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The Effect of a Multiple Modality Mind-Motor Exercise Intervention on Single and Dual-Task Gait, Balance, and Executive Function, in Community Dwelling Older Adults with a Subjective Cognitive Complaint: A Randomized Controlled Trial.

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A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Health and Rehabilitation Sciences

THE EFFECT OF A MULTIPLE MODALITY MIND-MOTOR EXERCISE INTERVENTION ON SINGLE AND DUAL-TASK GAIT, BALANCE, AND EXECUTIVE FUNCTION, IN COMMUNITY DWELLING OLDER ADULTS WITH A SUBJECTIVE COGNITIVE COMPLAINT: A RANDOMIZED CONTROLLED TRIAL.

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Abstract

Cognitive decline disorders are becoming increasingly prevalent, with older adults at increased risk. Combined exercise has been recently explored as an intervention to help to prevent the decline, however cognitive activation in combination with physical activity has yet to be explored. Therefore, the purpose of the study is to determine the effects of multiple modality exercise programs in combination with a mind-motor task and their effects on mobility and cognitive variables. A total of (n=89) older adults (55+ yrs), with subjective cognitive complaints participated in a multiple modality exercise class, three days a week over six months. The intervention group (n=48) performed the same along with a mind-motor exercise. Gait, balance and executive functioning variables were collected and analyzed. Significant differences (<0.05) were observed between groups in single task and dual task gait velocity, step length. No clinically significant differences were observed in balance or executive functioning, however improved scores were noted, with significant associations observed. Therefore, the intervention provided is useful in improving mobility and cognitive variables. Further research can be performed on cognitive activating modalities that also maintain a higher intensity for greater physiological adaptation.

Keywords

gait, balance, executive function, multiple modality, mind-motor, combined exercise, dual-task, single-task, cognition, exercise, subjective cognitive complaint, alzheimer's, dementia, SSE, cognitive activation, older adults, elderly, community dwelling.

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List of Abbreviations

ABPM	Ambulatory blood pressure monitor
AD	Alzheimers disease
AE	Aerobic Exercise
ARGC	Aging, Rehabilitation & Geriatric Care Center
CB	Counting backwards
CBS	Cambridge Brain Sciences
CES-D	Center of Epidemiology Studies Depression Scale
CI	Confidence interval
CIND	Cognitively impaired not demented
CoV	Coefficient of Variation
CSEP	Canadian Society of Exercise Physiology
DBP	Diastolic Blood Pressure
DT	Dual-task
EF	Executive Function
FAB	Fullerton Advanced Balance Scale
IADL	Instrumental activities of daily living
MCI	Mild Cognitive Impairment
mmHg	Millimeters of Mercury
MMSE	Mini-Mental State Examination
MoCA	Montreal Cognitive Assessment
MS	Multiple Sclerosis
M2	Multiple-Modality

M4	Multiple-Modality; Mind-Motor
PD	Parkinson's Disease
PFC	Pre-frontal Cortex
SBP	Systolic Blood Pressure
SCC	Subjective Cognitive Complaint
SD	Standard deviation
SF	Semantic Fluency
ST	Single-task
S7	Serial Seven's
V0	Baseline visit
V1	6-month visit
V2	12-month visit

Chapter One. Introduction

Older adults are beginning to live longer, and with this longevity there are still unknowns related to how these individuals will deal with a rapidly developing and changing world. At the same time it is generally known that health care costs continue to increase with the aging population, and that maintaining mobility and cognition are crucial elements of a person's ability to negotiate the world, especially with its changes[1]. Research is still needed regarding the sustainability of mobility and optimal quality of life during the latter years of life, especially when considering that a large number of older adults live with multiple co-morbidities[2]. The human body can be seen as a chain made up of multiple links. If a link is weakened in the chain, other areas will need to compensate for the other weakened parts. Age-related changes in physiology contribute to reduced function with increasing age[3]. One weakened link in the chain that has been at the forefront is cognitive disease. Cognitive related diseases such as dementia or Alzheimer's disease (AD) are a rising burden on the health care system. In 2012, there were close to 747,000 Canadians living with these diseases AD, accounting for 14.9% of Canadians over 65 with cognitive disease[4-5]. These diseases currently hold an economic burden of $33 billion in direct/indirect costs per year; the amount will increase sharply with an estimated burden of $293 billion per year by 2040 on the Canadian healthcare system[4,5]. With such dramatic costs, it is worthwhile to seek ways to contain them. Microvascular Subcortical Syndrome, a term coined by Pugh et al. explains that the degradation of frontal subcortical neural networks is responsible for and aids in explaining some of the noticeable features that are commonly seen in older adults, such as cognitive decline, and gait variability (the "shuffle")[6]. Without any appropriate treatments or interventions being implemented, this age-related functional decline will continue. Moreover, it has been found that older adults experience difficulty while focusing on one task while performing another (known as dual-tasking), further challenging their safety and their feeling of safety. Their executive function (EF) is weakened. EF is the cognitive ability to independently perform complex, goal directed and self-serving behaviors[7]. EF is regulated by the prefrontal cortex (PFC) and parietal cortices, as well as the subcortical networks between them[8]**.** Mobility impairments are usually observed in cognitively impaired older adults[9], and this relation is often a precursor for dementia[10]. Problems with gait can be tied to physical and cognitive impairments, often noted in older adults[11]. A key issue regarding cognitive decline, dual-tasking and exercise in community dwelling older adults is how to address an underlying cause for gait variability. Exercises focusing on balance have also been shown to improve mobility in this demographic[12]. Each exercise component has individually shown improvements in this population, however, the combination of all these exercises yield even greater overall results[13]. In particular, the work of Silsupadol et al., noted that individuals who performed dual-task training showed significant improvement in self-selected gait speed, compared to those who performed single-task conditions. Exercises that practice dual-tasking activities should be done in order to reduce the risk of falls and improve balance[14]. Having lessened variability in gait characteristics such as gait velocity, mean step length, or stride time variability balance improvements can be noted[15].

Taking into consideration the direction of research and the potential benefit of applying these cognitive activation techniques with exercise, the purpose of the present study was to determine if single and dual-task gait, balance and executive function, will improve to a greater extent when exposed to a multiple modality (M2) exercise along with a mind-motor (M4) intervention, rather than just a M2 exercise class, in older adults (55+) who are experiencing a subjective cognitive complaint. Further exploration will also be done to determine associations between areas of EF and mobility variables to determine if M4, rather than M2, can yield greater associations to EF and mobility. It is hypothesized that dual-task gait velocity, step length and stride-time variability will show greater improvements whilst exposed to the intervention rather than single-task gait. Significant improvements are also expected to show in balance outcomes in those exposed to the intervention, with executive functioning also expected to show greater improvement within the intervention group.

Chapter Two. Literature Review

2.1 Aging and Cognitive Impairment

As we age many physiological systems begin to decrease function. Our cognitive and mobility systems are not immune to these declines[14]. Older adults tend to have a harder time dealing with a greater amount of stimuli from busy street intersections for example, trying to process street signs, approaching cars, while maintaining movement. With increasing age, the ability of an older adult to move in a quick fluid motion is compromised for many reasons. Cognitive decline such as mild cognitive impairment (MCI) progressing to more severe diseases such as AD, has been shown to limit the ability to maintain usual movement[16,17]. Although attention is one of the first cognitive domains affected in aging, and can account for a large portion of the decline in objective cognitive performance[18], other cognitive domains and their associated brain regions, including executive function (EF) and the prefrontal and parietal cortices are also susceptible to functional and structural deterioration in the aging process[8]. These declines can evolve into more serious conditions, such as dementia, and mobility impairments[19].

2.1.1 Phases of Cognitive Decline

Individuals with subjective cognitive complaints (SCC) (i.e. "my memory is not as good as it was 5 years ago.") are at a greater risk for cognitive decline which will often increase the likelihood of progressing into AD or dementia, placing strain on the health care system[20]. Individuals who have had increasing issues with some form of subjective cognitive impairment, but have not been diagnosed with dementia are classified as having mild cognitive impairment (MCI) or cognitively impaired not demented (CIND)[11]. MCI represents cognitive decline that is not represented as dementia, but a decline normally associated with the aging process[21]. MCI is considered to be a precursor of AD, progressing from healthy cognitive function into cognitive decline associated with aging into more serious forms of impairment such as mild dementia or AD[21,22]. Individuals with MCI exhibit impaired objective cognitive functioning[23]. These subtle cognitive impairments often do not impact performance of basic daily tasks[23] but are associated with difficulties with performance in the complex or advanced aspects of daily living, including shopping and cooking, which one must still walk to do[24]. The Einstein Aging Study found that gait abnormalities are common in persons with MCI and raises the possibility of gait velocity predicting verbal IQ, EF, attention and memory[25]. MCI is typically defined by the presence of a subjective cognitive complaint that is typically corroborated by an informant objective cognitive impairment that is beyond what would be expected for age and education. These impairments do not affect basic daily functioning[18]. In contrast, individuals can be considered as CIND if there is a SCC with or without objective cognitive impairment[11]. The criteria to provide a diagnosis of MCI are as follows: (a) complaint of defective memory, (b) normal activities of daily living, (c) normal general cognitive function, (d) abnormal memory function for age, (e) absence of dementia[21]. Having these criteria to diagnose and classify MCI is beneficial to physicians and researchers in the identification of cognitive decline disorder leading to early treatment and as a preventative screening for cognitive impairment[22,26]. Therefore, further experimentation into treating an onset of a subjective or objective cognitive complaint is necessary to combat the development of more extreme cognitive diseases such as MCI, AD, or dementia.

2.1.2 Screening for Cognitive Decline

A widely used screening tool to test for dementia is the Mini-Mental State Examination (MMSE)[21,26]. A score of 26 on the MMSE may indicate the possibility of dementia. However, this protocol lacks the ability to accurately detect MCI[27]. The Montreal Cognitive Assessment

(MoCA) examines impairments commonly shown in MCI. This test looks at the participants' ability to remember cues and numbers, while also performing tasks targeted towards visuo-spatial processing[28]. The MoCA has a 90% sensitivity to detect MCI where as the MMSE has only a 65% sensitivity[29]. Further assessment for MCI is required if a participant scores less than 26 on the MoCA and 25 on the MMSE. Both tests are used to determine the prevalence and potential for cognitive decline and warrant further diagnoses from a physician[30]. However, the use of the MoCA permits a classification to determine inclusion or exclusion within cognitive variables.

2.2 Executive Function

Executive function is defined as a set of cognitive skills that are necessary to plan, monitor and execute a sequence of goal directed complex actions[7]. Gait is considered to be a task that requires EF, due to its planned execution of movement[15]. A highly developed structure that is responsible for executive control is the prefrontal cortex (PFC). The purpose of the PFC is to receive and project information coming from and to the brain to allow sensory and motor processes to carry out expected and planned movements[31]. All of these sequences occur within a bundle of interconnected networks that receive and relay information[31]. There are aging-related cognitive declines, therefore, it is expected that the PFC will also experience declined performance, limiting our ability for EF and leading to an altered or variable gait pattern[32]. Executive dysfunction is a symptom of certain dementias whereas AD would be dealing more with memory impairment[33]. Executive dysfunction removes one's ability to maintain focus on one set of tasks while performing another, causing decreased gait speed during dual tasks (DT)[34]. EF plays a key role in gait and multitasking, therefore, as we age the EF areas of the brain begin to decrease in function. A decreased EF may lead to mobility impairments associated with falls[35].

