The influence of physical activity on driving performance and cognitive functioning in older adults: A randomized controlled trial

Harpreet Kaur Chattha

Lakehead University

A dissertation submitted to the

Faculty of Graduate Studies in

partial fulfillment of the requirements

of the degree of Doctor of Philosophy

Advisor: Dr. Michel Bédard

Abstract

As individuals age, two central concerns involve driving safely and preserving cognitive faculties. While some research examining fitness effects on elderly cognition has been conducted, little has been done to investigate whether driving performance or driving relevant cognitive abilities might be affected by increased physical activity particularly in sedentary older adults. The present study examined the effects of a 12-week combined aerobic and anaerobic fitness intervention on a sample of older adults with a sedentary lifestyle. Twenty-nine older adults (55 years of age or older, M = 62.93 years) were assigned to either an experimental (n = 16) or wait-list control group (n = 13). Cognitive, driving performance and physical functioning data were collected on all participants at baseline and after the 12-week interval. These measures were selected based on empirical relevance, however some supplementary analyses were more exploratory in nature given the paucity of literature in the area. A significant intervention effect was found for general visual attention and also for selective attention when individual visual attention domains were assessed. A statistically non-significant effect was found for set-shifting/interference (i.e., Stroop Colour Word Test), however examination of effect size demonstrated that about 9% of group variance was explained by this variable. While expected, significant effects for physical and driving performance were not found. Given the preliminary nature of this research and limitations, more investigation is needed to provide more conclusive inferences. Future research directions are discussed.

Acknowledgements

I would like to acknowledge a number of people who contributed their time and effort towards completion of this dissertation. With great appreciation, I would like to thank my dissertation supervisor, Dr. Michel Bédard, for his continual guidance and commitment to this project. I would also like to thank the members of my dissertation committee, Dr. Gordon Hayman, Dr. John Jamieson, Dr. Ian Newhouse, as well as Dr. Janice Miller-Polgar from the University of Western Ontario for contributing their valuable input and expertise.

I am deeply indebted to my parents, my brother Sukhjeevan and sister Monica for their unwavering love and support throughout this entire process. And to my dear friend, Mun, for her invaluable encouragement, guidance and kindness without limits. Without these amazing people, this dissertation would not have been possible. Words cannot begin to express the extent of my gratitude to them.

I would like to dedicate this dissertation to my dear, sweet BeiJi, who will forever inspire me with her strength and resolve, which she demonstrated even at the most difficult of times.

Scholarship funding was provided from a Canadian Institutes of Health Research Doctoral Award. I wish to thank the Institutes for their financial support.

Table of Contents

List of Tables

List of Figures

The influence of physical activity on driving performance and cognitive functioning in older adults: A randomized controlled trial

Background

Older adults have become the fastest growing portion of the general population. In 1971, the proportion of individuals aged 65 and older comprised 8% of the overall population (Ramage-Morin, 2003). Recent statistics indicate that this demographic is now closer to 14% of the general population (Statistics Canada, 2008). Furthermore, as the "baby boomer" generation ages and life expectancy rates continue to climb (Ramage-Morin, 2003), the aging demographic experiences further growth. In fact, it is estimated that by 2026, one in five Canadians will be 65 years or older (Division of Aging and Seniors, 2002) and by 2030, forty percent of the overall population will be 55 years or older (Statistics Canada, 2005). After 2040, the number of Canadian citizens above 65 years of age is expected to rise upwards of 9.2 million nearly tripling 2001 figures (Division of Aging and Seniors, 2002). With the progressive growth of the elderly population, difficulties conventionally associated with age become more salient areas of concern.

As individuals age, they face an accelerated risk of declining physical health (Ahmed, Ness, Howard & Aronow, 2005). This risk is not limited to lower functioning older adults (i.e., those requiring long-term care or medical supervision), but also pertains to the healthier majority. In fact, four out of five community-dwelling older adults are diagnosed with a chronic medical illness, such as arthritis, diabetes or heart disease (Division of Aging and Seniors, 2002; Gilmour & Park, 2003). Those with certain chronic illnesses (e.g., arthritis, respiratory disorder) are more likely to need assistance for both basic activities (e.g., personal care, bathing) as well as instrumental activities of daily living (IADLs), such as managing finances or shopping (Gilmour & Park, 2003). In addition to physical health, age-related cognitive decline is another important consideration that can have a major impact on future health care needs of seniors. However, in contrast to physical illness, decreased cognitive ability may be less overt and thus, can be more challenging to detect, particularly when higher-order cognitive abilities (i.e., executive control processes) are affected.

Some researchers propose that age-related cognitive difficulties are chiefly responsible for some of the functional impairments seen with aging (e.g., Royall et al., 2004). In fact, higher-order cognitive skills are essential in performing important daily activities (e.g., managing finances, driving) that help one maintain independence and autonomy (Ramage-Morin, 2003). Further, the implications of declining cognitive ability reach beyond functionality and can affect one's perceived well-being. Those experiencing fewer cognitive difficulties with age tend to report a higher quality of life (National Research Council, 2000; Korten et al., 1999). Thus, it is not surprising that cognitive difficulties may also result in further declines to overall health. Older adults with intact cognitive functioning tend to live longer than their impaired counterparts (National Research Council, 2000; Korten et al., 1999). An additional consequence is the cost required to provide greater health care and support services to assist individuals experiencing these age-related deficits. It has been shown that older adults tend to require and utilize more health care services than other segments of the population (Andersen, 1995, Rapoport, Jacobs, Bell & Klarenbach, 2004, Verbrugge & Patrick, 1995). Thus, as the population ages, efforts to maximize and extend the independence of individuals as well as optimize physical and cognitive health will be important endeavours.

There has been an influx of recent initiatives to help promote healthy aging (e.g., Centers for Disease Control and Prevention, 2001, 2008, Hendrie et al., 2006, National Institute on Aging [NIA], 2009) in which the focus has been on optimizing physical health. One popular directive has involved promotion of physical activity in older adults (i.e., NIA, 2009, The Robert Wood-Johnson Foundation, 2001). And while the physical benefits of such an initiative have received much attention, less consideration has been given to the potential cognitive benefits of increased fitness in the elderly. Given the association of cognitive decline to poor functional and physical outcomes with age, a reasonable question is whether physical fitness improvements can result in cognitive benefits in addition to physical ones.

However, before precise strategies to target age-related cognitive difficulties can be formulated, it is necessary to better understand the nature of cognitive difficulties that arise in normal aging. There is considerable debate on the extent of age-related changes experienced by healthy older adults, specifically within the cognitive domain (e.g., Depp & Jeste, 2006, Rowe & Kahn, 1997). Potentially contributing to this lack of consensus is the diverse set of investigations and research methods used within the aging literature. Cognitive aging investigations, in particular, have varied considerably in their methodological approaches and research designs (e.g., brain research, neuropsychological performance, cognitive measurement and conceptualization). These areas are reviewed in the subsequent sections with an attempt to integrate findings across different research approaches and reconcile some the methodological difficulties mentioned.

Brain Structure and Aging

Data pertaining to brain morphology across the lifespan can provide insight about brain functionality and, more specifically, the emergence of cognitive difficulties that might occur with normal aging. This research has followed different lines of pursuit. One such approach has involved using animal proxies for direct examination and experimental research involving brain tissue. While animal research faces fewer restrictions on experimental design and methodology than human research based on greater ethical liberties, the difficulty in extrapolating findings across species is a constant limitation of this data. The other main approach to examining brain structure involves use of advanced imaging techniques (e.g., Magnetic Resonance Imaging [MRI], Positron Emission Tomography [PET]). Brain imaging techniques allow one to view not only brain structure, but also patterns of activation within the brain (e.g., cerebral blood flow). For example, PET scans use marked biologically-active metabolites (tracers) to determine which regions in the brain are activated and to what degree by reviewing patterns of tracer uptake during experimental tasks.

Brain imaging technology has had an important presence in aging research. From the research conducted to date, some key senescent structural changes have been identified. In particular, brain-imaging research in aging has focused primarily on brain volume or shrinkage, structural abnormalities (e.g., hyperintensities, neurofibrillary tangles) and brain activation patterns during cognitive task performance.

Brain Volume

Several imaging studies have noted a marked decrease in overall brain volume in older adults (e.g., Miller, Alston & Corselli, 1980, Jernigan et al., 1991; Resnick, Pham, Kraut, Zonderman & Davatzikos, 2003). Empirical evidence suggests that overall brain volume first begins to decrease after age 50 and then experiences further linear declines thereafter (DeCarli et al., 2005). While the majority of these investigations have involved cross-sectional comparisons of older and younger adults (e.g., Allen, Bruss, Brown & Damasio, 2005), longitudinal investigations in this area have also yielded similar findings (e.g., Raz, Rodrigue, Head, Kennedy & Acker, 2004b). Given the numerous studies that have replicated this finding, it is generally undisputed and has achieved consensus in the literature (Greenwood, 2007).

More precise investigations of elderly brain volume involving imaging specific regions of the brain have found that most of the loss in volume experienced by older adults occurs within the frontal lobe or prefrontal area (precise area of the frontal lobe) (e.g., Allen et al., 2005, DeCarli et al., 2005, Jernigan et al., 1991, Haugh & Eggers, 1991). Estimates of frontal volume decrease range from 10 to 17% (Haugh & Eggers, 1991), however, imaging results are mixed for the remainder of the brain regions assessed. Some posit that decreases in the temporal lobe closely follow the magnitude of loss seen in the frontal lobe and that negligible losses occur in other regions of the brain (DeCarli et al., 2005; Gallagher & Rapp, 1997; Jernigan et al., 1991). Other researchers maintain that only the prefrontal and parietal regions experience notable volume losses (Allen et al., 2005, Jernigan et al., 2001).

It should be noted that there are also considerable individual differences among brain imaging in older adults (Band, Ridderinkhof & Segalowitz, 2002; Raz et al., 2004a), where the degree of brain change can vary greatly across participants. It is likely that these individual differences contribute to the above-mentioned inconsistencies in the literature. Nonetheless, while there is debate over the precise pattern of volume loss in older adults, there is general consensus in implicating the prefrontal region as particularly sensitive to aging (Greenwood, 2007). However, ascertaining the exact nature of these changes, such as knowing the precise casual factors underlying these changes, is less clear. Investigations studying brain matter composition may provide some insight into these questions.

With the further development of advanced imaging technology (i.e., voxel-based morphometric imaging (VBM), high resolution MRIs), it has been possible to inspect beyond global brain structure and look more precisely at brain matter constitution. As a result of these investigations, specific properties of neuronal matter have been found to vary with age. Generally, this research has examined the two main types of neural matter: grey matter and white matter, but has focused on the latter. The distinction between these two types of brain tissue is not only based on morphology, but also function.

Grey and White Matter

Grey matter is comprised of neuronal cell bodies, is dense in nature and is located predominantly within the cortex, whereas white matter consists of neuronal extensions (i.e., axons), which expand to connect with other neurons throughout the brain particularly in the event that learning is taking place (Reisberg, 2005). In addition, white matter is responsible for inter-neuronal communication (Reisberg, 2005), thus deterioration in this material can not only influence the development of cognitive processes, but also the efficiency of these processes. In terms of developmental progression, losses in grey matter are found to occur as early as childhood and are thought to decrease steadily up until adulthood (Greenwood, 2007; Sowell et al., 2003). This "loss" is considered adaptive, since decreases in grey matter are less reflective of atrophy/pathology and more so of the development of neuronal connectivity or white matter which occupies the space formerly occupied by grey matter (Greenwood, 2007). This occurs with gradual learning and refinement of knowledge, which is seen at the cellular level as synaptic pruning or myelin development (Sowell, Thompson, Tessner & Toga, 2001). However, some researchers posit that the loss of grey matter after age 40 (middle age) is the result of degeneration rather than remodeling (Sowell et al., 2003), Nevertheless, studies investigating age-related volume losses within brain matter have found greater decreases in white matter compared to grey matter.

Cross-sectional investigations have found that grey matter loss associated with advanced aging ranges from 12-14%, but white matter loss is more substantial ranging from 23-26% over time (Allen et al., 2005, Jernigan et al., 2001). Longitudinal studies, while demonstrating that individual differences do result in varied presentations across older participants, generally confirm the cross-sectional trends of grey and white matter losses (Kramer et al., 2007; Raz et al., 2004a). Senescent structural changes for grey matter are generally found within anterior and posterior areas (Brickman, Habeck, Zarahn, Flynn & Stern, 2007) whereas white matter changes are observed in the frontal and temporal lobes as well as the corpus callosum (Allen et al., 2005, Brickman et al., 2007). Generally, white matter losses are found to occur after age 50 (Bartzokis et al., 2004) at then at an accelerating pace (Allen et al., 2005). As stated, white matter assists in interneuronal communication and expands with learning, thus it is reasonable to expect that these losses might also correspond with cognitive changes. While one may assume that changes in white matter integrity that occur with aging may account for losses in global and regional brain volume, recent evidence suggests that the relation between the two losses might not be linear or direct (Hugenschmidt et al., 2008). Thus, while white matter loss may contribute to volume loss, care should be taken not to presume that other significant brain changes are not also involved.

It is acknowledged that a variety of neurochemical and neurophysiological changes may contribute to the overall structural changes observed (i.e., changes in brain volume and matter) and that these mechanisms are not fully understood (Rabbitt et al., 2007). Furthermore, equating behaviours or cognitive functions wholly to specific brain changes may be challenging given the difficulty inferring direct structure-function relationships within the brain (Rabbitt et al., 2007). Nevertheless the findings uncovered from this research can provide some direction for more streamlined investigations in the future. Additionally, aging studies which include both neurostructural and cognitive measures can assist in bridging the gap between these two distinct, but interrelated areas.

Cognition and Age-Related Neurostructural Changes

While some studies investigating associations between senescent brain changes and cognitive performance have been conducted, comparisons among these studies are complicated by several characteristics of the research. Some examinations (e.g., Deary et al., 2003; Elderkin-Thompson, Ballmaier, Hellemann, Pham & Kumar, 2008) have targeted specific brain regions (i.e., frontal) or properties of neural tissue (i.e., white matter hyperintensities), whereas others (e.g.,Rabbitt et al., 2008) have employed more general imaging approaches (i.e., global MRIs). There is also significant variation in the types of cognitive tests administered within these studies as well as the cognitive constructs of interest and how they are conceptualized (and operationalized) across different research studies.

A meta-analysis of studies examining white matter lesions (WML) in healthy older adults found that an increased presence of WML was associated with several cognitive difficulties, including poorer memory, executive functioning and processing speed (Gunning-Dixon & Raz, 2000). While meta-analyses can overcome some of the limitations associated with individual studies mentioned above (i.e., different measures, approaches), the findings from Gunning-Dixon and Raz (2000) are largely correlational and thus, their posited link between WML and cognition is limited. Attention geared towards brain activation research may provide some important qualitative insight about the association between structural abnormalities in the aging brain and their related functional implications.

White Matter Abnormalities and Memory

There have been some challenges to the association of poor memory with WML. Recent investigations have revealed that while abnormalities in white matter are often correlated with memory difficulties, this association seems to be independent of age (Brickman et al., 2007, Rabbitt et al., 2008). Thus, it is possible that this link might be due to another factor (i.e., clinical pathology such as Alzheimer's Disease) that is not reflective of normative aging. Furthermore, brain activation patterns of individuals completing memory tests suggest reduced activation during the encoding phase may result in reduced retrieval scores (Grady et al., 2005). This indicates processing difficulties or reduced attention during stimulus presentation may be the more likely culprit. This position is supported by other researchers (i.e., Gallagher & Rapp, 1997, Parasuraman & Haxby, 1993, Schacter et al., 1996).

Frontal Lobe and Executive Functions

Comparisons of cognitive performance of healthy older adults and frontal lesioned adult patients (specifically in the dorsolateral prefrontal cortex) demonstrated that both groups performed poorly on a reasoning task that detects hallmark frontal dysfunction (Levine, Stuss & Milberg, 1997). In addition, increased volume in certain prefrontal areas has been associated with better performance on specific executive functioning tasks, such as response inhibition and nonverbal reasoning (Elderkin-Thompson et al., 2008). During executive function tasks, greater contralateral prefrontal cortical activation was found for older adults who performed more poorly on the tasks (Colcombe, Kramer, Erickson & Scalf, 2005). In addition, older adults were more likely to demonstrate a bilateral activation pattern and more performance difficulty on the task compared to younger adults (Colcombe et al., 2005). Generally, younger adults displayed more unilateral prefrontal activation and bilateral activation in older adults intensified with worse performance.

A similar result was found in a study by West and Schwarb (2006). In this study, a selective attention task was administered and response times were used to ascertain the degree of cognitive interference. In addition, event-related potentials (ERPs) were measured to determine the pattern and magnitude of brain activation occurring during the executive task. Greater interference occurred for older adults and the ERPs showed that older adults demonstrated more frontal recruitment during the task than younger participants. This is consistent with previous findings (i.e., Colcombe et al., 2005).

While some researchers (e.g., Deary et al., 2003) have suggested that the specific cognitive difficulties associated with age-related brain changes can be better accounted for by a general cognitive factor (i.e., *g* factor), certain higher-order cognitive functions appear to be exceptions (see Cognition and Aging section below for a review of this issue).

Summary

It appears that aging does effect brain structure and that certain brain regions (i.e., frontal, parietal) are particularly sensitive to senescent change. Some specific brain changes that are found to occur with age include decreased brain volume (particularly in the frontal region), increased white matter abnormalities, decreased grey matter and increased bilateral activation. Evidence suggests that age-related changes in brain morphology or activation may result in adverse consequences for the older adult. In particular, these changes seem to be associated with compromised cognitive abilities, especially with executive functions. Apparent difficulties with memory associated with WML appear to be better accounted for encoding or attentional difficulties.

While neuroimaging techniques may provide important information about potential causal precursors of age-related cognitive changes, some cognitive difficulties that occur with aging may not be detectable by current neuroimaging technology. Thus, the general literature on cognition and aging (i.e., cross-sectional and longitudinal comparisons of cognitive abilities and age) may also be informative about normative changes expected with age.

Aging and Cognition

A prominent hallmark of advancing age is decline in Activities of Daily Living (ADL). However, the precise nature of cognitive deterioration underlying these functional changes is less evident. Nevertheless, researchers in recent decades have begun to identify domains of cognition that may be prone to age-related declines. As reviewed above, brain morphological changes occurring with age have been associated with executive functioning. Additionally, evidence indicates that difficulties with executive function are correlated and even predictive of eventual functional decline (Grigsby et al., 1998). In fact, poor performance on executive tests is more predictive of instrumental functional decline (i.e., shopping, gardening) than other cognitive tasks (Cahn-Weiner et al., 2000). Furthermore, an older adult is likely to remain independent if his/her executive functioning abilities are intact regardless of decreased ability in other cognitive domains (Lezak, Howieson & Loring, 2004). Thus, understanding the nature of senescent executive changes is an important endeavour.

Executive Functioning

Generally, executive abilities are described as higher-order cognitive abilities that involve one's capacity to organize or interpret information in a sophisticated or meaningful way (Luria, 1973). Lezak (1983) indicated that these abilities primarily impact the way in which behaviour is expressed. Aside from these general depictions, the exact nature of the executive functioning construct has been conceptualized in a variety of ways. In fact, several popular models (e.g., Anderson, Anderson, Northam, Jacobs & Catroppa, 2001, Borkowsky & Burke, 1996, Lezak, 1983) have implicated a wide range of abilities as sub-components of executive functioning. These have included attentional control, cognitive flexibility, goal setting, strategy monitoring, volition and planning among others. Executive functioning is somewhat of a unique cognitive concept not only in its multifaceted nature, but also because of the posited relationship between components, which is a central part of the construct. These inter-component associations have also been widely debated upon.

In earlier models (i.e., Baddeley & Hitch, 1974, Norman & Shallice, 1986), the notion of an overarching, control mechanism subsuming other executive processes was a prominent feature. More specifically, these theories denoted that a "central executive" or "supervisory" process would govern other executive components, which were more automatic in nature. Thus, not only have these models included both automatic and controlled components, but also they are organized in a hierarchical structure with attentional control as the focal aspect of the construct subordinating the other elements. Results from more recent approaches to studying executive functioning have deemphasized the centralized model, instead suggesting that there are several related, but distinct and equal executive components involved (e.g., Boone, Ponton, Gorsuch, Gonzalez & Miller, 1998). However, the attentional control mechanism discussed by earlier models continues to be included in more current conceptualizations of the construct.

A more current approach to conceptualizing executive functioning was outlined by Miyake and authors (2000) in their investigation of inhibition, shifting and updating as three central executive functions. These researchers chose to focus on these abilities not only because of their popularity in the executive literature, but also because of their specific, circumscribed nature (compared to more abstract concepts like planning) and testability. Through latent variable analysis, it was found that while all these faculties were significantly represented in several common executive measures, they also demonstrated distinct aspects of executive control (Miyake et al., 2000). The importance of these three components in representing executive functioning has been supported by further research (e.g., Fisk & Sharp, 2004, Wecker, Kramer, Hallum & Dellis, 2005). As well, the relevance of these processes has also been demonstrated in other cognitive aging literature.

As stated, executive functioning has been recognized as particularly sensitive to the aging process. However, in recent years, some researchers (i.e., Salthouse & Miles, 2002, Salthouse, 2005, Salthouse & Siedlecki, 2007) have proposed that these executive changes could instead be explained by a different cognitive factor. This argument is a fair one given that executive functioning measures have been supposed to tap into other skills or abilities, such as intelligence, processing or psychomotor speed that have been proposed to underlie these age-related executive difficulties. In fact, findings resulting from these studies have shown some support for this hypothesis (i.e., Salthouse & Siedlecki, 2007), however, two of the executive components (shifting and inhibition) attended to by Miyake and colleagues (2000) seem to be an exception.

A study on cognition in older adults by Friedman and researchers (2006) found that while updating (i.e., monitoring information with subsequent modifications where necessary) was highly correlated with general intelligence even after accounting for shared inter-executive function variance (among different aspects of executive functions), the associations with shifting and inhibition were small and non-significant. Thus, not only do these two processes appear to be distinct and important components of executive functioning, they also seem to play a vital role in cognitive aging.

Set Shifting/Cognitive Flexibility

As stated, set shifting, also known as cognitive flexibility, has been identified as a key dimension of executive functioning (e.g., Anderson et al., 2001, Jurado & Rosselli, 2007, Miyake et al., 2000, Piquet et al., 2002). More specifically, it involves tracking stimuli and shifting between two different response sets (Wecker et al., 2005). This process is associated with a temporal cost (Rogers & Monsell, 1995), as disengagement from one task or set occurs before it is followed by the engagement with another (Miyake et al., 2000).

Cognitive aging studies have demonstrated that greater perseverative errors (failure to shift to a novel set) or poor performance on shifting tasks occurs as individuals age (Axelrod & Henry, 1992; Crawford et al., 2000). Based on their recent findings, Salthouse and researchers (2000) proposed that age-related decrements in set shifting were mediated by perceptual speed. However, these authors used a non-standardized proxy of the Trail Making Test (TMT) despite the popularity of the original in cognitive research. Thus, it is unclear whether these researchers tested the same construct. In contrast, a recent investigation by Wecker and colleagues (2005) found that perceptual speed, intelligence and other cognitive measures could not account for senescent changes in cognitive flexibility. Compared to Salthouse and colleagues (2000), not only did these authors use well-validated and standardized executive measures, but they also recruited a much larger participant sample. Furthermore, a study by Keys and White (2000) examining psychomotor speed, age and cognitive flexibility found results similar to

Wecker and colleagues (2005). In particular, a distinct age effect was found for cognitive flexibility even after accounting for other cognitive variables. Age-related executive changes have been further supported in other similar cross-sectional (e.g., Gunstad et al., 2006) and longitudinal investigations (e.g., Royall et al., 2004).

Inhibition/Interference Effects

Dual process theories of executive attention (e.g., Allport, 1989; Tipper, 1992) provide an appropriate context to understanding the concept of inhibition. A core element of these theories is the concept that attention is regulated by the interaction of excitatory and inhibitory processes. The excitatory component is needed for initial attention to stimuli (sometimes termed selective attention), while inhibition contributes to the efficiency of the process by disengaging from irrelevant or distractor stimuli (Kane, Hasher, Stoltfus, Zacks & Connelly, 1994). Much attention has been paid to the inhibitory aspect of attention given that it appears to be a multifaceted process and also that it appears to deteriorate with age (e.g., Hasher & Zacks, 1988). In relation to encoding information, inhibition is posited to have three main components: access, deletion and restraint (Zacks & Hasher, 1997). First, an individual attends to various stimuli and thus, provides working memory access to its mental representation. This can include processing both target and distractor stimuli (Hasher, Zacks & May, 1999). Then data believed to be not meaningful are deleted and finally, data that are encoded and kept, but not deemed relevant to a current task are restrained until needed. Research conducted on inhibition has worked to further elucidate the construct.

One particular phenomenon arising from research on the inhibitory mechanism, involves negative priming. In essence, this term pertains to the experimental finding that it takes longer to attend to previously ignored stimuli compared to novel, neutral stimuli (Kane et al., 1994). Negative priming is thought to represent a more automatic aspect of inhibition, since it is carried out so quickly and without much explicit deliberation (Houghton & Tipper, 1994). Research has shown that these more automatic facets of inhibition are more resistant to aging effects compared to more executively-controlled inhibition, like Stroop interference (Andres, Guerrini, Phillips & Perfect, 2008; Chodzko-Zajko & Moore, 1994; Little & Hartley, 2000; Rush, Barch & Braver, 2006). This difference is also found for controlled versus automatic retrieval during an interference task, where older adults perform more poorly compared to younger adults for controlled rather than automatic conditions (Ikier, Yang & Hasher, 2008).

Some scholars (i.e., Salthouse, Atkinson & Berish, 2003, Salthouse, 2006) have posited that like general executive functioning, inhibition effects can be better explained by other cognitive factors, such as speed of information processing. This theory has been disputed with studies that included both processing speed and inhibition measures in their methodology (e.g., Andres & Van der Linden, 2000; Kane, Hasher, Stotzfus, Zacks & Connelly, 1994; Rekkas, 2006), where distinct age-effects for inhibition are found. In fact, reducing distractors has been found to improve processing speed in older adults, but has little or no effect on performance in younger adults (Lustig, Hasher & Tonev, 2006). This suggests that inhibition or selective attention may, in fact, mediate processing speed. In addition, other evidence indicates that distraction control could also mediate age-related decrements in working memory and reasoning (Darowski et al., 2008). This suggests that ability to resist interference, particularly involving executive control declines with age and that this effect is likely independent of difficulties in other higher-order functions.

It appears that executive inhibition is an ability that is specifically affected in the aging process. Both cross-sectional (e.g., Miyake et al., 2001) as well as longitudinal (e.g., Royall et al., 2004) investigations support this finding. And while interference effects appear to be more pronounced in specific clinical populations, such as older adults with Alzheimer's Disease (Belleville, Roulleau & Van der Linden, 2006), these effects have been sufficient and significant in several normal older adult samples (e.g., Kane et al., 1994). In fact, a large scale normative study of older adults in the Netherlands found that the interference score on the Stroop Colour Word Test (SCWT), which is a measure of executive inhibition, showed a significant age effect, with performances worsening with age (Van der Elst, Van Boxtel, Van Bruekelen & Jolles, 2006).

The interference score for the SCWT is a popular measure for executive inhibition and it has demonstrated age-effects in a number of studies (e.g., Daigenault, Braun & Whitaker, 1992; Houx et al., 1993; Libon et al., 1994). A few select studies, which have disputed the influence of age on Stroop performance, have tended to modify the test (i.e., including numerical dual tasks) and its standardized administration or have neglected to use the interference score as an index of outcome (Salthouse, Atkinson & Berish, 2003, Salthouse & Meinz, 2005; Langley, Vivas, Fuentes & Bagne, 2005; Shilling, Chetwynd & Rabbitt, 2002).

Despite the methodological shortcomings that frequently arise when studying executive functioning (i.e., construct validity, operationalization), the research on inhibition and cognitive flexibility has seemed to overcome these limitations. Further, the research conducted on these executive abilities has provided compelling evidence that they are adversely impacted with age. While both processes are related to controlled or executive aspects of attention, a third component of attention also merits review. In fact, aside from its theoretical connection to these executive components (as discussed above), research findings suggest that selective attention also markedly deteriorates with normal aging.

Selective Attention

As stated, dual process models of attention have fractionated attention into excitatory and inhibitory mechanisms (Kane et al., 1994; Posner & Snyder, 1975). While inhibition is needed to disengage from irrelevant stimuli, one also needs to selectively attend to or engage with pertinent stimuli despite the presence of distractors. It has been acknowledged in the cognitive aging literature that older adults demonstrate reduced selective attention ability (see McDowd & Birren, 1990) however it is unclear whether this occurs because of a lack of efficient engagement with stimuli or limited resources to initiate engagement, or both (Madden, 1990). Much of the research on selective attention decrements in aging has focused on stimuli within the visual domain.

Space-based (i.e., spatial position) or object-based (i.e., shape, colour) aspects of stimuli can influence the complexity of the attentional task (Pesce et al., 2005). In cognitive aging research, these two variables have been shown to have differential effects. In particular, object-based distractors seem to affect selective attention in older adults to a greater degree than space-based distractors (Connelly & Hasher, 1993). Recent measures of visual attention, have combined both spatial- and object-based distractors (e.g., Useful Field of View test [UFOV]), thus, it is possible that use of the two distractors may have an additive aging effect. As well, older adults have also been found to exhibit difficulty attending to multiple targets (i.e., divided attention) (Hakamies-Blomqvist, 1996). Thus, other precise aspects of attention also warrant investigation. A greater focus on this cognitive process and aging has been attended to in the elderly driving literature (see Elderly Driving section below).

Certain types of cognition appear to be prone to deterioration with age. While executive functioning as a general construct has been implicated, it appears that specific aspect of this construct, namely cognitive flexibility and inhibition are especially important. In addition, selective attention appears to be another cognitive process that is sensitive to aging. As stated, difficulties in these areas underlie the functional capabilities of older adults, potentially risking their independence, autonomy and well-being (National Research Council, 2000, Korten et al., 1999). Furthermore, these cognitive abilities are required in some daily activities and as such, an older adult's range of activities may become restricted. One activity that is particularly relevant to this discussion is driving.

Elderly Driving

According to current Canadian statistics, elderly drivers (aged 55 or older) nearly double the number of drivers aged 16 to 24 (Nicolletta, 2002). In addition, the number of older drivers is steadily increasing. Older adults aged 65 and over represent the fastest growing portion of the driving population (Lynam, Ferguson, Braver & Williams, 2002). While casualty-producing collisions have decreased over time, the involvement of elderly drivers in these collisions has increased (Transport Canada, 2001). As the proportion of elderly drivers and elderly driving fatalities increase, the safety of older drivers as well as the public at large becomes a progressively more serious concern.

