August 2012

The Effects of a Home Based Virtual Reality Rehabilitation Program on Balance Among Individuals with Parkinson's Disease

Michelle L. Gu
The University of Western Ontario

Supervisor
Dr. Jeffrey D. Holmes
The University of Western Ontario

Joint Supervisor
Dr. Mary E. Jenkins
The University of Western Ontario

Graduate Program in Health and Rehabilitation Sciences

A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

THE EFFECTS OF A HOME BASED VIRTUAL REALITY REHABILITATION PROGRAM ON BALANCE AMONG INDIVIDUALS WITH PARKINSON'S DISEASES

(Spine title: Virtual Reality Rehabilitation On Balance in Parkinson's)

(Thesis format: Integrated Article)

by

Michelle Gu

Graduate Program in Health and Rehabilitation Sciences

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

The School of Graduate and Postdoctoral Studies
The University of Western Ontario
London, Ontario, Canada

THE UNIVERSITY OF WESTERN ONTARIO
School of Graduate and Postdoctoral Studies

CERTIFICATE OF EXAMINATION

Joint-Supervisor	Examiners
______________________________	______________________________
Dr. Jeffrey Holmes	Dr. Sandi Spaulding
Joint-Supervisor	______________________________
	Professor Lisa Klinger
______________________________	______________________________
Dr. Mary Jenkins	Professor Rebecca Timbeck
Supervisory Committee	
______________________________	
Dr. Andrew Johnson	

The thesis by

Michelle Li Ann Gu

entitled:

The Effects of a Home Based Virtual Reality Rehabilitation Program on Balance Among Individuals with Parkinson's Disease

is accepted in partial fulfillment of the
requirements for the degree of
Master of Science

______________________	______________________________
Date	Chair of the Thesis Examination Board

Abstract

Increasingly, the Nintendo Wii gaming system has been cited as an adjunctive tool for physical rehabilitation, particularly among older adults and individuals with limited mobility. However, evidence supporting "Wii-hab" remains predominantly anecdotal. The present study evaluates the effectiveness of a 12-week home-based exercise program designed around the Wii, in improving balance of individuals with Parkinson's disease (PD). Fifteen individuals with PD engaged in three 30-minute Wii balance-training sessions per week, for 12 weeks. Balance was assessed using a forceplate in 4 quiet standing conditions of varying difficulty at 3 testing sessions: (1) baseline; (2) 6 weeks; and (3) 12 weeks. Participants were also asked to complete a balance confidence survey at each testing session. Results suggest that the program had a positive effect on balance. Furthermore, results supported that the Wii training program had a significant effect on program adherence. Results suggested improvements in balance and balance confidence.

Keywords: home-based rehabilitation, balance, Parkinson's disease, virtual reality, Nintendo Wii, exercise adherence

Co-Authorship

This thesis contains material for a manuscript that is in final preparation. This principal author of the manuscript that results from this thesis will be J.D. Holmes, co-authored by M.L. Gu, M.E. Jenkins, and A.M. Johnson.

Acknowledgements

First and foremost I would like to thank my supervisors, Jeff and Mary, for their invaluable help, support and guidance throughout the past two years. The knowledge I have gained is immeasurable and I am grateful to have had such caring and supportive mentors.

Thank you to my parents, Mama and Papa Gu. Thank you for being patient with me while I figured out my path, for supporting me through all my endeavors (past and yet to come), and always being there for me with that tough love when times got rough. Without you I wouldn't be who or where I am today - literally and figuratively! The best parents I could have asked for; love you always and forever.

Yaya, thank you for the all support you've given me and for showing me the world.

Shoutouts to the Gu's, the Lang's and especially to my di, Ben, knowing that you were watching and looking up to me helped keep me motivated, thanks for believing.

A big thank you to my friends for their patience and support, for sticking by me and for all the times spent brainstorming, challenging me, camping out at Starbucks or Williams, and preparing me for the big day, I owe my sanity to you.

Finally; to my participants, without whom this study would not have been possible, thank you for your time and your inspiration.

Table of Contents

List of Tables

List of Figures

List of Appendices

CHAPTER 1: INTRODUCTION

Introduction to Parkinson's Disease

Parkinson's disease (PD) is a progressive neurological disorder characterized by bradykinesia (slowness of movement), rigidity (stiffness), resting tremor and postural instability (Jankovic, 2008). The average age of onset is 60 years of age (Korchounov, Schipper, Preobrazhenskaya, Kessler, & Yakhno, 2004). It is estimated that approximately 100,000 Canadians are currently living with the disease, and that number is expected to double by 2016 (Parkinson Society Canada, 2004). The clinical diagnosis of Parkinson's is based on the presence of two of the cardinal features of resting tremor, bradykinesia, and rigidity, as well as symptom improvement with the administration of levodopa (Lyons & Pahwa, 2011).

Pathophysiologically, PD stems from the progressive degeneration of dopaminergic neurons in the substantia nigra pars compacta (Fahn, 2003). These dopaminergic neurons in turn project from the substantia nigra to various nuclei that make up the basal ganglia including the putamen, caudate nucleus, subthalamic nucleus, and the globus pallidus interna and externa (Obeso et al., 2000). Collectively the basal nuclei are believed to play a role in not only the initiation and termination of voluntary movements, but are responsible for regulating the intensity of these movements (Marieb & Mallatt, 1992). Accordingly, insufficient levels of dopamine lead to impaired basal ganglial function, the consequences of which manifest as the cardinal features of PD (tremor, rigidity, bradykinesia, and postural instability) many of which lend themselves to an increased occurrence of falls (Bloem, Hausdorff, Visser, & Giladi, 2004).

When compared to other medical conditions, PD has been found to be the leading cause of falls in the elderly (Teno, Kiel, & Mor, 1990). The risk of falls and near falls in PD compared to the general population has been reported to be two and threefold respectively (Teno, et al., 1990). Prospective studies suggest that up to 70% of individuals with PD report experiencing a fall over one year (Balash, Peretz, Leibovich, Herman, Hausdorff, & Giladi, 2005; Bloem, Grimbergen, Cramer, Willemsen, & Zwinderman, 2001; Gray & Hildebrand, 2000; Wood, Bilclough, Bowron, & Walker, 2002), and that 10% report falling more than once per week (Koller, Glatt, Vetere-Overfield, & Hassanein, 1989). Forty to sixty-five percent of falls in PD have been reported to lead to injury, and over seventy-five percent of these injuries require healthcare services (Gray & Hildebrand, 2000; Wielinski, Erickson-Davis, Wichmann, Walde-Douglas, & Parashos, 2005). The most common injuries related to falls include bone fractures, skin lacerations to both the upper and lower extremities, and subdural hematomas (Balash, et al., 2005; Gray & Hildebrand, 2000). Johnell, Melton, Atkinson, O'Fallon, and Kurland (1992) reported that by 10 years after diagnosis, an estimated 27% of those in a Parkinsonian cohort had experienced a new hip fracture; a 20-fold increase in risk when compared with an age- and sex-matched control group.

Although the motor symptoms of PD dominate the clinical symptoms, it has been suggested that close to 90% of patients experience at least one non-motor symptom, and that about 10% exhibit five non-motor symptoms (Shulman, Taback, Bean, & Weiner, 2001). These symptoms include fatigue, sleep disturbance, constipation, bladder and gastrointestinal disturbance, and sensory complaints such as pain, numbness, tingling, and burning in the limbs (Fahn, 2003). Behavioral and mental symptoms are also common in individuals with PD and may include changes in mood such as depression, decreased motivation and apathy, slowness in thinking, and declining cognition that can progress to dementia (Chaudhuri & Schapira, 2009;

Fahn, 2003). Despite their common occurrence, non-motor symptoms often remain underreported by patients (Chaudhuri & Odin, 2010; Chaudhuri, Prieto-Jurcynska, et al., 2010). When asked why these symptoms remain undeclared patients report that they are not aware that the symptoms are related to PD; that the physician's questioning focused only on motor symptoms; and/or that they feel embarrassed, especially when discussing symptoms related to automatic functions (Chaudhuri & Schapira, 2009).

Management of Parkinson's Disease

Unfortunately, at present, there remains no cure for PD, as such treatment is focused on symptom management via dopamine replacement therapy. To date levodopa remains the single most effective drug available (Hely, Fung, & Morris, 2000; Silva, et al., 1997). Regrettably, after about 5 years of beginning treatment 50% of patients taking levodopa develop motor complications including dyskinesias (involuntary uncontrolled movements) (Kumar, Van Gerpen, Bower, & Ahlskog, 2005; Mazzella, et al., 2005; Rascol, 2000). To help delay the onset of these motor complications, pharmacological management often first begins with dopamine agonists rather than levodopa. Although several of these drugs are available (i.e., pramipexole, ropinirole), they tend to be less effective then levodopa. In a randomized controlled trial motor symptoms and activities of daily living were found to improve 40%-50% with levodopa, but only 30% with dopamine agonists (Holloway, et al., 2004; Lees, Katzenschlager, Head, & Ben-Shlomo, 2001; Rascol, 2000). Moreover, although less disabling then dyskinesias, dopamine agonists are more likely to cause side effects such as drowsiness, dry mouth, hallucinations, and confusion (Fahn, 2003; Munchau & Bhatia, 2000).

While medication has been found to work very well in improving some of the symptoms of PD such as bradykinesia, rigidity, and tremor, it has been found to be only partially effective in the treatment of balance, posture, and non-motoric symptoms (Bowes, et al., 1990; Levy-Tzedek, Krebs, Arle, Shils, & Poizner, 2011). For example, Koller et al. (1989) reported a decrease in falls with dopaminergic therapy due to a decrease in bradykinesia and gait impairments, but found that postural instability was generally unaffected. Furthermore, several authors have reported that pharmacological management either a) fails to improve postural stability or b) makes it worse secondary to side effects such as orthostatic hypotension, dyskinesias, and/or confusion (Bloem, 1992; Robinson, et al., 2005). Finally, as PD progresses, medication often becomes less effective and the response to medication becomes more variable (Gauntlett-Gilbert & Brown, 1998). For example, with advancing PD, patients will experience a loss of the beneficial drug effect prior to their next scheduled dose, a phenomenon referred to as "wearing off" or "end of dose" deterioration. While in the beginning, wearing-off may be subtle and take the form of mild sensory symptoms, over time the fluctuations tend to become increasingly unpredictable, and lead to spontaneous "off" episodes that are not related to the timing of medication dosing (Bhidayasiri & Truong, 2008).

Health Related Quality of Life in Parkinson's Disease

Taken together the motor and non-motor impairments coupled with side- effects, decreased efficacy, and fluctuations associated with pharmacotherapy have a considerable impact on an individual's well being (Hackney & Earhart, 2009). As a result, the quality of life of both individuals living with PD and their caregivers has been reported to be significantly impacted (Habermann, 2000). For example, many people with PD are embarrassed about their illness, and gradually socially withdraw as the disease progresses (Prediger, Matheus, Schwarzbold, Lima, & Vital, 2012). Specifically, resulting from highly visible symptoms such as decreased facial expressions, slurred speech, shuffling gait, and increased tremor, individuals often begin to loose the motivation to be socially active as they fear of being negatively evaluated in public (Prediger et al., 2012).

Acknowledging that the course of the disease is unpredictable and that their futures are uncertain (Habermann, 1996), individuals with PD who are employed often struggle with the decision as to whether they should remain in the workforce. Although the decision to cease working is sometimes necessary, it raises several concerns related to diminished productivity in society, financial dependence on others, and loss of identity as a working person (Habermann, 1996). Many of the participants interviewed in Habermann's study defined themselves as "workaholics", and subsequently described that when they ceased working they were left struggling to establish a meaningful identity without employment.

Similar to the way in which PD disrupts roles within the workplace, the disease often brings about changes in family life regarding how responsibilities at home are negotiated. While in some instances family members will take on additional responsibilities and accept the changes in roles smoothly, in other cases these changes may result in significant strain. For example, one participant in Habermann's study described how their physical deterioration contributed to the separation from their spouse, whereas another spoke of how the relationship with their children was negatively impacted due to an increasing level of dependence.

Economic Burden of Parkinson's Disease

In addition to significantly impacting quality of life, PD bears a considerable economic burden on society in terms of both direct and indirect costs. Direct costs include those that are associated with the prevention, detection, and treatment of PD. Typically categorized as hospitals, drugs, physicians and research, direct costs also include transportation costs to and from appointments (Parkinson Society Canada, 2004). Indirect costs are comprised of costs associated with a loss of productivity and informal care provided by care partners, family members, and friends. The total cost of PD in Canada in 1998 was estimated to be $558.1 million dollars with 70.2% of the cost coming from long-term disability, 7.1% from hospital visits, and 4.1% in Physician care (Parkinson Society Canada, 2004). In light of the fact that $24.1 million dollars per year is being spent on drugs alone (Parkinson Society Canada, 2004), the need to examine alternative treatment strategies as a means to more effectively manage the disease is exponentially growing.

