(3) able to turn 360 degrees safely one side only in 4 seconds or less

(2) able to turn 360 degrees safely but slowly

(1) needs close supervision or verbal cueing

(0) needs assistance while turning

12. PLACING ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.

(4) able to stand independently and safely and complete 8 steps in 20 seconds

(3) able to stand independently and complete 8 steps >20 seconds

(2) able to complete 4 steps without aid with supervision

(1) able to complete >2 steps needs minimal assist

(0) needs assistance to keep from falling/unable to try

13. STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place our foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width).

(4) able to place foot tandem independently and hold 30 seconds

(3) able to place foot ahead of other independently and hold 30 seconds

(2) able to take small step independently and hold 30 seconds

(1) needs help to step but can hold 15 seconds

(0) loses balance while stepping or standing

14. STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding.

(4) able to lift leg independently and hold >10 seconds

(3) able to lift leg independently and hold 5-10 seconds

(2) able to lift leg independently and hold = or >3 seconds

(1) tries to lift leg unable to hold 3 seconds but remains standing independently

(0) unable to try or needs assist to prevent fall

( ) TOTAL SCORE (Maximum = 56) ,a person scoring below 45 is considered to be at risk for falling.

Appendix G

Chair Stand Test

STATION 1

CHAIR STAND TEST

PURPOSE:
To measure lower-body strength

EQUIPMENT:
Straight-back chair (17 in. or 43.18 cm seat height); stopwatch

PROCEDURE:
- Have the participant sit in the middle of the chair, feet flat on the floor, arms across chest.
- On signal "go" have the participant rise to a full stand, then return to a fully seated position.
- After a warm-up trial to check for correct form, administer one test trial.
- The score is the number of stands completed in 30 seconds.

Appendix H

PDQ-39 QUESTIONNAIRE

Please complete the following

Please tick <u>one</u> box for each question

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

		Never	Occasionally	Sometimes	Often	Always or cannot do at all
1	Had difficulty doing the leisure activities which you would like to do?	☐	☐	☐	☐	☐
2	Had difficulty looking after your home, e.g. DIY, housework, cooking?	☐	☐	☐	☐	☐
3	Had difficulty carrying bags of shopping?	☐	☐	☐	☐	☐
4	Had problems walking half a mile?	☐	☐	☐	☐	☐
5	Had problems walking 100 yards?	☐	☐	☐	☐	☐
6	Had problems getting around the house as easily as you would like?	☐	☐	☐	☐	☐
7	Had difficulty getting around in public?	☐	☐	☐	☐	☐
8	Needed someone else to accompany you when you went out?	☐	☐	☐	☐	☐
9	Felt frightened or worried about falling over in public?	☐	☐	☐	☐	☐
10	Been confined to the house more than you would like?	☐	☐	☐	☐	☐
11	Had difficulty washing yourself?	☐	☐	☐	☐	☐
12	Had difficulty dressing yourself?	☐	☐	☐	☐	☐
13	Had problems doing up your shoe laces?	☐	☐	☐	☐	☐

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

Due to having Parkinson's disease, how often *during the last month* have you....   *Please tick <u>one</u> box for each question*

		Never	Occasionally	Sometimes	Often	Always or cannot do at all
14	Had problems writing clearly?	☐	☐	☐	☐	☐
15	Had difficulty cutting up your food?	☐	☐	☐	☐	☐
16	Had difficulty holding a drink without spilling it?	☐	☐	☐	☐	☐
17	Felt depressed?	☐	☐	☐	☐	☐
18	Felt isolated and lonely?	☐	☐	☐	☐	☐
19	Felt weepy or tearful?	☐	☐	☐	☐	☐
20	Felt angry or bitter?	☐	☐	☐	☐	☐
21	Felt anxious?	☐	☐	☐	☐	☐
22	Felt worried about your future?	☐	☐	☐	☐	☐
23	Felt you had to conceal your Parkinson's from people?	☐	☐	☐	☐	☐
24	Avoided situations which involve eating or drinking in public?	☐	☐	☐	☐	☐
25	Felt embarrassed in public due to having Parkinson's disease?	☐	☐	☐	☐	☐
26	Felt worried by other people's reaction to you?	☐	☐	☐	☐	☐
27	Had problems with your close personal relationships?	☐	☐	☐	☐	☐
28	Lacked support in the ways you need from your spouse or partner?	☐	☐	☐	☐	☐
	If you do not have a spouse or partner tick here		☐			
29	Lacked support in the ways you need from your family or close friends?	☐	☐	☐	☐	☐

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

Questionnaires for patient completion

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

Please tick <u>one</u> box for each question

		Never	**Occasionally**	**Sometimes**	**Often**	**Always**
30	Unexpectedly fallen asleep during the day?	☐	☐	☐	☐	☐
31	Had problems with your concentration, e.g. when reading or watching TV?	☐	☐	☐	☐	☐
32	Felt your memory was bad?	☐	☐	☐	☐	☐
33	Had distressing dreams or hallucinations?	☐	☐	☐	☐	☐
34	Had difficulty with your speech?	☐	☐	☐	☐	☐
35	Felt unable to communicate with people properly?	☐	☐	☐	☐	☐
36	Felt ignored by people?	☐	☐	☐	☐	☐
37	Had painful muscle cramps or spasms?	☐	☐	☐	☐	☐
38	Had aches and pains in your joints or body?	☐	☐	☐	☐	☐
39	Felt unpleasantly hot or cold?	☐	☐	☐	☐	☐

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

Thank you for completing the PDQ 39 questionnaire

Appendix I

Patient Goal Attainment Scaling Sheet (GAS)

Patient Name:.................................. **Age:**..........

Hospital No:...................................

Discharge date:...............................

Keyworker:......................................

Importance to patient: score little importance = 1 to 3 = very important.

Probability of achieving (professionals); score, doubtful = 1 to 3 = probable.

Goal attainment baseline usually set at -1 (occasionally -2 if couldn't be worse)

Goal attainment score: 0 = achieves goal as expected, -1 = less than expected,

(- 2 = much less than expected), +2 = much more than expected, +1 = more than expected.

PATIENT'S KEY GOALS FOR PROGRAMME:

Level of patient involvement in goal setting:

0 = no involvement   1=minimal   2=moderate   3 = with guidance only

	Patient's stated objective:	Related measurable outcome: (0 = achievement)	Importance	Probability	- - / 2 1 / 0 / + + / 1 2	Variance if scoring anything other than 0: 1. Describe function at Baseline (-1 or -2) 2. Describe function if '0' is not reached or is exceeded.
1					Baseline:	
					Score:	
2					Baseline:	
					Score:	
3					Baseline:	
					Score:	
4					Baseline:	
					Score:	

Results of GAS calculation	Baseline:	Achieved score:	Change score:	Date: