EXAMINING THE EFFECTS OF A MULTIMODAL STRUCTURED PHYSICAL ACTIVITY PROGRAM ON COMPLEX MOBILITY IN OLDER ADULTS

BY

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ABSTRACT

Erika Griffith

EXAMINING THE EFFECTS OF A MULTIMODAL STRUCTURED PHYSICAL ACTIVITY PROGRAM ON COMPLEX MOBILITY IN OLDER ADULTS

Thesis under the direction of Jeffery A. Katula, PhD., Department of Health & Exercise Science.

The purpose of the present study was to examine the impact of a multimodal physical activity program on complex mobility. Seventy older adults (mean ±SD age 78.07 ± 5.67 years) with impaired lower extremity functioning were recruited from the physical activity (PA) or successful aging (SA) groups of the LIFE study. The PA intervention combined aerobic, strength, and flexibility/balance training and met twice per week. Complex mobility was assessed using the Walking Decision Making Task (WDMT) and the 7 meter walk (7MW). The WDMT is an eight meter T-shaped walking task designed to present a cognitive challenge (i.e. making a turning decision), while walking at a quick pace. Directional stimuli presented during the task were neutral, congruent, or incongruent. During the 7MW, participants walked seven meters at a fast pace while stepping over two obstacles (6 and 30 cm tall). Performance times were assessed at baseline, 12, and 24 months. Although performance times on the incongruent conditions were significantly slower than both the neutral and congruent conditions (p’s <.0001), there were no significant between group differences in change scores from baseline to 12 or 24 month follow up on complex mobility (all p’s > 0.05). Further investigation is needed to understand the impact of PA on complex mobility.
INTRODUCTION

Mobility, or the ability to ambulate through daily life, is crucial for everyday function and independence (Gill, Allore, Hardy, & Guo, 2006; Studenski, 2009). Prevalence and incidence rates of mobility loss are increasing and are especially concerning in the older adult population, with prevalence rates in 65+ year olds of 31.7% being reported in 2005 by the Centers for Disease Control and Prevention (2009) and some incidence rates reaching upwards of 56% (Gill, Gahbauer, Murphy, Han, & Allore, 2012). The proportion of adults aged 65 and older is expected to rapidly increase over the next few decades, nearly doubling to 72.1 million people by 2030 (Aging, 2010), which may drastically increase prevalence and incidence rates of mobility loss in the upcoming years.

The consequences of mobility loss are significant, with a major concern being loss of independence due to its association with increased rates of mortality, morbidity, depression, and hospitalization, decreased cognitive functioning, and greater amounts of sedentary behavior (Bruce, 2001; Gill et al., 2006; Satariano et al., 2012). These negative health consequences can then trigger a cascade of negative outcomes that further accelerate mobility loss that, if left untreated, can lead to a downward spiral that significantly impacts the individual’s quality of life and healthcare costs (Fried & Guralnik, 1997; Gill et al., 2006). Therefore, it is important to first identify methods of assessing mobility so that we can then discover ways to delay or prevent age-associated declines in mobility.

Mobility can be measured using a variety of assessment strategies, the most common being the 400 meter walk test (400 MWT) at usual or fast pace, and the Short
Physical Performance Battery (SPPB), a lower extremity physical function measure. Although both of these measures have been used frequently throughout the literature for mobility assessment, it can be argued that they are time consuming and may be dependent on other constructs besides mobility for successful completion (Buchner, 2008; Guralnik et al., 2000). However, measuring gait speed over a relatively short distance has recently been evidenced to be a powerful indicator of mobility (Peel, Kuys, & Klein, 2013), having important benefits over existing measures, including ease and quickness of administration and applicability to lower functioning individuals who may not be able to complete the previously mentioned tasks.

Physical activity is one solution that has consistently shown to have a positive impact on mobility in older adults (Brown & Flood, 2013; de Vries et al., 2012; Gine-Garriga, Roque-Figuls, Coll-Planas, Sitja-Rabert, & Salva, 2013; Mian, Baltzopoulos, Minetti, & Narici, 2007). Multimodal interventions, or those that combine different training mechanisms including a combination of aerobic, strength, and/or flexibility/balance training, are most commonly used in the older adult population and provide more consistent benefits to mobility than when any of these training strategies are implemented in isolation (Gine-Garriga et al., 2013; Mian et al., 2007). The enhanced benefits of multimodal interventions may be the result of the simultaneous training of multiple systems, which is consistent with the idea that walking is not just a simple motor task, but one that is more complex (Hausdorff, Yogev, Springer, Simon, & Giladi, 2005). Unfortunately, the methods typically used for evaluating mobility have been quite simple, artificial, and lack ecological validity; they may not tap into the complex nature of walking ability.
Complex mobility refers to the idea that mobility in the real world requires one to navigate through many complex and challenging conditions, due to the highly variable demands of our environment (Shumway-Cook et al., 2007). Therefore, complex walking tasks, or those that challenge multiple systems involved in mobility, have been designed to more closely examine everyday mobility. Although the positive effects of physical activity on simple walking tasks have been widely documented, the effects on complex mobility measures are not well known. Therefore, the purpose of the current study is to determine the impact of a multimodal physical activity intervention on performance on two complex mobility tasks, the 7 Meter Walk (7MW) and Walking Decision Making Task (WDMT), in older adults with low physical functioning.
REVIEW OF LITERATURE

Importance of Mobility

Mobility, or the ability to ambulate freely, serves as the foundation for many activities of daily living (ADLs) that are necessary to maintain an independent lifestyle in older adults (Studenski, 2009). Declines in mobility commonly occur with advancing age, but more severe impairments can lead to loss of mobility, which can manifest in various ways (i.e. inability to walk up the stairs, get out of a chair, or walk at a certain speed or distance) and must be considered in context of an individual’s personal circumstances. The absolute end point of mobility loss is mobility disability, a chronic condition that is a major concern in the older adult population. Mobility disability is often operationally defined as the inability to walk one quarter of a mile or climb a flight of stairs without assistance, which lasts for greater than six months (Gill et al., 2006). It is most commonly classified as a progressive and dynamic condition that develops with advancing age, but can also occur as the result of an acute injury, such as a hip fracture or stroke, (Fried & Guralnik, 1997; Guralnik, Ferrucci, Balfour, Volpato, & Di Iorio, 2001) or a chronic health condition such as knee osteoarthritis (Messier et al., 2013).

Adults aged 65 or older represent the age group with the highest prevalence rates in the US for mobility disability, with reports from the Centers for Disease Control (CDC) in 2005 indicating that 31.7% of adults in this age group reported difficulty in walking three city blocks (Prevention, 2009). This is 20% more than the 54-64 year old age bracket. The incidence of mobility disability has been reported by the Established Populations for Epidemiologic Studies of the Elderly (EPESE), where 36.2% of people over the age of 65 who were non-disabled at baseline developed mobility disability over
the following four years and the risk of becoming disabled increased two-fold with each 10 year increase in age (Guralnik et al., 1993). More recently, the Precipitating Events Project, a longitudinal cohort study evaluating the risk factors for long term loss of the ability to walk 400 meters or drive a car, determined that 56% of non-disabled adults over the age of 70 developed lost their ability to walk 400 meters during an 11 year follow up (Gill et al., 2012).

Over the next few decades, incidence rates of mobility loss can be expected to steadily increase in accordance with the growth rate of 65+ year olds in our country. By 2030, the number of people over the age of 65 in the US is projected to nearly double from 39.6 million in 2009 to an estimated 72.1 million, or 19% of the population (Aging, 2010). The consequences of loss of mobility in older adults can have a profound impact on both the individual and society.

**Impact of Loss of Mobility**

Mobility plays a crucial role in leading a successful and independent life. Therefore, mobility loss can have a significant, negative effect on the life of those who suffer from it. For example, greater levels of mobility impairment increase the likelihood that the individual will need constant care either at home or an assisted living facility (Guralnik et al., 1994). Losing the ability to care for yourself is classified as loss of independence, a nationwide health concern in the older adult population today due to its association with various negative physical, psychological, emotional and social consequences that have a powerful impact on quality of life (Gill et al., 2006; Satariano et al., 2012).
Loss of mobility is associated with many adverse health outcomes such as higher rates of mortality, morbidity, and sedentary behavior (Gill et al., 2006; Satariano et al., 2012). A sedentary lifestyle and physical inactivity are major risk factors for many chronic diseases including cardiovascular disease, obesity, and diabetes. Having a greater number of chronic conditions has been associated with poorer mobility as indicated by slower gait speed, a consistent predictor of future mobility loss (Watson et al., 2010). The sedentary behavior that can result from loss of mobility may also accelerate the loss of lean muscle mass in the lower extremity, which greatly influences balance and increases fall risk (Fried & Guralnik, 1997; Scott et al., 2014). Losing one’s independence can also affect the individual’s mental health by restricting the activities they can engage in, which can result in social isolation, fewer social contacts, and less community involvement (Mezuk & Rebok, 2008). Isolation from the community and daily activities is associated with increased risk of depression (Bruce, 2001) and poorer cognitive functioning (Gill et al., 2006; Satariano et al., 2012). In combination, these consequences can cause a downward spiral that lead to numerous negative outcomes.

