The Effect of Physical Training Cessation on Cognitive and Mobility Performance of Older Adults

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ABSTRACT

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In order to prevent declines in cognition and mobility in older adults, physical activity has been looked to, to improve outcomes. The method in which past and current research has examined the effects of physical activity, is through exercise interventions. Multiple types of exercise interventions have been described as effective methods for improving cognition and mobility in older adults. Lack of adherence to exercise is a challenge, however, which may bring about periods of training cessation. Training cessation may lead to a to loss of fitness adaptations. The effects of cessation on cognitive performance, particularly executive functions, and mobility have yet to be elucidated, especially within the context of dual-tasking. This study examined the impact of an 8-week training cessation, on cognitive performance and mobility, after one of three interventions: combined lower body strength and aerobic (LBS+A), combined upper body strength and aerobic (UBS+A) or gross motor skills (GMS) training. Forty older adults (70.5 ± 5.5 years; 67.5% female) participated in 3x-weekly training sessions for 8 months prior to training cessation. Pre, post and follow-up (post-cessation) measures of executive function (Random Number Generation test – single and dual-task condition) and mobility (Timed-Up and Go Test, 10-metre maximal walk test, six-metre walk test) were assessed. Performance in certain inhibition indices, in single and dual-task conditions, and mobility tests retained improvement or continued to improve after cessation, after all exercise interventions. Our findings indicate the potential of resilience in benefits to executive function and mobility in older adults after the cessation of exercise.

Key words: Older Adults, Exercise, Cognition, Mobility, Training Cessation, Executive Function

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1 INTRODUCTION

The proportion of older adults, as a segment of the population, is increasing globally. By 2063, it is estimated that approximately one quarter of the Canadian population will consist of adults aged 65 years or older (Statistics Canada, 2015). It is also estimated that the global population of adults, aged 60 and older, will reach 2 billion by 2050 (World Health Organization, 2015). In response to this burgeoning population, greater resources and demands will be placed on healthcare systems and services.

The process of aging in older adults brings new challenges with respect to treatment, morbidity and prevention of disease. It is therefore incumbent upon healthcare providers, clinicians and researchers to develop treatment methods and understand lifestyle-related changes that may help mitigate declines associated with aging. One such approach to maintain or improve outcomes associated with aging, is the application of physical activity.

2 THE EFFECTS OF AGING ON FITNESS, MOBILITY AND COGNITION

During the aging process, physical fitness tends to deteriorate, and these losses may occur concurrently with diminished functional mobility. Physical fitness consists of multiple components such as cardiorespiratory endurance, muscular strength, body composition and flexibility (Caspersen, Powell, & Christenson, 1985). Additionally, cognitive performance is also negatively impacted by the aging process, further affecting mobility performance. The interrelated nature of physical fitness, cognition and mobility highlight the significant consequences of aging, and the necessity of improving and maintaining function in these areas.

Aerobic fitness or cardiorespiratory fitness is defined as the capacity of the cardiovascular and respiratory systems to supply oxygen-rich blood to the skeletal muscles during sustained physical activity (ACSM, 1998). Aerobic fitness is typically represented by the "gold standard" of VO_2max, the maximal amount of oxygen consumption, and upper limit of the cardiovascular system. Parameters of aerobic fitness, such as VO_2max, may undergo declines with age (McArdle, Katch, & Katch , 1991; Astrand, Astrand, & Hallback, 1973). For example, VO_2max has been observed to decrease with a rate of 10% per decade in sedentary men and women beginning at age 30 (Astrand, Astrand, & Hallback, 1973; Hawkins & Wiswell, 2003). Another parameter associated with cardiovascular function, maximal heart rate, which affects cardiac output and ultimately VO_2max, declines at a rate of 3-5% in older populations (Hawkins & Wiswell, 2003). Deterioration of these parameters may be tied to peripheral factors that also develop with age, such as increased body fat mass and reductions in lean body mass (Hawkins & Wiswell, 2003).

The rate of decline in aerobic fitness may be nonlinear for older adults, and actually accelerate with each passing decade (Fleg, et al., 2005; Jackson, et al., 2009). In a longitudinal study of 435 men and 375 women aged 21 to 87, peak VO_2 was observed to decline at a rate of greater than 20% per decade in individuals older than 70 years of age (Fleg, et al., 2005). Another longitudinal study of over 20,000 individuals, over a 20-year period had also observed a similar accelerated decline in aerobic fitness, in both men and women (Jackson, et al., 2009). Deterioration in aerobic fitness has further consequences for older adults, as the requirements of functional mobility require greater energy availability despite a lower aerobic capacity (Schrack, Simonsick, & Ferruci, 2010). The consequences of further deterioration in aerobic fitness itself, may result in poorer mobility performances, such as slower walking speed (Richardson, et al., 2015).

Parameters of neuromuscular fitness, defined as the capacity of the skeletal muscle to move an external load (ACSM, 2009), also experience significant decreases in performance with aging. Loss of muscle strength, or muscle weakness occurs at a rate of approximately 10% per decade, beginning at the fourth-to-fifth decade of life, and accelerating after age 70 to 25% to 40% every 10 years (Goodpaster, et al., 2001; Hughes, et al., 2001). In addition, another critical measure of neuromuscular fitness, muscle power, has been observed to decline with increasing age, and at greater rates than muscular force (Aagaard, et al., 2010; Skelton, et al., 1995). These decrements to neuromuscular parameters are attributed to age-related loss of muscle mass, also termed sarcopenia, as a result of motor unit loss and reduction of size or atrophy of muscle fibers (Lang, et al., 2010). Central (or neural) factors, such as a reduced efficiency of motor unit recruitment, lowered excitatory drive, also play a role in decline of muscular strength and power (Manini & Clark, 2012).

The consequences of poorer neuromuscular fitness are of major concern regarding the functional capacity in older adults. For example, lower extremity muscle strength is closely associated with the performance of functional mobility tasks such as walking (Hayashida, et al., 2014). Muscle power of lower extremities has also been described as an even stronger predictor of functional performances in older adults, independent of muscular strength (Suzuki, Bean, & Fielding, 2001; Reid & Fielding, 2012). Furthermore, muscle weakness and reduced muscle power in lower body limbs are a potential risk factor for the occurrence of falls in older adults (Moreland, et al., 2004; Skelton, Kennedy, & Rutherford, 2002). Declines in neuromuscular fitness may have severe impacts to mobility performance, much like decreases in aerobic fitness.

Age-related changes may also lead to functional decline in cognitive domains, particularly executive functions (Gunning-Dixon & Raz, 2003). These higher order cognitive processes entails the application and modification of sensory inputs coordinated in frontal cortex and associated brain systems, such as the parietal lobe and limbic networks (Yogev-Seligmann, Hausdorff, & Giladi, 2008). Executive function has been described in the extant literature as processes which involve controlled planning, monitoring, and adjustment of actions necessary for task-oriented behaviour (Miyake, et al., 2000). These processes can govern tasks such as planning, scheduling, working memory (or information "updating") and inhibition of prepotent responses ("inhibition") (Colcombe & Kramer., 2003; Kramer, et al., 1999; Miyake, et al., 2000). Brain structures and networks associated with executive function can experience significant changes during the aging process. Reductions in prefrontal cortex volume, and in the frontal cortex, the development of lesions, identified by white matter hyperintensities, are examples of morphological changes that may occur (Gunning-Dixon & Raz, 2003). These changes have been linked to the impairment of executive functioning in older adults (Gunning-Dixon & Raz, 2003). Age-related deterioration in executive functioning can result in poorer cognitive processes of response inhibition and working memory (Gunning-Dixon & Raz, 2003; Yogev-Seligmann, Hausdorff, & Giladi, 2008). Similarly, to age-related alteration of fitness parameters and subsequent effects on mobility, declines in cognitive domains, such as executive function, also play an important role in mobility.

3 Physical Activity and Exercise Effects on Fitness

Participation in physical activity has been a proposed method to mediate improved outcomes in mobility and cognition in older adult populations, through increased physical fitness (Bherer, Erickson, & Liu-Ambrose, 2013; Manini & Pahor, 2009). Physical activity is also beneficial to increase autonomy and maintain or improve quality of life for healthy older adults. Reduced incidence of diseases such as cancer, diabetes, cardiovascular and heart disease have also been observed as a benefit of physical activity (Booth, Gordon, Carlson, & Hamilton, 2000; Myers, et al., 2002).

In general, physical activity describes bodily movement that involves the use of skeletal muscle, resulting in energy expenditure above basal metabolic rate (Caspersen, Powell, & Christenson, 1985). In addition, physical activity may consist of recreation, sport and physical activities performed during active daily living, leisure, transportation and occupation (Garber, et al., 2011). Physical activity has been described to provide several positive benefits to health outcomes such as reduced rates of cardiovascular disease. To understand the effect and benefit of physical activity for older adults, despite its expansive meaning, a subset of physical activity, exercise, has been employed as an intervention method.

Exercise specifically involves a planned, structured and repetitive methodology to improve specific fitness parameters (aerobic and neuromuscular/strength, for example). Exercise interventions have employed older adult populations to improve declining aerobic and neuromuscular fitness parameters associated with aging. Success in mediating positive outcomes for both measures of physical fitness have been demonstrated in aerobic and strength/resistance exercise interventions (Huang, Gibson, Tran, & Osness, 2005; Peterson, Rhea, Sen, & Gordon, 2010).

Multiple intervention studies have demonstrated the benefit of aerobic fitness training and improved parameters associated with cardiovascular health (Huang, Gibson, Tran, & Osness, 2005). Aerobic training consists of exercise which involves the rhythmic movement of large skeletal muscles of the body in for an extended period of time (Chodzko-Zajko, et al., 2009). A meta-analysis conducted by Huang et al. (2005), looked at the effectiveness of aerobic training interventions on VO_2max in sedentary older men and women. Their findings had concluded that aerobic fitness could be improved when training at intensities corresponding to 60% of VO_2max and that longer training length elicited greater improvement. It was also determined that sedentary older adults, who were participating in a three sessions per week program, had demonstrated an increase of 16.3% in VO_2max, after training for 20 weeks or more. However, Huang et al. had also proposed that significant gains could be attained after 16 weeks of training. This meta-analysis of aerobic interventions had demonstrated the efficacy of such interventions in eliciting improvement to VO_2max, despite the effect of aging, particularly in sedentary older adults.

Strength/resistance exercise interventions have been utilized to improve neuromuscular fitness in older adults. Strength/resistance training consists of exercise which requires the use of muscles to exert force or resist against an externally applied force or weight (Chodzko-Zajko, et al., 2009). This may be performed through use of free-weights, machines or resistance bands. Strength/resistance interventions are effective in improving muscle strength and power and increasing muscle mass in older adults (Fielding, et al. 2002; Frontera, et al., 1988; Liu & Latham, 2009). A meta-analysis conducted by Peterson et al. (2010), had examined 47 resistance exercise interventions with over 1000 subjects, which had all elicited improvement in upper and lower body strength in older adults participating in strength/resistance exercise interventions. This improvement has also been observed in very old (>90 years) adults, as observed by Fiatarone et al. (1990). The culmination of a high-intensity strength intervention had induced increases in lower extremity strength that was 61% to 374% higher than baseline measures after eight weeks of training. Fiatarone et al., had demonstrated that muscle weakness and decline, associated with age-related processes may be mitigated or reversed even in very old and frail populations. Resistance training has also demonstrated efficacy in improving muscle power as described by studies conducted by Sayers, et al. (2003), and Henwood, et al. (2008). Henwood, et al., in particular, had also demonstrated improvements in muscle power, attributed to a resistance training, were associated with better performance of functional mobility tasks, such as climbing stairs or sitting up from a chair. Strength/Resistance interventions have demonstrated effectiveness by eliciting improvement in older adults, despite age-related declines of neuromuscular fitness.

Exercise interventions have also demonstrated effectiveness in improving cognitive outcomes while focusing on differing measures of physical fitness (Liu-Ambrose, et al., 2008; Colcombe, et al., 2004). Multiple meta-analyses and reviews have demonstrated that exercise interventions to improve aerobic/cardiorespiratory and neuromuscular fitness, can elicit benefit to cognitive performance as well as mobility for older adults (Bherer, Erickson, & Liu-Ambrose, 2013; Ballesteros, et al., 2015; Colcombe & Kramer, 2003; Smith, et al., 2010). The following section will focus on exercise interventions aimed at improving cognitive performance in older adults, through the improvement of different physical fitness measures.

4 AEROBIC, STRENGTH AND COORDINATION TRAINING APPROACHES TO IMPROVING COGNITIVE PERFORMANCE

4.1 AEROBIC FITNESS TRAINING INTERVENTIONS ON MOBILITY AND COGNITION

Greater aerobic fitness has been proposed as a protective factor against declines in cognitive performance (Barnes, et al., 2003). A longitudinal study conducted over 6 years by Barnes et al. examined the association between aerobic fitness measured at baseline and the maintenance of cognitive function over length of the study in 349 older adults. Their study concluded that higher baseline measures of aerobic fitness were related with better preservation of executive function and global cognition. In keeping with such findings, interventions aimed at improving aerobic fitness have therefore been employed to improve cognitive performance in older adults.

The positive effect of aerobic training programs have been demonstrated to elicit selective impact in areas of executive functions, such as processes involving multi-tasking, planning and inhibition (Colcombe, et al., 2004; Voss, et al., 2011; Bherer, Erickson, & Liu-Ambrose, 2013). Studies utilizing aerobic exercise interventions have done so in order to test a cardiovascular/cardiorespiratory hypothesis, which suggests that aerobic fitness is a physiological mediator of cognitive function. This reasoning implies that exercise regimens aimed at improving the aerobic fitness of older adults will result in benefits to cognitive performance.

Aerobic fitness interventions aimed at improving VO_2max performance, have also elicited selective benefit to performance in executive function (Colcombe & Kramer, 2003; Hall, Smith, & Keele, 2001; Kramer, et al., 1999). Studies have been able to demonstrate that an increase in VO_2max in elderly adults, is related to increased performance in markers of executive control (Bherer, Erickson, & Liu-Ambrose, 2013; Ballesteros, et al., 2015; Colcombe & Kramer, 2003). Investigations involving aerobic exercise interventions date back as far as 1984, with a study conducted by Dustman and colleagues. It consisted of a four-month aerobic exercise program which compared middle-aged and older adults who participated in an aerobic exercise program, with individuals who had undergone strength and flexibility training, and a control group which did not participate in any exercise program (Dustman, et al., 1984). Their study had determined that participants in the aerobic training group were the only group that had exhibited improvement in cardiorespiratory fitness, and an improvement in a simple Reaction Time Task, which was their measure of cognitive performance (Dustman, et al., 1984).

In a study, conducted by Kramer and colleagues (1999), 124 older adults, aged 60 to 75 years old, placed in an aerobic training group (using walking as the aerobic exercise intervention), were compared to a control stretching and toning intervention group over a six-month intervention period (Kramer, et al., 1999). Participants had their aerobic fitness assessed by measuring their VO_2max, along with their cognitive performance in tasks assessing attentional and executive control (task switching, response compatibility and stopping). Subjects in both interventions had exhibited similar fitness levels prior to the intervention, however, at the conclusion of the intervention, the aerobic group had exhibited a significant improvement in their VO_2max (an increase of 5.8%), in comparison to the control group. This improvement in fitness was also observed with better performance in tasks measuring executive control processes, in comparison to the control group.