Non-Pharmacological Therapies in Parkinson's Disease

Research has found that non-pharmacological therapies, such as exercise programming, is generally effective in alleviating symptoms of PD, and improvements have been demonstrated in strength, physical functioning, quality of life, balance, and gait speed (Goodwin, Richards, Taylor R.S., Taylor A.H., & Campbell, 2008). Given the sheer variety of physical activity options available, it is not surprising that interventions that have been examined are clinically heterogeneous with regards to the type of exercise. For example, research has investigated stretching (Palmer, Mortimer, Webster, Bistevins, & Dickinson, 1986), progressive exercise training (Comella, Stebbins, Brown-Toms, & Goetz, 1994), aerobic training (Burini, et al., 2006), relaxation and muscle activation (Schenkman, et al., 1998), strength and balance training (Hirsch, Toole, Maitland, & Rider, 2003; Toole, Hirsch, Forkink, Lehman, & Maitland, 2000), and treadmill walking (Toole, Maitland, Warren, Hubmann, & Panton, 2005). Similarly heterogeneous, the frequency and duration of the exercise protocols range between 6 to 36 hours spread over 4 to 12 weeks (Goodwin, et al., 2008). Interestingly, a review of the published literature concluded that the type of exercise is relatively unimportant for individuals with PD (Johnson & Almeida, 2007), and so the key to the effectiveness of a physical activity intervention is likely to be found within the ability of a program to create and sustain user interest. This is particularly important given that a frequently cited statistic in the physical activity literature is that approximately 20-50% of adults who begin an exercise program withdraw within the first 6 months (Dishman, 1988; Oldridge, 1984; Ward & Morgan, 1984); and these numbers are likely to be higher for individuals who experience mobility-related barriers.

Virtual Reality Training

One adjunctive strategy that may serve to create and sustain user interest is the use of virtual reality training. For many patient populations, virtual reality training has been embraced as an adjunct to conventional rehabilitation, and is showing very promising results in creating lasting motor changes (Deutsch, 2009; Dunning, Levine, Schmitt, Israel, & Fulk, 2008; Holden, 2005). As a relatively new treatment paradigm, it is not surprising that the training regimens described in the studies vary greatly, ranging from approximately twenty hours over a four-week period (one hour per day, five days of the week) (Piron, Cenni, Tonin, & Dam, 2001) to approximately 45 hours (five hours per day for nine consecutive days) (Taub, Uswatte, & Pidikiti, 1999). Despite this inter-study variability, however, the general conclusion appears to be that groups participating in virtual reality rehabilitation tend to have more favorable outcomes than groups that are not exposed to this adjunctive therapeutic approach (Holden, 2005).

Although previous research studies have evaluated the effects of incorporating virtual reality technology into rehabilitation strategies, these studies have typically focused on high-end, custom hardware and software, that is neither readily available nor affordable, thus making it unsuitable for large scale clinical or home implementation. In response to these limitations, researchers have recently focused their attention on consumer grade technology as it addresses both of these concerns. Specifically, the Nintendo Wii gaming console has drawn considerable attention from both the research and clinical community.

Nintendo Wii

The Nintendo Wii system is comprised of a console that attaches to a standard television, a wireless handheld controller, and several additional peripherals. One peripheral of particular interest here is the balance board. Similar to that of a bathroom scale, the board contains several sensors that measure body weight and respond to shifts in body position. Although originally designed for individual recreational entertainment within residential settings, a trend has developed to utilize the Wii system as an adjunctive tool within traditional rehabilitative contexts, a practice which has been termed Wii-habilitation. Specifically, the balance board has substantial potential to be beneficial in therapy with clients experiencing balance issues as it is easy to use, and can be used in conjunction with games such as Wii Fit Plus designed specifically to work on balance. For example, individuals may improve their ability to safely shift their weight by playing games that require the user to lean both forwards-backwards and side-to-side. Improvements in weight shifting may transfer to improvements in functional activities such as bed mobility that may in turn help increase ones level of independence (Hertz, 2009). In addition to balance, skills such as hand-eye coordination, motor planning, and figure-ground perception are targeted in several of the games. Positive reinforcement and knowledge of results that are provided help to further facilitate improvements in task performance (Saposnik et al. 2010). Finally, as there is an option to select varying levels of difficulty, the optimal level of physical and cognitive exertion can be set (Clarke & Kraemer, 2009), thus ensuring the user is presented with "just the right challenge" (Hertz, 2009).

Since its release in 2006, the Nintendo Wii has been cited as a potential adjunctive tool for physical rehabilitation, and has also been noted to have positive effects on mood and anxiety, particularly among older adults and individuals with limited mobility. The use of the Wii system as an adjunctive tool to train balance has many potential benefits over that of traditional therapy. In general, traditional therapy is relatively expensive, requires transportation to and from a clinic, and can result in diminished levels of adherence as individuals are forced to practice rote monotonous tasks. Alternatively, the Wii system is a low cost, commercially available option that allows individuals to engage in therapy on their own time within the familiar and convenient surroundings of their own home. With several interactive game options available to select from, the literature suggests that the Wii is fun and enjoyable, and may help to foster increased levels of adherence (Williams, Doherty, Bender, Mattox, & Tibbs, 2011).

Wii-habilitation

Although the Wii has emerged into the rehabilitation community as a promising new delivery method of rehabilitation, evidence supporting the utility of the Wii in this context remains limited. Initial research in this area has predominantly focused on stroke rehabilitation. For example, Saposnik et al. (2010) found the Wii to be a feasible, safe, and potentially effective intervention to enhance upper extremity motor function for those recovering from stroke. Similarly, Lange, Flynn, Proffitt, Chang, and Rizzo (2010) conducted a study on individuals affected with a stroke, where participants were interviewed concerning their experience using the Wii program. It was reported by all participants that the Wii activities were more enjoyable and engaging, in comparison to conventional physical and occupational therapy, even though all forms of therapy required similar levels of physical exertion. It was also noted that the games allowed participants to engage in activities not found in conventional therapy (Lange et al., 2010). A similar study conducted by Joo et al. (2010), discussed the overwhelmingly positive experiences of the participants, who felt that the Nintendo Wii was a more useful and effective therapy option than conventional therapy. The participants felt that the Wii was very enjoyable and would highly recommend the use of this tool for prospective clients.

In addition to stroke, the Wii has been investigated in several populations with diverse rehabilitation needs. Wuang, Chiang, Su, and Wang (2011) examined the sensorimotor changes in children with Down Syndrome using the Nintendo Wii compared to standard occupational therapy. Results indicated that participants in the Wii group had greater pre-post changes in motor proficiency, visual-integrative abilities and sensory integrative functioning as compared to those receiving standard occupational therapy treatment, thus demonstrating that the Wii could be used as a successful adjunctive form of treatment. Miller, Hayes, Dye, Johnson, and Meyers (2012) investigated the use of the Wii Fit balance games and body weight support to improve balance among two individuals with a lower limb amputation. The intervention consisted of 6 weeks of 2 supervised sessions per week including 20 minutes of Nintendo Wii Fit balance gaming and 20 minutes of gait training using body weight support. Both participants demonstrated improvement in dynamic balance and balance confidence with one participant reducing the need for an assistive device in community ambulation and the other participant improving his aerobic capacity. Deutsch, Borbely, Filler, Huhn, and Guarrera-Bowlby (2008) examined the efficacy of the Wii to augment the rehabilitation of an adolescent with Cerebral Palsy. The treatment program consisted of eleven training sessions of 60-90 minutes of playing Wii Sports, and was designed to address: postural control, functional mobility, and visual perceptual processing. Significant improvements were noted in all three domains.

Nintendo Wii Balance Training in Healthy Young and Older Adults

Although the Wii has been examined for its efficacy among several diverse rehabilitation contexts, a significant amount of attention has recently been placed on its utility as a tool to foster improvements in balance among both healthy young and older adults. Vernadakis, Gioftsidou, Antoniou, Ioannidis, and Giannousi (2012) examined the impact of the Wii as compared to traditional approaches within a sample of undergraduate students. The results indicated statistically significant improvements on the pre-post balance scores for each of the approaches, with no significant differences observed between approaches. Young, Ferguson, Brault, and Craig (2011) utilized the Nintendo Wii Balance Board to train standing balance in older adults using specially designed games. Six healthy older adults were recruited to participate in ten 20-minute sessions of game play over a four-week period. Mean sway variability was noted to decrease in both medial-lateral and anterior-posterior sway in both eyes open and closed conditions, however statistically significant improvements were found only in the eyes closed anterior-posterior sway condition. Bateni (inpress) conducted a preliminary study which compared changes in balance experienced by healthy older adults following a 4-week exercise program that used the Wii Fit gaming system and/or traditional physical therapy. Participants' were divided into three groups: one received both physical therapy and Wii training, one received physical therapy only, and the other received Wii training only. All three groups showed improvements on the Berg Balance Scale, however, while Wii Fit training alone did improve balance, physical therapy or a combination of physical therapy and Wii Fit training led to greater overall improvements in balance. Similarly, Crotty et al. (2011) investigated the use of the Wii in physiotherapy against conventional therapy for hospitalized older adults using functional outcome measures and found improvements in both groups with the Wii showing a small significant difference on balance and the Timed Up and Go Test compared to the conventional group.

Nintendo Wii Balance Training In Individuals with Known Balance Impairment

Using the Nintendo Wii as an adjunctive therapy, researchers have also demonstrated its capacity to improve balance among individuals with known balance impairments. Clarke and Kraemer (2009) examined the impact of providing six Wii therapy sessions to a long-term care resident with a significant risk of falling. Results from this study demonstrated a decreased risk of falls, as shown by improvements of the resident's Timed Up and Go and Berg Balance Scale scores. Deutsch (2009) compared a rehabilitation program based around the Wii Fit program to a standard balance and mobility program among individuals recovering from a stroke. Although the Wii program yielded a higher percentage of improvements than the standard program, a lower rate of retention in post-training results was revealed. Similarly, Bainbridge, Bevans, Keeley, and Oriel (2011) examined the effects of a Wii Fit balance program among community dwelling older adults with perceived balance deficits and demonstrated clinically significant improvements on the Berg Balance Scale following a 6-week intervention. Lastly, Meldrum, Glennon, Herdman, Murray, and McConn-Walsh (2012) assessed the usability of the Nintendo Wii Fit Plus system for the rehabilitation of balance impairment in vestibular and other neurologic diseases. Results revealed high levels of usability and enjoyment with 73% of participants experiencing more enjoyment and motivation over that experienced with traditional physiotherapy.

Nintendo Wii Balance Training in Parkinson's Disease

Although a growing body of knowledge is mounting, the literature currently contains few reports that examine the use of the Nintendo Wii within a clinical population of individuals with PD. Specifically, there have only been three investigations that examine the effects of utilizing the Wii to manage symptoms within this population. Hertz (2009) delivered an eight-week Wii exercise program in which 20 individuals with PD spent one hour playing the Wii three times per week. Significant improvements were found in rigidity, fine motor skills, energy levels, and depression. Interestingly, 60% of the participants decided to purchase a Wii of their own following the study, which Hertz believed to be testimony to the extent individuals enjoyed the program. Secondly, Alvarez and Rodriguez (2009) employed a case study design to examine the effectiveness of a 6-week Wii exercise program designed to improve the balance of a 68 year old male with an 8 year history of PD. Although preliminary, results illustrated a decrease in disease severity and suggested that the Wii program could provide a safe, effective and enjoyable method to reduce physical inactivity. Finally, and most directly related to this current study, Esculier, Vaudrin, Beriault, Gagnon, and Tremblay (2012) conducted a 6-week home-based Wii balance training program using the Wii Fit and Balance Board. Participants included ten individuals with moderate PD and eight healthy controls. The training program entailed 40 minutes of structured Wii based activity 3 days per week. Overall results were positive as significant improvements were noted on most functional outcome measures among both groups.

Present Research

Overall, although these research findings have contributed to our understanding of the effects of implementing the Nintendo Wii as a clinical rehabilitation tool, evidence supporting the utility of the Wii for improving symptoms in PD remains limited. The purpose of this study, therefore, is to evaluate the effects of a 12-week home-based exercise program designed around the Nintendo Wii system, on improving balance, balance confidence, and exercise adherence, in a clinical population of individuals with PD.

CHAPTER 2: METHODS

Recruitment Strategy and Study Sample

A total of fifteen individuals diagnosed with idiopathic PD were recruited to participate in this study. The diagnosis of idiopathic PD was confirmed by a neurologist (MEJ, study co-supervisor) specializing in movement disorders, based on established diagnostic criteria (Hughes, Daniel, Kilford, & Lees, 1992). Participants were purposively recruited from a neurological practice in Southwestern Ontario. In order to participate in this study, participants needed to be cleared by their physician as being safe to partake in an exercise regimen of this nature. Specifically, participants were asked to participate only if they had a diagnosis of mild to moderate PD, were experiencing only mild impairments in balance, were cognitively intact functionally, and resided within close proximity (<100km) from the testing location.