In terms of economic burden, individuals who have limited mobility are at a greater risk of institutionalization and have greater healthcare needs compared to individuals without mobility limitations (Fried & Guralnik, 1997). Slower gait speed, an indicator of mobility, has been found to be a predictor of hospitalizations, declines in global health, and the development of a new difficulty in personal care over one year in the Medicare population (Hardy, Kang, Studenski, & Degenholtz, 2011; Studenski et al., 2003). With greater utilization of healthcare resources, primarily via hospitalizations and outpatient care related to falls and acute illnesses, there is a direct impact on our
country’s medical costs. Older adults on Medicare who reported having limited ability to walk one quarter of a mile contributed an additional $42 million to the total annual healthcare costs in 2004 (Hardy et al., 2011). Being hospitalized for extended periods of time can also negatively impact a person’s functional ability and can even lead to incident loss of mobility (Guralnik et al., 2001). However, the majority of individuals suffering from mobility loss reside in the community, since most cannot afford to live in an assisted living facility, leaving their spouses/loved ones to act as their primary caregivers without compensation (Fried & Guralnik, 1997). This greatly increases indirect medical costs.

One important step for decreasing the medical costs related to loss of mobility is identifying who is at risk for this condition and intervening early to delay or prevent significant declines in mobility. The most prominent risk factor for loss of mobility is older age (Fried & Guralnik, 1997; Gill et al., 2006; Guralnik et al., 2001), but there are several others that will significantly affect future incidence rates. These include lower socioeconomic status (Fried & Guralnik, 1997; Satariano et al., 2012), lower scores on the Short Physical Performance Battery (SPPB) (Gill et al., 2012; Guralnik et al., 2000; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995), the presence of \( \geq 3 \) chronic conditions (Guralnik et al., 2001), female sex (Fried & Guralnik, 1997; Gill et al., 2006), and physical frailty (Gill et al., 2006). The latter two, along with older age, have independent associations with a greater likelihood of transitioning into a classification of mobility disability and less likelihood of regaining independence (Gill et al., 2006). When compared to those scoring in the highest range of the SPPB, scoring in the lowest range had a four to five fold increased risk of progressing to mobility disability over one
and four years (Guralnik et al., 1995). Therefore, early identification of risk factors is necessary to ensure that an appropriate intervention is implemented in a timely manner to prevent mobility loss from occurring. Evidence suggests that gait speed is a powerful indicator of mobility that can be used to identify at risk individuals as it is a predictor of numerous adverse health outcomes (Peel et al., 2013; Studenski, 2009).

**Mobility Assessment and Gait Speed**

Common methods for assessing mobility include the Short Physical Performance Battery (SPPB) and the 400 meter walk test (400MWT) (Sayers, Guralnik, Newman, Brach, & Fielding, 2006). The SPPB is an objective measure of lower extremity function that includes three separate assessments: timed repeated chair stands, three balance tests of varying complexity and usual walking pace over 8 feet (2.44 meters) (Guralnik et al., 1994). The SPPB is a tool that has been used in numerous epidemiological studies and randomized controlled trials to examine mobility (Gill et al., 2012; Schneider & Lichtenberg, 2011) and better performance on the SPPB has been associated with decreased risk for losing the ability to walk one half mile or climb stairs without assistance (Guralnik et al., 2000). During the 400MWT, individuals are instructed to walk 400 meters at either usual or fast pace and are timed from start to finish (Newman et al., 2006; Simonsick, Montgomery, Newman, Bauer, & Harris, 2001). A benefit of the 400MWT is the long duration of walking, which is thought to more closely simulate walking ability in everyday life, as compared to the short walking component of the SPPB. In addition, the 400MWT performance has been associated with aerobic capacity and muscular strength, with deficiencies in either physiological component predicting poorer performance (Buchner, 2008; Marsh et al., 2011). Although evidence supports the
validity of these methods for assessing mobility, they can be time consuming (Guralnik et al., 2000). Some have suggested that measuring gait speed alone may be a more beneficial way to assess mobility with important benefits over other mobility measures such as the 400MWT including: relative ease and quickness of administration and applicability to lower functioning individuals who may not be able to complete tasks of longer duration (Abellan van Kan et al., 2009; Studenski et al., 2011). This may increase the risk of misclassifying someone as having mobility loss.

Assessing gait speed provides a quick and simple way to evaluate mobility. Severely abnormal gait speed, which is defined as a usual gait speed of < 0.6 m/s, has been a consistent predictor of many adverse health outcomes and current mobility disability (Studenski et al., 2003). In a recent review, the International Academy of Nutrition and Aging (IANA) concluded that a usual gait speed of < 1 m/s is a predictor of several adverse outcomes including: mobility disability, cognitive decline, mortality, falls, and institutionalization, and their risk of developing these conditions is greater than individuals with usual gait speeds > 1 m/s (Abellan van Kan et al., 2009). Impaired gait speed also increases fall risk, which is a major cause of morbidity in older adults (Montero-Odasso, Verghese, Beauchet, & Hausdorff, 2012). Since gait speed has been shown to be an important indicator of mobility, and gait speed decline is commonly observed with advancing age, it is crucial to discover a way to delay or prevent age-associated declines in mobility.

