COMPARISON OF DUAL-TASK BALANCE AND POWER TRAINING IN OLDER ADULTS

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Abstract: The purpose of this study was to compare the effects of power training and dual-task balance training on single (ST) and dual-task (DT) condition postural sway and functionality, power, quality of life, confidence, and executive function. Participants were randomly assigned to a high-velocity (HV, n=5), dual-task (DT, n=9), or control (CG, n=8) group. The HV group trained at 40% 1RM in 5 different lower extremity exercises. The DT performed cognitive and physical tasks simultaneously. Both groups trained twice a week for 30 minutes over 16 weeks. Every 4 weeks, participants were tested on the Short Physical Performance Battery (SPPB) and Tekscan HR Mat System™ under ST and DT conditions, Activities-Specific Balance Confidence Scale (ABC), RAND-36, power, and Trail-Making Tests (TMT) parts A and B. Participants were tested t 4 weeks detraining. No significant group x time interactions occurred in average power ($F_{(5, 21)} = 1.52$, p=.21), peak power ($F_{(5, 21)}$= .33, p=0.75), average velocity ($F_{(5, 19)}$ = 1.61, p=.18), peak velocity ($F_{(5, 19)}$= 1.86, p=.09), confidence, ($F_{10, 21}$=1.64, p=.20), quality of life (QoL; $F_{10, 21}$=1.87, p=.18), TMT-A ($F_{8, 19}$=.81, p=.54) or B ($F_{8, 21}$=1.59, p=.23), SPPB single-task (ST; $F_{10, 19}$=1.25, p=.67) or DT scores ($F_{10, 21}$=1.71, p=.11), ST($F_{8, 20}$=0.69, p=.70) or DT ($F_{8, 20}$=1.48, p=.19) gait speed times or ST ($F_{8, 15}$=1.10, p=.37) or DT ($F_{8, 17}$=1.10, p=.37) chair stand times. A group x time interaction occurred for ML sway between the HV group and the DT ($F_{(8, 20)}$ = 1.61, p=.04). Meaningful improvements were seen in physical function among all groups, while the HV group experienced the greatest improvements in velocity and executive function. The DT group improved more on self-perceived outcomes of quality of life and balance-confidence, while the CG group experienced the greatest changes in DT outcomes. This could be due to less priority given to the cognitive task in this group. Further research should examine changes in perceived outcomes following DT training and executive function following HV training.

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CHAPTER I

INTRODUCTION

Significance

In 2012, unintentional injury was the seventh leading cause of death, with falls accounting for 24,190 (54.1%) of these mortalities in adults age 65 and over (CDC, 2012). Furthermore, hip fracture incidents result in a 12%-20% mortality rate among the afflicted (Riggs & Melton, 1986). Non-fatal injuries from falls consisted of 2,422,775 incidents. These incidents are estimated to have cost $30 billion dollars (Stevens, Corso, Finkelstein, & Miller, 2006), placing a financial burden on society, as well as the one in three adults over 65 who fall per year. These numbers become even more worrisome as those over age 65 are expected to increase to 16.3% of United States population by 2020, with one-third to one-half being disabled (CDC, 2012).

Aside from financial and mortality costs, falls also impair the ability to perform activities of daily living (ADLs; Cyarto, Brown, Marshall, & Trost, 2008). Furthermore, 33% of community dwelling older adults over age 65 fall annually, with 50% falling more than once. This rate may increase by as much as 60% with increasing age (Rubenstein, 2006). Routine daily activities account for 75% of falls. Indicators associated with future falls include gait and balance abnormalities (Brewer, Ciolek, Delaune, Newton, & Williams, 2007), postural instability (Wrisley, & Kumar, 2010), muscular weakness, aerobic capacity, flexibility (Edelberg, 2001), and fear of falling (Brewer et al., 2007). To mitigate the high costs and detrimental physiological impacts of falls, it is imperative to identify fall prevention protocols (Pamukoff, Haakonssen, Zaccaria, Madigan, Miller, & marsh, 2014) that are cost-effective (Melzer & Oddsson, 2012; Hruda et al., 2010). Successful aging includes the ability to independently complete ADL activities, such as stair-climbing, sitting to standing, lifting, and walking (Hazell, Kenno, & Jakobit, 2007). Maintaining this ability should be the highest priority for older adults (Hruda et al., 2003).

While aerobic capacity may be weakly associated with physical performance in older adults (Bean et al, 2010), researchers have concluded that exercise alone reduces falls effectively when a comprehensive program specifically including balance and strength training for at least 12 weeks is implemented (Costello & Edelstein, 2008). A review by Power & Clifford (2013) suggests training programs of approximately 16 weeks were more successful in reducing falls (Power & Clifford, 2013). Practicing balance-specific exercises has shown improvements in stability and dynamic balance (Wolfson et al., 1996) and a slowing of balance deficits and gait instabilities (Orr et al., 2006). More recently, dual-task training (DT), or training under conditions which require the individual to complete a motor and secondary task simultaneously, such as walking and memory recall (Venema et al., 2013), has been utilized as an effective training tool to improve gait speed (Silsupadol et al., 2006). There is strong evidence balance and gait activities require cognitive resources (Venema et al., 2013), however, the impacts of DT training and cognitive function are not well understood (Springer, Giladi, Peretz, Yogev, Simon, & Hausdroff, 2006). Notable improvements following DT training include single and double support balance (Li et al., 2010), step-execution time, lower extremity function (Melzer & Oddson, 2012), reaction time (Bruin, Reve, & Murer, 2012) and decreased postural sway (Pellechia, 2005).

Along with balance and cognitive decline, risk factors for falls are also typically related to decreases in strength and power (Gschwind et al., 2013), specifically due to the 20% to 30% of skeletal muscle commonly lost between young adulthood and 80 years of age (Carmeli, Coleman, & Reznick, 2002; Hruda, Hicks, & McCartney, 2003). It may be of importance to maintain muscular fitness, including peak power, strength, and endurance, in order to remain functionally able and independent (de Vos et al., 2005). Along with decreases in muscle mass, declines in neuromuscular facilitation also occur (Red et al., 2008; Hruda et al., 2003). More specifically, this is caused by the cessation of innervation of type II muscle fibers due to axonal withdrawal of high-threshold α-motor neurons from the neuromuscular junction. Eventually, the type II fibers will be permanently deinervated or the lower threshold α-motor neurons will attempt apoptosis, or reinervation of these type II fibers (Bunn, 2012), causing them to embody the characteristics of a slow-twitch, type I fiber in the aging population (as cited in Deschenes, 2004)As a result of decreases in the number and size of type IIb muscle fibers (Reid et al., 2008) and number of motor neurons (Wallerstein et al, 2012), a more marked and rapid degeneration in power rather than strength typically occurs in the aging population (Reid et al, 2008). Aniansson, Zetterberg, Hedberg, & Henriksson, (1984) also reported significantly lower type II fibers in hip fracture patients when examining muscle cross-sectional area. Wallerstein and associates (2012) concluded this loss of muscle mass and strength can be combatted with power training, such as applying high-velocity movements to common exercises including the lat pull-down, leg press, and hip extension at

30%-50% 1-RM. It has been suggested that training at an accelerated rate in the concentric phase and decelerated rate during the eccentric phase would improve muscular recruitment for postural control, reduced response latency, and sensory input, therefore improving balance (Orr et al, 2006; Russ, Gregg-Cornell**,** Conaway, & Clark, 2012). Furthermore, older adults may perceive power training as an easier bout of exercise than strength training (Sayers & Gibson, 2012). Despite the aforementioned benefits, traditional strength training, requiring 2-4 sets of 8-12 reps of weight lifting for each muscle group 2-3 days per week (ACSM, 2009), is still more likely to be used and high-resistance low velocity (LV) movements in the elder population are still supported (Wallerstein et al., 2012).

Purpose

There is a need for contributions to the physical activity recommendations for community-dwelling older adults over 65 who may suffer from impaired balance, functionality, power, and cognitive function or experience low levels of life satisfaction and confidence. The purpose of this research study was to compare the effects of power training and dual-task balance training on the multi-faceted effects on single and dual-task condition postural sway and functionality, power, quality of life, confidence, and executive function.

Null Hypotheses

$H_0$1: There will be no difference in changes over time between the dual-task balance, power, and control group in peak and average power production

$H_0$2: There will be no difference in changes over time between the dual-task balance, power, and control group in peak and average velocity

$H_0$3: There will be no difference in changes over time between the dual-task balance, power, and control group in medio-lateral (ML) or anterior-posterior (AP) postural sway on the following four stances: two-feet eyes open, two-feet eyes closed, right foot eyes open, and left foot eyes open

$H_0$4: There will be no difference in changes over time between the dual-task balance, power, and control group up balance confidence.

$H_0$5: There will be no difference in changes over time between the dual-task balance, power, and control group up in quality of life.

$H_0$6: There will be no difference in changes over time between the dual-task balance, power, and control group up in executive function.

$H_0$7: There will be no difference in changes over time between the dual-task balance, power, and control group in functionality, specifically gait speed and chair stand times.

Delimitations

In order to participate in this study, individuals must:

- be over age 65
- pass the Mini Mental State Exam (MMSE) with a score of 24 or above
- be able to walk independent of assistance

Limitations

- Balance confidence and quality of life will be self-reported
- Lack of sufficient sample size to produce power
- Error rates were not counted during DT testing
- Lack of control of outside activity participation
- Some individuals could not complete chair stands without the use of hands

Assumptions

- Participants completed self-reported questionnaires honestly and accurately

- Participants performed to the best of their abilities in spite of lack of consequences during testing involving DT
- Treatment was equivalent across both retirement communities

Operational Definitions

- Dual Task was defined as "engaging in two activities at the same time" (Pellechia, 2005) and "the ability to divide one's attention between motor and secondary tasks" (Venema et al., 2013). Cognitive DT training was utilized for the present study, requiring the completion of a cognitive and postural control task simultaneously (An et al., 2014).
- Power training was defined as moving an external load as quickly as possible during the concentric contraction and slowly (over a 3 second period) during the eccentric movement of returning to the starting position.
- Quality of life was considered that as described by Pavot and Diener (1993): a conscious judgment of satisfaction with one's life. This study analyzed this construct as it related to the following self-perceived health outcomes: physical function, emotional health, energy and fatigue, well-being, social function, pain, and general health.
- Balance is the capability to maintain equilibrium while undertaking static and dynamic tasks (Melzer, Benjuya, & Kaplanski, 2004).
- Conflicting definitions of functionality exist. For the present study, functionality was defined as the ability of an individual to perform a basic task without assistance by a person or device (Gosman-Hedstrom & Svensson, 2000).

- Activities of Daily Living (ADL) are activities involving independent and personal care for oneself, such as bathing, eating, and dressing (Klein, Stone, Phillips, Gangi, & Hartman, 2002).
- Confidence, or self-efficacy, is the degree of self-reliance an individual has that will not lose their balance during an ADL (Powell & Myers, 1995).
- Postural sway is defined as the amount of distance in the ML or AP direction the participant moved from equilibrium

CHAPTER II

LITERATURE REVIEW

Balance and Resistance Training

The central nervous system (CNS) and neuromuscular system properties decline with aging due to detriments in brain volume and losses of sensory and motor neurons, impacting balance and gait performance (Orr et al., 2006). The body operates as an integrated unit of muscular and skeletal parts, attributing balance control to the ability to move and function (Oddsson, Boissy, & Melzer, 2007). Therefore, any voluntary movement will cause a disturbance to posture and influence on balance. External perturbations are instances, such as a slip or trip, initiate delayed postural responses in order to restore equilibrium (Oddsson et al., 2007). In order to combat falls and promote balance, it is necessary to determine the most effective exercise protocol for older adults.

Latham, Anderson, Bennett, & Stretton (2004) reviewed 62 randomized controlled trials (*n*=3,674), finding no significant training effects occurred following progressive resistance training in balance as measured by the Berg Balance Scale, Timed Up and Go, or holding a position for time. Furthermore, authors discovered no significant effects from resistance training (RT) on quality of life (QOL) following synthesis of the results of 10 studies on 798 participants, concluding strength training is typically only successful when combined with balance training (Latham et al., 2004).

However, changes in physical function, such as stair climbing, walking, and standing from a chair were noted by another systematic review of 33 trials (*n*=2172) by Liu & Latham (2009), supporting RT as a method to improve ADL abilities (Liu & Latham, 2009). Many studies have contrarily seen improvements in balance function after strength training. However, such studies examined balance function with tests which relied predominantly on strength. These measures may not have been purely indicative of balancing capabilities and defined balance as what some might call physical function. Furthermore, many proposed interventions involving RT are developed with expensive equipment and one-on-one monitoring, creating a great need for cost-effective programming (Melzer & Oddsson, 2012; Hruda et al., 2010; Maughan, Lowry, Frankie, & Simely-Oyen, 2012).

Balance-specific exercises are increasing in support as a means to reduce fall-related injuries and the number of falls in older adults (Melzer & Oddsson, 2012). Power & Clifford (2013) reported balance, gait, and strength training should be included in exercise programs for seniors (Power & Clifford, 2013). Some methods to enhance balance in the elderly include the utilization of external perturbations, functional tasks, and static balance tasks (Melzer & Oddsson, 2012). Effective balance-specific activities include tandem walking, static single-leg stances, toe and heel walking, weight shifting, and sit-to stand (Costello & Edelstein, 2008). Studies have revealed improvements in balance in groups training from 5 to 13 weeks ranging from one to three sessions per week lasting 20 minutes to one hour (Edelberg, 2001; Maughan et al., 2012; Melzer & Oddsson, 2012; Nelson et al., 2007; Granacher, Muehlbauer, & Gruber, 2011).

Dual-Task (DT) Balance Training

Daily tasks are seldom singular in nature. For example, it is common for people to engage in walking while performing cognitive tasks during daily life, such as holding a conversation or memory recall (Borinpuntukal et al, 2014; Venema, Bartels, & Siu, 2013; Pellechia, 2005). Attempting to walk or maintain balance in addition to a secondary task, which is often cognitive in nature, is known as dual task (DT). Conversely, single task (ST) requires focusing on a gait or postural activity alone. Evaluations under DT condition are the most common approach to examining motor performance and cognitive processing interactions (as cited in Shin, & An, 2014).

Declines in the ability to coordinate tasks are causative factors for detriments in multiple-task performance (Pellechia, 2005; Plummer-D'Amato et al., 2012; Fuller et al., 2013). Shrinkage of the prefrontal portion of the brain could significantly contribute to this decline due to it's role in multi-task managements. Theories exist with regards to this cognitive multi-tasking process that attempt to determine what method should be utilized to best address the issue of dual-tasking. One theory suggests individuals will need a sum of attentional capacity equal to the additive attentional capacity of the two tasks. However, other researchers have conclu1ded this view of two independent actions is faulty because the latter theory suggests the two tasks will integrate into a higher order skill, justifying the use of DT practice to improve DT performance (Pellechia, 2005).

Some researchers have also suggested that the provision of "diverting activities" or a physical or mental activity during or between exhaustive bouts of muscular work might enhance performance. More specifically, individuals may be able to perform a greater amount of work in a contralateral muscle group after a fatiguing bout of exercise when a diverting activity is utilized between bouts of exercise (Stock, Beck, & DeFreitas; Asmussen & Mazin, 1978). This has even occurred during blood flow disruption which negates an explanation of circulatory blood flow as the causing factor for the performance increase (Asmussen & Mazin, 1978). Stock and colleagues (2011) demonstrated that the incorporation of 3 minutes of math problems between bouts of maximal, isokinetic, concentric leg extensions can result in 100% recovery of peak torque values as opposed to a decline in peak torque when just rest is administered (Stock et al., 2011). This research suggests that diverting activities may improve performance through the enhancement in recovery.

The American College of Sports Medicine (ACSM, 2009) recommends balance training for older adults at least twice per week and further suggestions include that exercises should contain multi-task situations due to the relevance of DT performance in every daily life (Granacher, Muehlbauer, Zahner, Gollhofer & Kressing, 2011), and components of overload and progression (Oddsson et al., 2007). It has been proven that gait and balance activities require attentional capacity (Li et al, 2010), which also includes activities which challenge steady-state, proactive, and reactive domains (Granacher, Muehlbauer, Zahner, Gollhofer & Kressing, 2011).

Dual-task (DT) training has often been utilized to determine the effects of postural control on cognitive tasks, as well as cognitive tasks on postural control (Silsupadol, Siu, Shumway-Cook, & Woolacott, 2006). Measuring balance in healthy young to middle-aged adults assigned to DT, ST, or no-training groups, Pellecchia (2005) found the DT group was only able to decrease body sway scores in DT levels after training. Silsupadol and colleagues (2009) trained older adults with balance impairment under ST, DT fixed priority (equal task emphasis), or DT variable priority (alternating task emphasis between blocks) protocols. Only the variable priority group showed a significant training effect on dual-task gait speed, maintaining these improvements at the 3 month follow-up (Silsupadol et al., 2009). Another method of dual-task treatment mimics real life by requiring the navigation of obstacles in the environment, as these obstacles are often completed in combination with a cognitive task, such as talking. Plummer-D’Amato et al. (2012) suggest the use of obstacle navigation within a DT training program. The aforementioned results may indicate a lack of consensus on DT training prescriptions.

Empirical evidence demonstrates activities requiring the performance of simultaneous cognitive and physical tasks produce slower reaction times (Lajoie, Teasdale, Bard, and Fleury, 1993), and increased sway (Pellecchia, 2005). The inability to perform two tasks simultaneously may also be a significant predictor of disability (Fuller et al, 2013; Plummer-D’Amato et al, 2012). Evidence of slower gait velocity, increased stride-to-stride variability, and larger postural sway under multi-task conditions further supports the claim that insufficient ability to perform under DT conditions is predictive of disability (Li et al.,, 2010). Furthermore, individuals with slower gait speed may be more negatively impacted by DT conditions (Plummer-D’Amato, Cohen, Daee, Lawson, Lizotte, & Padilla, 2012). These difficulties could further decrease participation and increase fall risk in older adults (Plummer-D’Amato et al, 2012).

Many researchers are beginning to utilize DT training as a method to improve motor performance presumably due to the relationship between DT and fall risk (as cited in Venema, Bartels, & Siu, 2013) and evidence supporting DT as a beneficial training method (Agmon, Belza, Nguyen, Logsdon, & Kelly, 2014). While researchers have concluded DT training is an effective intervention technique, literature is limited (Pellechia, 2005; Slsupadol et al., 2006).

Dual Task Costs. Dual-task performance subtracted from ST performance is called DT costs. When performance of either task decreases, attentional capacity has likely been surpassed (Schmidt, 2000), causing a DT cost. These costs are indicative of the interference of a motor task on the singular task (Li et al, 2010). However, some researchers have concluded DT costs will decrease with an increased challenge due to lack of participant willingness to relinquish attentional resources (Doumas, Smolders, & Krampe, 2008), and it is likely these costs increase with aging (Wollacott & Shumway-Cook, 2006; Lindenberg, Marsiske, & Baltes, 2000). Exercise modalities are necessary to combat these detriments. For example, Tai-chi, specifically, may improve dual-task costs for postural and cognitive measures, though not significantly (Hall et al., 2009). It appears there is less interference under DT conditions during step execution than during the gait cycle (Melzer & Oddsson, 2012), creating an interest in research involving DT and walking patterns.

Gait Variability. Gait patterns are likely impacted by the ability to balance (Shin & An, 2014). A review of current DT research concluded multi-task exercises may be necessary to improve walking while performing another task (Granacher, Muehlbauer, Zahner, Gollhofer, & Kressig, 2011). Quick stepping ability is likely to determine fall occurrence in older adults in both ST and DT conditions with inactivity and aging as leading contributory factors to falls due to inadequate stepping responses (Melzer, Marx, & Kurz, 2009). Furthermore, step-time is negatively correlated with balance scores (*r*=-

0.47 to -0.59) and lower extremity function (*r*=-0.48 to -0.60; Melzer, Marx, & Kurz, 2009).