Research on elderly driving has identified specific areas of difficulty for older drivers. In particular, older drivers commit errors in yielding to right-of-way, obeying traffic signs and signals and tend to make improper turns (Yaksich, 1985). They also have significant difficulty in more complex driving situations, such as crossing an intersection (Yaksich, 1985). It is posited that driving situations, which involve perception of several details and require sophisticated cognitive processing are particularly difficult for older drivers (Daigeneault, Joly & Frigon, 2002a). Pedal errors or unintended acceleration (i.e., mistaking the accelerator for the brake pedal) are most likely to be committed by older adults (U.S. Department of Transportation [U.S. DOT], 1989). Furthermore, in studies of driving behaviour, older drivers were found to typically drive at slower speeds than their younger counterparts (Daigenealt, Joly & Frigon, 2002a).

Previous research using self-reported driving behaviour questionnaires and measures of driving confidence indicate that older drivers with greater driving confidence tend to drive more frequently and drive more miles, yet driving confidence had no association with self-reported quality of driving performance (Marottoli & Richardson, 1998). While this implies that older drivers may lack insight into their driving behaviour, further evidence suggests otherwise. More specifically, older drivers with sensory or cognitive impairments have been found to adjust their driving behaviour (e.g., not drive at night, avoid challenging driving situations) to minimize their driving risk (Ball et al., 1998). This does not include individuals with mental status impairment who are generally unaware of their specific driving difficulties (Ball et al., 1993). Conversely, those with better cognition and sensory scores tend to drive longer distances and for longer periods of time (Anstey & Smith, 2003). However, compensatory driving behaviours seem to be insufficient to reduce elderly driving risk. Despite the tendency of elderly drivers to attempt to compensate for progressive driving difficulties, adverse driving events involving the elderly are still increasing (Transport Canada, 2001). At present, older drivers are the second highest demographic group at risk for crashes (Transport Canada, 2001). A review of the cognitive difficulties underlying unsafe elderly driving behaviours may help to generate interventions that can target improvement of these cognitive areas.

In driving research, sensory difficulties can often overlap with cognitive variables making it challenging to determine precisely how cognition influences unsafe driving. In their study, Kline and researchers (1992) were able to find a specific link between cognitive performance and self-reported driving difficulties even after controlling for the influence of pertinent sensory variables (i.e., contrast sensitivity, dynamic vision). In particular, they found that older drivers who experienced difficulties on specific cognitive tasks (i.e., visual search, visual processing speed) reported a greater incidence of driving errors. Specifically, these drivers reported difficulty assessing their own speed, they tended to be surprised by other vehicles in their periphery and found that other vehicles moved too quickly. These difficulties are consistent with some of the adverse driving incidents reportedly committed by older drivers, such as having difficulty merging lanes, yielding to others and turning accidents (e.g., Preusser et al., 1998). However, self-reported driving behaviours are limited by the participant's insight and awareness of their own difficulties and thus, more objective testing is needed to study driving-related cognitive abilities with adequate precision and in a valid manner.

Crash Incidence or Crash Risk

A common measure of driving outcome in the current literature is the use of crash incidence. This information can be obtained from state or provincial driving records. Since drivers with a past crash history may be at particular risk for adverse driving events, they may be ideal participants for cognition and driving research. Thus, their cognitive abilities may provide important information about factors influencing or contributing to unsafe driving.

Owsley and colleagues (1991a) examined retrospective crash history in addition to visual and cognitive variables in their study of older drivers (N=53, aged 57 to 83). Information pertaining to participants' driving history was obtained from state records for a five-year period preceding the study as well as self-reported driving behaviour. Both cognitive measures were found to explain a significant amount of variance associated with crash history. In particular, the UFOV and Mattis Organic Mental Status Syndrome Examination (MOMSSE) scores explained about 29% of the variance for crashes occurring in intersections and about 20% of the variance for overall crashes. However, nearly half the sample failed the UFOV test and eight had very high MOMSSE scores (indicative of poor mental status), therefore this sample may have been lower functioning than typically expected for a community sample. Furthermore, the types of cognitive variables examined were very limited, thus it is possible that other cognitive factors may have had a greater contribution to accident history than visual attention and mental status.

In their investigation of older drivers, Daigeneault, Joly and Frigon (2002b) chose to focus on the role of executive functions in relation to crash history. Specifically, four measures of executive functioning were administered: the Colour Trail Test (CTT), the Stroop Colour Word Test (SCWT), Tower of London (ToL) and the Wisconsin Card Sorting Test (WCST). Findings indicated that executive functioning speed differed significantly across groups and other executive outcome indices (i.e., number of errors made) were not informative. Furthermore, a logistic regression revealed that the combination of errors on all four measures resulted in an 80% accurate prediction of crash status. However, only participants with either a very safe driving history (i.e., no crashes within the past five years) or very poor driving history (i.e., more than three crashes) were recruited for participation in the study thus, these findings may not be reflective of the overall older adult population.

In another retrospective examination of crash risk conducted by Goode and colleagues (1998), several cognitive domains in addition to the ones used by Owsley and researchers (1991b) and Daigenault, Joly and Frigon (2002a) were investigated. More specifically, measures of visual attention (i.e., UFOV), visual memory (i.e., Wechsler Memory Scale – Visual Reproduction, Rey-Osterreith Complex Figures Test) and executive functioning (i.e., Trail Making Test) were included in the testing. Incidence of crashes from official records five years prior to study onset was used as the driving outcome variable. Participants were divided into two groups based on the presence or absence of crashes in their driving history. Among all the cognitive variables, the UFOV total score demonstrated the greatest predictive power for crash status (sensitivity of 86.4% and specificity of 84.3%). None of the other cognitive variables added any significant improvement to the UFOV score for this classification. While Goode and co-investigators attempted to increase the scope of cognitive variables considered in safe elderly driving, visual attention was still underscored as having a unique and substantial association with crash risk. Other research has suggested that deficits in certain aspects of attention, namely divided and selective attention, are important contributing factors to unsafe driving behaviours in older adults (Hakamies-Blomqvist, 1996).

A major caveat to all of the retrospective examinations reviewed is that crashes occurred prior to the measurement of cognitive performance. Thus, it is possible that cognition might have undergone further declines from the time the crashes occurred. Prospective investigations of cognition and crash incidence in older drivers were conducted by Owsley and authors (1998) and Sims and colleagues (2000).

Similar to their 1991 investigation, Owsley and authors (1998) administered measures of mental status (MOMSSE) and visual attention (UFOV) along with vision tests (i.e., acuity) in a sample of older drivers. It was found that participants who failed the UFOV (greater than 40% impairment in useful field of view) had a 2.2 times greater risk of being involved in a crash during the 3-year follow-up (Owsley et al., 1998). This was found after controlling for mental status, demographic variables (age, sex), presence of medical conditions and weekly mileage driven. Sims and colleagues (2000) examined the same cognitive variables, along with physical functioning (i.e., Performance Oriented Mobility Assessment, grip strength) and health variables (mood, drug/alcohol use), in their sample of older drivers. Driving data were also obtained from official records over the next five years and it was found that failing the UFOV provided a 1.9 relative risk for crash involvement along with deficits in IADLs, use of hypnotic medication and stroke/ischemic heart attack status, which each also contributed separate and significant relative risk for crash (Sims et al., 2000). Mental status did not provide a significant improvement to prediction of crash involvement, contrary to some of the findings in the above mentioned retrospective investigations (e.g., Owsley et al., 1991a).

A strong and pervasive limitation to both retrospective as well as prospective studies reviewed is that crash risk as the primary driving outcome variable may not be sufficient in identifying unsafe elderly drivers. More particularly, older drivers may commit driving errors or engage in other unsafe driving practices not captured by crash status (i.e., traffic violations, improper lane position). Further, the simplification of the driving variable into presence of crash, also may neglect other important information, such as types of driving situations. For example, older drivers may be more likely to crash or display unsafe driving behaviour in some driving situations than others (i.e., reduced visibility, denser traffic). This information cannot be gauged by a single measure of crash involvement. An additional line of investigation in cognition and safe driving for older adults is the use of performance-based driving measures for driving outcomes. These measures can range from standardized on-road tests to simulated driving scenarios, which can test driving performance in a number of contexts as well as employ additional non-collision criteria to assess driving behaviour.

Performance-Based Driving Outcomes

Odenheimer and colleagues (1994) conducted an investigation of driving performance and cognition in a convenience sample of 30 older drivers. The cognitive abilities examined by the researchers included mental status (MMSE), verbal and visual memory (Wechsler Memory Scale subtests), visual search (TMT-A) and both simple and complex reaction time (Neurobehavioural Evaluation System). A traffic sign recognition task was also administered along with a 45-minute road test evaluated by two trained raters. While participants were tested on different driving manoeuvres, within different driving situations (i.e., closed course, in-traffic) as well as rated on specific driving behaviours, only a total score summing all of these specific indices was used in the analyses. Correlational analysis indicated that all the cognitive variables were significantly correlated (with exception of simple reaction time) with performance-based indices. Mental status, visual attention (i.e., traffic sign recognition) and visual memory, in particular, associated most strongly with driving performance ($r = .72$, .65 and .54, respectively, $p < .01$). While the authors posited that visual attention was particularly influential in safe elderly driving, more direct measures of this construct (i.e., UFOV) were not administered. Furthermore, the cognitive tests selected for use in the study excluded other relevant constructs, such as executive function, thus the conclusions arising from the findings are limited.

In their study of cognition and driving performance, Richardson and Marottoli (2003) employed a more precise measure of visual attention (i.e., number cancellation task) along with other important measures of cognition, including executive function (i.e., TMTB), visual and verbal memory and visuospatial construction. Their sample consisted of 35 participants aged 72 years and older recruited from the community and each participant underwent a standardized on-road driving test in addition to the cognitive measures administered. The on-road evaluation consisted of various driving situations (i.e., urban, highway, suburban) and assessed a variety of driving behaviours (i.e., positions car for turns, responds to vehicles/pedestrians).

Correlational analyses indicated that visual attention, visual memory and executive function were highly and significantly correlated with several driving functions (partial $r = .43, .40, -.38$, respectively, $p < .05$). Visual attention was significantly associated with more driving indices and also accounted for more driving performance variance (about 18%) than other cognitive tests. Visual memory accounted for 16% of the driving variance followed by executive function (14%); however, executive function was significantly correlated with more road test items than visual memory. While there was much overlap between the correlations among these three cognitive variables, executive function was found to correlate more strongly with lane changes and merges than the other two variables. In addition, visual attention appeared to be more relevant to following appropriate driving rules (i.e., yielding to right of way, responding to traffic signals) as well as managing well with other vehicles (i.e., maintaining adequate distance from other cars, navigating traffic situations). Visual memory appeared most influential for perceiving the driving environment (i.e., side scanning, response to pedestrians). A unique aspect of this study was that analyses were not limited to a driving performance global score and thus, it was demonstrated that these different aspects of cognition were related to different aspects of driving not typically researched.

Two additional studies utilizing on-road driving tests with older adults also neglect to examine specific driving behaviours by limiting their assessment of driving performance to total scores (Baldock et al., 2007; Stav et al., 2008). In addition to the on-road test, Baldock and authors (2007) also administered the Computerized Visual Attention Test (CVAT) and measures of mental status (MMSE, 3MS), processing speed (Symbol Digit Modalities Test) and visuospatial memory (Spatial Span) to 90 older drivers (aged 60 – 90). Other variables (i.e., psychological functioning, visual acuity, neck mobility) were also examined. An advantage to the CVAT is that visual attention could be measured in many precise domains (single vs. dual task, distractions vs. no distractions). Of the cognitive measures, processing speed ($r = -.32$), visuospatial memory ($r = -.30$) and visual attention variables (ranged from $r = .30$ to $.46$) were significantly associated with on-road driving scores ($p < .01$). After a linear regression was performed, scores of visual attention reaction times (single task without distractors – simple visual attention; dual task with distractors – divided and selective attention) and visuospatial memory emerged as significant predictors of driving performance. This finding is consistent with that of Richarson and Marottoli (2003), except that Baldock and colleagues did not measure executive function.

A more recent investigation by Stav and researchers (2008) managed to include the Trail Making Test B (TMTB) amongst their cognitive variables, which also included visual attention (letter cancellation, UFOV), visuospatial perception (i.e., spatial orientation, visual closure), memory (i.e., digit span, delayed recall). These cognitive measures were selected by the researchers based on recommendations from the Older Driver Consensus Conference (Stephens et al., 2005). A measure of mental status (MMSE) was also administered to the participants. In fact, mental status scores along with UFOV and TMTB scores showed significant correlations with driving performance in the expected direction (better scores showed better driving performance) ($r_{UFOV} = -.575$, $r_{TMTB} = -.509$, respectively, $p < .001$). However, after a regression analysis was conducted, of the cognitive variables, only the UFOV and MMSE remained predictive of driving performance (adjusted $R^2 = .417$).

It should be noted that about 12.3% of Stav and authors' sample scored within the mild cognitive impairment range on the MMSE, suggesting that the participants recruited may have been more cognitively impaired than the general older adult population. Thus, the participants' performances on the TMTB might not have been reflective of the general population as well. Further, as stated, using the global on-road driving score as the primary outcome variable for driving may have simplified the driving construct and information pertaining to specific driving behaviours may have been lost as a consequence.

Based on studies of crash incidence in older drivers, measures of executive functioning and visual attention appear to be particularly relevant. In fact, specific measures such as the TMTB and the UFOV have been particularly implicated in the elderly driving literature (e.g., Ball et al., 1998, Myers, Ball, Kalina, Roth & Goode, 2000, Stutts, Stewart & Martell, 1998, Tarawneh, McCoy, Bishu & Ballard, 1993). A study by Edwards and researchers (2008) constructed a proxy test battery (including cognitive tests) to assess for driving performance and found that older drivers performed worse on the battery than younger drivers. They also found that older drivers with a crash history performed worse still. The cognitive tests included by Edwards and colleagues included the TMTB and the second subtest of the UFOV (divided attention). Despite, the important information uncovered by the studies reviewed above, expanding measured driving outcomes to include adverse driving behaviours other than those involving collisions may be helpful in identifying unsafe older drivers who are not involved in collisions, but perhaps, contribute to them.

Driving Simulation

Recently, driving simulators have surfaced as a popular testing alternative to on-road/closed-course driving evaluations in driving research. A concern has been raised that data obtained from virtual driving may lack external validity (Bieliauskas, 2005), however several researchers have asserted that it is reasonably sensitive to real-world driving errors (Ponds et al., 1988, Rizzo et al., 2001). In fact, research on driving simulation indicates that these simulation tests are comparable with on-road driving tests (Alexander, Barham & Black, 2002, Freund, Gravenstein, Ferris & Shaheen, 2002, Lee et al., 2003). In a study of older drivers, Freund and colleagues (2002) found that there was a strong association between hazardous and lethal errors committed on the simulator and failing an on-road driving test (hazardous: $r = -.830$, $p = .01$, lethal: $r = -.816$, $p = .011$). Furthermore, driving simulation also provides useful driving information, which may not be viable to obtain in actual driving tests (i.e., complex driving situations, driver reaction to sudden events) (Allen, Stein, Aponso, Rosenthal & Hogue, 1990, Bieliauskas, 2005). Unfortunately, the literature using driving simulators to examine cognitive abilities in older adults is limited, but emerging.

A study by Freund and researchers (2008) investigated older driver performance on cognitive measures (e.g., MMSE, TMT, Clock Drawing Test [CDT]) and incidence of pedal errors on a driving simulation. These authors found that the CDT was the best predictor of pedal errors (odds ratio = 10.04, $p < .0001$), while the TMT and MMSE, despite being previously implicated in the elderly driving research (e.g., Stav et al., 2008), were not found to be significant predictors. This finding may have resulted from the choice of pedal errors as the driving outcome variables, since other driving errors (e.g., collisions, centerline crossings) might be influenced to a greater degree by executive functions or visual attention.

Another study conducted by Freund and Colgrove (2008) used a number of driving simulation errors (i.e., maintaining correct vehicle position, avoiding hazards, traffic violations) to investigate a range of elderly driving skills and their relation to cognitive test performance (i.e., MMSE, TMTB and CDT). They found that after trichotomizing their sample into unsafe, conditional safe (safe in low-risk driving conditions) and safe drivers based on their driving simulation performance, cognitive test scores significantly differed across groups. In particular, safe and conditional-safe drivers scored better on the MMSE and the CDT than unsafe drivers. As well, safe drivers also scored significantly better than the conditional-safe and unsafe drivers on the TMTB. This suggests that the TMTB may be a good measure to detect older drivers who are clearly unsafe, but perhaps also those who are more subtly unsafe, but less detectable.

It appears that normative cognitive declines experienced by aging drivers impact their ability to drive safely. Some individuals aware of their deteriorating driving skills attempt to compensate for these difficulties (Nicoletta, 2002), whereas other are oblivious (i.e., Freund, Colgrove, Burke & McLeod, 2005). Another alternative for drivers is complete cessation of driving, which has been found to be associated with adverse effects to independence, emotional health and general well-being (Fonda, Wallace & Herzog, 2001, Marottoli et al., 2000). Thus, the situation for aging drivers appears discouraging when the two main alternatives are so extreme (i.e., driving cessation or continuing to drive with impairment). There is a strong need for a third alternative which can serve both the interests of the older adult while assuring the safety of the public. While there is some research investigating driving-retraining interventions or various compensatory strategies, little attention has been given to improving underlying cognitive abilities relevant to safe driving.

Fitness and Cognitive Aging

Some researchers theorize that physical activity selectively preserves cognitive abilities that decline with age (e.g., Burke et al., 2001). Various theories have been proposed to provide explanatory models that link physiological benefits of exercise with cognitive improvements (e.g., Cottman & Holets, 1985, Dustman et al., 1984). These theories often center on the effects of aerobic exercise (i.e., increased oxygen efficiency, circulation) and how these may relate to brain tissue or neurochemistry (i.e., neurotransmitters) (Chodzko-Zajko & Moore, 1994). An important application of these theories in aging research is the advent of fitness investigations that have tried to explicate the exact cognitive benefits that might result from exercise.

A major difficulty with the body of research on fitness and cognitive aging has been the varied use of fitness outcomes measures (i.e., self-reported fitness, objective submaximal fitness testing) as well as the use of a range of different cognitive measures. Several reviews conducted on fitness and cognitive aging (e.g., Chodzko-Zajko & Moore, 1994, Dustman, Emmerson & Shearer, 1994, Hall, Smith & Keele, 2001, Kramer, Hahn & McAuley, 2000) have highlighted the mixed findings that plague this research area. The varied methodologies and approaches to and theories about relevant cognitive variables have likely contributed to these equivocal results. Cognitive abilities examined have included general intelligence, processing speed, verbal memory and executive functions among others. In their review of fitness, cognition and aging, Chodzko-Zajko and Moore (1994) suggested that fitness has selective effects on cognitive aging, thus a more focal approach to this area might produce more clarity in the literature. In particular, it was proposed that fitness effects are greatest for tasks requiring novel or complex processing (Chodzko-Zajko & Moore, 1994). They also observed that cognitive processes with greater attentional demand seem to be particularly sensitive to increased exercise (Chodzko-Zajko, 1991, Stones & Kozma, 1988, Stones & Kozma, 1989).

A similarly-focused, but more recent review by Kramer, Hahn and McAuley (2000) forwarded an executive control/fitness hypothesis, which is consistent with the above proposals given that executive functions generally require complex processing and greater attentional resources. Furthermore, Hall, Smith and Keele's (2001) review examined different aspects of executive control that seem to be enhanced with exercise. More specifically, the researchers identified switching (or cognitive flexibility) and interference as two executive processes that have demonstrated improvement in elderly fitness interventions (Hall, Smith & Keele, 2001). Another consideration is that since attentional elements also are found to decrease with normative aging (e.g., Chodzko-Zajko & Moore, 1994, Hakamies-Blomqvist, 1996, Hawkins, Kramer & Capaldi, 1992), perhaps, more complex and controlled aspects of attention (i.e., selective and divided attention) might also be improved with increased fitness.

Cross-Sectional Fitness Investigations

A number of investigations on fitness effects and visual attention have been conducted in recent years with varied results. A study by Pontifex, Hillman & Polich (2009) on attention and older adults found that fitness levels (as determined by submaximal fitness testing) did not have a meaningful association with performance on attention orienting tasks. In contrast, a study comparing regular older athletes to older non-athletes determined that athletes performed significantly better than non-athletes on a number of complex visual attentional tasks. Two studies using the UFOV test and self-reported indices of fitness determined that high-fit older adults tended to obtain higher scores than their low-fit counterparts (Roth, Goode, Clay & Ball, 2003, Vance, Wadley, Ball, Roenker & Rizzo, 2005).

Despite Stones and Kozma's (1989) finding that exercisers and non-exercisers were affected to a similar degree by distractors on interference tasks, other recent investigations have shown contradictory findings. More specifically, older adults reporting a higher level of fitness have demonstrated less cognitive interference on interference tasks (e.g., Stroop interference, flanker task) (Hillman et al., 2006, Newson & Kemps, 2008). Given that different interference tasks were used in these studies, it is possible that the latter two studies administered cognitive measures that required more attentional demands or greater processing than the coding task used by Stones and Kozma (1989). As stated, some researchers posit that these more complex processes are more susceptible to fitness effects.

A major limitation of the studies discussed above is that the precise nature of the association or causal relationship between cognition and exercise is unclear. In particular, it is questionable whether or not fitness is responsible for the cognitive differences seen across high-fit and low-fit older adult. Other factors (i.e., lifestyle) not considered or formally examined may confound the results obtained in the cross-sectional investigations. Studies with prospective intervention-based designs are necessary to provide further insight into whether or not fitness effects on cognition in older adults occur.

Fitness Intervention Research

Fitness interventions considered to be long-term (i.e., six months or longer) have been shown to result in the reversal of changes in brain morphology that can occur with age. As reviewed, brain volume tends to decrease over time (Jernigan et al., 1991; Resnick et al., 2003) and the morphology of brain tissue also experiences adverse age-related changes (Kramer et al., 2007; Raz et al., 2004a). Colcombe and researchers (Colcombe et al., 2004, 2006) have found that long-term aerobic interventions can result in increased brain volume and increased neural tissue health in sedentary older adults. These results are very promising indicators that cognitive health might also be improved with increased fitness.

The authors of a recent meta-analysis reviewed 18 fitness intervention studies for effects on four main cognitive domains: executive function, processing speed, visuospatial skills and "controlled" abilities (i.e., choice reaction time, lower-demand attentional tasks) (Colcombe & Kramer, 2003). The results from the meta-analyses revealed a clear and significant effect of aerobic training on cognition. Of the different cognitive abilities examined, fitness training had the greatest influence on executive functioning (i.e., large effect). Moderate effects were also found for attention, visuospatial and processing speed.

Colcombe and Kramer (2003) also determined that the type of exercise included in the intervention influenced the size of the effect found on cognition. For example, when strength and flexibility components were coupled with aerobic training, the cognitive improvements were greater than compared to aerobic training alone. Cognitive enhancements were also greater if each fitness session lasted more than 30 minutes. There was a lack of information reported as to how the various cognitive abilities were coded under four main cognitive categories and some of the cognitive measures were coded across multiple categories. Nevertheless, this meta-analysis was a novel attempt to reconcile the mixed findings in the cognitive aging and exercise literature. According to the results from this examination, cognitive abilities, in particular executive-control functions, seem to be affected by increased physical activity.

A key investigation within this research area was conducted by Hawkins, Kramer and Capaldi (1992), which involved studying the effects of a 10-week aquatic exercise program on two aspects of attention in older adults. The attentional processes were tested using a dual-task paradigm in two conditions: attentional switching (alternating attention between two targets) and divided attention (attending simultaneously to two targets). It was found that older exercisers significantly improved on both tasks compared to older controls and no differences were found on single-task measures. Thus, this study demonstrated a clear fitness effect on cognitive flexibility/switching and attention as well as showing that a short-term fitness intervention can result in demonstrable cognitive improvements.

A recent randomized-clinical trial on exercise and cognition was conducted by Smiley-Oyen and authors (2008). Participants enrolled in either aerobic or strength training/flexibility exercise training for 10 months and a variety of cognitive tasks were administered at pre- and post- intervals. The authors selected cognitive tests from the four cognitive domains reviewed in Colcombe and Kramer's (2003) meta-analysis (processing speed, visuospatial skill, controlled ability and executive function). Consistent with previous proposals (i.e., Chodzko-Zajko & Moore, 1994; Stones & Kozma, 1989), the tasks requiring more complex processing or greater attentional demand showed significant fitness effects (e.g., Stroop Colour-Word Interference). This effect was significant for aerobic, but not strength/flexibility participants, demonstrating a differential fitness effect. In contrast, a study by Chang and Etnier (2009) found that acute strength training significantly improved performance on Stroop interference in a sample of middle-aged adults. It may be that older adults need more intense fitness intervention to gain a measurable effect for certain cognitive abilities. Nevertheless, it appears that an inclusive, liberal approach to employing an exercise program (i.e., by including both aerobic and strength training components) would be justified given the equivocal nature of the current fitness research for older adults.

Based on the empirical literature, it appears that fitness training is an appropriate intervention for cognitive enhancement in the elderly, particularly if the target cognitive skills are within the executive function and attention domains. There is evidence in the general cognitive aging literature to suggest that these faculties experience deterioration in normal aging. As well, both of these cognitive domains are also implicated in safe elderly driving. Thus, the question arises whether or not fitness interventions can also impact the driving abilities of older adults. While previous research employing exercise interventions (i.e., Marottoli et al., 2008; Ostrow et al., 1992) have demonstrated some benefits to elderly driving, these interventions have centered on flexibility and coordination and have neglected to examine driving-relevant cognitive abilities.

Research Objectives

The primary objective of the proposed study was to examine whether a comprehensive, short-term fitness intervention can improve performance in specific indices of cognition relevant to the driving performance of older adults. This study was a controlled trial where participants were randomized to one of two conditions: an exercise program condition with aerobic and anaerobic components or a no-exercise control condition. Predictors of driving outcome and changes associated with improvement in driving performance were also investigated.

It was hypothesized that participants who underwent the exercise intervention would demonstrate measurable cognitive improvement. More specifically, enhanced scores in 1) visual attention (i.e., divided and selective attention) and 2) executive functioning (i.e., cognitive flexibility, interference) were predicted to occur in the experimental group when compared to the control group at post-treatment (between group difference) after controlling for pre-treatment performance. It was also hypothesized that differences would be found in the same direction for 3) driving performance on the simulator scenarios chosen for the study.

Supplementary objectives of the study included examining group differences in physical functioning (i.e., endurance, body composition and flexibility) and associations among variables across domains. An additional objective was to investigate whether baseline measures of self-efficacy and well-being are associated with exercise adherence and improved physical functioning, as well as cognitive and driving outcomes. Moreover, it was assessed whether visual attention and executive functioning had an association with driving simulation errors made. Finally, changes in cognitive domains were compared with changes in the driving domain to determine whether significant associations were present.

Method

Recruitment Procedure. A multi-step protocol was used to recruit participants for the intervention. The recruitment period extended over an 8-month period and was conducted exclusively within the city of Thunder Bay, Ontario. The last three months of recruitment were concurrent with the first wave of participants entering the study. The recruitment process consisted of three phases.

Phase 1: General recruitment. Recruitment materials were targeted towards sedentary individuals age 55 and above with valid driving privileges. During this initial recruitment phase, a number of different methods were used to reach potential participants, including television and newspaper advertisements, posters and flyers. Letters describing the study and enrollment criteria were also distributed to interested participants who were contacted in person or for whom an address was available (see Appendix A). Announcements were also made in the Lakehead University community bulletin over several months, which was distributed to university staff and students by email and also displayed on the university website.

Methods of direct contact for recruitment were also used. For example, previous participants of the Driving Lab were contacted by phone to be informed of the study. Several community organizations (i.e., 55+ Health Centre, Thunder Bay District Health Unit, Dilico Family Health Team, local churches) were contacted and liaised with to recruit appropriate participants from within their membership. In some cases, formal letters were sent to community organizations (see Appendix B). Furthermore, given that older sedentary adults are more likely to engage in exercise if recommended by a physician (Schultzer & Graves, 2004), letters were also sent out to thirty-six local general physicians to inform them about this study as well as inclusionary criteria for participation in the study (see Phase 2 below for further detail on enrollment criteria). Interested participants were encouraged to contact the researcher for additional information and to formally enroll in the study.

Sedentary living was operationalized as not engaging in recreational physical activity. Participants who indicated they engaged in "occasional exercise" were excluded if their level of participation in these activities was regular (i.e., every week) and of greater aerobic intensity than the walking component of our intervention. In the event that potential participants were contacted through indirect means (i.e., poster, flyer), interested individuals were asked to contact the investigator for further information and a formal screening.

Phase 2: Initial screening. Individuals who received information through Phase 1, typically contacted the study investigator by phone or e-mail. Approximately 131 individuals received this initial screening, of which about 70 individuals satisfied the enrollment criteria and still wished to proceed with enrollment. Some individuals declined to participate further and they were not asked for their reasons and therefore, this segment of attrition could not be assessed in a formal way. The inclusionary and exclusionary criteria for participation were formally reviewed with individuals who indicated an interest in enrolling in the study. This study enrollment criteria are presented in Appendix C. Interested parties were sent more information about the study as well as given medical clearance forms (see ParMedX described below in measures).

Potential participants were instructed that these medical clearance forms were to be completed by a physician to ensure that participants were sufficiently healthy to participate in the study intervention.

Phase 3: Obtaining medical clearance. While some participants had little trouble obtaining medical clearance from their physicians, others encountered difficulties in obtaining this clearance for various reasons. Some physicians contacted by participants asked for a fee to complete the forms, in which case participants were asked to bill the driving lab for this fee and then participants were reimbursed. This situation occurred for about three participants. About 31 individuals had difficulty obtaining a timely appointment with their physicians due to vacations or waiting times, did not have a regular family physician that they could contact or simply wished not to continue with the study. For those individuals with difficulty having access to a physician, the researcher was able to contact a community family physician affiliated with Lakehead University who conducted about six assessments.

When individuals returned medical clearance forms that were not completed correctly (i.e., insufficient information, incomplete sections), the errors were verbally reviewed with these individuals and they were given documentation to take when returning to their physicians for a correctly completed form. This latter situation occurred for four participants. In all, forty-five individuals had completed the medical screening (i.e., PARMed-X, see Appendix D), of which six were excluded from participating when their physicians indicated that participation in the exercise intervention was contraindicated based on health issues.

