Specificity of Exercise on Enhancing Cognitive Abilities:
Argentine Tango and Walking

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ABSTRACT

The objective of this feasibility study was to determine for the elderly at-risk for falls the effects of a 10-week program in Argentine Tango dancing or Walking on cognition. Thirty healthy community dwelling seniors (60+) were recruited to take part in the study. They were evaluated at baseline, post-intervention and follow-up on divided attention (Walking-While-Talking) and working memory tasks. It was found that Tango dancing significantly improved divided attention capabilities while the Walk program significantly improved working memory. These findings need to be replicated with a larger number of subjects.
L’objectif de cette étude de faisabilité était de déterminer les effets d’un programme de 10 semaines de Tango argentin ou de marche sur les fonctions cognitives de personnes âgées à risque de chutes. Trente personnes âgées en bonne santé et de la communauté étaient recrutées pour assister à l’étude. Ils étaient évalués au niveau de référence, post-intervention et suivi sur des tâches d’attention partagée (parler en même temps que marcher) et de la mémoire de travail. L’étude a trouvé que la danse Tango a significativement amélioré les capacités d’attention partagée alors que le programme de marche a significativement amélioré la mémoire de travail. Ces résultats doivent être répliqués en utilisant un plus grand nombre de participants.
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1. INTRODUCTION

The Canadian society is growing older each year as the number of seniors living is increasing at a higher rate than their younger counterparts. To keep older adults physically and mentally healthy, it is imperative that they stay active and fit. A healthy lifestyle centered on physical activity helps to maintain seniors' quality of life and independence, as their health is intricately related to their independence. The infamous “use it, or lose it” theory applies directly to older adults because if seniors do not stimulate their cognitive and physical faculties, they will experience measurable decline in these abilities. However, despite government initiated programs to raise awareness about being active and pro-exercising advertising campaigns, approximately 60% of older adults in Canada are physically inactive (Statistics Canada, 2006). Low levels of physical activity reduce seniors’ aerobic capacity and strength, thereby lowering their functional independence and augmenting disuse atrophy of their muscles, consequently elevating fall risk. This relationship positively feeds back on the amount of exercise older adults engage in, resulting in a vicious cycle of decreasing levels of physical activity and escalating risk for falls (Figure 1).

There is a great need for an exercise program to be implemented in the community setting that is both sustainable and motivating for seniors.
Integrating a social component within the exercise intervention is also necessary as many older adults live alone and spend between 5 to 10 hours a day without any human contact (Statistics Canada, 2002). The Argentine Tango was chosen as such a leisure-based exercise program for numerous reasons. The Tango is improvisational and the dancers need to be creative as they dance, combining the steps they have learned while keeping in time and pace with the music. Both the leader and the follower must communicate with one another, their cues are signaled either by the pressure on the follower's back, leader's chest or upper arm in order to flow across the dance floor.

Tango is particularly challenging as an intellectual and postural exercise; to avoid other couples and maintain an overall counterclockwise progression, partners must navigate in the immediate space while anticipating where they will be moving, and, at the same time, respond to each other to perform the dance components in an improvised manner. They have to anticipate what others will be doing in the dance space, execute their own step sequence without bumping into another couple, and maintain independent postural control. This situation makes it difficult to predict in advance the sequence of movements to be performed. As partners are encouraged to exchange roles during the learning of Tango steps, both partners will gain experience in being the leader and follower,
eliminating the need to have equal numbers of men and women. In addition, Tango instruction also focuses on individual practice for the dual purpose of learning steps and for practicing balance maintenance, as it is critical that each partner maintain stability and balance without leaning on the other partner. These two elements of constant unpredictability and postural alignment are unique to the Argentine Tango instruction as other ballroom dancing classes focus on set combinations of steps or very routine steps that are repetitive. Line dancing is even more stereotypic and although it is social in nature, it does not require interaction between partners. In short, Tango is unpredictable because of the inter and intra partner interactions and the progression in the line of dance of everyone on the floor; it therefore has an increased cognitive load related to navigation in space, and rotation and can serve to focus attention on maintenance of balance when experiencing multidirectional perturbations.

As well, dancing is a fun, social activity that is in stark contrast to many of the exercise programs currently available in the community which are individually-based and introspective activities such as Tai Chi, yoga or gym circuit training. Furthermore, as a physical activity, Tango targets three important elements that are crucial for seniors to lead a healthy and active lifestyle: balance and mobility, cognitive skills and the promotion of social integration. Since the Tango generates specific, attainable goals,
such a program would incorporate social support and self-efficacy factors that would entice older adults to be motivated and continue exercising. Sustainability of these types of activities for this population is critical in prevention of isolation, physical decline and quality of life. It is of utmost importance that we promote physical activity which is also cognitively stimulating that will engage older adults and motivate seniors to keep active.
Figure 1. Relationship between physical activity and fall risk in the elderly

Illustration of the relationship between low levels of physical activity in the elderly which leads to increased risk for falls.
2. REVIEW OF THE LITERATURE

The elderly population is rapidly growing in Canada. According to the Annual Demographic Statistics, the total number of seniors (aged 65+) was approximately 5.7 million persons in 2005 (Statistics Canada, 2006). Seniors account for 17.8% of the total Canadian population, a percentage that has been steadily rising since 1981 and is expected to reach 22.6% by the year 2041 (Colin, 1999). The growing trend of older adults living in Canada in turn leads to an increased work load for medical and rehabilitation professionals, as the elderly are more likely to be hospitalized than any other age group (Statistics Canada, 2006). Once they are hospitalized, the length of stay of older adults (65+) is much longer than that of younger individuals (>65), an average of 17 days compared to averages between 3 to 8 days respectively (Colin, 1999). This increased use of the health care system entails greater costs due to hospital stays and procedures, treatment, medication, and home and residence care. Extended periods in hospitals result in more time spent on
bed rest, further exacerbating the associated risks of aging: osteoporosis, incontinence, deconditioning, and diminished functionality and mobility (Gill, Allore, & Guo, 2004). Among the elderly population, 38.6% of individuals aged 65-84 and 75.2% of people aged 85 and up have functional disabilities (Hogan, Elby, & Fung, 1999). Consequently, ways need to be found to reduce hospital stays and long periods of bed rest in this population.

2.1 SENIORS: AT-RISK FOR FALLS

In the elderly population, the reason for 10% of trips to the emergency room and 6% of urgent hospitalizations is a fall (Tinetti, 2003). Fall risk escalates as people age; approximately 1/3 of community dwelling older adults experience at least one fall per year, and this rate of falling increases by 10% for the population over 85 years of age (Tinetti, Speechley, & Ginter, 1988). As well, the first fall experienced by an older individual puts this person at risk for subsequent falls. If a person falls and sustains an injury, these injured fallers are 3 times more likely to use
hospital services and 16 times more likely to be placed into a nursing care facility than nonfallers (Rizzo et al., 1998). Concomitantly, there is a monotonic increase in hospital utilization costs associated with the severity of falls. The current cost in terms of health care and associated expenses is already large, as approximately 1 billion dollars is spent on treatment for seniors who have fallen (National Advisory Council on Aging, 1999). These costs will continue to grow as the baby boomer generation ages unless concrete programs are developed to decrease fall risk in this population. In fact, the annual cost of hospital fees for fallers who experienced an injury from a single fall is $988 more than for nonfallers, the total overall cost coming to an additional $2,500. The cost rises even more dramatically (Rizzo et al., 1998) as the number of falls experienced increases (2 falls, additional $4,175/year, total $11,900 more than nonfallers). SMARTRISK (1998) estimated that a reduction of twenty percent in falls by seniors would result in a savings of 138 million every
year, as it would decrease the number of hospitalizations and the number of people becoming permanently disabled over the age of 65.

2.2 ROLE OF COGNITION

There are many well documented risk factors for falls. While they include the obvious and publicized factors such as medication, functionality problems affecting the lower extremities, proprioception, low body mass index, balance and gait abnormalities, one of the most influential but lesser known risk factors is cognitive impairment (Alexander, Ashton-Miller, Giordani, Guire, & Schultz, 2005; Tinetti, 2003; Tinetti et al., 1988). The cognitive status of an individual is a critical issue as cognitive processes are heavily involved in the regulation of ambulation and movement in one’s everyday life. In situations where an older person is walking, the attentional costs of walking decrease the amount of attention that the person can allocate to a secondary task. Evidence of these increased attentional demands for the elderly while walking can be seen in their increased reaction time to a secondary stimulus (Sparrow, Bradshaw,
Lamoureux, & Tirosh, 2002). Brown, Shumway-Cook and Woollacott (1999) ascertained that the maintenance of one’s posture requires and is dependent on a person’s attentional capacities. This study also demonstrated that older adults necessitate greater attentional resources than younger adults when trying to stay upright following a perturbation. The competing demands on an older adult’s attention may lead them to experience a greater number of falls. Chen, Ashton Miller, Alexander, and Schultz (1994) found that while walking, older adults have more difficulty at avoiding obstacles than young adults. Older adults take significantly longer to perceive an obstacle in their way; their chances of veering away from an obstacle’s path decreases if there is only a short amount of time to notice it, for example, if the obstacle suddenly pops up. In a recent study (Schrodt, Mercer, Giuliani, & Hartman, 2004), elderly subjects were able to walk around an obstacle and accomplish a cognitive secondary task simultaneously. However, the obstacle was present at the beginning of testing and the participants were well aware of it. As such, they were able
to prepare themselves in advance for the upcoming obstacle. Schrodt et al. (2004) suggest that it is possible older adults have trouble avoiding obstacles when their attention is divided and a time constraint is felt. Schrodt et al. (2004) did observe that the older adults prioritized the maintenance of their stability, gait and ability to avoid obstacles over the secondary cognitive task. Shumway-Cook, Woollacott, Kerns, and Baldwin's 1997 study demonstrated that by adding a cognitive task or decreasing the stability of the surface that older adults are standing on, older adults will have an increasingly hard time at maintaining their upright posture. Therefore, when older adults try to stand upright while their posture is being challenged, simple cognitive tasks can adversely affect their ability to maintain their equilibrium. This type of situation is present in everyday life, for example, crossing an icy street in the winter while talking with a friend, or when carrying groceries. In environmental circumstances which threaten posture and stability, older adults will choose maintaining their posture their priority at the expense of accomplishing a secondary
task (Brown, Sleik, Polych, & Gage, 2002). This is because the elderly perceive the consequences of a fall to be severe.

2.3 CONSEQUENCES OF FALLING FOR SENIORS

The consequences of falls in the elderly are numerous. Falling can result in sprains, strains, fractures and even death (King, & Tinetti, 1995). Hip fractures, in particular, are extremely incapacitating for seniors. One year following a hip fracture, 40% of seniors are not able to walk independently, requiring a cane or walker to assist them while another 60% have difficulty performing essential activities of daily living, such as getting dressed and/or going to the bathroom (Public Health Agency of Canada, 2005). Twenty percent of the elderly are placed into long term care facilities after breaking their hip as their spouse or family can no longer care for them adequately. The mortality risk following hip fractures is estimated to be between 11.5% and 15% (Parker, & Anand, 1991; Richmond, Aharonoff, Zuvkerman, & Koval, 2003). Hip fractures and the associated costs and consequences will continue to plague Canadian
society as its population ages. Furthermore, falling and the fear of potential injuries greatly affect the confidence of elderly individuals which can lead to restricted activity and social isolation. Seniors begin to avoid leaving their homes for fear of hurting themselves. While being homebound can result in further deconditioning, this lack of mobility also leads to additional costs for social services for these house-bound seniors and isolation, which can put them at risk for cognitive impairment. This aspect is important as cognitive abilities play an instrumental role in activities of daily living, particularly in the domains of divided attention and working memory.