When considering average swing time in comparison with younger adults, older adults experience greater declines in performance under DT conditions when, though fallers are more likely to have detriments in swing-time variability than their non-faller counterparts (Springer et al., 2006). In order to compensate for the division of attentional resources, older non-fallers often decrease gait speed and swing times, while young adults typically decrease gait speed only. Elderly fallers cannot efficiently stabilize gait in DT conditions suggesting increases in gait variability may be age-related (Springer et al., 2006). In a study of DT performance on younger adults age 18-46, only the DT training group saw no changes in postural sway following training between ST and DT conditions, while the ST training group and control group saw significant detriments in performance (Pellechia, 2005). This is consistent with other research, suggesting DT costs increase with aging (Wollacott & Shumway-Cook, 2006; Lindenberg, Marsiske, & Baltes, 2000). Parkinson’s patients have similarly demonstrated improvements in step length while cognitively challenged after one 20 minute DT training session. Participants experienced increases in step length and gait speed and decreases in step length variability during DT conditions following training, but static balance, as indicated by double support time, did not significantly change. Interestingly, after count and word tasks, visuospatial performance improved, providing evidence for successful task transference when performing DT activities (Brauer & Morris, 2010). Further research uncovered meaningful improvements in step execution time by 0.19 seconds during DT conditions following a motor cognitive dual-task (MCDT) training intervention when compared with controls. Significant improvements included improvements in foot contact time and the step-initiation phase of the gait cycle under DT conditions following 24 sessions over 12 weeks (Melzer & Oddson, 2012). This is similar to significant improvements observed in step length, stride length, gait velocity, and cadence (Shin & An , 2014; Trombetti, Hars, Herrmann, Kressig, Ferrari, & Rizzoli, 2011) and gait speed and balance following DT training (Halvarsson et al., 2014).

DT conditions may also cause prolonged reaction and anticipatory adjustments phases during the gait cycle compared with ST conditions (Uemura et al., 2012). Plummer-D'Amato et al. (2012) demonstrated no differences between DT and ST performance on an obstacle course, the Timed Up-and-Go (TUG), or gait speed and no changes in DT cost. While both groups saw significant improvements in TUG and gait speed accompanied with large effect sizes, no improvements in confidence were noted. It should be noted, participants trained for four weeks, for a total of four hours (Plummer-D'Amato et al., 2012). This training time period is shorter than most other balance interventions producing significant results (Silsupadol et al., 2006; Shin & An, 2014; Melzer & Oddson, 2012). A longer period of training may yield greater positive results.

Contrary to the aforementioned research, Bruin, Reve, & Murer (2012) found no changes in gait velocity, cadence, step time, and step length following 12 weeks of balance, strength, and cognitive training. It should be noted, only 13 individuals with a high level of cognitive function as indicated by the MMSE took part in the latter study. Furthermore, the experimental group did not train cognitively and physically simultaneously as the aforementioned group did. Melzer, Marx, & Kurz (2009) documented a similar absence of improvements under DT conditions during step-execution times following exercise training not incorporating DT training. Authors observed no differences between active individuals and their sedentary counterparts during DT voluntary step execution. These findings are similar to those found by Silsupadol et al. (2006), who discovered significant changes in DT balance performance following DT training only (Silsupadol et al., 2006).

Studies combining strength and balance training add to the conflicting results. A 12-week combined strength and balance training program resulted in significant improvements in gait velocity and single support time under DT conditions in a group which completed additional cognitive-motor training via a dance video game versus just strength and balance alone. While both groups were able to achieve a significant improvement in the Falls Efficacy Scale assessment, neither were significantly different. Furthermore, anterior-posterior sway during the gait cycle increased, possibly caused by an increase in attention to walking velocity, which was significantly faster at post-test. This study supports the use of a CMDT intervention to improve performance in DT conditions (Pichierri et al., 2012). While results may provide conflicting evidence, the aforementioned research supports DT-specific training in order to produce positive impacts to multi-task walking within long-term interventions.

Executive Function. Previous research has provided evidence that gait is a complex task, utilizing executive function under DT conditions (Halvarsson et al., 2014). Executive function uses the regions of the brain which control and produce behavior to gain information from cortical sensory systems (Yogev, Hausdorff, & Giladi, 2008). It further controls attentional resources utilized for DT activities (Springer et al., 2006; Yogeve, Hausdorff, & Giladi, 2008). Consideration should be given to executive function when DT performance is of concern (Liu-Ambrose et al, 2009), especially due to the fact that the ability to perform tasks simultaneously is an early marker for dementia (Makizako et al, 2012).

Executive function and cognitive domain are significant aspects of DT capabilities. Executive function includes all the cognitive process that allow for the incorporation of multiple task completion at once, including the ability to divide attention (Springer et al, 2006). This information supports the use of DT as a means to improve the ability to allocate cognitive resources. Previous research has confirmed an increase in gait variability while attempting to divide attention between two tasks, specifically in cognitively impaired individuals (Borinpuntukal et al, 2014; Venema et al, 2013). Furthermore, by increasing the level of difficulty of the cognitive task increases gait variability, supporting executive function as an important component of fall causes (Springer et al, 2006).

Improved cognitive processing due to physical activity interventions is still considered speculative (Pichierri et al, 2012). There is strong evidence that balance and gait activities require cognitive resources (Venema et al, 2013), yet the impacts of DT training and cognitive function are not well understood (Springer, Giladi, Peretz, Yogev, Simon, & Hausdroff, 2006). Performance during DT requires cognitive allotment between two tasks indicative of efficient information processing capabilities (Shin & An, 2014). It is thought that DT training could improve DT abilities to due to improvements in neuroplasticity, thereby improving distribution and prioritization of executive function and decreasing fall risk (Bayona et al, 2005). Neuroplasticity is that which allows the brain to obtain or reacquire behaviors or accumulate and recall new experiences. The benefits of neuroplasticity are likely specific to the training type, and may be transferred into new activities (Klein & Jones, 2008). Improvements and the neogenesis of more cognitive resources could potentially provide a positive impact on many activities that require mental processing.

Much emphasis has been placed on the utilization of exercise to prevent cognitive decline. Cardiovascular training is considered an empirically supported method to improve cognitive function, specifically executive function (Lustig, Shah, Seidler, & Reuter-Lorenz, 2009), though other authors have noted the benefits did not transfer to balance under DT conditions (Melzer et al., 2009). Executive function predicts gait variability, an important component of falls risk in DT conditions (as cited in Springer et al, 2006), with lower executive function indicating increasing stride time variability and fall risk (Hausdorff et al., 2005). Research has revealed cognitive function possesses a linear relationship with DT performance during self-selecting walking speed for 6 meters and during the TUG. Cross-sectional research including 140 females with an average age of 69.6±3.0 years, demonstrated a relationship between executive function and DT gait performance. Specifically, set shifting, or switching back and forth between mental tasks, plays a significant role on walking under DT conditions. This is consistent with other research (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). However, under simple conditions, such as reciting the alphabet in order, executive function was not significantly related to DT performance during walking (Liu-Ambrose et al, 2009).

Improvements in gait speed are likewise positively correlated with increased executive function ability on the Stroop test (Liu-Ambrose et al., 2010). While

Marmeleira, Godinho, & Fernandes (2009) found no improvements in Stroop color word and Stroop interference tests following a DT balance intervention, increased processing speed and divided attention abilities did result (Marmeleira et al., 2009). However, Hiyamizu et al. (2011) discovered positive changes in Stroop task in a standing condition in a DT group over a control group. Researchers also found no significant improvements in executive function measured by the Trail Making Test (TMT; Hiyamizu et al., 2011). In an analysis of stroke patients, Donhoon et al. (2013) discovered a greater improvement in executive function measured by the TMT among a DT program utilizing both unstable surfaces and visual restriction during DT task training over DT groups utilizing only one of the aforementioned methods. The authors further emphasized the use of tasks requiring rotation of attention, separated attention, and strong attention during balancing (Donhoon et al., 2013). More specifically, frontal cognitive functioning may improve after 16 weeks of an MCDT intervention. Participants scored significantly greater on the Frontal Assessment Battery, Montreal Cognitive Assessment, and Clock Drawing Test following the program (De Andrade et al., 2013).

Tasks of increasing difficulty possess a stronger relationship with cognitive function (Liu-Ambrose et al., 2010). It has been determined that low cognitive load may not play a significant role in multi-task situations. Therefore, it may be important to train under cognitively challenging and attention demanding conditions. While the relationship between executive function and DT gait variability is well established, other parameters of physical function are not as well documented.

Physical Function. While traditional training methods of resistance and functional training improve functionality in single task conditions, little effect has been seen in DT conditions in older adults (Costello & Edelstein, 2008). When interventions focus on task-specific exercises, functional improvement and cortical reorganization may occur. These effects may not be transferred from ST to DT conditions (Bayona et al., 2005). As DT ability plays an important role in functional movement during ADLs (Shin & An, 2014), it is imperative to explore programming options to improve the body's ability to function under DT conditions.

Li and colleagues (2010) suggest the use of cognitive motor dual-task (CMDT) training unaccompanied by exercise may be sufficient to improve physical performance. This study required all participants to complete five computerized ST activities, and the experimental group to receive five extra sessions which incorporated DT training. The experimental group demonstrated greater improvements in single and double support balance via a force platform (Li et al, 2010). However, differences may be due to the extra sessions received by the DT group, and it cannot be concluded that the absence of a physical intervention produces improvements in physical performance under DT conditions. Furthermore, the physical parameters of gait speed and the Sit-to-Stand test (SST) were not significantly improved (Li et al., 2010).

Differentiating between motor dual-task (MDT), cognitive dual-task (CDT), and cognitive motor dual-task (CMDT) training, An et al. (2014) discovered that MCDT training clients experienced significantly greater improvements in functional reach (FRT) and the four square step tests (FSST) while CDT subjects did not. The combined group also scored significantly greater on the 10 meter walk. Both the CDT and MCDT groups significantly improved in the 6 min walk over the motor DT group (An et al., 2014). A convenience sample of older adults experienced similar improvements following a four month training program utilizing both motor and cognitive DT training. The intervention group experienced greater improvements in the number of TUG steps taken, 30 second sit-to-stand, and sit-and-reach test than the control group following 48 sessions, though not on the BBS (De Andrade et al., 2013). Marmeleira et al. (2009) reported significant improvements in TUG time by 3.3%. In contrast, both Yamada et al (2011) and Hiyamizu et al. (2012) observed no improvements in TUG time. Neither study confirmed changes in chair stand tests similar to research by Li et al (2010). The Yamada study participants did not experience any improvements in single leg balance tasks (Yamada, Aoyama, Hikita, et al., 2011). However, subjects in th Lajoie (2004) study saw positive changes in balance measured by the Berg Balance Score (BBS).

Researchers have further supported positive changes in reaction time (Bruin, Reve, and Murer, 2012; Marmeleira et al, 2009; Lajoie, 2004; Uemura et al, 2012), as well as self-reported lower extremity function by as much 6.8% following a CMDT program (Melzer & Oddson, 2012). Research is inconclusive and variable when evaluating DT effects (Gobbo, Bergamin, Sieverdes, Ermolao, & Zaccaria, 2014), specifically when the outcome is physical function.

Postural Sway. It is thought attentional factors are controlled by the CNS, while automatic factors are influenced by somatosensory, visual, and vestibular information (Hwang, Lee, Change, & Park, 2013). This could influence sway by creating a conflict in attentional resources during static stance tasks. A review by Gobbo et al. (2014) indicated only one study found improvements in static balance following 16 weeks of DT training, as indicated by a 1.92% improvement in medio-lateral (ML) sway. However, no changes were seen in anterior-posterior (AP) sway length. A lack of change in AP and ML sway length following 6 weeks of training three times per week (You et al., 2009), and 8 weeks (Lajoie, 2004) or 12 weeks of twice per week DT exercises (Hiyamizu et al., 2012; Lindemann et al., 2003) were discovered in similar research. You et al. (2009) reported non-significant improvements in AP and ML sway and gait velocity in a cognitive DT group (You et al., 2009) Furthermore, Hwang et al. (2013) reported a decreased amount of sway during single leg verbal DT conditions than under single leg verbal ST conditions. The same results did not hold true during nonverbal DT and ST analyses. Authors concluded an automatic response is less common in the left hemisphere which is activated by verbalization (Hwang et al., 2013). This could cause concentration on sway and balance to become a greater priority in older adults who fear falling. This has been confirmed by other research demonstrating older adults focus attention on postural control over cognitive tasks due to their fear arising from the high incidence of falls (Hwang et al., 2013). However, Morioka, Hiyamizu, & Yagi (2005) discovered postural sway may increase significantly when standing is specifically combined with a mathematical task and decrease with a motor task (Morioka et al., 2005). Due to this increased impairment during cognitive tasks, it may be important to train under these specific conditions.

Contrary to the aforementioned studies, following six weeks of training, MDT participants experienced greater improvements in postural sway compared to their ST counterparts following 6 weeks of 45 minute sessions twice per week (Shin & An, 2014). The utilization of both visual restriction and unstable surfaces during 30 minute DT training sessions produced superior improvements to postural sway in stroke patients compared with DT groups who trained solely in unstable or visionary restriction conditions. In the combined method group, center of pressure (COP) significantly improved by 5.3±1.7 cm. The two other groups experienced no significant improvements in postural sway after 24 sessions over 8 weeks. This evidence supports the method of utilizing both visually restrictive and unstable surfaces during balance training (Donghoon, Jooyeon, & Youngkeun, 2013). An et al (2014) provide further evidence of DT benefits on sway as a convenience sample of older adults significantly decreased their AP and ML postural sway compared to a control group (An et al, 2014).

Balance Confidence. A decreased ability to balance may have a substantial impact on falls risk, creating negative physical and psychological consequences (Myers, Powell, Maki, Holliday, Brawley, & Sherk, 1996), specifically a lack of physical activity participation. Gait deficits, impaired functional mobility, activity restriction, and increased falls risk are all associated with fear of falling (FoF). FoF is the self-perceived ability to perform ADLs without a fall (as cited in Uemura, Yamada, Nagai, Tanaka, Mori, & Ichichashi, 2012). Fear of falling limits activities and decreases function, but balance may provide the postural control to prevent accidents, as well as the self-assurance to keep up certain life behaviors (Kaneda, Sato, Wakabayashi, Hanai, & Nomura, 2008). As many as 10% to 55% of older adults may report a FoF , which can cause further detriment to balance capabilities due to restriction of activities (Brewer et al., 2007). While performing DT activities, those classified with FoF may also experience less balance control during gait (Uemura et al., 2012). Few studies have examined the relationship between DT performance (Liu-Ambrose et al., 2009) or gait (Donoghue, Cronin, Savva, O’Regan, & Kenny, 2013) and balance confidence.

Liu-Ambrose and colleagues (2009) discovered confidence is independently related to gait performance while talking when measured over a 40 foot distance in individuals with a mixed falling history. Furthermore, the contribution of balance confidence was experience to a greater extent than cognitive function, indicating activity can be predicted by perceived ability more than actual ability (Liu-Ambrose et al., 2009). Research has also provided evidence of an association between individuals who report FoF and inactivity with increased gait variability and and decreased gait performance under ST conditions (Rochat et al., 2008) and slower gait speed, shorter-stride length, and increased step width similarly under both ST and DT conditions (Donoghue et al., 2013). In fact, out of 57 community-dwelling older adults with an average of 79 years, 42% did not fear falling, while 58% were fall fearing. Those classed with FoF experienced longer anticipatory postural adjustment and reaction phases of the gait cycle under DT condtions (as cited in Uemura et al., 2012). These results are supported by Reelick, van Iersel, Kessels, Rikkert (2009) who discovered heightened gait variability in those walking at slower speeds in those with a fear of falling. While this fear had no impact on postural sway or cognitive performance (Reelick et al., 2009), it has also been reported to diminish cognitive resources during walking and balancing, which may have a greater impact during multi-task situations (Gage,Sleik, Polych, McKenzie, & Brown, 2003).

Limited and conflicting research exists on DT performance and balance confidence. While a four week intervention showed no improvements in balance confidence (Plummer-D’Amato et al., 2012), 12 weeks of DT training may be sufficient for exercisers to experience significant improvements in fall-related self-efficacy (Halvarsson, Franzen, & Stahle, 2014). Due to inconsistencies in results, researchers should consider balance confidence when evaluating and considering DT performance, specifically during gait (Liu-Ambrose et al., 2009).

Quality of Life (QoL). Subjects have reported high satisfaction on a 0-5 likert scale (*M*=4.7±0.5) during DT and induced perturbation exercises (Melzer & Oddsson, 2012) or described it as enjoyable (De Andrade et al., 2013). Furthermore, participants have confirmed they would recommend this DT to family or friends (Oddsson et al., 2007). However, statistical analysis of health-related quality of life (HRQoL) research is limited under DT conditions.

Rubenstein et al (2000), reported a group of fall-prone older men experienced greater QoL on the SF-36 global health outcome following 3 months of a multi-modal exercise program involving balance (Rubenstein et al., 2000) comparable to a 9 month high-intensity multi-modal program which produced improvements in SF-36 global health compared with a low-intensity home exercise group (Binder et al., 2002). Barnett, Smith, Lord, Williams, & Baumand (2003) found no improvements on the SF-36 following six months of multi-modal training (Barnett et al., 2003).

Power Training

Multiple studies suggest the importance of strengthening multiple muscle groups in the lower limbs to decrease falls risk (Costello & Edelstein, 2008). These decreases along with declines in balance and power increase fall-related risk factors. Researchers are beginning to focus on power training as an effective intervention (Fukumo et al., 2014), as it may be more optimal than strength training (Hazell et al, 2007). Granacher et al. (2011) concluded HV training is an effective method to improve strength, power, and functional outcomes, though study designs are inconsistent. More specifically, low-intensity training may improve balance to a greater extent than high-intensity. The latter has shown greater improvements in power and functionality (Granacher et al., 2011). Specifically training to activate muscles throughout the entire range of motion, focusing on a reduced speed for the eccentric phase and a quicker speed for the concentric phase, at lower loads has been revealed to possibly modify the neural pathway, thereby improving balance (Orr et al., 2006). Due to a decreased velocity of movement (Henwood, Riek, & Taafe, 2008) strength training has not significantly improved ADL ability in older adults (Earles, Judge, & Gunnarsson, 2001). Furthermore, producing maximal strength may require too much to achieve balance recovery during a fall situation (Granacher et al., 2011). Compared with traditional strength training, power has been shown to improve 8-foot-up-and-go (UPGO) and chair stand results to a greater extent, with only strength experiencing similar increases across groups (Bottaro, Machado, Nogueira, Scales, & Veloso, 2007). Utilizing HV training may specifically cause improvements in functionality (Bean et al., 2009; Sayers & Gibson, 2011), due to an improvement in firing rates, a decrease in activation threshold for Type II muscle fibers, resulting in an improvement in the rate of force development (Hakkinen et al., 2001). However, some equipment-based power studies have shown no difference in function (Earles et al., 2002 & Bean et al., 2009).

Functionality. According to cross-sectional research, beginning in the sixth decade, muscular strength likely declines by 15%, followed by 30% once the eighth decade is reached. Researchers have provided evidence that training for neuromuscular power has a greater impact on power and function more than strength training (Porter, 2006) and balance, specifically at low loads (Orr et al., 2006).