Phase 4: Study enrollment and testing. After appropriate medical clearance was received, thirty-nine participants were entered onto a list for enrollment and testing. When the testing intervals were ready to begin, seven participants either declined to participate further due to changing circumstances or having changed their minds about participating. Two participants did not respond to our attempts to set up a testing appointment. Thirty participants still wished to continue with their participation in the study and appointments for formal enrollment and initial testing were made. During these appointments, a research assistant explained participant involvement in the study (i.e., testing, intervention, randomization, risks/benefits) and informed consent was obtained before proceeding with the testing (see Appendix E). Medical clearance forms were verified for a final time to ensure appropriate clearance was obtained, as some participants had to get a second screening form completed due to erroneous completion of their original.

Participants

Testing was completed over two waves, the first beginning in September 2007 and the second in December 2007. Thirteen participants were entered during the first wave and sixteen participants were entered during the second wave (one of the female participants in the first wave decided not to continue with her participation, thus bringing the sample size to twenty-nine participants). Twenty-three females and six males, who ranged in age from 55 to 80 years ($M = 62.93$, $SD = 6.79$), completed the initial testing protocol. Twenty-eight participants were randomized into either the experimental or wait-list control group. One participant was put directly in the control group, as she was not able to participate in the intervention when the wait-list control group crossed over after twelve weeks into the study. In addition, participants who joined the study with a partner or friend were randomized as pairs. In total, eight participants were randomized as pairs. Finally, group assignment was stratified by age groups (55-59 years old, 60-64 years old, 65-69 years old, 70-74 years old, 75 years and up). After randomization, two participants randomized into the experimental group requested to be put into the control group because of extenuating circumstances that precluded them from entering the exercise intervention (i.e., family emergency, health issues). Thus, 13 participants were included in the experimental group and the control group consisted of 16 participants. (see Figure 1 for a flow diagram of recruitment and study enrollment)

Measures

As stated above, prior to enrollment in the study all potential participants were screened by a licensed physician using the medical screening measure (see PARMedX in Appendix A). After enrollment in the study, participants were administered a number of instruments at baseline, including self-report demographic and psychological measures as well as formal performance-based measures for cognition, physical fitness and driving. The cognitive, physical and driving measures were also administered at the post-intervention testing interval (12 weeks after the initial testing).

<u>Screening Measure</u>

Physical Activity Readiness Medical Examination (PARmed-X: Canadian Society for Exercise Physiology, 2002). This questionnaire is required to be completed by a licensed physician who is qualified to assess the physical limitations and capabilities of the potential participant. While a self-report version of the questionnaire (PAR-Q) is typically done for obtaining medical clearance for individuals with an absence of physical

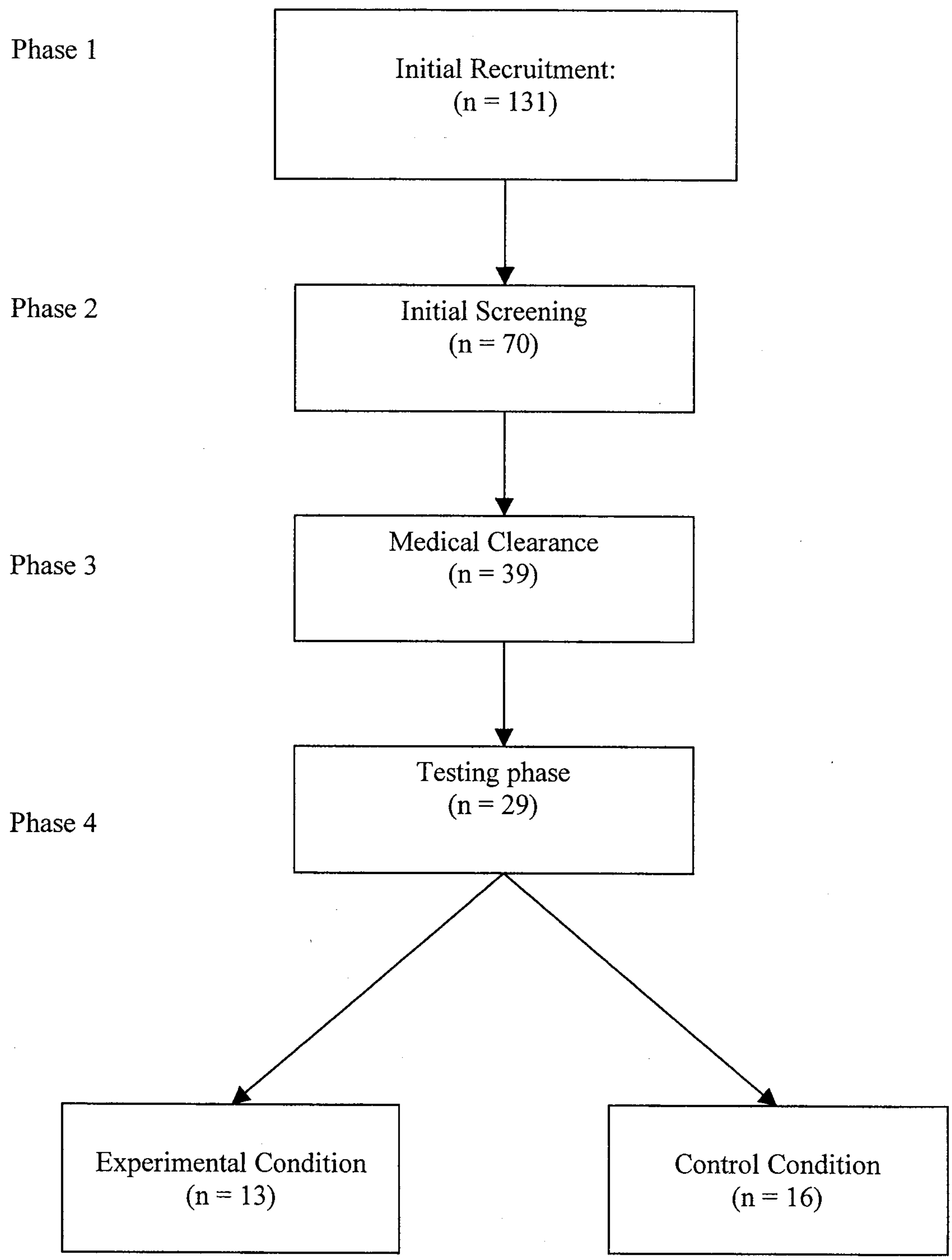


Figure 1. Flow Diagram of Recruitment and Study Enrollment

/health limitations or individuals under the age of 69, we asked all participants to have the more stringent physician-completed form for additional caution. Item B on the PAR-MedX questionnaire, which pertains to the individual's self-report of health risks (i.e., heart condition, chest pain at rest, bone or joint problem) was modified by having the physician indicate whether their patient had any of the conditions listed based on their review of the patient's medical history. Participants were also asked to take a letter to their physicians to accompany the PARMed-X to inform them about the nature of our exercise intervention and provide more information to assist them in completing the form (see Appendix F).

Cognitive Measures

Stroop Colour-Word Test. The Stroop Colour-Word Test (Stroop, 1935) is a measure of executive functioning (specifically interference) and consists of three trials, which progressively increase in difficulty. For this study, the Victoria Version (Spreen & Strauss, 1995) was used in which participants are shown different stimuli (i.e., dots, words) on stimulus cards and are asked to report the colour of the stimuli as quickly as possible.

The first trial consists of coloured dots arranged in rows for which the participants are to name the colours in order (left to right, row-by-row). The second trial consists of arbitrary words (i.e., "ball") with each word printed in a different colour. For this trial, participants are to name the colours in order and resist reading the words. On the third and most challenging trial, colour words (i.e., "red") are printed in a different colour ink. Participants are required to name the colours and to resist naming the colour word instead. For example, if the word "red" is printed in green ink, the participant is to say "green" rather than "red" for a correct response. Generally, performance is assessed by the number of errors made and time taken to complete the tasks.

A Stroop interference score was calculated by dividing the amount of time to complete the colour-word card by the amount of time to complete the colour card. The literature suggests that this method of computing Stroop interference is more meaningful and sensitive to cognitive difficulties in the older adult population than other Stroop performance scores (i.e., simple difference between the colour-word and colour trials) (Verhaeghan & DeMeersman, 1998). A higher discrepancy between time to complete the colour-word condition and the time to complete the colour trial suggests a higher interference effect and thus, will result in a higher interference ratio.

Trail Making Test. This test includes two subtests, A and B, which are readily available to the public. For both test versions, participants are presented with a series of circles and are required to connect the circles in a given order with a pencil. The circles in version A consist of numbers that participants are to connect in sequential order. In version B, participants are given numbers and letters, which participants are to connect alternating between numbers and letters, but in sequential order. Both versions contain sample tests prior to the main test stimuli, so that participants have an opportunity to practice and learn the task.

During the administration, participants were instructed to complete each version as quickly as possible and they are corrected when mistakes are made (i.e., connect a 3 to a 5 instead of a 4). Performance on the TMT is judged based on completion times. Generally, this test is a measure of executive ability, visual scanning and mental processing speed and is dependent upon visuomotor coordination (Gass &Daniel, 1990). More specifically, test A requires visual scanning, visuomotor speed and sequencing ability, while test B requires more cognitively complex processing which includes cognitive flexibility. In terms of reliability, while these tests are sensitive to practice effects (Fals-Stewart, 1992), the effects are normally demonstrated when the two tests are administered within the same day. Thus, a 12-week interval between testing periods for this measure was deemed appropriate. While both versions A and B were administered to participants in order to adhere with standardized administration of the measure, a greater focus was given to version B, as this version is a better measure of higher order abilities (i.e., cognitive flexibility), which may have greater relevance to safe driving.

Useful Field of View test (UFOV). The UFOV (PC Version 6.0.7) is a computer administered and computer scored test of visual function and visual attention. It is recommended for use with individuals aged 55 or older and consists of three visual processing subtests each with a different level of cognitive complexity. Performance on these subtests is used to determine the size of the participants' "perceptual window" or, in other words, the magnitude of the visual field in which the participant is able to detect and respond to visual stimuli. The subtests become progressively more difficult as cognitive demands increase.

During the first subtest (speed of information processing), visual stimuli are presented in the center of the computer screen at increasing speed, to which the participant is to respond by identifying the objects presented. In the second subtest (divided attention), participants are still asked to identify the centrally presented object, but they are also required to identify the location of a second object presented in the visual periphery. The third subtest (selective attention) is modified slightly from the second subtest by presenting distractors in the visual periphery in addition to the central and peripheral target stimuli.

The duration of stimulus presentation for all of the subtests is adjusted based on the accuracy of the participant's responding pattern. For example, consecutive correct responses cause the subsequent stimulus presentation time to be shortened and lengthened for consecutive incorrect responses. This technique is used to ascertain an estimate of the individual's perceptual threshold at a level of about 75% correct responses. This threshold is provided as a score reported in milliseconds (ms), which is calculated at the end of each of the subtests and presented at the end of the test. These scores can then be interpreted according to the cut-offs provided in the UFOV manual. In addition, the combination of the three scores can be used to predict driving risk level, ranging from 'very low' to 'very high'. This risk level is also computed and presented at the completion of the test, but guidelines for risk calculations that can be done by hand based on the subtests can also be found in the user's manual. Recent empirical evidence suggests the UFOV is a valid correlate of driving performance (Ball & Roenker, 1998) and a useful predictor of crash risk (Owsley et al., 1991a; Sims et al., 2000). The scores from this measure demonstrate good test-retest reliability and thus, the UFOV is appropriate for multiple testing intervals.

Driving Measures

Driving Simulation test. Driving skills were tested using three separate driving simulation scenarios each focusing on different driving challenges. The simulations were run on a Systems Technology STISIM (STISIM 400) driving simulator and the simulation scenarios were previously run in a study by Park and researchers (2006). The driving scenarios emulated three real-life driving situations and each presented different driving challenges to the participant. The three scenarios used were the rural highway, parking lot and construction zone.

Particular driving challenges on the rural highway included following posted speed limits appropriately, maintaining correct vehicular position within rural driving lanes and avoiding collisions. This scenario also required the participant to make an appropriate lane change while attending to distance from other vehicles traveling at different speeds as well as making a safe lane merge within the structural confines of the driving environment. Driving challenges during the parking lot scenario included obeying road signs, maintaining appropriate position in driving lanes, crossing an intersection safely and avoiding vehicle or pedestrian collisions in an environment of reduced visibility (i.e., other vehicles as visual obstacles). An additional challenge during this scenario was attending to sudden driving events (i.e., a car rapidly pulling out of parking spot, a pedestrian appearing from behind a visual obstruction). Finally, during the construction zone scenario main driving challenges included maintaining correct speed and lane position through a construction zone and avoiding collisions (i.e., traffic pylons, construction workers and other vehicles).

The driving simulation was administered at pre- and post- testing. Given that simulator sickness (e.g., symptoms of physical discomfort) is sometimes experienced in greater frequency within the older adult population, measures were taken to minimize the likelihood of these symptoms occurring (i.e., maintaining cool room temperature and air flow). Despite taking these precautions, seven participants experienced dizziness or nausea when completing one or more of the driving simulation scenarios during the pre-test interval and three during the post- test interval, so driving simulation data were not collected for these individuals. Two summary scores were computed from the computer-recorded driving data for each scenario. The first summary score totaled the number of collisions (e.g., off road crashes, vehicle collisions, pedestrian hits). The second summary score totaled the number of non-collision errors committed (e.g., speed exceedances, centerline crossings, road edge excursions or improper stops at stop signs). Scenarios were delivered in the same order for all participants, starting with the Rural Highway followed by the Parking Lot and Construction Zone scenarios. Furthermore, participants were instruction about how to operate the driving simulator equipment (i.e., steering wheel, pedals, screens) by a research assistant and a short sample scenario was presented to participants prior to the presentation of the three driving scenarios.

Fitness Measures

Research assistants administered these measures were trained using readings, discussion and practical instruction (i.e., mock participants). See Appendix G for training materials pertaining to the Fitness Measures.

Cardiorespiratory Fitness. Submaximal fitness endurance was assessed by using the YMCA submaximal ergometer test. The outcome variable for this test was the estimated maximal oxygen uptake (VO^2 max) that is used when participants have reached 85% of their predicted maximal heart rate (MHR). The 85% MHR was calculated by the following calculation:

$$85\%\ MHR = (220 - age) \times 0.85$$

This test was administered by a trained individual who monitored the participants' heart rate and subjective exertion throughout the test to assess for signs of exhaustion. Blood pressure readings were also taken before and after the test to ensure that participants recovered appropriately at the close of the endurance test (i.e., recovered to near baseline after exertion). Unfortunately, due to health restrictions (i.e., high blood pressure, knee difficulties) the fitness test was not attempted for two participants. The fitness test was attempted, but not completed for fifteen participants due to poor fitness levels (i.e., participants reached their 85% MHR prior to test completion) and thus, testing had to be stopped to avoid maximal and possibly dangerous exertion. For those participants with completed data on this measure, oxygen efficiency (VO^2 max), which is standard unit for physical fitness, was calculated using a plot of heart rate (HR) and workloads taken at the various resistance levels of the test (see Appendix H).

Another variable based on VO^2 max age- and gender-based endurance norms was computed by separating individual scores for those completing the endurance test into categories. These categories were based on an individual's relative performance compared to similarly-aged peers (see Endurance Level below). Within this new variable, the performances of those unable to complete the test were also accounted for.

Endurance Level. Corrected values for participants who completed the VO^2 max testing were calculated using age- and gender- endurance norms (Heyward, 1998). These corrected values polychotomized endurance into five categories (low, fair, good, excellent and superior) based on corresponding VO^2 max ranges. As stated, some individuals were unable to complete the endurance test due to health restrictions and did not receive a cardiorespiratory fitness score. Participants who attempted the fitness testing but could not complete it due to very poor fitness levels received a value corresponding with a very low fitness level. Thus, a category of "very low" was added to the five norm categories and received a score of one. The other categories were assigned values of two to six, accordingly (two = low, six = superior).

Body Composition. Two measures of body composition were taken: Body-Mass Index (BMI) and Waist-to-Hip Ratio (WHR). The BMI and HWR are both determined using simple calculations computed by measuring the participant's height and weight, and hip and waist circumference, respectively.

$$\text{BMI} = \text{weight} \div (\text{height})^2 \qquad \text{(units in kg/m}^2\text{)}$$

$$\text{WMR} = \text{waist circumference} \div \text{hip circumference} \qquad \text{(units in cm)}$$

Flexibility. This was assessed using a standard Sit and Reach test as well as an upper body Range-of-Motion test. The latter test is especially relevant in safe driving ability. For the Sit and Reach test, participants were positioned in a sitting position on the floor with their legs straight and asked to reach forward with their hands while maintaining their position. The distance of participants' reach was measured for four trials from which an average was calculated. For the Range-of-Motion test, participants were assessed on the degree of movement for various areas (e.g., neck, side bending, trunk, shoulder) using a goniometer. Right and left measures were taken where appropriate. Like the sit and reach test, multiple measures were taken from which an average score was computed. Range-of-Motion data for all participants were taken by one trained research assistant.

<u>Self-Report Measures</u>

Short Form 12 (SF-12). The SF-12 (Ware, Kosinski & Keller, 1996) survey is a self-report instrument which consists of 12 items representing eight health-related domains (See Appendix I). These domains include general health, social functioning, bodily pain, vitality, physical functioning, role disability due to physical health problems and role disability due to emotional problems. The item scores of the SF-12 are used to calculate a physical component summary (PCS-12) and mental component summary (MCS-12) score. Higher scores on this measure indicate better functioning in both physical and mental-health domains (i.e., PCS and MCS, respectively). This survey, which is a condensed version of the SF-36 survey, is considered a reliable and valid version (Bohannon, Maljanian & Landes, 2004).

Barriers Self-Efficacy. The Barriers Self-Efficacy (McAuley, 1992) scale is composed of 13 items, where participants are asked to rate their degree of confidence for exercise participation in various situations. Each item is rated from 0% (no confidence at all) to 100% (complete confidence) (See Appendix J). Every item included in this measure reflects common barriers to maintaining participation in an exercise program. Since self-efficacy reflects an individual's belief in their ability to accomplish or continue with an activity, it is a construct that is posited to correlate with exercise compliance. Some research has suggested that self-reported levels of self-efficacy may be associated with exercise adherence in older adults (McAuley, 1993). The average score across the individual items was computed and used as the self-efficacy outcome score for further analysis.

General Information Questionnaire. A general questionnaire booklet with questions about participant demographics, health and driving behaviour was distributed to all. These questions were adapted from a modified version of the Older and Wiser questionnaire (see Appendix K).

Design

The design of the study was a two by two model with a group factor (experimental, control) and two testing periods (pre- and post-measure). Several - measures were administered at both the first and the second testing interval. The principal dependent variables pertained to cognition and driving. More specifically, these included visual attention (i.e., UFOV subtests), executive functioning (i.e., TMT-B, Stroop Interference Score) and driving performance (i.e., collision and non-collision errors on the three simulator scenarios).

Procedure

This research project consisted of several phases including a multi-stage recruitment procedure (described above). Following the enrolment and initial testing phases, participants were randomized to one of two conditions: exercise intervention group and wait-list control group. All participants were assessed on the primary outcome measures at baseline and post-treatment (12 weeks). Control participants wishing to enter the fitness intervention at the end of the 12 weeks (three participants) were crossed-over to the intervention group, however, post-intervention data were not collected for these individuals.

Physical Activity Intervention

The design of the physical activity intervention for this study (i.e., duration, intensity, types of exercise) was based on empirical support and national guidelines (Health Canada, 2004, National Institute on Aging [NIA], 2004).

Duration

Several researchers who have conducted physical activity research have designed fitness interventions of a 12 week duration or less (e.g., Rejeski et al., 2005; Richeson et al., 2006). This length of time is believed to yield an optimal amount of participation from older adults. More specifically, one-third to one-half of older participants are expected to drop out of interventions after participating for 12 weeks (Resnick & Jenkins, 2000). Research on exercise and cognitive aging also suggests that exercise effects on cognition may be achieved within this time frame. According to a meta-analysis (Colcombe & Kramer, 2003), a large magnitude of change in cognitive abilities occurs within the one to three month period of increased physical activity in older adults ($d = 0.51$). Furthermore, individual studies examining improvement in executive control and attention after exercise interventions have also demonstrated that 12 weeks are sufficient to yield significant cognitive change within these domains (e.g., Hawkins, Kramer & Capaldi, 1992).

Specific Protocol

This exercise protocol was developed according to the recommendations of the Canada Physical Activity Guide for Older Adults (Health Canada, 2004) and the exercise guide published by the National Institute on Aging (NIA, 2004). Many of the home-based strength training exercises depicted in the NIA guide were matched with machine-based exercises targeting similar muscle groups (see Appendix L).

The exercise program consisted of both aerobic (cardiovascular) and anaerobic (strength, flexibility) components. It was decided that these multiple physical activity components would be included in an attempt to maximize the effect of the intervention on primary outcome variables. The cardiovascular training consisted of brisk walking for 30 to 40 minutes, three days per week. The target heart rate for participants to maintain during this activity was 60% of their maximum heart rate (MHR). During instructional sessions, participants were aided by research assistants (using heart monitors) in determining and reaching their 60% MHR with brisk walking. They were also instructed in how to detect and monitor their heart rate through counting their own heart rate in combination with use of the Borg scale to determine their subjective exertion. The muscular component included standard strength training exercises (i.e., leg press, arm curl, leg curl) for 1-3 sets of 10-15 reps of each exercise for 3 days per week. These strength exercises were selected to represent major muscles groups and are alternatives to those strength exercises outlined in NIA fitness programs for older adults (NIA, 2009). The flexibility component involved performing 4 reps of standard total body, static stretches for 3 days per week. The exercise protocol and training was completed at the Lakehead University athletic facilities.

The fitness instructors in the study were undergraduate students who went through a rigorous training process to provide appropriate fitness instruction to participants. In addition to having up-to-date Red Cross qualifications for safety/CPR, instructors were given literature on topics pertaining to exercise safety, fitness training principles and fitness instruction for older adults (see Appendix M). The researcher arranged several training sessions to provide direct instruction, discussion, teaching and practice-based training to the instructors. The instructors were to follow a predetermined set of instructions to impart to participants, which included exercise safety, obtaining 65% MHR, strength training principles and information on how to complete the exercise protocol. Instructors were also to contact the researcher and study-affiliated exercise physiologist for any questions or unique circumstances that arose during the fitness interventions (i.e., tailoring exercises based on individual limitations).

The fitness instruction provided to the participants followed a competency-based model. The week prior to starting the intervention, participants met with the fitness instructors responsible for teaching the intervention to participants. On the first day of meeting, these instructors reviewed the entire protocol with participants as well as pertinent information about aerobic fitness and anaerobic exercise (expectations, safety, sustaining motivation, recording progress, etc). The instructors also provided specific and detailed instructions on this first meeting and gradually provided less instruction and guidance for the participants as they became more independent and comfortable with the intervention. Two to four sessions were conducted with the instructors depending on the level of comfort of individual participants. While sessions were performed independently after this point, participants were able to contact instructors for additional clarification or assistance with increasing the intensity of their exercise program.

All participants were given exercise cards, which included clear and specific instructions on how to complete strength training exercises to help them remember their exercises and also to record their progress (see Appendix N). While participants were encouraged to complete these cards, it was not established as a requirement for remaining within the study. Participants were given the option to submit these cards for review by the fitness instructors. If participants did not submit cards, fitness instructors contacted participants periodically to check on their progress.

Main Hypotheses

Hypothesis 1

Based on empirical findings that have demonstrated improvements in general attention as a result of engaging in increased physical activity, it was expected that participants in the experimental condition would experience some improvements in visual attention relevant to safe driving. The different subtests of the UFOV would examine different aspects of visual attention (i.e., processing speed, divided attention, selective attention) and the potentially differential effects of increased physical activity.

Research has suggested that cognitive processes with greater attentional demand and complexity are more sensitive to aging and also more susceptible to intervention (Chodzko-Zajko & Moore, 1994). Thus, given that the UFOV subtests increase progressively in difficulty as well as the focus given to selective attention (and divided attention to a lesser degree) in the cognitive aging and fitness literature, it is expected that the latter UFOV tasks may be more sensitive to aging effects. As well, given that processing speed has been argued as a potential explanatory factor for age-related effects in other cognitive domains (Salhouse, 2006, Salthouse & Siedlecki, 2007), fitness effects on the first UFOV subtest (speed of information processing) can be compared against the other cognitive variables.

Hypothesis 2

According to a meta-analysis by Colcombe and Kramer (2003), increased physical activity coincided with a large improvement in executive functioning. Thus, it was expected that participants would experience an improvement in this cognitive domain after participating in the intervention. As stated earlier, a pervasive problem in the cognitive aging literature on executive functioning pertains to the operationalization of this construct based on various theoretical conceptualizations. Recent studies (e.g., Miyake et al., 2000) have focused on researching specific aspects of executive functioning, which has resulted in greater measurement precision. Two particular executive functioning abilities (interference/inhibition, cognitive flexibility) have been implicated as sensitive to deterioration with the normal aging process (e.g., Andres, et al., 2008, Chodzko-Zajko & Moore, 1994, Keys & White, 2000, Little & Hartley, 2000, Wecker et al., 2005) and additionally, they are relevant factors in safe elderly driving (e.g., Daigenault, Joly & Frigon, 2002a, Freund & Colgrove, 2008, Freund et al., 2008, Richardson & Marottoli, 2003). The executive functioning measures chosen (i.e., Trail-Making Test B, Stroop Interference) have been shown to be sensitive to cognitive changes in older adults (Spreen & Strauss, 1998) and have been used in many of the above-mentioned studies.

Hypothesis 3

It was predicted that visual attention and executive functioning would be improved by participating in the exercise intervention. Moreover, the participants would experience improved driving performance on different driving scenarios reflecting these cognitive abilities. This investigation extends the study of driving behaviour beyond collisions as driving outcomes to include non-collision driving behaviours that could potentially result in problematic driving situations. These include speed exceedances, speeding tickets, centerline crossings and road edge excursions. In addition, correct driving manoeuvres at traffic lights and stop signs were also included under non-collision errors. Collision errors included off road accidents, collisions and pedestrians hit. As stated, the three driving scenarios used in this study provided opportunities for simulated exposure to various challenging driving situations (e.g., changing lanes, navigating safely across a driving environment with visual obstacles), which encompass the cognitive abilities of interest (i.e., visual attention, executive functions).

Statistical Considerations

Statistical Analysis

To test hypotheses 1 through 3, separate MANCOVAs were conducted by entering post-test values as the dependent variables and pre-test values as covariates. Group type (i.e., experimental, control) was entered as an independent variable. Given the relatedness of variables within each of these hypotheses (based on theoretical and empirical justification) as well as evaluation of sphericity assumptions, MANCOVA was preferred for these analyses compared to multiple univariate analyses to account for possible shared variance across these related variables. However, significant MANCOVAs were followed up with more specific tests of between-subjects effects (F-tests on each DV) to evaluate the nature of any group differences. Significant simple effects guided the comparison of pre-treatment and post-treatment means across groups for the significant primary outcome variable so that the magnitude of change could be assessed. Clinical-significance was also examined where possible (i.e., mean UFOV risk levels derived from the three subtests).

Supplementary analyses included multiple ANCOVAs for primary physical functioning variables (i.e., endurance level, RHR), correlations between variables of possible association (e.g., self-efficacy and drop out status) as well as independent samples t-tests to examine mean differences across groups on secondary variables of interest (i.e., self-efficacy, range-of-motion). Difference scores were computed and used for the t-tests where T1 and T2 data were available. For variables with likelihood of smaller group sizes (due to participant attrition), t-tests were favoured over ANCOVAs so that violations of equal variance, should they have occurred, could be managed.

Preliminary Data Screening

Prior to completing the main analyses, data screening was performed to examine the accuracy of the data entered as well as assessment of missing data, normality and outliers. Accuracy checks on the data file were conducted by comparing values entered to recorded values from data record forms and computer-generated output. In addition, frequencies and descriptives were run on the main variables to identify odd or extreme values. Histograms and scatterplots were constructed to identify atypical or abnormal distributions. Main variables of interest (i.e., cognition, physical functioning, driving) were also transformed to z-scores to check for univariate outliers. From these investigations, four univariate outliers (z score >3.29, $p < .001$) were identified. Of these, one was determined to be a data inputting error. The remaining three were assigned new values, one unit larger than the next most extreme value in the variable distribution (Tabachnick & Fidell, 2001).

Multivariate outliers were identified by the Cook's distance statistic (D), which is a measure of multivariate influence across cases. The criteria of D >1 was used to identify extreme cases and potential multivariate outliers. One such case was identified (D = 2.63) and its values were visually-inspected across variables. The case was retained within the data set, as its values did not appear to be excessively or abnormally extreme.

Missing Data

To determine whether participants who dropped out of the trial differed significantly on baseline variables compared to "completers", independent sample t-tests were conducted to compare completers and drop-outs. A dummy variable was coded to differentiate between these two groups of participants and the variables examined included age, self-reported driving performance, physical and mental quality of life scores (i.e., PCS, MCS) and average self-efficacy score. Baseline values of the main dependent variables (i.e., physical fitness, cognition, driving) were also compared between these groups. Two-tailed significance values were evaluated for these variables and no significant differences between the two groups were found ($p > .05$).

Baseline dependent variables were generally missing at a rate of 10% or less, with exception of the driving outcome variables which were missing at a greater prevalence (between 17.2% to 24.1% across the three scenarios). The greater proportion of missing data for the driving variables was due to a small subset of participants experiencing simulator sickness during the simulations who were unable to complete the driving measure as a result.

A missing value analysis was conducted to examine the pattern of missing values across the data set. In particular, a test to determine whether the data were missing-completely-at-random (MCAR) was conducted. In addition, to determine whether missing data had an undue effect on the analysis of the overall data set, multiple imputation was used. More specifically, analyses were conducted on the imputed data sets and compared with the original data set to determine if significant differences arose. The results of these analyses are discussed further in the next section.

Results

Sample Characteristics

Differences across group means on demographic and baseline sample characteristics were examined by independent sample t-tests and the results are presented in Table 1. Scores on the SF-12, a measure of self-reported physical and mental health, were similar for both groups demonstrating a comparable level of health across groups. In addition, SF-12 component scores (the PCS and MCS) for both groups clustered closely around the general population mean of 50, PCS-12: M_{exp} (SD) = 51.81 (9.54), $M_{control}$ (SD) = 49.77 (8.47), MCS-12: M_{exp} (SD) = 51.97 (9.57), $M_{control}$ (SD) = 53.24 (9.25). Of the variables examined, only the average Barriers to Self-Efficacy score differed significantly across experimental and control participants, t (df=22.519) = -2.231, p = .036. Upon examination of group means, the experimental group reported significantly higher self efficacy than the control group: M_{exp} (SD) = 83.59 (10.31), $M_{control}$ (SD) = 69.71 (21.85).