**Physical Activity, Gait, and Mobility**

There are many benefits associated with leading a physically active lifestyle, especially in the older adult population. Increasing levels of physical activity has been
associated with decreasing risk of falls, lower mortality rates, and reduced rates of declines in mobility and physical function (Brown & Flood, 2013; Gine-Garriga et al., 2013). Unfortunately, only 14.3% of 65-74 year olds met the physical activity guidelines of 150 minutes of moderate intensity aerobic exercise per week in 2011, with that number decreasing with advancing age (2020, 2013). Physical inactivity has been associated with mobility limitations and various negative health outcomes, including sarcopenia, balance impairments, obesity, and low cardiorespiratory fitness (Fiatarone et al., 1994; Huang et al., 1998; Hyatt, Whitelaw, Bhat, Scott, & Maxwell, 1990). Therefore, increasing physical activity levels may be a solution in the prevention or deceleration of age-associated declines in mobility.

Recent reviews examining the impact of physical activity on measures of mobility have concluded that physical activity can improve performance on mobility measures in older adults (Brown & Flood, 2013; de Vries et al., 2012; Gine-Garriga et al., 2013; Marsh, Chmelo, Katula, Mihalko, & Rejeski, 2009; Mian et al., 2007; Rejeski et al., 2011). The four types of exercise interventions that are most frequently used are aerobic training, resistance training, balance/flexibility training, or combined training intervention, also known as multimodal, which include two or more of the former three training strategies. Multimodal exercise interventions are used most frequently in the older adult population (Gine-Garriga et al., 2013), followed by resistance training interventions, with aerobic training being the least common.
Aerobic Training

Although aerobic training alone is not one of the most common interventions for improving mobility, several studies have evaluated its effectiveness in improving mobility against controls (Malatesta, Simar, Saad, Prefaut, & Caillaud, 2010; Rejeski et al., 2011) and other types of interventions (Buchner et al., 1997; Holviala et al., 2012; Roma et al., 2013). When walking was the main focus of aerobic training interventions, there were significantly greater improvements in preferred walking speed when compared to controls after seven weeks of training (Malatesta et al., 2010). Significant improvements in 400 MWT were observed in a PA group consisting of thrice weekly walking in a group setting at six month follow up compared to a successful aging control group (Rejeski et al., 2011). However, those benefits were not present at 18 months, suggesting the beneficial impact of PA on mobility are short-lived. A similar pattern of improvement was also observed in six minute walk (6MW) time after 12 months of training, with aerobic training leading to significant improvements compared to resistance training alone (Roma et al., 2013).

Interventions using bicycle ergometry were not as effective at altering mobility outcomes, with no change in usual gait speed observed after 24 weeks (Buchner, 2008) and only modest improvements after 21 weeks (Holviala et al., 2012). Aerobic training may not consistently lead to improvements in measures of mobility because the goal of this type of training is typically to improve aerobic capacity and other health outcomes, such as cardiovascular risk, which is not a significant predictor of mobility. However, walking would be preferred over other modalities such as cycle ergometry, since the ability to walk is necessary for many activities in daily life.
**Resistance Training**

Loss of muscle mass and muscular strength are two major contributors to declines in mobility that are common amongst older adults. Resistance training (RT) has been shown to be effective in restoring muscle mass and improving muscular strength (Buchner et al., 1997; Chandler, Duncan, Kochersberger, & Studenski, 1998) and is therefore frequently used to improve mobility in older adults. Many studies have found resistance training to be effective in improving several measures of mobility including total SPPB scores (Roma et al., 2013), maximum walking speed, (Schlicht, Camaione, & Owen, 2001) and usual gait speed (Chandler et al., 1998; Holviala et al., 2012), while others have found no effect on usual gait speed (Buchner et al., 1997) or 6MW (Roma et al., 2013).

The benefits of resistance training programs on gait speed are largely dependent on intensity, which may explain some of the variability in the literature. Older adults who are frail or significantly detrained can see improvements in mobility with a low intensity resistance training program (Krebs, Jette, & Assmann, 1998), while community dwelling, independent older adults need to work at a higher intensity to see improvements (Fatouros et al., 2005; Seynnes et al., 2004). Older adults participating in higher intensity RT interventions have also been able to maintain significant improvements in mobility measures at eight and 12 month follow up while those in the lower intensity training groups did not (Fatouros et al., 2005). Overall, the consensus in the literature is that resistance training has small to moderate effects on gait speed and other mobility outcomes, although the interventions are highly variable (Latham, Bennett, Stretton, & Anderson, 2004; Lopopolo, Greco, Sullivan, Craik, & Mangione, 2006).
Since aerobic and resistance training offer unique benefits to various components of mobility, the two have often been combined in order to maximize the impact of physical activity on mobility in older adults. A flexibility/balance component is frequently added to aerobic and resistance training to address another dimension of fitness that plays a role in real world mobility.