Examining the selective impact of an aerobic exercise program on executive functioning in cognition, a shorter 12-week intervention study on older adults conducted by Renaud et al, (2010), was able to demonstrate an improvement in attentional control, determined by improved motor response preparation, for individuals in an aerobic exercise group when compared to a control group (Renaud, et al., 2010). This improvement was observed in addition to increased cardiorespiratory capacity (estimated with the Rockport one-mile test). These enhancements were evident despite a relatively shorter period of 12-weeks, as opposed to studies which used a 6 to 12-month time frame. (Renaud, et al., 2010).

Structural and functional changes that point to selective improvement in cognitive processes, such as executive functions, have also been attributed to improved aerobic fitness. An investigation conducted by Colcombe and colleagues (2004) had been able to observe these changes by looking at the results of a cross-sectional study of 41 community dwelling older adults and a separate randomized clinical trial (RCT). The RCT consisted of a separate sample of 29 older adults who participated in either a control (stretching and toning) group, or an aerobic training group (increasing duration and intensity of walking). Both groups underwent a six-month training period, with three training sessions per week. For both studies, the "higher-fit" and aerobic-trained individuals of their respective studies exhibited higher comparative VO_2max performance (Colcombe, et al., 2004). Higher-fit and aerobically trained individuals also had greater activity in frontal and parietal cortices of the brain which are relevant to conflict resolution and selective attention (domains of executive function). In addition, both groups demonstrated reductions in activation of the anterior cingulate cortex (ACC) of the brain (a region involved with behavioral conflict, the need to adapt attentional control processes), while also exhibiting improved performance in conflict resolution (Colcombe, et al., 2004).

The aforementioned exercise intervention studies, among many others, have been able to apply aerobic exercise interventions of varying lengths to induce improvement in aerobic fitness along with corresponding improvement in cognitive performance. While these studies do indicate a link between the positive effect of aerobic exercise interventions and improved performance in some domains of cognition in elderly adults, the aerobic fitness hypothesis, of a direct relationship between improvement in cardiovascular fitness measures and improvement in cognitive performance, has not been supported by all of the literature focusing on exercise and cognition in elderly adults (Etnier, et al., 2006; Smiley-Oyen, et al., 2008).

A randomized clinical trial conducted by Smiley-Oyen et al. (2008), had also sought to test the aerobic hypothesis using an intervention with an aerobic exercise regimen. They had deterimined that while aerobic exercise appeared to produce a benefit towards performance in the specific areas of executive control, actual improvement in aerobic fitness was not correlated with increased performance in cognition. Improvement in this domain was reported regardless of the aerobic fitness attained after the exercise regimen (Smiley-Oyen, et al., 2008). This contradictory finding, regarding the aerobic fitness hypothesis, has also been reported in a meta-analysis conducted by Etnier et al. (2006). Their examination of 37 cross-sectional and intervention studies had determined that there was not a significant relationship that supported the aerobic hypothesis of greater aerobic fitness correlating with better cognitive function.

Their conclusions on the aerobic fitness hypothesis notwithstanding, Etnier et al., still supported the idea of physical activity providing a beneficial effect to cognitive performance. However, as the aforementioned literature has stated, improvement in aerobic fitness is not a definite method to improve cognitive outcomes. Researchers have therefore looked to other methodologies such as strength/resistance training to provide cognitive benefit for older adults.

4.2 Strength/Resistance Training Interventions and Improvement in Mobility and Cognition

Strength/resistance training has also been able to contribute to significant improvements in cognitive function. Indeed, Colcombe and Kramer (2003), while acknowleging that aerobic interventions positively benefit executive functioning and other cognitive tasks, had also concluded, through a meta-analysis of 18 randomized-controlled trials, that combined strength and aerobic interventions may provide an improved cognitive performance than aerobic exercise alone for older adults (Colcombe & Kramer, 2003) supporting the notion that strength/resistance training may provide a pathway for improving cognition.

Resistance training has been associated with improved executive function and functional plasticity (Cassilhas, et al., 2007; Liu-Ambrose, et al., 2007; Liu-Ambrose & Donaldson, 2009). Cassilhas et al., (2007), were able to demonstrate the effectiveness of strength and resistance training through their randomized controlled trial of 62 elderly men, aged 65 to 75 years (Cassilhas, et al., 2007). These participants were assigned to one of three groups, two of which utilised resistance training (in either a moderate or high level of training intensity), and a control which used stretching and flexibility exercises without any resistance training methods. The intervention lasted six-months and their results yielded improved memory performance or verbal concept formation (processes of executive function) in groups that participated in the moderate and high intensity resistance training cohorts (Cassilhas, et al., 2007).

Improvement in cognitive performance due to strength/resistance training was also observed in a resistance training intervention study produced by Liu-Ambrose et al., (2007), which studied 155 community dwelling women, aged 65-75 years old, that had participated in a 12-month single-blinded randomized trial. Participants had been allocated into either a once-weekly or twice-weekly resistance training regimen or a control group which had underwent balance and tone training methods (Liu-Ambrose, et al., 2007). Participants in the twice-weekly training group increased their muscle power by 13.4%, in contrast to the once-weekly training and control group who had deteriorated at the conclusion of the study (Liu-Ambrose, et al., 2007). Liu-Ambrose and colleagues were also able to demonstrate the positive effects of strength/resistance training on cognitive performance as their study yielded improvement of task performance using executive function domains (selective attention and conflict resolution) of participants in the both resistance training groups, yet a decrease in performance was observed in the control group. Better performance in selective attention and conflict resolution was also associated with improved gait speed (Liu-Ambrose, et al., 2007), highlighting that positive effects of strength/resistance training on cognition also influence mobility.

Resistance training has also been used in concert with balance or coordination training methods as an effective intervention in elderly populations (Liu-Ambrose, et al., 2008). Liu-Ambrose and colleages, in another study, utilized an individualized home-based program that integrated balance and strength training (Otago Exercise Program), that was able to significantly improve executive function parameters of selective attention and conflict resolution, over a six-month period in a sample of elderly individuals aged 70 years or older, with a previous history of falls (Liu-Ambrose, et al., 2008).

4.3 Coordination and Balance Training Interventions

Coordination/Balance training, by itself, has been recently proposed as a promising new venture as a cognition-improving, exercise intervention (Voelcker-Rehage, Godde, & Staudinger, 2011). Voelcker-Rehage and colleagues (2011), conducted a twelve-month study comparing the effects of cardiovascular training to a coordination training group, focusing on fine- and gross- motor skills in 44 participants who were aged 62 to 79. The coordination training involved activities using hand-eye coordination, leg-arm coordination, balance and reaction to moving objects or persons. Cardiovascular training involved walking with increased duration and intensity. They had observed that in addition to improvements to executive functioning and perceptual speed observed in the cardiovascular training group, these measures had also improved in the coordination training groups as well (Voelcker-Rehage, Godde, & Staudinger, 2011), as demonstrated by performance of a modified Erickson Flanker Task (Li, et al., 2004; Voelcker-Rehage, Godde, & Staudinger, 2011). It was also determined that both interventions had led to a decrease in prefrontal cortex activation, indicating better information processing. Their findings were also able to illustrate that coordination training improved cognitive performance through a different pathway, increased activation of the visual-spatial network of the brain (right inferior frontal gyrus and superior parietal cortex), as opposed to changes to activation of the sensorimotor network of the brain associated with aerobic exercise (reduced level of activity in the ACC, less cortical activation in superior and frontal cortex).

In a study by Forte and colleagues (2013), a cohort of 42 community dwelling adults (aged 65 to 75 years) was enrolled in a twice-weekly, 3-month long intervention in either: multicomponent training that focused on coordination, balance, agility and executive control in cognition; or another group which participated in strength/resistance training (Forte, et al., 2013). At the conclusion of their study they had determined that inhibition (a facet of executive function), as assessed by the Random Number Generation (RNG) test, mobility (maximal walking speed), and dual-task performance had all improved for both training groups with no difference among these outcomes for both groups (Forte, et al., 2013).

Berryman et al. (2014), had also conducted a study to assess the effects of an 8-week, high-intensity exercise regimen on the executive function of 47 older adults (aged 70.7 +/- 5.6), who had completed either a combined strength and aerobic training regimen focusing on the lower extremities, an upper-body focused combined strength and aerobic training, or a gross motor skills (GMS) training regimen focusing on stretching, locomotion, manipulation and relaxation. To assess executive function, they had also utilized the RNG test, to assess a dual-task situation at different walking speeds (2.4, 4 and 5.6 km/h). Their results also yielded improvements to executive function in the RNG test, in measures of inhibition, across all training groups, similar to an improvement in the RNG scores for inhibition in the study conducted by Forte, et al. (Berryman, et al., 2014; Forte, et al., 2013). Improvements in inhibition were made regardless of the improvement in aerobic fitness attained (Berryman, et al., 2014). This study has highlighted that physical activity prescribed in exercise interventions, regardless of an aerobic, strength or coordination/balance perspective, may also be able to elicit results that lead to an improvement in cognitive performance.

As mentioned earlier, physical fitness, cognitive performance and mobility are interrelated and may experience declines due to the aging process. However, aerobic and strength/resistance interventions have been established as viable methods to improve cognitive function while also focusing on aerobic and neuromuscular fitness parameters. Additionally, as Forte et al., (2013), Voelcker-Rehage et al. (2011) and Berryman and colleagues (2014) have been able to demonstrate, multiple types of interventions, including coordination and balance training, can elicit similar benefits to mobility and cognition, suggesting diverse pathways are available to improve these domains.

These exercise interventions have demonstrated the beneficial effect of improved physical fitness on cognitive performance. The previously mentioned study by Liu-Ambrose et al. (2007), has also described that benefits to mobility are also observed, in addition to improved cognitive performance. Considering the close association of cognitive performance and mobility, it is therefore necessary to utilize a model of study which can examine this relationship.

5 EXECUTIVE FUNCTION, GAIT AND THE DUAL-TASK PARADIGM: THE LINK BETWEEN MOBILITY AND COGNITION IN AGING

Poorer functional mobility in older adults is symptomatic of the aforementioned consequences of aging on physical fitness and cognitive performance. Declines in mobility, have been observed to present themselves in concert with poorer cognitive performance in older adults (Camicioli, et al., 1998; Holtzer, et al., 2006). The severity of deficits to mobility are most prominent in individuals suffering from severe cognitive impairment and conditions such as dementia and Alzheimer's disease (Pettersson, Olsson, & Wahlund, 2005). For example, slower gait speed, an indicator of mobility, as been associated with future cognitive decline in older adults (Mielke, et al., 2013). Gait speed is particularly important, due to its association with survival in older adults (Studenski, et al., 2011) . Further decline in gait speed, has been pointed to as an indicator of future development of severe declines through development of dementia and Alzheimer's (Waite, et al., 2005; Aggarwal, et al., 2006).

Poorer performance in a facet of cognition, executive functioning, may predict consequences on mobility performance, such as gait speed, for healthy older adults, (Gothe, et al., 2014; Watson, et al., 2010; Ble, et al., 2005). Present studies have described that better performances in mobility are also observed in better executive functioning (Berryman, et al., 2013; Desjardins-Crépeau, et al., 2014). In a cross-sectional study of 48 older adults conducted by Berryman et al., (2013), it was determined that certain executive functioning processes were associated with faster performances in mobility tests. Individuals with faster performance in the Timed Up-and-Go (TUG) test and 10-metre maximal walking test had also fared better in the flexibility measure of the Stroop task than slower counterparts. Such findings have also been corroborated in cross-sectional study conducted by Desjardins-Crépeau et al., (2014) in a sample of 93 community-dwelling older adults. Better functional capacity, including measures of mobility, the 6-minute Walk Test (6MWT) and TUG, were associated with higher performance in assessments of executive functioning and processing speed.

The previously mentioned studies have assessed the relationship between executive function and performance in mobility tests. However, tasks of daily living consist of complex tasks which require cognitive processes in addition to appropriate mobility function. Assessing executive function separately from a mobility task (a “single-task” scenario) may not reflect situations found in everyday-living. In order to replicate this scenario, the “dual-task paradigm” is employed.

Dual-tasking assesses mobility (reflected by gait) and cognition by observing the simultaneous execution of a separate mobility and cognitive task. The dual-task paradigm has been commonly utilized in clinical and research applications to assess mobility and fall-risk (Beauchet, et al., 2009). Dual-tasking, within this context, assesses the consequence of performing of two tasks simultaneously (walking and a separate cognitively demanding task) by examining the altered execution of either task (Abernethy, 1988; Pashler, 1994). The concurrent performance of a mobility and cognitive task recreates situations which are relevant to everyday tasks for older adults. Impairment, or deterioration in these domains could lead to adverse events like falls, which may result in further complications such as severe injury (Lundin-Olsson, Nyberg, & Gustafson, 1997; Yogev-Seligmann, Hausdorff, & Giladi, 2008).

In an influential study conducted by Lundin-Olsson and colleagues (1997), the interaction between mobility and cognitive ability in elderly adults was observed within the scope of the dual-task paradigm. Fifty-eight older adult participants were observed while walking, and occasionally prompted to have a conversation. Their performance in this dual-task scenario was recorded, whether or not they had to stop walking in order to continue the prompted conversation or if they were able to continue walking while talking. For the 12 individuals who had needed to stop, 10 of this group had also recorded incidences of falls in a six-month follow up, and had also demonstrated poorer gait and slower mobility (Lundin-Olsson, Nyberg, & Gustafson, 1997). This study had observed the interaction between mobility and cognition through the use of the dual-task paradigm, determining that poorer cognition and poorer mobility were interrelated to one another. This finding relied on the premise that cognitive demands, in this instance, having a conversation, also influences demands required for continued walking (mobility performance).

The simultaneous performance of gait and a cognitive task requires divided attention and prioritization from areas of the brain associated with dual-tasking, such as prefrontal cortex and ACC. The allocation of "resources" to fuel both effective gait performance and cognitive task execution may be further affected by aforementioned structural and functional changes in the brain brought about by aging. Such changes may bring about increased dual-task decrements or dual-task "costs" as Hausdorff and colleagues (2008) have described.

In a study of 228 community-living healthy older adults, dual-task decrements (reduced performance between single-task and dual-task performance for each gait parameter) were correlated with executive function, as greater impaired executive function was associated with slower gait speed (Hausdorff, et al., 2008). Decrements in dual-task function may be related to an increased cost of utilizing cortical executive function and attentional processes for the process of walking (Montero-Odasso, et al., 2012). The relationship between impairment in cognitive performance, and the subsequent decline of mobility can be illustrated by the employment of the dual-task paradigm, when assessing executive function and gait.

The relationship of cognition and mobility domains particularly, executive function and gait, closely interrelated with one another. A relationship of physical fitness, mobility and cognition have been described, as well, through the lens of aging, and physical activity via exercise interventions. Exercise interventions, aimed at improving cognitive performance through multiple modalities, have also been described to be an effective method to improve fitness and mobility outcomes. However, the long-term effects of exercise, and more broadly physical activity, on cognition and mobility need to be fully addressed. To understand the long-term effects of exercise on cognition and mobility in older adults, this relationship must be assessed by looking at the consequences from a cessation of exercise.