2.4 EXERCISE AND FALL PREVENTION

In their examination of systematic reviews, Sherrington, Lord, and Finch (2004) found mounting evidence that group exercise interventions that target balance can reduce the incidence of falls among the elderly living in the community. In addition, using exercise as a means of reducing the risk for falls in older adults has been confirmed with several meta-
analyses (Chang et al., 2004; Hill-Westmoreland, Soeken, & Spellbring; Province et al., 1995). A randomized clinical trial (Barnett, Smith, Lord, Williams, & Baumand, 2003) reinforced the conclusions of the aforementioned meta-analyses as the researchers found that a group exercise program significantly reduced the rate of falls. Several studies using Tai Chi as an exercise intervention for older adults have shown improved postural (Tse, & Bailey, 1991), biomedical and psychosocial parameters as well as reducing fear of falling and rate of falls in seniors (Wolf et al., 1996). Tai Chi also positively effects physical functioning and self efficacy for older adults (Li et al., 2001). Improved flexibility, balance and total body strength have resulted from walking and resistance training program in the elderly (Simons, & Andel, 2006) while walking on a regular basis has been shown to ameliorate postural control in seniors (Melzer, Benjuya, & Kaplanski, 2003). These studies did not elaborate on the mechanism responsible for the reduction in the number of falls in the
elderly, as their primary objective was to determine the efficacy of the exercise program of preventing falls.

2.5 DIVIDED ATTENTION, AGING, AND FALL RISK

2.5.1 Definition of Divided Attention

Signalling to change lanes while driving, or double checking a recipe when stirring ingredients into a pot are just two examples of daily situations that require individuals to divide their attention efficiently. Divided attention is the ability of being able to focus and complete different tasks concurrently. Multi-tasking has become widespread in this era of increasingly sophisticated technologies, and the ability to accomplish more than one task simultaneously is of increasing importance for completion of daily tasks.

2.5.2 Attention and Aging

While taken for granted in many situations, multi-tasking can be demanding on the cognitive resources of an elderly person. This aspect has been especially well studied in driving using percentage of Useful
Field of Vision (UFOV) to measure divided attention capacity. In one study (Ponds, Brouwer, & van Wolffelaar, 1988), it was found that ability to divide attention weakens as one ages, as older subjects performed significantly worse than young and middle-aged participants on a dual task paradigm that simulated driving. A follow-up study (Brouwer, Waterink, van Wolffelaar, & Rothengatter, 1991) concluded that the reason for the poor divided attention skills in older individuals was due to impaired response integration abilities. Another driving study (Owsley et al., 1988) found that UFOV was a significant predictor for crash risk. Older adults who drive with large reductions in the percentage of UFOV (40% or more) were twice as likely to be involved in a car crash than older individuals whose UFOV was less reduced. Deficits in the divided attention component of the UFOV, in comparison to disabilities in selective attention and speed of processing, demonstrated a statistically significant augmented risk of being part of a car accident. Due to the cognitive
disadvantage suffered by the elderly, they must work even harder to maintain divided attention.

2.5.3 Attention and Balance

More recently, interest has revolved around the impact of divided attention tasks and balance maintenance, as this ability may be critical for reducing fall risk. For example, being able to avoid obstacles is dependent on one’s divided attention capacity, as it was shown that in older adults, the percentage of UFOV (Broman et al., 2004) is associated with colliding with objects while walking. Poor divided attention and visual processing skills, represented by large reductions in the percentage of UFOV, signified greater levels of bumping while walking. Owsley and McGwin’s study (2004) focused on the role of visual attention in relation to mobility in older adults. It was found that deficits in divided attention contribute to the problems that the elderly experience with ambulation and movement even after taking other covariates (such as age, sex and cognitive status) into consideration. This finding has direct implications on
the design of geriatric interventions which need to target divided attention, as this capability profoundly impacts older individuals' locomotion. Verghese et al. (2002) ascertained that the time needed to complete a divided attention task predicted falls in older individuals. Survival analysis showed that this divided attention task was able to identify fallers and nonfallers. Finally, Maki and colleagues (2001) have found that the elderly are less able to switch their attentional resources from a cognitive task to a balance threat than young adults, thereby negatively affecting their stability. Examining attention in relation to balance using dual task paradigms will help researchers and clinicians understand the effect of aging on divided attention as well as create better assessment and evaluation tools for populations at risk for falls and for persons with balance related problems (Woollacott & Shumway-Cook, 2002). Research into incorporating dual task paradigms into rehabilitation programs for the cognitively impaired geriatric population would be useful for ameliorating their poor postural control (Hauer et al., 2003).
2.6 WORKING MEMORY, AGING, AND ACTIVITIES OF DAILY LIVING

2.6.1 Definition of Working Memory

Working memory is the cognitive capacity that permits individuals to reason and make sense of the world around them, from recalling what needs to be bought at the grocery store to figuring out solutions to math problems. It is the memory system that allows one to understand, retain and integrate multiple facts and or thoughts (Baddeley, 1999). Baddeley (1998) has proposed that working memory uses conscious awareness to join all the sensory information the brain receives into a cohesive unit which is stored and can be recalled as needed. Complex thought processes such as comprehension, reasoning, learning and problem-solving are contingent upon working memory since this system is presumed to have a fixed capacity. Processing problems arise when working memory reaches its maximum capacity.

2.6.2 Components of Working Memory Model
Working memory was developed as a model to help comprehend how human memory functions. It began as a merger of short-term and long-term memory and has subsequently become more complex with increasing research into the domain of working memory. Currently, the most accepted model is that of Alan Baddeley and Graham Hitch (Baddeley, 1986). Their multi-component model is made up of the phonological loop, visuo-spatial sketchpad, the central executive (Figure 2a) and the recent addition of the episodic buffer (Figure 2b). The central element of working memory is the central executive which is assisted by the other subsystems. By funnelling off secondary and trivial tasks to its slave systems, the central executive frees itself up for more pressing and complex demands. The components of Baddeley and Hitch’s intricate working memory model are considered to be interdependent and there can be some overlap in each separate part’s function.

2.6.3 Phonological Loop
The phonological loop, one of the original components of Hitch and Baddeley's 1974 working memory model, is a subordinate system composed of an interim storage place and a rehearsal process. The phonological loop is where auditory memories can be kept and made permanent via the rehearsal mechanism. This mechanism is thought to be a kind of "sub-vocal speech" (Baddeley, 1999, p. 170) whereby repeating the new verbal stimuli in one's mind, a representation is stamped into storage by articulatory rehearsal. The phonological loop is the most studied constituent of the working memory model and is often the one at fault in patients with short-term memory problems. The function of the phonological loop is thought to be a reserve structure for comprehension as well as a method for acquiring language. The left temporoparietal cortex has been identified as the anatomical location of the phonological loop in lesion studies. The position of the storage component of the phonological loop is situated in Broadmann Area (BA) 40 and the rehearsal segment is located in Broca's area (BA 6/44) (Baddeley, 2003).
2.6.4 Visuo-Spatial Sketchpad

The second slave system of the 1974 working memory model is the visuo-spatial sketchpad. The visuo-spatial sketchpad preserves temporary traces of visual and spatial information. Much less is known for certain about this part of the model, it is hypothesized to be crucial in remembering visual attributes (colour, shape) and the idea of additional sub-systems within the visuo-spatial sketchpad has been raised. The capacity of the visuo-spatial sketchpad is approximately three to four items. Neuroimaging studies have identified the right hemisphere in association with visual working memory, in particular the right premotor cortex (BA 6), the anterior extrastriate occipital cortex (BA 19), the right inferior parietal cortex (BA 40) and the right inferior parietal cortex (BA 47) (Baddeley, 2003).

In the visual cortex, there are two major pathways for processing information. The ventral stream which goes through the temporal lobe is responsible for recognizing and retaining object information. This pathway
is also known as the “what” pathway. The other principal stream is the parietal stream whose functions include spatial orientation and guiding movement. The parietal pathway is also referred to as the “where” pathway (Baddeley, 2003; Undergleider & Mishkin, 1982). Spatial memory is lateralized to the right hemisphere of the brain while verbal and object memory is localized on the left (Smith & Jonides, 1997).

2.6.5 Central Executive

The attentional controller of the entire working memory system is the central executive. Despite being the most important constituent of the working memory model, there is the least amount of conclusive research concerning the central executive. It is believed to have a fixed capacity and is responsible for storing, organizing and synthesizing information. Central executive integrates knowledge from its slave systems in order to accomplish high level cognitive processes (for example, learning, understanding and analyzing). The central executive is linked with “midlateral prefrontal regions, particularly left and right dorsal lateral
prefrontal cortex” (Henson, 2001). Evidence from lesion and neuroimaging investigations confirms that executive working memory tasks are found to activate the prefrontal cortex, parietal cortex, cerebellum and striatum (Bunge, Klingberg, Jacobsen, & Gabrieli, 2000).

2.6.6 Episodic Buffer

Several flaws of the original three-part working memory model have emerged, compelling Baddeley to revisit and modify the theoretical account of working memory. Some of the problems identified were that there was no mechanism that could enable chunking\(^1\), no route to allow the phonological and visuo-spatial components to communicate and no means to account for working memory in conscious awareness (Baddeley, 2003). Thus, the fourth piece of the working memory model was

\(^1\) Chunking - Method of keeping a larger amount of units of information in short-term memory than would otherwise be possible by organising related units into one collective. This method is often used by chess players for remembering board positions and mathematicians for cutting down the necessary steps for solving a problem. Studies by Chase and Simon (1973) and Rosenbloom and Newell (1986) indicate that the larger the understanding of relations between positions or rules, the larger the amount of units in a chunk. [http://www.psybox.com/web_dictionary/Chunking.htm](http://www.psybox.com/web_dictionary/Chunking.htm). Retrieved January 10\(^{th}\), 2006.
introduced, the episodic buffer (Baddeley, 2000). The episodic buffer permits integration of knowledge from all the other components of the working memory model as well as long-term memory because the episodic buffer operates in a universal code. The episodic buffer is transitory with a limited capacity size. It is accessible via consciousness awareness but the episodic buffer is run by the central executive. The episodic buffer allows for the binding of new pieces of information or events together into an amalgamated, coherent unit that can be remembered and retrieved. The fourth component of working memory enables the brain to register new cognitive memories and representations, thereby aiding in problem solving situations. Its precise whereabouts are still unclear, however, findings from Prabhakaran et al.'s functional magnetic resonance imaging study (2000) suggests that the general location of the episodic buffer may be situated in the right frontal lobe as there was an increase in activation in this area by integrated units of verbal and spatial stimuli.
As with divided attention, most of the research in this area has focused on the role of working memory in relation to driving, as it plays a significant part in accomplishing this task well. In particular, the visual processing component is essential in order to accomplish the perception and gross motor actions that are necessary while driving (Lundberg, Hakamie-Blomqvist, Almkvist, & Johansson, 1998). More importantly, poor cognitive skills are linked with car crashes and collisions. Poor visuospatial memory, visuoconstructive ability and psychomotor speed have been implicated in crashes while poor performance on memory tests, specifically verbal and visuospatial ones, are features of elderly drivers who had been part of car collisions but not of older adults who did not experience them (Lundberg et al., 1998). In a retrospective cohort study of elderly drivers and car accidents, Lee, Lee, Cameron, and Li-Tsang (2003) used logistic regression analysis to determine that there is a forty-five percent reduction in risk of an accident associated for each additional
point on one’s working memory score. Further investigation by Lee and Lee (2005) led them to propose that driving interventions for older adults should incorporate elements focusing on working memory. These findings highlight the importance of being able to process information, manipulate, and make appropriate judgments, critical abilities that one needs to be capable of while navigating a car. As driving is closely linked with independence for many seniors, particularly those living in rural communities with poor public transport systems, maintenance of a functional working memory as one ages is important. As decreased independence reduces mobility and thereby increases fall risk, finding a way to preserve working memory would be useful to the aging population. Since there is little information directly related to working memory and exercise, exercise may be a venue for maintaining and/or improving working memory in seniors.