Table 1

Means and Standard Deviations for Demographics and Baseline Variables Across Groups.

	Control		Experimental	
	M (SD)	n	M (SD)	n
Age (years)	62.81 (6.12)	16	63.08 (7.81)	13
Waist-Hip Ratio	0.90 (0.25)	16	0.88 (0.10)	13
Self-Reported Driving Performance	2.56 (0.63)	16	2.33 (0.99)	12
Barrier Self-Efficacy Average score	69.71 (21.85)	16	83.59 (10.31)	12
Physical Well Being (PCS-12)	49.77 (8.47)	16	51.81 (9.54)	12
Mental Well-Being (MCS-12)	53.24 (9.25)	16	51.97 (9.57)	12

Missing Values Analysis and Multiple Imputation

As stated, a missing value analysis was conducted to determine whether data were MCAR as well as to assess whether missing data would influence the analysis of the completed data in a significant manner. A Little's Chi-squared statistic was computed and the results indicated that missing values were MCAR, χ^2 (df=84) = 90.33, p = .299. Multiple imputation for missing data was also conducted to assess whether the missing data might unduly influence the results obtained from the main analyses of the study.

Missing values were imputed by randomly-generated values within an expected range based on the completed data. The procedure was completed five times to generate five imputed data sets. From these generated sets, average parameter estimates (i.e., average regression coefficient, within imputation variance and between imputation variance) were computed and compared to values obtained from analysis on the original data set. In particular, a Student t-test statistic was computed to contrast the original data set to parameter estimates derived from multiple imputations (Rubin, 1987, Schaffer, 1999). No significant differences were found (see Table 2) with exception of the rural highway variable thus, the missing data could reasonably assumed to be missing-at-random as well as not having an undue influence on the main results of the study. Therefore, the rural highway variable was interpreted with caution.

Multivariate Assumptions

Assumptions for sphericity, which examined patterns of spherical intercorrelations among related outcome variables (i.e., Stroop interference and TMTB), were violated across all planned main analyses. In particular, a significant test of sphericity was found in each of the three hypotheses (visual attention (UFOV subtests 1 -

Table 2

Parameter Estimates and Student's t-test Statistics for Multiple Imputation.

Variable	Imputed Average β	Imputed Total Variance	Actual β	t	df	p-value
Endurance Level	1.51	2.49	1.63	-0.07	970.67	>0.20
Body-Mass Index (BMI)	0.87	5.61	2.63	-0.75	26.85	>0.20
Resting Heart Rate (RHR)	2.12	7.22	4.70	-0.98	29.05	>0.20
UFOV Subtest 1 (Speed of Information Processing)	0.24	3.19	0.50	-0.15	484.86	>0.20
UFOV Subtest 3 (Selective Attention)	70.79	104.46	89.55	-1.84	4.85	>0.10
Trailmaking Test B (TMTB)	1.26	7.35	3.49	-0.82	31.49	>0.20
Stroop Interference Score	0.32	0.58	0.34	-0.03	27.82	>0.20
Rural Highway Errors Errors	-0.39	-0.03	-1.07	3.69	280.40	<0.01
Parking Lot Errors	-0.22	0.30	0.48	-1.26	158.43	>0.10
Construction Zone Errors	0.15	0.71	0.02	0.15	514.29	>0.20

3): LR = .000, approx χ^2 (df=5) = 69.793, p < .0001; executive functioning (TMTB, Stroop Interference,): LR =.000, approx χ^2 (df=2) = 114.515, p < .0001; driving performance (total errors for the rural highway, parking lot and construction zone scenarios): LR = .000, approx χ^2 (df=5) = 16.153, p = .007). In the event of this pattern of intercorrelations (i.e., sphericity), repeated measures ANOVAs are not appropriate (Tabachnick & Fidell, 2001). For this reason as well as to account for shared variance among related dependent variables, MANCOVAs were used to investigate the three hypotheses instead of multiple ANCOVAs or split-plot ANOVAs.

The data were also assessed to determine whether assumptions of MANCOVA were met. The main dependent variables were grouped into the three main hypotheses of the study pertaining to specific cognitive variables and driving outcomes (see Methods) and assumptions for these variables were tested accordingly.

Linearity was examined through graphical checks and determined to be adequate. Multicollinearity and singularity were investigated by reviewing bivariate correlations between related variables (i.e., cognitive variables). No correlations above .70 were found and thus, the bivariate correlations showed no evidence for either singularity or multicollinearity (see Tables 3 and 4 for correlation matrices; TMTB and Stroop correlation = .376, p = .044). In addition, conditioning indices and variance proportions (collinearity diagnostics) were also examined for evidence of multicollinearity. These values were computed separately for the cognitive and driving variables, since multicollinearity is especially a concern for conceptually-related variables. Examination of the collinearity diagnostics for the cognitive variables demonstrated that while

Table 3

Correlation Matrix of Divided Attention Variables

	UFOV Subtest 1 (Speed of Info Processing)	UFOV Subtest 2 (Divided Attention)
UFOV Subtest 2 (Divided Attention)	.218	---
UFOV Subtest 3 (Selective Attention)	.132	.389*

*p< .05

Table 4

Correlation Matrix of Main Driving Variables

	Rural Highway Total Errors	Parking Lot Total Errors
Parking Lot Total Errors	.102	---
Construction Zone Total Errors	-.095	-.196

condition indices for the cognitive variables were greater than 30, the individual variables variance proportions did not exceed .50 more than once per variable, thus the criteria for multicollinearity was not met (Tabachnick & Fidell, 2001). The same result was found for the driving outcome variables.

Homogeneity of variance of the dependent variables was assessed using Levene's test. Of all the main variables examined, only the divided attention variable (second subtest on the UFOV) was found to violate this assumption ($F(1,22) = 7.380$, $p = .013$). As a result, the MANCOVA for hypothesis two was altered by removing divided attention from the model while retaining the other two variables (speed of visual information processing and selective attention). The divided attention subtest (UFOV2) was examined separately using a t-test with equal variance not assumed (see below). After removal of divided attention, homogeneity of variance was no longer violated (UFOV1: $F(1,22) = .000$, $p = .991$; UFOV3: $F(1,22) = 1.482$, $p = .236$). Furthermore, Bartlett's test of sphericity was run on the revised multivariate model and the assumption of sphericity was still violated: LR = .000, approx χ^2 (df = 2) = 53.057, $p < .0001$, thus a repeated measures ANOVA would still be deemed inappropriate.

Next, homogeneity of variance-covariance was assessed using Box's M test and no resulting violations were found for any of the hypotheses (visual attention: Box M = 1.562, $F(3, 1733838) = .489$, $p = .704$; executive functioning: Box M = 1.283, $F(3, 124907.1) = .387$, $p = .762$; driving: Box M = 2.826, $F(6,1157.949) = .356$, $p = .906$). Heterogeneity of regression was examined prior to the main analyses by entering interaction terms for the covariates (i.e., baseline outcome values) and grouping variable (i.e., experimental, control) into the multivariate model (see Table 5). Thus, the variance

Table 5

Homogeneity of Regression With Covariates and Grouping Variable (Control vs. Experimental)

Covariate Entered In Interaction	F	df	df error	p-value	partial eta-squared
Endurance Level	0.521	3	11	.677	.124
Body Mass Index (BMI)	3.840	3	11	.042	.512
Resting Heart Rate (RHR)	0.936	3	11	.456	.203
UFOV Subtest 1 (Speed of Info Processing)	3.863	2	17	.723	.037
UFOV Subtest 3 (Selective Attention)	0.091	2	17	.914	.011
Trailmaking Test B (TMTB)	0.781	2	18	.473	.080
Stroop Interference Score	0.410	2	18	.669	.044
Rural Highway Total Errors	2.359	3	6	.171	.541
Parking Lot Total Errors	2.054	3	6	.208	.507
Construction Zone Total Errors	0.276	3	6	.841	.121

associated with the interaction would be examined after accounting for the main effect (i.e., group) and each of the covariates (i.e., pre-test performances). Each of the three hypotheses was tested separately in this manner. None of the interactions computed were significant. As stated, examinations of the missing data demonstrated that data were missing-completely-at-random and did not likely have an effect on the overall main analyses of the actual data set.

Main Analyses

Increased Physical Activity and Cognitive Functioning

A general visual attention variable was computed by summing the three UFOV subtests and an ANCOVA was run on this variable (with pre-test scores serving as the covariate). A significant group difference was identified, $F(1, 21) = 5.695$, $p = .027$, partial $\eta^2 = .213$, obs power = .624, and an examination of mean differences demonstrated a change in favour of the experimental group (see Table 6 for means). An examination of driving risk level based on UFOV scores showed that the mean risk level for the experimental group remained 'very low' after the 12 weeks, T1: M_{exp} (SD) = 1.36 (.505), T2: M_{exp} (SD) = 1.60 (1.041), however the control group went from 'very low' to 'low' demonstrating a slightly increased risk (T1: $M_{control}$ (SD) = 1.67 (.816), T2: $M_{control}$ (SD) = 2.00 (1.225).

A MANCOVA was also performed to evaluate performance on two of the UFOV subtests (speed of information processing, selective attention) and determine whether they differed across groups at time 2. The covariates entered in the model were baseline scores on the dependent variables. A significant group effect was identified, $F(2, 19) = 6.834$, $p = .006$, partial $\eta^2 = .418$, obs. power = .872. An examination of between-subject

Table 6

Means and Standard Deviations for Visual Attention Variables Across Groups with Estimated Means

	Time 1		Time 2	
	Control (n = 13)	Experimental (n = 11)	Control (n = 13)	Experimental (n = 11)
UFOV Subtest 1 (Speed of Information Processing)	19.05 (7.55)	19.13 (5.60)	21.05 (9.34)	20.34 (8.10)
UFOV Subtest 2 (Divided Attention)	62.84 (81.92)	33.06 (21.39)	101.56 (114.29)	30.33 (21.65)
UFOV Subtest 3 (Selective Attention)	262.86 (124.57)	252.36 (103.79)	293.65 (111.61)	199.19 (80.15)
UFOV Total Score	344.76 (181.75)	304.55 (119.24)	416.27 (211.62)	251.10 (102.72)

effects revealed a significant group difference for UFOV subtest 3 (selective attention), $F(1, 20) = 14.14$, $p = .001$, partial $\eta^2 = .414$, obs power = .947, but not for UFOV subtest 1 (speed of information processing), $F(1,20) = .027$, $p = .871$, partial $\eta^2 = .001$, obs power = .053. An adjusted R^2 was also calculated for UFOV3 to determine effect size, adj R^2 = .387. Furthermore, group means for subtest 3 (selective attention) demonstrate that while both groups had similar means at the pre-test interval ($M_{exp} = 252.36$ m/s, $M_{control} = 262.86$ m/s,), the average experimental performance improved after 12 weeks ($M_{exp} = 199.19$ m/s) while the controls performance worsened ($M_{control} = 293.65$ m/s).

A t-test was conducted to examine group differences for UFOV subtest 2 (divided attention). Change scores were calculated for the divided attention variable and a t-test was conducted to examine group differences. Equal variances were not assumed in interpreting the effect (Levene's Test for Equality of Variances: $F = 11.962$, $p = .002$). Results indicated that group means on the UFOV subtest 2 did not differ significantly, μ diff = 40.21, SE = 31.96, 95% CI (-29.00 – 109.41), two-tailed $p = .231$. Despite this statistically non-significant finding, inspection of the divided attention risk categories across groups suggests clinically significant change. More specifically, the experimental group remained within the normal divided attention category at post-test, while the mean divided attention score for the control group dropped from the normal range to the mild difficulty category (Visual Awareness Inc., 2004). See Table 6 for specific mean values.

Post-intervention group differences on measures of executive functioning (TMTB, SCWT Interference score) were examined with a MANCOVA. Baseline scores on the dependent variables were entered as covariates to remove variance associated with baseline differences between groups. No significant group effect was found, $F(2, 20) =$

2.227, $p = .134$, partial $\eta^2 = .182$, obs power = .400, and therefore, hypothesis #2 was not supported. See Table 7. However, the partial eta-squared for the SCWT suggested that a substantial portion of variance attributed to the executive functioning domain may be accounted for by the SCWT, partial eta-squared = .013, thus, an adjusted R^2 value was also calculated as a measure of effect size, adj $R^2 = .093$. Furthermore, the experimental group mean on the interference score fell below normative ranges for this variable, indicating better performance than similarly aged peers (Van der Elst et al., 2006).

Increased Physical Activity and Driving Performance

A MANCOVA was conducted to investigate group differences for total driving errors (both collision and non-collision errors) on three different driving situations (rural highway, parking lot, construction zone). Scores on the dependent variables at time 1 were entered as covariates in the model to remove variance associated with baseline differences. Inspection of the results of the MANCOVA revealed a significant group effect, $F(3,9) = 4.739$, $p = .030$, partial $\eta^2 = .612$, obs power = .721. Further ANCOVAs were conducted on the specific driving variables (Rural Highway: $F(1,11) = 14.207$, $p = .003$, partial $\eta^2 = .564$, obs power = .428; Parking Lot: $F(1,11) = 0.222$, $p = .647$, partial $\eta^2 = .020$, obs power = .072; Construction Zone: $F(1,11) = 0.001$, $p = .981$, partial $\eta^2 = .000$, obs power = .050) which showed that the control group made significantly fewer total driving errors after 12 weeks only on the rural highway scenario. Review of mean rural highway errors showed that the control group errors decreased over testing periods, on average (T1: $M_{control} = 2.91$, T2: $M_{control} = 1.00$), while the mean number of errors made by the experimental group was generally consistent (T1: $M_{exp} = 2.00$, T2: adjusted $M_{exp} = 2.11$). See Table 8.

Table 7

Means and Standard Deviations for Executive Functioning Variables Across Groups with Estimated Means.

	Time 1		Time 2	
	Control (n = 13)	Experimental (n = 12)	Control (n = 13)	Experimental (n = 12)
Trailmaking Test B (TMTB)	61.32 (22.19)	86.04 (32.85)	57.37 (18.69)	66.76 (21.88)
Stroop Interference Score (STR)	2.33 (0.56)	2.34 (0.62)	2.26 (0.54)	1.95 (0.41)

Table 8

Means and Standard Deviations for Driving Errors Across Groups with Estimated Means

	Time 1		Time 2	
	Control (n = 7)	Experimental (n = 9)	Control (n = 7)	Experimental (n = 9)
Rural Highway (RH) Total Errors	3.00 (1.83)	2.00 (1.94)	1.00 (0.58)	2.11 (0.78)
Parking Lot (PL) Total Errors	3.43 (0.79)	2.33 (1.12)	3.00 (1.13)	2.44 (1.13)
Construction Zone (CZ) Total Errors	2.29 (0.95)	1.67 (1.22)	1.57 (1.13)	1.89 (1.45)

An analysis of length of run times for the rural highway scenarios at both testing intervals showed that the experimental participants completed this scenario much more quickly after the 12 weeks than they had at baseline, t (df=8) = 2.321, p = .049. Furthermore, examination of completion times suggested that the experimental group completed the scenario in less time at the final testing interval [initial completion time M (SD) = 242.43 (22.69), final completion time M (SD) = 224.46 (11.84)]. In contrast, the control group did not demonstrate a significant change in their completion time [initial completion time M (SD) = 241.80 (9.75), final completion time M (SD) = 238.07 (21.98)].

Supplemental Analyses

Physical Functioning – Endurance and Body Composition

Univariate Assumptions. Separate ANCOVAs were planned for several of the physical functioning variables, namely the endurance (i.e., endurance level, RHR) and body composition (BMI, WHR) variables. Prior to running these analyses, univariate assumptions were examined to determine whether the appropriate criteria were satisfied. An examination of homogeneity of variance by computing Levene's test statistic revealed that the assumption was met for endurance level, F(1,19)=1.462, p=.241, and RHR, F(1,21)=.291, p=.595, but violated for both BMI, F(1,21) = 6.873, p=.016, and for WHR F(1.21)=6.090, p =.022. As a result, a more stringent alpha (α=.025) was used to evaluate the main effects for the latter two ANCOVAs (Tabachnick & Fidell, 2001). To evaluate homogeneity of regression, an interaction term between group and covariate (baseline value of the DV) was entered in the model. The interaction term was non-significant for endurance level, RHR and WHR, but significant for BMI (F (1,21) = 17.337, p=.001) and thus, an ANCOVA was not run for this variable.

ANCOVAs. No significant group differences were found for endurance level, $F(1, 20) = 2.567$, $p = .127$, partial $\eta^2 = .125$, RHR, $F(1, 20) = .047$, $p = .831$, partial $\eta^2 = .002$ or WHR, $F(1, 20) = 1.956$, $p = .956$, partial $\eta^2 = .000$. (see Table 9 for descriptives)

Physical Functioning – Flexibility

Independent sample t-tests were conducted to determine whether group differences between experimental participants and controls existed on other secondary measures of physical functioning, such as Sit-and-Reach (SR) scores and various indices of Range-of-Motion (ROM; see Methods for all ROM variables examined), which allowed for evaluating assumptions of equal variance. In the event that this assumption was violated, statistics were interpreted with equal variances not assumed. Difference scores for these secondary physical functioning measures were used in the analysis, so that pre-test values could be taken into consideration. No significant group differences arose (see Table 10).

Associations between Quality of Life, Self-Efficacy, Self-Reported Driving Performance at Baseline and Outcome Variables

Bivariate correlations between indices of physical and mental well-being (PCS and MCS) and self-efficacy (BSE items) measured at baseline and indices of physical functioning (Endurance level, BMI and RHR) at both testing intervals were computed. Significant associations were found between the PCS score and BMI at both pre-test, $r = -.464$, $p = .013$, and post-test, $r = -.563$, $p = .005$. These correlations demonstrate that those participants with lower BMIs tended to report higher levels of physical well-being at both pre- and post- test intervals. No other significant associations were identified. These correlations are presented in Table 11.

Table 9

Means and Standard Deviations for Physical Functioning Variables Across Groups with Estimated Means

	Time 1				Time 2			
	Control		Experimental		Control		Experimental	
	M (SD)	n	M (SD)	n	M (SD)	n	M (SD)	n
Endurance Level	1.73 (1.49)	11	2.50 (1.68)	10	4.64 (2.11)	11	3.50 (1.35)	10
Resting Heart Rate (RHR)	81.75 (12.11)	12	76.64 (10.67)	11	80.75 (13.10)	12	80.64 (11.54)	11
Body-Mass Index (BMI)	28.34 (6.65)	12	28.08 (6.71)	11	33.76 (24.22)	12	28.49 (6.71)	11
Waist-to-Hip Ratio (WHR)	0.93 (0.28)	12	0.88 (0.89)	11	0.87 (0.08)	12	0.87 (0.06)	11

Table 10
Independent Sample t-tests for Between Group Differences on Flexibility Variables

	Control		Experimental				
Variable	T1 M (SD)	T2 M (SD)	T1 M (SD)	T2 M (SD)	t	df	p-value
Sit and Reach	25.00 (7.86)	27.13 (5.75)	22.20 (10.92)	26.11 (11.22)	0.904	21	0.38
Neck Flexion	37.25 (7.91)	38.88 (4.84)	33.36 (6.47)	39.14 (6.03)	1.486	21	0.15
Neck Extension	57.77 (11.47)	57.98 (13.39)	57.14 (12.30)	55.25 (13.88)	-0.510	20	0.62
Neck Rotation - Left	66.04 (7.10)	67.61 (6.07)	67.73 (10.07)	68.34 (7.85)	-0.325	21	0.75
Neck Rotation - Right	66.52 (6.66)	67.71 (6.29)	65.91 (11.60)	67.36 (7.74)	0.077	21	0.94
Side Bend - Left	20.42 (4.13)	20.54 (5.58)	23.70 (4.82)	21.76 (6.14)	-1.033	21	0.31
Side Bend - Right	25.10 (6.70)	23.40 (5.97)	28.53 (6.30)	28.39 (8.68)	0.507	21	0.62
Trunk Rotation - Left	36.21 (12.79)	35.94 (8.85)	32.89 (9.72)	38.00 (10.36)	1.069	21	0.30
Trunk Rotation - Right	37.23 (15.44)	34.31 (10.55)	32.93 (12.37)	36.57 (10.31)	1.609	21	0.12
Shoulder Flexion – Left	174.79 (12.18)	173.85 (11.37)	178.80 (8.28)	176.43 (9.64)	-0.504	21	0.62
Shoulder Flexion – Right	174.40 (8.53)	177.08 (5.83)	177.14 (8.28)	174.73 (8.28)	-1.716	21	0.10

Table 11

Correlation Matrix for SF-12, Self-Efficacy and Selected Physical Functioning Variables

		SF-12 Physical Component Summary Score (PCS)		SF-12 Mental Component Summary Score (MCS)		Barriers to Self-Efficacy Average Score (BSE)	
		r	p	r	p	r	p
MCS		.087	.66	---	---	---	---
BSE		.136	.49	.223	.25	---	---
Endurance Level	Time 1	.138	.49	.106	.59	.343	.08
	Time 2	.138	.55	.154	.50	-.133	.56
Body Mass Index (BMI)	Time 1	.464	.01	-.001	.99	.163	.41
	Time 2	.563	.01	.308	.15	.261	.23
Resting Heart Rate (RHR)	Time 1	.317	.10	-.008	.97	-.209	.29
	Time 2	.049	.82	.021	.92	.141	.52

Bivariate correlations were also examined between PCS, MCS, self-efficacy and cognitive outcome variables at both pre- and post-test. While no significant associations were found for the PCS and MCS across cognitive outcomes, a significant association was found between average BSE score and performance on the UFOV subtest 3 (selective attention) and Stroop interference score at time 2. More specifically, those demonstrating higher mean self-efficacy for physical activity at baseline had better selective attention scores, $r = -.544$, $p = .005$, and less cognitive interference on the Stroop test, $r = -.446$, $p = .025$, at the post-test interval (see Table 12). As stated, higher values on both the UFOV subtests and Stoop interference indicate worse performance on these measures, whereas high BSE scores demonstrate more self-efficacy, thus the negative association suggests that higher self-efficacy is correlated with faster performance on the UFOV and less interference on the Stroop measure.

In addition, self-reported driving performance at baseline was compared to pre- and post- driving outcomes (e.g., total errors in each of the three driving scenarios) along with the baseline SF-12 and self-efficacy scores (see Table 13). Self-reported driving performance at baseline showed no significant correlations with driving simulator performance at either the pre- or post- test intervals. However, the average self-efficacy score was significantly negatively associated with errors made on the rural highway scenario at baseline, $r = -.435$, $p =.049$, thus, those with more confidence in their ability to participate successfully in an exercise program tended to fewer driving errors on the rural highway at the first testing period. The association between baseline BSE and errors on the rural highway scenario at the final testing interval was not found to be

Table 12

Correlations between SF-12 Component Scores and Cognitive Variables

		SF-12 Physical Component Summary Score (PCS)		SF-12 Mental Component Summary Score (MCS)		Barriers to Self-Efficacy Average Score (BSE)	
		r	p	r	p	r	p
UFOV Subtest 1	Time 1	.097	.64	- .079	.70	.007	.97
	Time 2	.062	.77	.022	.92	-.050	.81
UFOV Subtest 2	Time 1	-.098	.63	.233	.25	-.169	.41
	Time 2	.171	.41	-.131	.53	-.336	.10
UFOV Subtest 3	Time 1	-.119	.56	.145	.48	-.202	.32
	Time 2	-.008	.97	.045	.83	-.544	.01
UFOV Total Score	Time 1	-.125	.54	.202	.32	-.221	.28
	Time 2	.082	.70	-.037	.86	-.484	.01
Trailmaking Test B (TMTB)	Time 1	-.055	.78	.006	.98	-.012	.95
	Time 2	-.049	.82	-.043	.84	.129	.54
Stroop Interference Score (STR)	Time 1	-.260	.18	.192	.33	-.101	.61
	Time 2	-.135	.52	.250	.23	-.446	.03

Table 13

Correlations between Baseline Self-Reported Driving Ability, SF-12, Barriers to Self-Efficacy Scores and Driving Errors

		Self-Reported Driving Ability		SF-12 Physical Score (PCS)		SF-12 Mental Score (MCS)		Barriers to Self-Efficacy Average Score (BSE)	
		r	p	r	p	r	p	r	p
Rural Highway Total Errors	Time 1	.146	.53	-.080	.73	-.280	.22	-.435*	.05
	Time 2	.002	.99	.025	.91	-.022	.92	.210	.36
Parking Lot Total Errors	Time 1	.118	.60	-.119	.60	.338	.12	-.097	.67
	Time 2	.331	.13	.304	.17	-.122	.59	-.068	.77
Construction Zone Total Errors	Time 1	.087	.69	-.086	.70	-.327	.13	.024	.91
	Time 2	.081	.73	.134	.56	-.394	.07	-.234	.31

significant. Thus, level of self-efficacy at the onset of the study was not associated with driving performance at the end of the 12-week interval.

Self-Efficacy and Attrition

An independent samples t-test was conducted to compare scores on BSE items and dropout status. A dummy variable was coded to separate the completers and dropout participants into groups. The resulting analysis indicated no significant differences were present between participants who dropped out of the study, M (SD) = 67.08 (24.72), and those who completed the study, M (SD) = 77.53 (17.52), based on their confidence in their ability to exercise (average BSE score, t (df=26) = 1.126, p = .271).

Associations between Cognitive Measures and Driving Simulation Errors at Baseline

Bivariate correlations were run between the cognitive variables (visual attention and executive functioning) and driving errors for the three different driving scenarios (i.e., rural highway, parking lot, construction zone) across participant scores at the pre-test interval. Instead of total errors for the driving scenarios, errors were classified as either collision or non-collision errors since the cognitive variables may have differential associations with these two types of driving errors. The resulting correlations for driving errors and visual attention variables are presented in Table 14, while executive functioning correlations are in Table 15. Of the bivariate correlations obtained, significant correlations were found for speed of information processing (UFOV1) and non-collision errors for the construction zone (r = -.482, p = .023). Performance on the TMT-B was also significantly negatively correlated with non-collision errors on the construction zone scenario (r = -. 479, p =.018), thus, participants taking less time to

Table 14

Pearson Correlations between Baseline Scores on Visual Attention and Driving Errors

	UFOV Subtest 1		UFOV Subtest 2		UFOV Subtest 3		UFOV Total Score	
	r	p	r	p	r	p	r	p
Rural Highway								
Collision Errors	.038	.87	.014	.96	.085	.72	.076	.75
Non-Collision Errors	.110	.64	-.005	.98	.341	.13	.255	.27
Parking Lot								
Collision Errors	-.151	.51	.176	.44	.224	.33	.235	.30
Non-Collision Errors	.099	.67	-.155	.53	-.146	.53	-.170	.46
Construction Zone								
Collision Errors	-.153	.50	.039	.86	-.254	.25	-.176	.43
Non-Collision Errors	-.482	.02	-.213	.34	-.029	.90	-.140	.54

Table 15

Pearson Correlations between Baseline Scores on Executive Functioning and Driving Errors

		Trailmaking Test B (TMTB)		Stroop Interference Score (STR)	
		r	p	r	p
Rural Highway					
	Collision Errors	-.053	.82	.248	.27
	Non-Collision Errors	.271	.21	.378	.08
Parking Lot					
	Collision Errors	-.247	.26	-.016	.94
	Non-Collision Errors	-.181	.41	.344	.11
Construction Zone					
	Collision Errors	-.053	.81	-.307	.14
	Non-Collision Errors	-.479	.02	.094	.66

complete the TMTB would also make more non-collision errors on the construction zone scenario.

Correlations at baseline amongst the two types of cognitive variables (i.e., visual attention and executive functioning) were also computed (see Table 16). As a result, some significant associations were found. More specifically, the TMT-B had significant positive correlations with UFOV subtest 2 (divided attention: $r = .427$, $p = .029$), UFOV subtest 3 (selective attention: $r = .494$, $p = .01$) and the Stroop interference score ($r = .376$, $p = .044$). Thus, a better performance on the TMTB tended to reflect better divided attention, selective attention and less interference on the Stroop task. The divided attention and selective attention subtests also demonstrated significant positive associations ($r = .389$, $p = .049$), so those performing well on the divided attention subtest tended to perform well on the selective attention subtest. This is expected as those with poor performance on one of these subtests generally tend to perform poorly on the other (Visual Awareness Inc., 2004).

Associations between Changes in Cognition and Driving Performance

Bivariate correlations were computed between difference scores on cognitive variables (UFOV subtests 1-3, TMTB, Stroop Interference) and the main physical functioning variables (endurance level, RHR, BMI and Waist-to-Hip ratio). The results of this correlational analysis are provided in Table 17. No significant associations between these two domains were found.

Visual Search Group Differences

Group differences on the TMT-A score were also examined by an ANCOVA as a supplementary analysis. A test of the assumption of equality of variances showed no

Table 16

Pearson Correlations between Visual Attention and Executive Functioning Cognitive Variables

	Trailmaking Test B (TMTB)		Stroop Interference Score (STR)	
	r	p	r	p
UFOV Subtest 1	.275	.17	.155	.45
UFOV Subtest 2	.427	.03	.044	.83
UFOV Subtest 3	.494	.01	.359	.07
UFOV Total Score	.562	.01	.295	.14

Table 17

Difference Score Correlations between Cognitive Variables, Endurance and Body Composition Variables

	Endurance Level		Resting Heart Rate (RHR)		Waist-to-Hip Ratio (WHR)		Body-Mass Index (BMI)	
	r	p	r	p	r	p	r	p
UFOV Subtest 1	-.199	.39	-.119	.59	-.125	.57	-.034	.88
UFOV Subtest 2	.345	.13	.022	.92	-.024	.91	-.062	.78
UFOV Subtest 3	-.203	.38	.161	.46	.096	.66	.084	.70
Trailmaking Test B (TMTB)	.068	.77	.081	.71	.013	.95	-.018	.93
Stroop Interference Score	-.125	.59	.129	.56	-.208	.34	-.251	.25

violation of this assumption, Levene's test: $F(1,23) = .724$, $p = .404$. From the findings from the ANCOVA, no significant group differences were found, $F(1,22) = .055$, $p = .816$.