6 THE EFFECT OF TRAINING CESSATION ON PHYSICAL FITNESS, MOBILITY AND COGNITION

It has been established that maintaining physical activity is an important behaviour in improving mobility and cognition (Bherer, Erickson, & Liu-Ambrose, 2013; Ballesteros, et al., 2015). An older individual may have difficulty adhering to a physical activity regimen, however, due to instances of injury, illness, lack of interest or motivation (Rhodes, et al., 1999) and a bout of inactivity, or withdrawal from a regimen may result in a period of training cessation. During this training cessation period, a process called "detraining" may occur, resulting in the partial or complete loss of training induced anatomical, physiological and performance adaptations that were obtained as a result of adherence to an exercise regimen (Mujika & Padilla, 2000)

Physiological measures such cardiorespiratory/cardiovascular fitness can decline after a cessation from a regimented physical activity (Mujika & Padilla, 2000). For example, VO_2max, has been demonstrated to decline in a short-term training cessation (4 weeks), even in individuals who originally had a significant training background and large aerobic power (Coyle, et al., 1984; Hawley, 1987). After a period of six weeks, gains in VO_2max performance in individuals without an extensive training background are completely eliminated (Mujika & Padilla, 2000). In strength/resistance parameters, a training cessation period can result in declines of muscular performance measures such as submaximal strength, maximal force and maximal power, as a meta-analysis by Bosquet and colleagues concluded (Bosquet, et al., 2013). Bosquet et al., (2013) had also observed that declines in muscular performance was greater in older adults, both male and female, (aged, > 65 years old) compared to other age groups. Greater effects of cessation were also observed in sedentary or inactive individuals, in comparison to more active counterparts, highlighting the importance of physical activity level and maintenance of exercise.

As mentioned previously, declines in physical fitness measures such as VO_2max and maximal muscle power have significance consequences to mobility. Likewise, considering the impact of exercise interventions on cognitive performance, a thorough understanding of the long-term effects after an exercise intervention has yet to be elucidated. Currently, the effects of a training cessation on mobility and cognition have not been studied extensively, however, the following section will describe the current literature on this topic.

6.1 Recent Study on Training Cessation and Mobility and Cognition in Older Adults

A study by Marshall and Berg (2010) examined the effect of a 12-week exercise cessation period in between a 36-week exercise programme, on the functional mobility of a small sample of 25 'High Functioning' (HF – individuals who could walk independently) or 'Low-Functioning' (LF – individuals who required a walking aid) older adults. Mobility for HF individuals was assessed by the 2 Minute Walking Test and gait speed. Examining specifically HF older adults, following the exercise-training period, their mobility (measured by gait speed and the 2 Minute Walking Test) had improved in contrast to the LF group, however these gains had deteriorated following the exercise cessation (Marshall & Berg, 2010). HF individuals had walked an average of 10 meters less over 2 minutes and had walked 0.07 m/s slower in mobility tests at the end of their 12-week cessation period. LF individuals had attained no improvement in mobility (assessed by the Physiotherapy Functional Mobility Profile and assessments of activities in daily living) after the first exercise program, however their measures of mobility had also declined after 12 weeks of training cessation (Marshall & Berg, 2010).

Interestingly, in their small sample of individuals, Marshall and Berg had also described a difficulty with maintaining adherence to the prescribed exercise program in the study for LF individuals, which, as mentioned before, is a cause of concern for maintaining benefits from exercise interventions. While this study examines institutionalized older adults, results pointing to mobility declines after cessation could be relevant to understanding the effect of cessations on community-dwelling older adults as well.

In light of this information regarding losses to physiological and mobility benefits in response to a training cessation period, the relationship between mobility declines and cognitive performance after a training cessation need to be elucidated. Training cessation effects have been assessed in a clinical population of older adults with mild cognitive impairment (MCI), a precursor stage to condition associated with cognitive deterioration such as Alzheimer's disease (Sacco, et al., 2016). Sacco et. al., assessed the effects of a 3-month cessation period after the implementation of an aerobic exercise or combined aerobic exercise-cognitive enrichment program. The executive function of inhibition was amongst the assessed cognitive measures, and had in both intervention groups. However, during the training cessation period, at a 1-month post intervention cognitive assessment, benefit to inhibition performance had returned to baseline performance levels.

Impacts on executive function has also been studied in healthy older populations, albeit with differing results. Recently, another study conducted by Eggenberger and colleagues (2015) examined cognitive domains including executive function, among others, in 47 older adults (aged 70 and up) without cognitive impairments, 1 year after the conclusion of a program, consisting of either virtual reality video game dancing, treadmill walking or treadmill walking with verbal memory training (Eggenberger, et al., 2015). Their findings indicated that improvements to executive function, while at rest, at the conclusion of the program were maintained in all training groups 1 year after the study had ended. This is significant because

Eggenberger et al., were able to demonstrate improvements of executive functions could be maintained or even improved upon despite a cessation period of 1 year (Eggenberger, et al., 2015). This finding yielded an important discovery regarding the performance of cognitive functions in older adults, after a training cessation has occurred. This study had also integrated multiple types of exercise interventions, addressing the notion that multiple pathways may exist to improve cognitive performance.

While findings from the study conducted by Eggenberger et al., are promising with relation to executive function after a training cessation period, they lack the appropriate context within the dual-task paradigm and its relation to mobility. This is due to their assessment of executive function, the Trail-Making-Test Part B, is conducted in a single task condition, and not while performing a mobility task like walking (Eggenberger, et al., 2015). As referred to earlier, dual-task performance is important to understanding underlying cognitive processes and its relationship to proper mobility, as demonstrated by the increased likelihood of falls and impaired gait performance in older adults with poorer cognitive function (Lundin-Olsson, Nyberg, & Gustafson, 1997; Hausdorff, et al., 2008).

7 SUMMARY

In conclusion, aging process plays an important role in the relationship between physical fitness, mobility and cognitive performance in older adults. Specific parameters of aerobic and neuromuscular fitness and the cognitive domain of executive function are involved with mobility. However, declines in fitness and cognitive measures, due to aging, may negatively impact mobility. Physical activity has been proposed as an approach to provide beneficial outcomes. To study the effects of physical activity, exercise interventions have been utilized in present study.

To seek improvement and/or prevent declines in mobility and cognitive performance in the older adult population, the current body of knowledge points to the use of exercise interventions. Existing research also points to multiple types of intervention methodology aimed at improving different facets of physical fitness. Multiple ranges of exercise interventions, focusing on a variety of fitness parameters from aerobic fitness interventions aimed at improving cardiovascular fitness, to resistance and strength-focused exercise focusing on improving neuromuscular parameters, have been demonstrated to be effective. Recently, the employment of less intensive general motor skills training has also been demonstrated to induce a positive effect to cognition. The beneficial nature of exercise on cognitive performance has been established, however the question of long term benefit and maintenance of improvements remain.

The additional challenge of adherence to an exercise program leads to questions about the long term effects of exercise after periods of training cessation. While the negative effects of training cessation are well known, with respect to aerobic and strength measures of fitness, there is currently a paucity of knowledge on the effects of training cessations from exercise interventions on cognitive measures. It is therefore imperative to continue to study the implications of a training cessation period on cognition. Unlike the aforementioned study described by Eggenberger, et al. (2015), in order to understand the impacts of training cessations on the relationship between mobility and cognitive performance, the dual task paradigm must be used to examine interaction between gait and executive function, within the appropriate context.

In the current literature, the dual-task paradigm has not been assessed within the context of training cessations, cognition and mobility. The effect of training cessations on parameters of aerobic and neuromuscular strength are well-studied, yet the impacts on cognitive performance must be explored, through a dual-task context. Therefore, the following investigation has assessed the effects of training cessation on cognitive performance and mobility within the scope of the dual-task paradigm. This study has also assessed the effects of training from different exercise interventions, understanding the variety of exercise interventions which produce benefit, while also addressing the consequences of cessations from different programs. Within the dual-task context, and applying the perspective of training cessation from multiple types of exercise interventions, this study is a unique investigation into the relationship between executive function and mobility in older adults.

8 Research Questions

The general objective of this investigation was to assess the impact of an 8-week cessation period after different types of exercise interventions (upper body strength and aerobic training, lower body strength and aerobic training, and general motor skills training). More precisely, the purpose of this study was to (1) determine if training cessation periods lead to a loss of benefits to cognitive performance (executive function as measured by the Random Number Generation test) in single-task and, (2) if these losses are observed in dual-task condition. We also sought to (3) determine if there is a relationship between changes in mobility (as measured by the Timed Up-and-Go Test, 10-metre maximal walking test, and six-minute walk test) and changes in cognitive performance, in dual-task condition; and (4) determine if there is an association between effects of cessation and type of intervention employed.

9 HYPOTHESES

We hypothesized that training associated benefits to cognitive performance, during the single-task condition will be maintained after the training cessation. These benefits to cognition gained from pre to post-intervention, when assessed in dual-task condition, would be lost after the cessation period. These losses in performance, in dual-task, would also be associated with decreased performance in mobility tests (Timed Up-and-Go Test, 10 metre-maximal walking test, and six-minute walk test). We had also hypothesized that each exercise intervention would elicit the same outcomes in cognitive performance and mobility, in single and dual-task, for pre to post-intervention, as well as after the cessation period.

10 METHODS

The following is an overview of the protocol originally employed in an intervention study conducted at the Laboratoire d'Étude de la Santé Cognitive des Aînés (LESCA), under the supervision of principal investigator Dr. Louis Bherer and Dr. Nicolas Berryman.

Study Design and Participants

This study design consisted of an 8-week training protocol including three 60-minute sessions weekly, for a total of 24 training sessions conducted at the Centre de Recherche

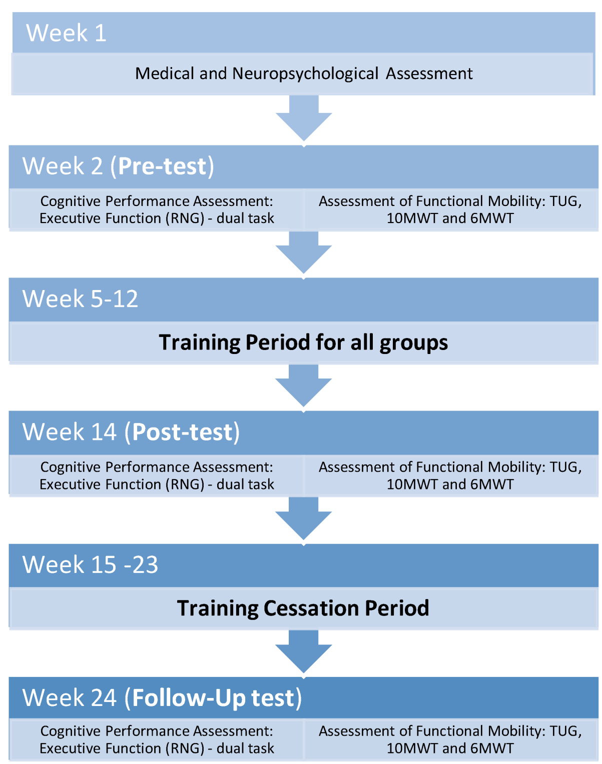

FIGURE 1: STUDY TIMELINE

l'Institut Universitaire de Montréal (CRIUGM). Each session had lasted approximately 60 minutes. Prior to the start of the training program, participants were required to undergo a geriatric assessment and neuropsychological battery of tests. To determine effects of the intervention on primary outcomes of cognition and mobility, participants were also required to complete a cognitive and functional mobility assessment, and the same assessments were conducted after the 8-week training period. To assess effects of the training cessation, cognitive and functional mobility was also assessed at an 8-week follow-up after the completion of the training program. An overview of study design and flow is presented in Figure 1.

Admission Criteria and Screening Process

Subjects who were considered for the study, were aged between 60 and 85 years old. Participants were excluded from the program if they were taking medication which would have had an effect on cognitive performance, gait and balance (benzodiazepines, neuroleptics and antidepressants). Participants were not included in the study if they were diagnosed with significant health (orthopaedic, neurological, cardiovascular or respiratory) conditions. If there was a diagnosis of a progressive somatic of psychiatric disease, these conditions would also be grounds for exclusion from the study. If participants were also treated with general anaesthesia 6 months prior to the beginning of the study, have impaired mobility (for example, using walking aids), suffer from movement disorders, epilepsy or experience serious visual and/or hearing impairment, they were also excluded from the study. In addition to medical and physical conditions, participants were to be excluded if they smoked cigarettes or ingested 10mg of nicotine a day, consumed higher than accepted amounts of alcohol (if ingested greater than 2 glasses/day for women or 3/day for men,) or engaged in alcohol or drug abuse. An assessment of cognitive ability was also conducted, using the Mini Mental State Examination (MMSE), with a minimum score of 24 out of 30 was required (Folstein, Folstein, & McHugh, 1975).

Criteria for inclusion/exclusion were assessed during a telephone screening and scheduled appointment conducted at the research center prior to the start of the training program. As part of the appointment, a neuropsychologist and geriatrician conducted separate evaluations to confirm that prospective participants were admitted into the study according to the aforementioned inclusion/exclusion criteria. In addition to these assessments, body composition measures at baseline was taken.

Geriatric Assessment

A geriatrician performed an evaluation of potential participants before they were to be officially included in the study. This evaluation consisted of five components: medical and family history, functional capacity (assessed by a questionnaire determining the ability to perform “Activities of Daily Living – ADL” and “Instrumental Activities of Daily Living – IADL”), current medication, a general overview of physiological systems, and a physical examination.

Neuropsychological Battery of Tests

As part of the neuropsychological battery of tests, global cognitive functioning (MMSE), abstract verbal reasoning (Similarities test – Weschler Adult Intelligence Scale, WAIS III), working memory (Digit Span backward/forward – WAIS III), and executive functions (Stroop Color-Word Test) were assessed pre and post-intervention.

When participants were determined to meet the criteria for inclusion into they study, they were required to read and sign a statement of informed consent. All protocol and procedures of the study were reviewed and approved by the Research Ethics Board of the Research Centre where the study had taken place. As part of the study, from pre to post-intervention, accepted participants were asked to maintain the same daily routines and eating habits. For participants who were assessed at the 8-week follow-up assessment, no requirements regarding habits or routines were made of them.

Tests and Measurements

Assessments of functional mobility and cognitive performance, conducted at the research center where this study had taken place, were taken at pre- and post-training program, as well as after an 8-week training cessation period as outlined in Figure 1.

Functional Mobility

Functional mobility was assessed, at pre, post-intervention and at the follow-up, by three separate tests: Timed Up-and-Go Test, TUG (Podsiadlo & Richardson, The timed "Up & Go": a test of basic functional mobility for frail elderly persons, 1991); 10-metre maximal walking speed, 10MWT (Berryman, et al., 2013); and the 6-minute walk test, 6MWT (Kervio, Carre, & Ville, 2003).

Timed Up-and-Go Test:

To conduct this test, participants were required to walk as fast as possible, starting from a seated position in an chair with armrests, to a pylon placed 3 metres in front of the chair. In a continuation of this movement, participants were asked to quickly turnaround the pylon while maintaining walking speed and return back to a seated position in the chair. During this test, participants were timed using a stopwatch, starting when the participant's back left the back of the chair, and stopping when the participant returned to a seated position. Participants completed two trials of the TUG, with the fastest trial used as the measure for analysis of this test.