**Combined Training**

The most common type of physical activity intervention used to improve mobility are those that combine multiple modalities, including but not limited to, any combination of resistance training, endurance training, flexibility, and balance/coordination activities (Gine-Garriga et al., 2013). It has been suggested that combined interventions are most effective at improving mobility because they train multiple systems of the body simultaneously (Mian et al., 2007). Walking requires the successful integration of multiple subsystems of the body (Ferrucci et al., 2000), therefore a training program that produces multi-systemic improvements would theoretically be the most efficient way to improve mobility.

Multimodal interventions that include a strength training component have reported the largest intervention effect on mobility outcomes due to the strong relationship between muscle strength and mobility (de Vries et al., 2012). Although the characteristics of the interventions varied, combined interventions have been reported to increase usual gait speed (Lord et al., 1996), physical function (Cress et al., 1999), and other unique measures of mobility (Cao, Maeda, Shima, Kurata, & Nishizono, 2007; Holviala et al., 2012). More recently, the LIFE Pilot data revealed that combined training
(PA) was also more beneficial than a successful aging (SA) education control group at improving total SPPB scores and 400 MWT in older adults at high risk for mobility disability (Pahor et al., 2006). The PA group had an average SPPB score that was 0.7 and 0.6 points greater than the control group at six and 12 months, respectively, a moderate effect that was considered meaningful (Perera, Mody, Woodman, & Studenski, 2006). Similarly, the PA group was able to maintain 400 MWT over both follow up time points while the SA group significantly declined. Most importantly, the beneficial effects of PA were observed even when variables such as gender, race, age, and baseline level of physical functioning were considered. However, no conclusions have been drawn about the most effective intervention for improving mobility because of the inconsistencies in the type of intervention (frequency, intensity, time and location), the modalities chosen (e.g. cycle ergometer or walking for aerobic training), the measures used to assess mobility, and the population being studied.

The assessment of mobility may be particularly important when evaluating the impact of physical activity interventions. Although traditional measures of mobility (e.g., 400MWT or SPPB) are reliable and well-established, some have questioned their ecologically validity and whether they adequately tap the complex interplay of systems involved during walking in a real world setting. For example, the gait speed component of the SPPB and 400MWT are commonly completed in an isolated corridor of a hospital or clinic. Most real world daily tasks, such as walking through the grocery store parking lot, require much more than just the physical capacity to walk, but also the cognitive ability to simultaneously process multiple stimuli (Buchner, 2008). Indeed, it has been argued that gait involves six physiological sub-systems, including the central and
peripheral nervous system, perceptual systems, musculoskeletal systems, and circulatory system (Ferrucci et al., 2000). For example, a growing body of literature suggests that cognition appears to play a significant role in gait (Ble et al., 2005; Martin et al., 2013; Shumway-Cook et al., 2007; Watson et al., 2010). Although gait has traditionally been viewed as an overlearned, automatic process, recent research suggests that it is a complex task that requires significant cognitive resources (Hausdorff et al., 2005). Therefore, it is important to expand upon simple mobility measures and develop measures that assess mobility in complex conditions and settings that are omnipresent in our everyday lives in order to address the role of other subsystems in walking.

**Complex Mobility**

Complex mobility refers to the concept that walking is a complex motor task that relies on the integration of multiple brain centers and physiological systems (Watson et al., 2010). Significant impairment in any of the individual systems may lead to observable changes in gait speed (Studenski, 2009). Navigating through daily life is a complex task that requires the simultaneous processing of multiple stimuli and often involves physical and mental obstacles at home and in the community. Successful completion of instrumental activities of daily living (IADLs), such as grocery shopping, is not only dependent on proper physical functioning (e.g. walking through the store, grabbing cans on the shelf, pushing grocery cart), but also good cognitive functioning (i.e. keeping track of grocery list, navigating through the store) (Yam & Marsiske, 2013).