2.3 Gait

Gait is defined as "bipedal, biphasic forward propulsion of center of gravity of the human body leading to alternate sinuous movements of different segments of the body"[36]. Gait is not only the propulsion of human movement but also the result of the coordination of multiple functional systems, and an outcome of EF. The action of walking is considered to be an autonomic motor activity controlled by subcortical and spinal regions[37]. As we age our ability to maintain gait becomes less automatic with increases in disease, attention to increasing stimuli, and monitoring. The main concern for older adults is walking patterns becoming increasingly variable between legs[38]. This leads to a higher risk of not following through with a stride or the inability to react to a perturbation, leading to a fall[38]. Studenski et al., found that single task (ST) gait speed was associated with survival among older adults[39]. Stride-to-stride gait fluctuation is considered to be gait variability[38] with variability among the spatial and temporal aspects of gait leading to impaired balance in older adults[38,40]. These fluctuations can be measured by determining the gait standard deviation (SD) from the gait mean (SD/mean x 100); this is also known as the coefficient of variation (CoV)[38]. By determining the CoV, a better understanding is developed as to how much time is spent on each leg during gait, as well as what changes are noted in step length and velocity. Additional findings have determined that IQ and memory are less of a factor in gait compared to poorer EF and attention[41]. Decreased EF and attention were also found to be the highest risk for single and recurrent falls in older adults[41]. Decline in EF is related to increased gait variability along with issues of stability while walking both in older adults as well as in healthy young adults[34]. The link between decreasing mobility and executive dysfunction is becoming a more accepted association to explain mobility issues in the older adult population, along with the more common contributors such as osteoporosis or arthritis.

2.4 Exercise in Aging

Exercise is defined as "any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase over resting-energy expenditure"[42]. As one ages there are many different ways to stay active. Common ways to stay active and physically fit are to incorporate one or more of a combination of muscular strength, endurance, anaerobic capacity, and aerobic capacity[43]. Although the importance of habitual exercise to ward off chronic age-related cognitions have been well established, the participation in physical activity declines with increasing age, reaching a point where over 2/3 of adults over the age of 65 do not meet the recommended exercise guidelines[44]. Each component has its own benefits to improving physical function and cognitive abilities, and aids in the ability to slow age-related decline. Older adults who are sedentary are more likely to be overweight and have multiple comorbidities (i.e. diabetes) compared to their more active peers[45]. Limiting mobility in the older adult population has been shown to affect physical, psychological, and social aspects in a negative way[45]. Exercises focusing on balance have also been shown to improve mobility in older adults[12]. The Canadian Society of Exercise Physiology (CSEP) published recommendations for the amount of exercise persons should perform per week in order to maintain and improve a healthy quality of life. Recommendations for older adults over the age of 65 include a total of 150 minutes of moderate- to vigorous intensity aerobic exercise per week, along with strength exercises two days per week[43]. Exercise is strongly recommended in the aging population, and will also help to remove some of the economic burden being placed on the health care system through limiting mobility related injuries associated with costs on the health care system such as falls[19].

2.4.1 Aerobic Exercise and Older Adults

The ability to maintain physical function can be determined by aerobic capacity. Aerobic capacity is the body's ability to produce energy by using oxygen[46]. Our aerobic capacity begins to decline at the age of 30, with a total decline from maximal values by 50% by 80 years of age[46]. With a decline in aerobic capacity there is less oxygen consumed; this lowers the amount of oxygen transported throughout the body to supply the brain and working muscles with nutrients and energy[46]. Cardiorespiratory fitness has also been shown to have associations with cognitive performance amongst older adults[47]. Increasing the level of aerobic exercise drives benefits in fitness, showing large improvements in EF process[48]. In a meta-analysis conducted by Colcombe and Kramer, those individuals who participated in 6 months of moderate-intensity aerobic exercise (AE) (40-70% of their heart rate reserve) had larger activity in the PFC and regions of the parietal cortex of the brain[49,50]. AE in this population will improve vascular compliance, leading to an improved circulation of oxygen through the peripheries and the brain[51]. With these improvements further exploration is needed in the effects of AE and cognition.

2.4.2 Resistance Training Among Older Adults

Muscular atrophy and sarcopenia are a part of age-related decline, and the loss in the size and strength of the musculature[3], with cross-sectional data suggests that there is a typical loss of 30-40% in back, arm and leg strength between the ages of 30-50[46,52]. The literature shows that resistance training aids in the maintenance of movement, increased strength, and improvements in frailty[46,53]. However, improvements in the planning and preparing areas of EF while exposed to a 12-month resistance training (RT) program have been shown[54]. Sarcopenia is prevalent in older adults. Sarcopenia is a muscular degenerative process affecting muscle mass and strength[53]. This decline has been associated with poor balance, gait variability, falls and fractures[53]. The ability to reverse these declines will aid in improving quality of life and movement, by maintaining strength of supporting structures involved in human movement. Chang et al. went on to further state that regular exercise in midlife and older age will show improvements in lower extremity function[55]. The benefits from exercise among older adults show strong promise in the ability to maintain movement, and good quality of life[13]. However, further research in RT within older adults is recommended.

2.5 Cognitive Training and Engagement

The ability to perform cognitive tasks requires a high level of attention and execution. Participation in various types of cognitively stimulating activities for older adults with cognitive impairment has the ability to maintain or improve cognitive functioning in later life[56,57,58]. Individuals who have completed at least 12 years of formal education show stronger cognitive functioning and decreased risk of cognitive disease in later life[11]. Older adults with lower levels of formal education are at greater risk for developing cognitive decline that can progress to impact their ability to maintain daily functioning[59]. Furthermore, cognitive rehabilitation, DT training, and computerized interventions have been administered in the past to those with stroke, traumatic brain injuries or in older adults[14]. Those who participate in cognitively stimulating activities that specifically target episodic memory functioning (e.g., reading or word games) at least once a week can allay the effect of low education on cognition in aging[60]. The London Tree Task is a cognitive exercise that has been designed to activate and assess areas of EF[61]. The purpose of the puzzle is to strategically organize randomized letters in a correct order[62]. Each move made had a sub-goal[62], therefore, further planning had to go into every executed movement. By providing a tool to allow tracking of certain areas of cognition, further examination into development of alternative forms is necessary. These observations suggest that even with lower level of education attainment, cognitive training can improve cognition. Klusmann et al., carried out a study on older women who performed a 6-month periodized program consisting of 90 minute sessions, 3 times per week consisting of computer cognitive games and aerobic/anaerobic exercises[63]. The study noted improvements and maintenance in episodic memory, working memory and EF in older women with mild to moderate cognitive impairment. The implementation of cognitively stimulating tasks can also improve EF and memory[63]. Therefore, cognitively stimulating activities hold the potential to improve various aspects of cognition in older adults with and without cognitive impairment. The current research discussing the improvements in cognitive abilities during the implementation of cognitively stimulating tasks suggest that this type of intervention could yield greater benefits in combination with other modalities of exercise.

2.6 Multiple-Modality Exercise Training

Literature is examining the effects of the combination of different modalities and the overall effect on health and wellness among the older adult population[13]. Multi-modality (M2) exercise are exercise modalities being performed together to work separate physiological systems in unison, leading to an overall improvement in cardiovascular capacity and balance[13]. A review by Baker et al., showed that training programs that incorporate aerobics, resistance training, and balance, and flexibility training reported improvements in falls prevention, while balance, aerobic fitness, and bone mineral density also improved[13]. However, there were no changes in strength, quality of life measures, and depression symptoms[13]. Karinkanta et al. showed a combination of multiple modalities was beneficial among older women between the ages of 70 and 78[64]. The intervention group performed a combination of resistance, and balance-jumping training. Significant improvements were shown in self-rated physical functioning, leg extensor force, as well as dynamic balance[64]. The combination of strength, balance, agility, and jumping training could prevent the functional decline in home-dwelling older women[13,64]. Performing weight training and aerobic exercise in combination has also been shown to improve postural control and frontal cognitive functions in those with Alzheimer's disease[65].

2.7 Dual-Task

The ability to maintain focus on one task while performing another is known as DT[16]. DT among the aging population can be a difficult thing to maintain. When older adults with MCI are exposed to a DT condition there is a greater variability in their gait (i.e. velocity, stride time variability, step length)[9]. A common issue among older adults is walking across a street. There are many variables for them to consider. For example, they must ensure the traffic lights do not change or there are no cars coming, or other people crossing in their way. This can lead to increased gait variability, which could lead to an increased risk of falls[38].

2.7.1 Dual-Tasks in Gait Evaluation

Dual tasks are commonly used to evaluate gait and gait impairments in older and clinical populations[66]. For example the researcher will ask the subject to walk in a straight line or on the GAITRite™ force platform that measures spatial and temporal gait characteristics while talking, or counting backwards[9]. The role of EF is displayed in the walking characteristics while performing additional cognitive or motor DT[67]. Gait patterns change under these DT conditions leading to a more variable gait pattern[9]. With the added task, the brain is asked to take on increasing stimuli, activating cognitive systems corresponding to a specific task[34]. Improvements in the ability of older adults to perform a second task while walking suggests that further improvements can be seen in EF, due to the increased blood flow during DT causing increased nutrients to PFC improving EF[68]. Silsupadol et al. noted that individuals who performed DT training showed significant improvements in self-selected gait speed, compared to those who performed ST conditions[69].

2.8 Novel Exercise

Research suggests that executive control processes and underlying structures can be modified by different modes of exercise training[70]. The development of valid and reliable novel exercise modalities is crucial for healthy improvement and also to broaden the availability of modalities to those who have functional and cognitive limitations. Cognition training is targeted to address various areas of the cognitive process, including attention, perception, memory and EF with benefits in aging and wellness being noted in older adults with the implementation of cognitively stimulating activities[50,56,57,58].

2.8.1 Exercise and Cognitive Training

The combination of physical activity along with cognitive training over six months with a frequency of 3 times a week for 90 minutes has shown promising results in the improvement in the maintenance of episodic memory, working memory and executive function[63]**.** The improvements shown in episodic memory and EF during cognitive training were also noted during a 6-month aerobic and balance training, these improvements also help to reduce the risk of dementia in older adults[71,72]. These findings warrant further research into the combination of exercise and cognitive training to improve cognitive functioning.

2.8.2 Exercise and Dual-Tasks

The decline in EF has been associated with the decline in gait performance and variability[73]. With improvements in EF shown in both cognitive training and aerobic exercise, the combination of these two modalities may potentially yield a greater improvement in cognition rather than just the use of one of these modalities. DT training is another multidimensional intervention that helps to target cognition and mobility, and may improve physical function in older adults and those with neurological impairment[14,50]. Dual tasking is often a reflection of the experiences of daily living among older adults, due to most tasks usually consisting of multiple components to focus on, and can provide insight into the functional capacity of these individuals[72]. The relationship between cognitive and physical in DT exercises is sensitive with time needed to be spent improving both individually and in unison. If the demand from cognition is too high during a task then mobility will begin to decrease[72]. The same can be said that if the mobility task is too demanding, cognitive performance will be affected[72]. There was a demonstrated shift in the location of DT related brain activity in young adults, suggesting a reorganization of cortical areas involving DT, leading to improved task performance[70]. A six week DT cognitive gait training intervention that involved walking and memory recall in cognitively healthy older adults found that balance and cognitive performance were improved during DT[74]. DT was done while performing balance activities, with the tasks ranging from counting backwards to multiples of 7's being subtracted[74]. Acute cognitive improvements have been shown in both ST and DT groups however, 12 weeks after the completion of the intervention training benefits remained only among those who performed DT training, suggesting that the benefits of DT can be optimized and maintained when attention is placed on both tasks at once when both tasks separately[50,74].

2.8.3 Mind-Motor Training

The prevention of falls in older adults is crucial for the maintenance of mobility and independence. Factors that influence falls among the elderly include decrease in reaction time and agility along with the decrease in power of the lower extremities[75]. Shigematsu et al., developed a novel intervention to aid improvement of the lower-extremity functional fitness in older adults[75]. This intervention is known as Square Stepping Exercise (SSE) and is essentially a thin mat with 40 squares allowing participants to work up from beginning stepping exercises to advanced steps[75]. The square stepping exercise (SSE) incorporates forward, backward, lateral and oblique progressive stepping patterns that participants must carry out[75]. The regimen followed in the study by Shigematsu et al., included 30 minutes of SSE, along with a 10-minute warm-up, 10 minutes of whole body resistance training, and a 10-minute cool down[76]. This regimen was performed for six months, once a week for 60 minutes[76]. Improvements in agility, leg power, locomotion speed, flexibility and balance were all found. Furthermore, this exercise has been shown to be a practical way to decrease falls in older adults through the techniques that promote mobility strengthening[76]. Further research has been done on the SSE's usefulness in improving balance and its long term use with the elderly[77]. With the improvements in lower body functioning, improvements in gait variability are also expected.