Lower extremity function is highly predictive of disability in older adults over age 70 (Earles et al.,2002). Functional performance is impacted by strength and power (Hruda et al., 2003). Power training research consistently provides evidence the relationship between power and function is stronger than strength and function, (Porter, 2006) improving balance in healthy community-dwelling older adults at low loads (Orr et al., 2006). Due to environmental demands of quick postural reactions (Henwood & Taaffe, 2005) specifically power training the lower extremities is essential in reducing falls risk (Granacher, Gollhofer, Hortobagyi, Kressig, & Muehlbauer, 2013) and counteracting muscle weakness, as lower extremity function is a predictor of disability (Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995) and physical performance in older adults (Bean et al., 2010).

Improvements in peak muscle power could improve single-step recovery, as insufficient power is a limiting factor (Pamukoff et al., 2014). Clinically meaningful changes of at least 0.1 m/s in the 4m walk or a one point increase on the SPPB were seen in 79% and 38% of 117 participants, respectively, following 16 weeks of training. Leg power, as opposed to strength, was the only variable significantly associated with these changes. This research supports increases in leg power as clinically important in regards to mobility outcomes. Researchers further suggested that it may be more imperative to individualize programs to strengthen the weak and increase the speed of the slow individuals (Bean et al., 2002).

During 10 weeks of strength training involving lower extremity exercises using resistance bands, participants gradually performed exercises more quickly. Researchers discovered the strongest relationship between average power with the functional tests 8-

ft-Up-and-go, 30 second chair stand, and 6-m walk. Compared with a control group, the exercise group realized significant changes in knee extensor peak torque between 25 and 29.5% and average power between 41.5 to 59.7%, concentrically and eccentrically, respectively. However, changes in functional outcomes were only significant in the 6-m walk, improving by 33% in the exercise group. Bassey et al. (1992) further supported a strong relationship between power and functionality, discovering leg extensor power in was correlated (*r*=.65-.88) with chair rising, stair climbing, and walking. Similarly, Bean et al. (2002) reported a greater contribution to function from leg power than leg strength, accounting for 43% and 39% of the variance, respectively.

Disability in individuals age 70 and over is significantly predicted by lower extremity function (Guralnik, Rerrucci, Simonsick, Salive, & Wallace, 1995), while strength has less of an influence on physical performance than leg power (Bean et al., 2002). In order to counteract the detrimental impact of muscle weakness on balancing ability, it is suggested resistance training for the lower extremities and trunk is imperative (Granacher, Gollhofer, Hortobagyi, Kressig, & Muehlbauer, 2013), specifically due to the attribution of muscle weakness in decrease in ADL function. (Bean et al., 2004).

Bean et al (2004) also utilized weighted vests for resistance, assigning weights of 2% of body weight and adjusting based on performance. Exercises mimicked daily activities, including chair stands, toe raises, step-ups, seated tricep dips, chest press, and pelvic raises. After evaluating power, participants saw increases from 12-36% on a pneumatic resistance machine, along with gait speed, balance, and SPPB performance (Bean et al., 2004). The time to complete five chair stands was also significantly improved. These results support the use of weighted-vest protocols when the desired outcome is power or functional performance (Hazell et al., 2007).

Power Output. Power training with body weight and resistance bands may be enough for older adults to improve muscular strength and power (Hruda et al., 2010). The ability to produce force in an adequate amount of time is a significant aspect of quick postural reactions in response to external stressors (Henwood & Taafe, 2005). Numerous studies support the use of power training to bring about improvements in ADL over strength training (Bassey et al., 1992; Miszko et al., 2003; Orr et al., 2006; Porter, 2006). Power training may be more beneficial due to the development of contraction speed and strength, mitigating the age-related decreases in skeletal-muscle function and ADL ability (Hazell et al., 2007). Fukumoto et al. (2014) further suggest HV training may require less time than low velocity (LV) training during exercise sessions, while still providing greater improvements in physical function (Fukumoto et al., 2014).

As few as eight weeks of power training at 35%-75% 1RM have produced 21% to 82% increases in strength, and 16%-33% increases in power, accompanied by an improvement in chair stands and the 6-meter walk (Henwood & Taafe, 2005) Contrarily, Wallerstein et al. (2012) found similar improvements in voluntary isometric torque, quadriceps cross-sectional area, and maximal dynamic strength following 14 weeks of strength training at 70-90% 1RM or power training at 30-50% 1RM. When the primary outcome is muscular strength or endurance, greater improvements may be seen at heavier external loads (de Vos et al., 2005). Power may also improve in very old (over 80 years) women. Research provided evidence training explosively at 75%-80% 1RM for 12 weeks may improve maximal isometric strength, rate of force development, and leg extensor power. Compared with their 60 year old counterparts, a greater relative increases was seen in jump height, mean power, impulse of rate of force development, and maximal voluntary contraction (de Vos et al., 2005).

Following 12 weeks of traditional strength training (80% 1RM) or power training (40%1RM), power training improved braking speed in a motor simulation and peak power, peak power velocity, and peak power force across resistances of 40%-90% 1RM. Strength trained individuals only experience improvements specific to their load of 70%-90% 1RM. Both methods resulted in an improvement in power, though power improved the velocity component more significantly than traditional strength training (Sayers & Gibson, 2012). Contrarily, Fukumoto et al. (2014) found no changes in muscular power, strength, muscle thickness, walking speed, a 3 minute walking test, or pain between a low-velocity and high-velocity groups with hip osteoarthritis. Greater improvements on the TUG were experienced by the HV group compared with the LV group (Fukumoto et al., 2014). Unlike Sayers & Gibson (2012), no measurements were taken to account for changes in velocity.

Zech et al. (2012) found similar improvements in both a strength (ST) and power trained (PT) group compared to controls when examining physical function. Interestingly, no improvements were seen in muscular power during the sit-to-stand test (Zech et al., 2012). This contradicts reports by Katula, Rejeski, & Marsh (2008) who discovered greater increases in lower extremity muscular power in the PT group compared with the ST group. Furthermore, Pereira et al. (2012) discovered significant improvements in power as indicated by countermovement jump, ball throwing distance, and 10m sprint time. Other significant results included increases in strength on the bench press, leg press, and handgrip, as well as sit-to-stand performance. This study only evaluated Caucasian women with average age of approximately 62 years, a younger population than the present study (Pereira et al., 2012).

Intensity. Training loads of 20%, 50%, and 80% 1RM have shown similar improvements in peak muscular power in older adults. The ACSM recommends training intensities of 40%-60% 1RM for HV. However, training at higher loads following 12 weeks of training showed greater improvements in muscular endurance and strength assessed by pneumatic resistance machines (de Vos et al., 2005).   More specifically, loads of 40%-60% are recommended for optimal gains in performance in power (Granacher, 2001), though some research has shown that power declines at a faster rate when working at a greater than 40% 1RM (Granacher, Muehlbauer, & Gruber, 2012).

Other researchers have suggested intensity is outcome dependent, with balance and gait speed being more positively impacted by 40% 1RM and chair stands and stair climbing by 80% 1RM (Cuoco et al., 2004). De Vos et al. (2005) specifically suggested heavier loads lifted as fast as possible was the most efficient means of improving power, strength, and endurance. Orr et al. (2006) further solidified utilization of a lower intensity during power training in healthy older adults when results provided evidence of greater improvements in balance at 20% 1RM to a greater extent than training at 40% and 80% 1RM (Orr et al., 2006). This has been further supported by Signorile, Carmel, Lai, and Roos (2005). More specifically, loads of 40%-60% are recommended for optimal gains in performance in power (Granacher, 2001), though some research has shown that power declines at a faster rate when working at a greater than 40% 1RM (Granacher et al., 2012). Orr et al. (2006) further solidified utilization of a lower intensity during power training in healthy older adults when results provided evidence of greater improvements in balance at 20% 1RM to a greater extent than training at 40% and 80% 1RM (Orr et al., 2006). In spite of the current research, some researchers still believe specific intensity recommendations cannot be made in this population (Hazell et al., 2007).

Power training can be safely completed in older adults (Earles et al., 2002; de Vos, 2005)

A study utilizing eight weeks of traditional training as a foundation for eight weeks of power training resulted in physiological improvements in adults aged 65-90 (Miszko et al, 2003). Participants completed total body exercises at 80% 1RM for eight weeks, followed by power training at 40% 1RM. While both interventions improved strength, the PT group improve from pre- to post- test in strength, power, and functional tasks measured via the Continuous Scale Physical Functional Performance test (Miszko et al., 2003). However, Earles, Judge, and Gunnarsson (2001) reported no improvements in functional performance following 12 weeks of HV training three times a week. Sets performed were equivalent in number to the present study at three sets of ten. However, researchers utilized a ramped protocol, allowing participants to split up sets into three reps at a comfortable pace, three reps slightly faster, and four reps as fast as possible. The lack of consistent high velocity repetitions may have prevented improvements on the 6-min. walk and SPPB. It should be noted increases in strength and power by 22% were seen on the leg press. This study is contrary to results seen by Henwood & Taafe (2005) who saw improvements in ADL following a consistently HV program for eight weeks, twice weekly. Three sets of eight repetitions at 35%, 55%, and 75% 1RM were completed (Henwood & Taafe, 2005).

Fatouros et al. (2005) reported greater improvements in physical function, anaerobic power, and mobility among inactive men strength training at 82% 1RM more so than those exercising at 55% 1RM. However, these individuals were performing traditional strength training exercises, with no speed component (Fatouros et al., 2005). Casserotti et al. (2008) suggest training at intensities closer to an older individual's maximum is more beneficial due to the requirement for this population to operate closely to their maximum during ADLs. These researchers found significant changes in leg extensor power, maximal isometric strength, and rate of force development following 12 weeks of training at 75%-80% 1RM (Casserotti et al., 2008). Fielding et al. (2002) also reported peak muscular power during the leg press in HV versus LV trained older women over 16 weeks of training. However, knee extensor peak power was not improved, and both groups experienced similar improvements in strength (Fielding, LeBrasseur, Cuoco, et al., 2002).

Executive Function. Following 52 weeks of once or twice weekly resistance training or balance exercises for 60 minutes has shown no improvements in cognitive function following 6 months of training in elderly women. After 12 months, however, the balance group experienced decreases in task performance on the Stroop test, while both the once weekly and twice weekly RT groups experienced 11% and 13% increases, respectively. No improvements in brain volume, set shifting, or working memory were reported between groups. These findings suggest task performance, similar to that required during DT conditions may be improved through strength training (Liu-Ambrose, Nagamatsu, Graf, Beattie, Ashe, & Handy, 2010). However, as noted previously, high-speed movement is a primary concern in order to reap several benefits from training (Hakkinen, Komi, & Alen, 1985).

QoL. Very little evidence evaluating quality of life as an outcome of resistance training has been reported, though upper-body strength and muscular endurance have a positive relationship with mood (Benjamini, Rubenstein, & Zaichowsky, 1997), while high-intensity resistance training may cause improvements in pain and emotional and social functioning in depressed patients (Singh et al, 1997) as well as quality of life, including self-efficacy, mood, physical function, and emotional health in cardiac rehabilitation patients (Beniamini, Rubenstein, & Zaichkowsky, 1997). Gains in muscular strength are further predictive of moderate to high increases in mental health accompanied by decreases in physical and emotional patients with fibromyalgia (Carus, Gusi, Hakkinen, Hakkinen, Raimundo, & Ortega-Alonso, 2009). Results were similar under women who had recently experienced a myocardial infarction. Both aerobic trained and aerobic plus resistance trained (55% 1RM) groups saw increases in emotional and global QoL after 8 weeks. Only the RT group experienced improvements in physical and social QoL (Hung, Daub, Black, Welsh, Quinney, & Haykowsky, 2004). Adults with peripheral neuropathies participating in a similar cardiovascular and RT program also improved role limitation, emotional, and social outcomes (Ruhland & Shields, 1997). Contrary to the aforementioned special populations, physically disabled patients experienced no improvements in mood, except vigor, following 6 months of home-based resistance training (Jette et al., 1999). Chin, Van Poppel, Twisk, & Van (2004) reported no effects on quality of life in larger sample (*n*=173) of healthy older adults (Chin et al., 2004).

These findings may suggest that QoL is more largely effected by resistance exercise in unhealthy populations, though conclusions cannot be made due to insufficient amounts of literature. Compared with a control group, both an aerobic and a resistance training group experienced and maintained similar non-significant improvements after 12 months of training and 3 months of detraining (Lobo, Carvalho, & Santos, 2010).

Only one study reported was discovered which supported changes in QoL due to power training. Upon completion of 12 weeks of total body exercises on pneumatic equipment at 70% 1RM, both strength and power trained individuals were compared with controls. Only the PT group significantly differed from the control group on all variables, including life satisfaction, satisfaction with physical function, and self-efficacy. The ST only experienced a significant improvement in self-efficacy with a meaningful increase in satisfaction with life (d=0.47) when compared with the controls (Katula et al., 2008). It may be important to examine a single exercise modality, as Liu & Latham (2004) confirmed no changes in QoL in 10 different studies solely focusing on RT.

Detraining

Older adults are often faced with numerous interests, which compete for their time, leading to interruptions in training. These periods of inactivity may also be due to health-related issues, causing detriments in physiological function (Zech, et al., 2012). While research proposes losses in muscular strength are dependent on training duration and intensity, few researchers have examined the impact of training intensity and detraining on functional loss (Henwood & Taafe, 2008). Researchers have questioned whether training improvements can be maintained following DT interventions (Li et al., 2010). Six months following a 12 week intervention, improvements in self-reported lower-extremity function, foot contact time, and gait cycle were all lost (Melzer & Oddsson, 2012).

Henwood & Taafe (2008) examined the effects of detraining and retraining following six months of twice weekly strength training at 75% 1RM or power training at 45%, 60%, and 75% 1RM. Following six months of detraining, subjects significantly decreased in lean mass and experienced no changes in balance confidence, quality of life, or physical activity levels. Researchers also discovered similar decreases after six months detraining and increases after three months retraining among both strength and power trained individuals from a 15.5±2.2% loss to a 24.9±1.9% gain in the former and a 17.8±1.8% loss and 25.6±2.4% gain. No changes were seen in physical function as measured by a floor rise to stand, stair climb, five time chair stand, 400m walk, functional reach test, and 6m walk measured at differential speeds, between groups at any time point. The declines in strength and power, but not physical function may suggest a more reserved impact of these variables on physical function than previously perceived (Henwood & Taafe, 2008).

These results are contrary to those found by Toraman & Ayceman (2005), who discovered decreases in functional ability two weeks after the termination of progressive resistance training (Toraman & Ayceman, 2005). Residual effects from training may exist to a greater extent in power trained than strength trained older adults (Zech et al., 2012). Following 12 weeks of strength or power training, 69 pre-frail older adults were examined for changes in physical function measured by the SPPB and muscular power in the sit-to-stand transfer. Both groups experienced a significant change in physical function, specifically the chair stand and balance tests, compared with the control group.

No changes were reported for power, gait speed, or self-reported function. Power trained individuals maintained the improvements in physical function at 12 and 24 weeks following the intervention while strength trained participants experienced a decline below baseline on the SPPB (Zech et al., 2012). This research suggests training may be maintained as long as three months following a power trained intervention, specifically when the outcome is balance.

Training intensity may also have an impact on residual training effects. While Henwood & Taafe (2008) reported decreased muscular strength and power among detrained strength and power trained individuals, Harris, DeBeliso, Adams, Irmischer, & Gibson (2007) also reported no difference in physiological changes from detraining between training intensities. However, inactive men exercising at 82% of their maximal strength maintained strength and mobility gains at 24 and 48 weeks following training. Those exercising at an intensity of 55% 1RM were unable to maintain their improvements at 4 and 8 months. Though both groups reported significant increases in anaerobic power following the 24 week strength training protocol, neither maintained these effects. These results suggest, strength training at a higher intensity may allow older adults to sustain physiological benefits for a longer period (Fatourus et al., 2005).

Examining detraining is important for the determination of which form of training will prevent the greatest loss in physical function in older adults (Henwood & Taaffe, 2008). It will also contribute to exercise programming in this population (Zech et al., 2012).

Summary

Both power training and DT training seem to have a positive effect on physical function, while improvements in executive function, confidence, and quality of life are speculative among both methods. Evidence points to the fact that DT training may be beneficial when walking or balancing under DT and ST conditions when the outcome variables are sway, gait speed, and functional balance. Research on detraining varies based on length, but evidence supports changes in strength and function may occur following a period of inactivity of 4 weeks to a year. Due to the popularity of both power training and DT training programs, and their perceived similar benefits, it is important to compare these two methods to aid in physical activity programming for older adults.

CHAPTER III

METHODOLOGY

Subjects

Upon receipt of Institutional Review Board (IRB) approval, participants (*n*=30) were recruited from two different senior centers in a mid-western city. Subjects were required to complete a Physical Activity Readiness Questionnaire (PAR-Q, Appendix A) and Health History Questionnaire (Appendix B) and receive medical consent (Appendix C) from a physician. Participants were randomly assigned to a control (CG, *n*=10), cognitive dual task (DT, *n*=10), or high-velocity resistance training (HV, *n*=10) group. Due to attrition, 22 participants, 5 males (22.72%) and 17 females (77.28%), completed the study. Gender participation was similar to other studies, with females participating more often (Melzer & Oddsson, 2012; Plummer-D'Amato et al., 2012). Census data reports women over age 65 outnumber men 58.8% to 41.2%, with this discrepancy increasing with each change in age range. This data could be the reason for a greater female participation in this study. Participants were required to attend at least 75% of sessions or their data was thrown out, which is consistent with other research (Melzer & Oddson, 2012; Pichierri et al., 2012). No participants were thrown out due to lack of attendance.

Attrition. Other researchers have reported compliance rates of 78%-81% in high velocity groups and 64%-86% for low-velocity groups in patients with hip osteoarthritis challenged to lower extremity weight-training (Katula et al., 2008, Fukumoto et al., 2014). Figure 1 displays the attrition rates of each group.

Testing

Participants were evaluated at pre-test, 4 weeks, 8 weeks, 12 weeks, 16 weeks, and 4 weeks post-test. Measurements of confidence, functionality, power, postural sway, and cognitive function were taken. The HV group completed 1 repetition maximum (1RM) testing at 8 weeks and 16 weeks.

Mini Mental State Exam (MMSE)

The Mini Mental-State Exam (MMSE, Appendix D) was utilized to determine subjects who were cognitively impaired. The MMSE is a 15 question test evaluating performance on orientation, attention, memory, language, and visual-spatial tasks (Folstein, Folstein, & McHugh, 1974). Participants with a score below 24 out of 30 points, indicating mild dementia, were not included in data analysis. No participant was excluded due to failure to pass the MMSE.