When discussing complex mobility, cognition is one system that has gained considerable attention in its role in walking and will therefore be used to explain the
complexity of real world mobility. A recent review of the literature examining the impact of cognition and attention on normal walking concluded that the role of cognition in gait is dependent on the nature of the task and that specific domains of cognition play a greater role than others (Yoge-Seligmann, Hausdorff, & Giladi, 2008). The domain of cognition that appears to be the most relevant during walking tasks is executive function (Ble et al., 2005; Hausdorff et al., 2005; Martin et al., 2013; Mielke et al., 2013; Yogev-Seligmann et al., 2008). Executive functions are primarily housed in prefrontal cortices of the frontal lobe and commonly referred to as the ‘control center’ due to its responsibility in processing numerous cognitive stimuli and regulating goal-oriented human behavior (Miyake et al., 2000). According to the model described by Miyake et al. (2000), there are three important components of executive function: shifting or the switching of attention back and forth between multiple tasks; inhibition or the deliberate suppression of an automatic or dominant response; and updating or the active, rather than passive, replacement of information that is no longer relevant to the task at hand with new information that is more useful to the current task (i.e. working memory). The literature consistently reports that as the complexity of the task increases, the influence of executive function on the performance of that task also increases, supporting the second conclusion that the role of cognition in gait is dependent on the nature of the task (Ble et al., 2005; Hausdorff et al., 2005; Yogev-Seligmann et al., 2008).

Although diverse study designs and assessments of cognitive function and gait speed have been used to examine interrelationships, results consistently show that poorer cognitive functioning is associated with slower gait speed (Mielke et al., 2013; Watson et al., 2010; Yogev-Seligmann et al., 2008). There are also several longitudinal studies that
have reported that lower levels of cognitive functioning were related to greater declines in gait speed over time (Atkinson et al., 2007; Buchman, Boyle, Leurgans, Barnes, & Bennett, 2011; Watson et al., 2010). When compared to older adults with normal levels of cognitive function, a 1 SD decrease in measures of cognition (global function, verbal, memory and executive function) has been associated with a 0.003-0.004 m/s greater gait speed decline over time (Watson et al., 2010). Similar studies have reported that a 1 unit higher score in baseline global cognitive function is associated with 40% slower rate of gait speed decline (Buchman et al., 2011). Scoring eight points or 1 SD lower on the Modified Mini Mental State Exam (3MS), a measure of global cognition, was also associated with a 0.012 m/s quicker decline in gait speed over a three year follow up (Atkinson et al., 2007). Thus, cognitive functioning appears to have a significant impact on gait performance.

Interestingly, evidence exists to suggest a reciprocal relationship between gait and cognition. Several studies have shown that slowing gait speed can predict future cognitive decline (Buracchio, Dodge, Howieson, Wasserman, & Kaye, 2010; Mielke et al., 2013). For example, Buracchio et al. (2010) followed older adults for up to 20 years and examined whether changes in gait speed were related to the development of mild cognitive impairment (MCI), the transition phase between normal age-related cognitive decline and Alzheimer’s disease. Results indicated that all participants experienced a 0.013 m/s age-related decline in gait speed per year, but those who converted to MCI had an additional 0.01 m/s and 0.02 m/s decline in gait speed per year, a rate that was observed up to 12.1 and six years prior to MCI diagnosis, in men and women, respectfully (Buracchio et al., 2010). It has also been reported that having a faster
baseline gait speed is related to slower rates of cognitive decline over a four year follow up (Mielke et al., 2013). Additionally, a number of reviews of randomized controlled trials have showed that physical activity interventions can improve several aspects of cognition in older adults (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Colcombe & Kramer, 2003). Although the research clearly supports the relationship between cognition and mobility, our understanding of this relationship has been limited by the traditional assessment of mobility.

Due to the complex nature of mobility and the significant role of cognition in walking, there is a need for measures of mobility that are more representative of mobility in the real world. Although the 400MWT and the SPPB gait speed component are valid measures of mobility and gait, they are relatively simple and may not truly tap the complexities inherent in real world mobility. Complex mobility tasks may be more accurate measures of mobility that simulate the physical and cognitive challenges encountered in the real world.

Complex Mobility Measures

Researchers in the InCHIANTI study developed a set of complex walking tasks (CWTs) for the evaluation of mobility in older adults (Shumway-Cook et al., 2007). The battery of tests included 13 walking tasks, referred to as the Walking InCHIANTI Toolkit (WIT), that were located at different points along the complexity continuum, ranging from simple walking tasks to those that challenged participants to adapt their walking to meet the various task or environmental demands. Examples of tasks from the WIT include: 4 meter walk at usual and fast paces; 4 meter walk at fast pace while remaining within a 25 or 15 cm box on the ground; 7 meter walk at usual pace; 7 meter walk at fast
pace while stepping over two obstacles placed two meters apart (6 cm and 30 cm tall) under a normal visual condition and while wearing sunglasses (Shumway-Cook et al., 2007). The role of executive function in the performance of each of these tasks was determined, and comparisons were made between the simple walking tasks and their corresponding complex versions regarding the role of cognition (e.g. comparing 4 meter walk at fast pace to 4 meter walk at fast pace while remaining within a 15 cm box on the ground). The number of older adults who were unable to complete the walking tasks increased under complex conditions, even among those who successfully completed the less challenging tasks (Shumway-Cook et al., 2007). When compared to usual walking speed under normal conditions, there was a significantly greater slowing in usual gait speed during complex tasks, with the greatest declines being observed in the older age groups. It has also been shown that having greater gait variability during several of the CWTs included in the WIT (7MW and 4 meter usual pace within a 15 cm box) than that observed in simpler gait speed assessments is predictive of future gait speed decline (Brach et al., 2011).