2.9 Steps Forward, Future Research

Despite the preliminary evidence that suggests that various forms of physical and cognitive exercise training can improve cognition and mobility in older adults with and without cognitive impairment, there is new evidence regarding the influence of combined physical and cognitive exercise training programs. Further research is needed to determine if the combination of a multiple-modality exercise class along with a mind-motor component will benefit mobility to a greater degree than multiple-modality exercise training alone. It is important to study this demographic of older adults in further detail to determine if there are interventions that slow cognitive impairment.

Chapter Three. Methodology

3.1 Study Design

This research study was a double-blinded, randomized control trial, pilot study. The six month intervention was performed at the Maranatha Christian Church, in Woodstock, Ontario, Canada, where the sample population was recruited. We recruited community-dwelling older adults (55+) with a subjective cognitive complaint (SCC), to examine the effects of a combined multiple-modality (M2), mind motor (M4) exercise program on gait, and whether or not such an intervention would show improved gait variability, balance scores and EF.

3.2 Participants

Community-dwelling older adults participants from Woodstock, Ontario, Canada, were recruited. These subjects were recruited through advertisements across Woodstock and "word-of-mouth" from members of the community. A total of 89 adults over the age of 55 years of age with a SCC were recruited. Baseline and follow up assessments were completed at the Salvation Army Church in Woodstock, Ontario, Canada. Day three of assessments was completed at the Aging, Rehabilitation and Geriatric Centre (ARGC), at Parkwood Institute, in London, Ontario, Canada. Those participants who were deemed eligible based on screening scores were contacted at a later date to perform baseline assessments over three days.

3.2.1 Inclusion/Exclusion Criteria:

Inclusion/exclusion criteria were determined a priori to establish participants' ability to be entered into the study. Before participants were randomized, screening packages were performed to determine eligibility. The screening process included going over the letter of consent and ensuring that any questions the participants had were clearly answered. After acquiring subjects' medical history a series of assessments were administered. Assessments included the Mini-Mental State Examination (MMSE)[21,26], Montreal Cognitive Assessment

(MoCA)[28] and the Lawton Brody questionnaire, which were used to assess the participants' ability to perform instrumental activities of daily living (IADL). We also administered the Center of Epidemiology Studies Depression Scale (CES-D). Inclusion criteria required participants to be over the age of 55, answer "yes" to a cognitive complaint question ("Do you feel that your memory or thinking skills have gotten worse recently?"), and have preserved Instrumental Activities of Daily Living, scoring 8/8 Lawton-Brody IADL Scale. Subjects were excluded if they exhibited:

1) Signs of dementia (i.e., diagnosis or MMSE <24);

2) Other significant neurological or psychiatric conditions (i.e., Parkinson's disease; Bipolar Disorder);

3) Severe sensory impairment;

4) Previous history of severe cardiovascular conditions (i.e., myocardial infarction in past year, end stage congestive heart failure, end stage renal disease);

5) Significant orthopedic conditions (i.e., severe arthritis);

6) Resting blood pressure was greater than 180/100 mmHg or less than 100/60;

7) Untreated depression [based on CES-D (score>16)];

8) Inability to comprehend questionnaire material;

9) Any other reason that would impact ability to fully participate in intervention (i.e., cannot commit to 80% of sessions).

3.3 Assessment Visits

Upon passing the first stage of screening, participants performed three days of baseline assessments (V0), with each visit taking approximately 1-2.5 hours. These assessments were then completed at six months (V1) from the start as well as one year later (V2). The exercise intervention was performed over six months with V2 being a follow up visit to determine the maintenance of training effects from the program.

Day one consisted of recording patients' subject characteristics, health questionnaires, as well as providing a practice day for subjects to become comfortable with the ergonomic mouse and the Cambridge Brain Sciences (CBS) cognitive computer games. Participants were instructed to wear a 24 hour SpaceLabs Ambulatory Blood Pressure Monitor (ABPM), model no:90207-30. Once the blood pressure cuffs were fitted on the participants, they were instructed that the ABPM's would take readings twice per hour during wake periods and once per hour during sleep periods. Patients were asked to record any activities throughout the day that they felt would have affected their blood pressure, to allow for an explanation as to any variances.

On day two, once the ABPM was removed, the CBS games were administered and recorded. Each of the 12 games were three minutes in length with a 10 second rest period taking place at the 1:30 mark. After the 12 games were completed the participants scores were loaded onto an encrypted universal storage device (USB) and uploaded onto a shared and secure network. To close out day two participants were given directions to the Aging, Rehabilitation & Geriatric Care Centre at Parkwood Hospital in London, Ontario, along with pre-ultrasound instructions to follow: no vigorous exercise, no alcohol consumption for 24 hours, no caffeine or smoking for 12 hours, and no eating four hours prior to the ultrasound.

On day three, once the participant arrived at the ARGC, they underwent the following tests:

1)Three blood pressure readings with final two averaged and recorded;

2) Ultrasound of the carotid artery;

3) Sensori-motor testing (Eye tracking);

4) Quantitative Gait Assessment;

5) Anthropometric Measures (i.e., height (m), weight (kg), waist circumference (cm), and body mass index);

6) Fullerton Advanced Balance (FAB) scale;

7) STEP test to predict aerobic VO_2 peak fitness level;

8) General health questionnaire.

Upon completing the day three assessments the participants were then randomized into either the multiple-modality (M2) (control) or multiple-modality, mind-motor (M4) (treatment). Those individuals who collected and analyzed data from the participants were blinded from the placement of participants in either group.

3.3.1 Quantitative Gait Assessment

Spatial and temporal gait characteristics were assessed using the GAITRite System ™ (Platinum Version). This program is an electronic walkway system that is 4.88m in length by 61m in width. Further specifications of the GAITRite mat can be seen in table1. This validated and reliable program has been found to be an effective method to assess gait in older adults and diseased population[78]. Pressure sensors along the mat are activated once the participant walks across them. Once the subject's foot is released from the sensor it is deactivated. As the participant walks over the sensors across the mat, the sensor will collect the foot-fall data and translate it onto the computer program, which will provide the series of visual foot patterns that were performed while walking across the mat, along with each characteristic involved in each step (i.e. average velocity, step length and stride time variability.). Once each trial was completed subject data was converted into a Microsoft Excel 2010 document, to allow organization and analysis.

The GAITRite™ mat was set up in a low traffic section in the ARGC at Parkwood Institute. Participants were instructed to walk at a comfortable, self-selected pace. One trial was performed to obtain a baseline output of their normal walking patterns. The other three trials were performed under a dual task (DT) condition. The DT used during gait analysis were counting backwards (CB) (from 100 at V0, 90 at V1, and 80 at V2), semantic fluency (SF) (naming animals at V0, naming vegetables at V1, naming countries at V2, and serial sevens (S7) (starting from 100 at V0, 90 at V1, and 80 at V2). Each trial was performed with the participant wearing shoes, with a 20-second rest interval between each trial. Approximately 1-meter before was allowed as a starting point to enable normal stride to begin before hitting the mat. The participant was also instructed to walk for 1-meter once the end of the mat was reached, to allow for proper deceleration.

Table 1. GAITRite™ Specifications

Overall Dimensions	**5.8 x .90 x 0.06m (L x W x H)**
Active Area	4.88 x .61 (L x W)
Weight	25 kg
Sampling Rate	60Hz, 120Hz, 180Hz, 240Hz
Communications	USB, Sensor: 1 cm square, dual control
Power Requirements	12Vdc
Number of Sensors	18,432 sensors, placed on 1.27cm centers arranged in a 48 x 384 grid
Top Cover	Vinyl with square thread reinforcement waterproof and chemical resistance
Bottom Cover	Open cell foam rubber
Computer Requirements	IBM® compatible personal computer with:Windows 95/98/ME/NT/2000, Pentium

	processor 64MB RAM

3.3.2 Balance Assessment

The Fullerton Advanced Balance (FAB) scale is a set of 10 static and dynamic balance tests progressing in difficulty[79]. The FAB is a valid and reliable test, designed for high functioning older adults and was performed to provide a better understanding regarding participants' balance[79]. The FAB scale consisted of stationary and mobile balance assessments, with external cues and perturbations also being used to affect balance. Quantitative data was used for scoring (i.e. time, or number of steps).

3.4 Training Protocol

The exercise intervention was a M2 exercise class designed specifically for the 55+ age group. The intervention was carried out over six months three times per week. All training was done at the Maranatha Church, in Woodstock, Ontario. Each group was lead by certified fitness instructors. Each group was identical in the type of exercise prescribed as well as time spent on each component. In the M2 group, the exercise intervention was as follows: five minute warm-up, twenty minutes of aerobic exercise, five minutes of aerobic cool down, ten minutes of resistance training, fifteen minutes of balance training, followed by five minutes of stretching. In the M4 group the only difference in exercise prescription was the fifteen minutes of balance training shown in the M2 group was substituted for fifteen minutes of the mind-motor task. Target heart rates (HR) were determined before the treatment began, using step test exercise prescription (STEP)[80]. Target HR varied between 65-80% of their predicted max, depending on the initial scoring.

3.4.1 Mind Motor Task

The square stepping exercise (SSE), was the mind-motor task in the treatment group (M4). The SSE was designed and developed to specifically target balance, and lower extremity functioning, and thereby minimize disability, and maintain independence, amongst older adults[76]. The SSE is a floor mat grid which requires participants to memorize progressively complex stepping patterns, first shown by the lead instructor. Patterns vary from beginner, to intermediate, finishing off at advanced steps. If the participants were unable to complete the stepping task, the lead instructor would then perform the stepping pattern again with counting cues, and if the participant was still unable to perform the patter, a verbal cue was initiated.

3.5 Feasibility

The feasibility of this research study included the ability of each participant to attend at least 80% of the sessions over the 6-month period; and to attend the post-intervention follow-up assessment. Also, for those who did not continue with the intervention participants were asked to perform each of the assessments, to allow for further data analysis. At the completion of the study participants were asked to provide feedback regarding the program, with those who did not participate being contacted regarding why, and what more could have been done to increase their interest. Adverse events were also recorded.

3.6 Data Management

All participant information was collected and stored in locked storage bins, in a controlled access room, to allow proper confidentiality. Participant information was not included in binders. Participants' demographical information, as well as general health questionnaires were recorded in case report forms. Once all data was collected it was entered onto a Microsoft Excel spreadsheet. Cognitive test scores (MMSE, MOCA) and questionnaires (IADL, CES-D) were then transferred into case report forms and inputted into the Microsoft Excel spreadsheet, after being transferred into participants' binder. Once the participant had completed the CBS cognitive games, their scores were stored on an encrypted USB and once the scores were printed off they were placed into binders. Upon collecting gait data, the data was exported from the GAITRite™ software into Microsoft Excel, which was then uploaded to the main data spreadsheets. ABPM monitors were collected and uploaded onto the computer using ABP Report Management System Version 1.03.16. Once the participant's file was saved, a diary print out was collected with key BP readings being transferred into a case report form and uploaded to the working spreadsheet. All spreadsheets were housed on a local network computer at Parkwood Institute, London, Ontario, with data being stored on a shared secured network drive. With participant personal information locked and secured, binders were identified by participants initials and participant number.

3.7 Statistical Analysis

After excluding participants who did not complete the full 6-month intervention, data was analyzed on a samples size of 74. Due to the primary variables explored in this study being secondary outcomes in a larger research trial, a power calculation was performed to determine sample size for the main study. A meta-analysis on the impact of aerobic fitness training on cognition in older adults suggested that physical exercise can improve cognition with an effect size of d=0.48[49]. A sample size for the proposed study must be approximated by using the effect size approach, combined with feasibility and comparisons to sample sizes used in other similar studies. Therefore, the proposed sample size for the larger study was 130 participants, with a power of 80% at a 5% significance level. With this calculation a sample size of 90 is sufficient to explore the secondary outcomes of this larger study. A repeated measures analysis of variance (ANOVA) was performed between groups using change scores for all gait, balance, and executive functioning variables, with the two time points as the repeated measures. All necessary assumptions were made before analyses were performed. Regarding the evaluation of the association between outcomes, Pearson correlations were performed on the EF variable with gait and balance variables. Descriptive statistics are reported as mean ± SD and variances reported in percentages. Paired sample t-tests were used to determine any within-group differences at baseline. Significance level was set at $p<.05$, and interpretation was based primarily on point estimates, 95% confidence intervals (CIs) and effect sizes. Statistical analyses were performed using IBM SPSS version 20.