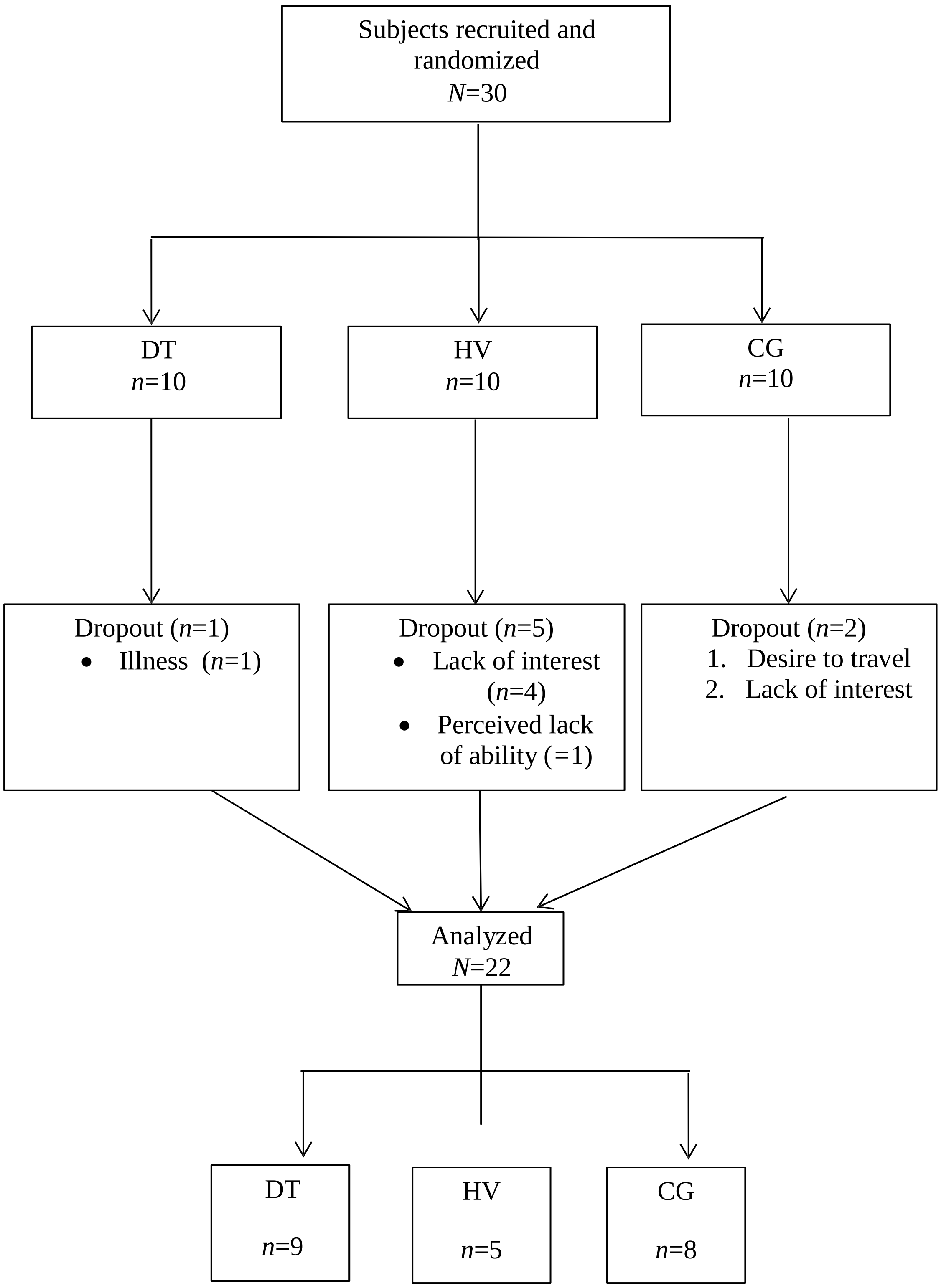

Figure 1. Random Allocation to Group Assignment

Instruments

Activities-Specific Balance Confidence (ABC) scale. The Activities-Specific Balance Confidence Scale (ABC, Appendix E) is a commonly used screening tool for fall prevention (Brewer et al, 2007) consisting of a 16 question scale assessing an individual's confidence level while maintaining their balance under certain conditions. The subject scores their confidence based on an 11 point scale from 0% to 100%, with the final score calculated as an average of each question. Scores of 80%, 50-80%, and below 50% indicate high, moderate, and low levels of physical functioning, respectively (Myers, Fletcher, Myers, & Sherk, 1998). A cutoff score of 67% indicates an increased risk for falling (Lajoie, 2004). The ABC scale is preferable to the Falls Efficacy Scale due to its' inclusion of a breadth of items of different difficulty levels and activities of daily living (ADLs), as well as high reliability (r=0.92, p<.001; Myers et al, 1996; Myers & Powell, 1995). Furthermore, this evaluation of confidence has been shown to have a significant, negative relationship with actual balancing ability based on postural sway scores and a significant, positive relationship with walking time (r=.56, p<.01; Myers et al, 1996).

Tekscan HR Mat System™. A force plate has been utilized in previous research to determine test-retest reliability under DT conditions. Results showed high to very high test-retest reliability during ML measures while standing on firm surfaces with eyes open (r=0.98) and eyes closed (r=0.95), as well as a foam surface with eyes closed (r=0.81). AP measures were also considered reliable under firm surface eyes-open (r=0.77), firm surface eyes-closed (r=0.86), and foam surface eyes-closed (r=0.82) conditions. These findings are similar to that of Conrdon & Hill (2002) who found reliability to moderate to high under all platform conditions in combination with a cognitive task (*r*>0.65), with the exception of the stable platform condition with cognitive task (*r*=0.48) and dynamic platform with no cognitive task (*r*=0.35; Condron et al., 2002). Intraclass correlation coefficients of *r*= 0.84-0.92 for antero-posterior (AP) and medio-lateral (ML) sway, with eyes open and closed have been reported for the Teskcan HR Mat System™ (Tekscan, Inc., 2014; Brenton-Rule et al, 2012). Measurement error may range from 1.27 to 2.35 mm. The Teskcan HR Mat System™ (Tekscan, Inc., 2014) was utilized to determine AP and ML sway analyzing oscillating movements via sensors inside a mat.

Participants in the current study were measured under ST and DT conditions while standing on the mat barefoot. AP and ML were measured with a two feet eyes open (TO), two feet eyes closed (TC), right foot single-leg stance (RT), and left foot single-leg stance (LT) using high-resolution sensors in the mat to detect anatomical excursion from the center of force (CoF) in the plantar surface during the specific stance. DT performance was measured by asking the participants to subtract seven from a three digit number, or the serial sevens test, while in each stance. The serial sevens test was included to assess dementia on the original MMSE (Folstein et al., 1974). The numbers selected differed between testing time points, but were the same for each individual during that round of testing. The order of stance conditions was randomized for each participant. Sway was recorded by the mat system for 10 seconds similar to research by using 8-10 second analyses (Hwang et al., 2013).

Trail Making Test (TMT). The Trail Making Test (TMT, Appendix F) is a test of executive function, processing speed, mental flexibility, and visual search (Tombaugh, 2004), which has been used in other DT studies (Li et al., 2010). The test includes two parts, A and B. Part A requires participants to connect circles numbered 1-25 in ascending order. Part B consists of numbers 1-13 and letters A-L, requiring participants to alternate connecting circles with numbers and letters in ascending order (i.e. 1-A-2-B-3-C). Both tests are timed with the purpose of completing the connection as quickly as possible without lifting the pen or pencil. As errors occurred, they were pointed out by the researcher in order that the participant could immediately correct the mistake. If five minutes elapsed, the test was terminated. Average times consist of 29 seconds and 75 seconds on parts A and B, respectively. Times extending over 78 seconds for part A and 273 seconds for part B are considered deficient (Tombaugh, 2004). Findings support the use of programs designed to improve cognitive function, possibly reducing falls risk (Springer et al., 2006). It has been reported that executive function and attention are distinct domains of cognitive function important for dual-tasking thus, more sophisticated measures of cognitive function that capture these domains may be useful in future studies.

Short Physical Performance Battery (SPPB). The Short Physical Performance Battery (SPPB, Appendix G) may predict future admission to a nursing home, mortality, disability, and hospitalization rates (as cited in Bean, Kiely, LaRose, Goldstein, Frontera, & Leveille, 2010). As a measure of lower extremity performance, it is reliable and valid (Bean et al., 2010). The SPPB was evaluated under single and cognitive dual-task conditions. The test consists of feet together, semi-tandem, and tandem stances, a four meter walk, and a timed chair stand task scored on a scale from 0-12 points. Participants were required to maintain each stance for 10 seconds. The feet together and semi-tandem stances were worth one point, while the tandem stance was worth two points. The four meter walk and the chair stand test were worth 0-4 points based on time to completion. Participants were instructed to walk at a normal pace during the gait test and perform five chair stands as fast as possible during the chair stand test (Guralnik et al., 1994). The four meter walk was a shorter gait assessment than is commonly used in similar studies (Springer et al, 2006; Melzer & Oddsson, 2012). Due to its' relationship to DT gait performance, set-shifting was utilized as a task of executive function in combination with balance training (Liu-Ambrose et al, 2009). Liu and colleagues (2009) and Verghese et al (2010) created a more challenging task by incorporating recitation of every other letter of the alphabet during a walking task. Similarly, the present study required individuals to recite every other letter of the alphabet or the alphabet backwards during the SPPB test. The starting point of the alphabet was randomly chosen by the researcher. For instance, subjects may have been asked to recite the alphabet backwards starting with the letter "p" or state every other letter of the alphabet starting with "g". These DT activities have been successfully used in previous research (Venema et al, 2013).

Correlation coefficients of the SPPB have ranged from 0.83-0.89 in two different older adult populations (Freire, Guerra, Alvarado, Gurlanik, & Zunzunegui, 2012). Previous research has provided evidence of an inverse relationship between slow gait speed and high fall incidents (Montero-Odasso, 2010). Changes in gait speed of 0.1 m/s and by one unit in SPPB scores are considered clinically meaningful (as cited in Bean, Kiely, LaRose, Goldstein, Frontera, & Leveille, 2010).

Power. Power was analyzed via the Tendo Power Analyzer (Tendo Sports Machines©, 2009). Participants were required to sit in a chair. A broomstick was attached to the

Tendo Power Analyzer and held firmly across the chest. Participants were instructed to stand up quickly and powerfully while maintaining the best possible postural alignment. Average and peak power (W) and average and peak velocity (m/s) were recorded. Three trials were performed with a 60 second break in between. The best of the three trials were recorded.

RAND-36-Item Health Survey 1.0. The RAND-36-Item Health Survey 1.0® (Appendix H), also known as the SF-36 ®, is a 36-itemhealth-related quality of life questionnaire. The survey evaluates eight health concepts: emotional well-being, energy/fatigue, pain, role limitations, social functioning, physical health issues, physical functioning, and general health perceptions. Participants self-reported how they perceive themselves in each of the aforementioned health concepts based on a Likert method of summated ratings. All scores are summed to produce raw scale scores for each concept, and then transformed into a score of 0-100 based on the average of the summated scores in that concept (Ware, Kosinski, & Keller, 1994).

Maximal Strength. In a study by Phillips and Colleagues (2004), one-repetition maximum (1RM) testing was determined to be more reliable than a 5RM and 10RM in older adults performing the chest and leg press. Furthermore, participants aged 61-80 years completed 1RM testing in 14 different research studies (Orr, Raymond, & Fiatarone, 2008). 1RM testing was completed using ankle weights on the following exercises: hip abduction (HA, Figure 2), glute kickback (GK, Figure 3), and hamstring curl (HC, Figure 4). The chair stand (CS, Figure 5) and calf raise (CR, Figure 6) were measured via a 10 repetition maximum (10RM) using weighted vests. A 10RM was utilized for the latter exercises to avoid significant loading of the spine. Repetition maximum was recorded when a subject attempted and failed at a certain weight. The last achieved weight (lbs) was recorded. Results support the use of weighted-vest protocols when the desired outcome is power or functional performance (Bean et al, 2002; Hazell et al, 2007).

Intervention

Warm up. Subjects walked for approximately five minutes at a self-selected pace prior to each session. The DT group then completed chair stands as part of their dynamic balancing warm-up. This group progressed from three sets of eight at baseline to three sets of 15 chair stands at the end of the program. Not everyone could complete all sets, and those with limitations were told to do as many as they were able and utilize their hands if necessary. The progression of the activities were supported by Oddsson et al. (2007), who incorporated balancing tasks with and without support in their initial two levels of training, with the second level mimicking ADLs. The third and fourth levels challenged individuals to balance with no external support and operate on one limb or in multiple directions, while the fifth stage incorporated external perturbation exercises, such as the rolling or throwing of a ball. It was also noted participants should briefly lose their balance during these exercises in order to generate a reactive response (Oddsson et al. 2007). Activities utilized are included in Table 1.

Power Training. The American College of Sports Medicine (ACSM) recommends older adults train at HV at 40-60% 1RM for one to three sets of six to ten repetitions. This study required participants to complete the concentric phase as fast as possible and the eccentric phase over a 2-3 second period, similar to prior protocols (Katula et al., 2008). Participants completed three sets of 10 of each exercise, twice weekly at 40% 1RM for 24 sessions. Exercises were similar to those chosen in previous research which utilized resistance machines and required subjects to perform a leg press, leg extension, leg curl, hip abduction, hip adduction, hip flexion, and calf press using pneumatic equipment (Pamukoff et al., 2014). In the present study, participants were loaded with ankle weights or weighted vests for HA, CS, HC, GK, and CR exercises.

Figure 2. Hip abduction

Figure 3. Glute Kickback

Figure 4. Hamstring Curl

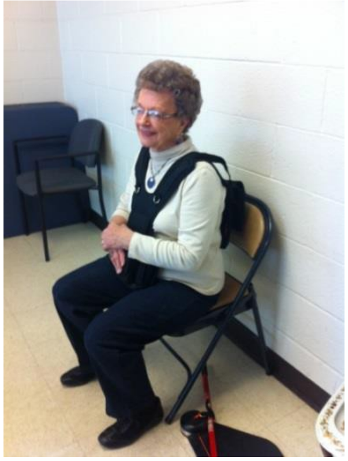

Figure 5. Chair Stand

Figure 6. Calf Raise

Dual Task Training. Balance classes were comprised of 4-5 individuals, a size considered adequate in previous research (Oddsson et al.., 2007) allowing the sole instructor the ability to give adequate attention and provide safe instruction to participants. More challenging exercises were performed one at a time to minimize risk, though it has also been suggested early support could decrease the learning effect and alter the desired response from the balancing individual (Oddsson et al., 2007). Therefore, careful judgments were made by the instructor who had five years of experience with group balance classes for seniors.

Participants completed 30 minutes of DT training twice each week. Cognitive tasks were modeled after previous research, mimicking a wide range of mental demands possible in daily life (Plummer-D'Amato et al., 2012). Exercises were customized to individual ability, as suggested in previous research (Melzer & Oddsson, 2012). Exercises and cognitive tasks can be found in Table 1. Pichierri, Murer, & Bruin (2012) and Beauchet, Dubost, Hermann, & Kressig (2005) also used counting backwards by seven from a three digit number for dual task costs (Pichierri, Murer, & Bruin, 2012; Beauchet, Dubost, Hermann, & Kressig, 2005)

Participants were required to switch between numerous tasks, often using methods of subtraction in between word generation and recall memory tasks (Liu-Ambrose et al, 2009).

Table 1

List of Balance and Cognitive Exercises Utilized in DT class

	Beginner	Intermediate	Advanced
Static Balance Exercises	Feet together, semi-tandem, tandem, and single leg stances on a stable surface	Feet together, semi-tandem, tandem, and single leg stances on an unstable surface	Feet together, semi-tandem, tandem, and single leg stances on an unstable surface with eyes closed
Dynamic Balance Exercises	Marching, Tandem Walking, Stepping over cones, Weight shifting	Marching, Weight shifting, Lateral steps-ups, front step-ups, “Clock” game on foam surface, lateral walking, tandem walking (Figure 7)	Walking knee marches (Figure 8), Tandem walking on foam balance pad (Figure 9), with or without addition of cone
Cognitive Exercises	Recite every other month, recite words beginning with a certain letter or belonging to a category, count backwards	Recite words that begin with a letter and belonging to a certain category or begin with a letter the last individual’s word ended with	Fill in the sentence, grocery list memorization, random number and math assignment alternating group members, recalling childhood memories

DT performance declines during tasks of greater difficulty. Researchers suggest intensity should be taken into consideration when prescribing DT exercises. For this reason, the present study progressively increased DT difficulty each week for 16 weeks (Venema et al., 2013). Donhoon et al. (2013) support the use of eyes closed and unstable surfaces during DT training, which were utilized in this study. Occlusion of the eyes could also enhance the somatosensory and vestibular balance inputs. Balance tasks challenged static and dynamic balance, as well as gait. Participants were progressively challenged with double or single-leg and wide or narrow stances with eyes open or closed initially. After two weeks, a foam balance pad was added as an external perturbation. After 8 weeks, a foam balance beam (Figure 9) was utilized for DT exercises involving walking.

Figure 7. Tandem walking

Figure 8. Dynamic Marching

Figure 9. Tandem walking on foam balance pad.

Statistical Analysis

The alpha level was set at .05. Utilizing G*Power3 and an effect size of 0.25, it was determined a sample size of 125 participants was necessary to achieve a desired power of 0.8. This sample size was not feasible for the present study due to lack of assistance and resources. Previous researchers determined a sample size of eight per group was necessary to detect a 0.1 m/s ±0.09m/s change in gait velocity. Data was analyzed using SPSS software (21.0; SPSS Inc., Chicago, IL). A repeated measures multivariate analysis of variance (ANOVA) was utilized to compare differences between groups. Descriptive statistics were calculated for each group on all dependent variables. Baseline characteristics were evaluated to detect homogenous groups.

CHAPTER IV

RESULTS

Hypotheses were tested with a repeated measures analysis of variance (ANOVA) to determine whether a significant difference between groups changed over time for each dependent variable. A probability level of 0.05 was used as the criterion value for all tests to determine significance. Standardized residuals were analyzed to detect outliers, and a residual value over 2.00 was removed from the analysis. Friedman's non-parametric test was utilized for all non-normal data. Cohen's *d* was utilized to detect meaningful changes over time within groups. Participant demographics (Table 2) and baseline characteristics (Table 3) were also calculated. Outcome variable descriptive statistics for physical function, confidence, and executive function (Table 4) and postural sway (Table 5) are displayed below followed by calculations by percent change between post-test and detraining (Table 6).