2.7 HOW EXERCISE MAY ENHANCE COGNITION
Among the healthy older population, there is a strong linear relationship between physical and cognitive function (Rosano et al., 2005). A longevity study (Schupf et al., 2004) found that maintenance of cognitive functions (memory, visuospatial, etc.) as well as partaking in activities of daily living were both predictors of living a longer life. The model proposed by McAuley, Kramer and Colcombe (2004) depicts the biological plausibility of using physical activity to promote cognitive functioning in the elderly (Figure 3). This model is based on animal and human studies which provide evidence that fitness and physical activity improves both brain structures involved in both cognition and cognitive processes themselves. Animal experiments have shown that physical activity resulted in a variety of gains, such as greater number of synapses and capillaries in the cerebellum of rats, and enhanced spatial learning and neurogenesis in mice (van Praag, Kempermann, & Gage, 1999). Aerobic exercise has multiple positive outcomes on the cognitive functioning of the aging population, including reducing the neural degeneration associated with growing older (Colcombe et al., 2003). Using high resolution magnetic resonance imaging, a high level of cardiovascular fitness in humans was shown to protect gray matter (frontal, parietal and temporal lobes) and white matter (anterior and transverse tracts), areas which are most susceptible to age related declines (Colcombe et al., 2003). Hall, Smith,
and Keele’s (2001) review lends further support to the notion that aerobic exercise produces positive improvements in executive function in the elderly population. Aging is known to have severe detrimental effects on executive functioning, which rely heavily on the brain’s frontal lobes. Hall et al. (2001) hypothesize that physical activity enhances executive functioning by increasing blood flow to the frontal lobes. However, to date, no study has truly investigated this hypothesis.

The FINE study (van Gelder, Tijhuis, Giampaoli, Nissinen, & Kromhout, 2004) concluded that physical activity of medium-low intensity or duration was associated with a smaller cognitive decline in older men. Greater cognitive deterioration occurred if there was a decrease in the duration or intensity of these individuals’ physical activity, illustrating the protective effects of exercise on cognition in the elderly. Rogers, Meyer, and Mortel’s 1990 longitudinal study examined the relationship between health, cognition and level of activity in the elderly who have retired. In comparison to retired-active and control working participants, retired-inactive subjects scored significantly lower on a global cognitive assessment test. Rogers et al. (1990) also examined regional cerebral blood flow (CBF) which is a sensitive marker for progressive cerebral atherosclerosis; CBF is known to decrease as one ages. The CBF levels of inactive-retired seniors progressively decreased with each follow-up
year, whereas the levels of CBF for the other two groups of subjects remained relatively stable over time. Rogers et al. (1990) concluded that older adults who retire and become inactive “are at increased risk of cerebrovascular disease and possibly cognitive impairments” (Rogers et al., 1990, p. 127). Results from a prospective cohort study by Laurin, Verreault, Lindsay, MacPherson, and Rockwood (2001) found that the likelihood of developing Alzheimer's disease and dementia is greatly reduced with medium to high amounts of physical activity. This trend was particularly strong in women and denoted “a significant dose-response relationship” (Laurin et al., 2001, p. 500), suggesting the more one is physically active, the less likely that person is to become demented. Laurin et al.’s findings are reinforced by another prospective study with community-dwelling women (Yaffe, Barnes, Nevitt, Lui, & Convinsky, 2001). This study investigated whether there was a protective effect of physical activity on the cognitive deterioration of older women. Yaffe et al. (2001) ascertained that the risk of mental decline was reduced in women who were more physically active at baseline as compared to those who were more sedentary 6 to 8 years after. Pignatti, Rozzini, and Trabucchi (2002) lend further strength to this line of thinking as their data replicated the same results as Yaffe et al.’s 2001 study. Of the women who suffered from cognitive decline, 16.7% had been classified in the high-level of
activity group as compared to 39.5% in the low level activity group. Pignatti et al. (2002) also established that there was an increased risk of cognitive deterioration associated with low amounts of physical activity.

2.8 SPECIFICITY OF EXERCISE

While physiological responses to specific types of exercise are well documented, the specificity of exercise relating to cognitive functions has only begun to be explored. Although there have been many studies conducted in order to determine the positive effects of fitness on cognition, the results have been mixed. Part of the reason for this discrepancy is due to problematic methodology across studies such as a variety of different exercises employed as the intervention, the age group targeted, the cognitive measures examined and the type of comparison group. However, a meta-analysis (Colcombe, & Kramer, 2003) demonstrated that exercise enhances cognitive performance of executive, controlled, spatial and speed tasks in the elderly population. The cognitive skill that had the largest improvements due to physical activity was executive control processes. It is possible that different types of exercise target particular aspects of cognition and this idea needs to be taken into account while designing a study.

An intervention geared towards increasing cognitive performance of divided attention abilities requires selection of an activity which evokes a
multi-tasking experience. Recently, Verghese et al. (2003) found that in a comparison of "playing tennis or golf, swimming, bicycling, dancing, participating in group exercises, playing team games such as bowling, walking for exercise, climbing more than two flights of stairs, doing housework, and babysitting" (Verghese et al., 2003, p.2510), the only form of physical activity associated with a reduced risk of developing dementia was dancing. However, they did not elaborate on the reasons for this result. It could be that dancing, more than the other activities evaluated, exercises cognitive functions. On the other hand, it could be that various aspects of cognitive function were enhanced with other activities, but either were not measured, or were too subtle to be observed with the study design. There is a paucity of literature related to dancing and its possible beneficial effects on cognition for seniors. In order to assess the role of physical activity in maintaining or enhancing cognitive function, we have chosen to compare walking with dance, and specifically the Argentine Tango. Both activities are of moderate intensity of three to six metabolic equivalents (Physical Activity for Everyone: Measuring Physical Activity Intensity, 2006). However, walking is a common activity of daily living, while the Argentine Tango is a novel experience that truly captures elements of divided attention due to the simultaneous need to pay attention to the rhythm of the music, guide one’s partner into the next
dance movement, or follow the cues of the leader. Furthermore, the navigational demands of the Argentine Tango increase the complexity of this activity as the dance requires the couple to maintain the flow around the dance floor in a counterclockwise direction while manoeuvring around the other couples on the dance floor. The primary objective of this thesis will be to assess the cognitive benefits of both a Tango dancing program and a Walk intervention in order to measure specific changes in divided attention or working memory that may be attributable to each specific program, and to discuss this with respect to specificity of exercise.

2.9 SIGNIFICANCE

The gains from such a program would not only include physical and cognitive stimulation but would also target the specific needs of elderly populations such as divided attention, balance and motor coordination. An improvement in these abilities could help lessen the fear of falling. In addition, this program would promote a sense of community through the formation of new partnerships and friendships. The socialization component would increase exercise adherence and potentially reduce social isolation. There are many biomechanical and psychosocial benefits to this exercise program that would make it a great service for vulnerable populations, such as the elderly, as well as to the medical profession. It is possible that the implementation of this kind of leisure therapy in a
community setting would help prevent the occurrence of fragility in seniors. The cost of this intervention program is reasonable and can be put into action easily at any community center, a friendly inviting atmosphere.

2.10 RATIONALE

The links between exercise specificity and cognitive gains are not clear in the literature. This study will help to explore this issue in greater detail and help to determine the sample size necessary for a larger randomized clinical trial.

2.11 OBJECTIVES

The objective of this feasibility study is to evaluate the efficacy of Tango and Walk programs in the promotion of cognitive skills.

1.11.1 Specific Objectives

The specific objectives are:

1. To determine if the cognitive function is increased after a Tango dancing or Walk intervention program.

2. To determine if these improvements are maintained after the cessation of the programs.

3. To establish the specific cognitive gains associated with each exercise intervention.

Two cognitive skills, divided attention and working memory, will be used to evaluate each of three research objectives.
2.11.2 Hypothesis

The hypothesis is that type of exercise will be specific to the aspects of cognition it enhances.

2.12 RESEARCH QUESTIONS

1. After a 10 week program in Argentine Tango dancing or walking, is there an increase in cognitive function?

2. Are observed changes maintained into the follow up period?

3. Does a 10 week exercise program in Tango result in different gains in cognitive function from those in a Walk program?
Figure 2. Working Memory Model

(a) Diagram of the Working Memory model with the original three components: phonological loop, visuo-spatial sketch pad and the central executive.

(b) Diagram of the Working Memory model with the new addition of the episodic buffer.

Adapted from Trends in Cognitive Sciences, pages 418 and 421, 2000.
Model proposed by McAuley, Colcombe and Kramer (2004) demonstrating how exercise may enhance cognition.
3. METHODOLOGY

3.1 DESIGN

This is a feasibility study that took place in the spring and summer of 2004 from May to September. It was designed to explore the use of an Argentine Tango dancing program as a means of exercise for the elderly at-risk for falls and its effectiveness for improving cognition, balance and mobility, and socialization. A Walk group was used for comparison. Subjects were randomized into the two intervention groups.

3.2 STUDY POPULATION

Community-dwelling older individuals living on the Island of Montreal were recruited to take part in this study through newspaper advertisements as well as flyers and posters in Centre Locaux De Services Communautaires (CLSCs) and community centers. This strategy would reach different segments of the elderly population living in Montreal and allow for the recruitment of many subjects within a short time period. An example of the recruitment ad is in Appendix 1.

Inclusion criteria consisted of healthy individuals (60 years old and up), to the extent that taking part in a Tango dancing or Walk program would not exacerbate any existing symptomatology, who reported a fear of falling, and had experienced a fall within the last year. A fall was defined as ‘events which lead to the conscious subject coming to rest inadvertently
on the ground’ (Barnett et al., 2003). This particular subgroup of the elderly population is relevant to the interests of science as they are at a higher risk for falling and the potential for improvement of divided attention skills is great. In addition, the participants must be able to understand written and spoken English or French.