10-metre maximal walking speed:

Participants were required to walk at their fastest possible pace (while refraining from running, both feet momentarily suspended in air) starting from a standing position to cone positioned 11 metres away. Walking time was measured over 10 metres using timing gates (TC-System, Brower Timing Systems, Draper, Utah, USA). Two trials were completed, with the fastest time recorded used in analysis.

6-Minute Walk Test:

This test consisted of participants walking continuously between two pylons placed 20 metres apart. Participants were required from one pylon to the next, at a regular walking pace, in order to cover the greatest distance possible within the allotted time of six minutes. The total distance in metres walked by the participant was measured and recorded for analysis.

Cognitive Assessment: Executive Function

Assessment of executive function (inhibition and working memory) was determined by the random number generation test (RNG) (Audiffren, Tomporowski, & Zagrodnik, 2009). This test was conducted at rest (single-task condition, ST) or while walking at a specific speed (dual-task, DT) on a treadmill. Participants were required to produce a random sequence of numbers (using numbers 1 to 9), at a pace of one number per second. The test required 100 numbers to be given by the subject for the test to be considered complete. To instruct the participants to elicit number responses in a random order, participants were asked to imagine removing randomly numbered balls from a hat. Subjects were first familiarized with the task and then were tested five times, each in a different condition (treadmill speed, or ST vs. DT condition). The first test, in the ST situation, was conducted twice (once before the DT condition and once after), while standing on a treadmill. The RNG scores for the ST condition were taken as the average of both ST tests.

The RNG was performed by participant while walking at three different experimental speeds (2.4 km/h, 4 km/h, and 5.6 km/h). on a treadmill The subjects walked for a period of 6 minutes for each different speed, with a 3-minute standing recovery period in between each trial. The DT situation of providing random sequences of numbers while walking, occurred at the fourth minute of the experimental speed, so that the subject was adequately familiarised with the walking speed. The typical time for the completion of the test, taking into account the pace of one response per second, was approximately 5 minutes and 40 seconds for each participant.

Using the randomly generated sequences that were given by participants, the RNG was assessed using six different scores, which examined the executive function domains of updating and working memory, and inhibition. Using RgCalc software (Towse & Valentine, 1997), values assessing inhibition: Turning Point Index (TPI), adjacency score (ATOT), runs score (RUNS), and assessing updating/working memory: redundancy index (R), coupon score (COUPON), and mean repetition gap (MRG), were calculated. Higher scores in TPI and MRG demonstrated improvement in these indices of inhibition and updating/working memory respectively. Lower scores in the remaining markers (ATOT, RUNS, R and COUPON) demonstrated better performance (Audiffren , Tomporowski, & Zagrodnik, 2009)

In instances where a subject gives a response with a strategy of counting (i.e. exhibiting difficulty in inhibiting counting, rather than provide a ‘random’ sequence), the sequence given by the subject will be characterized by a TPI score of less than 100%, a high RUNS score and a high ATOT score (Audiffren, Tomporowski, & Zagrodnik, 2009). If a subject tends to be repetitive in responses (i.e. exhibit difficulty with updating working memory), there will be a higher R, higher COUPON and lower MRG (Audiffren, Tomporowski, & Zagrodnik, 2009). Further detail regarding RNG scores, interpretation and range of values is presented in Table 1.

TABLE 1: DESCRIPTION OF RANDOM GENERATION TEST SCORES AT SINGLE-TASK AND DUAL-TASK (AUDIFFREN , TOMPOROWSKI, & ZAGRODNIK, 2009)

RNG Measure	Executive Function	Description	Range of Values	Improvement/ Impairment
TPI	Inhibition	The ratio between the observed number of turning points (change between ascending and descending series of numbers) within this sequence and an expected theoretical distribution* of random responses is calculated. Ascending sequences (i.e. "2,5,7') Descending sequences (i.e. "8,4,2") $\mathrm{TPI} = \frac{number\ of observed\ turning\ points}{\frac{2}{3} * N - 2} * 100$ *Theoretical distribution of 2/3*(N – 2) responses, where N is the number of random numbers.	0 - 150	Improvement: Higher Score Impairment: Lower Score
ATOT	Inhibition	The number of ascending (i.e. "4,5") or descending pairs (i.e. "8,7") of adjacent ciphers in random sequence given by the subject $\mathrm{ATOT} = \frac{number\ of\ pairs\ of\ adjacent\ ciphers}{number\ of\ pairs\ (adj\ or\ des)} * 100$	0 - 100	Improvement: Lower Score Impairment: Higher Score
RUNS	Inhibition	An index of the variability of ascending or descending successive runs of numbers. From the set of random numbers provided by the subject, the amount of responses given in successive ascending and descending runs is determined. RUNS will be the variance of these numbers. RUNS is calculated by determining the length of each run in the sequence of N ciphers and then calculating the variance of these length of runs. $\mathrm{RUNS} = \frac{\sum_{i=1}^{k} L_i^2 - \frac{(\sum_{i=1}^{k} L_i)^2}{k}}{k} * 100$ k = number of runs up (including runs of 1 number) L_i = length of runs up i	0 – 6.82	Improvement: Lower Score Impairment: Higher Score
R	Updating/ Working Memory	The ratio between the amount of variety of responses provided by the subject and the maximum total amount of variety in responses possible. $\mathrm{RUNS} = \left(1 - \frac{\log_2 N - \frac{1}{N} * (\sum_{i=1}^{a} \eta_i * \log_2 \eta_i)}{\log_2 a}\right) * 100$ N = number of responses given by participant η_i = frequency of occurrence of response, i a = number of response alternatives (i.e. 9)	0 - 100	Improvement: Lower Score Impairment: Higher Score
COUPON	Updating/ Working Memory	The number of responses given by the subject before all the response alternatives have been given	9 - 100	Improvement: Lower Score Impairment: Higher Score
MRG	Updating/Wor king Memory	The average number of responses given, in between the successive occurrence of the same digit (gap). A gap represents the number of digits between two occurrences of the same digit $\mathrm{MRG} = \frac{\sum_{i=1}^{a} g_{ij}}{\sum_{i=1}^{a} G_i}$ G_i = number of gaps for digit i g_{ij} = gap between occurrences j-1 and j a = number of response alternatives (i.e. 9)	1 - 9	Improvement: Higher Score Impairment: Lower Score

Training Programs

After the first appointment at the Research Center, accepted participants were randomly assorted into one of two combined strength and aerobic training programs: combined Upper Body Strength and Aerobic training (UBS+A), combined Lower Body Strength and Aerobic training (LBS+A); or a General Motor Skills (GMS) training program (Figure 2).

All training groups (UBS+A, LBS+A, and GMS) required participants to attend three sessions per week (Monday, Day 1; Wednesday, Day 2; and Friday, Day 3) for a total training period of 8-weeks. Each session (24 in total) was approximately 60 minutes. Training sessions for each group were supervised and led by a graduate student in kinesiology. All sessions would begin with the same warm-up program and then would be followed by the specific activity pertaining to the training group. For UBS+A and LBS+A groups, strength-based exercises were completed first, before the completion of the aerobic training component.

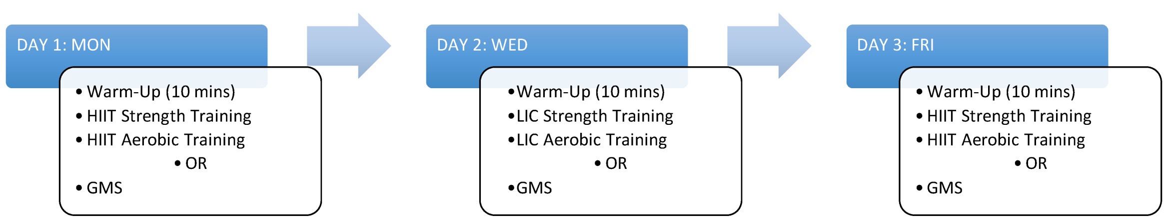

FIGURE 2: TRAINING SCHEDULE

Warm-Up

For the warm-up period, exercise using one of three ergometers (recumbent bike, elliptical or treadmill) would occur for 10 minutes. Participants were given instruction as to which ergometers were to be used for each session. After 10 minutes on an ergometer, both the UBS+A and LBS+A group would continue performing a specific warm-up which required light strength exercises. UBS+A required pushing and pull movements with elastic bands, while LBS+A would proceed with chair stands. The GMS group would differ from these two groups by moving straight to their main activities directly after the ergometer exercise.

Strength Training

For both the UBS+A and LBS+A groups, participants were required to complete four rounds of circuit training that began with exercises focusing on strength development (4-8 RM, repetition maximal) followed by exercises focusing on strength endurance development (12-20 RM), at corresponding stations. A training session would consist of four rounds of a two- to three-station circuit of these different exercises. Rest periods in between stations (approximately 30 seconds) was the time had elapsed while moving from one station to another. At the culmination of one round of a circuit, a further rest period of 2 minutes was allotted.

UBS+A group:

Two different types of training sessions were prescribed on alternating days. Day 1 and Day 2 would alternate between Monday, Wednesday and Friday. Twelve sessions were dedicated to seated chest presses and lateral/frontal shoulder abduction exercises (Day 1). Twelve other sessions were dedicated to wrist flexion, seated horizontal rowing and external shoulder rotation exercises (Day 2). Further detail for the training schedule and prescription is described in Table 2.

LBS+A group:

On days 1 and 3, leg press and plantar flexion exercises utilizing body weight (for a total of 16 sessions), were prescribed on the same day, while leg flexion exercises were performed on alternating days (12 sessions). Hip extension exercises were used on day 2 only (8 sessions in total). Exercise prescription and schedule is described in Table 3.

All strength training procedure, prescription of specific exercises and training volume were performed while observing ACSM guidelines regarding strength development for older adult populations (ACSM, 1998).

Table 2: Lower Body Strength (LBS) Training Schedule

Day 1	Day 2	Day 3
Leg Press (Machine Assisted) 4 – 6 RM (4 Sets)	Leg Extension/Flexion – Alternate each day (Machine Assisted) 6 – 8 RM (4 Sets)	Leg Press (Machine Assisted) 4 – 6 RM (4 Sets)
Leg Extension/Flexion –Alternate each day (Machine Assisted) 6 – 8 RM (4 Sets)	Unilateral Hip Extension (Body Weight) 12 repetitions (4 Sets)	Leg Extension/Flexion –Alternate each day (Machine Assisted) 6 – 8 RM (4 Sets)
Standing Plantar Flexion (Body Weight) Week 1 & 4: bilateral stance Week 5 & 8: unilateral stance 20 repetitions (4 Sets)		Standing Plantar Flexion (Body Weight) Week 1- 4: bilateral stance Week 5 - 8: unilateral stance 20 repetitions (4 Sets)

Rest between stations: approx. 30 seconds
Rest between circuit: 2 minutes

RM: Repetition Maximum

Table 3: Upper Body Strength (UBS) Training Schedule

Day 1	Day 2
Seated Chest Press (Machine Assisted) 4 – 6 RM (4 Sets)	Horizontal Rowing (Machine Assisted) 4 – 6 RM (4 Sets)
Shoulder Frontal/Lateral Abductions (Free Weights) 20 RM (4 Sets)	Shoulder External Rotations –Alternate each day (Machine Assisted) 12 repetitions (4 Sets)
Wrist Flexion (Body Weight) 12 RM (4 Sets)	

Rest between stations: approx. 30 seconds
Rest between circuit: 2 minutes

RM: Repetition Maximum

Aerobic Training

For both the UBS+A and LBS+A groups, aerobic training consisted of two different types of exercise regimen. For one day out of the week, participants were required to cycle continuously on a recumbent ergometer (LifeFitness, Kinequip, St-Hubert, Quebec, Canada) for 20 minutes. Participants were first instructed to cycle at 60% intensity for 4 weeks, and then at 60% for the following weeks. Bookending this low intensity continuous (LIC) cycle exercise session, was aerobic training consisting of a high intensity interval training (HIIT) regimen for the other sessions in the week. Participants were required to undergo 15-second periods of cycling at an intensity corresponding to their MAP determined during the incremental bike test. A 15-second "active" recovery period followed, consisting of continued cycling at an intensity of 60% of the participant's MAP.

At each training session, participants had performed two sets of this interval training. Each set had consisted of 2 to 3.5 minutes of intensive cycling at their respective MAP's. In between these sets, a "passive" recovery period of 5 minutes was given. Further detail into the aerobic training schedule, exercise prescription and intensity is presented in Table 4.

Table 4: Aerobic Training Schedule

Week	Volume
5 & 9	10 Repetitions (2 Sets)
6 & 10	12 Repetitions (2 Sets)
7 & 11	14 Repetitions (2 Sets)
8 & 12	8 Repetitions (2 Sets)

Duration of high intensity cycling bout: 15 seconds at MAP
Duration of active recovery: 15 seconds at 60%
Duration of passive recovery: 5 minutes

General Motor Skills training

The GMS training protocol initially started with instruction requiring stretching, aimed at improving body flexibility for the participants for the first two weeks of training (six sessions). These stretching activities consisted of joint rotation and mobilization and static stretching activities. These stretching exercises were conducted in different positions, such as standing, sitting in a chair, or while on a yoga mat. Following these sessions, participants underwent exercises focused on relaxation and changing behaviour to lower the breathing rate.

For the following three weeks, training involved locomotion exercises which involved walking through obstacle courses, or moving different objects to a specific area. Other activities continued to similar stretching, relaxation and breathing exercises as previously mentioned. For the final three weeks of training, participants started training with exercises focusing on ball manipulation, i.e. juggling, throwing at a fixed target, within the context of small games. These last sessions would then transition to the previous activities conducted three and five weeks prior (locomotion, stretching and relaxation focus).

Statistical Analyses

Baseline differences of patient characteristics, RNG scores and mobility tests (TUG, 10MWT and 6MWT) were assessed with one-way ANOVAs. Differences between the number of each sex (a categorical variable), amongst each group was determined with a Chi^2 test. Training-related effects on RNG and mobility performance were analysed using two-way analysis of variance (ANOVA) with repeated measures on the time factor (pre-, post-intervention and follow-up). The magnitude of the observed differences on the time factor was assessed for each group by Hedges g (Dupuy, et al., 2014). Using the scale proposed by Cohen (Cohen, 1988), the magnitude of the effect was considered small ($0.2 < ES \leq 0.5$), moderate ($0.5 < ES \leq 0.8$), or large ($ES > 0.8$). If there were significant interactions found, relative differences ((post-pre)/pre*100) and (follow-up – post/post*100) between measurement times were compared between groups using one-way ANOVAs. When one-way ANOVAs were found to be significant ($p < 0.05$), post-hoc analyses using the Bonferroni test were conducted.

Pearson's correlations coefficients (r) were also computed to verify the association between relative change in performance in RNG and mobility tests between the pre-post, and post-to follow-up assessments. We considered a correlation over 0.90 as very, between 0.70 and 0.89 as high and between 0.50 and 0.69 as moderate (Munro, 1997). Statistical analyses were conducted using IBM SPSS Statistics Software, version 23.0 (IBM Corp., Armonk NY, USA). The threshold for significance, for all analyses, was set at $p < 0.05$.