Table 2

Demographic Information for Participants by Group

	DT (*n*=9)	HV (*n*=5)	CG (*n*=7)	Total (*n*=22)
Mean Age (yrs.)	81	82	77	79.77
(SD)	(2.52)	(1.76)	(2.56)	(6.86)
Gender				
Male	2	1	2	5
Female	7	4	6	17
Education				
H.S. Diploma	3	2	2	7
Some College	2	1	1	4
Bachelor's	2	0	2	4
Master's	2	2	3	7

Note. SD = standard deviation; DT= dual-task training; CG = control group; HV = high-velocity

Table 3

Mean Baseline Characteristics by Group

	DT (*n*=9)	HV (*n*=5)	CG (*n*=7)	Total (*n*=22)
MMSE	28.56	28	28.75	28.50
(SD)	(.44)	(0.63)	(.70)	(1.57)
Days/Wk.	4.0	3.40	3.38	3.64
(SD)	(.78)	(1.44)	(.71)	(2.34)
Minutes/Wk.	287.22	207	182.50	230.91
(SD)	(82.12)	(103.53)	(58.54)	(211.79)

Note. SD = standard deviation; DT= dual-task training; HV= high-velocity training; CG = control group; MMSE= Mini Mental State Exam

Table 4

Outcome Variable Means for Physical and Executive Function and Confidence at Baseline and 16 Weeks

Variable	*n*	DT		*n*	HV		*n*	CG		*N*	Total	
		Pre	Post		Pre	Post		Pre	Post		Pre	Post
ABC (%)	9	75.59	81.56	5	87.25	94.50	8	73.57	76.16	22	77.70	82.84
(SD)		(20.16)	(15.81)		(11.09)	(5.90)		(20.94)	(21.70)		(18.70)	(17.28)
RAND-36	9	69.94	89.62	5	83.83	85.10	8	59.31	68.15	22	69.23	80.79
(SD)		(18.62)	(27.03)		(10.03)	(13.22)		(16.08)	(24.17)		(18.05)	(24.60)
Pk. Power (W)	9	754.89	730.44	5	823.40	837.00	8	632.25	706.88	22	725.86	746.09
(SD)		(360.92)	(308.31)		(253.60)	(93.72)		(312.20)	(303.60)		(316.75)	(266.96)
Pk. Velocity(m/s)	7	.99	.99	5	1.07	1.26	8	.90	.95	20	.98	1.05
(SD)		(.39)	(.31)		(.16)	(.19)		(.17)	(.17)		(.26)	(.26)
Avg. Power (W)	9	387.89	468.56	5	520.80	493.40	8	406.71	467.71	22	443.81	474.19
(SD)		(152.00)	(228.24)		(202.95)	(92.69)		(222.12)	(238.01)		(187.87)	(199.17)
Avg. Vel. (m/s)	7	.51	.64	5	.70	.74	8	.60	.60	20	.60	.65
(SD)		(.19)	(.27)		(.05)	(.13)		(.14)	(.09)		(.16)	(.18)
TMT-A (sec.)	9	59.22	42.40	5	39.90	34.25	6	44.98	44.79	20	50.12	41.08
(SD)		(51.04)	(36.97)		(19.93)	(4.88)		(31.36)	(34.25)		(38.90)	(30.11)
TMT-B (sec.)	9	135.13	136.57	5	144.79	112.08	8	133.05	139.86	22	136.57	132.20
(SD)		(110.68)	(107.00)		(99.53)	(72.20)		(103.80)	(100.36)		(100.83)	(94.01)
SPPB-ST	9	8.56	9.56	5	11.00	11.20	8	10.38	10.63	22	9.78	10.32
(SD)		(3.21)	(3.13)		(2.24)	(.84)		(1.69)	(1.77)		(2.64)	(2.32)
SPPB-DT	9	6.67	8.11	5	8.60	8.80	8	8.13	9.25	22	7.64	8.68
(SD)		(2.78)	(2.80)		(1.94)	(1.92)		(1.81)	(1.98)		(2.34)	(2.30)
CS- ST (sec.)	6	12.98	10.27	4	8.45	8.08	6	11.46	9.46	16	11.27	9.46
(SD)		(2.40)	(1.64)		(1.73)	(.86)		(.71)	(1.71)		(2.45)	(.62)
CS- DT (sec.)	7	13.63	11.95	4	14.15	11.46	7	13.02	11.34	18	13.51	11.60
(SD)		(8.58)	(2.54)		(5.36)	(1.78)		(2.12)	(2.03)		(5.73)	(2.09)
GS-ST (m/s)	8	.93	1.09	5	1.11	1.22	8	.95	1.16	21	.98	1.15
(SD)		(.13)	(.25)		(.15)	(.22)		(.16)	(.20)		(.16)	(.22)
GS-DT (m/s)	9	.59	.65	4	.62	.75	8	.61	.77*	21	.61	.71
(SD)		(.12)	(.27)		(.16)	(.29)		(.15)	(.20)		(.13)	(.25)

**Note.* DT= dual-task; HV= high-velocity; CG = control group; ABC= Activities-Specific Balance Confidence; Pk. = Peak; Avg. = Average; Vel. = Velocity; TMT= Trail Making Test; CS= Chair Stand; ST= Single Task; GS = Gait Speed

Table 5

Outcome Variable Means For Postural Sway at Baseline and 16 Weeks

Sway (mm)	*n*	DT		*n*	HV		*n*	CG		*N*	Total	
(SD)		Pre	Post		Pre	Post		Pre	Post		Pre	Post
Two Ft. EO (SD)												
AP ST	9	47.24	46.23	5	48.26	56.13	7	40.13	55.37	21	45.21	51.56
		(26.42)	(24.64)		(19.56)	(19.81)		(13.46)	(20.57)		(20.57)	(21.84)
AP DT	8	57.15	77.72	5	52.58	74.17	7	44.20	58.17	20	56.64	70.10
		(19.81)	(52.58)		(17.27)	(25.15)		(16.76)	(19.56)		(23.88)	(36.83)
ML ST	8	24.38	27.18	5	26.42	28.70	8	23.11	30.99	20	24.38	28.96
		(13.72)	(11.68)		(14.22)	(10.41)		(9.65)	(11.68)		(11.94)	(12.60)
ML DT	9	33.78	70.87	5	36.58	64.01	8	23.88	37.85	22	30.99	57.40
		(16.51)	(80.52)		(18.80)	(19.05)		(18.54)	(18.03)		(17.78)	(53.59)
Two Ft. EC												
AP ST	8	49.02	74.93	5	54.36	77.22	7	54.61	63.25	20	52.32	71.37
		(9.91)	(31.50)		(23.62)	(23.37)		(14.99)	(26.42)		(15.24)	(27.18)
AP DT	9	58.42	77.98	4	71.88	96.52	8	64.52	73.41	21	63.5	79.76
		(24.13)	(33.27)		(38.61)	(36.58)		(29.46)	(31.50)		(27.94)	(32.77)
ML ST	9	29.21	41.40	5	34.04	53.60	8	31.50	28.70	22	30.73	39.62
		(12.7)	(18.03)		(23.11)	(30.73)		(16.76)	(17.78)		(16.26)	(22.35)
ML DT	9	38.1	49.28	5	43.18	36.83	8	26.42	36.07	22	35.05	41.66
		(29.72)	(28.96)		(26.92)	(16.51)		(13.97)	(25.15)		(24.13)	(25.15)
Rt. Ft. EO												
AP ST	9	152.65	118.11	5	201.42	160.27	8	109.99	137.67	22	148.37	134.87
		(84.58)	(52.83)		(156.21)	(57.40)		(39.88)	(84.07)		(95.50)	(65.79)
AP DT	9	94.23	115.57	5	112.52	166.12	7	100.08	113.28	21	100.58	127
		(28.45)	(54.61)		(31.24)	(95.25)		(52.83)	(62.23)		(37.59)	(68.33)
ML ST	9	283.72	64.01	5	252.22	147.58	8	51.56	103.38	22	192.28	97.28
		(248.92)	(40.39)		(242.32)	(88.90)		(28.70)	(119.63)		(27.93)	(89.41)
ML DT	9	131.06	43.18	5	164.60	134.62	7	95.00	138.43	21	127.00	96.77
		(141.99)	(61.47)		(153.16)	(109.98)		(109.22)	(138.43)		(130.56)	(109.22)
Lt. Ft. EO												
AP ST	9	151.38	128.52	5	125.98	182.63	8	147.17	140.46	22	144.02	145.29
		(70.36)	(52.05)		(54.86)	(110.24)		(81.79)	(70.61)		(69.34)	(73.66)
AP DT	9	147.58	105.66	5	75.44	203.96	8	118.36	126.75	22	120.40	135.64
		(109.73)	(46.99)		(54.10)	(212.34)		(42.67)	(37.08)		(80.77)	(106.93)
ML ST	9	281.18	128.52	5	139.19	197.61	8	187.96	184.15	22	215.14	164.34
		(188.47)	(130.05)		(101.85)	(107.44)		(202.44)	(236.73)		(180.85)	(168.40)
ML DT	9	113.03	32.26	5	106.43	140.21	8	99.57	115.82	22	106.68	87.12
		(83.31)	(22.86)		(87.88)	(193.80)		(114.55)	(122.17)		(92.20)	(120.90)

Note. DT = Dual-task; HV = High-velocity; CG = control group; ft. = feet; EO = eyes open; EC = eyes closed; ST= single task; AP= Anterior-Posterior; ML= Mediolateral; Lt.=left; Rt. = right

Results of Hypothesis 1

$H_0$1: There will be no difference between the dual-task balance (DT), high-velocity (HV), and control group (CG) in peak and average power production from baseline to 16 weeks and following four weeks of detraining.

The researcher failed to reject the null hypothesis. No significant within-subjects interactions were seen across group x time for average power ($F_{(5, 21)} = 1.52$, $p=.21$) and peak power ($F_{(5, 21)}= .33$, $p=0.75$) . Average power did change significantly over time ($F_{(10, 21)}$, $p=.01$). Changes in the DT group from pre- to post-test were of a moderate effect size ($d=0.42$).

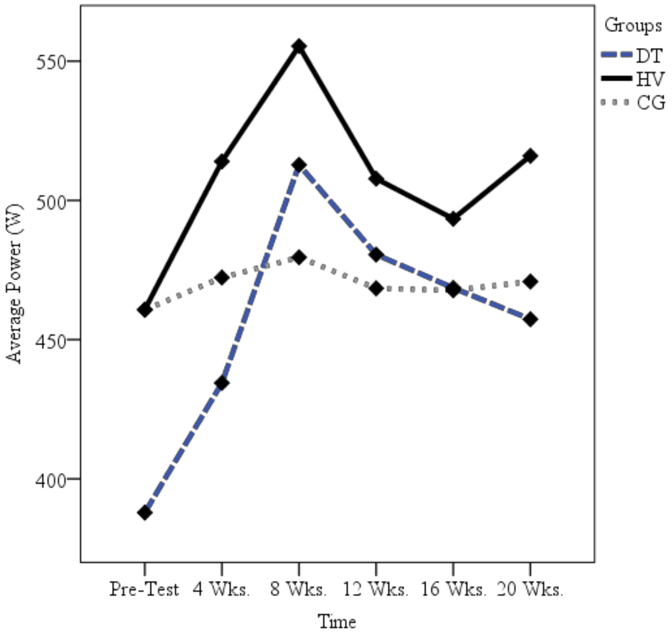

Figure 10. Mean changes in average power (W) between groups from pre-test to detraining

Results of Hypothesis 2

$H_0$2: There will be no difference between the DT, HV, and CG in peak and average velocity from baseline to 16 weeks and following four weeks of detraining.

The researcher failed to reject the null hypothesis. No significant within-subjects interactions were seen across group x time for average velocity ($F_{(5, 19)} = 1.61$, $p=.18$) and peak velocity ($F_{(5, 19)}$= 1.86, p=0.13). Changes in the HV for peak velocity from pre- to post-test were large (d=1.08) and moderate in regards to average velocity (d=.41). The DT group experienced moderate changes in average velocity (d=0.56).

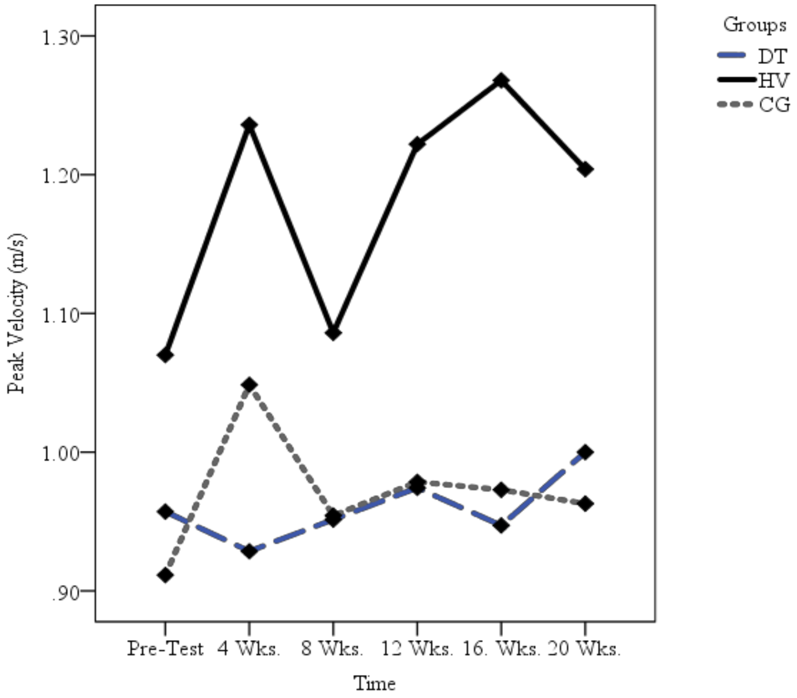

Figure 11. Mean changes in peak velocity (m/s) between groups from pre-test to detraining.

Results of Hypothesis 3

$H_0$3: There will be no difference between the DT, HV, and CG in medio-lateral (ML) or anterior-posterior (AP) postural sway on the following four stances: two-feet eyes open (EO), two-feet eyes closed (EC), right foot (RF) eyes open, and left foot (LF) eyes open from baseline to 16 weeks and following four weeks of detraining.

The researcher failed to reject the null hypothesis for each variable accept for ST right-foot (RF) ML sway between groups. A group x time interaction occurred for ML sway between the HV group and the DT ($F_{(8, 20)}$ = 1.61, p=.04) with a mean difference of -2.69 mm. A significant time effect also occurred during ST-ML conditions in the LF stance (*$F_{8, 21}$*=4.70, *p*=.00). All other results regarding postural sway variables are displayed in Table 6.

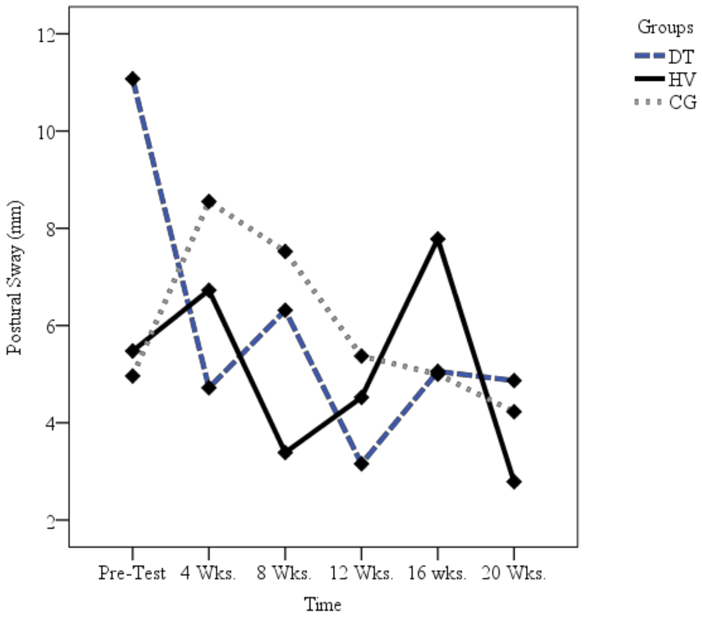

Figure 12. Mean changes in ML sway during LF stance between groups from pre-test to detraining.

Results of Hypothesis 4

$H_0$4: There will be no difference between the DT, HV, and CG in balance confidence from baseline to 16 weeks and following four weeks of detraining.

The researcher failed to reject the null hypothesis. No significant within-subjects interactions were seen across group x time for confidence (*$F_{10, 21}$*=1.64, *p*=.20).). A Shapiro-Wilks test revealed non-normality for the ABC test scores at all time points (*p*<.01). A Friedman’s test revealed a significant difference between pre-test to 4-weeks (X^2=5.00, *p*=.03), 8 weeks (X^2=5.00, *p*=.03)’ 8 weeks (X^2=5.00, *p*=.03) 12 weeks, (X^2=5.00, *p*=.03) and pre-test and 16 weeks (X^2=5.00, *p*=.03). A large effect size was reported for the HV group between pre- and post-test (*d*=.82). A moderate effect size occurred in the DT group (*d*=.33).

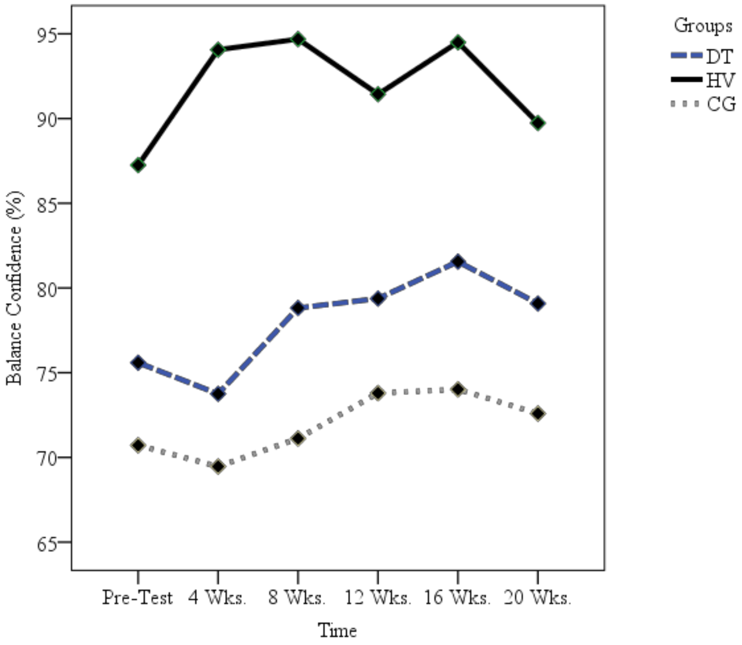

Figure 13. Mean changes in balance confidence between groups from pre-test to detraining.

Results of Hypothesis 5

$H_0$5: There will be no difference between the DT, HV, and CG in quality of life (QoL) from baseline to 16 weeks and following four weeks of detraining.

The researcher failed to reject the null hypothesis. No significant within-subjects interactions were seen across group x time for QoL ($F_{10, 21}$=1.87, *p*=.18). A large effect size was reported for the DT group between pre- and post-test (*d*=.85). A moderate effect size occurred in the CG (*d*=.43).

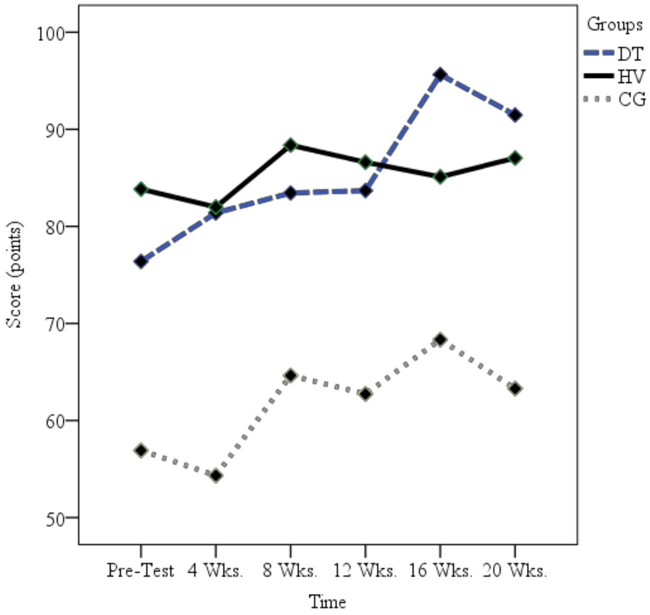

Figure 14. Mean changes in RAND-36 scores between groups from pre-test to detraining.

Results of Hypothesis 6

$H_0$6: There will be no difference between the DT, HV, and CG in executive function from baseline to 16 weeks and following four weeks of detraining.

The researcher failed to reject the null hypothesis. No significant within-subjects interactions were seen across group x time for executive function as observed by the Trail-Making Test (TMT) part A ($F_{8, 19}$=.81, *p*=.54) or part B ($F_{8, 21}$=1.59, *p*=.23). Moderate improvements on the TMT-A were seen in the DT (*d*=0.38) and the HV (*d*=0.39) groups and the TMT B in the HV group (*d*=0.38).