Individuals with cognitive impairments (a score of less than twenty-four on the Mini-Mental State Examination), progressive or unstable neurological or musculoskeletal conditions were excluded to reduce the confounding effects of these health states on the impact of the interventions.

Individuals who responded to the advertisements were given a preliminary screening to determine if they had fallen within the past year, were afraid of falling, and were available for the entire length of the study. Those individuals who appeared to fit the general criteria were asked if they would accept to be interviewed over the telephone by a physiotherapist to answer some questions related to their health status. 40 subjects were further screened with the interRAI, a telephone interview, by a licensed physiotherapist. The interRAI is a validated and standardized assessment instrument of physical and cognitive functioning in the geriatric population (Challiner, Carpenter, Potter, & Maxwell, 2003). Following the telephone interview, 34 potential subjects were invited to an
information session where the coordinators of the study explained in detail the study protocol, the various testing procedures, and answered any questions that the older adults had. As well, the principal investigators re-evaluated the individuals based on the inclusion and exclusion criteria and then consent forms were distributed. 30 of the 34 seniors attending the information meeting gave their informed consent to participate in the study. Subjects went to the Constance-Lethbridge Rehabilitation Center (CLRC) later that week for baseline evaluation. After completing the baseline assessment, subjects were randomly allocated to the experimental (Argentine Tango Program) or control group (group Walk Program) by selecting envelopes which contained group codes. Men were stratified in order to have equal number of men in each group. Walking was selected as a control activity as it is often used as such in exercise physiology research (McAuley, Jerome, Marquez, Elavsky, & Blissmer, 2003), since it is a familiar activity of daily living which can be combined with social interactions, when participating either with a partner or group. Thus this activity was selected to compare how the specifics of each exercise program might differentially target aspects of socialization, cognition and mobility and balance, depending on the task demands and concomitant group dynamics. The post program evaluation took place following the termination of both interventions programs, and one month
later the follow-up evaluation occurred (Figure 4). The subjects who were randomized to the control group were promised a 10 week Argentine Tango course at the end of the feasibility study as an incentive to complete the study and the Argentine Tango group was given the opportunity to participate in either a Walk program or to continue with a Tango course once a week.

3.3 INTERVENTION PROGRAMS

Both programs were given for 2 hours twice a week for 10 weeks, for a total of 40 hours. 40 hours of instruction seems to be critical for establishing gains with Tai Chi and other exercise programs in this population (Wu, 2002).

The Argentine Tango program was led by a qualified Argentine Tango instructor who had prior experience teaching older populations. The classes were held in the gym at a local senior centre that contained a mirrored wall and wooden floor. Attendance was recorded by the Tango instructor. The sessions followed a standard formula, starting with 30 minutes of warm up and single practice, 30 minutes of instruction and practicing, a short break and 50 minutes of partner practicing. Single practice was designed to rehearse weight shifting, proper postural alignment and walking and pivoting, and practice of new and old dance patterns while maintaining proper posture and balance. The couple
practice then reinforced the steps learned and rehearsed in the single practice. The partner practice periods consisted of dancing in couples with frequent switching of partners and changing of roles (leader or follower). The dance steps progressed at a pace that was attainable by the participants. Every week, the instructor incorporated new patterns of steps into the sessions.

The group Walk program consisted of twice-weekly excursions to various parks and locations in the greater Montreal area such as Mount Royal, Ile de la Visitation and the Botanical Gardens. The seniors met as a group at the Cummings Jewish Senior Centre and then went together in taxis to the designated site. They returned to the centre for refreshments at the end of the exercise period. The sessions were held outdoors, unless the weather dictated otherwise, at which time they went to indoor malls to walk. This happened approximately 3 times during the 10 weeks of the Walk program. The majority of places that the Walk group visited on their excursions were novel settings for the cohort, most of them never having been to those areas before. Two guides who were graduates of the Exercise Science program at a local University supervised, led and coordinated the outings and served to counterbalance the effects of social stimulation and attention of the Tango instructor.
3.4 MEASUREMENT INSTRUMENTS

3.4.1 Screening Tools

The **interRAI Community Health Assessment** instrument is a reliable measure to determine the physical and cognitive functioning in the elderly. It is a short questionnaire that was developed to be used across domains to ascertain whether older individuals require further evaluation because their health or mental capacities are declining (interRAI, 2006).

The **Mini-Mental State Examination (MMSE)** was used as a screening tool for cognitive status during the baseline (T1) assessment. The MMSE is a valid and reliable test used to assess cognitive function (Folstein, Folstein, & McHugh, 1975). The MMSE is a simple, standardized test that is reasonably fast to administer. Higher scores reflect better cognitive status, the maximum score being 30.

3.4.2 Outcome Measures

For divided attention, the **Walking-While-Talking (WWT) Complex Task** was selected as the measurement tool, as it is a quick clinical test that assesses one's divided attention capacity in the performance of a cognitive and manual/mobility task simultaneously. The subject must walk from a fixed starting point to an end point, turn and walk back while reciting every other letter of the alphabet (a, c, e...) in French or English, whichever was the most familiar or the mother tongue. During the course
of the WWT, the participant walks a distance of 20 feet, turns around and walks back to the starting point for a total of 40 feet (12.19 meters). The evaluator demonstrated the task once and the participant could ask questions before performing the task to make sure that the task was understood. The subjects were told to walk as quickly as possible while reciting every other letter of the alphabet as accurately as possible. This measure has been validated in the geriatric population and has high interrater reliability (Verghese et al., 2002). Verghese et al. (2002) also found that the WWT-complex task had highest specificity and moderate sensitivity in comparison to other commonly used measures that identify older individuals at-risk for falls (Tinetti Balance and Mobility Scale and Timed Gait). The WWT requires no expensive equipment, making it easy to use. As well, Chronister (2003) suggested that combining an ambulatory task with a cognitive one would be a stronger predictor of falls as this type of task would more accurately reflect the divided attention situation individuals are faced with everyday.

There are several different measures which enable researchers to evaluate the executive function of divided attention (Beauchet, Dubost, Aminian, Gonthier, & Kressig, 2005). Other dual-task paradigms have also used verbal cognitive tasks (Brown et al., 1999; Shumway-Cook et al., 1997) or a reaction time task (Brown et al., 2002; Sparrow et al., 2002) to
overload the subjects’ attentional systems while attempting to maintain balance following an unexpected perturbation. Reaction time tasks tend to influence participants’ gait characteristics as they need to focus on the visual stimulus instead of their feet (Sparrow et al., 2002) and are used to examine the effects of ageing on attention. Verbal cognitive tasks are generally employed to study the prioritization of balance versus successfully accomplishing a cognitive task. Another executive function measure used in the InCHIANTI study (Ble et al., 2005) is the Trail Making Test. This written cognitive test requires subjects to join together a series of numbers in sequential order in the first part, and in the second section, they must link numbers and letters together while alternating in numerical and alphabetical order. The goal is to complete both parts as quickly and as accurately as possible. A modified version of the Trail Making Test, the Walking Trail Making Test (Alexander et al., 2005), requires the participants to accomplish the same tasks while walking instead of writing. We selected the WWT as it is a clinically relevant method with established metric properties for evaluating fall risk improvement and examines divided attention in a typical activity of daily living that is known to place seniors at risk for falls (Kwon, & Verghese, 2005; Verghese et al., 2002).
**Working Memory** was measured by using the Wechsler Memory Scale-III which is composed of two subtests, Letter-Number Sequencing and Spatial Span. Each subtest examines a different aspect of working memory. Together the results of each subtest are combined to give a total score for Working Memory. The Wechsler Memory Scale-III is a reliable and generalizable tool with content, criterion-related and construct validity (Wechsler, 1997). The Wechsler Memory Scale-III is the standard measure to evaluate memory function in clinical and research settings and it is highly regarded for its ability to investigate age-related changes of specific memory processes.

**Letter-Number Sequencing**, the first subtest, examined the subjects’ auditory memory and capability to maintain and manipulate verbal information concurrently. Letter-Number Sequencing is a short standardized test with normative data for different age groups. The test begins with the evaluator reading aloud to the participant a jumbled series of letters and numbers. To formulate a correct answer, the subject must remember all the letters and numbers and reorganize them in his or her response such that the numbers are stated first in ascending order, followed by the letters in alphabetical order. Prior to starting the actual test, the subject goes through a set of practice trials to familiarize themselves with the testing procedure. For every level of the Letter-
Number Sequencing, there are three trials, each one having the same quantity of stimuli but composed of different letters and numbers. As Letter-Number Sequencing progresses, the string of letters and numbers increases in length until the participant fails to achieve the proper order in any of the three trials with a level and receives a score of 0. The length span of the sequences starts at two elements and proceeds to a maximum of eight. The highest possible score one can achieve is 21. Letter-Number Sequencing is a reliable and valid test with good test-retest reliability (Lemay, Bedard, Rouleau, & Tremblay, 2004).

Spatial memory was assessed using Spatial Span based on the Corsi Block-Tapping task (Corsi, 1973). The Spatial Span task has been utilized for both clinical evaluation and scientific research purposes to measure spatial span and memory. The apparatus is a white plastic square board (22 by 28 centimetres) with 10 blue blocks (3 by 3 centimetres) situated arbitrarily on it. The examiner taps a series of blocks in a predetermined randomized order at a rate of one block per second. Once the examiner has completed the demonstration of the sequence, the subject may begin to reproduce the path under two different recall conditions. The Forward Spatial Span task requires the subject to repeat the same sequence of blocks as the examiner had, whereas in the Backward Spatial Span, the participant must tap the blocks in the reverse
order that was demonstrated by the evaluator. Both conditions have high interrater reliability (Wechsler, 1997). Similar to Letter-Number Sequencing, the subjects went through several simulated trials in order to become accustomed to the manner in which the Spatial Span is conducted. There are two trials within one level of testing and as one reaches the higher levels, the block span increases; beginning from two blocks to the maximum of nine. As long as the subject successfully recreates one out of the two sequences the examiner showed within a level, the subject may continue on the following level of the Spatial Span. Each of the recall conditions consist of eight levels, for a total of 16 points. The maximum score on the Spatial Span subtest is 32 (Wechsler, 1997).

3.5 DATA COLLECTION

The week following the informational meeting with the study coordinators and participants, at which the consent forms were signed, the subjects had appointments at the CLRC for their baseline assessment. Research assistants blind to group assignment conducted a series of functional measures. The cognitive measures were performed by another research assistant who was also blinded to group assignment. These preliminary tests served to establish baseline comparability between the groups. The same sets of tests were repeated by the same evaluators during the post-Tango/Walk and follow-up assessment periods. Both the
post-intervention and follow-up evaluation took place within a week of the last intervention session and one month later, at week 11 and week 22 respectively.

3.6 STATISTICAL ANALYSIS

Statistical analyses were performed with GB-Stat version 9.0 software. Descriptive analyses of the two groups were calculated at baseline pre-Tango/Walk on all measures. Paired t-tests were conducted in order to evaluate the within-group differences for the Tango and the Walk groups (Question one and two). Between-group differences were measured using 2 (intervention: Tango vs. Walk) x 3 (time: pre, post, follow-up evaluation periods) way repeated measures ANOVAs and examined graphically with box-and-whisker plots to analyze the variability and distribution of the scores of each cohort.