Chapter Four. Results

4.1 Baseline Characteristics

A total of 122 people were assessed for eligibility. Of the 122 individuals, 23 declined to participate and 10 did not meet the exclusion criteria [no cognitive complaint n=2, depression n= 1, significant neurological disorder n= 5, significant cognitive impairment (i.e., MMSE<24) n= 1, high blood pressure >180/100 n= 1]. The remaining 89 were randomized into the M2 (n=41) and M4 groups (n=48). Following those who did not complete the intervention in its entirety, 74 participants remained and were subsequently used for analyses. Final sample sizes for statistical analyses were n=34 (M2) and (M4) n=40. The CONSORT (Consolidated Standards of Reporting Trials) diagram (**Figure.** 1) shows the number and distribution of participants over 6-months. Reasons for lack of interest and recruitment included: 1) unable to adhere to the time commitment; 2) uninterested in additional exercise; 3) work conflicting; 4) personal reasons.

Of the 89 participants enrolled at the beginning of the study all received baseline assessments. Table 2 displays baseline characteristics for the sample population. The distribution of gender between groups was 26.8% and 35.4% for men in M2, and M4, respectively, with a distribution of 73.2% and 64.6% for women in M2, and M4, respectively. However, a paired t-test showed no significant differences of age between groups (p=0.39). Years of education (p=0.25), body mass index (BMI) (p=0.27), waist circumference (p=0.15), and cardiovascular scores (predictive $V0_2$) (p= 0.37), were also shown to have no significant differences at baseline. The mean 24-hour systolic and diastolic blood pressure readings were similar at baseline with both M2 and M4 groups showing no significant differences (p=0.27, p= 0.30), respectively. Mean scores in the MMSE and MOCA also yielded no significant differences at baseline amongst groups (p=0.74, p= 0.39), respectively. Lastly, all gait, balance, and cognitive outcomes were also assessed at baseline to ensure homogeneity, with all showing no significant differences at baseline between groups (p=>0.05).

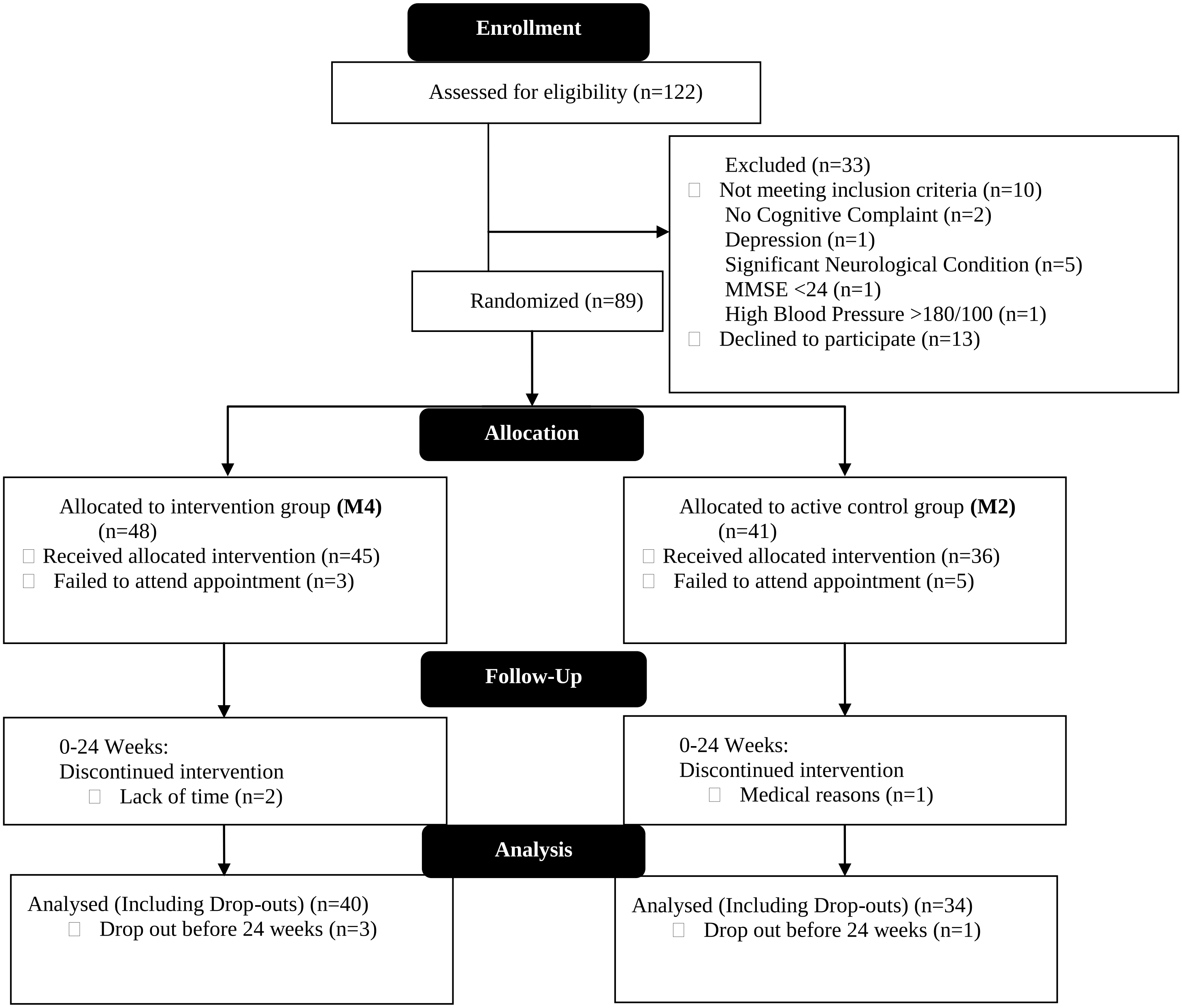

Figure 1. Consort Diagram

Table 2. Baseline Subject Characteristics

	M2 (n=41)	**M4 (n=48)**
Gender (%)		
Men	26.8	35.4
Women	73.2	64.6
Age	66 (6.3)	67 (7.5)
MMSE /30	29 (1.2)	29 (1.2)
MOCA /30	26 (2.5)	25 (2.8)
Education (Yrs)	14 (3.4)	13 (2.7)
24-hour ABPM (SBP/DBP)	130/74 (14.5/9)	127/73 (11.7/8.5)
BMI	30.3 (6.7)	29.1 (4.1)
WC (cm)	96.1 (19.2)	94.4 (12.6)
Peak VO_2 (ml/kg/min)	25.5 (8.4)	27.4 (8.4)

Legend: MMSE; mini-mental state examination, MOCA; Montreal Cognitive Assessment, Yrs; Years, ABPM; Ambulatory blood pressure monitor, SBP; Systolic Blood Pressure, DBP; Diastolic Blood Pressure. Numbers in brackets represent the standard deviation.

4.2 Post-Intervention Outcomes

4.2.1 Single-Task Gait

Mean single-task (ST) gait velocity was shown to increase over time in the control group (M2) with a mean change of 0.02m/s (95% CI; 1.13 to 1.25, 1.15 to 1.27), however in the treatment group (M4) there was a decrease in average velocity, with a mean change of 0.06m/s (95%CI; 1.13 to 1.25, 1.07 to 1.19). There were significant differences shown between groups over time (p=0.012), with significant decreases in the treatment group. ST step length was also shown to yield significant differences (p=0.012). Mean changes in the M2 group showed an increase in step length with a mean change of 0.9cm (95%CI; 62.5 to 68.7, 63.4 to 70). A significant decrease in mean step length was observed in the M4 group with a mean change of 1.7cm (95%CI; 63 to 68.7, 61.3 to 67.1). Changes in ST stride time variability were also noted, however these changes were not significantly different between groups (p=0.490). A mean increase in stride time variability of 0.2% (95%CI; 1.41 to 2.23, 1.7 to 2.4) was noted in the M2 group with no change being noted in the M4 group (95%CI; 1.9 to 2.6, 1.9 to 2.6).

Table 3. Single-Task Gait Variables

	M2 (n=34)		M4 (n=40)			
Assessment Date	V0	V1	V0	V1	F-Score	P-value
Velocity (m/s)	1.19(0.17)	1.21(0.13)	1.19(0.20)	1.13(0.22)	6.714	0.012**
Step Length (cm)	65.6(8.1)	66.5(7.21)	65.9(9.9)	64.2(10.4)	6.699	0.012**
Stride Time Variability (CoV,%)	1.8(1.0)	2.0(0.91)	2.3(1.4)	2.3(1.3)	0.480	0.490

Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit, m/s; meters per second. **; significant difference p<0.05. Numbers in brackets represent the standard deviation.

4.2.2 Dual-Task Gait

There were two separate dual-tasks (DT) used; semantic fluency (SF), having the participant list off various words corresponding to a certain topic, as well as serial sevens (S7), having the participant count backwards by seven starting from a pre-determined number. There were no significant changes observed between groups over time among mean gait velocity, under the SF task (p=0.062). Increases in the M2 group were shown, with a mean change of 0.03m/s over time (95%CI; 0.92 to 1.09, 0.95 to 1.10). Mean velocity under the SF task in the M4 group did note a decrease in mean velocity, with a change of 0.05m/s (95% CI; 0.88 to 1.04, 0.84 to 0.98). Step length under SF did yielded a non significant difference between groups' over time (p= 0.112). Step length SF was shown to decrease over time in both groups with mean changes of 0.6cm (95% CI; 58. 9 to 65.8, 58.5 to 65) and 2.5cm (95%CI; 58. 2 to 64.6, 56 to 62) in the M2 and M4 groups, respectively. Decreases were noted in stride time variability under SF, with a mean change of 1.7% (95% CI; 3.2 to 8.1, 2.2 to 5.5) in the M2 group, with a decrease of 0.2% in the M4 group(95% CI; 4.0 to 8. 6, 4.6 to 7.6). No significant changes were noted between groups stride time variability under SF (p=0.263). The secondary DT, S7, was also used to assess changes in gait performance. An significant increase in mean velocity under this DT was noted in the M2 group with a mean change of 0.1m/s (95% CI; 0.81 to 1, 0.93 to 1.09), while a decrease in average velocity was noted in the M4 group with a mean change of 0.02m/s (95% CI; 0.79 to 0.96, 0.78 to 0.92). However, there were significant differences noted between groups over time, (p=0.008). Significant differences were also shown in step length under this DT between groups over time, (p=0.050). Mean increases in step length under S7 in the M2 group was 1.3cm (95% CI; 57.6 to 64.6, 59.1 to 65.7), however a mean decrease of 1.1cm was noted in the M4 group (95% CI; 56.9 to 63.5, 56 to 61.1). Similar findings there observed in DT stride time variability between groups over time, with no significant differences noted (p=0.125). A mean decrease of 2.3% (95% CI; 4.3 to 9.6, 2.1 to 7.1) was noted in the M2 group with a mean increase of 1% observed in the M4 group (95% CI; 4.3 to 9.2, 5.4 to 10).