Discussion

Much of the previous fitness and cognition research with the elderly population has been limited to examining the effects of increased physical activity on general cognitive constructs without much empirical attention to the practical implications of such findings. Given that meta-analytic investigations have implicated executive functioning and attention as particularly sensitive to increased physical activity in sedentary older adults, a logical extension was to examine whether driving performance is also affected especially since these cognitive abilities are also important in safe driving. This study represents a novel attempt to connect these different lines of research. Furthermore, the present study also demonstrates that an unsupervised fitness intervention of short-term duration can produce significant cognitive changes in sedentary older adults, which are particularly relevant to safe driving.

Cognitive Outcome Variables

Analyses showed that those participating in the 12-week exercise intervention demonstrated significantly improved visual attention compared to wait-list controls as shown by the overall UFOV score. In addition to an analysis of the UFOV total score, specific aspects of visual attention were also examined. An examination of group means showed that the experimental group's mean score on selective attention improved by 43.37 ms, while the control group's mean declined 43.19 ms after 12 weeks. As well, selective attention accounted for about 39% of the group variance. As stated, selective attention refers to an individual's ability to detect and respond to objects both in their central focus and periphery and is the most complex of the three visual attention tasks investigated in this study. No significant group differences were found for UFOV subtest 1 (speed of information processing) or UFOV subtest 2 (divided attention). These results suggest that selective attention is particularly sensitive to fitness effects compared to the other two lower demand attention tasks. This finding is consistent with previous research (i.e., Stones & Kozma, 1989; Hawkins, Kramer & Capaldi, 1992; Chodzko-Zajko & Moore, 1994) which proposed that fitness effects are likely to be more pronounced for tasks of greater complexity and which require greater mental resources. As well, this finding is supported by the literature which has hypothesized that cognitive improvements facilitated by increased fitness are likely within the domain of controlled processes (e.g., dual task, speeded tasks) as opposed to more automatic abilities (e.g., recognition; Chodzko-Zajko & Moore, 1994). Given that the subtests of the UFOV become progressively more challenging, with the selective attention subtest being the most cognitively demanding of the three), it is logical that fitness effects would be more salient for this subtest. Furthermore, while the information processing speed variable has been suggested to best account for age-related decreases in cognition (e.g., Salthouse, 2006), scores across groups on the UFOV subtest 1, which represents this cognitive construct, suggested that it was not influenced by increased fitness.

Despite some consideration given to divided attention in the aging and driving literature (e.g., NHTSA, 2003), a significant intervention effect was not found for this variable. It should be noted however that an examination of trends shows that the control group took longer to complete the divided attention trial at the second testing interval (after 12 weeks), whereas the experimental participants' mean score remained generally stable. Furthermore, while the experimental group's performance on this subtest remained within the 'normal' risk category after the 12-weeks, the control group's performance fell from 'normal' risk to the 'mild difficulty' category. It is possible that a larger sample size and thus, greater statistical power may result in a significant finding on this variable.

While a significant between-group intervention effect was not found for the Stroop interference and TMTB scores, examination of effect sizes and trends reveal some useful information. In particular, performance on both the TMTB and SCWT for the experimental group seemed to show a trend towards faster response (i.e., improved performance) over the 12-week intervention, while control group performance remained stable on the TMTB and slightly faster on the SCWT after 12 weeks. In addition, the adjusted R2 value for the SCWT showed a sizable proportion of variance explained (about 9%) between groups.

It has been established that cognitive tasks with stimulus-response incompatibility (e.g., SCWT colour-word trial) result in longer response times than more compatible conditions (e.g., Chodzko-Zajko & Moore, 1994) and that this effect is especially striking in older adults (Light & Spirduso, 1989). In addition, older adults participating in chronic exercise have been found to have more pronounced improvements on novel/unfamiliar tasks than over-learned cognitive tasks (Stones and Kozma, 1989). This suggests that a fitness intervention may have a greater influence on tasks that require more central processing and cognitive resources. This is consistent with the significant exercise effect on selective attention and indication of effect on SCWT interference.

The TMT-B has frequently been included in proposed driving screening evaluations (i.e., NHTSA, 2003) due to its theorized link to safe driving and has even been recommended for use by the American Medical Association (Elkin-Frankston et al., 2007) to be included in driving competency evaluations. The cognitive flexibility and visual scanning requirements of the task seems to underlie several behaviours imperative to safe driving (e.g., detection of the driving environment, switching from attention to traffic signals to surrounding vehicles). However, TMTB did not appear to account for much group variance in our study. Thus, according to results from this study, it appears that among the two measures of executive functioning that represented different elements of the construct, inhibition/interference seems to be more susceptible to increased fitness in older adults than cognitive flexibility.

According to our study, exercise effects were more pronounced for visual attention than for executive functioning. This seems to be in contrast to the meta-analyses conducted by Colcombe and Kramer (2003), which found that exercise in sedentary older adult populations demonstrated a larger effect size for executive control processes than 'controlled' processes (such as complex attention tasks). However, it should be noted that the present study specifically examined attention in the visual modality as opposed to general attention. Furthermore, these general constructs were examined by a variety of different instruments across studies surveyed for the meta-analysis and thus, it is possible that effects on more precise cognitive abilities were washed out. For the present study, cognitive measures were also chosen based on their theoretical or empirical relation to safe-driving (i.e., cognitive flexibility, divided and selective attention) rather than selecting general cognitive measures. Thus, it was predicted that changes in these cognitive measures would also correspond with changes on driving outcome measures; however, this did not occur.

Driving

Those participating in the physical activity intervention did not show significantly fewer errors on the driving scenarios (i.e., less driving errors) after 12 weeks of the exercise intervention. However, the waitlist-control group, who was not expected to demonstrate change in driving performance over the 12 weeks, committed fewer non-collision errors on the rural highway scenario when compared to their initial performance on the same simulator scenario.

While the experimental group committed more non-collision errors on the rural highway scenario, inspection of length of run times demonstrated that these participants completed the scenario more quickly than they initially had at baseline. Thus, perhaps behavioural slowing was reduced in experimental participants at the cost of driving precision (e.g., not crossing centerline, attention to speed). Furthermore, despite the quicker completion time for the rural highway scenario for the experimental group, the two groups did not differ on collision errors for this driving scenario. Thus, the decreased non-collision errors in the control group may have reflected a more slow and deliberate approach to the scenario compared to the quicker completion by the experimental group. No significant differences were found on any of the other driving scenarios or other driving errors. Finally, given the results of the multiple imputation missing data analysis, this result may be a spurious finding due to attrition bias.

While it is plausible that selective attrition occurred and thus, those who may have demonstrated poorer driving performance dropped out of the study, the missing data analysis did not indicate any undue influence of missing data. Effects of selective attrition might also be more evident in a study with a sample much larger than the current sample size.

The driving scenarios and specific driving events used in the current study were chosen based on theoretical relevance to the cognitive abilities proposed to be relevant to safe driving (i.e., executive functioning, visual attention). For example, in the parking lot scenario, a driving event believed to test selective attention was used when participants were required to navigate through the lot while attending to potential driving hazards approaching from the periphery. Despite choosing face valid scenarios for testing, the reliability and validity of these scenarios has not yet been established. In particular, external validity, that is the degree to which driving simulations provide information related to actual driving behaviour is a centrally important consideration. For example, it is unclear where the events used are sufficiently difficult or perhaps even, too difficult, to simulate real-life driving events. Whether participants have tried driving simulation in the past (i.e., former studies) was not formally investigated and it is possible past experience may have had an influence on current driving performance.

Recent investigations of driving safety also suffer from similar limitations of external validity. Furthermore, simulations designed to measure specific cognitive abilities (i.e., selective attention, divided attention) typically include situations that are never encountered in an actual driving environment (e.g., Lee et al., 2003). Some researchers have suggested appropriate driving –relevant cognitive skills that may be useful to recreate in driving scenarios. For example, Preusser and collegues (1998) discussed the importance of detecting (i.e., divided attention) and evaluating (i.e., selective attention) peripheral objects when entering an intersection.

Given that the events used in driving scenarios can be dangerous to test in real-life driving tests, the challenges behind establishing simulator validity are evident. Researchers may need to propose more creative means of testing or to rely more heavily upon correlational research to investigate simulator validity. However, as an initial step, establishing validity for driving scenarios might be better guided by a rational framework, where there is a balance between choosing driving situations which focus on relevant cognitive skills as well as being at least face valid. One difficulty with some of the driving scenarios used in the research is that participants are required to perform cognitive tasks while driving (e.g., counting red triangles appearing in the driving environment, making a response every time a target stimulus appears), which are not tasks that would be done in an actual driving situation. Perhaps greater attention and effort towards finding driving situations which are conceptually-related to driving-relevant cognitions would benefit this area of research. These scenarios might then be further modified and refined based on further testing, however the initial and conceptually-based development of these scenarios is an important first step.

Supplementary Analyses

Cardiovascular Endurance and Body Composition

Despite including elements of cardiovascular and strength training into the exercise protocol, no significant group differences between experimentals and controls in physical endurance (i.e., RHR and VO^2 max level) and body composition (i.e., BMI) were found. Within-group comparisons also demonstrated a lack of significant findings across these physical functioning variables. It is plausible that the methods and measures chosen to detect changes in endurance and body composition may not have been sufficiently sensitive to detect changes that occurred from increased exercise. Some participants were unable to complete the submaximal endurance test at one or both of the testing intervals and thus the endurance score was converted to a categorical score, in which participants who were unable to complete the test due to endurance limitations were given the lowest score. Those completing the endurance test were given scores according to levels comparable to age and gender-based norms. It should be noted that it is estimated that as many as 30% of the general older adult population are unable to complete submaximal tests of endurance (Sidney & Sheppard, 1977) and thus, the fact that some participants were unable to endure the testing is not abnormal.

The categorical conversion of the endurance score done in this study was justified as it has been employed by other researchers (Heyward, 1998). Nevertheless, this conversion may have caused the loss of important differences in endurance. While it might have been at the cost of precision, it is possible that more VO^2 max estimates could have been derived if a less demanding submaximal test (e.g., Rockport Walk-a-Mile test) was used. Generally however, submaximal tests of endurance are less sensitive to fitness changes in older adults than other maximal endurance tests (ACSM, 2000). Moreover, submaximal estimates in older adults are expected to underestimate endurance by at least 25% (Sidney & Sheppard, 1977). However, despite its greater accuracy, use of maximal endurance tests in this population also poses a greater risk of injury to participants than submaximal tests (ACSM, 2000; Pollock & Willmore, 1990). Thus, it was decided that to maximize participant well-being in the study and to minimize attrition, submaximal testing would be used. Nevertheless, it appears that fitness testing with older adults is generally limited by costs of either poor attrition or precision.

Another important consideration is whether the use of measures used to detect typical fitness changes (i.e., cardiovascular or body composition) are too "global" and thus, avoid detection of other physical changes which may be more reflective of the cognitive changes that occur in sedentary older adults after starting a physical activity intervention (Kramer & Erickson, 2007). There is some evidence to suggest that cardiovascular changes (as measured by heart rate and oxygen consumption) may not occur in adults within short-term, combined fitness interventions. According to a meta-analysis review of elderly fitness studies which measured changes in oxygen consumption as a function of exercise, these changes may not occur until after 20 weeks of moderate and consistent aerobic activity (Huang, Gibson, Tran & Osness., 2005). However, independent investigations have demonstrated cognitive changes and improved oxygen consumption after shorter aerobic interventions (e.g., 10 weeks; Osteras, Hoff & Helgrud, 2005); thus it appears that the findings are mixed. More importantly however, significant cognitive changes have also been detected in the absence of changes in oxygen consumption (Colcombe & Kramer, 2003).

An additional question is whether the fitness intervention used in the study was sufficiently intense and of appropriate duration. It is possible that a longer and more involved fitness intervention may have produced tangible physical benefits in addition to more cognitive benefits than what was observed as seen in previous investigations (e.g., Dustman et al., 1984; Rikli & Edwards, 1991). Furthermore, the question of treatment fidelity is also an important concern given that the intervention was independently conducted and was not closely supervised. It is possible that the same intervention with greater efforts towards monitoring participants may have produced significant fitness effects and greater cognitive effects than what is indicated in our present findings. Furthermore, it is also possible that control participants engaged in exercise during the study while waiting to participate in the intervention. More research is needed to determine stringent guidelines about the appropriate duration, frequency, types and intensity of exercise required to produce physical and cognitive benefits in older adults. Still, this would be a difficult endeavour since individual differences in this population would also need to be considered in prescriptive exercises. While it is possible that the significant cognitive changes found in this study were spurious, given that some cognitive changes were observed in the expected direction it is also plausible that physical changes did occur, but were not detectable given the measures we used for examining physical functioning changes.

In a recent review of older adult fitness intervention literature (Kramer & Erickson, 2007), it was proposed that exercise-induced cognitive enhancements might be independent of VO^2 max outcomes. This proposition is consistent with findings from the current study. Thus, perhaps measures of oxygen consumption and body composition may not be sufficiently sensitive to detect the physical changes that coincide with or underlie cognitive changes occurring as a result of increased physical activity. Examination of changes in cognition compared to changes in fitness in the present study indicated that changes in these two domains were not significantly associated, which adds further support to previous theories in the literature (e.g., Kramer & Erickson, 2007).

Thus, more exercise-intense fitness interventions or fitness programs of greater frequency or duration may not explicate the underlying mechanisms of fitness-related cognitive change. Some literature suggests that changes occurring due to increased fitness may be better captured by measures designed to detect changes at the brain or neural level (Etnier et al., 2006). This is consistent with meta-analytic research (Colcombe & Kramer, 2003) which has demonstrated that physical activity interventions for older sedentary adults resulting in improvements in cognitive performance have not consistently resulted in concurrent changes in fitness outcome indices. In fact, within older adult fitness research, there is evidence suggesting that specific brain changes, such as in brain neurochemistry (Dishman et al, 2006; Kohut et al., 2006) or morphology (Colcombe et al., 2006; Dishman et al., 2006) may occur from increased physical activity. In their recent meta-analysis on intervention studies of physical activity and cognition, Etnier and researchers (2006) did not find support for the cardiovascular-fitness hypothesis and employment of alternative physiological measures were recommended.

In contrast to several other studies whose exercise interventions centered on one specific aspect of fitness (e.g., Ostrow et al., 1992), the intervention employed in this study combined elements of both aerobic (i.e., walking) and anaerobic exercise (i.e., strength training, stretching). The cardiovascular and strength training exercises included in the intervention were also to be performed consistently at a moderate level of intensity (i.e., 65% MHR) so as to achieve fitness gains, but also minimize the risk of strain or injury (ACSM, 2000). Thus, it was expected that any physical benefits achieved from the intervention would be maximized. Despite these attempts, improvements on physical outcome variables involving common fitness indices (i.e., endurance, body composition) were not found, but nevertheless, it cannot be concluded that physical benefits were not achieved.

Other Aspects of Physical Functioning

Secondary fitness outcome variables (i.e., Sit and Reach, Range of Motion) examining flexibility were examined for between group differences. Significant group differences were not found on these measures despite previous research to the contrary (e.g., Ostrow et al., 1992). Thus, it is possible that our inclusion of flexibility exercises were not sufficient (in quality, duration, frequency or intensity) to achieve benefits in the fitness domains of flexibility/range-of-motion. Additionally, given that the present fitness intervention combined several different types of exercise (aerobic, strength training and flexibility) and was unsupervised, it is possible that participants may have put a greater emphasis on completing the other aspects of the intervention or completed the flexibility portion of the exercise protocol in a less thorough manner.

Quality of Life and Self-Efficacy

After examining physical and mental well-being and self-efficacy scores at baseline in relation to the main physical functioning outcome scores, only the PCS and BMI were found to be significantly associated at both pre- and post- test intervals. Further inspection of this association suggested that participants reporting better physical well-being tended to have a lower BMI. It is a reasonable assumption that generic body composition or total body mass can influence physical health and daily activity, particularly within the extreme ranges (i.e., very high or very low body weight). Mean values of BMI in the control group (M=28.6) and experimental group (M=27.66) were very similar and within the middle of the overweight range. Research has found that those with higher BMIs reported poorer physical health (e.g.., Yan et al., 2004), which is consistent with our findings. Interestingly, no association between MCS and BMI was found, suggesting that the effects of weight were generally restricted to perceived physical health and without a significant influence on mental health and well-being. The amount and type of exercise prescribed in the current study could reasonably produce changes in body composition according to established recommendations (Pollock et al., 1998). In fact, while no significant group differences for BMI were found, the participants in the experimental group showed little change in their BMI at final measurement (M = 28.49), while the final control group mean BMI moved from the overweight category to place within the obese range (M = 33.76). Thus, even though participation in the exercise intervention did not seem to effect significant changes in body mass, it may have helped to maintain current body mass or protect against further gains.

Self-efficacy was found not to be associated with likelihood of completing the study (i.e., attrition) or with fitness improvement (i.e., changes in physical functioning). Neither individual items of self-efficacy or mean self-efficacy score seemed to differ across participants in a meaningful way, but it is possible that subtle differences in self-efficacy across participants were not detected by the current study due to the limited sample size. No significant associations were found between self-efficacy and mental/physical well-being despite some indication of this association in the literature (i.e., Resnick & Jenkins, 2000). However, it should be noted that self-efficacy was not measured at the final testing interval (after the 12 week period), thus it is unclear whether participation in the intervention may have elevated self-efficacy. Furthermore, measures of well-being (i.e., SF-12) were also only administered at baseline (due to resource constraints), thus it is plausible that changes in self-efficacy after the 12 weeks might have correlated with changes in self-reported physical and/or mental health.

Associations between average self-efficacy scores and cognitive outcomes were also examined. Interestingly, significant negative associations were found between mean self-efficacy and post-test selective attention ($r = -.544$) and Stroop interference scores ($r = -.446$). In other words, higher self-efficacy at baseline was correlated with better performance on selective attention and Stroop interference after 12 weeks. While it is possible that this finding was spurious given that many correlations were performed, it is also possible, that those with a higher confidence in their ability to successfully participate in the exercise program were more engaged in the intervention and demonstrated greater cognitive benefits. It should be noted that these two cognitive scores accounted for the most variance across groups among all the cognitive variables (selective attention: 39%, Stroop: 9%). This finding may provide additional support that although significant physical changes were not detected, participants still achieved beneficial cognitive effects from exercising (i.e., Kramer & Erickson, 2007). This finding is also consistent with previous research where individuals with higher exercise self-efficacy benefited more from exercise interventions (e.g., Allison & Keller, 2004). However, this conclusion is limited in the current study, since self-efficacy levels were not considered in group assignment of participants. Thus, a more stringent investigation of self-efficacy, cognition and fitness in older adults would be needed to lend further support for these trends. Nevertheless, findings from this study suggest that cognitive improvements in the program may have been further influenced by participant attitudes towards exercise at the onset of the study. However, further research would be needed to lend further support to this claim as well as to better explicate the association between psychological factors and exercise compliance.

Analysis of self-efficacy and driving errors on the simulation showed a lack of significant associations with exception of one finding. A significant negative correlation was found between self-efficacy and baseline performance on the rural highway. Those with a higher exercise self-efficacy tended to commit fewer total errors (collision and non-collision errors combined) on the rural highway scenario. However, this association diminished by the second testing interval. Findings from the literature have related instrumental activities of daily living with driving performance (i.e., Sims et al., 2000), yet no significant correlations between the SF-12 and driving simulator scores were found in the analyses.

Baseline Associations Between Cognition and Driving

Bivariate correlations between the cognitive outcome variables and driving simulation errors were conducted to examine whether any significant associations occurred. Only pre-test scores of participants were used in this comparison so that potential relationships among cognitive and driving variables could be identified irrespective of fitness effects. The results from this analysis showed that the non-collision errors made in the construction zone scenario were significantly negatively correlated with both the speed of processing score (UFOV1) and the TMTB score. This result suggests that participants making more non-collision errors (i.e., speed exceedances, road edge excursions) in this particular scenario were likely to perform better (i.e., more quickly) on the UFOV1 subtest and the TMTB. Interestingly, both the

UFOV1 and TMTB are measures reflective of processing speed (the TMTB is also further constrained by psychomotor speed).

It is plausible that those with poorer processing speed took a more deliberate and cautious approach while navigating through the construction zone scenario. Thus, participants with slower processing may have been demonstrating compensatory driving behaviour. In fact, in their review, Chodzko-Zajko and Moore (1994) indicated that "behavioural slowing" is an expected consequence of aging. It may be that fitness can also impact one's behavioural slowness, which is not captured by standard cognitive measures of speed of information processing. A similar finding occurred in the main analyses where control participants exhibited less non-collision errors on the rural highway after 12 weeks than experimental participants, but took more time to complete the scenario.

The findings from the current study represent a novel attempt to bridge experimental research on elderly cognition and physical activity with applied research pertaining to older drivers. Review of this literature has revealed some important areas of overlap, which has culminated in the current investigation. A study recently published by Marmeleira, Godinho and Fernandes (2009) had made similar hypotheses regarding executive functioning, visual attention, fitness and driving. These authors employed a 12-week physical activity intervention consisting mainly of walking exercises, which also included concurrent cognitive exercises (i.e., responding to auditory cues while walking). Significant group differences found by Marmeleira and colleagues were limited to improvements in reaction time and processing speed. These authors also conducted within-group analyses, in which they found that experimental participants had improved divided attention after the intervention. No differences were found for the TMTB or Stroop Interference score. While the intervention in the present study did not include cognitive exercises, it is possible that this inclusion may have resulted in a more pronounced effect on divided attention. However, the exercise effects seen for selective attention and interference may suggest that some exercise components in this intervention not considered by Marmeleira, Godinho and Fernandes (2009) may have resulted in greater enhancements in driving-related cognitive abilities.

Marottoli and researchers (2008) found that those participating in their intervention (centered on flexibility and coordination) tended to maintain their baseline driving performance, while those in the control group tended to exhibit a decline in their performance. While this finding was not statistically significant, further examination of their results suggested clinical significance (Marottoli et al., 2008). This trend is consistent with some of the cognitive findings in the current study (i.e., divided attention).

Limitations and Directions for Future Research

It is plausible that some of the indices chosen in the present study, particularly driving and physical functioning variables, were not sufficiently sensitive to detect changes resulting from the exercise intervention. It should be noted that the validity for the driving scenarios used in the study has not been established, and thus, it is unclear as to whether errors committed in these scenarios are appropriately reflective of actual driving errors and crash risk.

As for the physical functioning measures chosen, precise VO^2 max estimates could not be provided for all participants, particularly at baseline. Tests of physical endurance causing less exertion and physical demand on participants (i.e., Rockport Walk-a-Mile test) may be considered for future studies involving sedentary older adults. While a moderate to high-intensity fitness program is expected to produce changes in cardiovascular endurance in older adults, this was not found in the present study. It is unclear what minimum duration and frequency is required to achieve improved endurance for this population, thus more data regarding this is needed.

Given that only participants who reported an absence of health difficulties and who were medically cleared to participate in the intervention were selected, it can be assumed that the generalizability of the current findings are limited to the healthy segment of the older adult population. Further support for this comes from examination of sample characteristics as the sample endorsed a level of physical and mental health within the normal range (i.e., SF-12 scores similar to the mean values in the general population). If participants reporting worse health were recruited this may have resulted in general poor performance across measures. Furthermore, the presence of individuals from clinical populations (e.g., older adults with cognitive impairment) in the sample may have been more likely. The recruitment of participants from a small community (Thunder Bay) may also influence the generalizability of the findings (i.e., different driving exposure). For example, participants from smaller communities may have less exposure to challenging driving situations (e.g., greater number of vehicles in driving environment, complex intersections) and thus, this may have resulted in poorer driving simulation performance. It is possible that age-related difficulties experienced by older drivers with greater driving experience in urban areas may be more salient, given that they may perform better on the driving scenarios that are not expected to be significantly influenced by age, whereas rural older drivers may show more uniform difficulties.

The current sample was also sedentary, which is reflective of the overall older adult population (Administration on Aging, 2002), however, the operational definition of sedentary differs across studies. While an inclusive definition was chosen for the current sample (i.e., not engaging in regular physical activity), other studies (e.g., Hillman et al., 2002) have been more restrictive (i.e., no participation in exercise over the last five years at time of study enrollment). Furthermore, while age was stratified across groups, the overall sample consisted of participants over three decades. It is possible that more precise age differences might have been washed out due to the large age range included in the study. Given the small sample size, specific comparisons by age could not be conducted, however future research would be beneficial to explore whether differential effects of aging may occur.

While the sample size of the current investigation was comparable to previous studies with similar methodology (e.g., Marmeleira, Godinho & Fernandes, 2009; Hawkins, Kramer & Capaldi, 1992; Blumenthal & Madden, 1988), the power was limited within the current study. It is plausible that some trends that were deemed non-significant may have been significant with a larger sample. Nevertheless, the recruitment methods and study enrollment for this type of investigation is resource and time intensive and thus, a similar study with a larger sample may need to be conducted at multiple geographical sites. A study by Jancey and authors (2006) had a participation rate of 13.6% for their fitness intervention for older adults despite having the advantage of using electoral lists to recruit participants.

Our participation rate of 17.7% fares slightly better. However, to maximize the rate of participation in this study, a few modifications to group assignment and testing were done. In particular, participants entering the study with a partner (i.e., spouse or friend) were given the option to participate in the same group. In addition, the enrollment and testing were conducted in two separate waves about 12 weeks apart. This was done to accommodate individuals who could not participate during the timing of the initial wave.

The physical activity intervention administered in this study was designed so that participants could complete the program relatively independently (excluding the initial training and subsequent consultations given over the course of the program). This structure has the advantages of minimizing resources required to conduct interventions as well as maximizing participation rates due to eliminating several constraints relating to time or scheduling. However, the participants were not followed as closely as they would have been in a supervised intervention and thus, treatment fidelity was not examined as vigilantly as would be the case in more directive exercise programs. While the participants were contacted throughout the study and asked to submit or report on their progress, this was not done in a uniform manner across participants. Thus, some received more contact with trainers than others based on their initiative. This could be more stringently controlled in further investigations.

The current investigation suggests that a short-term, independent physical activity intervention can result in improved visual attention and executive functioning, particularly in the areas of selective attention and cognitive flexibility. These cognitive abilities are important in driving performance and have been shown by previous literature to impact safe elderly driving. While the direct implications for driving are unclear, future investigations with similar methodology might consider employing validated, performance-based driving measures which test older driving behaviours influenced by visual attention and executive functioning.

References

American College of Sports Medicine [ACSM]. (2000). *ACSM's Guidelines for Exercise Testing and Prescription* (6th ed.). Philidelphia: Lippincott Williams and Wilkins.

Administration on Aging. (2002). *A profile of older Americans.* U.S. Department of Health and Human Services.

Ahmed, A., Ness, J., Howard, G. & Aronow, W. S. (2005). Cerebrovascular diseases as primary hospital discharge diagnoses: National trend (1970-2000) among older adults. *Journal of Gerontology: Medical Sciences*, 60A, 1328-1332.

Alexander, J., Barham, P. & Black, I. (2002). Factors influencing the probability of an incident at a junction: results from an interactive driving simulator. *Accident Analysis & Prevention*, 34(6), 779-792.

Allen, J. S., Bruss, J., Brown, C. K. & Damasio, H. (2005). Normal neuroanatomical variation due to age: the major lobes and a parcellation of the temporal region. *Neurobiology and Aging,* 26, 1245-1260.

Allen, R. W., Stein, C. A., Aponso, B. L., Rosenthal, T. J. & Hogue, J. R. (1990). *A low cost, part task driving simulator based on microcomputer technology.* Paper presented at the 69th Annual Meeting of the Transportation Research Board, Washington, DC.

Allison, M. J. & Keller, C. (2004). Self-efficacy intervention effect on physical activity in older adults. *Western Journal of Nursing Research, 26(1),* 31-46.

Allport, A. (1989). Visual attention. In M.I. Posner (Ed.), *Foundations of cognitive science* (pp. 631-682). Cambridge, MA: MIT Press.

Andersen, R. M. (1995). Revisiting the behavioural model and access to medical care:

does it matter? *Journal of Health and Social Behavior*, 36, 1-10.

Anderson, V., Anderson, P., Northam, E., Jacobs, R. & Catroppa, C. (2001). Development of executive functions through late childhood and adolescence in an Australian sample. *Developmental Neuropsychology,* 20(1), 385-406.

Andres, P., Guerrini, C., Phillips, L. H. & Perfect, T. J. (2008). Differential effects of aging on executive and automatic inhibition. *Developmental Neuropsychology*, 33(2), 101-123.

Andres, P. & Van der Linden, M. (2000). Age-related differences in supervisory attentional system functions. *Journal of Gerontology: Psychological Sciences*, 55B(6), P373-P380.

Anstey, K. J. & Smith, G. A. (2003). Associations of biomarkers, cognition and self-reports of sensory function with self-reported driving behaviour and confidence. *Gerontology*, 49, 196-202.

Axelrod, B. N. & Henry R. R. (1992). Age-related performance on the Wisconsin card sorting, similarities, and controlled oral word association tests. *Clinical Neuropsychologist*, 6(1), 16–26.

Baddeley, A., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.) *Recent advances in learning and motivation.* Vol. 8 (pp. 47-89). New York: Academic Press.

Baldock, M. R. J., Mathias, J., McLean, J. & Berndt. A. (2007). Visual attention as a predictor of on-road driving performance of older drivers. *Australian Journal of Psychology,* 59(3), 159-168.

Ball, K., Owsley, C., Sloane, M., Roenker, D. & Bruni, J. (1993). Visual attention problems as a predictor of vehicle accidents among older drivers. *Investigative Ophthalmology & Visual Science,* 34(11), 3110-3123.

Ball, K., Owsley, C., Stalvey, B., Roenker, D. L., Sloane, M. E. & Graves, M. (1998). Driving avoidance and functional impairments in older drivers. *Accident Analysis and Prevention*, 20, 313–322.

Ball, K. & Roenker, D. (1998). *Useful field of view*, San Antonio, TX: The Psychological Corporation.

Band, G., Ridderinkhof, K. R., & Segalowitz, S. (2002). Explaining neurocognitive aging: Is one factor enough. *Brain and Cognition,* 49, 259–267.

Bartzokis, G. (2004). Age-related myelin breakdown: A developmental model of cognitive decline and Alzheimer's disease. *Neurobiology of Aging*, 25, 5–18.

Belleville, S., Rouleau, N. & Van der Linden, M. (2006). Use of the Hayling task to measure inhibition of prepotent responses in normal aging and Alzheimer's disease. *Brain & Cognition*, 62, 113-119.

Bieliauskas, L. A. (2005). Neuropsychological assessment of geriatric driving competence. *Brain Injury*, 19(3), 221-226.