3.7 ETHICS APPROVAL

The Conseil d’Éthique du Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain (CRIR) approved this project (Appendix 2). Prior to the commencement of the RCT, subjects had the opportunity to ask questions in regards to the study and gave their written, voluntary, informed consent at the informational meeting (Appendix 3). Consent forms were available in both English and French.
Figure 4. Flow chart of the study

- Preliminary Screening
  - Telephone calls to respondents assessed by PT using the interRAI
  - n = 34

- Introductory meeting
  - Signing of consent forms
  - n = 30

- Assessment T1
  - Pre-Tango/Walk

- Randomization by selecting envelopes containing group codes

- Tango Group
  - n = 14
  - Argentine Tango Group
  - 2 hours twice a week for 10 weeks
  - Evaluation T2
    - Post-Tango
  - Evaluation T3
    - Follow-up
    - 1 month later

- Walk Group
  - n = 11
  - Group Walking Program
  - 2 hours twice a week for 10 weeks
  - Evaluation T2
    - Post-Walk
  - Evaluation T3
    - Follow-up
    - 1 month later

- dropout
  - n = 1
  - unrelated knee injury

- dropout
  - n = 4
  - not receiving Tango
4. RESULTS

4.1 DESCRIPTION OF SUBJECTS

Thirty participants took part in the baseline evaluation, following which five subjects dropped out of the study before the 10 weeks were completed. Four were dissatisfied with the group allocation to the Walking program and therefore withdrew, while one participant left the Tango group because of an unrelated knee ailment. Twenty-five participants completed the two interventions, with fourteen subjects in the Tango group and eleven in the Walking group. Attendance in both programs was over ninety percent. Ten subjects attended all twenty sessions, twelve missed one day and three were absent twice. As one subject from the Tango program was unable to come in for the FUP evaluation, this subject was removed from the data analysis, leaving thirteen subjects in the Tango group. At baseline, the two groups were comparable in terms of age, male-female ratio and score on the Mini Mental State Exam (Table 1). Although there were no statistical differences between the Tango and the Walk groups at baseline for the outcome measures, there was a difference between the two cohorts in the spatial span score that approached significance ($p = .12$), indicating that the conclusions drawn about Spatial Span need to be treated with caution.

4.2 WITHIN GROUP CHANGES
Within group paired \( t \)-tests were used to statistically compare baseline with post-intervention values to assess improvement and between baseline and follow-up values to assess persistence of gains. These results are presented in Table 2. Since statistical significance does not always convey relevant improvement in task performance, we also examined issues related to meaningful clinical outcomes. These topics included the fall risk changes associated with the time required to execute the divided attention task, as well as working memory in comparison to percentiles of normal age matched population and risk for driving accidents. An improvement of one point represents a 45% decrease in the risk of being a driver in a car accident for the elderly (Lee et al., 2003), which signifies a clinically important change.

4.3 STATISTICAL ANALYSES

For the Tango group, the WWT task for divided attention was significantly improved from baseline at both post-intervention and at follow-up, thus demonstrating a gain that persisted (Table 2). For the Walk group, significant improvement was observed in the WWT at follow-up, indicating that there might be a delayed effect, or that a longer period of walking is necessary for improvement to emerge (Figure 5). By contrast, the letter-number sequencing (Figure 6) for the auditory memory component of working memory and the summary score for working
memory (Figure 7) were significantly improved for the Walk but not the Tango group at post-intervention. Only the working memory was sustained into follow-up for the Walk group. Spatial memory was improved at both post-intervention and follow-up for both groups, but these results were not significant (Figure 8). Similarly, the Tango group showed continued improvements in the letter-number sequencing task and working memory throughout the study, although there was no significant improvement at either post-intervention or at follow-up.

4.4 CLINICAL ANALYSES

4.4.1 Divided Attention

There were also clinically meaningful changes in the divided attention task performances of the individuals. In Figures 9 (a) and (b), each individual's performance on the WWT over the three measurement periods was plotted, using the high and low fall risk time demarcations as proposed by Verghese et al. (2002). The changes in divided attention from pre- to post-evaluation are examined in relation to performance time and risk for falls. Individuals who finish the WWT task in 28.9 seconds or more are at a higher risk for falls than those who are able to achieve the WWT in 20.1 seconds or less (Verghese et al., 2002); these boundaries were used to categorize clinical significance of the changes with respect to fall risk. We have chosen to characterize the zone between high and low fall...
risk as a transition or moderate risk zone. Thus the movement of each individual performance can be observed from a perspective of increased or decreased fall risk over time. For the Tango group (Figure 9a), eight subjects improved their WWT times from pre- to post-evaluation. Of the eight subjects, three individuals started out in the high risk zone at the pre-evaluation. Two of these participants moved into the moderate risk zone in the post-evaluation and the last one improved to the extent that this participant landed in the low risk or non-fallers zone in the post-evaluation. Two subjects showed no change and the time to complete the WWT for three other subjects increased slightly in the post-evaluation. Overall, there was a meaningful improvement for 62% of the subjects in this cohort. When comparing baseline values with the follow-up scores, nine participants improved the time to execute the divided attention task and four subjects took longer to complete the task. Two of three individuals whose baseline values placed them most at risk for falls were able to maintain lower risk for falls into the follow-up period.

By contrast, in the Walk group (Figure 9b), there were only two subjects who greatly improved (from high risk to moderate) while three others showed slight gains in their time to complete the WWT at the post-intervention time period. Two individuals had no change in their WWT times from pre- to post-evaluation and three participants took longer to
complete the WWT in the post-intervention period. Overall, 45% of the participants in the Walk group showed meaningful improvements in the divided attention task. Examining baseline values with respect to the follow-up evaluation scores, nine subjects ameliorated their time to execute the divided attention task and two participants took longer to complete the WWT than they had at baseline. As well, the performance of the task was highly variable in this cohort and did not show any specific trends throughout the study.

4.4.2 Working Memory

Using age-based norms, percentile rankings for working memory scores were calculated. Prior to taking part in the study, the Tango group was ranked at the 50\textsuperscript{th} percentile and the Walk group was ranked lower, at the 40\textsuperscript{th} percentile (Figure 10). By the post-intervention evaluation, the Tango group had an average ranking at the 56\textsuperscript{th} percentile and the Walk group at the 52\textsuperscript{nd} percentile. At follow-up, the Tango group ranked in the 57\textsuperscript{th} percentile and the Walk group stayed at the 52\textsuperscript{nd} percentile. Therefore, both groups were able to move above the 50\textsuperscript{th} percentile ranking and to maintain these gains into the follow-up period. While this effect was larger for the Walk group, the Tango group continued to improve in the follow-up interval, while the Walk group remained at the same level as at post-intervention.
In Figure 11, histograms illustrate the number of individuals in each cohort who showed gains or losses by score changes in working memory for both post-intervention and follow-up with reference to baseline. In general, subjects in both groups improved their baseline scores by at least one point into post-intervention and follow-up periods, indicating a 45% decrease in driving risk for accidents (Lee et al., 2003). When comparing the overall gains made by each group from baseline to follow-up, 69% of the Tango group and 63% of the Walk program had clinically meaningful improvement of at least one mark higher on their composite Working Memory score. However, the distribution of gains and losses in Working Memory was much more variable in the Tango group than in the Walk cohort for both intervals. As well, there were more participants whose scores decreased or did not improve following the Tango intervention and into the follow-up as compared to the walk program. From baseline to post-Tango, three subjects’ scores decreased and two individuals showed no change in Working Memory. In the Walk program, none of the subjects had lower scores than baseline, although three individuals had no change in their Working Memory values in the post-intervention evaluation. When comparing follow-up values to baseline, the Tango group had four participants who scored lower than their baseline values while only two individuals in the Walk group fell into this category.
4.5 COMPARISON BETWEEN GROUPS

A series of 2 by 3 way repeated measures ANOVAs were calculated in order to determine the differences between the two intervention programs (Table 3).

4.5.1 Divided Attention

There was no effect of treatment, however, there was a significant effect in time ($p = .014$) but no significant interaction was observed.

4.5.2 Working Memory

No significant effects for treatment and time were found for Letter-Number Sequencing and Spatial Span. Also, for both subtests of Working Memory, there were not any significant interaction effects. For Working Memory, no difference was found for the intervention between the groups but there was a significant effect of time ($p = .022$) but not a significant interaction effect.

4.6 EFFECT SIZES

As this was a feasibility study, effect sizes were also calculated$^2$. The effect sizes for each cognitive measure were calculated comparing each group’s means and standard deviations at the post-intervention evaluation (Table 4).

4.6.1 Divided Attention

A small effect size was found ($r = .199$) suggesting that there was a 14.7% non-overlap between the two distributions and that the mean of the Tango cohort was at the 58th percentile of the Walk cohort.

4.6.2 Working Memory

In terms of Letter-Number Sequencing, no effect size was seen ($r = .004$) indicating that the distributions of both groups completely overlapped and that the mean of the Tango group was at the 50th percentile of the Walk program. For Spatial Span, an effect size of 0.115 was calculated. This signifies that there was approximately 7.7% non-overlap between the Tango and Walk programs and the mean of the Tango group was at the 54th percentile of the Walk intervention. Finally, an effect size of 0.077 was found for Working Memory, suggesting that there is close to 7.7% non-overlap between the two intervention programs and that the Tango group was approximately at the 54th percentile of the Walk group.

4.7 BOX-AND-WHISKER PLOTS

Box-and-whisker plots were used to examine the distribution, variability and outliers for both intervention programs at pre, post and follow-up intervals. In Figure 12, WWT distributions are represented. For the Tango group, there was a decrease in the variability from baseline to follow-up, and a decrease in the actual time it took for 75% of the
participants to execute the WWT to well below the fall risk zone (15 sec). Most of the variability can be found in the fourth quartile that extended into the high fall risk zone for three participants. The Walk group increased in variability at post intervention, while at the follow-up period, the box-and-whisker plot more closely resembled that for the Tango group, although the median was not skewed toward faster times as it was for the Tango group.

The most interesting observations are related to the median scores in Letter-Number Sequencing (Figure 13) Although the changes for the Walk group were significant while those for the Tango were not, it can be seen that the median scores for the Walk cohort were at 10 for both pre- and post-intervention, while those for the Tango cohort moved up from 10 to 11. At follow-up, the median score for the Tango stayed at 11 while the Walk group moved up to 11. Also, at baseline, the distribution for the Tango group was spread out as compared to the Walk group whose third quartile was equal to its median. Thus, the trend towards higher scores was more prominent for the Tango cohort between pre- and post-intervention while this trend was more prominent at follow-up for the Walk group, reflecting a similar pattern to the divided attention task.

For both groups, the spatial span distribution showed considerable overlap across time periods (Figure 14). However, as reflected in the
baseline $p$ value ($p = 0.12$) the distribution for the Walk group was skewed towards lower scores than those of the Tango group. In the post-intervention period, there was an upward improvement in scores above the median score for the Walk group. The Tango group did not experience much change at the post-intervention evaluation, although there were three outliers whose scores were lower than the 1st quartile.