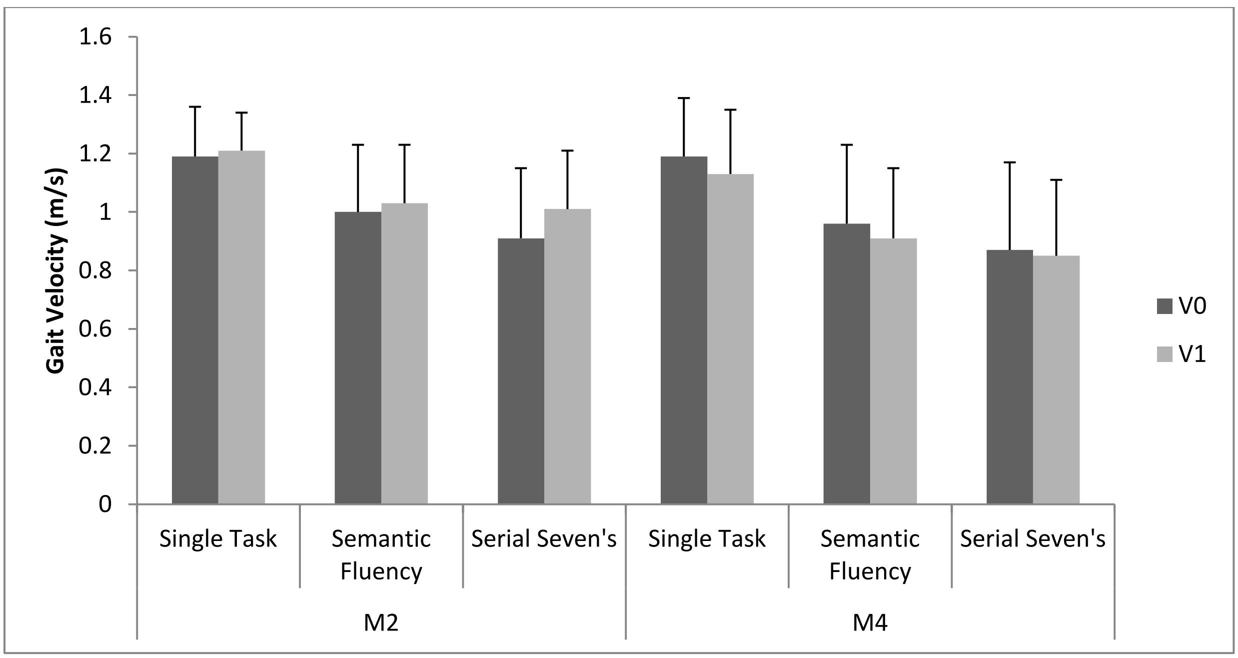

Figure 2. Changes in Gait Velocity under Single and Dual-Tasks
Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit, m/s; meters per second, **; significant difference p<0.05

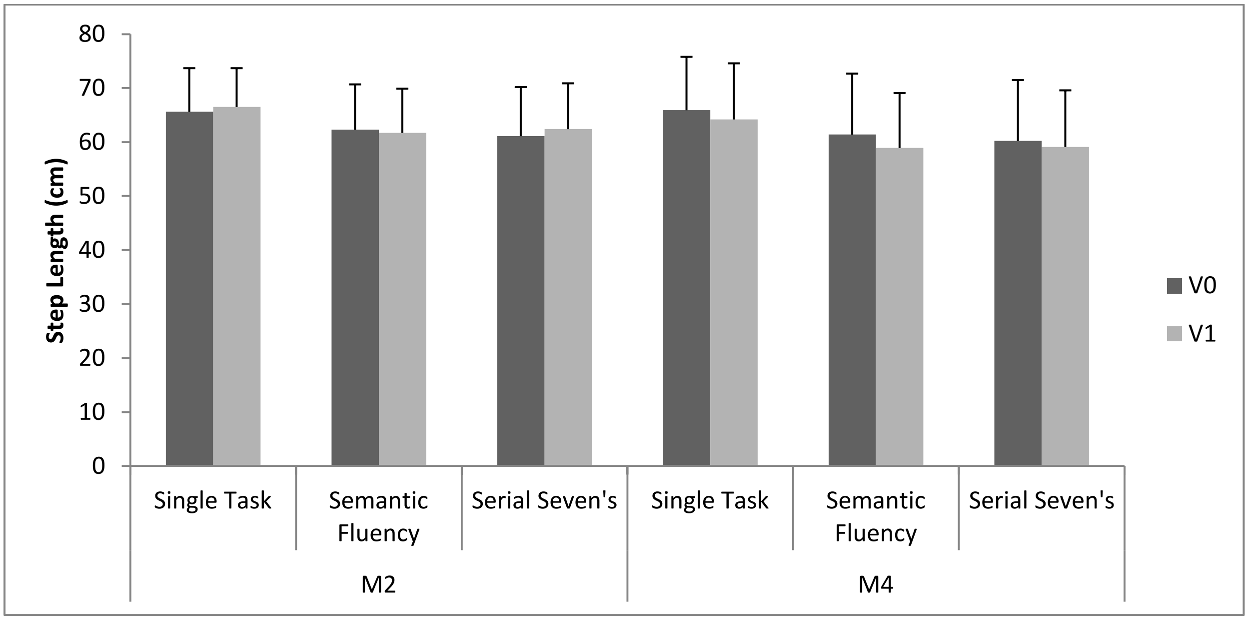

Figure 3. Changes in Step Length under Single and Dual-Tasks
Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit, m/s; meters per second.

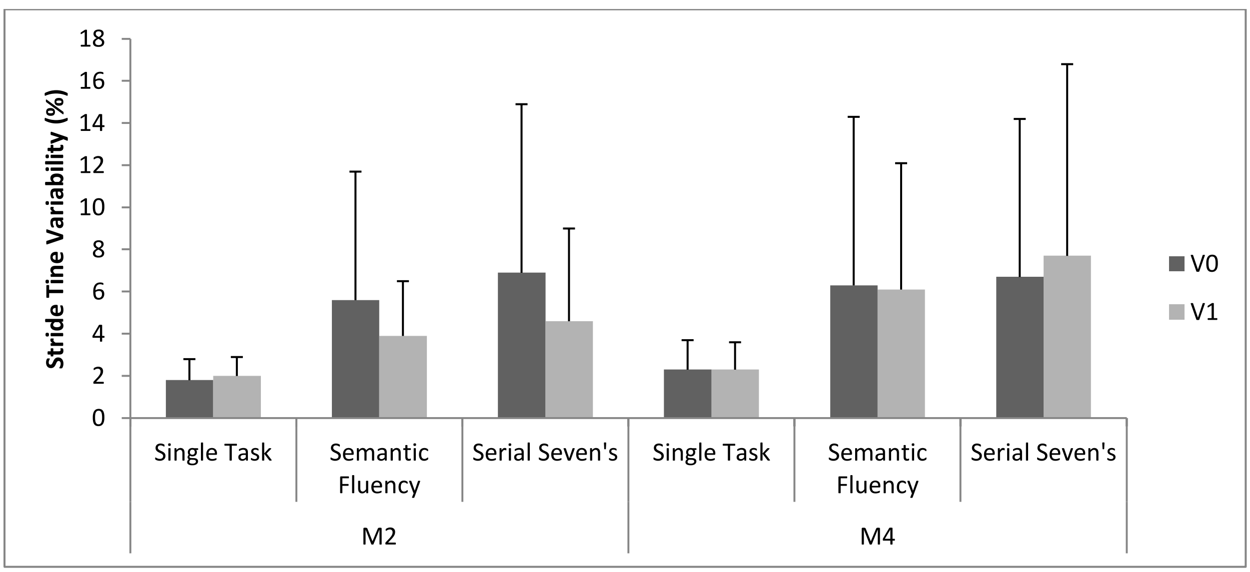

Figure 4. Stride Time Variability under Single and Dual- Tasks
Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit.

Table 4. Dual-Task Gait Variables

	M2 (n=34)		M4 (n=40)			
Assessment Date	V0	V1	V0	V1	F-Score	P-value
Velocity (m/s)- DT (SF)	1.00(0.23)	1.03(0.20)	.96(0.27)	.91(0.24)	3.600	0.062
Step Length (cm)- DT (SF)	62.3(8.4)	61.7(8.2)	61.4(11.3)	58.9(10.2)	2.592	0.112
Stride Time Variability (CoV,%)- DT (SF)	5.6(6.1)	3.9(2.6)	6.3(8.0)	6.1(6.0)	1.275	0.263
Velocity (m/s)- DT (S7)	.91(0.24)	1.01(0.20)	.87(0.30)	.85(0.26)	7.324	0.008**
Step Length (cm)- DT (S7)	61.1(9.1)	62.4(8.5)	60.2(11.3)	59.1(10.5)	3.973	0.050**
Stride Time Variability (CoV,%)- DT (S7)	6.9 (8.0)	4.6(4.4)	6.7(7.5)	7.7(9.1)	2.403	0.125

Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit, m/s; meters per second, DT; Dual-Task, SF; Semantic Fluency, S7; Serial Sevens, **; significant difference p<0.05. Numbers in brackets represent the standard deviation.

4.2.3 Balance

Mean balance scores did note changes, however, there were no significant differences shown between groups over time (p=0.241). The M2 group did note an average increase of 1 (95% CI; 34 to 36, 35 to 36) in total score over the length of the intervention with the M4 group also noting a subtle mean increase of 0.4 (95% CI; 33 to 35, 33 to 36). Table 3.4 describes the changes noted in the balance outcome.

Table 5. Balance Scores

Outcome Characteristics	M2 (n=34)		M4 (n=40)			
Assessment Date	V0	V1	V0	V1	F-Score	P-value
FAB Total	35(3)	36(2)	34(4)	35(6)	1.401	0.241

Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit, FAB; Fullerton Advanced Balance Scale. Numbers in brackets is the standard deviation.

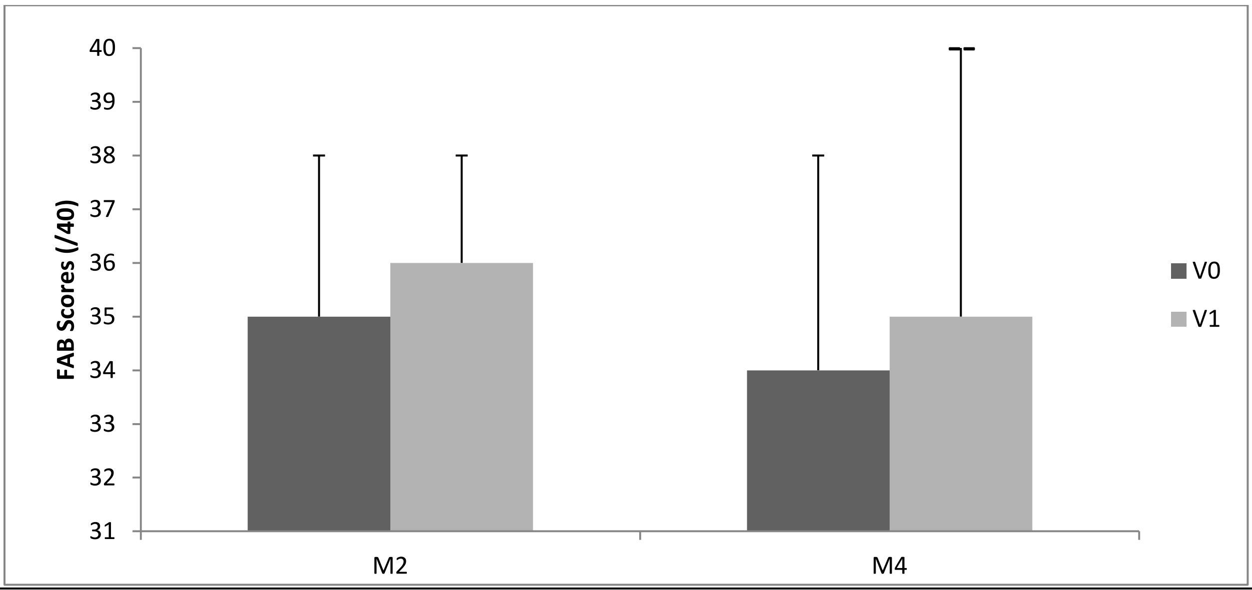

Figure 5. Changes in Balance Scores Between Groups over Time
Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit, FAB; Fullerton Advanced Balance Scale

4.2.4 Executive Function

Mean scores amongst executive functioning did yield a decrease within the M2 group with a mean change of 1 (95% CI; 11.2 to 15.3, 9.6 to 14.2) with no change being noted in the M4 group (95% CI; 9.8 to 13.6, 10.3 to 14.5). There were no significant differences noted in executive functioning scores between groups (p=.239). Correlations were made between executive functioning scores and mobility variables to determine associations. Correlations were performed with post-intervention data. Significant associations were made between executive functioning and balance scores (p=0.047), ST average velocity (p= 0.026), DT average velocity(SF) (p= 0.005), DT step length(SF) (p= 0.015), DT coefficient cycle time(SF) (p= 0.017), DT average velocity (S7) (p=0.018), DT coefficient cycle time (S7) (p=0.008). Table 6 illustrates the mean change scores for executive functioning scores. Pearson correlation coefficients are shown on table 7.