Severity of PD was assessed using the motor subscale of the Unified Parkinson Disease Rating Scale (UPDRS) (Fahn S and Elton R, 1987) and the Modified Hoehn and Yahr Staging Scale (H&Y) (Hoehn M and Yahr M, 1967). The UPDRS is a standard clinical evaluation tool that rates rigidity, bradykinesia, tremor and mobility – scores range from 0 to 56, with 56 indicating severe symptoms. The H&Y is a functional scale that classifies PD on a scale from 1 to 5, where 1 is unilateral involvement, 3 is bilateral involvement with mild balance impairment, and stage 5 is bedridden. Participants were tested during their self-determined peak or “ON” phase of their medication cycle. To help ensure that all clinical participants were within their “ON” phase, testing was conducted approximately two hours after individuals took their usual medications, per the recommendations of Gauntlett-Gilbert and Brown (1998). Participants were excluded from the study if they reported experiencing major back or lower limb pathology that may influence standing balance or if they obtained a score higher than a stage 3 on the Modified Hoehn & Yahr scale, as these individuals have (by definition) difficulty standing without assistance, and were considered to present an unacceptable risk of falling. Participants' demographics are presented in Table 1. The research protocol, recruitment method, and mechanism for obtaining informed consent were approved by the Health Sciences Research Ethics Board, at the University of Western Ontario (Appendix A). All participants provided free and informed written consent.

Table 1.

Participant Demographics

Participant	Sex	Age	Duration of Illness (years)	Medication	UPDRS III	Hoehn & Yahr
1	M	68	3	Levodopa 300 mg, Mirapex 0.375mg	34	2.0
2	F	73	6	Levodopa 200mg	12	2.0
3	F	68	7	Levocarb 300mg, Mirapex 1.5mg	25	2.0
4	M	60	5	Levodopa 30mg, Mirapex 2.25mg	24	2.0
5	M	66	6	Levodopa 600mg	49	2.0
6	F	71	12	Levodopa 300mg	9	2.0
7	M	75	9	Levodopa 700mg	29	3.0
8	F	63	16	Levodopa 150mg, Mirapex 2.25mg	10	2.5
9	M	58	6	None	26	2.0
10	M	58	13	Levodopa 500mg	21	2.5
11	M	73	10	Levodopa 700mg, Mirapex 4.5mg, Amantadine 300mg	38	3.0

Testing Procedure

All testing took place in the Interdisciplinary Movement Disorders Laboratory, located in Elborn College at the University of Western Ontario. Participants were assessed at three different time points throughout the course of the study: 1) baseline (within 1 week prior to starting the exercise program); 2) mid-intervention (6 weeks into the exercise program); and 3) post-intervention (within 1 week after completing the exercise program). The testing protocol as outlined below was identical at all three time periods.

Testing Sessions

Prior to the baseline testing session participants were invited to read the letter of information describing the protocol for the study (Appendix B) and to sign a consent form (Appendix C) indicating that they were willing to participate. Participants were encouraged to ask any questions and were also made aware of their right to withdraw from the study at any time without any consequences. To ensure that individuals who volunteered were safe to participate in an exercise program of this type, each volunteer was assessed by a neurologist (MEJ) specializing in movement disorders. Consenting participants were rated on the Unified Parkinson's Disease Rating Scale (UPDRS Subsection III) and the Modified Hoehn and Yahr.

Unified Parkinson's Disease Rating Scale Subsection III – Motor Examination *UPDRS-III) (Appendix D). Subsection III of the UPDRS was developed to incorporate elements from existing scales to provide a comprehensive but efficient and flexible means to follow the longitudinal course of motor symptoms of PD. Usually evaluated in the form of an assessment with a physician, the scale consists of 14 items that are rated on a 5-point scale ranging from 0 to 4 (Movement Disorder Society, 2003). Individual item ratings are summed to a total possible score of 56, with larger values corresponding to greater impairment.

Modified Hoehn and Yahr (Appendix E). The modified Hoehn and Yahr stages PD on a scale from 1 to 5, ranging from unilateral involvement (Stage 1), to bilateral involvement with postural instability but no gait aids required (Stage 3), and finally to bedridden (Stage 5). Participants were included with Stages 1-3.

Following these assessments, individuals cleared to participate completed the testing protocol as outlined below:

Force Plate Measurement of Postural Stability (Centre of Pressure Length). Postural stability of each participant was quantitatively assessed using a model OR6-5 biomechanics force platform (AMTI Model OR6-5, Watertown, MA, U.S.A.), mounted flush with a wooden walkway. This device measures ground reaction forces, moments, and the centre of pressure under the feet. The force platform consists of an aluminum plate with embedded electronic force sensors. The output from the force sensors and the force platform amplifier provides force measurements in the three principal axes, and torque measurements about these axes.

Postural stability was assessed under the following four standing balance tasks: 1) eyes open feet apart; 2) eyes open feet together; 3) eyes closed feet apart; and 4) eyes closed feet together. These tasks were selected based on their varying difficulty and common use in previous literature (Bauer, Groger, Rupprecht, & Gassmann, 2008). For each task, participants completed three 30-second trials, for a total of 12 trials (4 tasks x 3 trials). Immediately prior to each trial participants were instructed to keep their hands at their side, and to remain as still as possible for the duration of the trial. Participants received 30 seconds of rest between successive trials within each task, and a minimum of 60 seconds of rest between tasks. The testing order of tasks was randomly assigned for each participant.

The balance outcome measure used in this study was the total length of centre of pressure path (COPL) as it has been shown to be a valid and reliable measure of postural stability (Salavati et al., 2009). The COPL was calculated from data acquired using the force plate via the BioAnalysis software package [version 2.2] produced by the platform manufacturer. To minimize the potential for outlying data to influence the results, trials were averaged within each task such that a single COPL value was obtained for each task. For the purpose of this study, improvement in balance will be defined as a decrease in the total length of the centre of pressure pathway. It is believed that a decrease in this measure is suggestive of greater postural stability, as it corresponds to a decrease in magnitude of overall body sway. In addition to quantifying improvements in stability (i.e., reduced COPL), the exercise program was evaluated on its efficacy in improving balance confidence, and maintaining participant adherence.

For trials involving a normal stance (feet apart), participants were instructed to self-select an initial foot position that was comfortable with their feet approximately shoulder-width apart. For trials involving a narrow stance (feet together), participants were instructed to stand with their feet together and heels aligned.

In addition to the aforementioned biomechanical assessment, participants were asked to complete the short version of the Activities-Specific Balance Confidence Scale (ABC).

Activities-Specific Balance Confidence Scale (ABC) (Appendix F). Balance confidence was measured using the short version of the Activities-Specific Balance Confidence Scale (ABC) (Powell & Myers, 1995). Participants were given a list of 6 balance-challenging tasks (e.g., standing on tip toes reaching for something above your head), and asked to rate their confidence level when performing each activity. The scale ranges from 0% to 100%, whereby 100% represents full confidence (i.e., no fear of falling). This measure has been found to be a valid and reliable measure of balance and has demonstrated stronger relationships to falls than the full version of the measure (Schepens, Goldberg, & Wallace, 2010).

Intervention: Wii Exercise Program Training

Once all assessments were completed, participants were given a brief orientation to the Wii console and balance board, and scheduled an appointment within the following week to have the Wii system installed in their homes and to review the exercise program. Overall each testing session took approximately 1 hour to complete, and involved no risks or discomforts beyond those normally experienced when standing still for periods of 2 or 3 minutes.

To ensure that all consoles were properly set-up, and placed in a safe location within the home, each participant received a home visit by an occupational therapist, the co-supervisor (JDH). During the visit, the Wii system was installed, and participants received instruction, and were provided with hands on demonstrations of the safe performance of each activity, including how they could be graded for difficulty to meet individual needs (i.e., performing balance activities while holding onto the back of a chair). To ensure that each participant could operate the Wii system independently, participants were asked to demonstrate how to turn on the system and access one of the activities included in the exercise program.

Participants were instructed that they were to engage in 30 minutes of Wii based activity three times per week, for a total of 90 minutes of activity per week for 12 consecutive weeks. All activities included in the exercise program utilized the Balance Board accessory, and were from the video game Wii Fit Plus, which focuses on physical fitness. Although this game includes several activities in each of 4 fitness areas: (yoga, strength training, aerobics, and balance) the exercise program included only activities from the balance domain. To help sustain user interest, participants were free to select which balance activities they engaged in each session. Participants were, however, encouraged to select a variety of games (and just not their favorite) to ensure they practiced weight shifting in each direction. In addition, participants were discouraged from trying the Ski Jump game, as this activity requires the user to adopt positions and movements that may place them at an increased risk for a fall. A brief description of each balance activity is presented in Table 2.

Prior to completing the home visit, participants were provided with written step-by-step instructions to refer to if needed, and were provided with a telephone number to call for ongoing support throughout the duration of the study. In addition, participants received a weekly telephone call by a member of the research team throughout the duration of the exercise intervention as to ensure participants were not experiencing technical difficulties and/or ill health concerns.

Table 2.

Description of Balance Games

Game	Description
Balance Bubble	Participant directs a bubble by shifting their weight right or left down a winding river while trying to avoid the edges of the river. Shifting weight forward increases speed. Game ends when bubble reaches the end of the river, or when the bubble "pops" if it comes into contact with the side of the river.
Table Tilt	Participant shifts their weight right, left, forward and/or backward to tilt a table surface to direct a series of rolling balls into holes in the table. Difficulty level increases when each series of balls are successfully navigated into the holes. Game ends when time runs out.
Soccer Heading	Participant shifts weight right or left to head a series of soccer balls that are kicked at them while trying to avoid distracter objects (ie. soccer cleats, panda heads). Game ends when time runs out.
Tightrope Tension	Participant walks in place while attempting to cross a tightrope. Participant must bend and extend knees to jump over obstacles. Game ends when participant falls off tightrope, reaches other side, or when time runs out.
Penguin Slide	Participant shifts their weight right or left to tilt an iceberg and slide a penguin back and forth to catch fish. Faster weight shift makes the iceberg toss the penguin up to catch fish worth more points. Game ends when time runs out.
Ski Slalom	Participant shifts their weight right and left to navigate through a series of gates on a slalom ski course. Game ends when the end of the course is reached.
Snowboard Slalom	Participant stands on the balance board sideways and shifts their weight forwards and backwards to navigate through a series of gates on a slalom snowboard course. Shifting weight to the right increases speed. Game ends when the end of the course is reached.

CHAPTER 3: RESULTS

It is important to note that although fifteen participants were originally enrolled in this study, data analysis was only conducted on a total sample of eleven participants. Within the initial phase (first 6 weeks), 2 participants withdrew from the study secondary to medical conditions unrelated to participation in the exercise program, and one participant withdrew because her dyskinesias limited her ability to maintain a safe stance on the balance board. In addition, one participant was found to exhibit mean COP path length values greater than 3 standard deviations away from the group mean for each of the balance tasks and therefore her data was thought to be questionable thus she was considered an outlier and removed from all subsequent analyses.

Balance Centre of Pressure Length (COPL)

To evaluate the effect of the Wii exercise program on balance, a two-way within subject analysis of variance was conducted. The dependent variable was the length of the centre of pressure pathway. The within subject factors were condition with 4 levels (eyes open feet apart; eyes open feet together; eyes closed feet apart; eyes closed feet together), and time with 3 levels (baseline (0 weeks); mid-intervention (6 weeks); and post-intervention (12 weeks)). The time x condition interaction effect and the main effect of time were tested using Wilk's Lambda. The main effect of condition was not assessed as this comparison was not the intent of this study.

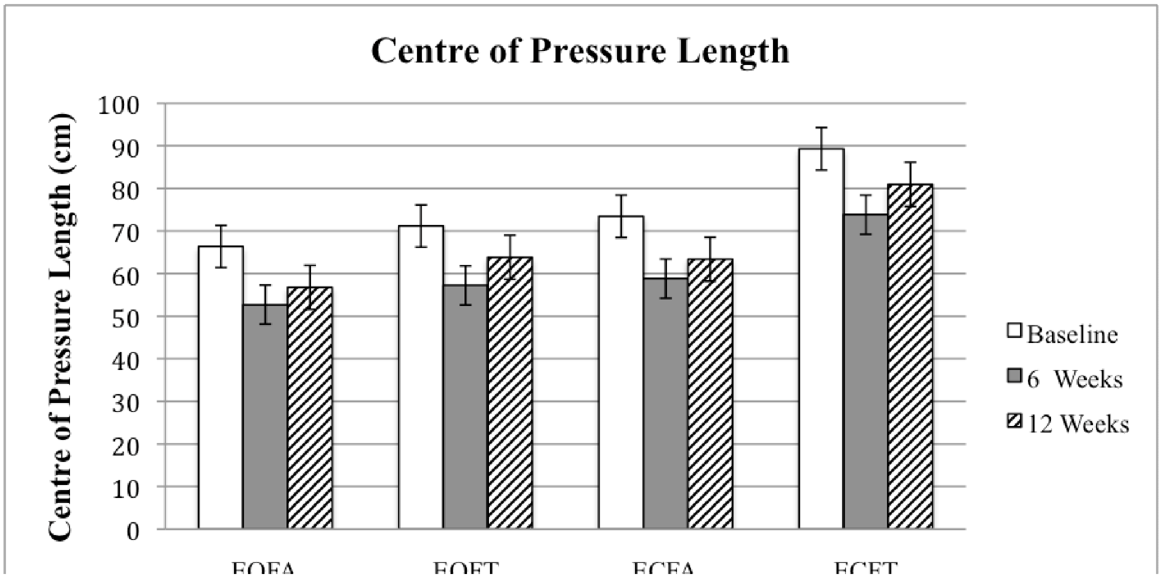
The means and standard deviations for COPL for each condition separated by time are presented in Table 3. The time x condition interaction effect was non-significant, Wilks' λ = 0.692, $F(6,5) = 0.370$, $p = 0.87$, as was the main effect of time, Wilks' λ = 0.771, $F(2, 9) = 1.333$, p = 0. 311, thus indicating that the exercise program did not lead to statistically significant balance improvements. Although non-significant, the results demonstrated a clear pattern of balance improvement for each of the 4 conditions (Figure 1).