11 RESULTS

As described in Fig. 2, participants were randomized into three experimental groups. Participants' educational and cognitive (MMSE) characteristics and number of medications at baseline are presented in Table 4. Participants who had completed the training program, and follow-up had demonstrated high compliance during training, attending 96.9% (+/- 4) of all training sessions. From 51 individuals initially enrolled, 40 participants completed pre, post, and follow-up assessments (21.5% attrition) and were included in final analysis. Six participants dropped out prior to post assessments, and 5 participants dropped out prior to follow-up (Fig. 3). The attrition rate due to dropouts fell within the acceptable range for randomized controlled trials (Jackson & Waters, 2005), therefore selection bias was not considered.

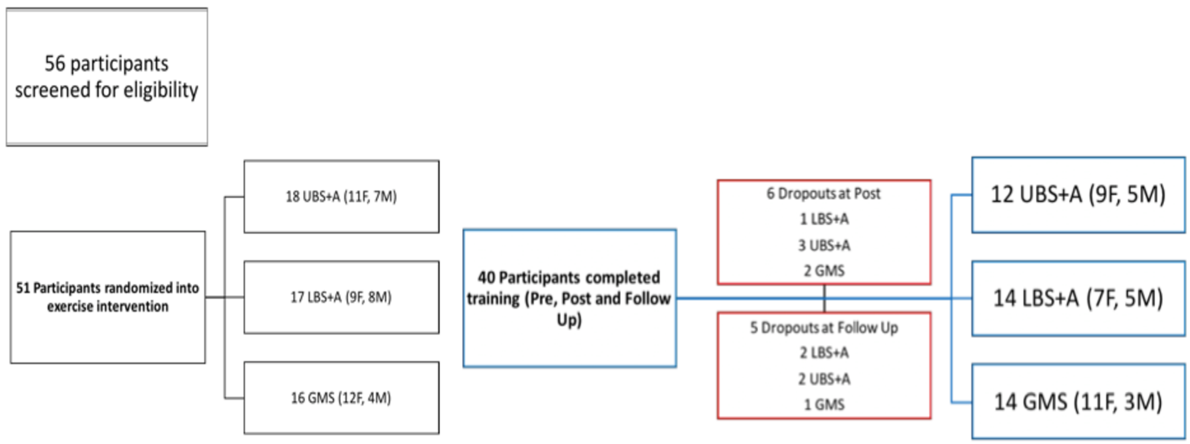

FIGURE 3: PARTICIPANT FLOW CHART 1

No significant differences were observed between groups for sex, age, years of education, MMSE score, body mass index (BMI), weight (in kg) and number of medications (Table 5). However, participants in GMS group had significantly lower ($p < 0.05$) VO_2Max in comparison to LBS+A and UBS+A groups at baseline. Average VO_2Max in all three groups were higher than the threshold of 20 ml/kg per min, below which physical function in adults aged 65 and older, is impacted by poor fitness level (Cress and Meyer, 2003). The average BMI for GMS (26.5 kg/m^2) and UBS+A (25.4 kg/m^2) participants were considered overweight (25.0 kg/m^2 – 29.9 kg/m^2), while the average BMI for participants in the LBS+A group fell within the normal weight range, 18.5 kg/m^2 – 24.9 kg/m^2 (NHLBI, 1998).

Table 5: Characteristics of Participants at Baseline

General	LBS+A	UBS+A	GMS
N	14	12	14
Sex (number of females/males)	9/5	7/5	11/3
Age (years)	69.6 (3.7)	70.1 (6.7)	71.7 (1.6)
VO_2Max (ml/kg/min)	25.8 (3.5)*$^{0.015}$	25.6 (6.0)*$^{0.025}$	20.5 (4.5)
BMI (kg/m^2)	24.2 (2.5)	25.4 (2.5)	26.5 (5.0)
Weight (kg)	62.9 (9.3)	65.7 (9.7)	66.9 (11.9)
MMSE – score/30	29.2 (1.0)	28.4 (0.9)	28.8 (1.3)
Number of Medications	3.92 (3.6)	3.25 (3.1)	4.5 (2.0)
Education (years)	15.4 (3.5)	14.7 (2.6)	14.2 (3.1)

Data are reported as "Mean (SD)" or number of participants
UBS+A - Upper Body Strength and Aerobic, LBS+A - Lower Body Strength and Aerobic training, GMS - General Motor Skills
**p* value, different at baseline from

Functional Mobility Tests

Table 6 presents the performance of functional mobility tests, TUG, 10MWT and 6MWT at pre, post and follow-up assessments.

Significant group differences ($p < 0.05$) were observed at baseline, with faster speeds performed by LBS+A vs. GMS in the TUG and the 10MWT. In addition, LBS+A participants walked further than GMS participants in the 6MWT at baseline. A general effect of time ($p < 0.05$) was observed for TUG, 10MWT, and 6MWT. However, no interaction was observed, indicating similar changes across time between groups.

In the 10MWT, all groups demonstrated faster performances from pre to post-intervention ($p < 0.001$; $g = -0.20$, -0.55 and -0.36 for LBS+A, UBS+A and GMS, respectively). At follow-up, 10MWT performances had remained improved in comparison to pre-intervention ($p < 0.001$, $g = -0.42$, -0.68, -0.46 for LBS+A, UBS+A and GMS, respectively). For the TUG, performances had improved pre to post ($p = 0.02$; $g = -0.26$, -0.24 and -0.18 for LBS+A, UBS+A and GMS, respectively). Performances at follow-up, however, returned to speeds observed at pre-intervention. In the 6MWT, all groups walked further at post-intervention in comparison to pre-intervention ($p < 0.001$; $g = 0.23$, 0.49 and 0.19 for LBS+A, UBS+A and GMS, respectively). The performances at follow-up remained improved in comparison to pre-intervention ($p < 0.001$; $g = 0.31$, 0.38, and 0.33 for LBS+A, UBS+A and GMS, respectively).

Table 6: Functional Mobility

	LBS+A (n=14)			UBS+A (n=12)			GMS (n=14)		
	Pre	Post	Follow-Up	Pre	Post	Follow-Up	Pre	Post	Follow-Up
TUG (s) a0.02	5.1 (0.6)*0.01	4.9 (0.6)	5.2 (0.6)	5.4 (0.7)	5.2 (0.6)	5.2 (0.7)	6.1 (1.1)	5.9 (0.9)	6.0 (1.0)
10MWT (s) a<0.001, b<0.001	4.8 (0.6)*0.003	4.7 (0.6)	4.5 (0.6)	5.1 (0.5)	4.8 (0.6)	4.6 (0.8)	5.7 (0.8)	5.4 (0.9)	5.3 (0.8)
6MWT (m) a<0.001, b<0.001	635.6 (50.8)*0.01	648.9 (54.7)	654.8 (61.2)	580.0 (69.5)	616.7 (55.1)	608.3 (66.1)	556.6 (76.3)	572.5 (78.0)	583.1 (68.9)

Data is reported as "Mean (SD)"
TUG – Timed Up and Go, 10MWT – 10 Metre Maximal Walking Test, 6MWT – 6 Minute Walk Test
Significant change: a: Pre/Post, b: Pre/Follow-Up
(a,b)*p* value, time effect
**p* value, different at baseline from GMS

Table 7: Random Number Generation (Single Task)

	LBS+A (n=14)			UBS+A (n=12)			GMS (n=14)		
	Pre	Post	Follow-Up	Pre	Post	Follow-Up	Pre	Post	Follow-Up
Inhibition – at Rest									
TPI a0.015, b<0.001, c0.006	81.3 (13.1)	84.3 (12.3)	87.4 (10.7)	75.4 (16.6)	79.5 (14.2)	83.87 (19.4)	81.3 (17.5)	86.2 (12.2)	87.8 (13.9)
Runs	1.0 (0.4)	1.1 (0.3)	0.9 (0.3)	1.3 (0.3)	1.1 (0.4)	1.1 (0.5)	1.2 (0.6)	1.0 (0.4)	1.0 (0.3)
ATOT a<0.001, b<0.001, c0.006	38.1 (8.5)	33.2 (10.9)	31.6 (9.6)	46.4 (15.1)	40.2 (15.9)	38.4 (15.2)	36.2 (16.6)	32.5 (11.8)	28.6 (8.5)
WM – at Rest									
R b0.001, c0.004	1.7 (1.4)	1.6 (0.7)	3.0 (1)	1.5 (1.1)	2.4 (1.3)	2.2 (2.4)	1.2 (0.6)	1.0 (1.5)	1.0 (1.2)
Coupon	17.9 (4.2)	16.9 (2.0)	18.8 (0.9)	18.2 (3.4)	18.9 (5.4)	19.6 (5.8)	16.9 (3.1)	16.9 (3.7)	22.0 (13.0)
MRG	7.7 (0.6)	7.6 (0.6)	7.8 (0.7)	7.8 (0.6)	7.3 (0.9)	7.8 (0.6)	7.9 (0.5)	7.3 (0.5)	7.4 (0.6)

Data is reported as "Mean (SD)"
Indices: Runs, ATOT, R, Coupon – Lower scores indicate better performance/ TPI, Runs, ATOT – Higher scores indicate better performance
Significant change: a: Pre/Post, b: Pre/Follow-Up, c: Post/Follow-Up (a,b,c)*p* value, time effect

Cognitive Performance (RNG at single-task and dual-task)

RNG: Single-Task

Table 7 presents the performance of the RNG in single task while at pre, post and follow-up assessments. No significant differences were observed between groups at baseline.

Significant time effects ($p < 0.05$) were observed for two indices of inhibition (TPI and ATOT) and one working memory score (R). However, no interaction was observed, indicating similar changes across time between groups. TPI had improved pre-post ($p = 0.015$; $g = 0.30$, 0.23 and 0.28 for LBS+A, UBS+A and GMS respectively), and continued to improve from post to follow-up ($p = 0.006$; $g = 0.47$, 0.16 and 0.42 for LBS+A, UBS+A and GMS respectively). ATOT had improved pre-post ($p < 0.001$; $g = -0.42$, -0.31 and -0.36 for LBS+A, UBS+A and GMS respectively), and continued to improve post to follow-up ($p = 0.006$; $g = -0.57$, -0.59 and -0.05 for LBS+A, UBS+A and GMS respectively). For indices of working memory, R had demonstrated an overall decrease in performance pre- to follow-up ($p = 0.001$; $g = 0.11$, 0.34, and 0.58 for LBS+A, UBS+A and GMS respectively), with decline observed from post to follow-up ($p = 0.004$; $g = 0.32$, 0.33 and 0.45 for LBS+A, UBS+A and GMS respectively).

Table 8: Random Number Generation (Dual Task)

	LBS+A (n=14)			UBS+A (n=12)			GMS (n=14)		
	Pre	Post	Follow-Up	Pre	Post	Follow-Up	Pre	Post	Follow-Up
Inhibition – 2.4 km/h									
TPI $^{b0.002}$	80.7 (8.6)	84.0 (14.0)	84.7 (15.8)	72.2 (17.5)	75.9 (22.5)	81.2 (20.9)	82.9 (18.6)	87.1 (12.4)	89.3 (15.7)
Runs	1.2 (0.5)	1.1 (0.5)	1.2 (0.6)	1.7 (1.1)	1.5 (1.4)	1.3 (0.7)	1.2 (0.8)	1.0 (0.4)	1.0 (0.4)
ATOT $^{a<0.001, b<0.001}$	38.1 (10.4)	34 (10.1)	32.7 (12.8)	44.5 (13.2)	39.2 (16.8)	39.1 (16.8)	38.6 (15)	28.7 (9.8)	30.4 (9)
WM – 2.4 km/h									
R $^{a0.003, b0.003}$	1.3 (1.0)	1.6 (0.8)	3 (2.8)	1.5 (1.0)	2.4 (2.0)	2.2 (1.8)	1.7 (1.2)	2.4 (1.5)	2 (1.4)
Coupon	20.7 (21.0)	17.1 (2.9)	22.3 (11.9)	18.0 (3.9)	20.0 (9.3)	18.9 (9.5)	17.2 (4.6)	20.9 (9.1)	17.6 (3.9)
MRG	8.1 (0.6)	7.6 (0.8)	7.6 (0.9)	7.8 (0.9)	7.8 (1)	7.8 (0.5)	7.8 (0.8)	7.5 (0.7)	7.5 (0.7)
Inhibition – 4 km/h									
TPI $^{b0.003, c0.019}$	80.5 (11.8)	82.7 (16)	86.7 (16.7)	73.1 (18.5)	70.7 (21.4)	78.3(16.7)	80.5 (17.8)	86.9 (13.3)	87.8 (8.6)
Runs $^{a0.043, b0.002}$	1.1 (0.5)	1.2 (0.5)	1.0 (0.5)	1.7 (0.8)	1.5 (0.9)	1.3 (0.8)	1.4 (0.8)	0.8 (0.5)	0.8 (0.4)
ATOT $^{a0.048, b<0.001, c<0.001}$	37.9 (10.9)	34.2 (11.1)	29.7 (12)	44.1 (13.2)	42.8 (17.2)	35.8 (13.2)	37.5 (16.2)	32.7 (10.0)	29.2 (9.3)
WM – 4 km/h									
R $^{b=0.02}$	1.7 (0.9)	1.4 (0.8)	1.8 (1.0)	1.9 (1.1)	2 (1.3)	3 (2.4)	1.4 (0.6)	2.3 (1.5)	2.0 (1.2)
Coupon	16.7 (3.3)	16.3 (2.6)	16.9 (2.7)	20.5 (8.1)	19.9 (8.5)	20.4 (11)	17.2 (3.4)	20.5 (5.3)	20 (5.9)
MRG	7.6 (0.7)	7.8 (0.6)	7.9 (0.7)	7.8 (0.6)	7.5 (0.7)	7.4 (0.8)	7.7 (0.7)	7.4 (0.6)	7.7 (0.7)
Inhibition – 5.6 km/h									
TPI $^{b0.013}$	79.2 (13.1)	82.7 (12.3)	83.9 (10.7)	73.6 (16.6)	76.3 (14.3)	77 (19.4)	81.3 (17.5)	87.8 (12.2)	90.1 (11.1)
Runs	1.3 (0.5)	1.1 (0.4)	1.0 (0.4)	1.5 (0.8)	1.6 (1.0)	1.4 (0.6)	1.6 (1.8)	0.8 (0.3)	1.0 (0.3)
ATOT $^{a0.009, b0.001}$	38.1 (8.5)	33.2 (10.9)	31.6 (9.6)	44.3 (13.8)	38.8 (15.8)	38.3 (15.2)	36.2 (16.6)	32.5 (11.2)	28.6 (8.5)
WM – 5.6 km/h									
R $^{a0.019}$	1.5 (0.8)	1.9 (0.8)	1.9 (1.5)	1.8 (1.1)	2.6 (2.0)	1.8 (1.1)	1.7 (1.0)	1.8 (0.9)	2.0 (1.6)
Coupon	19 (4.9)	18.1 (5.0)	17.6 (5.7)	18.2 (7.4)	23.8 (20.3)	20.2 (7.9)	17.9 (5.0)	19.7 (5.4)	19.3 (5.8)
MRG $^{a0.001}$	7.7 (0.6)	7.7 (0.6)	7.8 (0.7)	7.8 (0.6)	7.3 (0.9)	7.8 (0.6)	7.9 (0.5)	7.3 (0.5)	7.4 (0.6)

Data is reported as "Mean (SD)"
Indices: Runs, ATOT, R, Coupon – Lower scores indicate better performance/ TPI, Runs, ATOT – Higher scores indicate better performance
Significant change: a: Pre/Post, b: Pre/Follow-Up, c: Post/Follow-Up
$^{(a,b,c)}p$ value, time effect

RNG: Dual-Task

Table 8 presents the performance of RNG task while walking (dual task) at three different speeds (2.4 km/h, 4 km/h, and 5.6 km/h). For all experimental conditions, no significant differences were observed between groups at baseline. Similarly, no time×group interaction was found for all walking conditions, suggesting that changes across time were equivalent no matter the intervention.