Table 6. Executive Function Scores

Outcome Characteristics	**M2 (n=34)**		**M4 (n=40)**			
Assessment Date	V0	V1	V0	V1	F-Score	P-value
CBS- Tree Task	13(6)	12(6)	12(7)	12(7)	1.409	0.239

Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit, CBS; Cambridge Brain Sciences. Numbers in brackets is the standard deviation.

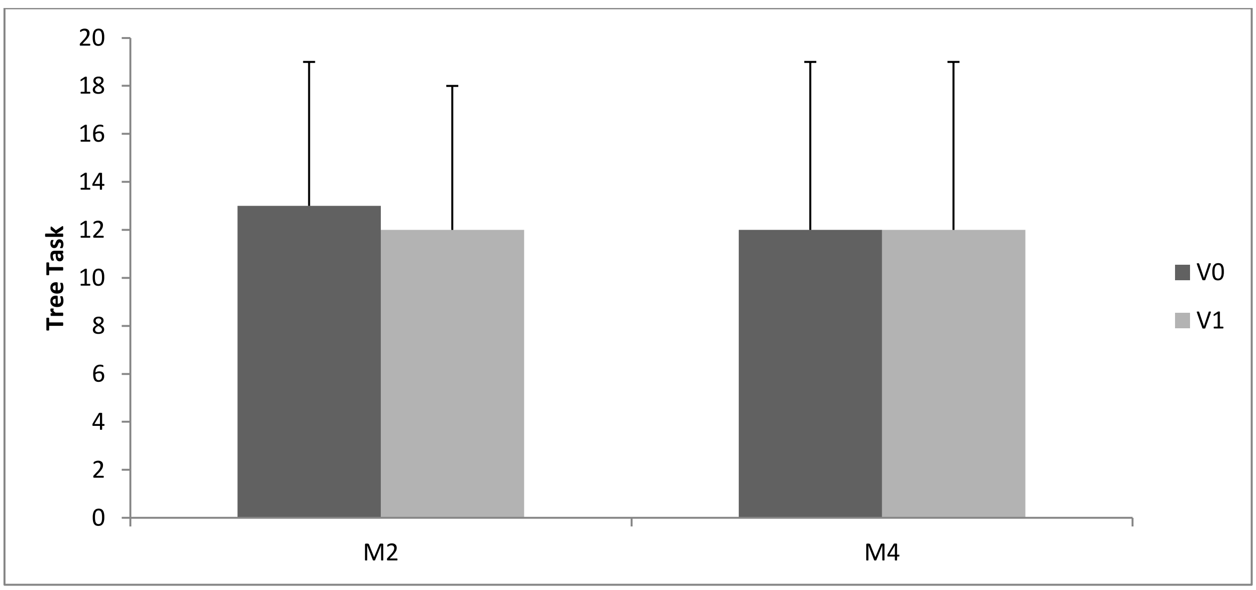

Figure 6. Changes in Executive Functioning Scores Between Groups over Time
Legend: M2; Multiple-Modality, M4; Multiple Modality, Mind Motor, V0; Baseline Visit, V1; 6-month visit.

Table 7. Associations between Executive Function and Mobility Variables

		Pearson Correlation	Sign. (2-Tailed)
Single Task	FAB Total	0.232	0.047**
	Velocity (m/s)	0.259	0.026**
	Step Length (cm)	0.162	0.167
	Stride Time Variability (%)	-0.113	0.336
Dual Task (SF)	Velocity (m/s)	0.322	0.005**
	Step Length (cm)	0.283	0.015**
	Stride Time Variability (%)	-0.277	0.017**
Dual Task (S7)	Velocity (m/s)	0.275	0.018**
	Step Length (cm)	0.217	0.063
	Stride Time Variability (%)	-0.304	0.008**

Legend: m/s; meters per second, DT; Dual-Task, SF; Semantic Fluency, S7; Serial Sevens, FAB; Fullerton Advanced Balance Scale, **; significant difference p<0.05.

4.3 Feasibility

Subject recruitment was collected in waves, to ensure proper focus amongst the participants, and limit overcrowding within the classes. Promotion of this research study was performed all throughout Woodstock, Ontario, with posters, local media advertisements, and friends and family being the primary modes of recruitment.

4.4 Adverse Events

Certain adverse events occurred that are often associated with a group exercise class. Knee pain (n=1), back pain (n=2), and lightheadedness (n=1) were observed in certain participants. One participant experienced mild syncope, suffering minor bruising to right elbow. After passive and active rest periods he/she was able to continue and complete the remainder of the class. A mild arrhythmatic attack was noted in an individual during exercise once their heart rate reached over the prescribed target heart rate. This participant performed light active cool down exercises to lower the heart rate and returned to complete the class once normal ranges were reached. Although certain participants did note adverse events, all were minor and treated with active and passive movements in order to return to the intervention.

Chapter Five. Discussion

As previously hypothesized, it was expected that significant improvements in gait, balance and executive functioning would be observed in those who participated in the M4 group. The findings in the study are not as originally expected. However, the present study did provide some insight into the improvement and maintenance of mobility among older adults, with a subjective cognitive complaint (SCC), while exposed to a multiple-modality (M2) exercise class in combination with a mind-motor (M4) task. Over the six month intervention there were significant differences noted in certain gait variables between groups under single (ST) and dual-task (DT). Some of these findings are as originally hypothesized, with changes occurring in the control group. However, the findings do show promise in future studies, and provide insight into the effects of exercise on mobility. Contrary to our original expectations, no significant differences were noted in EF, or balance variables. On the other hand, significant associations were made between EF and mobility variables. These associations provide positive insight into mind-motor application, and its effect on executive function and cognitive activation.

As the increasing risk of cognitive decline continues to grow with age, many challenges are beginning to arise. These include growing direct and indirect costs associated with these declines[4,5]. Cognitive decline has been associated with mobility issues including, but not limited to; increased gait variability leading to altered gait, decreases in balance and the inability to react to perturbations[17,35]. These mobility issues put increased strain on the health care system, as well as the individuals' independence[11]. Single task gait findings noted in this controlled trial, more specifically velocity, step length, and stride-time variability, are common across current literature[7,15,14,69,74,81]. Single task gait velocity, and step length showed significant differences between M2 and M4 with increases in M2 and declines in M4. However, the declines noted in

M4 still fell within the normal range. Gait velocity under 1m/s has been determined to be an objective measure of cognitive decline with a strong indication of mobility impairment amongst older adults[39]. In the presented study significant associations were made between EF and ST gait speed, providing insight into how cognitive performance effects our walking speed. Our study corroborated that of Wang et. al, noting similar improvements in ST gait velocity, step length and stride-time variability while exposed to a 12-week combined exercise program, performed three times a week for one hour[82]. Zhuang et. al, was able to conclude that performing combined exercise over 12-weeks will further yield improvements in gait velocity, step length and stride-time variability[83]. Improvements in gait velocity and step length were believed to be attributed to improvements in strength of the lower extremity[83,84]. Developing literature provides insight and explanations as to how combined exercise can improve gait velocity, step length and stride-time variability over a minimum of 12-week exposure. The six-month intervention performed in this presented study yields findings that are common with literature, further indicating that combined exercise incorporating strength, balance, and cardiovascular components help to improve certain gait variables in older adults. Brach et. al, noted that as gait speed and step length increases, stride-time variability should decrease in community dwelling older adults[40]. However, the findings in ST stride-time variability are uncommon, with a subtle increase in M2 with no change in M4. Stride-time variability has been associated with low function and performance[38]. Lower extremity function is affected by decreased strength, leading to further variances in stride time[38,85]. Combined exercise classes with a strength training component, performed at an increased maximal voluntary contraction, while also performing a greater number of lower body compound (i.e. squats), compared to isolated exercises (i.e. hip abduction), were able to note decreases in stride-time variability[82,83]. Whereas combined exercise classes focusing on lower impact, gradual progressive resistance training, while performing a greater amount of isolated exercises, yielded no changes in variability of stride-time[86,87]. Further explanations towards the lack of change in stride-time variability is increased time spent on the push-off phase of gait[88]. This usually occurs due to a decrease in strength of the plantar-flexor muscles[88]. The lack of change in stride-time variability could be attributed to the increase in time spent carrying out the pattern, focusing more on the next movement rather than maintaining continuous forward movement. Therefore, one may conclude that the cause of increased stride-time variability was due to a lack of muscle activation, along with insufficient intensity to cause greater strength development among older adults.

The dual task square stepping exercise (SSE) is a visuospatial working memory motor task used as our mind-motor intervention. Literature has provided insight into improvements in gait whilst performing single and dual-tasks[7,14,69,74,81]. Similar findings were noted in the presented study yielding significant differences between groups. Increases in velocity, step length, and decreased stride-time variability were noted in M2, with decreases in DT velocity, step length, and increases in stride-time variability in the M4 group. While exposed to naming and counting DT during balance training, Silsupadol et al. was able to determine that self-selected gait speed showed significant improvements[74]. After a six week verbal fluency and arithmetic dual-task walking intervention, there were no improvements in gait speed[81]. The difference in findings amongst these two studies may be caused by the interventions applied. As dual-tasks were applied during balance interventions, changes in gait variability were observed[74]. Findings are similar within our intervention as both M2 and M4 groups were exposed to components addressing balance. However, velocity, step length and stride-time variability was shown to have greater improvements in M2 group whilst exposed to serial sevens (S7) DT, with no significant improvements noted during exposure to semantic fluency (SF) DT. Improvements in stride-time variability were observed in M2 under both DT. These findings are also common, affirming an inverse relationship between increases in velocity and step length and declines in stride-time variability[40]. However, declines in gait velocity, step length and stride-time variability were observed in the M4 group. A pilot study was able to conclude that exposure to a 12-week strength-balance combined exercise program, did not improve dual-task gait velocity and step length, once combined with cognitive stimulating computerized tasks[89]. A six week DT training program performed on a treadmill yielded improvements in gait speed as well as cognitive functioning in older adults with greater risk of falls[90]. This program also indicated improvements in executive performance while exposed to dual-tasks[90]. These findings are common with our findings, as associations between EF and gait variables under both DT were observed. This further illustrates the connection between cognitive functioning and mobility performance under multiple DT. Executive function and attention are regularly mentioned in discussions regarding DT interventions, with attention being directly linked to an example of DT[72,91,92]. This can help to further explain the declines in gait noted in the M4 group. Tombu et al. developed a theory that explains why changes under dual-tasks can affect changes in gait[93]. The capacity-sharing theory states that as dual-tasking is performed the ability to maintain one task will lead to deterioration in the performance of the secondary task[93]. The SSE incorporates progressive stepping patterns, with progression not occurring until two consecutive trips of the same pattern are completed. The DT in this intervention is the ability to remember the presented stepping pattern, and then process, execute and maintain forward gait. Time of completion was not an outcome during performance of SSE. Due to this factor a decreased gait speed, and closer steps were performed in order to complete the tasks. With a decrease in these variables an increase in stride-time variability was observed, also an expected outcome amongst these variables[40]. Therefore, gait execution was the secondary task that was affected in M4. We attribute declines in gait to the greater attention placed on the completion of stepping patterns, along with limited muscle activation to allow for prolonged strength and power development.