Table 3.

Means and (standard deviation) of center-of-pressure length in centimeters for each condition at baseline, mid-intervention (6 weeks) and post intervention (12 weeks)

	EOFA	EOFT	ECFA	ECFT
Baseline	66.35 (56.52)	71.14(42.36)	73.43(60.83)	89.28(49.64)
Mid-intervention	52.69(20.75)	57.23(21.71)	58.80(25.24)	73.81(33.88)
Post-intervention	56.76 (37.07)	63.80 (31.45)	63.35(36.25)	80.92(43.93)

EOFA= eyes open feet apart, EOFT= eyes open feet together, ECFA= eyes closed feet apart, ECFT= eyes closed feet together


Centre of Pressure Length
Centre of Pressure Length (cm)
100
90
80
70
60
50
40
30
20
10
0
Baseline
6 Weeks
12 Weeks

participant levels of balance confidence. However, as was also demonstrated for COPL, a pattern emerged whereby balance confidence was noted to improve from baseline (*M*= 66.73, *SD*= 20.68) to mid-intervention (*M*= 71.09, *SD*= 18.95), and then fall back to near baseline values post-intervention (*M*= 67.52, *SD*=22.52).

Adherence to Exercise Program

To determine if participants adhered to the exercise program equally throughout the duration of the study, a within subject multivariate analysis of variance was conducted. The within subject factor was time period with 2 levels (baseline to mid-intervention, and mid-intervention to post-intervention), and the dependent variables were, number of exercise sessions participants engaged in, the mean amount of time spent actively participating in the exercise activities each session, and the total amount of time engaged in actively exercising. The multivariate effect of time period was tested using Wilk's lambda and was found to be non-significant, Wilks's □ =0.68 , $F(3,8)$ =1.24 , p=0.358, thus indicating that participants adhered to the exercise program equally throughout the duration of the study. Means and standard deviations, along with individual participant data for each of the dependent variables are presented in Table 4.

Table 4.

Record of program adherence for individual participants and sample mean for Baseline to Mid-intervention and Mid-intervention to Post-intervention timeframes.

	Baseline to Mid-intervention			Mid-interventions to Post-intervention		
Participant	Active Play Time (min)	# of Sessions	Mean Active Time per Session (min)	Active Play Time (min)	# of Sessions	Mean Active Time per Session (min)
1	995	34	29.26	851	26	32.73
2	1136	36	31.55	584	19	30.07
3	429	17	25.24	785	27	29.07
4	582	27	21.56	378	17	22.24
5	506	18	28.11	361	16	22.56
6	375	22	17.05	406	27	15.04
7	315	18	17.50	225	14	16.07
8	271	18	15.06	174	12	14.5
9	418	20	20.09	313	15	20.87
10	189	15	12.60	438	17	25.76
11	709	24	29.54	568	18	31.56
Mean (SD)	538.64 (299.05)	22.64 (7.00)	22.50 (6.56)	462.09 (215.42)	18.91 (5.34)	23.68 (6.68)

CHAPTER 4: DISCUSSION

The purpose of this study was to evaluate the effects of a using the Nintendo Wii video game system and balance board as part of a 12 week home-based exercise program designed to improve balance in a clinical population of individuals with PD. Consistent with previous reports the results suggest an exercise regime using the Wii system appears to be a viable option for improving balance within this population (Alvarez & Rodriguez, 2009; Esculier et al., 2012; Hertz, 2009). Furthermore, the present results suggest that although useful as an adjunctive therapy, the delivery of home-based Wii therapy should be monitored by trained professionals as periodic adjustments in exercise programming may be warranted.

Improvement Trends in Balance and Confidence

Although there was found to be no statistically significant improvement in either the biomechanical measure of balance (COPL) or the balance confidence scale (ABC), a clear pattern for both balance and confidence to improve emerged over time. This finding is consistent with previous research that failed to find significant levels of improvement, but rather reported trends. For example, Bainbridge et al. (2011) conducted a 6-week program that consisted of 30 minutes of Wii based activity twice per week, within a cohort of community dwelling older adults with balance deficits. Although no statistically significant changes were found for any of the outcome measures, a trend for balance to improve was noted for 4 out of the 6 participants.

These findings also confirm and extend previous research whereby significant improvements were identified. For example, Nitz, Kuys, Isles and Fu (2010) demonstrated statistically significant improvements in balance following a training program that provided 30 minutes of Wii Fit training twice per week for a ten-week period. Significant improvements in balance were also reported in a 4-week pilot study conducted by Williams et al. (2011), whereby community living older adults completed twelve 20 minute sessions using various Wii programs. Of particular relevance to the current study, significant findings have also been reported within two of the studies that have evaluated using the Wii to improve balance among individuals with PD. Hertz (2009) identified significant improvements in rigidity, fine motor skills, energy levels and depression following an 8-week exercise program involving one hour of playing the Wii three times per week. Similarly, significant improvements in balance were realized by Esculier et al. (2012) following the completion of a 6-week home based exercise training protocol that involved individuals with PD completing specific Wii activities 40 minutes a day, 3 days per week.

Rationale for Non-Significant Findings

In contrast to the studies mentioned above, there are a number of potential reasons why statistically significant differences were not found within the current study. Firstly, the sample consisted of a small number of participants (N=11), which affords limited statistical power. In comparison, several of the studies that reported significant findings involved samples that were twice as large (Hertz, 2009; Williams et al., 2011). In addition, participants included in this study were in the early stages of the disease process (i.e., stage 3 or lower on the Hoehn and Yahr scale), which by definition suggests that their balance remains relatively intact – a methodological consideration that similarly reduces the statistical power of the analyses conducted herein.

Secondly, it is likely that differences in the potency of the interventions used across studies is a key contributing factor for the differential findings reported. In the current study, participants were asked to engage in 30 minutes of Wii based activity three times per week for a total of 90 minutes of activity per week. In comparison, the studies conducted by Esculier et al. (2012) and Hertz (2009), entailed participants completing three 40-minute sessions, and three 60-minute sessions per week for a total of 120 minutes, and 180 minutes of activity per week respectively. Moreover, participants in the current study were limited to engage in activities that utilized the Wii Balance Board and were part of the balance domain of the game Wii Fit Plus. In comparison, Hertz (2009) asked participants to engage in a variety of activities such as boxing and tennis that were from the Wii Sports game, which does not involve the Balance Board accessory. Similarly, Esculier et al. (2012) also asked participants to engage in activities from the Wii Sports game that do not involve the Balance Board, however, unlike the training program utilized by Hertz (2009), participants in Esculiers' study were only permitted to play 10 minutes of either golf or bowling, and only after having completed 30 minutes of various Wii Fit Plus activities using the Balance Board. It is possible that the differences in game selections could have contributed to the differential findings as the games target different aspects of balance. For example, the activities associated with the Wii Fit Plus game (i.e., table tilt, ski slalom, balance bubble, and penguin slide) require the user to make slow controlled movements in a closed environment that are centered around learning how to shift their weight forwards-backwards, and side-to-side, thus working to improve static balance. In contrast, without the confines of standing on the Balance Board, the Wii Sports games tend to focus on rapid powerful movements that occur in an open environment, thus targeting dynamic balance. Moreover, although participants in the current study were encouraged not to participate in the ski jump activity due to safety concerns, the training program delivered by Esculier et al. (2012) included this activity. This difference in programming is particularly interesting given that Esculier et al. (2012) attributed significant improvements in overall functional strength of the lower limbs to engagement in this particular activity. Coupled with the fact that evidence in the literature suggests lower body muscle strength has a strong relationship with balance in PD (Toole, Hirsch, Forkink, Lehman, & Maitland, 2000), it is possible that significant improvements in balance reported by Esculier et al. (2012) and not in the current study were in part because Esculier et al., included the ski jump activity, whereas this study did not.

Finally, intervention studies in PD present many challenges. The degenerative nature of PD means that improvement within the outcome measures of any long term program may need to be redefined to take into account the progressive course of this disease (Jankovic, 2008). In addition, the individual progression of PD varies from person to person thus it is difficult to quantify improvement and establish a standard baseline across all participants (Jankovic et al., 1990). A lack of measurable improvement on the outcome measure could be considered a positive effect, potentially attributed to the program, as long as the participants' balance does not deteriorate beyond that which it was at baseline. Within this study an overall trend for balance to improve was identified; given the degenerative nature of PD this trend may in fact be representative of a significant effect of the training program to slow the progression of the disease. Evidence to support this assertion stems from the finding that no significant differences were identified between sessions for either the UPRDS (baseline M=25.18,SD=12.29; mid-intervention M=25.27,SD=9.98; post-intervention M=25.36,SD=9.36) or the H&Y scale (baseline M=2.27,SD=0.41; mid-intervention M=2.18,SD=0.34; post-intervention M=2.27,SD=0.41). However caution should be taken when interpreting this finding, as PD is a naturally slowly progressive disease. Although the non significant changes in the aforementioned outcome measures may indicate the Wii exercise program helped to slow the progeession of the disease, it could also just be representative of the natural course of disease progression.

Plateau Effect

Despite the fact that improvements in balance within the present study failed to reach statistical significance, an interesting trend emerged which suggested that gains in balance that were found to occur from baseline to mid-intervention, plateaued/fell back towards baseline values at post-intervention. This fallback phenomenon is consistent with the principle of detraining, whereby the partial or complete loss of training-induced adaptations occurs in response to an insufficient training stimulus (Mujika & Padilla, 2000).

Interestingly this trend emerged from both the objective biomechanical data and the self-report balance confidence measure. Given that research suggests that approximately 20-50% of adults who begin an exercise program withdraw within the initial six months (Dishman, 1988), one possible explanation for this finding might be that participants started to lose interest in the program, and therefore began to limit the amount of time they spent engaged in training. Although possible, this is unlikely as the current exercise program occurred over a relatively short time period (3 months), and no significant differences in program adherence were found between baseline to mid-intervention and mid-intervention to post-intervention time periods, a finding that will be discussed later.

A second possible explanation for why balance improvements were found to plateau following mid-intervention may be related to the body's ability to adapt to the demands being placed on it. It is widely accepted that the greatest neuromuscular adaptations occur within the first 6 weeks of a training program (Sale, 1986, 1987). This effect of early training results is highlighted in the study by Bateni (inpress) whereby the greatest improvements were identified within the first 6 training sessions. If however, at 6 weeks the program is not altered in a way that places additional demands on the body, continued gains are unlikely and a plateau effect may result (Sale, 1986, 1987). When the training stimulus is insufficient, detraining may occur resulting in a loss of training-induced adaptations (Mujika & Padilla, 2000). This was reflected in the consistent decrease to near baseline levels in the balance and balance confidence outcome measures. In this current study, the exercise regime remained consistent over the course of the 12-week intervention, thus it is possible that participants adapted to the demands of the balance activities which may have subsequently resulted in their performance leveling off. Evidence to support that changes in the exercise regime may have been warranted following 6 weeks of training is provided by Gusi et al. whereby a 12-week long intervention program that involved changes every two weeks, led to significant improvements and no apparent plateau effect. Although programming changes to the exercise routine were not made in the current study, it should be noted that the Wii Fit Plus software used has an option that allows users to select the level of physical and cognitive exertion required (Clarke & Kraemer, 2009), thus ensuring they are presented with "just the right challenge" (Hertz, 2009). Although each participant within this study was educated about this feature in his or her orientation session, it is unknown whether it was appropriately utilized.

Balance Improvements

Irrespective of whether participants experienced a plateauing effect, the results of this study clearly demonstrate a pattern for balance to improve over the course of the 12-week intervention. Several explanations may account for this improvement. One possibility is that training with the Wii and Balance Board forced participants to focus conscious attention on their balance. For example, one participant noted that participating in the Wii activities helps to “connect his feet to his head” whereas another participant reported that “it wakes up his body so that he can start his day”. The ability to be able to focus attention on maintaining balance is particularly important for individuals with PD as it has been well established in the literature that when individuals with PD shift their focus away from balance (i.e., during the performance of an attention demanding secondary task) their postural stability deteriorates which in turn may place them at an increased risk for a fall (Holmes, Jenkins, Johnson, Adams, & Spaulding, 2010).

A second possible explanation may be that increased levels of dopamine could have brought about improvements in balance. Although we do not have the capacity in which to test this hypothesis, it is nonetheless feasible as exercise has been reported to stimulate dopamine synthesis in the remaining dopaminergic cells, thus reducing symptoms (Fox et al., 2006). Similarly, de la Fuente-Fernandez, Phillips, et al. (2002) and de la Fuente-Fernandez, Schulzer, and Stossl (2004) suggest that when individuals engage in activities that are motivating and provide a challenge, an expectation for clinical benefits may result, which in turn may cause a placebo effect that stimulates dopamine production. Given that feedback received from participants indicated that they “liked the increasing challenge provided by the balance games” and that they felt “motivated to exceed their previous score”, it is possible that certain challenging games may have also led to additional dopamine synthesis above that which can be attributed to exercise alone.