<u>*2.4 km/h*</u>

An effect of time ($p < 0.05$) was observed for two indices of inhibition TPI and ATOT. TPI demonstrated overall improvement from pre to follow-up ($p = 0.002$; $g = 0.22$, 0.43 and 0.34) (Appendix A). ATOT had demonstrated significant improvement pre to post intervention ($p < 0.001$; $g = -0.36$, -0.32 and -0.70 for LBS+A, UBS+A and GMS, respectively). In addition, ATOT demonstrated sustained improvement at follow-up compared to pre-intervention ($p < 0.001$; $g = -0.40$, -0.31, and -0.56 for LBS+A, UBS+A and GMS, respectively). A working memory score, R, had declined from pre to post ($p = 0.003$; $g = 0.31$, 0.43, 0.49 for LBS+A, UBS+A and GMS, respectively) and exhibited overall decline from pre to follow-up ($p = 0.003$; $g = 0.48$, 0.40 and 0.22 for LBS+A, UBS+A and GMS, respectively).

<u>*4 km/h*</u>

At 4 km/h, an effect of time ($p < 0.05$) was determined for all three indices of inhibition (TPI, Runs, and ATOT) and one index of WM (R) (Appendix A). TPI had demonstrated significant improvement post to follow-up for TPI ($p = 0.019$; $g = 0.41$, 0.39, and 0.22 for LBS+A, UBS+A and GMS respectively). Overall, improvement was sustained for TPI pre to follow-up ($p = 0.03$; $g = 0.07$, 0.52 and 0.57 for LBS+A, UBS+A and GMS respectively). For Runs, improvement was observed pre to post ($p = 0.043$; $g = -0.12$, -0.28 and -0.77 for LBS+A, UBS+A and GMS respectively). Improvement was retained for Runs at follow-up in comparison to pre-intervention ($p = 0.002$; $g = -0.12$, -0.19, and -0.76 for LBS+A, UBS+A and GMS respectively). Improvement was observed pre to post ($p = 0.048$; $g = -0.32$, -0.07, and -0.30 for LBS+A, UBS+A and GMS respectively) and continued post to follow-up (p < 0.001; $g = -0.36$, -0.38 and -0.34 for LBS+A, UBS+A and GMS respectively) for ATOT. Overall, improvement for

ATOT was sustained pre to follow-up ($p < 0.001$; $g = -0.67$, -0.59 and -0.56 for LBS+A, UBS+A and GMS respectively).

For measures for WM, only R exhibited significant change over the course of study. Overall, R had declined pre to follow-up ($p < 0.02$; $g = 0.07$, 0.52 and 0.57 for LBS+A, UBS+A and GMS respectively).

5.6 km/h

An effect of time ($p < 0.05$) was observed for two indices of inhibition TPI and ATOT, and two indices of WM, R and MRG (Appendix A). TPI, at 5.6 km/h, had improved significantly from pre- to follow-up ($p = 0.013$; $g = 0.39$, 0.16 and 0.48 for LBS+A, UBS+A and GMS respectively). ATOT had improved pre-post ($p = 0.009$; $g = -0.45$, -0.34 and -0.25 for LBS+A, UBS+A and GMS, respectively) and remained improved at follow-up, compared to pre ($p = 0.001$; $g = -0.67$, -0.38 and -0.48 for LBS+A, UBS+A and GMS, respectively). WM indices, R and MRG, had both exhibited significant change in performance from pre to post-intervention. R performance had declined pre to post ($p = 0.019$; $g = 0.41$, 0.39 and 0.19 for LBS+A, UBS+A and GMS respectively). MRG performance, however, actually improved pre to post ($p = 0.001$; $g = -0.11$, -0.45 and -0.38 for LBS+A, UBS+A and GMS respectively).

Correlational Analysis

For the purposes of determining an association between change in mobility performance (TUG, 10MWT and 6MWT) and change in dual-task performance (indices of inhibition and working memory of the RNG), a correlational analysis of change in these measures pre-post and post to follow-up was conducted. For the majority of measures of inhibition and WM, no correlations were observed between pre-post changes of performance in all mobility tests, and pre-post change of RNG measures at while walking (2.4 km/h, 4 km/h and 5.6 km/h). However, ATOT (pre to post change) reported a negative correlation with TUG, $r(38) = -0.31$, $p = 0.049$, a negative correlation with 10MWT, $r(38) = -0.35$, $p = 0.026$), at 2.4 km/h and 5.6 km/h respectively. No correlation was observed post to follow-up (the cessation period), between the change in performance of the inhibition and working memory RNG indices (at all walking speeds) and change in performance of mobility tests. Further description of Pearson correlations of percentage change in performance in RNG indices, at all walking speeds, and change in performance of mobility tests can be found in Appendix B.

12 DISCUSSION

As previously stated, the main objective of this investigation was to assess the impact of an 8-week cessation period after different types of exercise interventions (upper body strength and aerobic training, lower body strength and aerobic training, and general motor skills training).

As part of this objective, we had sought to determine if a training cessation period lead to a loss of improvement in executive function performance in both a single-task and dual-task condition. In accordance with our first hypothesis, improvements in certain inhibition measures (TPI and ATOT) of the RNG were sustained or even improved upon, after a cessation period in the single-task condition. The caveat to sustained/improved measures of inhibition after cessation was that working memory/updating indices did not improve or sustain improvement through the course of study. In fact, one measure of working memory/updating, R had actually declined through the course of the intervention and cessation.

The specific improvement of inhibition performance and physical activity has been described in previous study. Generally, the relationship between the level of physical activity and inhibition had been examined by Hillman et al. (2006). Assessing inhibition using a modified Eriksen flanker task, their results had determined that greater accuracy in the task was related to self-reported physical activity. Additionally, this relationship was observed only in older adults, rather than younger adults in the study. The selective nature of the relationship of physical activity, physical fitness parameters and inhibition has also been described in the literature (Boucard, et al., 2012). Boucard, et al. (2012), had examined cardiovascular fitness (VO_2max) levels, physical activity level, and performance in inhibition and working memory in a cross-sectional study, using the RNG test amongst, in single-task, other executive function tests. Their results, from a sample of young adults (18-28 years), young-old adults (60-70 years) and old adults (71-81 years), observed that higher physical activity levels had also occurred in individuals with better inhibition performance, but interestingly, only observed in the old adults group. This benefit was mediated by higher cardiovascular fitness. This relationship between physical activity level and working memory was, however, not significant.

Our study had also observed a selective improvement of inhibition in single-task condition, after the culmination of each exercise intervention. Therefore, it appears that the exercise interventions employed in our study, as a method to simulate "controlled" physical activity, were successful in providing benefit, and indeed it appears these benefits can also extend past an 8-week training cessation period. The mediating effect of physical activity and fitness on cognition was explored by Hotting et al. (2012), within the context of exercise interventions and training cessation periods. Hotting et al., utilized a one-year follow up and determined that cardiovascular fitness was proposed as a mediator for retention of benefit to cognition (Hotting, Schauenburg, & Roder, 2012). A sample of 25 subjects (aged 42 to 57), participated in six months of cycling, or stretching and coordination training, and both groups demonstrated improvement in selective attention, and verbal learning and memory. At the one-year follow-up period however, these benefits were only retained in "high" cardiovascular fit subjects, rather than low-fit participants. These two studies raise further question in the length of cessation observed and the mediating effects of physical fitness measures on cognitive performance after cessation.

Our findings of maintenance or improvement of executive functioning in single-task was also observed by Eggenberger et al. (2015), which had assessed cognitive performance after a follow-up period of one year. As mentioned previously, Eggenberger et al. conducted a six-month RCT, with 89 subjects participating in cognitive+physical training (virtual reality video game dancing or treadmill walking and concurrent verbal memory training) or treadmill walking group. Cognitive performance of the participants was assessed at baseline, three months into the intervention, at the end of the intervention (at six months) and one year after the end of the training program. Executive functioning (TMT-B), and specifically working memory (Executive Control Task) were among the domains of cognition examined. The training regimen, for each group, had consisted of two 1-hour long sessions per week over the six-month period. Moreover, participants of each group were given strength and balance training, in addition to their training program. Effectively, all participants were completing a strength and aerobic (walking on treadmill) training, with variations on the cognitive task performed during training. Ultimately, 47 participants had concluded the training program and follow-up assessment. Their performance in TMT-B (executive function – shifting attention) had continued to improve from the end of the intervention to the one-year follow-up, in all groups. Improvements made to working memory, as tested by their Executive Control Task, were also maintained, across all groups.

These findings, also yielded from single-task condition, coincide with our results but also diverge in certain aspects. The performance of these executive functions was maintained, or even showed improvement, even though the length of cessation was much longer than the period of eight weeks which we utilized. Both physical and cognitive+physical interventions retained benefits cognitive performance improvements after the one-year cessation period. Unlike our results, however, the virtual dance and treadmill walking group, working memory had also improved and maintained performance, which Eggenberger et al., had attributed this benefit to the cognitively enhancing portions of the training program. The performance of dual-tasking, cognitive+physical training in this context, during an intervention may explain the greater global benefit to executive function observed and maintained, as opposed to the selective benefit to inhibition elicited in our study. Multiple physical training methods and a cognitive training component could be a factor in eliciting broader improvement and maintenance of executive functions, than those seen in our study.

While the advantages of cognitive+physical training are apparent, improvement to cognitive functions and retention has still been described after supposedly only "physical" interventions, as demonstrated in our study and Eggenberger et al (2015). It could be postulated that physical multicomponent interventions, without an explicit cognitive component, may still contain some degree of intrinsic cognitive training.

Though our study did not explicitly combine a cognitive task with physical training, the types of interventions (LBS+A, UBS+A and GMS), may have provided cognitive stimulation due to the multicomponent nature of the interventions themselves. GMS training, for example, involved movement requiring coordination and spatial navigation (juggling and obstacle navigation were apart of the training regimen). These tasks involve the acquisition and performance of complex motor skills that employ multiple higher order cognitive processes (Voelcker-Rehage et al., 2011) which could point to an intrinsic cognitive training component. For the LBS+A and UBS+A interventions, repetitive and learned coordinated movement are components of both the strength and aerobic aspects of the training, specifically with respect to the body weight and non-machine assisted exercises. Developing the motor skills necessary to perform multiple types of exercises in LBS+A and UBS+A groups, and therefore the implied use of cognitive processes, could be an example of how these interventions contain an intrinsic cognitive training component. In order to assess intrinsic cognitive training characteristics of physical training, the complexity and cognitive demands of the type of intervention (i.e. simple tasks vs. complex movement, repetitive vs. varying regimens) study should be taken into account.

With respect to the maintenance of improvement in cognitive function, this result may also be a product of a longer duration of training itself. Hotting et al. (2012), and Eggenberger et al. (2015), had both utilized six-month training interventions with twice-weekly sessions, in comparison to our eight-week intervention. An intriguing question raised, in comparison to our shorter intervention and cessation, is the effect of training duration, frequency and length of training cessation on the retention of benefit, and the length of time that benefit can be observed. Answering these questions may provide a better understanding of the dose-response relationship regarding exercise and cognitive performance.

The simultaneous cognitive+physical training programs used by Eggenberger et al. (2015), was an interesting component, however their assessment of executive function was only examined in a single-task condition. Considering the relative importance of dual-tasking and executive function performance within in this context in particular, our study was unique in assessing this performance in this condition. In the dual-task condition studied (performance of RNG test walking speeds at 2.4 km/h, 4 km/h and 5.6 km/h), the results were contrary to our hypothesis that dual-task improvements after an exercise intervention would be lost after cessation. At each walking speed, improvements to at least two indices of inhibition were observed. Specifically, at the walking speed of 4 km/h, all indices of inhibition maintained benefits gained through the intervention, in comparison to baseline performance. Indeed, TPI and ATOT had appeared to continue to improve after the culmination of the intervention. These improvements to executive function were as similarly selective as the single-task condition. Working memory indices had either not changed through the course of the study, or had declined in performance (R), with the exception of MRG at 5.6 km/h. The retention or improved benefit of inhibition performance in dual-task was a novel finding of our study. Our study is the first, to our knowledge, to assess this relationship within context of cessation after different interventions. While previous study has described the multiplicity of exercise interventions, in imparting benefits to cognitive performance (Berryman, et al., 2014; Voelcker-Rehage, Godde,

& Staudinger, 2011; Forte, et al., 2013), our study has been among the first to examine the long-term effects to cognitive performance in dual-task conditions, by examining performances after cessation.

The maintenance or improvement of dual-tasking performance could be an expression of cognitive adaptation elicited by the exercise interventions used. Though physiological benefits to aerobic and neuromuscular fitness may be lost due to detraining during a cessation period, LBS+A, UBS+A and GMS interventions may have imparted benefit through other underlying mechanisms. Aerobic and strength training has been associated several processes which may elicit mechanisms associated with neuroplasticity and ultimately improved cognitive performance. Strength and aerobic training components of the LBS+A and UBS+A training programs could induce long-term improvement to executive function through neuro-motor, cognitive, vascular and neurological pathways. For example, strength and aerobic exercise has been associated with an increased expression of brain-derived neurotrophic factor (BDNF), a neurotrophin that has been proposed to be involved with neurogenesis and neural development and functioning (Knaepen, et al., 2010). Strength exercises have also been demonstrated to increase vascularization, allowing for increased blood flow and transport of essential nutrients to the brain (Gorelick, et al., 2011). The exercise interventions employed may induce physiological and neurobiological changes which underlie maintenance or continued improvement in certain facets of executive functioning. These effects may also persist past the detraining effects on physical fitness measures. We can only infer that these mechanisms have imparted selective benefit to inhibition, therefore future study should examine these neurobiological and physiological pathways in the context of cessation effects on executive function in single and dual-task.

Another objective of our study was to observe the relationship of cessation-related change in executive function in dual-task, and functional mobility. With relation to our hypothesis, that losses in dual-task condition executive function would be related to a decline in functional mobility (as measured by the TUG, 10MWT and 6MWT), our results were also not in accordance. As previously stated, sustained or continued benefit was observed for inhibition measures, and mobility had also maintained improvement (10MWT and 6MWT) or returned to baseline performance (TUG). Correlational analysis of all relative change in indices of inhibition and working memory/updating had revealed that were was no relationship between the magnitude of change in executive function and the magnitude of change in mobility performance after the end of training to the end of the cessation period (post-assessment to follow-up). Likewise, for pre to post change in performance, only measure of inhibition, ATOT, while walking at 2.4 km/h and 5.6 km/h demonstrated significant relationship with mobility tests TUG and 10MWT, respectively (Appendix B). These results do not indicate a broader overall relationship between change in inhibition performance and change in mobility performance. These findings are peculiar considering the close relationship of executive function processes and performance in mobility tests utilized in our study (Donoghue, et al., 2012; Ferreira, et al., 2015). For example, the TUG, a complex task which involves turning, and transfer rom a seated position to walking, involves multiple cognitive domains. Such tasks involve planning and execution of task-directed behaviours, which are central to executive function (Donoghue, et al., 2012). It is possible that indices of inhibition as measured by the RNG, which had maintained or improved, may not be sensitive to performances to the TUG.