The SSE mind-motor component was integrated as our intervention due to its ability to target lower extremity function and balance, while also stimulating cognition in older adults[75,76]. The SSE was performed in M4 to substitute for the balance component performed in M2, allowing the participants to receive balance training in each group. There were no significant differences between groups, over time in the balance outcome. However, improvements were observed in both groups. A reason for no significant change could be due to the higher baseline scores, not allowing for a significant change to occur. These findings are common during exposure to combined exercise, under DT[13,65,76]. After exposure to ST and DT feedback-based core resistance, exercise balance improvements were observed[94]. Core engagement provides the ability to maintain upright posture. A sway in posture can lead to increased perturbations, and difficulty maintaining movement[87]. A common example of a perturbation is walking, with core engagement and balance needed to maintain postural sway and single support stance[95]. Our intervention involved increased perturbations from continuous movement during pattern execution in M4, and balance components in M2. By doing so the core muscles were continuously engaged. Therefore, improvements in balance can be observed from improved core strength and endurance during balance interventions in both groups. Balance declines have also been noted as a variable in chronic disease populations who suffer from cognitive disorders such as Parkinson's disease (PD), Multiple-Sclerosis (MS), or Alzheimers disease (AD)[96,97,98]. An 8-week upper and lower body balance training program was shown to improve balance and dual-task gait performance in middle-aged PD patients[98]. Balance and functional performance also showed improvements in MS patients after performing static and dynamic balance exercises over

12-weeks[96]. A combined balance training program performed twice a week over three-months noted improvements in balance and gait functioning, among patients with Alzheimers' disease (AD)[97]. Findings such as these help to provide greater insight into how those experiencing cognitive decline, both in extreme cases, (PD, MS, AD) and early signs of decline (SCC), can benefit from specific exercise modalities including balance to improve mobility. The findings in the presented study show similar results. Significant associations were made between balance and EF, providing insight into how cognition can affect balance and the benefits of specific exercise on EF. The continuous activation of EF, and core stabilizers in our intervention will hopefully provide further insight into the use of cognitive activation during combined exercise, and its beneficial effect on improving balance.

A decline in EF has been associated with impaired mobility and gait[91]. Similar associations were made between EF and individual gait and balance variables, under ST and DT conditions, with exposure to our intervention. There were no clinically significant differences of EF observed in the presented study. It is expected that with exposure to combined exercise with a DT that cognitive domains such as EF will improve, among older adults[99]. Various interventions targeting specific variables such as cardiovascular, strength, coordination, and balance, were effective in targeting and improving cognitive function, as well as EF[100,101,102]. Therefore, the combination of various modalities will also help to further improve EF among older adults[48,99]. Erickson et al. was able to determine that upon exposure to aerobic exercise training, hippocampal volume had increased in those diagnosed with dementia[103]. Findings such as these provides insight into the physiological adaptations derived from exercise. The discrepancies in findings between M2 and M4 regarding our EF variables can be attributed to the cognitive activation from our intervention. As previously mentioned, EF activation was observed whilst performing a dual-task[91], however no change was observed in the M4 group, with a slight decrease in the M2 group. These discrepancies of findings could be due to the belief that EF was not the primary area of cognitive activation. Under DT conditions EF is usually activated to a greater extent compared to ST[91.] Therefore, it is believed that the SSE is not a DT, but rather a ST. Upon breaking down the mind-motor task it is essentially just a single task. The visuospatial working memory task is a ST intervention due to the only task being executed is the progressive stepping patterns, this was not as previously thought. Furthermore, the EF variable assessed was not the appropriate cognitive domain to assess cognitive improvement from this intervention. During exposure to the SSE attention was the cognitive domain shown to improve in non-demented older adults[104]. With attention being the cognitive domain primarily activated under ST[91] this further allows for the conclusion that the SSE is a ST and alternate cognitive domains should be explored. The significant associations made in this intervention study provide further evidence that EF is related to single and dual-task gait performance, as well as balance. EF activation is critical in combined exercise, to maximize improvements in gait and balance amongst older adults, and with greater emphasis in dual-tasking in combination with exercise to improve EF domains.

5.1 Limitations

The intensity at which the SSE was performed was limited, not allowing for the maintenance of a pre-determined target heart rate, and strenuous muscle activation. If a mind-motor intervention had been used that was able to maintain an increased heart rate, with increased development of strength and power during cognitive activation, perhaps further significant improvements in cognition and mobility would have been noted. One component of the execution of gait is the ability to maintain balance, and lower extremity movement. This is caused by skeletal muscle activation. Therefore, further assessment and tracking of specific properties (i.e. motor units) of the musculoskeletal system during exposure to combined exercise would have allowed for an explanation of the change. Further, in the presented study there was a lack of exploration of different cognitive domains during the intervention. The use of an MRI would be useful in identifying the specific areas of activation during dual-tasks or the performance of the cognitive computer games. If insight into improvements in specific cortical areas were explored, perhaps a greater explanation as to why there were improvements in one group (M2) rather than the other (M4), with enough attention being provided to those areas causing specific improvements in mobility, and EF variables. A non exercise control group was not implemented in this study. One would be recommended to allow to track changes made from just the exercise intervention and if benefits from exercise are prevalent. A comparable frequency, intensity and time is recommended for all exercise components incorporated into multiple-modality exercise studies. There was a substantially larger number of women than men in the study and a more balanced sample would have been desirable. This study was also slightly under powered. However, the larger study is still in progress with 12-month data being collected on these variables as well as the primary variables within the larger study. With 12-month data being collected we hope to further notice significant changes amongst the examined variables.

5.2 Conclusion

The findings presented in this study help to provide insight into the effectiveness of multiple-modalities in combination with a mind-motor task, on improvements in gait and balance. With significant improvements in gait variables being noted in the control group further exploration into mind-motor tasks that also target gait improvements is recommended. Future research should explore and refine mind-motor tasks further including ways in which intensity can be maintained or even increased whilst also performing cognitive tasks. Increased duration being spent on strength, power and balance development are also recommended in future combined exercise interventions to allow further improvements in gait and balance. Examining these in further detail help to provide greater physiological adaptations to musculoskeletal properties, leading to further improvements in the mechanisms involved in mobility. In conclusion, this multiple-modality, mind-motor intervention did show improvements in gait, balance and executive functioning amongst older adults with subjective cognitive complaints. However, clinically significant differences were only observed in single and dual task gait variables, with clinically significant associations made on EF and mobility variables. These associations also help to provide insight into how EF performance can affect mobility performance. Therefore, future multiple modality mind-motor studies should explore further areas of cognition that also affect mobility. By doing so proper implementation can be placed on interventions addressing improvement of various areas of cognition. This intervention can be implemented in confidence with beneficial effect. Future interventions such as these should be explored to further improve cognitive and mobility functioning, while also building a threshold to prevent declines.

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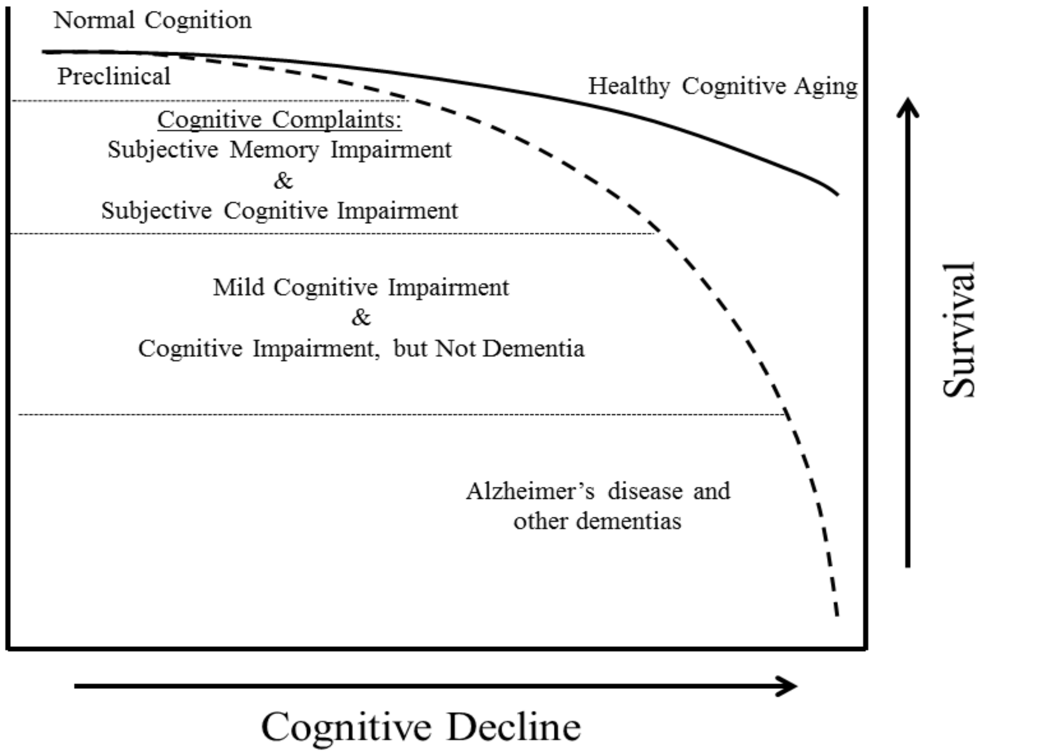
Appendix A.



Adapted from: Jessen F, et. al., (2013) AD dementia risk in late MCI, in early MCI, and in subjective memory impairment. *Alz & Dement*, 1-8.

Figure 7. The cognitive continuum in Aging and Dementia

i) Beginner Pattern – focused on walking-like movements and simple steps

Start Walk									**Finish Walk**
	2		**4**		**2**		**4**		
		3		**6**		**3**		**6**	
	1		**5**		**1**		**5**		

ii) Intermediate Pattern – incorporates forward, lateral and diagonal movements

Start Walk	**3**	**5**	**3**	**5**	**3**	**5**	**3**	**5**	**Finish Walk**
	1	**4**	**1**	**4**	**1**	**4**	**1**	**4**	
	2	**6**	**2**	**6**	**2**	**6**	**2**	**6**	

iii) Advanced Pattern – a large number of steps per pattern with multiple movement types

Start Walk									**Finish Walk**
	1	**3**	**7**	**5**	**1**	**3**	**7**	**5**	
	4	**2**	**6**	**8**	**4**	**2**	**6**	**8**	

Figure 8. SSE Stepping Patterns

Task Name	Cognitive Domain	Brief Description	Outcome Measure	Literature Informing Task
Hampshire Tree Task (Spatial Planning)	Planning	Numbered beads are positioned on a tree shaped frame. The participant repositions the beads so that they are configured in ascending numerical order running from left to right and top to bottom of tree	Total score (After each trial, the total score is incremented by adding the minimum number of moves required x2- the number of moves actually made, thereby rewarding efficient planning)	Based on Tower of London Task- widely used to measure executive function (Shallice, 1982).

Figure 9. Hampshire Tree Task Description

M2: Multi-Modality Exercise Training (Exercising Control)	M4: Multi-Modality, Mind-Motor Exercise Training (Exercising Intervention)
5 minute warm-up - light aerobics - dynamic range of motion of the major joints	**5 minute warm-up** - light aerobics - dynamic range of motion of the major joints

25 minutes Aerobic Exercise
- large rhythmical endurance activities
    - walking, marking, sequenced aerobics
- moderate to vigorous intensity
    - target heart rate zones of 65-80%
    - perceived exertion 4-7 (modified Borg Scale 0-10)
	25 minutes Aerobic Exercise
	- large rhythmical endurance activities
	    - walking, marking, sequenced aerobics
	- moderate to vigorous intensity
	    - target heart rate zones of 65-80%
	    - perceived exertion 4-7 (modified Borg Scale 0-10)

5 minute Aerobic Cool Down	**5 minute Aerobic Cool Down**
15 minutes Resistance Training - all major muscle groups - hand weights and resistance bands, and core strengthening	**15 minutes Resistance Training** - all major muscle groups - hand weights and resistance bands, and core strengthening
10 minutes Balance Training - dynamic static and functional balance training	**5 minutes Balance Training** - dynamic static and functional balance training
10 minutes Stretching	**5 minutes Stretching**
5 min Breathing Exercises	**15 minutes Mind-Motor Training** - Square Stepping Exercise
TOTAL: 75 minutes **75 min** Multi-Modal Exercise Training	**TOTAL: 75 minutes** **60 min** Multi-Modal Exercise Training **15 min** Mind-Motor Training

Figure 10. Exercise Allocation

Appendix B.

Western Research

Research Ethics

Use of Human Participants - Revision Ethics Approval Notice

Principal Investigator: Dr. Robert Petrella
File Number: 102434
Review Level: Delegated
Protocol Title: Aerobic and Cognitive Exercise in Community-Dwelling Older Adults (REB# 18858)
Department & Institution: Schulich School of Medicine and Dentistry\Geriatric Medicine, Western University
Sponsor: Canadian Institutes of Health Research

Ethics Approval Date: October 11, 2013 **Expiry Date:** December 31, 2014
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	includes July/2013 and Sept/2013 amendment-Received Sept 19, 2013	
Instruments	Phone-FITT (received Sept 19, 2013)	
Instruments	Description of 12 Cognitive tasks from Cambridge Brain Sciences Battery-Received Sept 19, 2013	
Recruitment Items	Poster for Parkwood Cohort-Received Sept 19, 2013	
Recruitment Items	Poster for South Gate Centre Cohort-Received Sept 19, 2013	
Recruitment Items	Telephone Script-Received Sept 19, 2013	
Revised Letter of Information & Consent	Parkwood Cohort	2013/09/03
Revised Letter of Information & Consent	South Gate Centre Cohort	2013/09/03

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 revision(s) or amendment(s) 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 University of Western Ontario Updated Approval Request Form.