A third possibility is that balance improvements may have emerged as an indirect result of the impact that the exercise program had on participants’ psychological well-being. One participant stated that engaging in the Wii Fit program on a daily basis has helped to reduce levels of stress as she stated, “It distracts me and takes my mind off of other things in my life.” Given that current research suggests that elevated levels of anxiety have a negative impact on balance (Stins, Ledebt, Emck, van Dokkum, & Beek, 2009), it is possible that interventions that reduce anxiety may also help to improve balance. Therefore, the trend for balance to improve in the current study could in part be associated with the anecdotal evidence suggesting that the Wii program helped to reduce levels of stress/anxiety.

Exercise Adherence

In addition to identifying that the Wii training program lead participants to experience improvements in both balance and confidence, an important finding of this study is that the program was able to sustain user interest. As previously mentioned, no significant differences in exercise adherence were noted between baseline to mid-intervention and mid-intervention to post-intervention time periods. This finding was demonstrated as the majority of participants completed the requisite number of training sessions (thirty-six) over the course of the study (3/week x 12 weeks). Motivation and enjoyability are two key factors that help foster adherence in an exercise program. In addition, evidence suggests that in order to maintain continued adherence, programs should focus on integrating training into the participants everyday life in such a way that they merge together to generate a new lifestyle. For example, Sze et al. reported that a community step-down program that followed a multidisciplinary falls prevention clinic was crucial in maintaining the intervention effects within a sample of community dwelling elders who were at a high risk for a fall (2008). Specifically, Sze et al., (2008) noted that regular reinforcement and education in the step-down program played a pivotal role in maintaining compliance (Sze et al., 2008). In the current study, participants received a weekly telephone call from a member of the research team throughout the duration of the exercise intervention.

Designed originally as a means to ensure that participants were not experiencing technical difficulties and/or ill health concerns, it is possible that the weekly phone calls may have also helped participants to remain engaged in the training program over the course of the 12-week intervention.

Interestingly, although there were no apparent significant differences in adherence, the average number of sessions that participants engaged in from mid-intervention to post-intervention (18.91) was slightly less then the average number of sessions they completed during the first 6 weeks of the program (22.64). Not surprisingly, this decrease in the number of sessions completed was reflected in the total amount of time in minutes spent actively participating in the training program from the first half of the study (538.64 min) compared to the second half (462.09 min). Although this could suggest that participants may have started to lose interest in the program, this is unlikely as participants were found to spend slightly more time in minutes per session in the second half of the study (23.68 min) as compared to the first half (22.50 min). In addition, upon completing the exercise program, 82% of participants expressed a desire to purchase the Nintendo Wii Fit program and Balance Board in order to continue a similar exercise routine independently – a finding you would not expect had interest been lost. Moreover, several participants also commented that they “thoroughly enjoyed using the system” and that although they did not notice a substantial improvement in their balance, they did, however, find enjoyment while participating in the Wii Fit program and that “it was not a chore.” These findings are consistent with research by Meldrum et al. (2012) who assessed the useability of the Nintendo Wii Fit balance games for individuals with balance impairments and reported high levels of usability and enjoyment with no serious adverse effects with 73% of participants reporting higher levels of enjoyment and motivation than with traditional physiotherapy.

One possible explanation that may account for the differences in the amount of time participants spent engaged in training between the first and second half of the program could be related to the time of year in which the study was conducted. For example, the majority of participants were enrolled in the study and completed the exercise training during the summer months of June, July, and August. This time of year tends to be particularly busy as many social gatherings such as family reunions, weddings, and vacations, which might involve travel out of town, are scheduled during this period. As a result, participants may have found it difficult at times to complete the requisite three training sessions per week. Anecdotal feedback received supports this possibility as one participant suggested "It may have been more beneficial to have done the exercise program in the winter." However, it should be noted that although the Wii program may be better suited to be delivered in the winter months when participants are more likely to be at home and have additional free time to participate, this study was conduced in the summer as to avoid concerns with participants traveling for purposes of testing when the weather is inclement.

Finally, it is interesting to note that the percentage of participants who identified that they would be interested in continuing to use the Wii system following the current study (82%) was substantially greater, than the percentage of participants who identified that they purchased the Wii system (60%) after completing the 8-week training program delivered by Hertz (2009). One explanation that may account for this disparity is that although 82% of individuals in the current study indicated that they would be interested in purchasing the Wii, it is reasonable to expect that not everyone will follow through in doing so; thus the proportion of participants who may actually purchase the Wii for their personal use may in fact end up being similar to the 60% reported by Hertz (2009). A second possibility may be due to the fact that the training program delivered by Hertz (2009) used the Wii Sports software as opposed to the training program delivered in the current study that used the Wii Fit Plus software. It is possible that participants may have enjoyed the activities that were available via the Wii Fit Plus game more then the activities available via Wii Sports, as they focus more on static balance, and utilize the Balance Board accessory, whereas the activities included in Wii Sports focus more on dynamic balance, and do not incorporate the Balance Board. A third and final explanation that may account for the aforementioned differences may be related to the fact that the current study was delivered as a home-based intervention, whereas the program delivered by Hertz (2009) was carried out as a centre based intervention. This difference may have resulted in participants in the current study experiencing greater satisfaction with the Wii program as they were able to complete the training at their leisure and within the comfort of their own homes; whereas participants who completed the program delivered by Hertz (2009) were required to schedule weekly appointments and travel to a central location.

Limitations and Future Directions

Although the results of this study are promising, there are a few limitations that warrant attention when interpreting the findings. First, as previously indicated, this study was relatively small in scale (N=11), thus it is unknown whether the lack of statistical findings are a result of limited statistical power related to a small sample size, related to the potency of the intervention, or a combination of both. It should be noted however, that although the data were statistically analyzed using only 11 cases, 15 participants were originally enrolled in the study. Two participants voluntarily withdrew from the study secondary to medical conditions unrelated to participation in the exercise program, one participant withdrew because her dyskinesia's limited her ability to maintain a safe stance on the balance board, and one participant was considered to be an outlier secondary to her data exceeding 3 standard deviations away from the group mean for each of the balance tasks, thus her data were not included in the analyses. Future research should be conducted using a larger sample size to ensure that the magnitude of balance improvement is related to the true effect of the intervention program, and not as a function of the size of the sample.

Another limitation of this study is that adjustments to the exercise program were not made at the mid-intervention time point, a decision that may have resulted in balance improvements plateauing from mid-intervention to post-intervention. The decision not to make programmatic adjustments was partially made because the intervention was a home-based program wherein participants completed the activities independently. As a result, there would be no way to determine the magnitude of required adjustments, nor would there be a way to safely monitor how participants' tolerated the adjustments, especially given that this is the first study to examine the utility of the Wii in PD over a 12-week period. Given that the current findings indicate that the program was in fact well tolerated for the full 12 weeks, future research should determine safe and effective limits for adjusting program difficulty. Specifically, future studies should consider adopting a mixed methodology approach as this would afford participants the opportunity to provide rich in depth qualitative feedback on their experiences of using the Wii in a rehabilitation context. In doing so participants could provide important information related how the program impacted their functional abilities and overall health related quality of life. Moreover, the mixed methodology approach would also provide the opportunity for participants to complete a written exercise log after each training session. The activity logs could serve to provide researchers with important details regarding the level of effort and difficulty participants experienced which would help to provide insight into how to safely and effectively alter the training program. Similarly, future studies should examine different ways in which the training program could be strategically altered as to prevent participants from becoming accustomed to the exercises, subsequently triggering a plateau in improvement. Two possibilities may be for future research to explore other domains available on the Wii Fit game such as aerobics, yoga, and strength training, and to expand the home-training program to incorporate other Wii games that specifically focus on balance and or strength training.

Finally, this study used a purposive sampling recruitment methodology, wherein individuals asked to participate were selected based upon fitting certain criteria that would make them good candidates for the intervention. For example, individuals asked to participate all had a diagnosis of mild to moderate PD, were experiencing only mild impairments in balance, cognitively were functionally intact, and resided within close proximity (<100km) from the testing location. Moreover, all of the individuals were tested within a timeframe of the day when they were in their "on" state of the medication cycle. Although both of these methodological considerations were made to ensure the safety of participants, the generalizability of the findings is nonetheless limited. Future research is therefore warranted to determine if these results can be further generalized to individuals with more advanced PD. Moreover, given that motor fluctuations are a global limitation within this population, similar protocols should also be examined wherein balance testing occurs over multiple sessions throughout the course of the medication cycle, such that a better understanding of how participants respond to the training program both "on" and "off" their medication cycle can be obtained.

CHAPTER 5: CONCLUSION

Parkinson's disease is a progressive neurological disorder that results in both motor and non-motor symptoms Jankovic, (2008). Although characterized predominantly by the classic motor symptoms of postural instability, bradykinesia, rigidity and resting tremor, close to 90% of individuals with PD also experience at least one non-motor symptom, and that about 10% exhibit five non-motor symptoms (Shulman et al., 2001). These symptoms include fatigue, sleep disturbance, constipation, bladder and gastrointestinal disturbance, and sensory complaints such as pain, numbness, tingling, and burning in the limbs (Fahn, 2003). It is estimated that approximately 100,000 Canadians are currently living with the disease with that number expected to double by 2016 (Parkinson Society Canada, 2004). PD is a leading cause of falls in the elderly with studies suggesting that up to 70% of individuals with PD report experiencing a fall over one year (Ashburn, Stack, Pickering, & Ward, 2001; Balash et al., 2005; Bloem et al., 2001; Gray & Hildebrand, 2000). Failure to prevent falls in PD is believed to be in part due to the inability of pharmacotherapy to diminish postural instability (Koller et al., 1989). Although pharmacotherapy has been found to be essentially ineffective in treating postural instability, non-pharmacological therapies, such as exercise programming, have been found to lead to significant balance improvements (Goodwin et al., 2008).

Structured exercise protocols delivered by physical and occupational therapists typically deliver gait, strength and balance training as a means to help improve balance via an outpatient delivery model. Although generally effective, traditional therapy is relatively expensive, requires transportation to and from a clinic (which is especially troublesome for individuals living in rural areas or regions subject to severe weather), and can result in diminished levels of adherence as individuals are typically required to practice rote monotonous tasks. As an alternative to traditional therapy, the Nintendo Wii gaming system offers a low cost commercially available option that allows individuals to engage in exercise therapy on their own time within the familiar and convenient surroundings of their own home. With several interactive game options available to select from, the literature suggests that the Wii is fun and enjoyable, and may help to foster increased levels of adherence (Williams et al., 2011). Although the Wii has been examined for its efficacy among several diverse rehabilitation contexts, the literature currently contains few reports that examine the use of the Nintendo Wii within a clinical population of individuals with PD.

The results of this study extend the findings of Esculier et al. (2012) to suggest that home based virtual reality training using the Nintendo Wii gaming system has the potential to serve the purpose of improving balance, and balance confidence, while maintaining user interest. Although the Wii training program delivered in this study did not elicit statistically significant improvements in balance, clear trends for balance, and balance confidence to improve were evident. Moreover, anecdotal feedback received from participants was generally positive, and identified that the training program was well received, a finding that was further evidenced, as exercise adherence was found to be successfully maintained throughout program delivery.

In conclusion, although home-based “Wii-habilitation” training shows great promise for being an innovative rehabilitation strategy that affords older adults with PD a flexible and fun means with which to practice improving their balance, future research is needed before this novel technology is implemented on a large scale basis within the mainstream clinical community.

REFERENCES

Alvarez, M., & Rodriguez, M. (2009). How effective is the wii program as physical therapy intervention of patient with Parkinson's disease? *Parkinsonism and Related Disorders, S29*.

Ashburn, A., Stack, E., Pickering, R. M., & Ward, C. D. (2001). A community-dwelling sample of people with Parkinson's disease: characteristics of fallers and non-fallers. *Age and Ageing, 30*(1), 47-52.

Bainbridge, E., Bevans, S., Keeley, B., & Oriel, K. (2011). The effects of the nintendo wii fit on community-dwelling older adults with perceived balance deficits: A pilot study. *Physical & Occupational Therapy in Geriatrics, 29*(2), 126-135.

Balash, Y., Peretz, C., Leibovich, G., Herman, T., Hausdorff, J. M., & Giladi, N. (2005). Falls in outpatients with Parkinson's disease: frequency, impact and identifying factors. *Journal of Neurology, 252*(11), 1310-1315. doi: 10.1007/s00415-005-0855-3

Bateni, H. (inpress). Changes in balance in older adults based on use of physical therapy vs the wii fit gaming system: a preliminary study. *Physiotherapy*.

Bauer, C., Groger, I., Rupprecht, R., & Gassmann, K. G. (2008). Intrasession reliability of force platform parameters in community-dwelling older adults. *Archives of Physical Medicine and Rehabilitation, 89*(10), 1977-1982. doi: S0003-9993(08)00437-1 [pii]10.1016/j.apmr.2008.02.033

Bhidayasiri, R., & Truong, D. D. (2008). Motor complications in Parkinson disease: clinical manifestations and management. *Journal of the Neurological Sciences, 266*(1-2), 204-215. doi: S0022-510X(07)00573-4 [pii]10.1016/ j.jns. 2007.08.028

Bloem, B. R. (1992). Postural instability in Parkinson's disease. *Clinical Neurology and Neurosurgery, 94 Suppl*, S41-45.