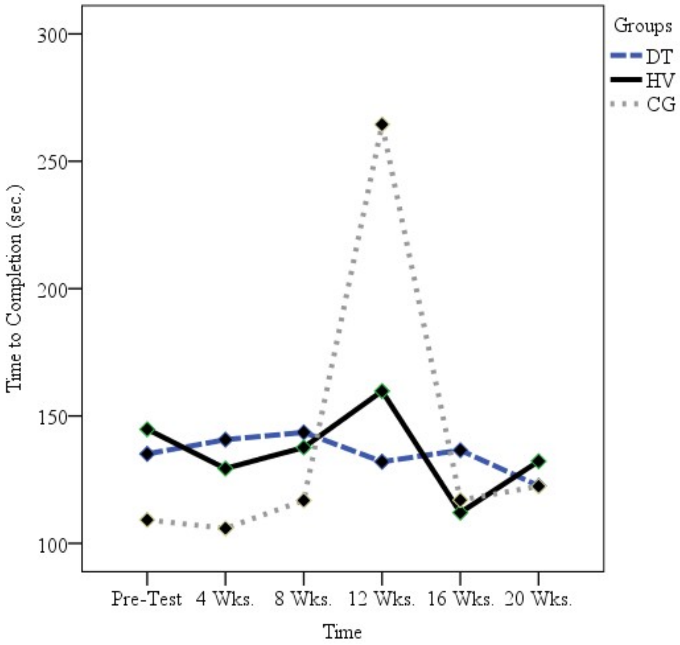

Figure 15. Mean c hanges in TMT-B time to completion between groups from pre-test to detraining.

Results of Hypothesis 7

$H_0$7: There will be no difference between the DT, HV, and CG in functionality, specifically gait speed and chair stand times from baseline to 16 weeks and following four weeks of detraining.

The researcher failed to reject the null hypothesis. No significant within-subjects interactions were seen across group x time in SPPB single task (ST; $F_{10, 19}$=1.25, p=.67) or DT scores ($F_{10, 21}$=1.71, p=.11), ST($F_{8, 20}$=0.69, p=.70) or DT ($F_{8, 20}$=1.48, p=.19) gait speed times or ST ($F_{8, 15}$=1.10, p=.37) or DT ($F_{8, 17}$=1.10, p=.37) chair stand times. A significant time interaction did occur for gait speed under ST ($F_{8, 20}$=4.74, p=.00) and DT conditions ($F_{8, 20}$=3.05, p=.02) and chair stands under ST ($F_{8, 17}$=9.16, p=.00) and DT conditions ($F_{8, 20}$=24.12, p=.02). A Shapiro-Wilks test revealed non-normality for the SPPB DT test scores at 8 weeks (p=.01) and 20 weeks (p=.02). A Friedman's test revealed a significant difference between pre-test and 12 weeks (X^2=6.00, p=.01) and pre-test and 16 weeks (X^2=5.44, p=.02). A Shapiro-Wilk test revealed non-normality for the DT gait speed times at 16 weeks (*p*=.03) A Friedman's test revealed a significant difference between pre-test and 4 weeks (X^2=4.50, *p*=.03) , 12 weeks (X^2=4.50, *p*=.03).) and 16 weeks (X^2=4.50, *p*=.03). Improvements of a moderate effect size were found in the Short Physical Performance Battery (SPPB) under ST conditions for the DT (*d*=0.32), and under DT conditions for the DT group (*d*=0.52) and CG (*d*=0.59). Chair stands also meaningfully improved in ST conditions in the DT (*d*=1.32) and CG (*d*=1.53) groups and DT conditions in the HV (*d*=0.67) and CG (*d*=.81). The DT, HV, and CG all experienced moderate to large effects in ST gait speed of 0.80, 0.58, and 1.16, respectively. The HV (*d*=0.56) and CG (*d*=0.91) improved their DT gait speed time to a greater effect than the DT group (*d*=0.29).

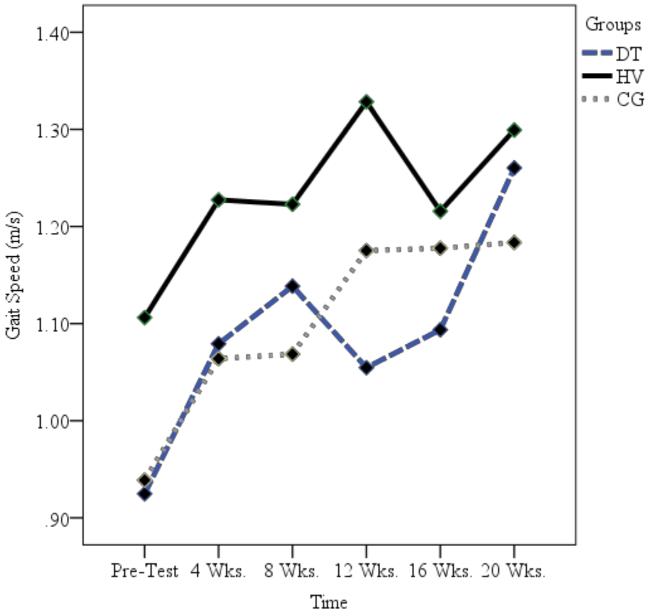

Figure 16. Mean changes in ST gait speed (m/s) between groups from pre-test to detraining.

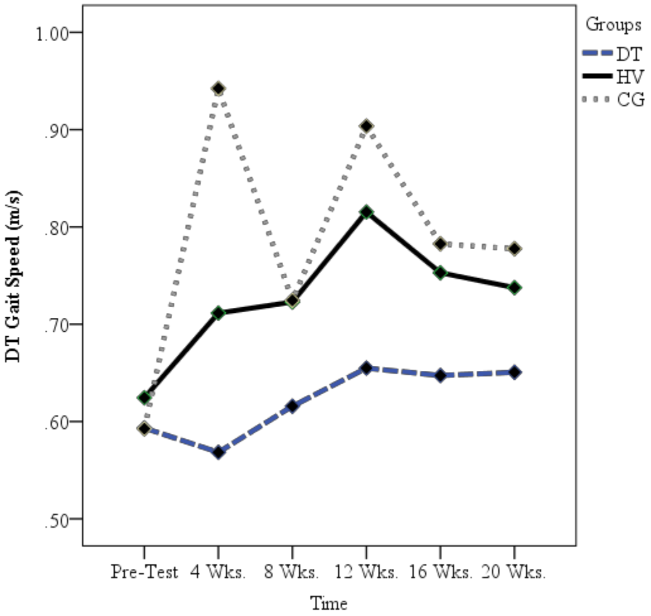

Figure 17. Mean changes in DT gait speed (m/s) between groups from pre-test to detraining.

Table 6

Mean Percent Changes After Four Weeks of Detraining

	DT			Power			Control			Total		
	n	DTR	% Change	*n*	DTR	% Change	*n*	DTR	% Change	*N*	DTR	%Change
ABC	9	73.53	-10.16%	5	89.74	+5.03%	7	73.30	-3.75%	21	77.31	-5.3%
(SD)		(28.93)			(11.70)			(22.73)			(23.83)	
RAND-36	9	87.40	-2.40%	5	87.04	+2.3%	7	63.29	-7.15%	21	79.28	-1.87%
(SD)		(28.54)			(13.82)			(15.55)			(23.89)	
Pk. Power (W)	9	747.44	+2.38%	5	823.40	-13.6%	7	701.86	-0.71%	21	750.33	+0.56
(SD)		(297.41)			(134.00)			(326.89)			(270.54)	
Pk. Velocity(m/s)	7	1.00	-1.01%	5	1.20	-6.00%	7	.96	+1.05%	19	1.04	-0.95%
(SD)		(.21)			(.23)			(.16)			(.21)	
Avg. Power (W)*	9	457.33	+2.40%	5	516.00	+4.50%	7	470.86	-0.67%	21	475.81	+0.34%
(SD)		(202.28)			(67.78)			(237.62)			(186.53)	
Avg. Vel. (m/s)	7	.56	-12.5%	5	.76	+2.7%	7	.63	+5.00%	19	.63	+3.08%
(SD)		(.21)			(.16)			(.12)			(.18)	
TMT-A (sec.)	9	39.56	-6.70%	5	41.64	+21.58%	5	55.50	+23.91%	19	45.37	+4.29%
(SD)		(25.44)			(12.12)			(58.29)			(36.91)	
TMT-B (sec.)	9	122.59	-10.24%	5	132.24	+17.99%	7	122.44	-17.42%	21	124.84	-7.36%
(SD)		(104.66)			(121.38)			(87.21)			(98.12)	
SPPB-ST	9	9.78	+2.3%	5	11.40	-1.79%	7	10.86	+2.16%	21	10.52	+1.94%
(SD)		(3.56)			(.89)			(1.68)			(2.56)	
SPPB-DT	9	7.67	-5.43%	5	8.80	0.00%	7	9.29	+0.43%	21	8.48	2.30%
(SD)		(3.67)			(2.68)			(1.98)			(2.93)	
CS- ST (sec.)	6	10.91	+6.23%	4	8.65	+6.58%	5	9.08	-4.02%	15	9.71	+2.64%
(SD)		(1.87)			(.98)			(.67)			(1.67)	
CS- DT (sec.)	7	14.05	+17.57%	4	17.18	+49.91%	6	11.13	-1.58%	17	13.94	+20.17%
(SD)		(7.12)			(15.01)			(1.74)			(8.81)	
GS-ST (m/s)	8	1.26	+15.60%	5	1.30	+6.58%	7	1.18	-1.72%	20	1.24	+7.83%
(SD)		(.36)			(.05)			(.11)			(.23)	
GS-DT (m/s)	9	.65	0.00%	4	.74	-1.33%	7	.78	+1.30%	20	.71	+0.00%
(SD)		(.24)			(.20)			(.19)			(.22)	

**Note*. ABC = Activities-Specific Balance Confidence Scale; Pk. = Peak; Avg. = Average; TMT = Trail Making Test; SPPB= Short Physical Performance Batter; ST= Single Task; DT= Dual-Task; CS= Chair Stand; GS= Gait Speed

Table 7

Repeated Measures ANOVA Results for Within Groups Variability from Pre- to Post-Test for Measures of Physical and Executive Function and Confidence

Source	SS	*Df*	Mean Square	F	*p*	η_p^2
ABC						
Time	428.99	2.62	163.89	1.64	.20	.08
Time* Group	301.71	10	30.17	.58	.83	.06
RAND-36						
Time	1349.64	1.662	812.15	1.87	.18	.10
Time*Group	634.87	3.32	191.02	.44	.75	.05
TMT-A (sec.)						
Time	1396.96	2.34	595.32	.88	.44	.04
Time *Group	2569.11	4.69	547.42	.81	.54	.08
TMT-B (sec.)						
Time	5763.09	1.205	4744.22	1.59	.23	.08
Time *Group	87008.15	2.78	21351.18	1.20	.33	.12
SPPB-ST						
Time	12.42	3.07	4.04	1.73	.17	.09
Time*Group	10.49	8.37	1.25	.73	.67	.08
SPPB-DT						
Time	14.55	4	3.64	1.71	.16	.08
Time*Group	29.12	8	3.64	1.71	.11	.15
CS- ST (sec.)	63.18	5	12.64	9.16	.00	.40
Time***						
Time*Group	164.85	4.49	36.71	1.10	.37	.13
CS- DT (sec.)						
Time	1801.12	1.76	1022.00	24.12	.00	.62
Time*Group	164.85	4.49	36.71	1.10	.37	.13
GS-ST (m/s)						
Time	.41	4	.10	4.74	.00	.21
Time*Group	.12	8	.02	.69	.70	.07
GS-DT (m/s)						
Time***	.35	3.62	.10	3.05	.02	.15
Time*Group	.34	7.23	.05	1.48	.19	.15

Note. SS= Sum of squares; *df*= degrees of freedom; DT= dual-task; ABC= Activities-Specific Balance Confidence; TMT= Trail Making Test; SPPB = Short Physical Performance Battery (SPPB); CS= Chair Stand; ST= Single Task; GS = Gait Speed

Table 8

Repeated Measures ANOVA Results for Between and Witihng Groups Variability from Pre- to Post-Test for Measures of Power

Source	SS	*Df*	Mean Square	F	*p*	η_p^2
Pk. Power (W)						
Time	20977.21	5	9102.78	.33	.75	.02
Time*Group	76891.28	10	16682.98	.61	.68	.06
Pk. Vel.(m/s)						
Time	.14	4	.04	1.86	.13	.09
Time*Group	.16	8	.02	1.86	.19	.09
Avg. Power (W)						
Time	62268.46	5	26818.71	4.59	.01	.20
Time*Group	41246.79	10	8882.39	1.52	.21	.138
Avg. Vel. (m/s)						
Time	.06	4.27	0.14	1.61	.18	.08
Time*Group	.08	6.24	.01	1.04	.41	.10

Note. SS= Sum of squares; *df*= degrees of freedom; Pk. = peak; Vel. = velocity; Avg. = average;

Table 9

Repeated Measures ANOVA Results for Within Groups Variability from Pre- to Post-Test for Measures of Postural Sway During Double Support Conditions

Source	SS	*df*	Mean Square	F	*p*	η_p^2
Two Ft. EO						
ST AP						
Time	13.83	4	3.46	3.78	.00	.17
Time* Group	5.67	8	.71	.77	.63	.08
DT AP						
Time	5.78	2.51	2.31	1.25	.30	.30
Time*Group	5.78	2.51	2.31	1.25	..30	.30
ST ML						
Time	.71	4	.18	.75	.56	.04
Time*Group	2.16	8	.27	1.14	.35	.11
DT ML						
Time	21.12	5	4.22	1.73	.14	.09
Time*Group	13.63	10	1.36	.56	.84	.06
Two Ft. EC						
ST AP						
Time	31.86	4	7.97	7.25	.00	.18
Time*Group	4.82	8	.60	.55	.82	.11
DT AP						
Time	6.33	4	1.58	1.91	.12	.10
Time*Group	7.17	8	.90	1.08	.39	.11
ST ML						
Time	2.36	4	.59	1.54	.20	.08
Time *Group	4.25	8	.53	1.39	.22	.13
DT ML						
Time	4.47	5	.90	1.52	.19	.08
Time *Group	3.38	10	3.4	.57	.83	.06

Note. SS= sum of squares; *df*= degrees of freedom; ft. = feet; EO = eyes opens; ST = single task; DT = dual-task; AP = anterior-posterior; ML = medio-lateral

Table 10

Repeated Measures ANOVA Results for Within Groups Variability from Pre- to Post-Test for Measures of Postural Sway during Single Support Conditions

Source	SS	*df*	Mean Square	F	*p*	η_p^2
Rt. Ft.						
ST AP						
Time	12.59	2.75	4.58	.37	.76	.02
Time*Group	100.33	5.50	18.26	1.47	.21	.13
DT AP						
Time	4.07	4	1.02	1.71	.16	.08
Time*Group	3.52	8	.44	.74	.66	.07
ST ML	283.17	2.95	95.99	1.86	.15	.09
Time						
Time*Group	440.07	5.90	74.59	1.45	.21	.13
DT ML						
Time	164.68	2.73	60.44	1.99	.13	.10
Time*Group	356.29	8	44.54	2.15	.04	.19
Lt. Ft.						
ST AP						
Time	6.99	5	1.40	.234	.95	.01
Time*Group	62.69	10	6.27	1.05	.41	.10
ST ML						
Time***	509.06	5	101.82	4.70	.00	.21
Time*Group	311.85	10	31.18	1.44	.18	.14
DT AP						
Time	23.02	4	5.76	.60	.66	.03
Time* Group	132.04	8	16.51	1.73	.11	.15
DT ML						
Time	158.93	5	31.79	1.21	.31	.06
Time*Group	346.15	10	34.62	1.32	.23	.13

Note. SS= sum of squares; *df*= degrees of freedom; ft. = feet; EO = eyes opens; ST = single task; DT = dual-task; AP = anterior-posterior; ML = medio-lateral; Rt. = right; Lt. = left

CHAPTER V

DISCUSSION

Physical Function

While no significant changes between groups occurred over time, meaningful improvements did occur in all groups on single task (ST) Short Physical Performance Battery (SPPB) and dual task (DT) SPPB scores from pre- to post-test, as well as in gait speed and chair stands under ST and DT conditions. An increase in the SPPB or gait speed (GS) tests and a decrease on the chair stand (CS) test is seen as an improvement in performance. Interestingly, the control group (CG), experienced the greatest improvement in all DT conditions, including GS and CS time, and SPPB DT scores, when comparing effect sizes. However, the DT group did experience a moderate improvement in SPPB DT scores, as did the high-velocity (HV) group in GS DT testing. A similar lack of improvement in GS was seen in a study by Bruin and associates (2012) and Melzer et al. (2009). During ST conditions, the HV group experienced the least improvement, though a moderate effect did occur in gait speed from pre-to post-test. This change in gait speed is similar to that of Bean and colleagues (2002), who noted an improvement of at least 0.1 m/s in the 4m walk in 79% of participants. Leg power was the most significant predictor of this improvement. It is surprising, therefore, more changes were not seen on the SPPB under either condition for the HV group, as HV training at low loads has been shown to improve balance in healthy community-dwelling older adults at low loads (Orr et al., 2006) and lower extremity function is a significant predictor of physical performance (Bean et al., 2010). This lack of change in the HV group on components of peak and average power may help explain this lack of change in SPPB scores. Interestingly, the HV group did increase performance more than the DT group on the GS and CS in DT conditions. Silsupadol and colleagues (2006) found evidence ST training could transfer to better performance under DT conditions. While HV training is not balance-specific, it has been shown to improve measures of balance which could have had a transfer effect to DT conditions. This evidence suggests HV training should be investigated further for its’ benefits on cognitive DT abilities.

Each group improved by more than 0.1 m/s in the GS ST test, which is considered clinically meaningful over a distance of 4m (Bean et al., 2002), with the DT group improving by another 0.17 m/s following four weeks of detraining. An improvement of one point on the SPPB is also considered clinically meaningful. Over 16 weeks the DT group improved their score by exactly one point in ST conditions and 1.44 points in DT conditions. However, the control group also improved in the SPPB DT test by 1.12 points, creating caution for the interpretation of these results to be attributed to the DT training program.   It should also be noted one participant in the DT group was unable to perform the chair stand test without using her hands at baseline. During 8 week testing, this participant was able to perform the CS test without the use of support, which could also be considered clinically meaningful.

DT costs may have confounded the ability to interpret the results of physical function during DT testing. It has been suggested costs during DT conditions will decrease with an increased challenge due to lack of participant willingness to relinquish attentional resources (Doumas et al., 2008). An improvement in the ability to perform cognitive tasks may have created less of a challenge for participants in the DT group, allowing for them to give up attentional priority from the physical function task and concentrate on the cognitive task. As errors on cognitive performance of DT tests were not tracked and priorities were not set for either task, it cannot be concluded whether attentional resources had an impact on the results of this study.

The largest effects were seen in ST conditions for CS time and GS time in the CG, with the DT group following closely behind in improvements. The greatest improvements in the DT and HV groups on ST-GS were seen between pre-test and 4 weeks. After four weeks of detraining, the DT group experienced the greatest percent decreases in performance on the SPPB DT (-5.43%) and SPPB ST (+2.3%) tests and the largest increase in GS ST performance (+15.60%), while the HV declined more in the CS (+49.91%) and GS (-1.33%) DT tests and CS ST (+6.58%) test following detraining.

Executive Function

Deficiencies in the TMT are considered relevant when time to completion surpasses 78 and 273 seconds on parts A and B, respectively. Under these standards, none of the groups were considered deficient. Similar improvements among the DT and HV groups were seen on the Trail Making Test Part A (TMT-A). Each group decreased in time from pre- to post-test. However, only the HV experienced a meaningful decrease in time during the TMT Part B (TMT-B), which reflects executive functioning to a greater extent than TMT-A. This group also experienced the largest increase in time to complete (17.99%) following detraining. Liu-Ambrose and associates (2010) also saw greater improvements among a resistance-trained group than a balance trained group in executive function following 52 weeks of training. The results may provide evidence executive function is a trainable component of HV training that cannot be sustained for longer than 4 weeks after 4 months of training. Both the DT group and CG experienced improvements 4 weeks after training of 10.24% and 17.42%, respectively.