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.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

LAWSON HEALTH RESEARCH INSTITUTE

FINAL APPROVAL NOTICE

RESEARCH OFFICE REVIEW NO.: R-12-265

PROJECT TITLE: HM2: Healthy Mind, Healthy Mobility - Dual-task Aerobic Exercise for Older Adults with Cognitive Impairment

PRINCIPAL INVESTIGATOR: Dr. Robert Petrella

DATE OF REVIEW BY CRIC: June 12, 2012

Health Sciences REB#: 18858

Please be advised that the above project was reviewed by the Clinical Research Impact Committee and the project:

Was Approved

PLEASE INFORM THE APPROPRIATE NURSING UNITS, LABORATORIES, ETC. BEFORE STARTING THIS PROTOCOL. THE RESEARCH OFFICE NUMBER MUST BE USED WHEN COMMUNICATING WITH THESE AREAS.

Dr. David Hill
V.P. Research
Lawson Health Research Institute

All future correspondence concerning this study should include the Research Office Review Number and should be directed to Sherry Paiva, CRIC Liaison, LHSC, Rm. C210, Nurses Residence, South Street Hospital.

cc: Administration

ClinicalTrials.gov PRS
Protocol Registration and Results System

ClinicalTrials.gov PRS DRAFT Receipt (Working Version)
Last Update: 06/10/2015 14:44

Body and Brain Exercise for Older Adults With Memory Complaints

This study is ongoing, but not recruiting participants.

Sponsor:	Lawson Health Research Institute
Collaborators:	Canadian Institutes of Health Research (CIHR)
Information provided by (Responsible Party):	Rob Petrella, Lawson Health Research Institute
ClinicalTrials.gov Identifier:	NCT02136368

Purpose

The purpose of this study is to investigate whether an exercise class with a cognitive (or brain) training component was more effective than a usual combined aerobic and resistance exercise class for older adults with cognitive complaints (such as concerns about changes in memory or thinking skills). It is hypothesized that the group randomized to the exercise class that includes additional brain training will have greater improvements in brain health.

Condition	Intervention	Phase
Cognitive Ability, General	Behavioral: Multi-modal exercise Behavioral: Mind-Motor Exercise Behavioral: Balance and range of motion exercises	N/A

Study Type: Interventional
Study Design: Prevention, Parallel Assignment, Single Blind (Outcomes Assessor), Randomized, Efficacy Study
Official Title: A Combined Exercise Program Plus Cognitive Training for Older Adults With Self-reported Cognitive Complaints: The Multi-modal, Mind-motor (M4) Study

Further study details as provided by Rob Petrella, Lawson Health Research Institute:

Primary Outcome Measure:

- Composite score from Cambridge Brain Sciences Cognitive Battery - 12 tasks [Time Frame: 6 months] [Designated as safety issue: No]
  To assess global cognitive function

Secondary Outcome Measures:

- Composite score from Cambridge Brain Sciences Cognitive Battery - 12 tasks [Time Frame: 12 months] [Designated as safety issue: No]
  To assess global cognitive function
- Gait variability (stride time) under dual-task conditions [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Gait variability is the stride-to-stride fluctuations of the way someone walks and will be calculated as the coefficient of variation of step length (SD/mean x100). Measured with GAITRite system.

- Gait variability (stride time) under single-task conditions [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Gait variability is the stride-to-stride fluctuations of the way someone walks and will be calculated as the coefficient of variation of step length (SD/mean x100). Measured with GAITRite system.
- Gait velocity (speed) under dual-task conditions [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Average walking speed (gait velocity) measured with the GAITRite system
- Gait velocity (speed) under single-task conditions [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Average walking speed (gait velocity) measured with the GAITRite system
- Step length (average) under dual-task conditions [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Mean step length calculated from GAITRite system
- Step length (average) under single-task conditions [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Mean step length calculated from GAITRite system
- Carotid Artery Compliance [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Measured from non-invasive vascular assessment with B-mode Ultrasound over the carotid artery (in the neck).
- Carotid Artery Intima-media thickness [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Measured from non-invasive vascular assessment with B-mode Ultrasound over the carotid artery (in the neck).
- Ambulatory Systolic Blood Pressure [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Average systolic blood pressure over a 24 hour time period.
- Clinic Systolic Blood Pressure [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Average systolic blood pressure from in clinic final 2 (out of 3) readings
- Ambulatory Diastolic Blood Pressure [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Average diastolic blood pressure over a 24 hour time period.
- Clinic Diastolic Blood Pressure [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Average diastolic blood pressure from in clinic final 2 (out of 3) readings
- Composite score of memory tasks from Cambridge Brain Sciences Cognitive Battery [Time Frame: 6 & 12 months] [Designated as safety issue: No]
- Composite score of executive function tasks from Cambridge Brain Sciences Cognitive Battery [Time Frame: 6 & 12 months] [Designated as safety issue: No]
- Composite score of concentration tasks from Cambridge Brain Sciences Cognitive Battery [Time Frame: 6 & 12 months] [Designated as safety issue: No]
- Total balance score [Time Frame: 6 & 12 months] [Designated as safety issue: No]
  Total score calculated from the the Fullerton Advanced Balance scale

Other Pre-specified Outcome Measures:

- Prosaccade reaction time in response to flash of light. [Time Frame: 6 months] [Designated as safety issue: No]
  The reaction time of the eye when instructed to look toward a flash of light.
- Change in blood flow to the pre-frontal cortex in response to a randomly selected cognitive task. [Time Frame: 6 months] [Designated as safety issue: No]
  Neuroimaging assessment with functional magnetic resonance imaging
- Antisaccade reaction time in response to flash of light. [Time Frame: 6 months] [Designated as safety issue: No]
  The reaction time of the eye when instructed to look away from a flash of light.
- Change in blood flow to the parietal cortex in response to a randomly selected cognitive task. [Time Frame: 6 months] [Designated as safety issue: No]
  Neuroimaging assessment with functional magnetic resonance imaging

Estimated Enrollment: 140
Study Start Date: January 2014
Estimated Primary Completion Date: October 2015
Estimated Study Completion Date: April 2016

Arms	Assigned Interventions
Experimental: Multi-Modal, Mind Motor Exercise (M4) Attend 60 minute exercise class three times per week for 24 weeks. Exercise class includes 45 minutes of multi-modal exercise and 15 minutes of mind-motor exercise.	Behavioral: Multi-modal exercise Community-based group exercise classes following Canadian Centre for Activity and Aging exercise guidelines. Exercise classes consist of 5 min warm-up, 20 min aerobic exercise, 5 min aerobic cool-down, 10 min full-body resistance exercise, 5 min stretching (total 45 min) Other Names: Exercise intervention Behavioral: Mind-Motor Exercise Square Step Exercise involves mimicking a stepping pattern demonstrated by an instructor. The stepping patterns become progressively difficult and involve forward, backward, lateral and diagonal movements on a 250cm long mat with 25cm square grids (15 min). Other Names: Square Stepping Exercise
Active Comparator: Multi-Modal Exercise (M2) Attend 60 minute exercise class three times per week for 24 weeks. Exercise class includes 45 minutes of multi-modal exercise and 15 minutes of balance and range of motion exercises.	Behavioral: Multi-modal exercise Community-based group exercise classes following Canadian Centre for Activity and Aging exercise guidelines. Exercise classes consist of 5 min warm-up, 20 min aerobic exercise, 5 min aerobic cool-down, 10 min full-body resistance exercise, 5 min stretching (total 45 min) Other Names: Exercise intervention Behavioral: Balance and range of motion exercises Community-based group exercise designed to improve balance and range of motion of the joints (15 min)

Detailed Description:

Older adults with self-reported cognitive complaints (CCs) may be at increased risk for the development of Alzheimer's disease and dementia. Cognitive decline in older adults, particularly reduced memory and executive function is associated with functional decline, institutionalization, and increased health care costs. Similarly, cardiovascular risk factors have been associated with cognitive and functional impairment in aging. Aerobic exercise has been shown to improve vascular function and blood flow in the brain's prefrontal cortex. In turn, resistance training can produce functional changes within distinct cortical regions during the encoding and recall of association tasks and has been shown to increase circulating neural growth factors (i.e., a proposed mechanism by which cognition may be preserved or improved in old age). Recent evidence also suggests that cognitive training may improve the cognitive performance of older adults.

Therefore, we will investigate the impact of a combined exercise program (multi-modality exercise; M2) compared to a combined exercise program with a cognitive component (multi-modality, mind-motor exercise; M4) on cognition, cognitive-motor, mobility, neural functioning and vascular outcomes in older adults with cognitive complaints. Community-based exercise programs for older adults provide widespread access, are relatively inexpensive, and provide opportunities for social interaction.

The primary purpose of this study is to compare the effects of the M2 and M4 exercise programs on brain health. This study will also examine the effects of the different exercise programs on cardiovascular risk factors and mobility. In a subset of participants, cognitive-motor and neural functioning outcomes will be examined.

Eligibility

Ages Eligible for Study: 55 Years and older
Genders Eligible for Study: Both
Accepts Healthy Volunteers: Yes

Criteria

Inclusion Criteria:

- aged 55 years or older
- self-reported cognitive complaint (defined as answering yes to the question "Do you feel like your memory or thinking skills have gotten worse recently?).
- independent on instrumental activities of daily living

Exclusion Criteria:

- Probable Dementia (i.e., diagnosis OR Mini-Mental State Examination score <24)
- Other neurological conditions or major psychiatric disorders (i.e., Parkinson's disease; bipolar disorder)
- Previous history of severe cardiovascular conditions (i.e., myocardial infarction or stroke <1-year ago; end stage congestive heart failure; end stage renal disease)
- Severe sensory impairment (i.e., blind)
- Significant orthopedic conditions (i.e., severe osteoarthritis)
- Clinical depression (determined via >=16 on the Center for Epidemiologic Studies - Depression Scale AND review by primary study physician)
- Have blood pressure >180/100 mmHg or <100/60 mmHg
- Unable to comprehend questionnaire material
- Any other factors that could potentially limit ability to fully participate in the intervention

Contacts and Locations

Locations
Canada, Ontario
Gymnasium
Woodstock, Ontario, Canada, N4V 0B1

Investigators

Principal Investigator:	Robert J Petrella, MD, PhD	The University of Western Ontario

More Information

Responsible Party:	Rob Petrella, Principal Investigator, Lawson Health Research Institute
Study ID Numbers:	M4W18858
Health Authority:	Canada: Institutional Review Board

Curriculum Vitae

Name	John P. Bocti
Post-Secondary Education and Degrees	George Brown College Toronto, Ontario 2007-2009. Advanced College Diploma in Fitness and Lifestyle Management
	University of British Columbia Kelowna, British Columbia 2010-2013. Bachelor of Human Kinetics
	University of Western Ontario London, Ontario 2013-Present. M.Sc Candidate (Health and Rehabilitation Sciences)
Honours and Awards	Dean's Honour Roll 2012
Related Work/Volunteer Experience	Laboratory Assistant Healthy Exercise and Aging Lab University of British Columbia 2012
	Exercise Physiologist Cardiovascular Rehabilitation Unit Toronto Western Hospital 2012
	Research Assistant Healthy Exercise and Aging Lab University of British Columbia 2013
	Teaching Assistant Physical Therapy, Therapeutic Modalities University of Western Ontario 2013-2014
	Research Assistant Aging, Rehabilitation and Geriatric Care Research Center Parkwood Institute 2013-Present

Academic Presentations

HM2: Effects of combined aerobic exercise and dual-task training on gait variability in community-dwelling older adults. (Oral/Poster)
ARGC/HRS Symposium
February 2014