The working memory plots (Figure 15) illustrated the high amount of overlap between the two interventions making them indistinguishable. The median increased from 21 to 22 in the post-intervention for the Tango group and from 20 to 21 in the Walk group. These shifts in the median were maintained into the follow-up period. When comparing the pre- and post-evaluation plots for the Walk group, we saw a decrease in the variability, resulting in a much tighter distribution of scores in the post-intervention.
Table 1. Baseline Measures

A. Subject Demographics by Group Allocation

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<td>Mean (SD)</td>
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<td>MMSE</td>
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<tr>
<td>Mean (SD)</td>
<td>28.43 (1.74)</td>
<td>28.73 (1.42)</td>
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B. Baseline Outcome Scores by Group Allocation

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<tr>
<td>Mean (SD)</td>
<td>18.14 (7.554)</td>
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<tr>
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<td>18.45 (3.532)</td>
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Note. All p-values are two-tailed.
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Table 2. Within Group Changes (continued)

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Note. All $p$-values are one tailed.

* $p < .05$
Table 3. Analysis of variance for the Two Interventions

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<tr>
<td>Interaction</td>
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<td>0.666</td>
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Note. All p-values are one tailed.
* p < .05
<table>
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<td>(6.231)</td>
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<td>Mean</td>
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<tr>
<td>(SD)</td>
<td>(3.427)</td>
<td>(3.776)</td>
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This bar graph with standard error bars represents the average time (in seconds) to complete the Divided Attention Task (black bars represent the Tango cohort, and white bars represent the Walk cohort). An improvement on this task is a DECREASE in the amount of time needed to complete the task.

* indicate significance at $p < .05$ for a one-tailed $t$-test.
Figure 6. Auditory Memory

Bars represent normalized scores (for age) for the auditory memory component of the Wechsler Memory Scale-III. Conventions as in Figure 5.

* $p < .05$
Bars represent normalized scores (for age) for working memory of the Wechsler Memory Scale-III. Conventions as in Figure 5.

* $p < .05$
Bars represent normalized scores (for age) for spatial memory component of the Wechsler Memory Scale-III. Conventions as in Figure 5.

* $p < .05$
Individual scores are represented along the x-axis for all participants in the Tango group. Filled diamonds, clear squares and filled circles represent pre-intervention (Pre), post-intervention (Post) and follow-up (FUP) values respectively. The small dotted line (28.9 seconds) represents the demarcation for high risk for falls while the large dashed line (20.1 seconds) signifies the boundary for low risk for falls (Verghese et al., 2002). The area between the two dashed lines is a transitional area of moderate risk for falls.
Individual scores are represented along the x-axis for all participants in the Walk Group. Conventions as Figure 9(a).
Bars represent percentiles for working memory of the Wechsler Memory Scale-III. Conventions as in Figure 5.
Figure 11. Changes in Working Memory Scores

(a) Changes in Working Memory: Post-Pre Tango

(b) Changes in Working Memory: FUP-Pre TANGO

(c) Changes in Working Memory: Post-Pre Walk

(d) Changes in Working Memory: FUP-Pre Walk
Histograms showing the number of individuals who experienced the same amount of change in working memory between pre- and post-intervention (a,c) and pre- and follow-up (b,d). Negative values indicate a poorer score from pre-intervention values, and positive values indicate an improved score. Tango values are on the left side in black (a, b), while Walk values are on the right side in white (c, d).
Boxes represent the spread of the 2\textsuperscript{nd} and 3\textsuperscript{rd} quartiles of each cohort. Black boxes represent the Tango cohort while the white boxes represent the Walk cohort. Medians are represented by triangles.
Boxes represent the spread of the 2nd and 3rd quartiles of each cohort. Black boxes represent the Tango cohort while the white boxes represent the Walk cohort. Medians are represented by triangles.
Boxes represent the spread of the 2\textsuperscript{nd} and 3\textsuperscript{rd} quartiles of each cohort. Black boxes represent the Tango cohort while the white boxes represent the Walk cohort. Medians are represented by triangles.
Figure 15. Box-and-whiskers Plots: Working Memory

Boxes represent the spread of the 2nd and 3rd quartiles of each cohort.
Black boxes represent the Tango cohort while the white boxes represent the Walk cohort. Medians are represented by triangles.
5. DISCUSSION

This feasibility study has demonstrated that both Walking and Tango result in cognitive gains that persist for one month post-intervention. These gains may be exercise specific as significant improvements for only the Tango group were seen in the divided attention task while the significant improvements for only the Walk group occurred in working memory at post-intervention. However, caution must be exercised in the interpretation of this limited data set as no significant interaction effects were seen in the 2 x 3 way repeated measures ANOVAs. Each cognitive skill will be discussed in terms of all three research questions.

5.1 DIVIDED ATTENTION

Significant improvements immediately following the Tango program and persistence at one month after the cessation of this intervention indicate that dancing the Tango effectively targets divided attention capacity in seniors and does not decay for a one month period after cessation of the activity. While it is possible that this cohort continued to practice Tango during the one month interval before follow-up testing, distance and cost for Tango schools in Montréal decreased the likelihood of this. As well, the Tango community in Montreal is sufficiently small, that we were able to monitor this to our satisfaction. However, we were not
able to monitor the walk group as rigorously. Indeed several of the participants mentioned in exit interviews that they had continued to enjoy walks with their new friends in the follow-up period. The significant effect (p = .036) observed in the follow-up evaluation for the Walk group therefore might indicate that a lengthier program is necessary to observe significant changes in this outcome measure. Alternatively, it might be a function of a delayed effect. We hypothesize that it is the former phenomenon. Therefore, we cannot unequivocally state that divided attention was specifically addressed by the Tango intervention.

However, the magnitude of improvement experienced by the Tango group was greater than that of the Walk program for the pre- to post-interval and persisted into the follow-up period. The average time to complete the WWT from baseline to follow-up decreased from 19 seconds to 17 seconds for the Walk group whereas the Tango group average time decreased from 18 seconds to 15 seconds. Concomitantly, only the Tango cohort demonstrated meaningful clinical improvements. As can be seen from Figure 9(a), those subjects with the greatest risk for falls in the Tango group were able to improve the time it took them to accomplish the WWT from pre to post-evaluation, moving them from the fallers zone into the transitional area and even into the nonfallers zone. These results indicate that the individuals who were the most at risk showed the greatest benefit
by decreasing their risk for falls in a clinically significant manner. Also, those participants in the Tango group who were in the nonfallers zone in the pre-evaluation period showed improvements in the WWT. In contrast, this effect was not observed in the Walk group. Those with the greatest risk for falls in the Walk group failed to improve and took longer to complete the WWT in the post-evaluation as compared to their pre-evaluation times.

This being said, our results do suggest that walking may increase the ability to perform divided attention tasks, but that the response may require a longer time period to emerge. This phenomenon may be due to the fact that our subjects were asked to walk in novel surroundings rather than in the mall or on a treadmill. It is possible that each of these paradigms may convey different benefits to physical, social and cognitive health. For example, treadmill walking may be the best choice for increasing aerobic fitness or training walking patterns, as the individual is constrained to walk at a specific speed for the duration of the exercise. Walking freely in a mall or park permits one to stroll at a varying pace that is not always conducive to aerobic training, but may afford other advantages, especially those in the social and cognitive domain. Treadmill walking is often used in rehabilitation programs for stroke patients to force the individual to walk at a specific pace (Daly, Roenigk,
Holcomb, Rogers, Butler, Gansen, McCabe, Fredrickson, Marsolais, & Ruff, 2006; Macko, et al., 2005), and music cueing using rhythmic auditory stimulation while walking has been shown to help Parkinson’s patients normalize gait parameters during corridor walking (McIntosh, Brown, Rice, & Thaut, 1997).

By contrast, overground walking has been shown to have more positive benefits as an exercise activity than treadmill walking in the geriatric population (Marsh, Katula, Pacchia, Johnson, Koury, & Rejeski, 2006) because of the added social component. For example, one report suggested that older adults saw mall walking as a way to socialize and make new acquaintances in a safe surrounding (Travis, Duncan, & McAuley, 1996; Duncan, Travis, & McAuley, 1995). These authors postulated that taking part in mall walking gave the seniors a routine to adhere to and a sense of belonging. It is possible that walking in novel environments provided additional cognitive stimulation.

Thus it can be argued that attentionally challenging locomotor activities are critical for improvement in this function, and the more challenging the activity, the more rapid and large are the gains. This hypothesis is supported by the INCHIANTI study (Ble et al., 2005) where it was determined that executive functioning (and therefore divided attention) is intricately related to the performance of attentionally
challenging lower extremity mobility activities in the healthy community dwelling geriatric population. Indeed, Hausdorff, Yogev, Springer, Simon, & Giladi (2005) found that performance on the Stroop test, which taxes decision making abilities and reaction time parameters of executive function, was correlated with the gait parameters of stride time and variability. They further suggested that walking is more cognitively complex than one might suspect, as it demands input from executive functioning. This is consistent with research concerning the gait patterns of Alzheimer’s patients. When forced to divide their attention between motor and cognitive tasks, Alzheimer’s patients are less able to properly regulate their stride-to-stride variability while walking (Sheridan, Solomont, Kowall, & Hausdorff, 2003). These results further emphasize the importance of finding an intervention that targets divided attention in older adults in order to prevent the decline in executive function associated with normal aging. Poor executive functioning skills could lead to the inability to quickly process and plan motor responses in complex attentional situations.

With respect to divided attention, one has to ask why the Tango cohort responded more rapidly and vigorously to this divided attention task than the Walking cohort. It is not unusual to have a conversation with a friend, colleague or family member while walking. Be it to the cafeteria, grocery store or even movie theater, walking while talking with a
companion is a routine activity. Therefore walking with a companion may not necessarily promote the development of divided attention skills as rapidly as dancing. As mentioned previously, the spontaneity and improvisational nature that is inherent to the Argentine Tango, combined with the necessity of being aware of the other couples on the dance floor and the signals from one’s partner, increases the cognitive load whilst dancing. It is therefore understandable that Tango dancing as an intervention is more responsive than walk for enhancement of walking while talking as a measure of divided attention.