Power

Very little change in peak power or velocity occurred among the DT group, though a moderate effect size was achieved from pre- to post-test on average power and velocity. Little change was seen in peak power across groups. As expected, the HV group experienced some improvements in power, specifically peak and average velocity in the first 4 weeks. Interestingly, however, the aforementioned group produced the least improvements in peak and average power over time, with improvements in average power being greatest in the DT group, followed by the CG when comparing effect sizes. The HV also experienced the greatest declines in peak power (-13.60%) and velocity (-6.00%) following 4 weeks of detraining and largest increase in average power (+4.50%). Average velocity declined by 12.5% in the DT, while it improved slightly in both the HV (+2.70%) and the CG (+5.00%).

While a change in power was not expected in the DT and CG groups, improvements among the HV group were. It is apparent that this group was able to produce a greater amount of speed during the chair stand movement, but not a greater amount of force. This suggests a lack of improvement in strength may have occurred at 40% 1RM. However, this is not supported by the changes in 1RM from pre- to post- test (Table 11), specifically in the chair stand test which improved from 13.50 to 22.91 kg from pre-test to 8 weeks in HV participants. This period of time was also when the greatest improvements in average power occurred for both the HV and DT groups. When performing the sit-to-stand test, Zech et al. (2012) experienced a similar absence of improvement in power following HV training. However, Katula et al. (2008) and Pereira and associates (2012) did see significant improvements in power variables following HV training. The limited number of participants in the HV group may have influenced the lack of change. It is also quite possible training at 40% 1RM may not be beneficial for outcomes of power, which is supported by previous research of de Vos and colleagues (2005) who found evidence higher external loads may be necessary for improvements in muscular fitness.

Table 11

1 and 10-RM Weight Lifted Among HV Group Participants at Pre-Test and 8 Weeks

Exercise	Pre-Test (kg)	8 Weeks (kg)
Chair Stand (10RM)	13.50	22.91
Calf Raise (10RM)	22.09	45.91
Glute Kickback (1RM)	12.27	17.27
Hip Abduction (1RM)	11.00	14.91
Hamstring Curl (1RM)	13.10	14.64

Note. RM= repetition maximum; KG = kilogram

Quality of Life

Overall quality of life (QoL) measured by the RAND-36 improved in the DT group, generating a large effect from pre- to post-test. Moderate effects were seen in the CG, while the HV group experienced very little change. Small changes were seen from post-test to detraining, as the DT group declined in overall QoL (-2.40%) along with the CG (-7.15%) and the HV group improved their score slightly (+2.3%). The DT group saw the greatest improvements from 12 to 16 weeks, which may suggest a time period of at least 16 weeks is important to produce meaningful changes in overall perceived health.

This is one of the first studies to examine health-related QoL following a DT or HV intervention. Rubenstein (2012) found similar improvements when comparing a balance training program to a high-intensity program. It has also been suggested that QoL is more likely to experience an improvement following resistance training in disabled populations (Chin et al., 2004). This population was apparently healthy, as seen by the above average scores in quality of life measures on the RAND-36, specifically in the HV group, which had very little room to improve. Furthermore, the constructs of the RAND-36 (emotional well-being, energy/fatigue, pain, role limitations, social functioning, physical health issues, physical functioning, and general health perceptions) may have been influenced by extraneous variables. Older individuals may experience more pains or trauma as they age, causing their perception of each construct to change due to events other than class. For example, one individual experienced a joint issue outside of class around week 16 of DT training. This likely influenced her scores on physical function and pain.

Confidence

Activities-Specific Balance Confidence (ABC) is a measure of confidence during various ADL's. It is expected that a balance-trained group might make the greatest improvements in perceived confidence of their balance. In the present study, however, the HV group saw the greatest improvements from pre- to post-test, specifically in the first 4 weeks. It should be noted that the DT group did see some improvements in confidence, as did the CG, though the latter's were miniscule. It also seems the DT group lost the most confidence between post-test and detraining (-10.16%), followed by the CG (-3.75%). The HV group further increased their balance confidence past baseline by another 5.03%. These results add to the inconsistency of improvements in confidence in DT training (Liu-Ambrose et al., 2009). However, the improvements in the study may be used as evidence that any physical activity may be beneficial to increase the level of balance confidence. While research points to improvements in balance in both HV and DT trained groups, it is inconclusive whether these results come from a perceived or actual improvement in balance outcomes. The results of this study suggest it may be a perception, as the HV group experienced the greatest improvement in confidence, but little improvement in SPPB balance outcomes or postural sway. However, because perceived ability can be predictive of actual ability (Liu-Ambrose et al., 2009), specifically during gait tasks in ST and DT conditions (Donoghue et al., 2013), results are important regardless of why the improvements were experienced.

Postural Sway

During eyes open (EO) ST and DT conditions every group increased in medio-lateral (ML) and anterior-posterior (AP) sway from pre- to post-test. AP sway was greater than ML sway during double support stances on average, indicating greater sway from front to back when participants are standing in EO or eyes-closed (EC) conditions. However, during single support conditions, ML sway was more likely to be greater than AP sway, with less sway occuring during DT conditions. This is contrary to double-support conditions, which were more likely to cause an increase in sway during DT testing. This could be due to the fact that participants were allowed to have a chair nearby in case of a fall. All but two participants relied on the chair in the single support conditions via tapping of a finger to putting a hand down fully on the chair. The introduction of a DT test could have caused participants to rely more greatly on the chair, thereby decreasing sway.

Participants in the DT and HV group were the only ones to experience improvements during right foot (RF) stances in all conditions, with the exception of AP sway under the DT conditions. Gobbo et al. (2014) reported a comparable lack of change in AP sway following 16 weeks of DT training. Similar research reported a lack of change in AP and ML sway length following 6 weeks of training three times per week (You et al, 2009), and 8 weeks (Lajoie, 2004) or 12 weeks of twice per week DT exercises (Hiyamizu et al., 2012; Lindemann et al., 2003).   However, older adults in a study by An et al. (2014) significantly decreased their AP and ML postural sway compared to a control group (An et al., 2014). There did not seem to be different improvements between ST and DT conditions.

The DT group in the present study experienced improvements in sway among all variables and conditions during LF stances. Due to the differences among individual support via the chair, it is difficult to make a conclusion based on single-support data. While these changes should be interpreted with caution, they could indicate improvements in single support stances following DT training.

Limitations

As with many studies, participant dropout was an issue with this study (Table 1). Along with dropouts due to illness or lack of interest, a CG participant passed away between post-testing and detraining. Accompanied with a small sample size, demographic-specific challenges created some limitations for this study. The TMT test requires participants to connect dots containing numbers and/or letters with a pen. Two participants were visually challenged, causing a delay in their test time which may not be attributable to function. Other participant limitations included the lack of ability of three participants to perform the CS test required by the SPPB and the inability of all but two participants to perform the one-legged stance without some assistance.

Design limitations may have also limited the study. Errors during DT performance, such as miscounting or misstating a letter, were not tracked. Hwang et al. (2013) have previously provided evidence that older adults are likely prioritize postural control over cognitive tasks (Hwang et al., 2013). This, accompanied with a perceived lack of negative impacts when errors occurred, could have caused individuals not to focus on the cognitive task as they might in a real-life situation. Furthermore, participants in the present study were instructed to walk at a normal pace during the SPPB gait test. Research has shown that those who walk (over 1.0 m/s) are less likely to experience DT interference. Changes in walking speed in the present study may have changed the amount of interference experienced by the individual (Plummer-D'Amato et al, 2012). It has also been suggested that variable priority instructions, in which the participant is instructed to focus on each task might be more beneficial than a fixed priority program, such as the one at present (Agmon et al., 2014). Instructions were not given to focus on each task, which may have created inconsistent training between participants who were focusing more on one task than other. While the Tekscan™ is an empirically supported for its' reliability, little researcher has been completed to prove its' validity. Values should be analyzed with caution. Lastly, testing was completed every 4 weeks in a 20 week period. Frequent testing may have caused a learning effect among participants.

This is demonstrated in the substantial improvements among the CG from pre-test to post-test in every area but executive function and average velocity.

Due to illness and lack of interest, attrition created unequal sample sizes between groups. The lack of an adequate number of individuals per group, specifically in the HV group created difficulties in assessing changes between and within groups which can be generalized to the population. In many variables, outliers further complicated this issue. Some extraneous variables were also outside the control of the researcher. While participants were told to keep the same activity level, changes in physical activity or activities of daily living (ADL's) were not tracked. This may limit the internal validity of the study.

Conclusions

No significant changes occurred between groups over time in postural sway, power, balance confidence, physical function, or executive function. However, many meaningful changes did occur, specifically during the first 4 to 8 weeks of training. All groups performed better at post-test on all SPPB outcomes under ST and DT conditions, with clinically meaningful increases in gait speed occurring for each group. The CG group improved more than either group on CS time and GS time under all conditions, making it difficult to conclude whether HV or DT should be suggested programs for physical function compared with other measures. Creating more concerns with interpretation, the HV group improved in speed of movement during the chair stand. The training load of 40% 1RM may not have been significant enough to induce a change in power production. Confidence and QoL outcomes benefited from DT training more than both other groups. This indicates that perceptions may of health and balance may be improved more when individuals change physically and cognitively simultaneously.

Further research using larger sample sizes should investigate the effects of HV training DT outcomes, as well as executive function. Researchers should also attempt to control for DT performance by tracking errors during tasks requiring both a cognitive and physical task. This might hold participants accountable for performing adequately under DT conditions. Studies should also incorporate longer periods of detraining to assess more significant changes over time.

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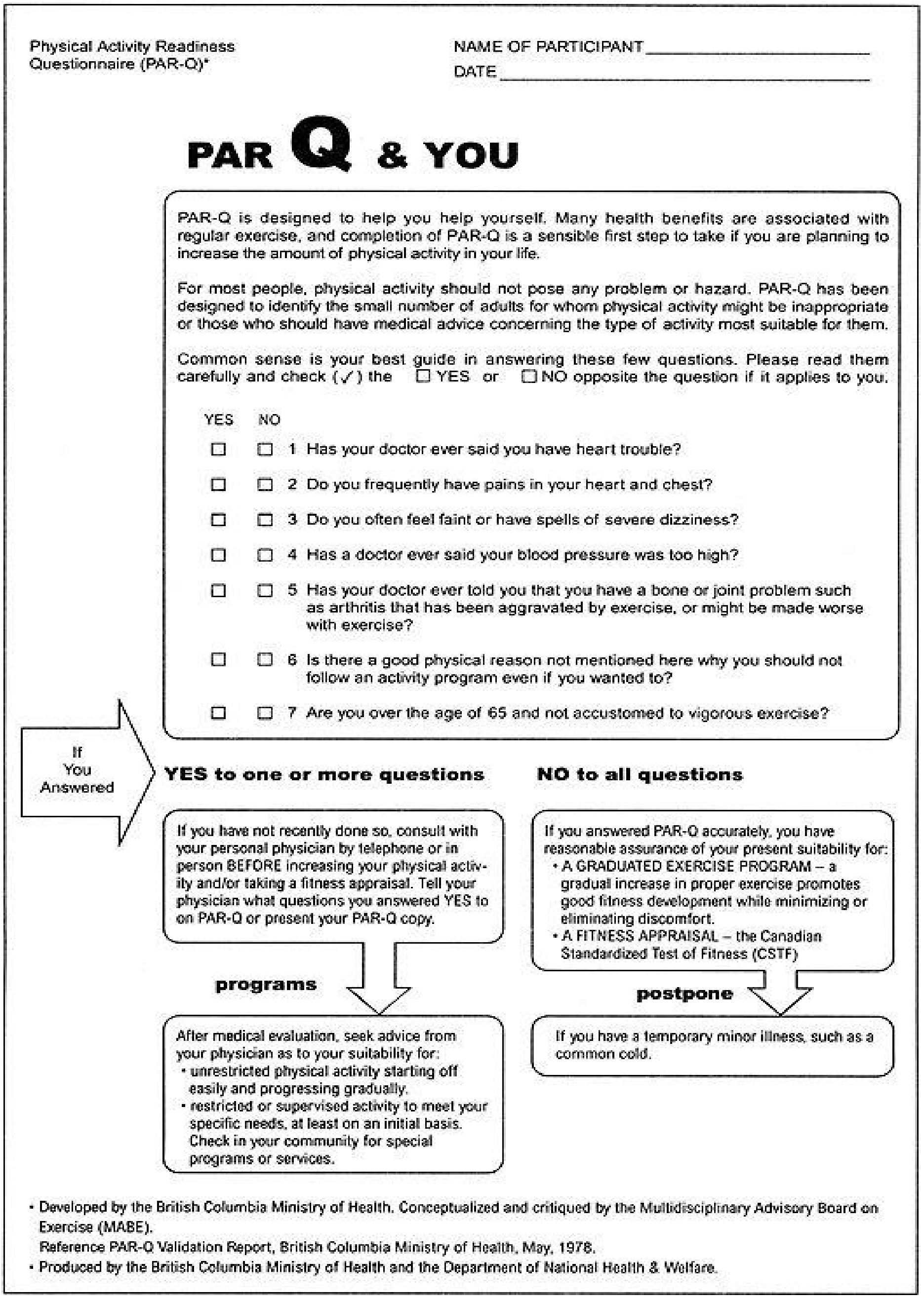
APPENDIX A - Physical Activity Readiness Questionnaire (PAR-Q)



Physical Activity Readiness
Questionnaire (PAR-Q)*

NAME OF PARTICIPANT ________________________
DATE ________________________

PAR Q & YOU

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people, physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check (✓) the ☐ YES or ☐ NO opposite the question if it applies to you.

YES	NO	
☐	☐	1 Has your doctor ever said you have heart trouble?
☐	☐	2 Do you frequently have pains in your heart and chest?
☐	☐	3 Do you often feel faint or have spells of severe dizziness?
☐	☐	4 Has a doctor ever said your blood pressure was too high?
☐	☐	5 Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
☐	☐	6 Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
☐	☐	7 Are you over the age of 65 and not accustomed to vigorous exercise?

If You Answered

YES to one or more questions

If you have not recently done so, consult with your personal physician by telephone or in person BEFORE increasing your physical activity and/or taking a fitness appraisal. Tell your physician what questions you answered YES to on PAR-Q or present your PAR-Q copy.

programs

After medical evaluation, seek advice from your physician as to your suitability for:
- unrestricted physical activity starting off easily and progressing gradually.
- restricted or supervised activity to meet your specific needs, at least on an initial basis. Check in your community for special programs or services.

NO to all questions

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for:
- A GRADUATED EXERCISE PROGRAM – a gradual increase in proper exercise promotes good fitness development while minimizing or eliminating discomfort.
- A FITNESS APPRAISAL – the Canadian Standardized Test of Fitness (CSTF)

postpone

If you have a temporary minor illness, such as a common cold.

- Developed by the British Columbia Ministry of Health. Conceptualized and critiqued by the Multidisciplinary Advisory Board on Exercise (MABE).
  Reference PAR-Q Validation Report, British Columbia Ministry of Health, May, 1978.
- Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare.

APPENDIX B – Healthy History Questionnaire

Health History & Physical Activity
Participant Information Form

Name: ____

Gender: ___M ___ F Date of birth: _____________

Age: _____

Education Level: _____H.S. not completed____H.S.Diploma ____Some college

____Bachelor's Degree completion_____Graduate School completitium

Personal Physician: ____

Telephone: ____

Person to notify in case of an emergency: ___________________________

Relationship: ____

Telephone: ____

Medication List				
Medication	Dosage	When Taken	Reason Taken	Special Instructions

PHYSICAL/ACTIVITY HISTORY

Do you have a regular exercise routine? Y N

If yes, please list (walking, biking, strength training, etc...):

Activity: ____________________ Times/per week: ___________ Duration____________

Activity: ____________________ Times/per week: ___________ Duration____________

Activity: ____________________ Times/per week: ___________ Duration____________

Activity: ____________________ Times/per week: ___________ Duration____________

Activity: ____________________ Times/per week: ___________ Duration____________

Activity: ____________________ Times/per week: ___________ Duration____________

APPENDIX C – Medical Consent Form

MEDICAL CONSENT FORM

Your patient has been invited to take part in a research study titled "Effects of Dual-Task Balance and Power Training on Balance, Functionality, Quality of Life, and Cognition in Older Adults". Signing of this form will medically release the patient to be a part of this study. This study is being conducted by Larissa Boyd, doctoral student at Oklahoma State University.

Purpose: The purpose of this study is to evaluate the impacts of power training and dual-task training in older adults over age 65 on balance, confidence, functionality, quality of life, and cognitive function. This study has been approved by the Institutional Review Board at Oklahoma State University.

Procedures: Participants will be randomly assigned to either a control group (CG), power training (PT), or dual-task (DT) balance intervention. All subjects will be tested at pre-test, four-weeks, eight weeks, 12 weeks, 16 weeks into the intervention, and four weeks following the end of the intervention. Those in the PT will participate in power training at 40% of their maximal strength twice a week for 30 minutes and be required to perform 1-RM testing at pre-test and eight weeks. Power training has become known as a beneficial activity at this intensity specifically among the older adult population and is becoming commonly prescribed. Those in the DT group will participate in dual task training for 30 minutes twice per week. Exercises will mimic multi-tasking activities of daily living by requiring balancing while doing a cognitive task such as counting backwards by seven from 100. Measurements of balance and confidence will be measured via the Tekscan HR^{TM} Mat system and Activities Specific Balance Confidence Scale (ABC), respectively. The Short Physical Performance Battery (SPPB) will be utilized to measure functionality, and the Trail Making Test (TMT) will be used to measure cognitive improvements. Quality of Life will measured by the RAND 36. The Tekscan HR^{TM} Mat system is a high-resolution floor mat system for capturing barefoot plantar pressure, assessing foot function, and analyzing gait. It can monitor improvements in balance, strength and weight bearing (Tekscan, Inc., Boston, MA). The ABC scale is a 16 item survey which evaluates the participants' confidence in their ability to handle situations which could challenge their balance on a scale of 0-100%. The SPPB requires participants to perform balance tests, a chair stand test, and a gait speed test in order to measure functionality. The TMT consists of two parts. Participants will be required to draw lines in numerical order for time in the first part. In the second part, subjects will be timed on how fast they can draw lines in numerical and alphabetical order, switching between letters and numbers. The RAND 36 will evaluates perceptions of physical functioning, bodily pain, role limitations due to physical health problems, role limitations due to personal or emotional problems, emotional well-being, social functioning, energy/fatigue, and general health via a 36 question survey. The control group will participate in all assessments and received a delayed intervention following the study's end.

Risks and Benefits of Being in the Study:

The risks associated with participation in the research study are minimal. Your complete confidentiality will be maintained as described below. Should an injury occur, neither Oklahoma State University, the researchers, or the retirement community are liable. Risks associated with fitness testing may include muscle soreness and tiredness. Potential, but rare, risks include joint pain and muscle injury. We will teach you how to perform the test before you complete it. These tests are safe and often used to test physical fitness in people over the age of 60 years.