The 6MWT, has also been associated with inhibition and working memory (Ferreira, et al., 2015). However, its maintenance of improvement could also be tied to potential limitation of our study, which may also influence cognitive performances. Maintenance of performance in this test could be caused by maintained cardiovascular fitness or muscular strength, however, as mentioned previously, detraining effects, due to cessation, would diminish physical fitness benefits attained through training (Bosquet, et al., 2013; Coyle, et al., 1984). Therefore, it could be assumed that participants remained active at greater levels than at baseline at the culmination of the study. In the previously mentioned study by Hotting et al. (2012), physical exercise self-efficacy, an important predictor of continued physical activity, was positively correlated with hours of participation in a sport activity. Hotting et al. had posited that highly structured exercise program may mediate greater self-efficacy, and therefore continued participation in physical activity would lead maintained physical fitness. A maintenance of physical activity could explain the resilience or continued improvement of not only mobility performances, but also executive functioning.

Our final objective was to also observe if the effects of cessation were caused by the specific type of exercise intervention employed. All changes observed in dual-task and single-task, for inhibition and working memory/updating, after the intervention and after cessation were consistent across all exercise groups. Interestingly, performances in all mobility tests had also changed similarly in each training group. This finding was in accordance with our hypothesis of that improvement and level of change in executive function would occur in despite different training modalities in single-task, as observed by Forte et al. (2013), and Berryman et al. (2014).

Berryman et al. (2014) and Forte et al. (2013), had both described improved performance in indices of inhibition of the RNG after the culmination of different exercise interventions, which was reaffirmed in our study. It also appears that continued change during cessation is also not mediated by the type of intervention used. Therefore, it can be assumed that benefits to cognition that are retained or improved upon are not conditional on the type of intervention, which suggests a broad applicability of exercise for sustaining long-term cognitive benefit.

The performances in functional mobility had also been demonstrated to change regardless of intervention type in the study by Forte et al (2013), and this finding was also observed in our study. Indeed, we had also observed a pre to post improvement in maximal walking speed (10 MWT) that was similar for all different training groups, which had also been described by Forte et al. (2013). Like inhibition indices, it appears that maintenance of performance in certain mobility tests are not dependent on exercise type. Despite, LBS+A focusing on lower extremities, which would provide muscular strength and power advantages for walking, it does not appear to have had a more influential effect on walking tasks, 10MWT and 6MWT.

While our study was novel in its approach and findings, several limitations are to be acknowledged. Firstly, the relatively small sample size of this study could explain the lack of time x group differences in performance on RNG indices and mobility tests with relation to our hypothesis concerning effects of differing interventions. However, we are confident that our findings are representative of training and cessation related effects on executive function. Regarding our examination of the effect of exercise interventions for pre-post comparisons, significant benefit to cognition is observed in studies with similar or smaller sample size (N= 42, Forte, et al., 2013; N=32, Fabre, et al, 2002). The number of studies assessing of the effect of training cessation on cognitive performance is few, but previously discussed studies have similar sample sizes at follow-up (N=47, Eggenberger et al., 2015; N=25, Hotting et al., 2012). Our observations of training related effects on mobility and inhibition indices of RNG, in particular, corroborate with the findings of previous studies (Forte, et al., 2013; Berryman, et al., 2013). The maintenance and/or improvement of executive functions has also been described (Eggenberger, et al., 2015; Hotting et al., 2012), though the long-term on effects executive function needs to be elucidated. Pertaining to the test of executive function, the RNG test, a general learning effect of the RNG in the single-task and dual-task condition may be another shortcoming attributed to this study. This occurrence can not be pointed to in our study, however, as previous literature has described that a practice effect does not affect the RNG test (Towse & Valentine, 1997; Audiffren, Tomporowski, & Zagrodnik, 2009).

The nature of the training cessation period itself is also of concern regarding our study. Our study, while it assesses performance of specific cognitive and mobility measures *after* cessation, does not determine the level of physical activity *during* cessation. Participants were not told to maintain a certain level of physical activity or not to participate in their own self-directed exercise regimens. The levels of physical activity during this cessation period was also not recorded. While participants may have continued their own regimen, the specific advantage of participating in the exercise intervention with regular adherence and increasing intensity while being directed by a professional, is not to be discounted. Future studies studying the effect of a training cessation on cognition and mobility should consider the level of physical activity during this period. Providing direction, such as suspending strict exercise regimens, or recording physical activity levels during cessation, would provide a more complete picture of how cessation may mediate changes.

Our investigation has demonstrated that selective benefits to executive function (inhibition), gained after an exercise intervention, can be sustained or further improve after a cessation period of eight weeks. Improvements in tests of functional mobility (10MWT and 6MWT) can also be sustained after a cessation period as well. These effects can be elicited regardless of the type of intervention employed prior to the cessation period. Indeed, the specific benefits to executive function can be observed in both single-task and dual-task conditions. These findings highlight the diversity of methodology that is effective in improving cognitive performance in older adults, and the potential long-term benefit that such interventions can confer. The aforementioned limitations to our study can also provide direction for future investigations to provide a better understanding of the impact of training cessation. As mentioned before, monitoring or defining activity during cessation, a shortcoming in our study, is essential to understanding cessation-related effects more completely. Furthermore, while knowledge of cessation related effects on physical fitness parameters (ex. VO_2max and muscular strength) has been described in previous literature, our study has not assessed these specific parameters and their relationship to cognitive performance. Future study should examine the context of training and cessation-related effects on specific physical fitness parameters when assessing cognitive and mobility performance. A more complete picture of effect to cognitive performance and mobility performance could be provided with additional information on cessation-related effects to physical fitness parameters.

Additionally, future investigation should consider how potential physiological and neurobiological changes, along with how change at the structural and functional level of the brain, are impacted by cessation. Research into biomarkers associated with improved cognitive function (ex. BDNF), and activity and morphology at brain-level (ex. activity in prefrontal cortex, and white matter volume in the frontal cortex) is needed. For example, a recent study by Aflini, et al., (2016) had examined the effects of detraining after a 10 day cessation period in master athletes (adults aged ≥ 50 years, with a history of endurance training ≥ 15 years). Their findings had discovered a decrease in cerebral blood flow in specific brain regions, such as bilateral regions of the hippocampus, were responsive to the cessation period. This approach could be applied to more sedentary older adults, and after a longer cessation period, to assess change or lack thereof at brain level, and relationship to cognitive and mobility performance. Future studies may include aspects of neuroimaging, along with including neurological and physiological parameters to provide understanding of the specific underlying mechanisms which cause the maintenance/improvement of cognitive performance after cessation, or lack thereof.

This study has been a novel foray into understanding the long-term effects of exercise interventions on cognitive performance and mobility, with a unique focus on dual-tasking, a condition very relevant to everyday living for older adults. Our findings point to a potential for resilience in certain facets of executive function, in both single-task and dual-task condition. Indeed, we also describe that such retention of training-related benefits to executive function and mobility is not exclusive to a a specific type of exercise interventions. However, further research is needed to elucidate the extent of mediation that physical fitness measures have on retention or improvement of benefit. Furthermore, further study is required to determine the extent of the relationship on executive function and mobility performance, and physical activity levels during cessation, to provide better context of our findings. Finally, future study should also examine the physiological and neurological mechanisms which underlie the loss or retention of cognitive benefits post-cessation.

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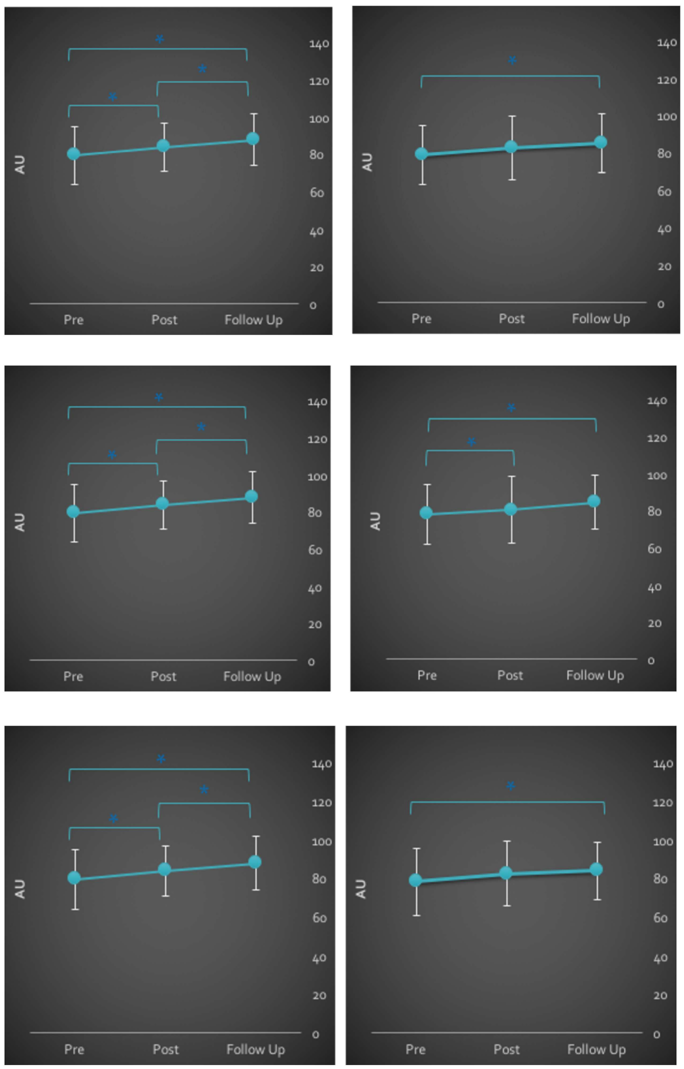
14 Appendix A

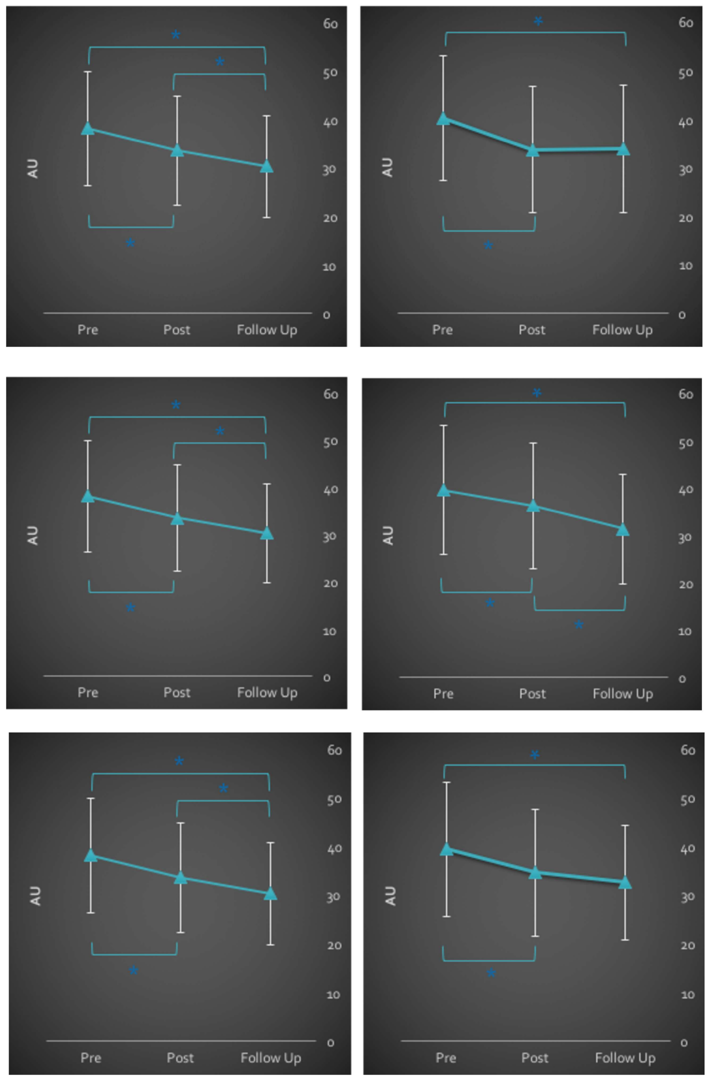
1. Mean Score TPI (of all groups: LBS+A, UBS+A and GMS) of TPI Single-Task and Dual-Task (at 2.4 km h^{-1}, 4 km h^{-1}. 5.6 km h^{-1}) condition at Pre, Post and Follow-Up.

Single Task Dual Task



2. Mean Score (of all groups: LBS+A, UBS+A and GMS) of ATOT in Single-Task and Dual-Task (at 2.4 km h^{-1}, 4 km h^{-1}. 5.6 km h^{-1}) condition at Pre, Post and Follow-Up.