5.2 WORKING MEMORY

Two individuals in the Tango group had scores that were 6 and 7 points below baseline at post-intervention and follow-up, respectively. As these were outliers (Figure 11), we took a close look at their folders to see if there had been a significant event that might have affected their performance. One subject contracted shingles during the latter part of the intervention and was still symptomatic in the follow-up period, while the other subject had a close family member who had been diagnosed with a terminal illness during the follow-up period. Given the nature of these traumatic physical and emotional events, we re-examined the data pertaining to the composite working memory score when these two subjects were eliminated from the data base as chronic pain and
emotional distress may affect performance on the working memory tests (Dick, Eccleston, & Crombez, 2002). The paired t-tests were re-calculated for working memory without these two subjects. The paired t-tests showed significant differences from baseline to post-evaluation and follow-up ($p = .008$ and $p = .009$, respectively), thereby indicating that when these outliers were excluded from the sample the Tango intervention had positive effects on Working Memory that were seen in the post-intervention and persisted into the follow-up period. The histograms now showed that only one person performed poorly in the post-intervention as compared to baseline performance, two subjects showed no change and eight participants improved, a clinically meaningful improvement in 72% of subjects (Figure 16a). When looking at working memory scores at follow-up evaluation, two subjects had worse scores and nine improved (Figure 16b). While there was a significant effect of time ($p = .001$) in the re-calculated ANOVA, no significant interaction effect was seen for Working memory. While there were three subjects in the Tango group who improved greatly (gains of 5 points or more), and although such large gains seem relatively unlikely, there was nothing in their files to suggest why this would be so. Perhaps these individuals were having health problems at baseline, so that the post-intervention and follow scores more truly reflect their performance abilities. Thus we suggest that in future
studies with this age group, it would be helpful to administer a Health Status visual analogue scale in order to document the subject’s perception of their health at the time of testing. This information would allow us to gauge how reliable their performance is and identify any confounders. Another aspect that should also be considered is related to their psychosocial affect. Although we have reported that sense of well being, loneliness and social provisions did not correlate with performance on the working memory tasks for the two cohorts combined (Jacobson, McKinley, & Rainville, 2006), the two individuals who were outliers for working memory in the Tango cohort did show striking decreases in the social provisions scale and sense of well being (Appendix 4), suggesting that this aspect also needs to be considered when performance is drastically changed. It is important to remember that while the results for either cohort could not be considered statistically significant, we found clinically significant improvements in the composite working memory scores. The majority of subjects in both groups showed positive improvements of at least one point on working memory in post-intervention and follow-up evaluation (Figure 11) as compared to baseline, signifying substantial reduction in the risk for being in a car accident (Lee et al., 2003).

Although the paired t-tests for both post-intervention and follow-up for the Walk cohort approached significance but not those of the Tango
group (Table 1), at baseline the two groups were close to being statistically different ($p = .12$). The box-and-whisker plots for spatial memory (Figure 14) showed that while the distributions for the Tango group at each time interval overlapped, the improvement shown in the Walk group did not exceed the values of the Tango group. It is possible that a ceiling effect might exist that would prevent scores from improving as much in those age-based norms where scores are already above the 50th percentile at baseline. Spatial span is more adversely affected by age than other WMS-III subtests (Myerson, Emery, White, & Hale, 2003); it undergoes a linearly decreasing trend with age (Park, Lautenschlager, Hedden, Davidson, Smith, and Smith, 2002), raising the possibility that early on in adulthood, the capacity to retain spatial information is negatively affected by the aging process (Myerson et al., 2003). As well, spatial span is also a measure of fluid intelligence which is known to decrease with age, making improvement harder to observe (Baddeley, 1999). Our results indicate that neither Tango dancing nor walking significantly enhances spatial memory in older adults, which is consistent with current cognitive thought that working memory deteriorates as people grow older. More research is needed in order to understand whether spatial memory can experience measurable gains in the elderly, or stabilize rather than decline with age.
The effects of an exercise intervention on working memory have not been well addressed in the literature. One study that did test working memory compared older adults in the community who vigorously exercised to sedentary individuals (Clarkson-Smith, & Hatley, 1989). These authors observed that those who exercised performed significantly better on cognitive measures which included reasoning, reaction time and working memory. However, as the study relied on self-report of exercise intensity and duration only, there is no information on the types of exercise or on the actual fitness of these individuals. Therefore, the specifics of the exercise effect in this study are not clear cut.

Two other studies that specifically evaluated physical activity and cognitive function assessed either enhanced memory span and reaction times (Williams, & Lord, 1997), or orientation, concentration, remote and recent memory (Verghese et al., 2003) but not working memory. Both studies found that exercise was useful in enhancing cognitive function. Williams and Lord (1997) found that women randomized to a group exercise program had enhanced memory span, reaction times and measures of well-being, as compared to the women in the control group, while Verghese et al. (2003), using the Blessed information memory concentration test to correlate cognitive decline and physical activity, found that dance was the only physical activity that lessened the risk of
developing dementia. Thus, the beneficial effects of exercise on cognition are beginning to emerge. Our study is the first to show that exercise, specifically walking, can enhance working memory in seniors.

5.3 SAMPLE SIZE

A critical issue for the future randomized clinical trial is the number of subjects recruited to take part in the study. As expected, some people withdrew from our feasibility study because they were not assigned to the Tango intervention. Also, upon further investigation, two extremely negative outliers in the working memory task were found to have confounding circumstances that called for reevaluation of the data without these two subjects. It is imperative that while planning a study where the target population is the elderly, the research team ensures that enough subjects are recruited beyond the calculated sample size because growing older creates situations that affect and can confound one’s analysis and interpretation. As can be seen from Table 4, when comparing post-Tango and post-Walk values, a small effect size ($r = .199$) for divided attention was found. An effect size of 0.199 implies that there is 14.7% non-overlap between the two distributions and that the mean of the Tango group is at the 58th percentile of the Walk group. In order to find a statistically significant result in the future, there needs to be approximately 395 subjects in each intervention program.
5.4 CLINICAL IMPLICATIONS

Older adults may benefit from a variety of different exercises, each one having their own specific effect on cognition. This study demonstrates that both Tango dancing and walking result in specific positive gains on older adults’ cognitive skills. As well, it is suggested that the more challenging the activity, the more responsive the individual is to the intervention. Both Tango and Walk programs were challenging in different ways. Our Walk program was specifically designed to avoid drop-outs by walking in parks, botanical gardens and nature preserves with the goal of combining physical activity with social interaction. Each session was more like an excursion to a new environment where the participants had to way find in a stimulating and rich surrounding. These enriching experiences might explain the cognitive gains seen in this study. This could be an important feature which requires further consideration. Indeed there is a paucity of information related to development of cognitive skills and physical activity, including walking. Most of the studies have addressed correlations between decline in cognitive function and decline in specific gait parameters such as stride length (Sheridan, et al., 2003), speed (Ble et al., 2005), or variability (Springer et al., 2006), or divided attention performance and moving over and around obstacles (Brown, McKenzie, & Doan, 2005). The two studies that did assess the effect of physical activity
on slowing the decline in cognitive function over the long term (6-15 years) used questionnaires (Weuve et al., 2004) or self-reported number of blocks or flights of stairs walked (Yaffe et al., 2001) to compare changes in cognition with respect to estimated exercise. Thus, to our knowledge, this is the first study to specifically address walking as an intervention aimed to improve cognitive skills in the elderly. This is important, as group walking in novel environments is an activity that can be easily incorporated into most community centers. However it should be emphasized that the social component and novel stimulating environments may be key elements for clinical gains in cognition.

Similarly, research utilizing dancing as a form of intervention in the elderly has been sparse and the little that has been published focused on the effect of dancing on balance or in patients with dementia. One pilot study (Rösler et al., 2002) established that learning to dance the waltz helped Alzheimer’s patients with their ability to learn motor skills. Another preliminary study (Hokkanen, Rantala, Remes, Härkönen, Viramo, & Winblad, 2003) used a dance/movement therapy training for patients with dementia to determine if this program would help improve these subjects’ verbal and cognitive status and behavioral symptoms. The dance/movement therapy seems to positively affect the subjects’ language skills, as they produced more information units after the dancing sessions.
While no change was seen in terms of cognitive level, Hokkanen et al. (2003) ascertained that this was a positive finding because of the expected decline of cognitive function associated with dementia. Behavioral symptoms stayed relatively unchanged. One recent study (Shigematsu, Chang, Yabushita, Sakai, Nakagaichi, Nho, & Tanaka, 2002) concluded that an aerobic exercise program based on dancing improved certain measures of balance and locomotion in older women. Another study (Federici, Bellagamba, & Rocchi, 2005) employed Caribbean dancing as an exercise intervention for the “young old” men and women aged 58 to 68, and found that the Caribbean dancing exercise program improved balance in this cohort of subjects. As the dancing exercise component is not well described in these studies, it is not clear whether or not these interventions include dancing with partners or as individuals. In balance studies, they appear to resemble more closely the individually oriented type of dancing found in aerobic dancing exercises. Thus the cognitive load of interacting with a partner may not be a fundamental part of these programs. The only study where it is clear that couples danced together is that of Rösler, Seifritz, Kräuchi, Spoerl, Brokuslaus, Proserpi, Gendre, Savaskan, & Hofmann (2002). Unfortunately, no follow-up measurements were reported for these studies, thus whether these gains persisted is not known. As well, there were no other comparable studies
that evaluated the effect of dancing on cognition in the healthy community dwelling elderly. Thus, to the best of our knowledge, this study is breaking new ground in the area of cognition and exercise. However, as this was only a feasibility study, we must be cautious and not overemphasize the results. Further studies with a larger sample size will confirm or reject our findings.

An added benefit of the Tango is that the movements are performed to music, which is known to facilitate performance of ambulatory activities in neurological movement disorders such as Parkinson’s, stroke and cerebral palsy as well as in healthy older adults (Thaut, 2005; Thaut, McIntosh, Prassas, & Rice, 1992). As such, adapting Tango dance programs for the needs of persons with inner ear problems, multiple sclerosis, Parkinson’s disease or following a stroke could be developed. Also, further research can investigate the assessment of possible teaching methods that are the best for retention of steps, engagement and sustainability of the dance program in the senior population, and the development and testing of a universal Tango instruction kit that can be used in senior community centers world-wide. Lastly, but importantly, this program was proven to be self-sustaining. At the end of the follow-up period our subjects were offered a choice of taking the walk program or continuing with the Tango dancing, and all chose to
continue Tango dancing. Due to the popularity of the Tango classes, the community center has continued to offer Tango lessons at a nominal cost, and this dance class is now a regular part of their activity program. Thus this activity engages the elderly and is sustainable in the community setting.

5.5 CONCLUSIONS AND SUMMARY

In conclusion, our research shows partial support for the research hypothesis that specificity of exercise relates to improvement in different cognitive abilities. This can be seen by the significant gains in divided attention for the cohort that practiced Tango as compared to the significant gains in working memory for those who engaged in the Walk program. As sample sizes were small, however, it is difficult to state unequivocally that each exercise was specific to a particular cognitive skill. As well, evaluating the literature concerning exercise and cognition is particularly difficult as there is a wide variety of types of exercise employed as an intervention from strength training to dancing, a large number of cognitive skills and measures examined and different age groups targeted in the elderly population. There is a real need to develop a standardized battery of cognitive tests to allow for study comparisons as well as truly determine which exercises specifically serve different cognitive skills. A meta-analysis could elucidate which exercises have been used and produced
positive gains in cognition as well which cognitive skills and measures were examined in order to create a springboard for future research.

5.5.1 Limitations

Our study has a few limitations. Firstly, it was a feasibility study conducted with a relatively small number of participants. Our findings need to be replicated with a larger sample size. Also, all the subjects volunteered to take part in this study because they were interested in learning how to dance the Argentine Tango.