Blumenthal, J. A. & Madden, D. J. (1988). Effects of aerobic exercise training, age, and physical-fitness on memory-search performance. *Psychology and Aging*, 3, 280–285.

Bohannon, R. W., Maljanian, R. & Landes, M. (2004). Test-retest reliability of short form (SF)-12 component scores of patients with stroke. *International Journal Rehabilitation Research. 27(2)*, 149-50.

Boone, K. B., Ponton, M. O., Gorsuch, R. L., Gonzalez, J. J. & Miller, B. B. (1998).

Factor analysis of four measures of prefrontal lobe functioning. *Archives of Clinical Neuropsychology,* 13, 585-595.

Borkowsky, J. G., & Burke, J. E. (1996). Theories, models and measurements of executive functioning: An information processing perspective. In G. R. Lyon, & N. A. Krasnegor (Eds.) *Attention, memory and executive function.* Baltimore, MD: Paul H. Brookes.

Brickman, A. M., Habeck, C., Zarahn, E., Flynn, J. & Stern, Y. Structural MRI covariance patterns associated with normal aging and neuropsychological functioning. *Neurobiology of Aging,* 28, 284-295.

Burke, G. L., Arnold, A. M., Bild, D. E., Cushman, M., Fried, L. P., Newman, A., Nunn, C. & Robbins, J. (2001). *Factors associated with healthy aging: The Cardiovascular Health Study*, 49(3), 254-262.

Cahn-Weiner, D., Malloy, P., Boyle, P., Marran, M. & Salloway, S. (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *Clinical Neuropsychology*, 14, 187195.

Canadian Society for Exercise Physiology (2002). *Physical Activity Readiness – Medical Examination*. Ottawa: Author.

Canadian Society for Exercise Physiology (2002). *Physical Activity Readiness Questionaire.* Ottawa: Author.

Centers for Disease Control and Prevention. (2001). Physical activity trends – United States 1990-1008. *Morbidity and Mortality Weekly Report,* 50(9), 166-169.

Centers for Disease Control and Prevention. (2008). *Growing stronger – strength* *training for older adults*. Retrieved September 2008 from http://www.cdc.gov/physicalactivity/growingstronger/index.html

Chang, Y. & Etnier, J. L. (2009). Effects of an acute bout of localized resistance exercise on cognitive performance in middle-aged adults: a randomized controlled trial study. *Psychology of Sport and Exercise,* 10, 19-24.

Chodzko-Zajko, W. J. (1991). Physical fitness, cognitive performance and aging. *Medical Science, Sports and Exercise,* 23, 868-872.

Chodzko-Zajko, W. & Moore, K. A. (1994). Physical fitness and cognitive functioning in aging. *Exercise, Sports and Science Review*, 22, 195–220.

Colcombe, S. J., Erickson, K. I., Scalf, P. E., Kim, J. S., Prakash, R., McAuley, E., Elavsky, S., Marquez, D. X., Hu, L. & Kramer, A. F. (2006). Aerobic exercise training increases brain volume in aging humans, *Journal of Geronotology: Medical Sciences,* 61A(11), 1166-1136.

Colcombe, S. & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychological Science*, 14(2), 125-130.

Colcombe, S. J., Kramer, A. F., Erickson, K. I. & Scalf, P. (2005). The implications of cortical recruitment and brain morphology for individual differences in inhibitory function in aging humans. *Psychology and Aging*, 20, 363–375.

Colcombe, S. J., Kramer, A. F., Erickson, K. I., Scalf, P., McAuley, E., Cohen, N. J., Webb, A., Jerome, G. J., Marquez, D. X. & Elavsky, S. (2004). Cardiovascular fitness, cortical plasticity, and aging. *Proceedings of the National Academy of Sciences*, 101, 3316-321.

Connelly, S. L. & Hasher, L. (1993). Aging and the inhibition of spatial location. *Journal* *of Experimental Psychology: Human Perception and Performance,* 19(6), 1238-1250.

Cottman, C. W. & Holets, V. R. (1985). Structural changes at synapses with age: plasticity and regeneration (pp. 617-644). In C. E. Finch and E. I. Schneider (Eds.). *Handbook of the Biology of Aging* (2nd ed.). New York: Van Nostrand Rinehold.

Crawford, J., Bryan, J., Luszcz, M., Obonsawin, M. & Stewart, L. (2000). The executive decline hypothesis of cognitive aging: Do executive deficits qualify as differential deficit and do they mediate age-related memory decline? *Aging, Neuropsychology and Cognition*, 7, 9–31.

Daigneault, S., Braun, C. M., & Whitaker, H. A. (1992). Early effects of normal aging on perseverative and non-perseverative prefrontal measures. *Developmental Neuropsychology*, 8, 99–114.

Daigenault, G. Joly, P. & Frigon, J. (2002a). Executive function in the evaluation of accident risk of older drivers. *Journal of Clinical and Experimental Neuropsychology*, 24, 221-238.

Daigenault, G. Joly, P. & Frigon, J. (2002b). Previous convictions or accidents and the risk of subsequent accidents of older drivers. *Accident Analysis and Prevention*, 34, 257-261.

Darowski, E. S., Helder, E., Zacks, R. T., Hasher, L. & Hambrick, D. Z. (2008). Age -related differences in cognition: the role of distraction control. *Neuropsychology*, 22(5), 638-644.

Deary, I. J., Leaper, S. A., Murray, A. D., Staff, R. T. & Whalley, L. J. (2003). Cerebral white matter abnormalities and lifetime cognitive change: a 67 year follow-up of the Scottish Mental Survey of 1932. *Psychology and Aging*, 18(1), 140-148.

DeCarli, C., Massaro, J., Harvey, D., Hald, J., Tulberg, M., Au, R. et al. (2005). Measures of brain morphology and infarction in the framington heart study: establishing what is normal. *Neurobiology of Aging,* 26, 491-510.

Depp, C. A. & Jeste, D. V. (2006). Definitions and predictors of successful aging: a comprehensive review of larger quantitative studies. *American Journal of Geriatric Psychiatry*, 14(1), 6-20.

Dishman, R. K., Berthoud, H., Booth, F. W., Cotman, C. W., Edgertone, V. R., Fleshner, M. R. et al. (2006). Neurobiology of exercise. *Obesity*, 14(3), 345-356.

Division of Aging and Seniors. (2002). *Canada's aging population.* (Statistics Canada Catalogue No. H39-608/2002E). Ottawa, ON: Minister of Public Works and Government Services Canada.

Dustman, R. E., Emmerson, R. & Shearer, D. (1994). Physical activity, age and cognitive-neuropsychological function. *Journal of Aging and Physical Activity*, 2, 143-181.

Dustman, R. E., Ruhling, R. O. Russell, E. M., Shearer, D. E., Bonekat, H. W., Shigeoka, J. W., Wood, J. S. & Bradford, D. C. (1984). Aerobic exercise training and improved neuropsychological function of older individuals. *Neurobiology and Aging*, 5, 35-42.

Edwards, J. D., Leonard, K. M., Lunsman, M., Dodson, J., Bradley, S., Myers, C. A. & Hubble, B. (2008). Acceptability and validity of older driver screening with the Driving Health Inventory. *Accident Analysis and Prevention*, 40, 1157-1163.

Elderkin-Thompson, V., Ballmaier, M., Hellemann, G., Pham, D. & Kumar, A. (2008). Executive function and MRI prefrontal volumes among healthy older adults. *Neuropsychology*, 22(5), 626-637.

Elkin-Frankston, S., Lebowitz, B.K., Kapust, L., Hollis, A.M. & O'Connor, M.G. (2007). The use of the Color Trails Test in the assessment of driver competence: Preliminary report for a culture-fair instrument. *Archives of Clinical Neuropsychology,* 22(5), 631-635.

Etnier, J. L., Nowell, P. M., Landers, D. M. & Sibley, B. A. (2006). A meta-regression to examine the relationship between aerobic fitness and cognitive performance. *Brain Research Reviews,* 52, 119-130.

Fals-Stewart, W. (1992). An interrater reliability study of the Trail Making Test (Parts A and B). *Perceptual and Motor Skills, 74,* 39-42.

Fisk, J. E. & Sharp, C. A. (2004). Age-related impairment in executive functioning: updating, inhibition, shifting and access. *Journal of Clinical and Experimental Neuropsychology*, 26(7), 874-890.

Fonda, S. J., Wallace, R. B. & Herzog, A. R. (2001). Changes in driving patterns and worsening depressive symptoms among older adults. *Journals of Gerontology. Series B: Psychological Sciences & Social Sciences, 56,* S343-S351.

Freund, B., Colgrove, L. A. (2005). Self-rated driving performance among elderly drivers referred for driving evaluation. *Accident Analysis and Prevention*, 37, 613-618.

Freund, B. & Colgrove, L. A. (2008). Error specific restrictions for older drivers: promoting continued independence and public safety. *Accident Analysis and Prevention*, 40, 97-103.

Freund, B., Colgrove, L. A., Burke, B. L. & McLeod, R. (2005). Self-rated driving performance among elderly drivers referred for driving evaluation. *Accident Analysis and Prevention*, 37, 613-618.

Freund, B., Colgrove, L. A., Petrakos, D. & McLeod, R. (2008). In my car the brake is on the right: pedal errors among older drivers. *Accident Analysis and Prevention*, 40, 403-409.

Freund, B., Gravenstein, S., Ferris, R. & Shaheen, E. (2002). Evaluating driving competence of cognitively impaired and healthy older adults: a pilot study comparing on-road and driving simulation performance. *Journal of the American Geriatrics Society*, 50 (7), 1309–1310.

Friedman, N. P., Miyake, A., Corley, R. P., Young, S. E., DeFrias, J. C. & Hewitt, J. K. (2006). Not all executive functions are related to intelligence, *Psychological Science*, 17(2), 172-179.

Gallagher, M. & Rapp, P. R. (1997). The use of animal models to study the effects of aging on cognition. *Annual Review of Psychology*, 48, 339-370.

Gass, C. S. & Daniel, S. K. (1990). Emotional Impact on Trail Making Test Performance. *Psychological Reports, 67,* 435-438.

Gilmour, H. & Park, J. (2003). *Dependency, chronic conditions and pain in seniors.* (Statistics Canada Catalogue 82-003, Supplement to Health Reports, Volume 16). Ottawa, ON: Health Statistics Division.

Goode, K. T., Ball, K. K., Sloane, M., Roenker, D. L., Roth, D. L., Myers, R. S. &

Owsley, C. (1998). Useful field of view and other neurocognitive indicators of crash risk in older adults. *Journal of Clinical Psychology in Medical Settings,* 5(4), 425-440.

Grady, C. L., McIntosh, A. R., Horwitz, B., Maisog, J., Ungerleider, L. G., Mentis, M. J., Pietrini, P., Schapiro, M. B. & Haxby, J. V. (1995). Age-related reductions in human recognition memory due to impaired encoding. *Science*, 269, 218–21.

Greenwood, P. M. (2007). Functional plasticity in cognitive aging: review and hypothesis. *Neuropsychology*, 21(6), 657-673.

Grigsby, J., Kaye, K., Baxter, J., Shetterly, S. M. & Hamman, R. F. (1998). Executive cognitive abilities and functional status among community-dwelling older persons in the San Luis Valley Health and Aging Study. *Journal of the American Geriatrics Society*, 46, 590–596.

Gunning-Dixon, F. M. & Raz, N. (2000). The cognitive correlates of white matter abnormalities in normal aging: A quantitative review. *Neuropsychology*, 14, 224 – 232.

Gunstad, J., Paul, R. H., Brickman, A. M., Cohen, R. A., Arns, M., Roe, D., Lawrence, J. J. & Gordan, E. (2006). Patterns of cognitive performance in middle-aged and older adults: a cluster analytic examination. *Journal of Geriatric Psychiatry and Neurology*, 19(2), 59-64.

Hakamies-Blomqvist, L. (1996) Research on older drivers: a review. *Journal of International Association of Traffic and Safety Sciences* 20, 91-101.

Hall, C. D., Smith, A. L. & Keele, S. W. (2001). The impact of aerobic activity on cognitive function in older adults: a new synthesis based on the concept of executive control. *European Journal of Cognitive Psychology*, 13(1/2), 279-300.

Hasher, I. & Zacks, R. T. (1988). Working memory, comprehension and aging: a review and a new view. *Psychology, Learning and Motivation*, 22, 193-225.

Hasher, L., Zacks, R. T. & May, C. P. (1999). Attention and performance XVII: Cognitive regulation of performance: Interaction of theory and application. In D. Gopher & A. Koriat (Eds.). *Attention and performance.* (pp. 653-675). Cambridge, MA: The MIT Press.

Haug, H., & Eggers, R. (1991). Morphometry of the human cortex cerebri and corpus striatum during aging. *Neurobiology of Aging*, 12, 336–338.

Hawkins, H. L., Kramer, A. F. & Capaldi, D. (1992). Aging, exercise and attention. *Psychology and Aging*, 7(4):643-653.

Health Canada. (2004). *Canadian Physical Activity Guide for Older Adults.* Reference no. H39-429/1999-1E

Hendrie, H. C., Albert, M. S., Butter, M. A., Gao, S., Knopman, D. S., Launer, L. J. et al. (2006). The NIH cognitive and emotional health project – report of the critical evaluation study committee. *Alzheimer's & Dementia*, 2, 12-32.

Heyward, V. H. (1998). *Advance fitness assessment and exercise prescription.* Champaign, IL: Human Kinetics.

Hillman, C. H., Weiss, E. P., Hagberg, J. M. & Hatfield, B. D. (2002). The relationship of age and cardiovascular fitness to cognitive and motor processes. *Psychophysiology*, 39 (3), 303–312.

Hillman, C. H., Motl, R. W., Pontifex, M. B., Posthuma, D., Stubbe, J. H., Boomsma, D.

I. et al. (2006). Physical activity and cognitive function in a cross-section of younger and older community-dwelling individuals. *Health Psychology,* 25(6), 678-687.

Houghton, G. & Tipper, S. P. (1994). A model of inhibitory mechanisms in selective attention. In D. Dagenback, & T. Carr (Eds.), *Inhibitory mechanisms in attention, memory, and language* (pp. 53–112). San Diego, CA: Academic Press.

Houx, P. J., Jolles J. & Vreeling, F. W. (1993). Stroop interference: aging effects assessed with the Stroop colour-word test. *Experimental Aging Research,* 19:209 – 24.

Huang, G., Gibson, C. A., Tran, Z. V & Osness, W. H. (2005). Effect of controlled endurance exercise training on VO^2max changes in older adults: A meta-analysis. *Preventive Cardiology*, 8(4), 217-25.

Hugenschmidt, C. E., Peiffer, A. M., Kraft, R. A., Casanova, R., Deibler, A. R., Burdette, J. H. et al. (2008). Relating imaging indices of white matter integrity and volume in healthy older adult. *Cerebral Cortex*, 18, 433-442.

Ikier, S., Yang, L. & Hasher, L. (2008). Implicit proactive interference, age, and automatic versus controlled retrieval strategies. *Psychological Science*, 19(5), 456-461.

Jancey, J., Howat, P., Lee, A., Clarke, A., Shilton, T., Fisher, J. et al. (2006). Effective recruitment and retention of older adults in physical activity research: PALS study. *American Journal of Health Behaviour,* 30(6), 626-635.

Jernigan, T. L., Archibald, S. L., Berhow, M. T., Sowell, E. R., Foster, D. S., &

Hesselink, J. R. (1991). Cerebral structure on MRI, Part 1: Localization of age-related-changes. *Biological Psychiatry*, 29, 55– 67.

Jurado, M. B. & Rosselli, M. (2007). The elusive nature of executive functions: a review of our current understanding. *Neuropsychology Review*, 17, 213:233.

Kane, M. J., Hasher, L., Stoltzfus, E. R., Zacks, R. T. & Connelly, S. L. (1994). Inhibitory attentional mechanisms and aging. *Psychology and Aging*, 9(1), 103-112.

Keys, B. & White, D. (2000). Exploring the relationship between age, executive abilities, and psychomotor speed. *Journal of the International Neuropsychological Society*, 6, 76–82.

Kline, D. W., Kline, T. J. B., Fozard, J. D., Kosnik, W., Schieber, F. & Sekuler, R. (1992). Vision, aging and driving: the problems of older drivers. Journal of Gerontology: *Psychological Sciences, 47(1):*P27-34.

Kohut, M., McCann, D. A., Russell, D. W., Konopka, D. N., Cunnick, J. E., Franke, W. D., Castillo, M. C., Reighard, A. E. & Vanderah, E. (2006). Aerobic exercise, but not flexibility/resistance exercise, reduces serum IL-18, CRP, and IL-6, independent of β-blockers, BMI, and psychosocial factors in older adults. *Brain, Behaviour and Immunity*, 20, 201–209.

Korten, A. E., Jorm, A. F., Jiao, Z., Letenneur, L., Jacomb, P. A., Henderson, A. S., et al. (1999). Health, cognitive, and psychosocial factors as predictors of mortality in an elderly community sample. *Journal of Epidemiology and Community Health*, 53, 83– 88.

Kramer, A. F., Cassavaugh, N., Horrey, W. J., Becic, E. & Mayhugh, J. L. (2007).

Influence of age and proximity warning devices on collision avoidance in simulated driving. *Human Factors,* 49(5), 935-949.

Kramer, A. F. & Erickson, K. I. (2007). Capitalizing on cortical plasticity: influence of physical activity on cognition and brain function. *Trends in Cognitive Science,* 11, 342–348.

Kramer, A. F., Hahn, S. & MacAuley, E. (2000). Influence of aerobic fitness on the neurocognitive function of older adults. *Journal of Aging and Physical Activity*, 8, 379-385.

Langley, L. K., Vivas, A. B., Fuentes, L. J. & Bagne, A. G. (2005). Differential age effects on attention-based inhibition: inhibitory tagging and inhibition of return. *Psychology and Aging*, 20(2), 356-360.

Lee, H. C., Lee, A. H., Cameron, D. & Li-Tsang, C. (2003). Using a driving simulator to identify older drivers at inflated risk of motor vehicle crashes. *Journal of Safety Research,* 34, 453-459.

Levine, B., Stuss, D. T. & Milberg, W. P. (1997). Effects of aging on conditional associative learning: process analyses and comparison with focal frontal lesions. *Neuropsychology,* 11(3), 367-381.

Lezak, M. D. (1983). *Neuropsychological assessment* (2nd ed.). New York: Oxford University Press.

Lezak, M. D. , Howieson, D. B. & Loring, D. W. (2004). *Neuropsychological assessment* (4th ed.). New York: Oxford University Press.

Libon, D. J., Glosser, G., Malamut, B. L., Kaplan, E., Goldberg, E., Swenson, R. et al.

(1994). Age, executive functions, and visuospatial functioning in healthy older adults. *Neuropsychology*, 8, 38-43.

Light, K. E. & Spirduso, W. W. (1990). Effects of adults aging on the movement complexity factor of response programming. *Journals of Gerontology*, 45(3), P107-P109.

Little, D. M. & Hartley, A. A. (2000). Further evidence that negative priming in the Stroop Colour-Word Task is equivalent in older and younger adults. *Psychology and Aging*, 15(1), 9-17.

Luria, A. R. (1973). *The Working brain: An introduction to neuropsychology.* New York: Basic.

Lustig, C., Hasher, L. & Toney, S. T. (2006). Distraction as a determinant of processing speed. *Psychonomic Bulletin & Review*, 13(4), 619-625.

Lynam, S., Ferguson, S. A., Braver, E. R. & Williams, A. F. (2002). Older driver involvements in police reported crashes and fatal crashes: trends and projections. *Injury Prevention, 8,* 116-120.

Madden, D. J. (1990). Adult age differences in attentional selectivity and capacity. *European Journal of Cognitive Psychology*, 2, 229-252.

Marmeleira, J. F., Godinho, M. B. & Fernandes, O. M. (2009). The effects of an exercise program on several ability associated with driving performance in older adults. *Accident Analysis and Prevention*, 41, 90-97.

Marottoli, R. A., Allore, H., Araujo, K. L. B., Iannone, L P., Acampora, D., Gottschalk,

M. et al. (2008). A randomized trial of a physical conditioning program to enhance the driving performance of older persons. *Journal of General Internal Medicine,* 22(5), 590-597.

Marottoli, R. A., Mendes-deLeon, C. F., Glass, T. A., Williams, C. S., Cooney, L. M. Jr. & Berkman, L. (2000). Consequences of driving cessation: decreased out-of-home activity levels. *Journals of Gerontology: Series B – Psychological Sciences & Social Sciences, 55B(6),* S334-S340.

Marottoli, R. A. & Richardson, E. D. (1998). Confidence in, and self-rating of, driving ability among older drivers. *Accident Analysis & Prevention*, 30(3), 331-336.

McAuley, E. (1992). The role of efficacy cognitions in the prediction of exercise behavior in middle-aged adults. *Journal of Behavioral Medicine, 15*, 65-88.

McAuley, E. (1993). Self-efficacy and the maintenance of exercise participation in older adults. *Journal of Behavioral Medicine, 16,* 103-113.

McDowd, J. M. & Birren, J. E. (1990). Attention and aging. In J. E. Birren & K. W Schaie (Eds.), *Handbook of the psychology of aging* (3rd ed., pp. 222-233). San Diego, CA: Academic Press.

Miller, A. K., Alston, R. L. & Corselli, J. A. (1980). Variation with age in the volumes of grey and white matter in the cerebral hemispheres of man: Measurements with an image analyzer. *Neuropathology and Applied Neurobiology*, 6, 119–132. 2011–2017.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: a latent variable analysis. *Cognitive Psychology*, 41, 49-100.

Myers, R. S., Ball, K. K., Kalina, T. D., Roth, D. L. & Goode, K. T. (2000). Relation of Useful Field of View and Other Screening Tests to On-Road Driving Performance. *Perceptual and Motor Skills*, 91(1), 279-290.

National Highway Traffic Safety Administration [NHTSA]. (2003). *Model driver screening and evaluation program – final technical report.* DOT HS 809 582.

National Institute on Aging [NIA]. (2004). *Exercise: A guide from the National Institute on Aging.* NIH Publication No. 01-4258.

National Institute on Aging [NIA]. (2009). *Exercise & Physical Activity.* NIH Publication No. 09-4258.

National Research Council. (2000). *The aging mind: Opportunities in cognitive research.* Washington, DC: National Academy Press.

Newson, R. S. & Kemps, E. B. (2007). Relationship between fitness and cognitive performance in younger and older adults. *Psychology & Health*, 23(3), 369-386.

Nicolletta, J. (2002). *Driving characteristics of the young and aging population.* Statistics Canada Research Paper. Catalogue no. 53-F0007-XIE.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, et al. (Ed.) *Consciousness and self-regulation* (vol. 4, (pp. 1–18)). New York: Plenum.

Odenheimer, G. L., Beaudet, M., Jette, A. M., Albert, M. S. et al. (1994). Performance-based driving evaluation of the elderly driver: safety, reliability and validity. *Journals of Gerontology, 49(4),* M153-M159.

Osteras, H., Hoff & Helgerud, J. (2005). Effects of high intensity endurance training on maximal oxygen consumption in healthy elderly people. *Journal of Applied Geronotlogy*, 24(5), 337-387.

Ostrow, A. C., Shaffron, P. & McPherson, K. (1992). The effects of a joint range-of-motion physical fitness training program on the automobile driving skills of older adults. *Journal of Safety Research, 23*, 207-219.

Owsley, C., Ball, K., McGwin, G., Sloane, M. E., Roenker, D. L., White, M. F. & Overley, T. (1991a). Visual processing impairment and risk of motor vehicle crash among older adults. *Journal of the American Medical Association, 279(14),* 1083-1088.

Owsley, C., Ball, K., McGwin, G., Sloane, M. E., Roenker, D. L., White, M. F. & Overley, T. (1998). Visual processing impairment and risk of motor vehicle crash among older adults. *Journal of the American Medical Association*, 279, 1083-1088.

Owsley, C., Ball, K., Sloane, M. E., Roenker, D. L. & Bruni, J. R. (1991b). Visual/cognitive correlates of vehicle accidents in older drivers. *Psychology and Aging, 6(3),* 403-415.

Parasuraman, R. & Haxby, J. V. (1993). Attention and brain function in Alzhemer's disease: a review. *Neuropsychology*, 7, 242-272.

Park, G. R., Allen, W. & Fiorentino, D. (2006). *Simulator sickness scores according to symptom susceptibility, age and gender for an older driver assessment study.* Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting, 2702-2706.

Pesce, C., Guidetti, L., Baldari, C., Tessitore, A. & Capranica, L. (2005). Effects of aging on visual attentional focusing. *Gerontology*, 51, 266-276.

Piguet, O., Grayson, D. A., Broe, G. A., Tate, R. L., Bennett, H. P., Lye, T. C. et al. (2002). Normal aging and executive functions in "old-old" community dwellers: poor performance is not an inevitable outcome. *International Psychogeriatrics, 14(2),* 139-159.

Pollock, M. L., Gaesser, G. A., Butcher, J. D., Depres, J., Dishman, R. K, Franklin, B. A. & Ewing, G. C. (1998). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness and flexibility in healthy adults. *Medicine & Science in Sports & Exercise,* 30(6), 975-991.

Pollock, M. L. & Wilmore, J. H. (1990). *Exercise in Health and Disease: Evaluation and Prescription for Prevention and Rehabilitation,* (2nd Ed., pp. 91-160). Philadelphia: W. B. Saunders.

Ponds, R. W., Brouwer, W. H. & van Wolffelaar, P. C. (1988). Age differences in divided attention in a simulated driving task. *Journal of Gerontology*, 43, 151–156.

Pontifex, M. B., Hillman, C. H. & Polich, J. (2009). Age, physical fitness and attention: P3a and P3b. *Psychophysiology,* 46, 379-387.

Posner, M. I. & Snyder, C. R. R. (1975). Attention and cognitive control. (pp.317-342). In R. L. Solso (Ed.) *Information Processing and Cognition.* Hillsdale, N.J.: Lawrence Erlbaum.

Preusser, D. F., Williams, A. F., Ferguson, S. A., Ulmer, R. G. & Weinstein, H. B. (1998). Fatal crash risk for older drivers at intersections. *Accident Analysis & Prevention, 30(2),* 151-159.

Rabbitt, P., Ibrahim, S., Lunn, M., Scott, M., Thacker, N., Hutchinson, C. et al. (2008). Age-associated losses of brain volume predict longitudinal cognitive declines over 8 to 20 years. *Neuropsychology*, 22(1), 3-9.

Rabbitt, P., Scott, M., Lunn, M, Thacker, N., Lowe, C., Pendleton, N. et al. (2007). White matter lesions account for all age-related declines in speed but not in intelligence. *Neuropsychology*, 21(3), 363-370.

Ramage-Morin, P. (2003). *Successful aging in health care institutions.* (Statistics Canada Catalogue 82-003, Supplement to Health Reports, Volume 16). Ottawa, ON: Health Statistics Division.

Rapoport, J., Jacobs, P., Bell, N. R. & Klarenbach, S. (2004). Refining the measurement of the economic burden of chronic diseases in Canada. *Chronic Diseases in Canada*, 25(1), 13-21

Raz, N., Gunning-Dixon, F., Head, D., Rodrigue, K. M., Williamson, A. & Acker, J. D. (2004a). Aging, sexual dimorphism, and hemispheric asymmetry of the cerebral cortex: Replicability of regional differences in volume. *Neurobiology of Aging*, 25, 377–396.

Raz, N., Rodrigue, K. M., Head, D., Kennedy, K. M., & Acker, J. D. (2004b). Differential aging of the medial temporal lobe: A study of a five-year change. *Neurology*, 62, 433– 438.

Reisberg, D. (2005). *Cognition: exploring the science of the mind* (3rd ed.). New York: Norton.

Rejeski, W. J., Katula, J., Rejeski, A., Rowley, J. & Sipe, M. (2005). Strength training in older adults: does desire determine confidence? *Journal of Gerontology: Series B: Psychological Sciences and Social Sciences, 60B(6),* 335-P337.

Rekkas, P. V. (2006). Interference resolution in the elderly: evidence suggestive of differences in strategy on measures of prepotent inhibition and dual task processing. *Aging, Neuropsychology and Cognition*, 13(3), 341-365.

Resnick, B. & Jenkins, L. S. (2000). Testing the reliability and validity of the Self-Efficacy Exercise Scale. *Nursing Research*, 49(3), 154-159.

Resnick, S. M., Pham, D. L., Kraut, M. A., Zonderman, A. B., & Davatzikos, C. (2003). Longitudinal magnetic resonance imaging studies of older adults: A shrinking brain. *Journal of Neuroscience*, 23, 3295– 3301.

Richardson, E. D. & Marottoli, R. A. (2003). Visual attention and driving behaviours among community-living older persons. *Journal of Gerontology: Medical Sciences*, 58(9), 832-836.

Richeson, N. E., Croteau, K. A., Jones, D. B. & Farmer, B. C. (2006). Effects of a pedometer-based intervention on the physical performance and mobility-related self-efficacy of community-dwelling older adults: an interdisciplinary preventive health care intervention. *Therapeutic Recreation Journal*, 40(1), 18-32

Rizzo, M., McGehee, D. V., Dawson, J. D. & Anderson, S. N. (2001). Simulated car crashes at intersections in drivers with Alzheimer disease. *Alzheimer Disease and Associated Disorders*, 15, 10 – 20.

Rogers, R. D. & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General*, 124, 207 –231.

Roth, D. L., Goode, K. T., Clay, O. J. & Ball, K. K. (2003). Association of physical activity and visual attention in older adults. *Journal of Aging and Health*, 15(3), 534-547.

Rowe, J. W. & Kahn, R. L. (1997). Successful aging. *The Gerontologist,* 37(4), 433–440.

Royall, D. R., Palmer, R., Chiodo, L. K. & Polk, M. J. (2004). Declining executive control in normal aging predicts change in functional status: the Freedom House Study. *Journal of the American Geriatrics Society, 52(3),* 346-352.

Rubin, D. B. (1987). Multiple imputation for survey nonresponse. New York: Wiley.

Rush, B. K., Barch, D. M. & Braver, T. S. (2006). Accounting for cognitive aging: context processing, inhibition or processing speed? *Aging, Neuropsychology and Cognition*, 13(3), 588-610.

Salthouse, T. A. (2005). Relations between cognitive abilities and measures of executive functioning. *Neuropsychology*, 19(4), 532-545.

Salthouse, T. A. (2006). Mental exercise and mental aging. *Perspectives on Psychological Science,* 1(1), 68-87.

Salthouse, T. A., Atkinson, T. M. & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *Journal of Experimental Psychology: General,* 132(4), 566-594.

Salthouse, T. A. (2000). Aging and measures of processing speed. *Biological Psychology,* 54, 35-54.