In an effort to create a measure of gait that explicitly involves a cognitive challenge, researchers at Wake Forest University have developed the Walking Decision Making Task (WDMT) (Yamamoto, 2011). The three conditions of the task (neutral, congruent, and incongruent), vary in complexity with neutral being the simplest and incongruent being most complex. It is designed to challenge a person’s executive functioning skills by forcing individuals to make a quick decision to turn left or right through a predetermined course while walking at a quick pace. When compared to other measures of physical function, the congruent and incongruent conditions were
significantly correlated with the SPPB, Mobility Assessment Tool-Short Form (MAT-SF), 400MWT, and 4 meter gait speed, with spearman correlations ranging from 0.463-0.838. However, only the incongruent condition was positively related to global cognition measured via the Mini Mental State Exam (MMSE) ($r = 0.413$) and negatively related to executive function via the Trails Making Task (TMT) ($r = -0.331$) (Yamamoto, 2011). When stratified for level of cognitive function, those with poorer cognitive function performed slower on the incongruent condition than those with higher cognitive functioning. These findings suggest that the WDMT is a good measure of physical function/mobility and the conditions require different levels of cognition.

The 7MW is a complex walking task (CWT) from the WIT, a compilation of walking tasks designed to address the environmental factors that may mediate the relationship between functional limitations and mobility disability. Shumway-Cook et al. (2007) concluded that with increasing complexity, there was an increase in the number of older adults who were unable to complete those tasks, despite their ability to complete the less complex tasks, specifically 42.7% and 77.5% of 75-84 and 85+ year olds, respectively. The reliability of the 7MW has been assessed over two weeks and was reported to be high (ICC=0.893) (Bandinelli et al., 2006). For these reasons as well as the ease of administration and set-up, it has been used more frequently than some of the other WIT tasks in the research setting, including the present study.

Therefore, these complex mobility tasks may be more representative of mobility tasks that older adults may encounter in the real world, as they provide various task and environmental demands commonly experienced during walking. Therefore, complex
mobility tasks attempt to provide a more accurate assessment and a deeper understanding of mobility status in a person’s natural environment.

Summary

Taken together, the evidence suggests that multimodal physical activity programs can improve measures of mobility in older adults. It has been argued that traditional measures of mobility may lack ecological validity as they tend to include relatively simple tasks that do not appreciate the complexities of mobility in the real world. Thus, measures of complex mobility may offer additional insight into the dynamic process of mobility and mobility loss beyond information gathered from traditional measures of mobility. However, although it is well-documented that physical activity interventions can improve and/or maintain gait functioning in older adults, the efficacy of interventions to improve performance under complex conditions has yet to be evaluated.

Purpose

The purpose of the present study was to determine if a multimodal physical activity intervention has an effect on measures of complex mobility in older adults. The complex mobility measures chosen for this study are the Walking Decision Making Task (WDMT) and the 7 meter walk (7MW). Both tasks present a challenge, physical and/or cognitive, to the participants while walking, which activate the components of executive functioning as described by Miyake et al. (2000): inhibition, updating and switching.

The overarching hypothesis was that the physical activity group would experience greater decreases in performance times on the complex mobility tasks from baseline to follow up as compared to the control group. More specifically:
1. The physical activity group will experience greater decreases in performance times on the incongruent condition of the WDMT and 7MW from baseline to 12 months than the control group.

2. The physical activity group will experience greater decreases in performance times on the incongruent condition of the WDMT and 7MW from baseline to 24 months than the control group.
METHODS

Overview of the Study

This complex mobility (CM) study involved a subset of participants from the Lifestyle Interventions and Independence for Elders (LIFE) study, a multi-center study spanning eight sites across the country with a total of 1,635 participants. The purpose of the LIFE-Main Trial was to compare the long term effects of a moderate intensity multimodal physical activity program (PA) with a successful aging health education control group (SA) on the incidence of major mobility disability. In the current study (LIFE-CM), we used longitudinal data from the Wake Forest University site to compare differences between the SA and PA groups’ change in performance times from baseline to follow up on two complex walking tasks, the Walking Decision Making Task (WDMT) and 7 meter walk (7MW).