Bloem, B. R., Grimbergen, Y. A., Cramer, M., Willemsen, M., & Zwinderman, A. H. (2001). Prospective assessment of falls in Parkinson's disease. *Journal of Neurology, 248*(11), 950-958.

Bloem, B. R., Hausdorff, J. M., Visser, J. E., & Giladi, N. (2004). Falls and freezing of gait in Parkinson's disease: a review of two interconnected, episodic phenomena. *Movement Disorders, 19*(8), 871-884. doi: 10.1002/mds.20115

Bowes, S. G., Clark, P. K., Leeman, A. L., O'Neill, C. J., Weller, C., Nicholson, P. W., … Dobbs, R.J. (1990). Determinants of gait in the elderly parkinsonian on maintenance levodopa/carbidopa therapy. *British Journal of Clinical Pharmacology, 30*(1), 13-24.

Burini, D., Farabollini, B., Iacucci, S., Rimatori, C., Riccardi, G., Capecci, M., … Ceravolo, M.G. (2006). A randomised controlled cross-over trial of aerobic training versus Qigong in advanced Parkinson's disease. *European Journal of Physical and Rehabilitation Medicine, 42*(3), 231-238. doi: R33061642 [pii]

Chaudhuri, K. R., & Odin, P. (2010). The challenge of non-motor symptoms in Parkinson's disease. *Progress in Brain Research, 184*, 325-341. doi: S0079-6123(10)84017-8 [pii]10.1016/S0079-6123(10)84017-8

Chaudhuri, K. R., Prieto-Jurcynska, C., Naidu, Y., Mitra, T., Frades-Payo, B., Tluk, S., … Martinex-Martin, P. (2010). The nondeclaration of nonmotor symptoms of Parkinson's disease to health care professionals: an international study using the nonmotor symptoms questionnaire. *Movement Disorders, 25*(6), 704-709. doi: 10.1002/mds.22868

Chaudhuri, K. R., & Schapira, A. H. (2009). Non-motor symptoms of Parkinson's disease: dopaminergic pathophysiology and treatment. *The Lancet Neurology, 8*(5), 464-474. doi: S1474-4422(09)70068-7 [pii]10.1016/S1474-4422(09)70068-7

Clarke, R., & Kraemer, T. (2009). Clinical use of nintendo wii bowling simulation to decrease fall risk in an elderly resisdent of a nursing home: A case report. *Journal of Geriatric Physical Therapy, 32*, 174-179.

Comella, C. L., Stebbins, G. T., Brown-Toms, N., & Goetz, C. G. (1994). Physical therapy and Parkinson's disease: a controlled clinical trial. *Neurology, 44*(3 Pt 1), 376-378.

Crotty, M., Laver, K., Quinn, S., Ratcliffe, J., George, S., Whitehead, C., … Davies, O. (2011). *Is use of the nintendo wii fit in physiotherapy as effective as conventional physiotherapy training for hospitalised older adults?* Paper presented at the International Conference on Virtual Rhabilitation, Switzerland.

de la Fuente-Fernandez, R., Phillips, A. G., Zamburlini, M., Sossi, V., Calne, D. B., Ruth, T. J., … Stoessl, A.J. (2002). Dopamine release in human ventral striatum and expectation of reward. *Behavioural Brain Research, 136*(2), 359-363. doi: S0166432802001304 [pii] de la Fuente-Fernandez, R., Schulzer, M., & Stoessl, A. J. (2004). Placebo mechanisms and reward circuitry: clues from Parkinson's disease. *Biological Psychiatry, 56*(2), 67-71. doi: 10.1016/j.biopsych.2003.11.019S000632230301240X [pii]

Deutsch, J. E. (2009). Virtual reality and gaming systems to improve walking and mobility for people with musculoskeletal and neuromuscular conditions. *Stud Health Technol Inform, 145*, 84-93.

Deutsch, J. E., Borbely, M., Filler, J., Huhn, K., & Guarrera-Bowlby, P. (2008). Use of a low-cost, commercially available gaming console (Wii) for rehabilitation of an adolescent with cerebral palsy. *Physical Therapy, 88*(10), 1196-1207. doi: ptj.20080062 [pii]10.2522/ptj.20080062

Dishman, R. K. (1988). Exercise adherence research: Future directions. *American Journal of Health Promotion, 3*, 52-56.

Dunning, K., Levine, P., Schmitt, L., Israel, S., & Fulk, G. (2008). An ankle to computer virtual reality system for improving gait and function in a person 9 months poststroke. *Topics in Stroke Rehabilitation, 15*(6), 602-610. doi: 54N111456211823K [pii]10.1310/tsr1506-602

Esculier, J. F., Vaudrin, J., Beriault, P., Gagnon, K., & Tremblay, L. E. (2012). Home-based balance training programme using wii fit with balance board for Parkinson's disease: a pilot study. *Journal of Rehabilitation Medicine, 44*(2), 144-150.

Fahn, S. (2003). Description of Parkinson's disease as a clinical syndrome. *Annals of the NY Academy of Science, 991*, 1-14.

Fahn S, Elton R. Unified Parkinson's disease rating scale. In: Fahn S, Marsden CD, Calne DB, eds. *Recent developments in Parkinson's disease*. London: Macmillan; 1987:153-163.

Fox, C. M., Ramig, L. O., Ciucci, M. R., Sapir, S., McFarland, D. H., & Farley, B. G. (2006). The science and practice of LSVT/LOUD: neural plasticity-principled approach to treating individuals with Parkinson disease and other neurological disorders. *Seminars in Speech and Language, 27*(4), 283-299. doi: 10.1055/s-2006-955118

Gauntlett-Gilbert, J., & Brown, V. J. (1998). Reaction time deficits and Parkinson's disease. *Neuroscience and Biobehavioural Reviews, 22*(6), 865-881. doi: S0149763498000141 [pii]

Goodwin, V. A., Richards, S. H., Taylor, R. S., Taylor, A. H., & Campbell, J. L. (2008). The effectiveness of exercise interventions for people with Parkinson's disease: a systematic review and meta-analysis. *Movement Disorders, 23*(5), 631-640. doi: 10.1002/mds.21922

Gray, P., & Hildebrand, K. (2000). Fall risk factors in Parkinson's disease. *Journal of Neuroscience Nursing, 32*(4), 222-228.

Gusi, N., Carmelo Adsuar, J., Corzo, H., Del Pozo-Cruz, B., Olivares, P. R., & Parraca, J. A. (2012). Balance training reduces fear of falling and improves dynamic balance and isometric strength in institutionalised older people: a randomised trial. *Journal of Physiotherapy, 58*(2), 97-104. doi: S1836-9553(12)70089-9 [pii]10.1016/S1836-9553(12)70089-9

Habermann, B. (1996). Day-to-day demands of Parkinson's disease. *Western Journal of Nursing Research, 18*(4), 397-413.

Habermann, B. (2000). Spousal perspective of Parkinson's disease in middle life. *Journal of Advanced Nursing, 31*(6), 1409-1415. doi: jan1457 [pii]

Hackney, M. E., & Earhart, G. M. (2009). Health-related quality of life and alternative forms of exercise in Parkinson disease. *Parkinsonism Related Disorders, 15*(9), 644-648. doi: S1353-8020(09)00065-0 [pii] 10.1016/j.parkreldis. 2009.03.003

Hely, M. A., Fung, V. S., & Morris, J. G. (2000). Treatment of Parkinson's disease. *Journal of Clinical Neuroscience, 7*(6), 484-494. doi: 10.1054/jocn.2000.0766S0967-5868(00)90766-5 [pii]

Hertz, N. B. (2009). The wii and Occupational therapy. *OT Practice, 14*(7), 19-25.

Hirsch, M. A., Toole, T., Maitland, C. G., & Rider, R. A. (2003). The effects of balance training and high-intensity resistance training on persons with idiopathic Parkinson's disease. *Archives of Physical Medicine and Rehabilitation, 84*(8), 1109-1117. doi: S0003999303000467 [pii]

Hoehn M, Yahr M (1967). "Parkinsonism: onset, progression and mortality." *Neurology* 17 (5): 427–42.

Holden, M. K. (2005). Virtual environments for motor rehabilitation: review. *Cyberpsychology, Behaviour, and Social Networking, 8*(3), 187-211; discussion 212-189. doi: 10.1089/cpb.2005.8.187

Holloway, R. G., Shoulson, I., Fahn, S., Kieburtz, K., Lang, A., Marek, K., … Watts, A. (2004). Pramipexole vs levodopa as initial treatment for Parkinson disease: a 4-year randomized controlled trial. *Archives of Neurology, 61*(7), 1044-1053. doi: 10.1001/archneur.61.7.104461/7/1044 [pii]

Holmes, J. D., Jenkins, M. E., Johnson, A. M., Adams, S. G., & Spaulding, S. J. (2010). Dual-task interference: the effects of verbal cognitive tasks on upright postural stability in Parkinson's disease. *Parkinsons Disease, 2010*, 696492. doi: 10.4061/2010/696492

Hughes, A. J., Daniel, S. E., Kilford, L., & Lees, A. J. (1992). Accuracy of clinical diagnosis of idiopathic Parkinson's disease: a clinico-pathological study of 100 cases. *Journal of Neurology, Neurosurgery and Psychiatry, 55*(3), 181-184.

Jankovic, J. (2008). Parkinson's disease: clinical features and diagnosis. *Journal of Neurology, Neurosurgery and Psychiatry, 79*(4), 368-376. doi: 79/4/368 [pii] 10.1136/jnnp.2007.131045

Jankovic, J., McDermott, M., Carter, J., Gauthier, S., Goetz, C., Golbe, L., et al. (1990). Variable expression of Parkinson's disease: a base-line analysis of the DATATOP cohort. The Parkinson Study Group. *Neurology, 40*(10), 1529-1534.

Johnell, O., Melton, L. J., 3rd, Atkinson, E. J., O'Fallon, W. M., & Kurland, L. T. (1992). Fracture risk in patients with parkinsonism: a population-based study in Olmsted County, Minnesota. *Age and Ageing, 21*(1), 32-38.

Johnson, A. M., & Almeida, Q. J. (2007). The Impact of Exercise Rehabilitation and Physical Activity on the Management of Parkinson's disease. *Geriatrics and Aging, 10*(5), 318-321.

Joo, L. Y., Yin, T. S., Xu, D., Thia, E., Chia, P. F., Kuah, C. W., … He. K.K. (2010). A feasibility study using commercial off the shelf computer gaming in upper limb rehabilitation in patients after stroke. *Journal of Rehabilitation Medicine, 42*, 437-441.

Koller, W. C., Glatt, S., Vetere-Overfield, B., & Hassanein, R. (1989). Falls and Parkinson's disease. *Clinical Neuropharmacology, 12*(2), 98-105.

Korchounov, A., Schipper, H. I., Preobrazhenskaya, I. S., Kessler, K. R., & Yakhno, N. N. (2004). Differences in age at onset and familial aggregation between clinical types of idiopathic Parkinson's disease. *Movement Disorders, 19*(9), 1059-1064. doi: 10.1002/mds.20061

Kumar, N., Van Gerpen, J. A., Bower, J. H., & Ahlskog, J. E. (2005). Levodopa-dyskinesia incidence by age of Parkinson's disease onset. *Movement Disorders, 20*(3), 342-344. doi: 10.1002/mds.20360

Lange, B., Flynn, S., Proffitt, R., Chang, C. Y., & Rizzo, A. S. (2010). Development of an interactive game-based rehabilitation tool for dynamic balance training. *Topics in Stroke Rehabilitation, 17*(5), 345-352. doi: 3R2237HX21302105 [pii]10.1310/tsr1705-345

Lees, A. J., Katzenschlager, R., Head, J., & Ben-Shlomo, Y. (2001). Ten-year follow-up of three different initial treatments in de-novo PD: a randomized trial. *Neurology, 57*(9), 1687-1694.

Levy-Tzedek, S., Krebs, H. I., Arle, J. E., Shils, J. L., & Poizner, H. (2011). Rhythmic movement in Parkinson's disease: effects of visual feedback and medication state. *Experimental Brain Research, 211*(2), 277-286. doi: 10.1007/s00221-011-2685-0

Lyons, K. E., & Pahwa, R. (2011). Diagnosis and initiation of treatment in Parkinson's disease. *International Journal of Neuroscience, 121 Suppl 2*, 27-36. doi: 10.3109/00207454.2011.620197

Marieb, E. N., & Mallatt, J. (1992). *Human Anatomy*. Don Mills, Ontario: The Benjamin/Cummings Publishing Company, Inc.