Salthouse, T. A. & Meinz, E. J. (1995). Aging, inhibition, working memory and speed. *Journal of Gerontology: Psychological Sciences,* 50B(6), P297-P306.

Salthouse, T. A. & Miles, J. D. (2002). Aging and time-sharing aspects of executive control. *Memory & Cognition,* 30(4), 572-582.

Salthouse, T.A. & Siedlecki, K. L. (2007). Efficiency of route selection as a function of adult age. *Brain and Cognition,* 63, 279-286.

Schacter, D. L., Savage, C. R., Alpert, N. M., Rauch, S. L., Albert, M. S. (1996). The role of the hippocampus and frontal cortex in age-related memory changes: a PET study. *Neurological Report,* 7, 1165-1169.

Schafer, J. L. (1999). Multiple imputation: a primer. *Statistical Methods and Medical Research,* 8, 3-15:

Schultzer, K. A. & Graves, B. S. (2004). Barriers and motivations to exercise in older adults. *Preventative Medicine,* 39, 1056-1061.

Shilling, V. M., Chetwynd, A. & Rabbitt, P. M. A. (2002). Individual inconsistency across measures of inhibition: an investigation of the construct validity in older adults. *Neuropsychologia,* 40, 605-619.

Sydney, K. H. & Sheppard, R. J. (1977). Activity patterns of elderly men and women. *Journal of Gerontology,* 32, 25-32.

Sims, R. V., McGwin, G., Allman, R. M., Ball, K. & Owsley, C. (2000). Exploratory study of incident vehicle crashes among older drivers. *Journals of Gerontology: Series A: Biological Sciences and Medical Sciences, 55A(1),* M22-M27.

Smiley-Oyen, A. L., Lowry, K. A., Kohut, M. L. & Ekkekakis, P. (2008). Exercise, fitness and neurocognitive function in older adults: the selective improvement and cardiovascular fitness hypotheses. *Annals of Behavioural Medicine,* 36, 280-291.

Spreen, O. & Strauss, E. (1998). *A compendium of neuropsychological tests.* New York: Oxford University Press.

Sowell, E. R., Peterson, B. S., Thompson, P. M., Welcome, S. E., Henkenius, A. L. &

Toga, A. W. (2003). Mapping cortical change across the human life span. *Nature Neuroscience,* 6, 309 –315.

Sowell, E. R., Thompson, P. M., Tessner, K. D. & Toga, A. W. (2001). Mapping continued brain growth and gray matter density reduction in dorsal frontal cortex: Inverse relationships during postadolescent brain maturation. *Journal of Neuroscience*, 21, 8819 – 8829.

Statistics Canada. (2005). *Population projections for Canada, provinces and territories*. Catalogue No. 91-520-XIE.

Statistics Canada. (2008). Seniors. *Canada Year Book.* Retrieved in September 2008. http://www41.statcan.gc.ca/2008/70000/ceb70000_000-eng.htm

Stav, W. B., Justiss, M. D., McCarthy, D. P., Mann, W. C. & Lanford, D. N. (2008). Predictability of clinical assessments for driving performance. *Journal of Safety Research,* 39, 1-7.

Stephens, B., McCarthy, D. P., Marsiske, M., Classen, S., Shechtman, O. & Mann, W. C. (2005). International Older Driver Consensus Conference on Assessment, Remediation and Counseling for Transportation Alternatives: Summary and Recommendations. *Physical & Occupational Therapy in Geriatrics,* 23, 103–121.

Stones, M. J., & Kozma, A. (1988). Physical activity, age and cognitive/motor performance. In M. L. Howe & C. J. Brainerd (Eds.), *Cognitive development in adulthood: Progress in cognitive development research* (pp. 273-322). New York: Springer-Verlag.

Stones, M. J. & Kozma, A. (1989). Age, exercise and coding performance. *Psychology and Aging*, 4(2), 190-194.

Stroop J.R. (1935) Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643-662

Stutts, J. C., Stewart, J. R. & Martell, C. (1998). Cognitive test performance and crash risk in an older driver population. *Accident Analysis & Prevention*, 30(3), 337-346.

Tabachnick, B. G. & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Boston, MA: Allyn and Bacon.

Tarawneh, M. S., McCoy, P. T., Bishu, R. R. & Ballard, J. L. (1993). Factors associated with driving performance of older drivers. *Transportation Research Record,* 1405, 64 – 71.

The Robert Wood-Johnson Foundation. (2001). National blueprint: Increasing physical activity among adults 50 and older: background section. *Journal of Aging and Physical Activity*, 9, S5-S12.

Tipper, S. P. (1992). Selection for action: The role of inhibitory mechanisms. Current Directions in Psychological Science, 7, 105-109.

Transport Canada. (2001). Mature *drivers in casualty motor vehicle collisions, 1988 -1998.* Fact sheet #RS2001-04 TP 2436E.

U.S. Department of Transportation (U.S. DOT), (January 1989). *An examination of Sudden Acceleration,* Report HS-807-367. Cambridge, MA: Transportation Safety Systems Center

Van der Elst, W., Van Boxtel, M. P. J., Van Bruekelen, G. J. P. & Jolles, J. (2006). The Stroop Colour Word Test: influence of age, sex and education; and normative data for a large sample across the adult age range. *Assessment,* 13(1), 62-79.

Vance, D. E., Wadley, V. G., Ball, K. K., Roenker, D. L. & Rizzo, M. The effects of physical activity and sedentary behaviour on cognitive health in older adults. *Journal of Aging and Physical Activity,* 13, 294-313.

Verbrugge, L. M. & Patrick, D. L. (1995). Seven chronic conditions: their impact on U.S. adults' activity levels of use of medical services. *American Journal of Public Health*, 85(2), 173-182.

Verhaeghen, P. & DeMeersman, L. (1998).Aging and the Stroop effect: a meta-analysis. *Psychology and Aging*, 13,120–126.

Visual Awareness Inc. (2004). *Useful Field of View User's Guide,* Version 6.0.9. Birmingham, AB: Southbridge Center.

Ware, J. E., Kosinski, M. & Keller, S. D. (1996). A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity, *Medical Care, 34,* 220–233.

Wecker, N. S., Kramer, J. H., Hallum, B. J. & Dellis, D. C. (2005). Mental flexibility: age effects on switching. *Neuropsychology*, 19(3), 345-352.

West, R. & Schwarb, H. (2006). The influence of aging and frontal function on the neural correlates of regulative and evaluative aspects of cognitive control. *Neuropsychology*, 20(4), 468-481.

Yaksich, S. (1985). Interactions of older drivers with pedestrians in traffic. In J. W. Malfetti (Ed.), *Needs and problems of older drivers: Survey results and recommendations* (pp. 87-95). Falls Church, VA: AAA Foundation of Traffic Safety.

Yan, L. L., Daviglus, M. L., Liu, K., Pirzada, A., Garside, D. B., Schiffer, L., Dyer,

A. R. & Greenland, P. (2004). BMI and health-related quality of life in adults 65 years and older. *Obesity Research,* 12(1), 69-76.

Zacks, R. & Hasher, L. (1997). Cognitive gerontology and attentional inhibition: a reply to Burke and McDowd. *Journal of Gerontology: Psychological Sciences*, 52B(6), P274-P283.

Appendix A:
Participant Letter

Dear Participant:

We would like to invite you to participate in a study involving the impact of physical activity on driving performance and cognitive functioning of healthy, but sedentary older adults aged 55 and older. Measures that are designed to assess physical and cognitive abilities which may be relevant to safe driving will be administered to all participants in the study. Participants will receive free access to the Lakehead University Athletic facilities. In addition, participants will receive detailed instruction on the exercise intervention from individuals supervised by an exercise physiologist. Thus, participants will learn how to increase their physical activity in a safe and effective manner.

The intervention will involve cardiovascular and strength training exercises, which can be modified over the course of the study as participants obtain gains in endurance and strength. The participants will complete cardiovascular exercises for 30-40 minutes, three times a week, while they will complete strength and flexibility exercises 30-50 minutes, three times a week. The intervention will last for a duration of 12 weeks and participants will be randomly assigned to a program starting in the Spring/Summer 2007 or Fall 2007. Assessment measures will be administered for at least two intervals: upon entering the study and 12 weeks after entering the study.

All information collected during the study will be shared only amongst researchers and will be securely stored at Lakehead University for seven years. Participants' names will be replaced by random numerical codes to preserve confidentiality and to ensure that the data collected from participants remain anonymous. Furthermore, participants' names will not be used at any time in reporting or use of information collected.

Participation is completely voluntary and participants can withdraw from the study at any time. We expect that this study will improve cognitive, physical and driving abilities in individuals that complete the intervention. We require that all participants undergo a standard medical examination from their family physicians before entering the study. All participants are required to have a licensed physician to complete physical activity readiness forms to ensure that it is safe for participants to enter the study. If your family physician has not yet received the required documentation, please let us know. If you have any questions, please feel free to contact Harpreet Chattha, Dr. Michel Bedard or the Lakehead University Research Ethics Board at the numbers listed below. Thank you.

Sincerely,

Harpreet Chattha, M. A.
Department of Psychology
Lakehead University
807-766-7256
hchattha@lakeheadu.ca

Michel Bédard, Ph. D.
Public Health Program
Northern Ontario School of Medicine
Lakehead University
807-343-8630
mbedard@lakeheadu.ca

Lakehead University Research Ethics Board
343-8283

Appendix B:
Organization Letter

Dear Sir or Madam:

We would like to inform you about our research project on physical activity which strongly coincides with the objectives of your organization regarding health promotion in the Thunder Bay region. Physical activity has been demonstrated to decrease the risk of chronic ailments, such as heart disease and stroke, as well as improve the overall health and well-being of older adults. Research also suggests that physical activity can have positive influences on cognitive abilities such as attention, concentration, and memory. These cognitive abilities support many activities and are crucial to maintain an active lifestyle. One important activity that may benefit from increased physical activity is driving. Safe driving may be enhanced by increasing physical activity in older drivers but no research has been conducted to examine this possibility. For our research project we propose to promote physical activity in older adults by offering a structured exercise intervention and instruction for sedentary older adults. We expect that in addition to increases in physical fitness, increased physical activity may also result in increases in cognitive abilities important in safe driving, and may also translate into safer driving.

Participants entering this study will gain free access to the Lakehead University athletic facility and will also receive direct instruction from trained individuals on aerobic and anaerobic exercise. Participants will be randomly assigned to one of two exercise interventions commencing in Spring/Summer 2007 or Fall 2007. The exercise intervention involves completion of 30-40 minutes of cardiovascular activity and 30-50 minutes of strength and flexibility training three times a week for 12 weeks. All participants are required to complete a standardized medical examination from their family physician for medical clearance to enter the study. The standard forms for family physicians can be obtained from us upon request. In particular, we are seeking individuals aged 55 years or older, in good health (without serious musculo-skeletal or cardiac illness) who are not currently engaged in regular physical activity.

Any assistance you and your organization can offer to help us recruit participants for this study would be appreciated. In addition, we would be open to any suggestions or ideas you may have to gain access to older adults we may not otherwise have come across. If desired, our research team would be willing to provide further information to members of your organization and make a formal presentation if desired. Please feel free to contact us with any questions regarding the project. We will contact you in the near future.

Sincerely,

Harpreet Chattha, M.A.
Department of Psychology
Lakehead University
807-628-9947

hchattha@lakeheadu.ca

Michel Bédard, Ph.D.
Public Health Program
Lakehead University
Northern Ontario School of Medicine
807-343-8630
mbedard@lakeheadu.ca

Appendix C:
Recruitment Criteria

RECRUITMENT INFORMATION

Inclusionary/Exclusionary Criteria:

- Aged 55 or older
- Sedentary (not involved in regular/frequent physical activity)
- Must have a valid Ontario driver's licence
- Must not have a serious medical condition (i.e., musculo-skeletal or cardio/respiratory ailments that may interfere with the participants' ability to fully participate in the intervention)
- Understand that after initial testing/enrollment in the study, will be randomly assigned to one of the 12 week sessions being conducted.
- Must be willing to fully participate (satisfy the duration and frequency of the fitness sessions – 3 to 5 X week aerobic session (minimum 30-40 minutes), strength training sessions and flexibility sessions 3 X week; aim to about 3X minimum a week (can ease participants into strength training 2X week at first).
- Must be able to transport oneself to and from the fitness center at the Lakehead University campus.

Appendix D:
Physical Activity Readiness Medical Examination

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

The PARmed-X is a physical activity-specific checklist to be used by a physician with patients who have had positive responses to the Physical Activity Readiness Questionnaire (PAR-Q). In addition, the Conveyance/Referral Form in the PARmed-X can be used to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. The PAR-Q by itself provides adequate screening for the majority of people. However, some individuals may require a medical evaluation and specific advice (exercise prescription) due to one or more positive responses to the PAR-Q.

Following the participant's evaluation by a physician, a physical activity plan should be devised in consultation with a physical activity professional (CSEP-Professional Fitness & Lifestyle Consultant or CSEP-Exercise Therapist™). To assist in this, the following instructions are provided:

PAGE 1: • Sections A, B, C, and D should be completed by the participant BEFORE the examination by the physician. The bottom section is to be completed by the examining physician.

PAGES 2 & 3: • A checklist of medical conditions requiring special consideration and management.

PAGE 4: • Physical Activity & Lifestyle Advice for people who do not require specific instructions or prescribed exercise.

• Physical Activity Readiness Conveyance/Referral Form - an optional tear-off tab for the physician to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

This section to be completed by the participant

A PERSONAL INFORMATION:

NAME ____________________

ADDRESS ____________________

____

TELEPHONE ____________________

BIRTHDATE ____________________ GENDER ____________

MEDICAL No. ____________________

B PAR-Q: Please indicate the PAR-Q questions to which you answered YES

- ☐ Q 1 Heart condition
- ☐ Q 2 Chest pain during activity
- ☐ Q 3 Chest pain at rest
- ☐ Q 4 Loss of balance, dizziness
- ☐ Q 5 Bone or joint problem
- ☐ Q 6 Blood pressure or heart drugs
- ☐ Q 7 Other reason:

C RISK FACTORS FOR CARDIOVASCULAR DISEASE:

Check all that apply

- ☐ Less than 30 minutes of moderate physical activity most days of the week.
- ☐ Currently smoker (tobacco smoking 1 or more times per week).
- ☐ High blood pressure reported by physician after repeated measurements.
- ☐ High cholesterol level reported by physician.
- ☐ Excessive accumulation of fat around waist.
- ☐ Family history of heart disease.

***Please note:** Many of these risk factors are modifiable. Please refer to page 4 and discuss with your physician.*

D PHYSICAL ACTIVITY INTENTIONS:

What physical activity do you intend to do?

____

____

____

This section to be completed by the examining physician

Physical Exam:

Ht	Wt	BP i) /
		BP ii) /

Conditions limiting physical activity:

- ☐ Cardiovascular
- ☐ Musculoskeletal
- ☐ Respiratory
- ☐ Abdominal
- ☐ Other

Tests required:

- ☐ ECG
- ☐ Blood
- ☐ Exercise Test
- ☐ Urinalysis
- ☐ X-Ray
- ☐ Other

Physical Activity Readiness Conveyance/Referral:

Based upon a current review of health status, I recommend:

- ☐ No physical activity
- ☐ Only a medically-supervised exercise program until further medical clearance
- ☐ Progressive physical activity:
  - ☐ with avoidance of: ____________________
  - ☐ with inclusion of: ____________________
  - ☐ under the supervision of a CSEP-Professional Fitness & Lifestyle Consultant or CSEP-Exercise Therapist™
- ☐ Unrestricted physical activity–start slowly and build up gradually

Further information:
- ☐ Attached
- ☐ To be forwarded
- ☐ Available on request

Supported by: Health Canada Santé Canada

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

Following is a checklist of medical conditions for which a degree of precaution and/or special advice should be considered for those who answered "YES" to one or more questions on the PAR-Q, and people over the age of 69. Conditions are grouped by system. Three categories of precautions are provided. Comments under Advice are general, since details and alternatives require clinical judgement in each individual instance.

	Absolute Contraindications	Relative Contraindications	Special Prescriptive Conditions	ADVICE
	Permanent restriction or temporary restriction until condition is treated, stable, and/or past acute phase.	Highly variable. Value of exercise testing and/or program may exceed risk. Activity may be restricted. Desirable to maximize control of condition. Direct or indirect medical supervision of exercise program may be desirable.	Individualized prescriptive advice generally appropriate: • limitations imposed; and/or • special exercises prescribed. May require medical monitoring and/or initial supervision in exercise program.	
Cardiovascular	❑ aortic aneurysm (dissecting) ❑ aortic stenosis (severe) ❑ congestive heart failure ❑ crescendo angina ❑ myocardial infarction (acute) ❑ myocarditis (active or recent) ❑ pulmonary or systemic embolism—acute ❑ thrombophlebitis ❑ ventricular tachycardia and other dangerous dysrhythmias (e.g., multi-focal ventricular activity)	❑ aortic stenosis (moderate) ❑ subaortic stenosis (severe) ❑ marked cardiac enlargement ❑ supraventricular dysrhythmias (uncontrolled or high rate) ❑ ventricular ectopic activity (repetitive or frequent) ❑ ventricular aneurysm ❑ hypertension—untreated or uncontrolled severe (systemic or pulmonary) ❑ hypertrophic cardiomyopathy ❑ compensated congestive heart failure	❑ aortic (or pulmonary) stenosis—mild angina pectoris and other manifestations of coronary insufficiency (e.g., post-acute infarct) ❑ cyanotic heart disease ❑ shunts (intermittent or fixed) ❑ conduction disturbances • complete AV block • left BBB • Wolff-Parkinson-White syndrome ❑ dysrhythmias—controlled ❑ fixed rate pacemakers	• clinical exercise test may be warranted in selected cases, for specific determination of functional capacity and limitations and precautions (if any). • slow progression of exercise to levels based on test performance and individual tolerance. • consider individual need for initial conditioning program under medical supervision (indirect or direct).
			❑ intermittent claudication	progressive exercise to tolerance
			❑ hypertension: systolic 160-180; diastolic 105+	progressive exercise; care with medications (serum electrolytes; post-exercise syncope; etc.)
Infections	❑ acute infectious disease (regardless of etiology)	❑ subacute/chronic/recurrent infectious diseases (e.g., malaria, others)	❑ chronic infections ❑ HIV	variable as to condition
Metabolic		❑ uncontrolled metabolic disorders (diabetes mellitus, thyrotoxicosis, myxedema)	❑ renal, hepatic & other metabolic insufficiency	variable as to status
			❑ obesity ❑ single kidney	dietary moderation, and initial light exercises with slow progression (walking, swimming, cycling)
Pregnancy		❑ complicated pregnancy (e.g., toxemia, hemorrhage, incompetent cervix, etc.)	❑ advanced pregnancy (late 3rd trimester)	refer to the "PARmed-X for PREGNANCY"

References:

Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. **J. Clin. Epidemiol.** 45:4 419-428.

Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy. In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health.** Champaign, IL: Human Kinetics.

PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). **Can. J. Spt. Sci.** 17: 4 338-345.

The PAR-Q and PARmed-X were developed by the British Columbia Ministry of Health. They have been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Évaluation médicale de l'aptitude à l'activité physique (X-AAP)»

Continued on page 3...

Physical Activity Readiness
Medical Examination
(revised 2002)

	Special Prescriptive Conditions	ADVICE
Lung	❑ chronic pulmonary disorders	special relaxation and breathing exercises
	❑ obstructive lung disease ❑ asthma	breath control during endurance exercises to tolerance; avoid polluted air
	❑ exercise-induced bronchospasm	avoid hyperventilation during exercise; avoid extremely cold conditions; warm up adequately; utilize appropriate medication.
Musculoskeletal	❑ low back conditions (pathological, functional)	avoid or minimize exercise that precipitates or exasperates e.g., forced extreme flexion, extension, and violent twisting; correct posture, proper back exercises
	❑ arthritis—acute (infective, rheumatoid; gout)	treatment, plus judicious blend of rest, splinting and gentle movement
	❑ arthritis—subacute	progressive increase of active exercise therapy
	❑ arthritis—chronic (osteoarthritis and above conditions)	maintenance of mobility and strength; non-weightbearing exercises to minimize joint trauma (e.g., cycling, aquatic activity, etc.)
	❑ orthopaedic	highly variable and individualized
	❑ hernia	minimize straining and isometrics; stregthen abdominal muscles
	❑ osteoporosis or low bone density	avoid exercise with high risk for fracture such as push-ups, curl-ups, vertical jump and trunk forward flexion; engage in low-impact weight-bearing activities and resistance training
CNS	❑ convulsive disorder not completely controlled by medication	minimize or avoid exercise in hazardous environments and/or exercising alone (e.g., swimming, mountainclimbing, etc.)
	❑ recent concussion	thorough examination if history of two concussions; review for discontinuation of contact sport if three concussions, depending on duration of unconsciousness, retrograde amnesia, persistent headaches, and other objective evidence of cerebral damage
Blood	❑ anemia—severe (< 10 Gm/dl) ❑ electrolyte disturbances	control preferred; exercise as tolerated
Medications	❑ antianginal ❑ antiarrhythmic ❑ antihypertensive ❑ anticonvulsant ❑ beta-blockers ❑ digitalis preparations ❑ diuretics ❑ ganglionic blockers ❑ others	NOTE: consider underlying condition. Potential for: exertional syncope, electrolyte imbalance, bradycardia, dysrhythmias, impaired coordination and reaction time, heat intolerance. May alter resting and exercise ECG's and exercise test performance.
Other	❑ post-exercise syncope	moderate program
	❑ heat intolerance	prolong cool-down with light activities; avoid exercise in extreme heat
	❑ temporary minor illness	postpone until recovered
	❑ cancer	if potential metastases, test by cycle ergometry, consider non-weight bearing exercises; exercise at lower end of prescriptive range (40-65% of heart rate reserve), depending on condition and recent treatment (radiation, chemotherapy); monitor hemoglobin and lymphocyte counts; add dynamic lifting exercise to strengthen muscles, using machines rather than weights.

*Refer to special publications for elaboration as required

The following companion forms are available online: http://www.csep.ca/forms.asp

The Physical Activity Readiness Questionnaire (PAR-Q) - a questionnaire for people aged 15-69 to complete before becoming much more physically active.

The Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for PREGNANCY) - to be used by physicians with pregnant patients who wish to become more physically active.

For more information, please contact the:

Canadian Society for Exercise Physiology
202 - 185 Somerset St. West
Ottawa, ON K2P 0J2
Tel. 1-877-651-3755 • FAX (613) 234-3565 • Online: www.csep.ca

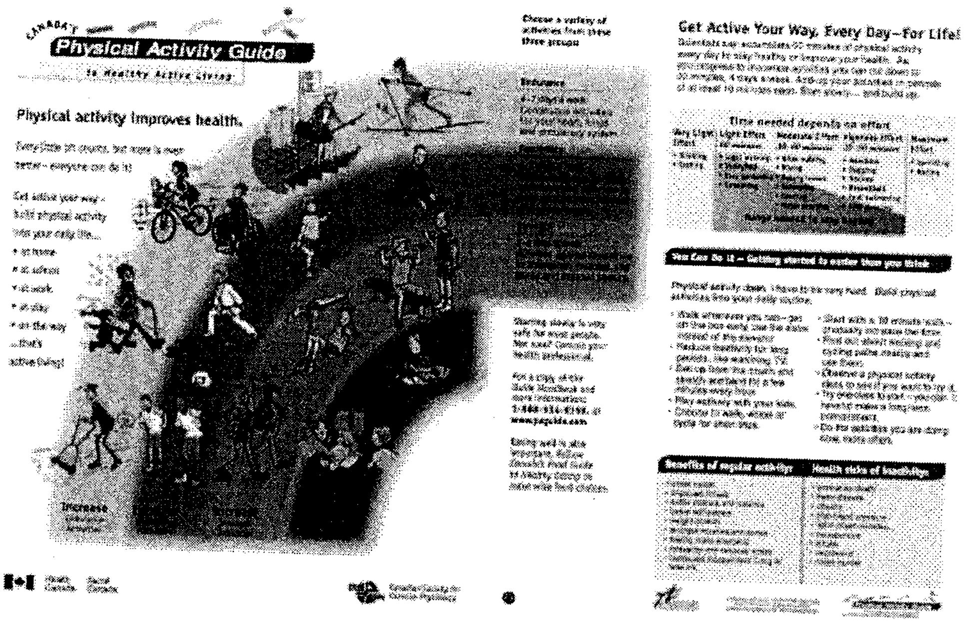
Note to physical activity professionals...

It is a prudent practice to retain the completed Physical Activity Readiness Conveyance/Referral Form in the participant's file.

Continued on page 4...

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION



Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf.

PARmed-X Physical Activity Readiness Conveyance/Referral Form

Based upon a current review of the health status of ______________________, I recommend:

- ❑ No physical activity
- ❑ Only a medically-supervised exercise program until further medical clearance
- ❑ Progressive physical activity
  - ❑ with avoidance of: ______________________
  - ❑ with inclusion of: ______________________
  - ❑ under the supervision of a CSEP-Professional Fitness & Lifestyle Consultant or CSEP-Exercise Therapist™
- ❑ Unrestricted physical activity — start slowly and build up gradually

Further Information:
- ❑ Attached
- ❑ To be forwarded
- ❑ Available on request

Physician/clinic stamp:

______________________ M.D.

______________________ 20____
(date)

NOTE: This physical activity clearance is valid for a maximum of six months from the date it is completed and becomes invalid if your medical condition becomes worse.

4

Appendix E:
Consent Form

Consent Form

1. Title of Research Project: The impact of physical activity on driving performance and cognitive functioning of older adults: a randomized control trial

2. I, ______________________________ consent to take part in a study which will examine the effects of cardiovascular and strength training exercises on cognitive and physical functioning as well as driving performance. I understand that I will be randomly assigned to an exercise program beginning in Spring/Summer 2007 or to a program starting in Fall 2007. The exercise involves 30-40 minutes of aerobic exercise (e.g., walking) and 30-50 minutes of anaerobic exercise (e.g., arm raises, leg press, stretches) about three times per week for a duration of 12 weeks. I will undergo cognitive and physical testing at two periods: upon entering the study and again after 12 weeks. These tests will involve completing computerized and paper-and-pencil tests of cognitive abilities, such as my level of attention and speed of processing information. I will also undergo assessments to determine my cardiovascular fitness, body composition, flexibility and driving ability. These tests may take a few hours to complete in total and do not pose any risks of physical or emotional harm to me.

3. The exercises involved in this program will be taught to me by a qualified instructor so as to minimize improper form and potential injury. To enter this study, my family physician must complete the Physical Activity Readiness Medical Examination (PAR-MedX) to ensure that I am sufficiently healthy to participate. I understand that by increasing my physical activity, I may experience some muscular discomfort and fatigue. I also understand that the risk of a serious event, such as a heart attack during exercise is small, particularly with the low-impact exercise involved in the intervention. I will consult my physician should I experience any physical symptoms that are concerning to me.

4. I understand that I will receive free access to the Lakehead University Athletic facilities for the duration of the study. I also understand that I may withdraw from the study at any time, even after signing this form. Any information that is collected about me during this study will be shared only amongst the researchers and will be securely stored on the Lakehead University campus for seven years. If the results are published, I will not be identified in any way. If I wish to be informed of the summary of research results for this study, I will indicate so to the researcher when completing this form.

____

Signature of Participant — Date

____

Signature of Witness — Date

5. I have explained the nature of the study to the participant and believe he/she has understood it

____

Signature of Researcher — Date

Appendix F:
Physician Letter

Dear Sir or Madam,

We would like to inform you about our research project on physical activity which you may find of particular interest as it may provide important resources for some of the older patients in your care. As you are aware, physical activity has been demonstrated to decrease the risk of chronic ailments, such as heart disease and stroke as well as improve the overall health and well-being of older adults. Research also suggests that physical activity can have positive influences on cognitive abilities such as attention, concentration, and memory. These cognitive abilities support many activities and are crucial to maintain an active lifestyle. One important activity that may benefit from increased physical activity is driving. Safe driving may be enhanced by increasing physical activity in older drivers but no research has been conducted to examine this possibility.

For our research project we propose to promote physical activity in older adults by offering a structured exercise intervention and instruction for sedentary older adults. We expect that in addition to increases in physical fitness, increased physical activity may also result in increases in cognitive abilities important in safe driving, and may also translate into safer driving. We are seeking individuals, **aged 55 years or older with a valid driver's license, in good health (without serious musculo-skeletal or cardiac illness) who are not currently engaged in regular physical activity.**

Participants entering this study will gain free access to the Lakehead University athletic facility and will also receive direct instruction from trained individuals on aerobic and anaerobic exercise. Participants will be randomly assigned to one of two exercise interventions commencing in Spring/Summer 2007 or Fall 2007. The exercise intervention involves completion of 30-40 minutes of cardiovascular activity and 30-50 minutes of strength and flexibility training three times a week for 12 weeks. All participants are required to complete a standardized medical examination from their family physician for medical clearance to enter the study. The standard forms created by Health Canada (Physical Activity Readiness Medical Examination: PAR-Med-X) can be obtained from us upon request. Please note that although we are **unable to enroll participants who require CSEP supervision** in their exercise program, our program is taught to participants by trained individuals. Your role is our project is very important since current research suggests that the strongest factor associated with older adults starting and continuing with an exercise program is advice from a physician.

Any assistance you can offer to help us recruit participants for this study would be appreciated. In addition, we would be open to any suggestions or ideas you may have to gain access to the older adults population we may not otherwise have considered. Please feel free to contact us with any questions or comments regarding the project. We would be delighted to hear from you.

Sincerely,

Harpreet Chattha, M.A.
Department of Psychology
Lakehead University
807-628-9947
807-766-7256
hchattha@lakeheadu.ca

Michel Bédard, Ph.D.
Public Health Program
Lakehead University
Northern Ontario School of Medicine
807-343-8630
mbedard@lakeheadu.ca

Appendix G:
Physical Functioning Measure Training Materials

PHYSICAL FUNCTIONING MEASURES

YMCA Submaximal Cycle Test (summarized w/measurement pts):

→ record the resting HR and present the Borg scale
→ calculate the 85% MHR; which is = (220 – age) * 0.85

- set the metronome at 100 bpm, for a rate of 50 rpm (one beat for each foot down); start with a 2-3 minutes warm-up to help the participant get adjusted to the cadence;
- set the initial workload at 150 kg* m/min and have them cycle for 3 minutes
  → check the HR at 2 min to approximate what the heart rate will be at 3 minutes
  → check the HR at 3 min and determine the resistance level for the second workload; RECORD THE HR AT 3 MIN; see chart below);
  ** if this initial HR reading is greater than 110 bpm, only continue with one more workload
- be cognizant of signs of exhaustion, unusual strain/response in the participant
- the tests/workloads stop once the participant reaches their 85% MHR or 150 bpm

	HR < 80	HR 80-89	HR 90-100	HR > 100
2nd Stage	750 kgm / min (2.5 kg)*	600 kgm / min (2.0 kg)	450 kgm / min (1.5 kg)	300 kgm / min (1.0 kg)
3rd Stage	900 kgm / min (3.0 kg)	750 kgm / min (2.5 kg)	600 kgm / min (2.0 kg)	450 kgm / min (1.5 kg)
4th Stage	1050 kgm / min (3.5 kg)	900 kgm / min (3.0 kg)	750 kgm / min (2.5 kg)	600 kgm / min (2.0 kg)

***taken from the ACSM's Guidelines for Exercise Testing and Prescription, 5th edition, 1995, pg. 69-70**

After completing the test, the participant should be encouraged to continue pedaling at the first stage resistance or lower to allow their heart rate to slow down appropriately.