Single Task Dual Task

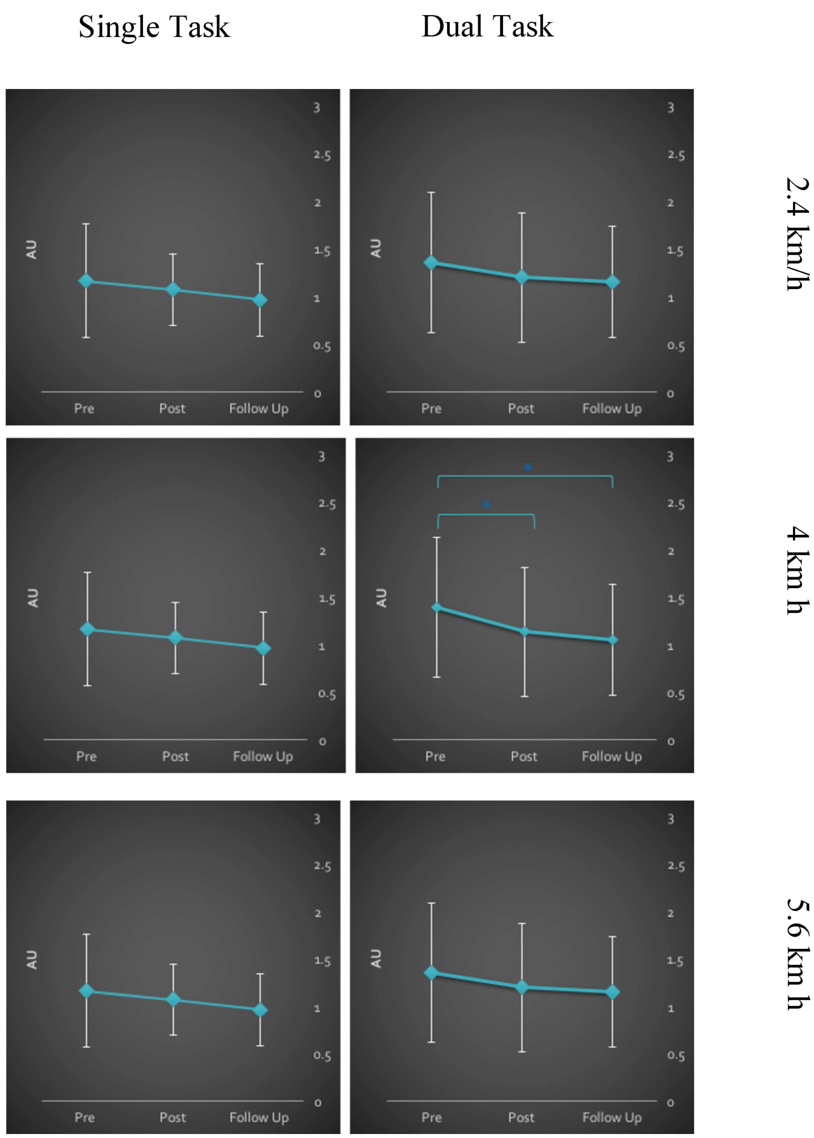


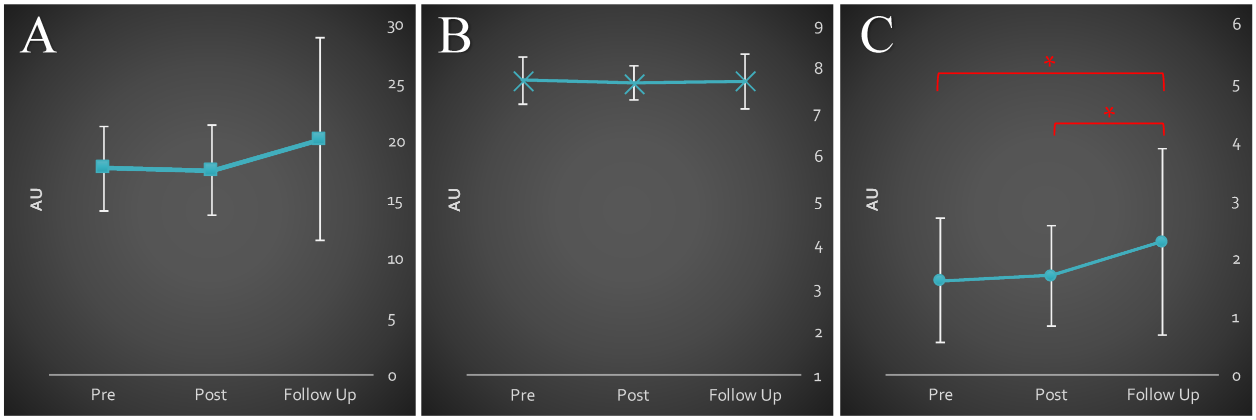
2.4 km h

4 km h

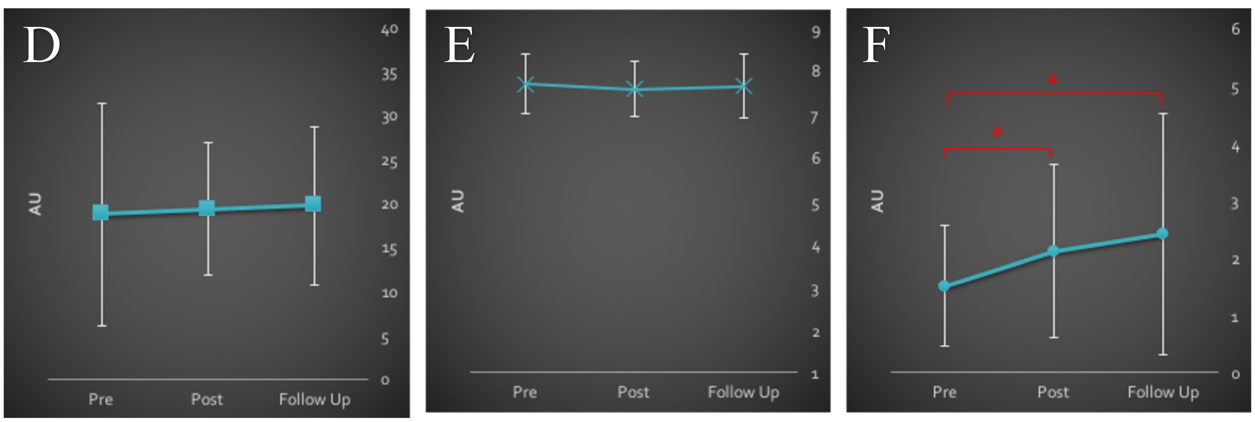
5.6 km h

3. Mean Score (of all groups: LBS+A, UBS+A and GMS) of Runs in Single-Task and Dual-Task (at 2.4 km h^{-1}, 4 km h^{-1}. 5.6 km h^{-1}) condition at Pre, Post and Follow-Up.

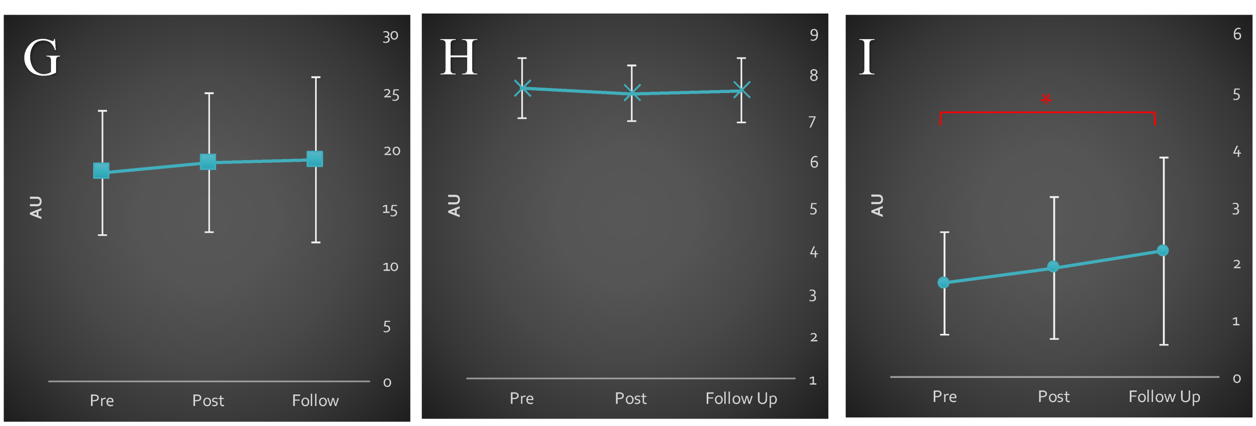




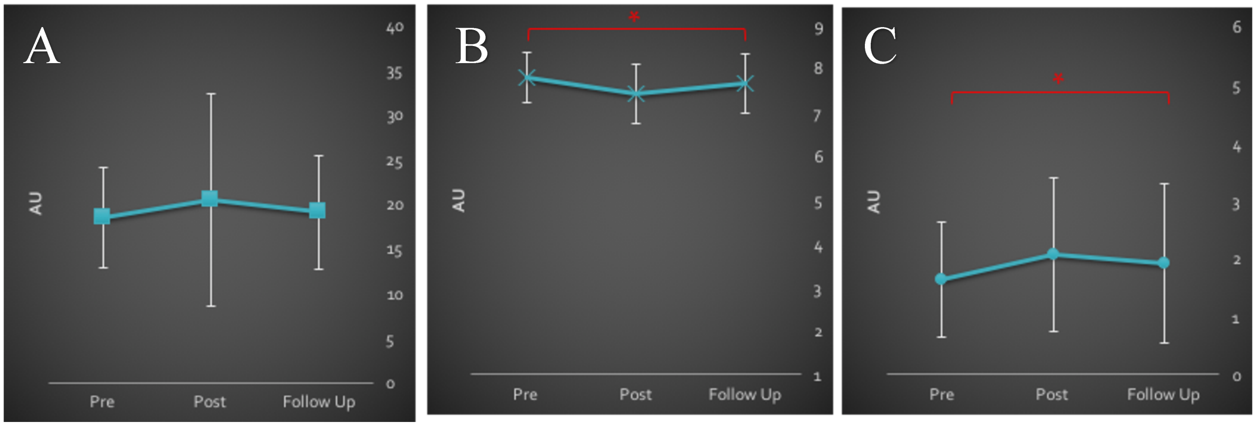
4. Mean Performance of Working Memory/Updating RNG indices, Coupon (A), MRG (B) and R (C), +/- SD in Single Task at Pre, Post and Follow-Up.



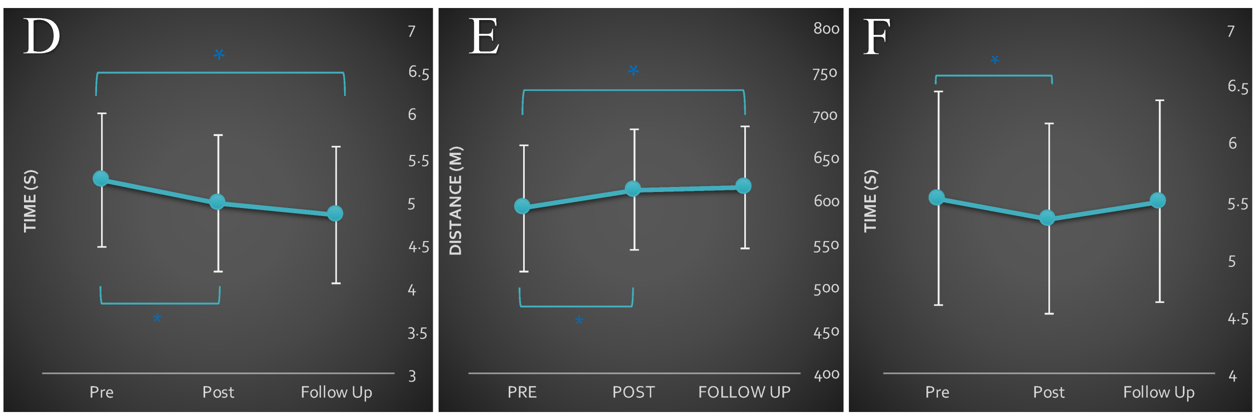
5. Mean Performance of Working Memory/Updating RNG indices, Coupon (D), MRG (E) and R (F), +/- SD in Dual Task (2.4 km/h) at Pre, Post and Follow-Up.



6. Mean Performance of Working Memory/Updating RNG indices, Coupon (G), MRG (H) and R (I), +/- SD at Pre, Post and Follow-Up.



7. Mean Performance of Working Memory/Updating RNG indices, Coupon (A), MRG (B) and R (C), +/- SD in Dual Task (5.6 km/h) at Pre, Post and Follow-Up.



8. Mean Performance +/- SD (LBS+A, UBS+A and GMS) of 10MWT (D), 6MWT (E) and TUG (F) at Pre, Post and Follow-Up.

15 APPENDIX B

Table of Correlations

Table 9: Percentage Change (Pre to Post) in Performance of Mobility Tests and RNG Indices at 2.4 km h^{-1}: Pearson Correlations

Table 10: Percentage Change (Post to Follow Up) in Performance of Mobility Tests and RNG Indices at 2.5 km h^{-1}: Pearson Correlations

Table 11: Percentage Change (Pre to Post) in Performance of Mobility Tests and RNG Indices at 2.4 km h^{-1}: Pearson Correlations

Table 12: Percentage Change (Post to Follow Up) in Performance of Mobility Tests and RNG Indices at 4 km h^{-1}: Pearson Correlations

Table 13: Percentage Change (Pre to Post) in Performance of Mobility Tests and RNG Indices at 5.6 km h^{-1}: Pearson Correlations

Table 14: Percentage Change (Post to Follow Up) in Performance of Mobility Tests and RNG Indices at 5.6 km h^{-1}: Pearson Correlations

Table 15: Percentage Change (Pre to Post) in Performance of Mobility Tests and RNG Indices at Rest: Pearson Correlations

Table 16: Percentage Change (Post to Follow Up) in Performance of Mobility Tests and RNG Indices at Rest: Pearson Correlations

Table 9: Percentage Change (Pre to Post) in Performance of Mobility Tests and RNG Indices at 2.4 km h^{-1}: Pearson Correlations

Pre/Post Percentage Change:	TUG	10MWT	6MWT
TPI	0.25	0.08	-0.19
RUNS	0.08	0.11	-0.02
ATOT	-0.31*0.049	0.06	0.27
R	0.20	-0.10	0.11
Coupon	0.31	0.14	-0.15
MRG	0.11	-0.16	0.04

**p* Correlation is significant at the 0.05 level (2-tailed).

Table 10: Percentage Change (Post to Follow Up) in Performance of Mobility Tests and RNG Indices at 2.4 km h^{-1}: Pearson Correlations

Pre/Post Percentage Change:	TUG	10MWT	6MWT
TPI	-0.15	-0.01	-0.06
RUNS	-0.13	0.03	-0.16
ATOT	-0.04	0.14	-0.18
R	-0.15	-0.05	0.05
Coupon	0.12	-0.14	0.26
MRG	0.12	-0.28	-0.11

**p* Correlation is significant at the 0.05 level (2-tailed).

Table 11: Percentage Change (Pre to Post) in Performance of Mobility Tests and RNG Indices at 4 km h^{-1}: Pearson Correlations

Pre/Post Percentage Change:	TUG	10MWT	6MWT
TPI	-0.15	-0.01	-0.06
RUNS	-0.13	0.03	-0.16
ATOT	-0.04	0.14	-0.18
R	-0.20	0.06	0.09
Coupon	0.31	0.07	-0.29
MRG	-0.08	0.11	0.06

**p* Correlation is significant at the 0.05 level (2-tailed).

Table 12: Percentage Change (Post to Follow Up) in Performance of Mobility Tests and RNG Indices at 4 km h^{-1}: Pearson Correlations

Post/Follow Up Percentage Change:	TUG	10MWT	6MWT
TPI	-0.15	-0.01	-0.06
RUNS	-0.13	0.03	-0.16
ATOT	-0.06	0.14	-0.18
R	-0.19	0.06	0.09
Coupon	0.31	0.07	-0.29
MRG	-0.08	0.11	0.06

**p* Correlation is significant at the 0.05 level (2-tailed).

Table 13: Percentage Change (Pre to Post) in Performance of Mobility Tests and RNG Indices at 5.6 km h^{-1}: Pearson Correlations

Pre/Post Percentage Change:	TUG	10MWT	6MWT
TPI	0.11	0.31	-0.04
RUNS	-0.06	0.22	0.04
ATOT	-0.06	-0.35*0.026	-0.08
R	-0.09	0.22	0.08
Coupon	0.01	0.10	0.07
MRG	-0.14	0.03	-0.11

**p* Correlation is significant at the 0.05 level (2-tailed).

Table 14: Percentage Change (Post to Follow Up) in Performance of Mobility Tests and RNG Indices at 5.6 km h^{-1}: Pearson Correlations

Post/Follow Up Percentage Change:	TUG	10MWT	6MWT
TPI	-0.10	-0.29	-0.08
RUNS	0.29	0.01	-0.09
ATOT	0.09	0.12	-0.14
R	-0.19	-0.12	0.02
Coupon	-0.39*	-0.05	0.10
MRG	0.17	-0.09	-0.22

**p* Correlation is significant at the 0.05 level (2-tailed).