Mazzella, L., Yahr, M. D., Marinelli, L., Huang, N., Moshier, E., & Di Rocco, A. (2005). Dyskinesias predict the onset of motor response fluctuations in patients with Parkinson's disease on L-dopa monotherapy. *Parkinsonism and Related Disorders, 11*(3), 151-155. doi: S1353-8020(04)00158-0 [pii]10.1016/j.parkreldis.2004.10.002

Meldrum, D., Glennon, A., Herdman, S., Murray, D., & McConn-Walsh, R. (2012). Virtual reality rehabilitation of balance: assessment of the usability of the Nintendo Wii((R)) Fit Plus. *Disability and Rehabilitation: Assistive Technology, 7*(3), 205-210. doi: 10.3109/17483107.2011.616922

Miller, C. A., Hayes, D. M., Dye, K., Johnson, C., & Meyers, J. (2012). Using the nintendo wii fit and body weight support to improve aerobic capacity, balance, gait ability, and fear of falling: Two case reports. *Journal of Geriatric Physical Therapy, 35*(2), 95-104.

Movement Disorder Society. (2003). The Unified Parkinson's Disease Rating Scale (UPDRS): status and recommendations. *Movement Disorders, 18*(7), 738-750. doi: 10.1002/mds.10473

Mujika, I., & Padilla, S. (2000). Detraining: loss of training-induced physiological and performance adaptations. Part I: short term insufficient training stimulus. Sports Medicine, 30(2), 79-87.

Munchau, A., & Bhatia, K. P. (2000). Pharmacological treatment of Parkinson's disease. *Postgraduate Medical Journal, 76*(900), 602-610.

Nitz, J. C., Kuys, S., Isles, R., & Fu, S. (2010). Is the Wii Fit a new-generation tool for improving balance, health and well-being? A pilot study. *Climacteric, 13*(5), 487-491.

Obeso, J. A., Rodriguez-Oroz, M. C., Rodriguez, M., Lanciego, J. L., Artieda, J., Gonzalo, N., … Olanow, C.W. (2000). Pathophysiology of the basal ganglia in Parkinson's disease. *Trends in Neurosciences, 23*(10 Suppl), S8-19.

Oldridge, N. B. (1984). Compliance and drop-out in cardiac exercise rehabilitation. *American Journal of Cardiology, 4*, 166-177.

Palmer, S. S., Mortimer, J. A., Webster, D. D., Bistevins, R., & Dickinson, G. L. (1986). Exercise therapy for Parkinson's disease. *Archives of Physical Medicine and Rehabilitation, 67*(10), 741-745. doi: 0003-9993(86)90007-9 [pii]

Parkinson Society Canada (Producer). (2004). Annual Report. Retrieved from http://www.parkinson.ca/society/Documents/2004AnnualReportEng.pdf

Piron, L., Cenni, F., Tonin, P., & Dam, M. (2001). Virtual Reality as an assessment tool for arm motor deficits after brain lesions. *Stud Health Technol Inform, 81*, 386-392.

Powell, L. E., & Myers, A. M. (1995). The Activities-specific Balance Confidence (ABC) Scale. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 50A*(1), M28-34.

Prediger, R. D., Matheus, F. C., Schwarzbold, M. L., Lima, M. M., & Vital, M. A. (2012). Anxiety in Parkinson's disease: a critical review of experimental and clinical studies. *Neuropharmacology, 62*(1), 115-124. doi: S0028-3908(11)00372-8 [pii]10.1016/j.neuropharm.2011.08.039

Rascol, O. (2000). The pharmacological therapeutic management of levodopa-induced dyskinesias in patients with Parkinson's disease. *Journal of Neurology, 247 Suppl 2*, II51-57.

Robinson, K., Dennison, A., Roalf, D., Noorigian, J., Cianci, H., Bunting-Perry, L., … Stern, M. (2005). Falling risk factors in Parkinson's disease. *NeuroRehabilitation, 20*(3), 169-182.

Salavati, M., Hadian, M. R., Mazaheri, M., Negahban, H., Ebrahimi, I., Talebian, S., … Parnianpour, M. (2009). Test-retest reliability [corrected] of center of pressure measures of postural stability during quiet standing in a group with musculoskeletal disorders consisting of low back pain, anterior cruciate ligament injury and functional ankle instability. *Gait & Posture, 29*(3), 460-464. doi: S0966-6362(08)00392-5 [pii]10.1016/j.gaitpost.2008.11.016

Sale, D. G. (1986). Neural adaptation in strength and power training *Human Muscle Power* (pp. 289-307). Champaign, IL: Human Kinetics.

Sale, D. G. (1987). Influence of exercise and training on motor unit activation. *Exercise and Sports Science Reviews, 15*, 95-151.

Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D., … Bayley, M. (2010). Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation: a pilot randomized clinical trial and proof of principle. *Stroke, 41*(7), 1477-1484. doi: STROKEAHA.110.584979 [pii] 10.1161/ STROKEAHA.110.584979

Schenkman, M., Cutson, T. M., Kuchibhatla, M., Chandler, J., Pieper, C. F., Ray, L., … Laub, K.C. (1998). Exercise to improve spinal flexibility and function for people with Parkinson's disease: a randomized, controlled trial. *Journal of the American Geriatrics Society, 46*(10), 1207-1216.

Schepens, S., Goldberg, A., & Wallace, M. (2010). The short version of the Activities-specific Balance Confidence (ABC) scale: its validity, reliability, and relationship to balance impairment and falls in older adults. *Archives of Gerontology and Geriatrics, 51*(1), 9-12. doi: S0167-4943(09)00145-9 [pii]10.1016/j.archger.2009.06.003

Shulman, L. M., Taback, R. L., Bean, J., & Weiner, W. J. (2001). Comorbidity of the nonmotor symptoms of Parkinson's disease. *Movement Disorders, 16*(3), 507-510.

Silva, M. A., Mattern, C., Hacker, R., Tomaz, C., Huston, J. P., & Schwarting, R. K. (1997). Increased neostriatal dopamine activity after intraperitoneal or intranasal administration of L-DOPA: on the role of benserazide pretreatment. *Synapse, 27*(4), 294-302. doi: 10.1002/(SICI)1098-2396(199712)27:4<294::AID-SYN3>3.0.CO;2-7 [pii]10.1002/(SICI)1098-2396(199712)27:4<294::AID-SYN3>3.0.CO;2-7

Stins, J. F., Ledebt, A., Emck, C., van Dokkum, E. H., & Beek, P. J. (2009). Patterns of postural sway in high anxious children. *Behavioural and Brain Functions, 5*, 42. doi: 1744-9081-5-42 [pii]10.1186/1744-9081-5-42

Sze, P. C., Cheung, W. H., Lam, P. S., Lo, H. S., Leung, K. S., & Chan, T. (2008). The efficacy of a multidisciplinary falls prevention clinic with an extended step-down community program. *Arch Phys Med Rehabil, 89*(7), 1329-1334. doi: S0003-9993(08)00233-5 [pii]10.1016/j.apmr.2007.11.044

Taub, E., Uswatte, G., & Pidikiti, R. (1999). Constraint-Induced Movement Therapy: a new family of techniques with broad application to physical rehabilitation--a clinical review. *Journal of Rehabilitation Research and Development, 36*(3), 237-251.

Teno, J., Kiel, D. P., & Mor, V. (1990). Multiple stumbles: a risk factor for falls in community-dwelling elderly. A prospective study. *Journal of the American Geriatrics Society, 38*(12), 1321-1325.

Toole, T., Hirsch, M. A., Forkink, A., Lehman, D. A., & Maitland, C. G. (2000). The effects of a balance and strength training program on equilibrium in Parkinsonism: A preliminary study. *NeuroRehabilitation, 14*(3), 165-174.

Toole, T., Maitland, C. G., Warren, E., Hubmann, M. F., & Panton, L. (2005). The effects of loading and unloading treadmill walking on balance, gait, fall risk, and daily function in Parkinsonism. *NeuroRehabilitation, 20*(4), 307-322.

Vernadakis, N., Gioftsidou, A., Antoniou, P., Ioannidis, D., & Giannousi, M. (2012). The impact of nintendo wii to physical education students' balance compared to the traditional approaches. *Computers and Education, 59*, 196-205.

Ward, A., & Morgan, W. P. (1984). Adherence patterns of healthy men and women enrolled in an adult exercise program. *Journal of Cardiac Rehabilitation, 4*, 143-152.

Wielinski, C. L., Erickson-Davis, C., Wichmann, R., Walde-Douglas, M., & Parashos, S. A. (2005). Falls and injuries resulting from falls among patients with Parkinson's disease and other parkinsonian syndromes. *Movement Disorders, 20*(4), 410-415. doi: 10.1002/mds.20347

Williams, B., Doherty, N., Bender, A., Mattox, H., & Tibbs, J. R. (2011). The effect of nintendo wii on balance: A pilot study supporting the use of the wii in occupational therapy for the well elderly. *Occupational Therapy in Health Care, 25*(2-3), 131-139.

Wood, B. H., Bilclough, J. A., Bowron, A., & Walker, R. W. (2002). Incidence and prediction of falls in Parkinson's disease: a prospective multidisciplinary study. *Journal of Neurology, Neurosurgery and Psychiatry, 72*(6), 721-725.

Wuang, Y. P., Chiang, C. S., Su, C. Y., & Wang, C. C. (2011). Effectiveness of virtual reality using Wii gaming technology in children with Down syndrome. *Research in*

Developmental Disabilities, 32(1), 312-321. doi: S0891-4222(10)00240-4 [pii]10.1016/j.ridd.2010.10.002

Young, W., Ferguson, S., Brault, S., & Craig, C. (2011). Assessing and training standing balance in older adults: a novel approach using the 'Nintendo Wii' Balance Board. *Gait & Posture, 33*(2), 303-305. doi: S0966-6362(10)00381-4 [pii10.1016/j.gaitpost.2010.10.089

APPENDICES

Appendix A: Ethics Approval

Western

Office of Research Ethics

The University of Western Ontario
Room 4180 Support Services Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
Website: www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. J. Holmes
Review Number: 17341 **Review Level:** Full Board
Review Date: August 10, 2010 **Approved Local # of Participants:** 120
Protocol Title: The effects of virtual-reality home-based rehabilitation on motoric and psychosocial symptoms of Parkinson's disease: A pilot study
Department and Institution: Occupational Therapy, University of Western Ontario
Sponsor:
Ethics Approval Date: September 20, 2010 **Expiry Date:** August 31, 2015
Documents Reviewed and Approved: UWO Protocol, Phase I Letter of information & consent form and Phase II Letter of information & consent form & 2 Advertisements
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

[redacted]

Chair of HSREB: [redacted]
FDA Ref. #: IRB 00000940

[redacted]

UWO HSREB Ethics Approval - Initial
V.2008-07-01 (rptApprovalNoticeHSREB_Initial) 17341 Page 1 of 1

Appendix B: Letter of Information

The Effects of Virtual Reality Home-Based Rehabilitation on Motoric and Psychosocial Symptoms of Parkinson's disease

INVESTIGATORS:

Dr. Jeffrey Holmes, PhD
Dr. Andrew M. Johnson, PhD
Dr. Mary Jenkins, BSc (PT), MD, FRCPC
Dr. Shauna Burke, PhD

You are invited to participate in a study in which we will evaluate the effects of a 12 week home-based exercise program designed around the popular virtual reality gaming system (Nintendo Wii), on improving balance, gait, and exercise adherence, and reducing depressive symptoms, anxiety, and fear of falling.

Background

Increasingly, the Nintendo Wii virtual reality system has been cited by popular media outlets as a potential adjunctive tool for physical rehabilitation, and has also been noted to have positive effects on mood and anxiety, particularly among older adults and individuals with limited mobility. Although several press releases have highlighted the benefits of using the Wii system in clinical settings, evidence supporting the utility of the Wii for improving balance and psychosocial coping mechanisms remains predominantly anecdotal.

Inclusion and Exclusion Criteria

We plan to test a total of 30 participants aged 40 and older who have a confirmed diagnosis of idiopathic Parkinson's disease. In order to be eligible for participation, you must be free of any neurological (other than Parkinson's disease), inner ear, or orthopedic condition, as well as any medical condition that would impair balance or gait, or compromise your ability to safely participate in an exercise program of this sort. You must also have access to either a telephone, or to an email account.

Description of Research

All testing will take place in the Interdisciplinary Movement Disorders Laboratory, Room 1545 Elborn College, at the University of Western Ontario. To ensure that you are "safe to participate" in an exercise program of this sort, you will be assessed by a physician at the outset of the study. Following this assessment, individuals cleared to participate will complete all baseline assessments (as outlined below), and will schedule a date and time to take part in a small group (3 participants) training session.

Training Session

To help you become familiar with the Wii gaming system, you will be placed in groups of three and will be given an orientation to the Wii console, balance board, and controller, and will receive instruction (and see demonstrations of) the safe performance of each activity included in the exercise program, including methods for grading the activity difficulty (e.g., performing balance activities with a chair in front of the balance board). You will also be given an instructional pamphlet that includes frequently asked questions about the Wii system, the activities used in this exercise program, and the rationale for each of the balance exercises.

Home Exercise Program

You will be given a series of exercises to do, along with detailed instructions as to how these exercises can be accessed. You will be asked to perform the activities for approximately 5 minutes each in series, three times per week. In total, you will be asked to perform 30 minutes of activity per session, in your own home, and will be asked to engage in three sessions per week, for a total of 90 minutes of activity per week, for 12 consecutive weeks.

You will be provided with a Wii gaming system (console, controller, balance board, and software) to take home with you for the duration of your involvement in this study. To ensure that all consoles are properly set up, and placed in a safe location within the home, you will receive a home visit by an occupational therapist (the principal investigator, or a graduate student under his supervision). Thereafter, you will be given a phone number that you can call for support. Issues that require hands-on assistance will be addressed through follow-up home visits as necessary.