5.5.2 Future Directions

This study needs to be replicated with a larger sample size in order to accurately determine the effect of such exercise interventions. Future studies could explore the effect of different types of dance as compared to Argentine Tango on various cognitive skills, including divided attention and working memory.
Figure 16. Changes in Working Memory without the two outliers

(a) Changes in Working Memory: Post-Pre Tango

(b) Change in Working Memory: FUP-Pre Tango
Histograms showing the number of individuals who experienced the same amount of change in working memory between pre- and post-intervention (a) and pre- and follow-up (b) after removing 2 subjects who were considered extreme outliers. Negative values indicate a poorer score from pre-intervention values, and positive values indicate an improved score. Tango values are on the left side in black (a, b)
LIST OF REFERENCES


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InterRAI. Retrieved February 3rd, 2006.

http://www.interrai.org/section/view/?fnode=31


APPENDICES

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APPENDIX 1: Recruitment Ad

SPECIAL RESEARCH PROJECT

Can Tango Dance Classes
And/or
A Walking Group
Improve your Balance and Mobility?

IF YOU....
✓ ARE IN PRETTY GOOD HEALTH
✓ HAVE FALLEN AT LEAST ONCE IN THE LAST YEAR
✓ HAVE 2 AFTERNOONS FREE FOR 10 WEEKS

Then you may be eligible to participate in a special research project designed to improve your balance and mobility.

For purposes of the study, you will be placed at random in either Tango Dance Classes or in a Walking Group followed by tango lessons.

NO PARTNERS REQUIRED!

WHEN: Spring 2004 (exact date TBA)
WHERE: Cummings Jewish Centre for Seniors
5700 Westbury Ave.
FEE: CJCS Members – No Charge
-Registration Necessary
NON-MEMBERS: Fees paid by the research project

For Information Contact the Project Director
Patricia McKinley: (514) 487-1891 Extension 352

In cooperation with:

McGill
APPENDIX 2: Ethical Approval

Certificat d'éthique

Par la présente, le comité d'éthique de la recherche des établissements du CRIR (CER) atteste qu'il a évalué le projet de recherche intitulé:

«The use of argentine tango dance to promote socialization, enhanced balance and mobility, and cogntion in : elderly in transition to frailty».

Présenté par: Patricia McKinley

Le comité d'éthique de la recherche composé de :

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<tr>
<td>Mme Isabelle Bilodeau</td>
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<td>Mme Nicol-Kornor-Bitensky</td>
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<td>Mme Julie-Anne Couturier</td>
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INFORMED CONSENT TO PARTICIPATE IN A STUDY ON THE USE OF ARGENTINE TANGO DANCE EXERCISES TO PROMOTE SOCIALIZATION, ENHANCED BALANCE AND MOBILITY AND COGNITION IN THE ELDERLY.

I, the undersigned, ___________________ 

Consent to participate in the research study entitled: The use of argentine tango dance to promote socialization, enhanced balance and mobility, and cognition in: elderly in transition to frailty. 
Objective of the research study
The objective of the study is to assess the feasibility of tango dance as a physical and social activity for the elderly. 

Participation in the study / Nature of my participation
1. Pre-exercise participation
   - I will be assigned to either a walk group or a tango group. If I am assigned to the walk group, I will be offered information about tango courses in the community at the end of the study.
   - I am required to attend an information session regarding the study, where I will be informed about the exercise sessions and the study. At that time I will be asked to fill out some questionnaires regarding my feelings of happiness, loneliness, my social support system and
satisfaction with my life\(^3\). As well, I may be asked to participate in some tests conducted by a neuropsychologist.

- Within the next week, I will be asked to go to either the Constance Lethbridge rehabilitation Centre (CLRC) or the Jewish Rehabilitation Centre (JRH) for a functional evaluation of my balance. This evaluation will be under the direction of a licensed physiotherapist and will take approximately 1 hour.

- If I volunteer for the dynamic balance tests I will go to the JRH in Laval. In addition to the functional evaluation of my balance tests, I will participate in tilt tests on a motion platform where I will be placed in a safety harness while asked to maintain upright two legged stance while experiencing a tilt in 8 directions. This extra testing will take approximately 1 hour.

2. Exercise Participation

If I am assigned to the TANGO GROUP:

- I will then be required to attend the tango dance exercise classes for the following ten weeks. The classes will be held two times per week, and each session will be one and one half (1 1/2) hours long. The classes will consist of warm up exercises, individual practice of the steps in a group, and then with partners. I will be taught by an experienced tango dance instructor and her assistants. I may be asked to switch between being the leader and the follower, so that I learn both aspects of the dance. There will also be a health professional in attendance at all the classes to assist me, if I require help. If I do not feel like dancing with a partner during the “couples practice”, I may continue the exercises on an individual basis, or with an instructor or aide as a partner.

- I will be required to attend at least 17 of the 20 exercise sessions to stay in the project.

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\(^3\) This meeting will take place at the Cummings senior Centre.
☐ I will be required to participate in group discussion at the end of each tango class where I will be asked my frank opinion about the class content.

☐ At the end of the exercise classes, I will be given information regarding places where I might continue to learn the tango or practice what I have learned. I will be asked to fill out a satisfaction questionnaire, and other questionnaires concerning my global health status.

If I am assigned to the WALK GROUP

☐ I will be asked to walk at least for 15 minutes per day, on days when I do not attend walking sessions, and to attend at least 2 supervised walking sessions per week with the exercise science student-supervisor. I will be asked to try to walk a total of 3 hours per week. If I am assigned to the walking group, I will be offered a tango course at the Cummings Senior Centre at the end of the study.

☐ I will have to monitor my daily activity with a log-book

☐ I will have to attend 3 social sessions at the Cummings Centre

☐ I will have to maintain 3 hours of walking per week for at least 7 of the ten weeks, or I will be dropped from the study.

Post exercise session all participants // Post exercise session

for all participants

☐ 1. Within a week after the last class, I will be asked to return to the CRCL (unless I am one of the volunteers for testing on the motion platform) to re-do the functional balance tests and to answer the questionnaires. This will take approximately an hour of my time.

☐ 2. If I am part of the group with testing on the motion platform I will be asked to return to the JRH to re-perform the functional balance tests and the dynamic balance exercises. This will take approximately 2 hours of my time.
After a period of approximately three months, I will receive a phone call to make an appointment for a third evaluation of my functional balance, and to fill out the questionnaires one last time as in step 1 and 2 above. Thus the total time that I will be asked to participate for this study is approximately 50-55 hours in tango class or walking and social events, and 4.5 hours of testing at the CRCL and if I form part of the group tested on the motion platform, 7.5 hours of testing at the JRH.

I will be provided directly taxi cab service to either the CRCL or the JRH.

Disadvantages for participation in this study
The principle disadvantage of participating in this study is the time that it will take for participation in the classes and in the functional measurement assessment, and answering the questionnaires. When performing some of the tests, I might feel fearful of losing my balance. However, the physiotherapist will be there to reduce my risk of falling. If I volunteer for testing with the motion platform, I will be placed in a harness, suspended from the ceiling to make sure that I do not fall. There is also the possibility that I may lose my balance during performance of the dance exercises. However, I will have the option of using a “barre” (support rails), cane or other walking aid, for performance of some of the exercises if I prefer.

Advantages for participation in this study
There is the possibility that my balance will improve and my fear of falling may diminish. While we do not know whether the tango exercises are better or worse than walking exercises for improving balance or reducing fear of falling, the information obtained from this study will help to better serve the needs of the elderly who may be at risk for falling, by giving them a choice of exercises in which to participate.

Confidentiality of information
I have been assured that the information collected from this study will be held in strictest confidence and will not be used except for research purposes. To this end, my file will be coded in a way that will insure
anonymity and any published results will be presented with complete anonymity. The personal data sheet (e.g. address and telephone number) will be kept in a separate file folder, accessible only by the researchers responsible for the project. This information will be destroyed at the end of the project.

Ethical considerations
If I have any concerns regarding ethical questions and my participation in this study, I may discuss these with the research co-ordinator at the JRH, or CLRC, Drs McKinley or Fung.

Questions concerning this study
I understand that I may ask all my questions regarding this study and they will be answered; these questions may be addressed to Dr. McKinley, Dr. Berg, Dr. Fung, Dr. Leroux, Dr. Rainville, or Dr. Rossignol.

Responsibility clause
In accepting to participate in this study, you will not relinquish any of your rights and you will not liberate the researchers nor their sponsors or the institutions involved from any of their legal or professional obligations.

Contact person
If you have any questions concerning your rights and your recourse or on your participation on this research project, you can contact Me Anik Nolet, coordonnatrice à l’éthique de la recherche des établissements du CRIR at (514) 527-4527 extension 2643 or by email at the following address: anolet.crir@ssss.gouv.qc.ca.

Responsibility of the principal investigator
I, the undersigned, ______________________ , certify that (a) I have explained to the participant the terms of the present agreement, (b) I have responded to all the questions posed to me (c) I have clearly indicated that the participant is free to leave the study described above at any time (d) and that I will give him a signed and dated copy of this form.

Withdrawal from the study
I understand that my participation in voluntary, and I may withdraw from the project without prejudice, penalty or loss of service or benefits in the community or in the health system.

_________________________________________  ______________________
signature of participant                      signature of witness

Date

I (co-ordinator) __________________ certify that I have explained to the above mentioned participant the nature of the study, the known disadvantages for participation, and that the participant may withdraw from the study at any time. I have assured the participant that the information obtained in the study will remain confidential.

Signature of coordinator __________________  Date __________

Project co-ordinators:

Patricia McKinley, (514) 487-1891, ext.: 352
Joyce Fung , (450) 688-9550, ext.: 429
Michel Rossignol, (514) 528-2400, ext.: 3261
Constant Rainville, (514) 340-3540, ext.: 4022
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Katherine Berg,
APPENDIX 4: Social Scales

UCLA Loneliness scale (revised) (Russell, 1996) is considered the gold standard of loneliness measures and is a 20-item scale ranging from 20-80 with internal consistency ranging from $\alpha = 0.89-.94$; construct validity is supported by significant relations with measures of adequacy of the individual's interpersonal relationships, and be correlations between loneliness and measures of health and well-being. The French version (De Grace, Joshi, & Pelletier, 1993) shows comparable validity, test-retest reliability and internal consistency.

Social Provisions Scale (SPS) (Cutrona, & Russell, 1987) takes 15 minutes to complete, consists of 24 items using a Likert scale to measure 6 dimensions of social support: emotional support, aid, counseling, social integration and need to feel useful and necessary. The authors concluded that the SPS assesses both specific components and overall levels of social support. Internal consistency for the total SPS ranges from $\alpha = 0.83-0.90$. A French version with comparable psychometrics is available (Caron, 1996; Tempier, Caron, Mercier, & Leoffre, 1995).

Satisfaction with life Scale (SWLS) (Diener, Emmons, Larsen, & Griffin, 1985) consists of five statements with a 7 point scale indicating the amount of agreement (7 = strongly agree) or disagreement (1 = strongly disagree; 4 = neither agree or disagree). Initial and subsequent studies have examined the internal consistency and alpha coefficients have repeatedly exceeded 0.80 (Pavot, & Diener, 1993). It has good construct validity. Test retest reliability is high ($r = 0.89$) within a two week period, but declines as time increases, suggesting that the instrument is sensitive to changes that occur with life and not just a direct effect of stable personality traits. It also shows consistent differences between populations that would be expected to have different qualities of life (psychiatric patients, or male prison inmates), and has been found to change in the expected directions in response to major life events (Pavot, & Diener,