Monitoring of HR, BP, Client Signs/Symptoms should be continued for about 4 minutes of recovery (extend cool-down minutes and monitor longer if abnormal readings/signs).

Waist-Hip Ratio:

With a tape measure, record the waist circumference at the narrowest point on the participant's torso. This point should be between the ribs and hips as viewed from the front when the individual is exhaling. With a tape measure, examine the hip circumference where the buttocks are maximally extended as viewed from the side. Record both measurements in inches and to calculate Waist-to-Hip Ratio divide the waist circumference measurement by the hip circumference measurement.

Body-Mass-Index:

This index is a relatively crude measure of assessing degree of obesity. It is considered relatively crude since the participant's weight is not assessed for degree of fat mass and fat-free mass. To calculate BMI, you need to record the participant's height (in inches) and weight (in pounds) and plug into the following formula:

$$\text{BMI} = \frac{\text{(weight in lbs)}}{\text{(height in inches)}^2} \times 703$$

Sit-and-Reach Test (tests lower back and hamstring flexibility):

To complete this test, seat the participant on the floor with their knees straight. Ask the participant to reach forward with both hands (fingertips together), while maintaining their position. Ensure that the participant's legs remain straight and feet remain flush against the hard surface of the reach box. The test administrator should warn the participant not to make fast, jerky movements. The reach box should be positioned against a wall to prevent sliding of the apparatus during measurement. Ensure that the participant is not wearing shoes. The participant is given three or four trials to reach and the best of the four measurements is taken as the final measure. During the measurement, the participant must be able to hold the position for at least 2 seconds. Measure to the nearest half or quarter inch. The legs should be as straight as possible.

Borg Scale:

This scale was developed by Gunnar Borg (hence the name) and can be converted into a modified Rate of Perceived Exertion (RPE) scale. Nevertheless, the Borg scale ranges from 6 to 20 and is a subjective self-evaluation of exercise intensity level. The participant needs to be educated about this scale and needs to become adept in assessing their level of exertion when completing exercises in order to train effectively.

See the below instructions for teaching participants about the Borg Rate of Perceived Exertion scale.

Instructions for Borg Rating of Perceived Exertion (RPE) Scale

"While doing physical activity, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.

Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number from below that best describes your level of exertion. This will give you a good idea of the intensity level of your activity, and you can use this information to speed up or slow down your movements to reach your desired range.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number."

6--No exertion at all------

7----------------------------
Extremely light (7.5)
8----------------------------

9--Very light--------------- 9 = "very light" exercise. For a healthy person, it is like walking slowly at his/her own pace for some minutes

10--------------------------

11--Light-------------------

12--------------------------

13--Somewhat hard------- 13 = "somewhat hard" exercise, but it still feels OK to continue

14--------------------------

15--Hard (heavy)-----------

16--------------------------

17--Very hard--------------- 17 = "very hard" or very strenuous. A healthy person can still go on, but he/she really has to push him/herself.

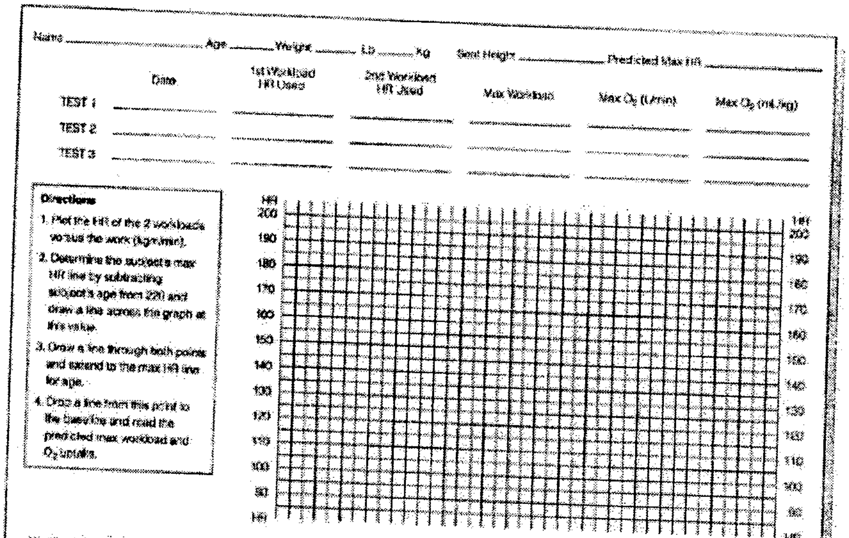
18--------------------------

19--Extremely hard-------- 19 = extremely strenuous exercise level. For most people, this is the most strenuous exercise they have ever experienced.

20--Maximal exertion-----

Borg RPE scale

Appendix H:
Cardiovascular Endurance Workload Form



Workload (kgm/min)	150	300	450	600	750	900	1050	1200	1350	1500	1650	1800	1950	2100
Max O_2 Uptake (L/m)	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.8	3.2	3.6	3.9	4.2	4.6	5.0
KCal Used (kcal/m)	3.0	4.5	6.0	7.5	9.0	10.5	12.0	14.0	16.0	17.5	19.5	21.0	23.0	25.0
Approx Met Level (for 132 lb)	3.3	4.7	6.0	7.3	8.7	10.0	11.3	12.7	14.0	15.3	16.7	18.0	19.3	20.7
Approx Met Level (for 176 lb)	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0

Figure 4.15 Graph for determining $\dot{V}O_{2max}$ from submaximal heart rates obtained during the YMCA's submaximal cycle test. Source: Reprinted from Y's Way to Physical Fitness (3rd ed.), with permission of the YMCA of the U.S.A., 101 N. Wacker Drive, Chicago, IL 60606.

Appendix I:
SF-12 Health Survey

SF-12 Health Survey

INSTRUCTIONS: This questionnaire asks you about your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities.

Please answer every question by marking one box. If you are unsure about how to answer, please give the best answer you can.

1) In general, would you say your health is:

❑1	❑2	❑3	❑4	❑5
Excellent	**Very good**	**Good**	**Fair**	**Poor**

The following items are about activities you might do during a typical day. Does <u>your health now limit you</u> in these activities? If so, how much?

	Yes, Limited A lot	**Yes, Limited A little**	**No, Not Limited At all**
2) **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	❑1	❑2	❑3
3) Climbing **several** flights of stairs	❑1	❑2	❑3

During the past <u>4 weeks</u> have you had any of the following problems with your work or other regular daily activities <u>as a result of your physical health</u>?

	YES	**NO**
4) Accomplished less than you would like	❑1	❑2
5) Were limited in the **kind** of work or other activities	❑1	❑2

During the <u>past 4 weeks</u>, have you had any of the following problems with your work or other regular daily activities <u>as a result of any emotional problems</u> (such as feeling depressed or anxious)?

	YES	NO
6) **Accomplished less** than you would like	❑ 1	❑ 2
7) Didn't do work or other activities as **carefully** as usual	❑ 1	❑ 2

8) During the <u>past 4 weeks</u>, how much did <u>pain</u> interfere with your normal work (including both work outside the home and housework)?

❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Not at all	**A little bit**	**Moderately**	**Quite a bit**	**Extremely**

These questions are about how you feel and how things have been with you <u>during the past 4 weeks</u>. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the <u>past 4 weeks</u>-

	All of the time	**Most of the time**	**A good bit of the time**	**Some of the time**	**A little of the time**	**None of the time**
9) Have you felt calm and peaceful?	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6
10) Did you have a lot of energy?	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6
11) Have you felt downhearted and blue?	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	❑ 6

12) During the <u>past 4 weeks</u>, how much of the time has your <u>physical health or emotional problems</u> interfered with your social activities (like visiting with friends, relatives, etc.)?

❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
All of the time	**Most of the time**	**Some of the time**	**A little of the time**	**None of the time**

Appendix J:
Barriers Self-Efficacy Questionnaire

Barriers Self-Efficacy

The following items reflect situations that are listed as common reasons for preventing individuals from participating in exercise sessions or, in some cases, dropping out. Using the scales below please indicate how confident you are that you could exercise in the event that any of the following circumstances were to occur.

Please indicate the degree to which you are confident that you could exercise in the event that any of the following circumstances were to occur by circling the appropriate %. Select the response that most closely matches your own, remembering that there are no right or wrong answers.

For example, in question #1 if you have complete confidence that you could exercise even if "the weather was very bad," you would **circle 100%.** If, however, you had no confidence at all that you could exercise, if you failed to make or continue making progress (that is, confidence you would not exercise), **you would circle 0%.**

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

NOT AT ALL CONFIDENT — MODERATELY CONFIDENT — HIGHLY CONFIDENT

I BELIEVE THAT I COULD EXERCISE 3 TIMES PER WEEK FOR THE NEXT 3 MONTHS IF:

1. The weather was very bad (hot, humid, rainy, cold).

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

2. I was bored by the program or activity.

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

3. I was on vacation.

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

Mark your answer by circling a %.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
NOT AT ALL CONFIDENT					MODERATELY CONFIDENT				HIGHLY CONFIDENT	

I BELIEVE THAT I COULD EXERCISE 3 TIMES PER WEEK FOR THE NEXT 3 MONTHS IF:

4. I was not interested in the activity.

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

5. I felt pain or discomfort when exercising.

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

6. I had to exercise alone.

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

7. It was not fun or enjoyable.

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

8. It became difficult to get to the exercise location.

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

9. I didn't like the particular activity program that I was involved in.

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

Mark your answer by circling a %.

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

NOT AT ALL CONFIDENT — MODERATELY CONFIDENT — HIGHLY CONFIDENT

I BELIEVE THAT I COULD EXERCISE 3 TIMES PER WEEK FOR THE NEXT 3 MONTHS IF:

10. My schedule conflicted with my exercise session.

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

11. I felt self-conscious about my appearance when I exercised.

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

12. An instructor does not offer me any encouragement.

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

13. I was under personal stress of some kind.

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

Appendix K:
Demographic and General Information Questionnaire

Demographic Information

For this study we need to know some information about you. All responses are completely confidential.

1) Date of completion of Questionnaire: __ __ / __ __ / __ __ __ __
MM DD YYYY

2) Gender: Check only one ☐ Male₁ ☐ Female₂

3) Date of Birth: __ __ / __ __ / __ __ __ __
MM DD YYYY

4) Marital Status: Check only one

☐ Married/Cohabitating₁
☐ Single₂
☐ Widowed₃
☐ Separated₄
☐ Divorced₅

5) Please indicate ***each*** education level that you have completed:

	Yes	No
Elementary	☐₁	☐₂
Secondary	☐₁	☐₂
College	☐₁	☐₂
University	☐₁	☐₂

5b) Please indicate your total years of education: __ __

6) Please indicate your total household pre-tax income. Check only one:

- ☐ ***0-$10,999*** *1*
- ☐ $11,000-$20,999 2
- ☐ $21,000-$30,999 3
- ☐ $31,000-$40,999 4
- ☐ $41,000-$50,999 5
- ☐ $51,000-$60,999 6
- ☐ $61,000-$70,999 7
- ☐ $71,000-$80,999 8
- ☐ $81,000-$90,999 9
- ☐ ≥$100,000 10

7) Indicate your principle place of residence. Check only one:

- ☐ House 1
- ☐ Apartment 2
- ☐ Senior Citizens Home 3
- ☐ Retirement Community 4
- ☐ Assisted Living Facility 5

8) Do you live alone: ☐ Yes_1 ☐ No_2

IF NO, please indicate the people that live in your household and if they hold drivers licenses.

	Live With		Drivers License	
	Yes	No	Yes	No
Spouse	☐ 1	☐ 2	☐ 1	☐ 2
Daughter	☐ 1	☐ 2	☐ 1	☐ 2
Son	☐ 1	☐ 2	☐ 1	☐ 2
Another Relative	☐ 1	☐ 2	☐ 1	☐ 2
Friend	☐ 1	☐ 2	☐ 1	☐ 2
Other	☐ 1	☐ 2	☐ 1	☐ 2

If other, Please Specify: ______________________________

____

9) Please indicate, as best as possible, Check only one:

☐ Area away from a major centre - population less than $10{,}000_1$
☐ Small urban centre - population more than 10,000 but less than $50{,}000_2$
☐ Mid-urban centre - population between 50,000 to $100{,}000_3$
☐ Large urban centre - population more than $100{,}000_4$

10) Which of the following conditions do you believe affect a person's ability to drive safely?

	Yes	No
Diabetes or high blood sugar	❑1	❑2
Heart disease	❑1	❑2
Stroke	❑1	❑2
Seizures or epilepsy	❑1	❑2
Parkinson's disease	❑1	❑2
Sleep apnea or sleeping sickness	❑1	❑2
Narcolepsy	❑1	❑2
Dementia (e.g., Alzheimer disease)	❑1	❑2
Physical Frailty (reduced flexibility or reduced muscle strength)	❑1	❑2
Poor hearing	❑1	❑2
Poor vision	❑1	❑2
Arthritis	❑1	❑2
Broken bones	❑1	❑2
Sudden lapses in consciousness (Syncope)	❑1	❑2
Other	❑1	❑2

Please specify for other:

____

11) Please list all your current medications; write the specific name(s) as printed on the label(s) and then indicate whether you believe these would affect a person's ability to drive safely.

A) Medication Name	**B) Affects Driving** Yes	No
1) ______________________	❑1	❑2
2) ______________________	❑1	❑2
3) ______________________	❑1	❑2
4) ______________________	❑1	❑2
5) ______________________	❑1	❑2
6) ______________________	❑1	❑2
7) ______________________	❑1	❑2
8) ______________________	❑1	❑2
9) ______________________	❑1	❑2
10) ______________________	❑1	❑2

12) Do you currently own a vehicle? ❑ Yes$_1$ ❑ No$_2$

If **YES**, please ***estimate*** the cost to maintain your vehicle for one year: $ _ _ _ _ _

13) Compared to other drivers in your age group, how would you rate your driving abilities: Check only one.

❑ A lot better$_1$
❑ Better$_2$
❑ The same$_3$
❑ Worse$_4$
❑ Much worse$_5$

Appendix L:
Exercise Protocol

Exercise Protocol –

Strength Training/Anaerobic (done about 3X/wk)

Type of Exercise	Exercise	Major Muscle(s) Worked	Secondary Muscle(s) Worked	Easier Alternative
Multi-Joint – Upper	Lat Pull-Down (seated)	**Back (middle/Lat)**	Shoulders, Biceps	Non-Weighted w/Chair
Multi-Joint – Lower	Leg Press (seated)	**Quadriceps**	Hamstrings, Calves, GM	Hip Flexion w/ Chair; Side Leg Raise
Core	Core Extension ("birddog")	**Lumbar Extensors**		Chair Stand
Core (no weights)	Crunches	**Abdominals**		Reaches
Single Joint – Upper	Butterfly Press	**Chest**	X	Non-Weighted Bench Press
Single Joint – Lower	Leg Curl	**Hamstring**	X	Knee Flexion w/Chair
Single Joint – Lower	Leg Extension (seated)	**Quadriceps**	X	Knee Extension w/Chair
Single Joint – Upper	Arm Raises (seated)	**Shoulder**	X	Non-Weighted
Single Joint – Upper	Bicep Curls	**Biceps**	X	Non-Weighted w/Chair
Single Joint – Upper	Tricep Extension	**Triceps**	X	Non-Weighted w/Chair

- All weighted exercises should be first taught with no weight used. Then after motion and form is correct, try lowest weight with participant if ready.
- Next, adjust the weight according to the participant's comfort.
- The level of difficulty should be "hard" where the participant can safely complete about 8 repetitions without a rest interval.
- Each strength exercise (with exception of the crunches) should progress at 8 repetitions for 2 sets with a 1 minute rest between sets and exercises.
- Crunches and core extensions should be done at a moderate level individualized for each participant. Try 10-15 core extensions for each side (left and right) and the same amount of crunches at first (according to the Fitness Instructor's Handbook), but adjust to participant's fitness level (either up or down) as needed.

Aerobic (done 3X/week to 5X/week):

1) Warm-Up:
- 5 minutes of walking at a comfortable pace

2) Walking:
- 20-30 minutes of walking at 60% MHR (according to RPEs/Borg Scale 13; moderate) → 30-40 minutes walking target; (**intensity**: according to the NIA guide, individuals should work up to 13 on the Borg scale and 11-13 of the Borg scale is within the endurance training zone, where 11 is considered "fairly light" and 13 is considered "somewhat hard");
- The NIA and Health Canada's Physical Activity Guide for Older Adults recommend working up to a minimum of 30 minutes most or all days of the week

3) Cool-Down:
- 5 minutes of walking at a comfortable pace to lower heart rate to resting

4) Stretches (done 3 to 5X/week) :
- Neck (three stretches – six positions; hold each for 10 seconds)
- Shoulder (two positions – hold each for 10 seconds)
- Triceps Stretch (two positions – hold each for 10 seconds)
- Wrists (four – hold each for 10 seconds)
- Hip Rotation (two positions - hold each for 10 seconds)
- Sitting Hamstring/Ankle Stretch (four positions – hold each for 10 seconds)
- Standing Quadriceps Stretch (two positions – hold each for 10 seconds)
- Standing Calf Stretch (two positions – hold each for 10 seconds)

*each stretch can be held for 10-30 seconds
* do stretching routine about 2X each exercise session

*no alteration of Warm-Up, Cool-Down or Stretches over 12 weeks, but Walking and Strength Training portions should increase in duration or difficulty, respectively

Appendix M:
Research Training Materials

Training for the Research Project

Stage 1: Knowing the Research and Recruitment

- knowledge about the project
- knowledge about the recruitment process
- assisting with recruitment

Stage 2: Testing and Scoring

- knowledge about the testing process (informed consent, test administration, test motivation)
- learning about how to obtain informed consent
- developing proficiency in testing – cognitive, driving and fitness
- recording scores/entering data
- scheduling appointments/coordinating with the group
- safety issues and precautions

Stage 3: Exercise Protocol

- learning safety precautions/obtaining qualifications
- knowledge about the exercise protocol
- knowledge about administering an exercise protocol
- developing proficiency in exercise training

Stage 4: Adminstration of Protocol and Participant Progress

- learning about how to adjust the exercise protocol, if needed
- learning how to gauge participant progress
- teaching participants how to gauge their own progress
- helping participants become independent in their exercise program; teaching them how to modify the protocol to keep it challenging
- receiving progress updates from participants

EXERCISE PRESCRIPTION FOR MUSCULAR STRENGTH AND ENDURANCE TRAINING (Taken from Health Fitness Instructor's Handbook)

FUNDAMENTAL EXERCISE PRINCIPLES (also, functional relevance, accommodation and challenge)

The "Overload Principle":

- to enhance muscular performance: must exercise at a level beyond where normally stressed; increase stress/intensity when current exercise becomes too easy; e.g., lifting 20 lb weight for bicep curls can be done easily for 10 reps → increase weights

Principle of Progressive Resistance:

- continual and progressive demands placed on the body, which are greater than normal demands
- guideline: increase the training weight about 5% and decrease the repetitions by 2 to 4 when a specific load can be performed for the desired number of repetitions with proper exercise technique (FORM)

Principle of Specificity:

- the "specific adaptation to imposed demands" (SAID) principle; certain exercises target certain muscle group(s) and can result in improved endurance in activities which rely upon these given muscle groups;

In summary,

"Gains in muscular strength and local muscular endurance will occur only if the overload placed on a muscles or muscle group is greater than that to which it is normally accustomed.

To make continual gains, the athlete must increase the overload by varying the intensity, duration, and/or frequency of training.

The design of the strength training program will influence the specific training –induced adaptations that occur. A sport-specific or activity-specific strength training program should include exercises that meet specific training objectives."

STRENGTH TRAINING BACKGROUND

Types of Strength Training:

- Isometrics:
-
- Dynamic Constant External Resistance (DCER) Training:
    - Involves lifting (concentric) and lowering (eccentric) phases → "dynamic";

  - these exercises typically involve use of free-weights and weight machines;
  - predetermined ROM;
  - limitation of DCER exercises is that difficulty of lifting the weight varies according to change of position during the exercise (in ROM) → this limitation is addressed in VRT;

- Variable Resistance Training:
  - adjust the force on the muscle by causing it to contract maximally throughout the ROM by varying the resistance to match the strength curve;
-
- Isokinetics:
  - often used in rehab;
  - where applied force is met with equal reaction force, thus giving almost a consistent maximal contraction of the muscle, except does not when considering the acceleration and deceleration involved when starting and ending the exercise/ROM;
-
- Plyometrics:
  - "jump training";
  - aim is for target muscle to reach maximal force in the shortest possible time;

Mode of Strength Training:

- weight machines can be ideal for sedentary or inexperienced individuals, since the exercise motion is controlled by the machine and usually only occurs in one anatomical plane;

- more difficult to master proper exercise techniques when using free weights; but advantages – no "fit" needed; provides variety; use of additional stabilizing and assisting muscles to hold the correct body position during an exercise; deaths have occurred from weight training equipment esp bench press/supine free weight exercises;

body weight exercises (push-ups, curl-ups, etc): limitation is adjusting the body weight to individual's strength level; sedentary individuals may not be even to perform one repetition of the exercise; use of medicine balls, elastic tubing, stability balls;

SAFETY

Safety Issues:

- "Most acute injuries are the results of improper exercise technique, excessive loading or inadequate supervision."

Client Safety and First Aid

(from the International Curriculum Guidelines for Preparing Physical Activity Instructors of Older Adults) –

- What are the signs for immediate exercise cessation/immediate medical consultation?
- What are the appropriate First-Aid/CPR responses?
- What is the emergency action plan?
- How am I making sure that the exercise environment is safe and age-friendly? (climate already established/controlled by LU, but periodic check that machines are in working order)

Safety Recommendations for Strength Training

- Review participants' health/history questionnaires before they begin strength training
- Provide adequate supervision and instruction when necessary
- Regularly practice emergency procedures
- Encourage participation in warm-up and cool-down activities
- Move carefully around the strength training area, and don't back up without looking first
- Fix broken or malfunctioning equipment immediately or put an "out of order" sign on it; Periodically check all strength training equipment.
- Be aware of proper spotting procedures and offer assistance when needed
- Model appropriate behaviour and do not allow "horseplay" in the fitness center
- Demonstrate correct exercise technique and do not allow participants to train improperly
- Ensure the training environment is free of clutter and appropriately maintained
- Stay up to date with current strength training guidelines and safety procedures for special populations

Supervision and Instruction:

- fitness instructors should be able to correctly perform the exercises they prescribe and should be able to modify exercise form and technique if necessary
- responsible for enforcing safety rules and safe training procedures
- should understand strength training principles and appreciate individual differences;

Warm-up and Cool-down:

- strength training should be preceeded by 5-10 minute warm-up of low-to-moderate intensity aerobic exercise, such as slow jogging or stationary cycling
- a proper warm-up: increases blood flow, increases body and muscle temperature, and decrease the likelihood of injury;

- a specific warm-up involves movement that are the same or similar to the strength training exercises prescribed (so, after a general warm-up, could do some light weight repetitions on the machine they are about to use; e.g., chest press, lat pull-down)
- after a strength training work-out it is good to cool-down with general calistenics and static stretching exercises; this can help relax the body and possibly reduce muscle stiffness and soreness;

Strength Training Frequency:

- should not be done on consecutive days (48 to 72 hours rest between sessions, unless working different muscle groups);
- this spacing out of sessions avoids overtraining;

Problems:

- Overtraining: excessive frequency, volume and intensity of training combined with inadequate rest and recovery; exercise training exceeds rate of adaptation; symptoms of overtraining: decreased body weight, loss of appetite, sleep disturbances, decreased desire to train, muscle tenderness, increased risk of infection
- Overreaching: short-term overtraining;

Older Adults:

- ACSM recommends individuals aged 50 to 60 y.o. train with a moderate load that can be performed for 10-15 repetitions; also,
  - Undergo careful pre-screening
  - All strength training should be preceeded by 5 to 10 min warm-up of low-intensity aerobic exercise and stretching
  - Learn proper breathing patterns and should be cautioned about the "Valsalva maneuver" (attempting to hold one's breath during the exercise forcing air into the middle ear)
  - Begin with 1 set of 10-15 reps on 8-10 exercises
  - Initially, seniors should use a light weight to allow for connective tissue adaptations
  - Seniors should begin on weight machines and progress to free weights (which require more balance, skill and coordination)
  - Should strength train at least 2x/week and allow 48-72 hrs rest between sessions
  - Exercises should be performed within a pain-free ROM

During the initial phase of training, qualified fitness professionals should provide guidance and offer assistance as needed;

Appendix N:
Fitness Intervention Progress Cards

Lakehead
UNIVERSITY

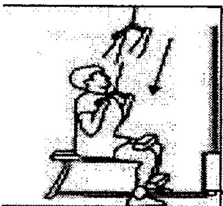
Physical Activity Research Project

Driving Research Lab

STANDARD PROTOCOL

Clients Name: Name
Date (YY/MM/DD): ####

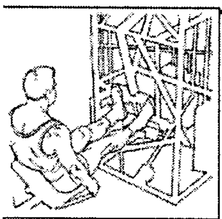
Page: 1



1) Lat Pull-Down (seated)

→While sitting on the seat, place both knees under the exercise pad and fully extend both arms to the bar handles above.
→ Grip the bar with your palms towards your face.
→ While keeping the upper body erect, slowly pull down the bar to just under your chin.
→ Allow the bar to return slowly until arms are again fully extended.

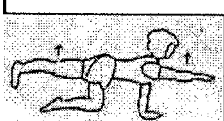
Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		



2) Leg Press (seated)

→ Start in a sitting position with your knees bent at 90°.
→Your feet should be placed about shoulder-width apart on the footpad.
→Your torso should be erect and your back should be pressed against the back of the seat.
→Extend your legs almost completely (without "locking" your knees) and slowly returning to the starting position.

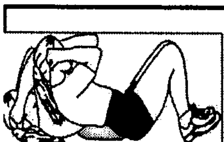
Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		



3) Core Extension (superman/bird-dog)

→ Kneel on a mat and support your body weight on both hands and knees.
→ Extend your right leg backwards and your left arm forwards until both limbs are parallel to the floor.
→ Pause briefly and return to the starting position.
→ Repeat the exercise with the opposite arm and leg.

Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		



4) Abdominal Crunches

→ Lie down facing up with your knees bent. Your feet should be flat on the floor.
→ Cross your arms across your chest or position your fingers lightly at the side of your head.
→ Tuck your chin to your chest and curl your upper body towards your knees until your upper back is off the mat.
→ Lower your shoulders slowly to the mat and repeat.

Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		

Lakehead
UNIVERSITY

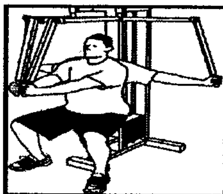
Physical Activity Research Project

Driving Research Lab

STANDARD PROTOCOL

Clients Name: Name
Date (YY/MM/DD): ####

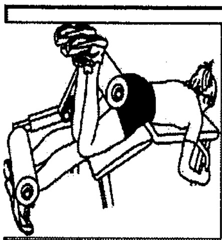
Page: 2



5) Chest (seated)

→ When seated on the chest press seat, make sure your back is pressed against the back of the seat and that your feet are shoulder width apart.
→ Place arms behind machine's arm pads so that palms are flat against the pads/Grip handles. Your arms should be bent at the elbow at 90°
→ While keeping your arms in the same 90° position, slowly bring arms towards the middle so that forearms are coming towards each

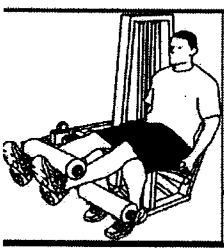
Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		



6) Leg Curl

→→ Sit down on the leg curl seat with your knees positioned underneath the knee pad and your ankles are above the roller pad.
→ With your hands gripping the seat handles, bend your legs at the knees bringing the roller pad down until your legs make a 90° angle.
→ Slowly bring your legs with a controlled movement to the starting position and repeat.

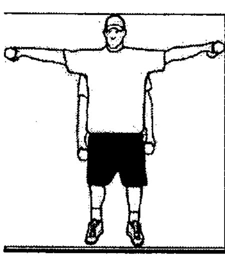
Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		



7) Leg Extension (seated)

→ After sitting down on the seat, place your ankles under the roller pad.
→ With your hands gripping the seat handles, extend your legs at the knees until they are straight.
→ Lower them slowly in a controlled movement to the starting position and repeat.

Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		



8) Arm Raises (standing/seated)

→ Stand with a dumbbell in each hand (palms facing your sides) with your arms at your sides.
→With elbows slightly bent, raise upper arms to sides until elbows are shoulder height.
→ Slowly return to your starting position and repeat.

Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		

Lakehead
UNIVERSITY

Physical Activity Research Project

Driving Research Lab

STANDARD PROTOCOL

Clients Name: Name
Date (YY/MM/DD): ####

Page: 3

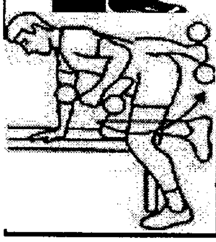
9) Bicep Curls

Stand with a dumbbell in each hand (palms facing forward) with ur arms at your sides.
Slowly bend both your elbows to bring the weights toward the oulders.
Slowly return to the starting position and repeat.

Vhile completing this exercise, do not swing your torso or bend ur back.

Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		

) Tricep Extension



→ Stand with a dumbbell held behind your head with both of your hands gripping the uppermost part of the dumbbell. Your elbows should be bent and your upper arms should be at either side of your head.
→ While keeping your upper arms relatively stationary, slowly move the dumbbell st that your arms are extended.
→ Slowly return to the starting position and repeat.

Set		Load x Reps
Set 1		
Set 2		
Set 3		
Set 4		
Set 5		
Set 6		
Set 7		
Set 8		