Contacts and Questions:

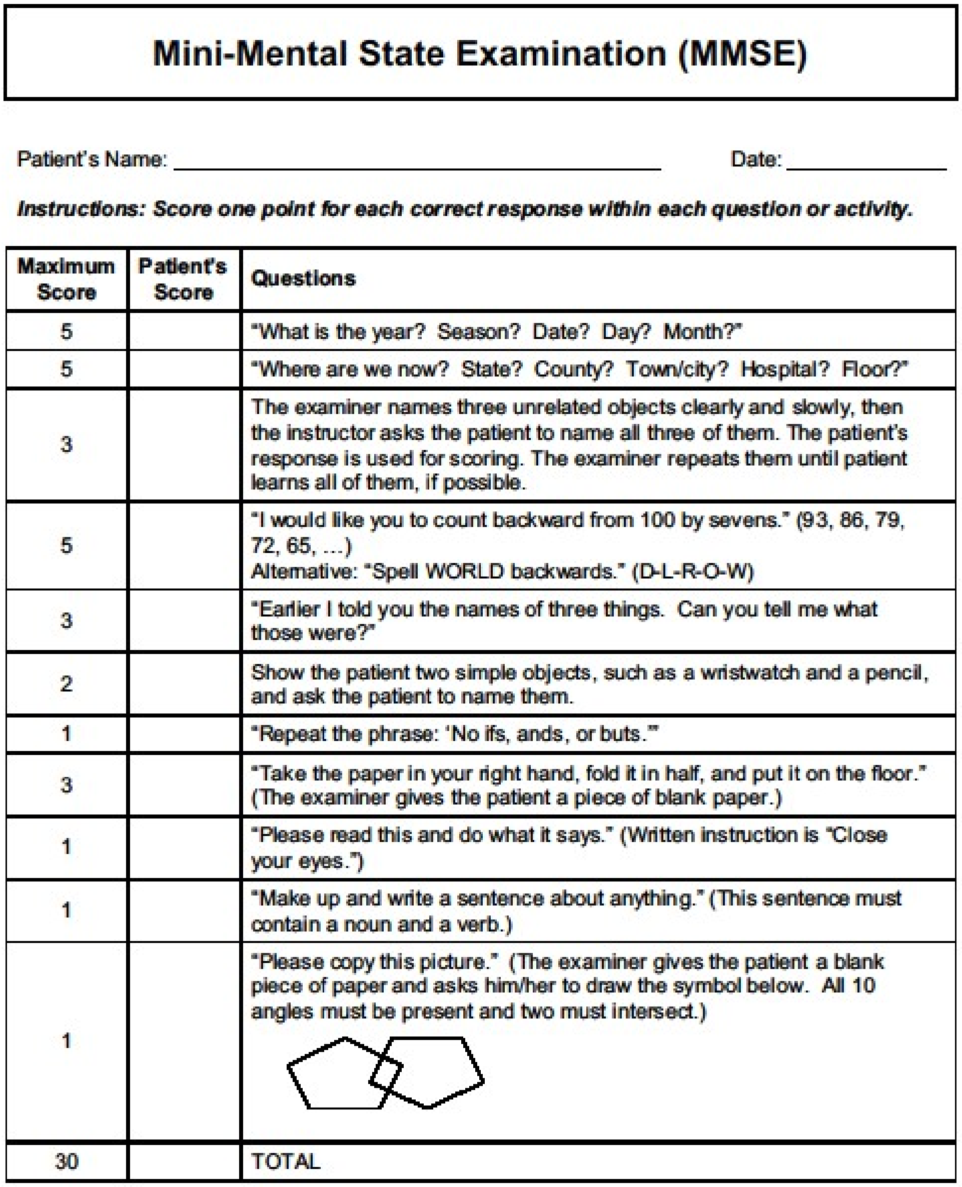
You may ask any questions you have by contacting the researcher at 405-471-1792 or larissa.boyd@okstate.edu.

By signing this form, you are releasing your patient to participate in this study.

Statement of Consent:

I have read the above information and I feel I understand the study well enough to make a decision about my patient's involvement.

APPENDIX D – Mini Mental State Exam



Mini-Mental State Examination (MMSE)

Patient's Name: ______________________________ Date: __________

Instructions: Score one point for each correct response within each question or activity.

Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day? Month?"
5		"Where are we now? State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then the instructor asks the patient to name all three of them. The patient's response is used for scoring. The examiner repeats them until patient learns all of them, if possible.
5		"I would like you to count backward from 100 by sevens." (93, 86, 79, 72, 65, …) Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"
3		"Take the paper in your right hand, fold it in half, and put it on the floor." (The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1		"Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10 angles must be present and two must intersect.)
30		TOTAL

APPENDIX E – Activities-Specific Balance Confidence Scale (ABC)

The Activities-specific Balance Confidence (ABC) Scale

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

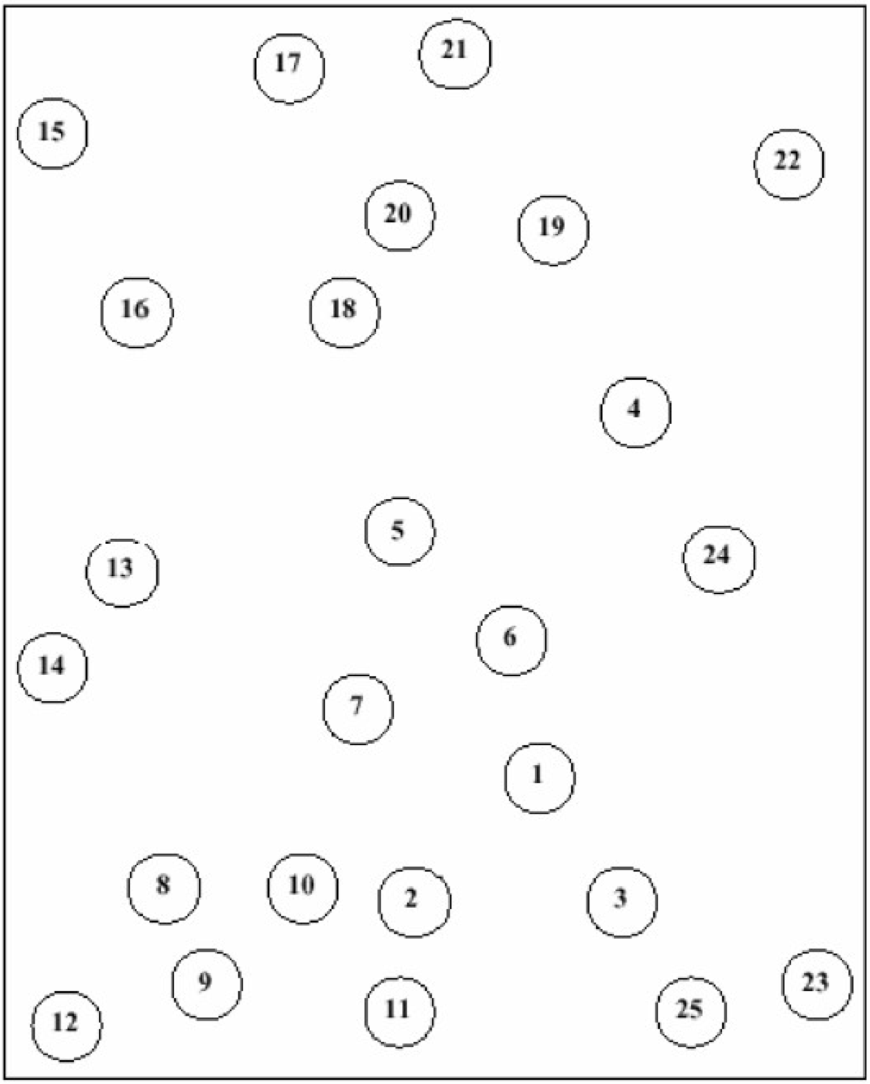
0%	10	20	30	40	50	60	70	80	90	100%
no confidence							completely confident			

“How confident are you that you will <u>not</u> lose your balance or become unsteady when you…
…walk around the house? ____%
…walk up or down stairs? ____%
…bend over and pick up a slipper from the front of a closet floor ____%
…reach for a small can off a shelf at eye level? ____%
…stand on your tiptoes and reach for something above your head? ____%
…stand on a chair and reach for something? ____%
…sweep the floor? ____%
…walk outside the house to a car parked in the driveway? ____%
…get into or out of a car? ____%
…walk across a parking lot to the mall? ____%
…walk up or down a ramp? ____%
…walk in a crowded mall where people rapidly walk past you? ____%
…are bumped into by people as you walk through the mall?____%
… step onto or off an escalator while you are holding onto a railing? ____%
… step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? ____%
…walk outside on icy sidewalks? ____%

APPENDIX F – Trail Making Test

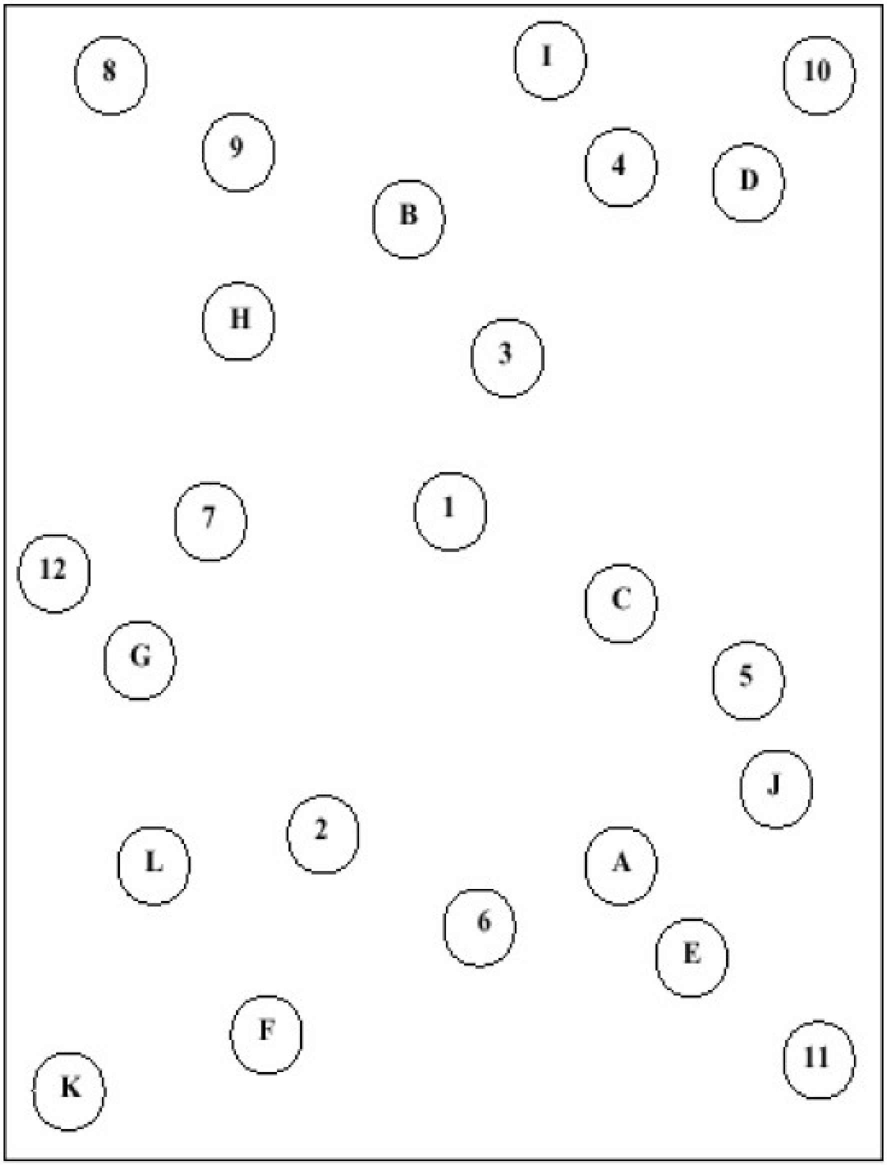
Trail Making Test Part A

Patient's Name: ______________________________ Date: ____________________

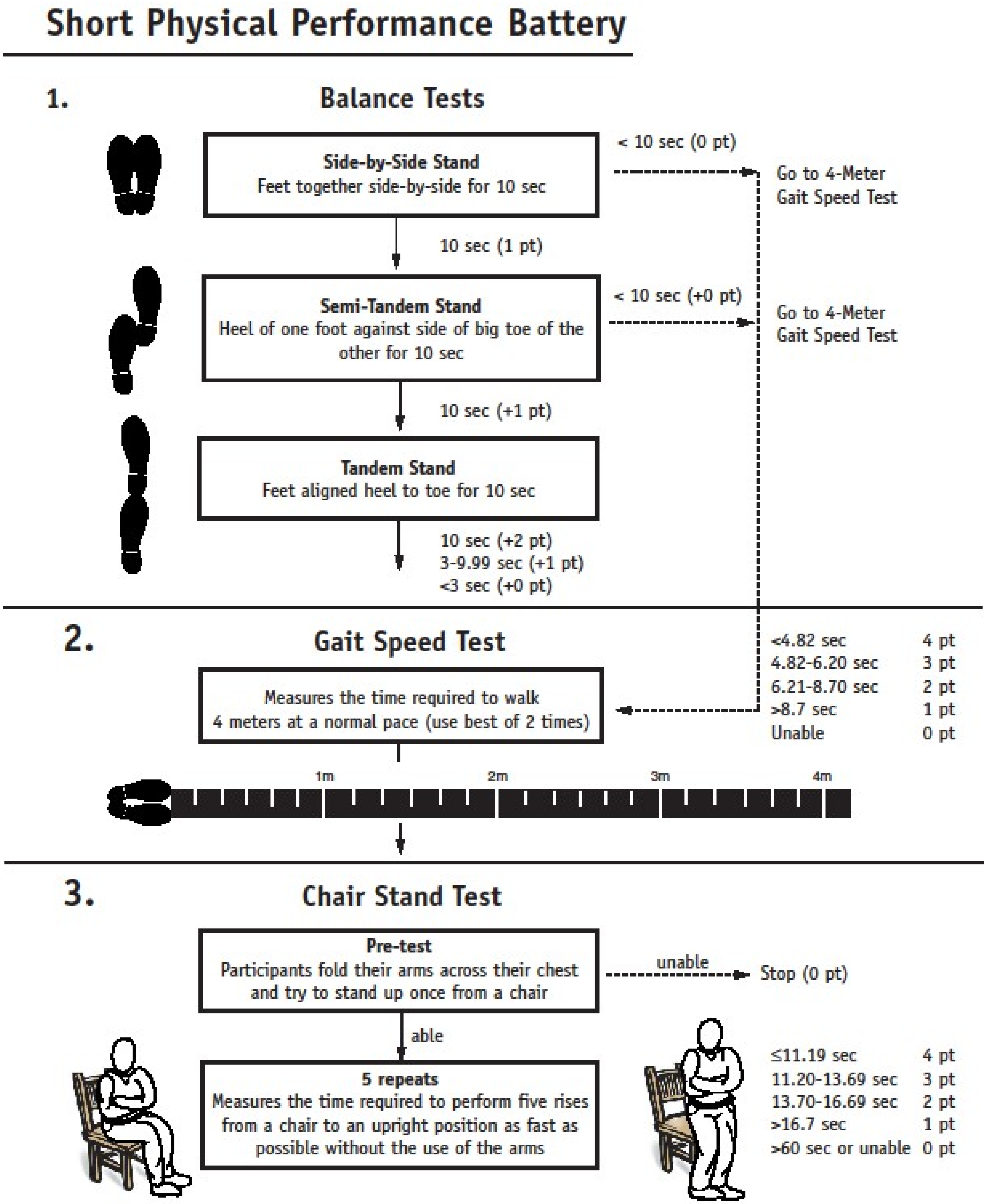


Trail Making Test Part B

Patient's Name: ______________________________ Date: ____________________



APPENDIX G – Short Physical Performance Battery (SPPB)



Short Physical Performance Battery

1. Balance Tests

Side-by-Side Stand
Feet together side-by-side for 10 sec

< 10 sec (0 pt) → Go to 4-Meter Gait Speed Test

10 sec (1 pt)

Semi-Tandem Stand
Heel of one foot against side of big toe of the other for 10 sec

< 10 sec (+0 pt) → Go to 4-Meter Gait Speed Test

10 sec (+1 pt)

Tandem Stand
Feet aligned heel to toe for 10 sec

10 sec (+2 pt)
3-9.99 sec (+1 pt)
<3 sec (+0 pt)

2. Gait Speed Test

Measures the time required to walk 4 meters at a normal pace (use best of 2 times)

<4.82 sec	4 pt
4.82-6.20 sec	3 pt
6.21-8.70 sec	2 pt
>8.7 sec	1 pt
Unable	0 pt

3. Chair Stand Test

Pre-test
Participants fold their arms across their chest and try to stand up once from a chair

unable → Stop (0 pt)

able

5 repeats
Measures the time required to perform five rises from a chair to an upright position as fast as possible without the use of the arms

≤11.19 sec	4 pt
11.20-13.69 sec	3 pt
13.70-16.69 sec	2 pt
>16.7 sec	1 pt
>60 sec or unable	0 pt

APPENDIX H – RAND-36

RAND 36

1. In general, would you say your health is:	
Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

2. **Compared to one year ago**, how would your rate your health in general **now**?	
Much better now than one year ago	1
Somewhat better now than one year ago	2
About the same	3
Somewhat worse now than one year ago	4
Much worse now than one year ago	5

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

(Circle One Number on Each Line)

	Yes, Limited a Lot	Yes, Limited a Little	No, Not limited at All
3. **Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports	[1]	[2]	[3]
4. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	[1]	[2]	[3]
5. Lifting or carrying groceries	[1]	[2]	[3]
6. Climbing **several** flights of stairs	[1]	[2]	[3]
7. Climbing **one** flight of stairs	[1]	[2]	[3]
8. Bending, kneeling, or stooping	[1]	[2]	[3]
9. Walking **more than a mile**	[1]	[2]	[3]
10. Walking **several blocks**	[1]	[2]	[3]
11. Walking **one block**	[1]	[2]	[3]
12. Bathing or dressing yourself	[1]	[2]	[3]

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

(Circle One Number on Each Line)

	Yes	No
13. Cut down the amount of time you spent on work or other activities	1	2
14. **Accomplished less** than you would like	1	2
15. Were limited in the **kind** of work or other activities	1	2
16. Had **difficulty** performing the work or other activities (for example, it took extra effort)	1	2

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

(Circle One Number on Each Line)

	Yes	No
17. Cut down the **amount of time** you spent on work or other activities	1	2
18. **Accomplished less** than you would like	1	2
19. Didn't do work or other activities as **carefully** as usual	1	2

20. During the **past 4 weeks,** to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

(Circle One Number)

Not at all 1

Slightly 2

Moderately 3

Quite a bit 4

Extremely 5

21. How much **bodily** pain have you had during the **past 4 weeks**?

(Circle One Number)

None 1

Very mild 2

Mild 3

Moderate 4

Severe 5

Very severe 6

22. During the **past 4 weeks,** how much did **pain** interfere with your normal work (including both work outside the home and housework)?

(Circle One Number)

Not at all 1

A little bit 2

Moderately 3

Quite a bit 4

Extremely 5

These questions are about how you feel and how things have been with you **during the past 4 weeks**. For each question, please give the one answer that comes closest to the way you have been feeling.

How much of the time during the **past 4 weeks** . . .

(Circle One Number on Each Line)

	All of the Time	Most of the Time	A Good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
23. Did you feel full of pep?	1	2	3	4	5	6
24. Have you been a very nervous person?	1	2	3	4	5	6
25. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
26. Have you felt calm and peaceful?	1	2	3	4	5	6
27. Did you have a lot of energy?	1	2	3	4	5	6
28. Have you felt downhearted and blue?	1	2	3	4	5	6
29. Did you feel worn out?	1	2	3	4	5	6
30. Have you been a happy person?	1	2	3	4	5	6
31. Did you feel tired?	1	2	3	4	5	6

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

(Circle One Number)

All of the time 1

Most of the time 2

Some of the time 3

A little of the time 4

None of the time 5

How TRUE or FALSE is <u>each</u> of the following statements for you.

(Circle One Number on Each Line)

	Definitely True	Mostly True	Don't Know	Mostly False	Definitely False
33. I seem to get sick a little easier than other people	1	2	3	4	5
34. I am as healthy as anybody I know	1	2	3	4	5
35. I expect my health to get worse	1	2	3	4	5
36. My health is excellent	1	2	3	4	5

VITA

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