Balance, Gait, and Psychosocial Assessment

You will be assessed in the Interdisciplinary Movement Disorders Laboratory (room 1545, Elborn College) at a total of 4 time periods within the study: (1) 4 weeks prior to the start of the exercise protocol; (2) immediately prior to beginning the exercise protocol; (3) 6 weeks into the exercise protocol; and (4) immediately after the exercise protocol has concluded. The testing protocol will be identical at all 3 time periods.

All testing will take place in the Interdisciplinary Movement Disorders Laboratory, Elborn College, at the University of Western Ontario. The tasks involved in each testing session will take approximately 45 minutes to complete, and involve no known risks or discomforts beyond those normally experienced by you in performing 3 walks of a 20 foot distance, or when standing still for periods of 2 or 3 minutes. If you agree to participate, we will ask you your birth date, which will be used solely for the purpose of computing your age in years and months, and will then be discarded.

To measure your balance, you will be asked to stand as still as possible on our laboratory forceplate. This device consists of an aluminum plate with embedded electronic force sensors. These sensors feed information to an attached computer, and this information is utilized to provide us with information concerning your balance (e.g., how far your body moves in a forward-backward, and side-to-side fashion, while you attempt to remain as still as possible).

To measure your walking pattern, you will be asked to walk at your normal pace down a GAITRite instrumented carpet, a device with approximately 16,000 sensors built into its surface. These sensors feed information to an attached computer, and this information is utilized to provide us with information concerning your walking (e.g., the length of each step you take, the speed at which you walk, etc.).

At each of the 4 assessment sessions you will also be asked to complete questionnaires that ask you about your satisfaction with physical function, fear of falling, and depression. In addition, you will be asked to complete a written activity log each week indicating the exercises/activities completed each day, along with the approximate duration and intensity of each exercise or activity.

Potential Benefits

Although you may not experience any direct benefits from participating in this research, we anticipate that you will experience an improvement in your balance and psychosocial functioning. In addition, we anticipate that the results obtained through this study will provide us with valuable information concerning the benefits of implementing the Wii gaming system as a clinical rehabilitation tool. This information may also lead to the development of a series of home-based protocols that would be useful as adjunctive therapy in the management of Parkinson's disease.

Potential Risks or Discomforts

There is a small risk in this study that you may experience a temporary loss of balance while performing the balance activities that comprise the home exercise program, and/or during the completion of tasks used to assess your balance and gait within the laboratory setting. To minimize your risk of losing your balance and falling during the performance of home exercises and/or the laboratory balance assessments, a sturdy chair will be placed directly in front of you – you may grasp the chair to regain your balance. In addition, when participating in the home exercise program it is strongly recommended that a family member, friend, or care-provider be on hand to provide assistance. During the laboratory based balance assessments a member of the research team will be available to assist you. You may also feel anxious during the home visit(s), as an unfamiliar person (investigator and/or graduate student under his supervision) must enter your home.

Finally, there is a risk that you may experience difficulty completing some of the Wii activities, or may not perform as well as you would like, which may cause you to feel upset/sad or anxious. Please contact the principal investigator and/or your physician if you need support at any time during the study. Contact information is provided below.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Voluntary Participation and Protection of Information

Your participation in this research project is voluntary. You may refuse to participate, refuse to answer any questions, and you may withdraw your participation at any time with no effect on your future participation in university-sponsored activities, or if applicable, on your academic status, or your future medical care. If you withdraw your participation in the study before the conclusion of data collection, your data will be destroyed. In order to assure complete confidentiality, no identifying information will be attached to the data collected in this study. The only record of your name that will be retained will be on the attached consent form, and this information will be stored in a locked file cabinet, within a locked room, that is (in turn) inside the Interdisciplinary Movement Disorders Laboratory (which remains locked at all times). This information will not be linked, in any way, with the study information. This also means that your data may not be withdrawn from the study after the testing session is concluded, and the information is entered into the computer. If the results of this study are published, your name will not be used, and no information that discloses your identity will be released or published without your explicit consent to the disclosure. Electronic data collected during the course of this study will be kept indefinitely. Representatives of the University of Western Ontario Health Sciences Research Ethics Board may contact you or may require access to your study related records, to monitor the conduct of the research.

You will not receive remuneration for participation in this study. However if you drove to the experiment today, we will provide you with a parking voucher for your vehicle, or if you took public transit today, we will reimburse you the value of a round-trip bus ticket.

You will be asked on the consent form accompanying this letter to indicate if you agree to be contacted about future research opportunities. Your decision to be contacted has no impact on your ability to participate in the present research.

Further Questions

If you have any questions about this research project, please contact the principal investigator, Dr. Jeffrey Holmes, at xxxxxxxxxx, or by email at xxxxxxxxxx. If you are participating in this research as a healthy young or older control participant and have any questions about your rights as a research participant, or the conduct of this study, you may contact the Office of Research Ethics, xxx xxx-xxxx, email: xxxxxxxxxx If you are participating in this research as a participant with Parkinson's, and have any questions about your rights as a research participant, or the conduct of this study, you may contact Dr. David Hill, Scientific Director, Lawson Health Research Institute at xxx xxx-xxxx. You are not waiving any legal rights by signing the attached consent form. This letter is yours to keep.

Appendix C: Consent Form

The Effects of Virtual Reality Home-Based Rehabilitation on Motoric and Psychosocial Symptoms of Parkinson's disease

Please sign this form to indicate that you agree with the following statement:

I have read the Letter of Information, have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction.

Participant (Printed Name):

____

Participant (Signature):

____

Person Obtaining Informed Consent (Printed Name):

____

Person Obtaining Informed Consent (Signature):

____

Date: ____________________________

I consent to having my name added to a list of potential participants in future research. I may withdraw this consent at any time, by contacting the principal investigator (Dr. Holmes). *Note: this consent has no impact on your ability to participate in the present research.*

Participant (Printed Name):

____

Participant (Signature):

____

Appendix D: Unified Parkinson Disease Rating Scale Subsection III

Unified Parkinson's Disease Rating Scale (□) III. Motor Examination

(Fahn S and Elton R, 1987)

18. Speech

0 = Normal.□1 = Slight loss of expression, diction and/or volume.□2 = Monotone, slurred but understandable; moderately impaired. 3 = Marked impairment, difficult to understand.□4 = Unintelligible.

19. Facial Expression

0 = Normal.□1 = Minimal hypomimia, could be normal "Poker Face".□2 = Slight but definitely abnormal diminution of facial expression.□3 = Moderate hypomimia; lips parted some of the time.□4 = Masked or fixed facies with severe or complete loss of facial expression; lips parted 1/4 inch or more.

20. Tremor at rest (head, upper and lower extremities)□

0 = Absent.□1 = Slight and infrequently present.□2 = Mild in amplitude and persistent. Or moderate in amplitude, but only intermittently present. 3 = Moderate in amplitude and present most of the time. 4 = Marked in amplitude and present most of the time.

21. Action or Postural Tremor of hands

0 = Absent.□1 = Slight; present with action.□2 = Moderate in amplitude, present with action.□3 = Moderate in amplitude with posture holding as well as action. 4 = Marked in amplitude; interferes with feeding.

22. Rigidity (Judged on passive movement of major joints with patient relaxed in sitting position. Cogwheeling to be ignored.)□

0 = Absent.□1 = Slight or detectable only when activated by mirror or other movements.2 = Mild to moderate.□3 = Marked, but full range of motion easily achieved. 4 = Severe, range of motion achieved with difficulty.

23. Finger Taps (Patient taps thumb with index finger in rapid succession.)□

0 = Normal.□1 = Mild slowing and/or reduction in amplitude.□2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.□3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement. 4 = Can barely perform the task.

24. Hand Movements (Patient opens and closes hands in rapid succesion.)

0 = Normal.□1 = Mild slowing and/or reduction in amplitude.□2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.□3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement. 4 = Can barely perform the task.

25. Rapid Alternating Movements of Hands (Pronation-supination movements of hands, vertically and horizontally, with as large an amplitude as possible, both hands simultaneously.)□

0 = Normal.□1 = Mild slowing and/or reduction in amplitude.2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.□3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement. 4 = Can barely perform the task.

26. Leg Agility (Patient taps heel on the ground in rapid succession picking up entire leg. Amplitude should be at least 3 inches.)□

0 = Normal.□1 = Mild slowing and/or reduction in amplitude.2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.□3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement. 4 = Can barely perform the task.

27. Arising from Chair (Patient attempts to rise from a straightbacked chair, with arms folded across chest.)

0 = Normal.□1 = Slow; or may need more than one attempt.□2 = Pushes self up from arms of seat.3 = Tends to fall back and may have to try more than one time, but can get up without help. 4 = Unable to arise without help.

28. Posture

0 = Normal erect.□1 = Not quite erect, slightly stooped posture; could be normal for older person.□2 = Moderately stooped posture, definitely abnormal; can be slightly leaning to one side. 3 = Severely stooped posture with kyphosis; can be moderately leaning to one side.□4 = Marked flexion with extreme abnormality of posture.

29. Gait

0 = Normal.□1 = Walks slowly, may shuffle with short steps, but no festination (hastening steps) or propulsion.□2 = Walks with difficulty, but requires little or no assistance; may have some festination, short steps, or propulsion.□3 = Severe disturbance of gait, requiring assistance. 4 = Cannot walk at all, even with assistance.

30. Postural Stability (Response to sudden, strong posterior displacement produced by pull on shoulders while patient erect with eyes open and feet slightly apart. Patient is prepared.)□

0 = Normal.□1 = Retropulsion, but recovers unaided.2 = Absence of postural response; would fall if not caught by examiner. 3 = Very unstable, tends to lose balance spontaneously.□4 = Unable to stand without assistance.

31. Body Bradykinesia and Hypokinesia (Combining slowness, hesitancy, decreased armswing, small amplitude, and poverty of movement in general.)

0 = None.□1 = Minimal slowness, giving movement a deliberate character; could be normal for some persons. Possibly reduced amplitude.□2 = Mild degree of slowness and poverty of movement which is definitely abnormal. Alternatively, some reduced amplitude.□3 = Moderate slowness, poverty or small amplitude of movement. 4 = Marked slowness, poverty or small amplitude of movement.

Appendix E: Modified Hoehn and Yahr Scale

Modified Hoehn and Yahr Staging (Hoehn M and Yahr M, 1967)

STAGE 0 = No signs of disease.

STAGE 1 = Unilateral disease.

STAGE 1.5 = Unilateral plus axial involvement.

STAGE 2 = Bilateral disease, without impairment of balance.

STAGE 2.5 = Mild bilateral disease, with recovery on pull test.

STAGE 3 = Mild to moderate bilateral disease; some postural instability; physically independent.

STAGE 4 = Severe disability; still able to walk or stand unassisted.

STAGE 5 = Wheelchair bound or bedridden unless aided.

Appendix F: Short Version - Activities Specific Balance Confidence Scale (ABC)

The Activities-specific Balance Confidence (ABC) Scale*

Instructions to Participants:

For each of the following, please indicate your level of confidence in doing the activity without losing your balance or becoming unsteady from choosing one of the percentage points on the scale form 0% to 100%. If you do not currently do the activity in question, try and imagine how confident you would be if you had to do the activity. If you normally use a walking aid to do the activity or hold onto someone, rate your confidence as it you were using these supports. If you have any questions about answering any of these items, please ask the administrator.

The Activities-specific Balance Confidence (ABC) Scale*

For each of the following activities, please indicate your level of self- confidence by choosing a corresponding number from the following rating scale:

0% 10 20 30 40 50 60 70 80 90 100%

no confidence completely confident

"How confident are you that you will not lose your balance or become unsteady when you...

1...walk around the house? ____%

2...walk up or down stairs? ____%

2...bend over and pick up a slipper from the front of a closet floor ____%

4...reach for a small can off a shelf at eye level? ____%

5...stand on your tiptoes and reach for something above your head? ____%

6...stand on a chair and reach for something? ____%

7...sweep the floor? ____%

8...walk outside the house to a car parked in the driveway? ____%

9...get into or out of a car? ____%

10...walk across a parking lot to the mall? ____%

11...walk up or down a ramp? ____%

12...walk in a crowded mall where people rapidly walk past you? ____%

13...are bumped into by people as you walk through the mall?____%

14... step onto or off an escalator while you are holding onto a railing? ____%

15... step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? ____%

16...walk outside on icy sidewalks? ____%

---

*Powell, LE & Myers AM. The Activities-specific Balance Confidence (ABC) Scale. *J Gerontol Med Sci* 1995; 50(1): M28-34

CURRICULUM VITAE

Name:	Michelle Gu
Post-secondary Education and Degrees:	University of Western Ontario London, Ontario, Canada 2004- 2005, 2008-2010 Honors Specialization B.A. Kin
	The University of Western Ontario London, Ontario, Canada 2010-2012 M.Sc.
Related Work Experience	Teaching Assistant The University of Western Ontario 2010-2012
	Certified Kinesiologist University of Western Ontario 2010-2012
	Certified Strength and Conditioning Specialist University of Western Ontario 2010-2012