Participants

Recruitment for the LIFE-CM study began in September of 2010, which was approximately a six month delay from the date of the first randomization for the LIFE-Main Trial (Marsh et al., 2013). Therefore, the participants who were recruited at the Wake Forest University site of the LIFE-Main Trial from September 2010 onward were offered the opportunity to participate in the LIFE-CM study during their second screening visit (SV2). A LIFE study staff member obtained written informed consent (See Appendix A) from all willing participants during SV2 and contact information for those participants was forwarded to the LIFE-CM study staff. Participants were then scheduled for an additional clinic visit with a LIFE-CM staff member following SV2 (post LIFE study randomization), but prior to the first intervention where baseline complex mobility
data was collected. All complex mobility data was collected at Reynolds Gymnasium on the Reynolda Campus of Wake Forest University. No additional eligibility criteria were applied during the recruitment process. The inclusion criteria implemented by the LIFE-Main trial targeted individuals who were: 70-89 years old; sedentary (< 20 minutes/week of regular physical activity in the past month and < 125 minutes/week of moderate physical activity); at high risk for mobility disability (SPPB ≤ 9); could walk 400 m within 15 minutes without sitting, leaning or personal assistance; able to safely participate in an exercise intervention. A full list of inclusion and exclusion criteria for the LIFE Study is listed elsewhere (Fielding et al., 2011) and is reproduced in Appendix B.

**Intervention Groups**

This study was a single-blind, randomized controlled trial with two intervention arms. The design of the intervention groups was theoretically based, drawing upon and integrating principles of the social cognitive theory and applications of the Transtheoretical model (e.g., self-efficacy for participation, readiness for change/action) to create a modified group-mediated approach to behavior change. These theoretical principles were applied by: educating participants on effective goal setting and how to self-regulate their physical activity, providing tailored social problem-solving strategies to overcome barriers related to long term maintenance of physical activity, and increasing exercise self-efficacy. Prior to randomization, prospective participants met with a LIFE study staff member for a 45 minute informational session where the details of the SA or PA intervention were explained. The PA intervention sessions were held at Wake Forest University’s Clinical Research Center and the SA intervention sessions were held at the
Senior Services building, a local facility in Winston-Salem that offers a wide array of services and programs for seniors living in the community.

**Successful Aging Intervention**

The SA health education group served as an active control. A trained LIFE staff member organized workshops on topics relevant to older adults that were delivered by community experts. Meetings were held weekly during the first 26 weeks and from week 27 until the end of follow up, sessions were offered twice a month with participants being required to attend at least one session per month.

Examples of session topics include nutrition, medications, where to go for reliable health care, and recommendations for preventive health services for different age groups. The program was designed to educate participants to actively take charge of one’s health. An informational brochure containing basic information about physical activity was given to participants at the first session, but all subsequent sessions refrained from any discussion about physical activity. To wrap up each session, instructors led the group through 5-10 minutes of upper extremity stretching and/or flexibility exercises.

**Physical Activity Intervention**

The PA intervention was multimodal and included aerobic, strength, flexibility, and balance training. The primary focus of the intervention was on the aerobic component, achieved through walking, and supplemented with short strength and flexibility/balance routines. The PA intervention consisted of both center and home based sessions where frequency of activity and duration of walking was progressively increased to reach the long term target goal of 150 minutes/week of walking.
Center based sessions

The center based sessions were held two days/week throughout the entire intervention period and lasted for approximately 60 minutes. Upon arrival, resting blood pressures were obtained and participants walked around the track for a short warm up. Participants were then encouraged to begin walking for approximately 10-12 minutes (as tolerated) and progressively increased their minutes of walking to a maximum of 40 minutes throughout the intervention period. Participants were instructed to progressively increase walking intensity over the first two to three weeks, working up to a 13 on the Borg Rating of Perceived Exertion (RPE) Scale. Stopwatches were carried around the participants’ necks to keep track of their walking minutes.

After the walking component was complete, participants engaged in a 10 minute strength training routine which consisted of five groups of exercises (Table 1). Participants completed the wide leg squat and one exercise from the remaining four categories, to give each person a total of five exercises. Knee extension was performed in the seated position with a towel roll under his/her knee, while the other exercises were performed standing. Each exercise was performed in two sets of 10 repetitions, with one minute of rest between sets. Both sets were completed on one limb before switching to the other. Ankles weights ranging from 2-15 lbs were used to provide resistance during the leg curl, hip extension, knee extension with and without ankle circles, and lateral hip raises. Initially, men started with 3 lbs and women with 2 lbs while they familiarized themselves with the resistance training exercises. The weight could be increased throughout the intervention under the supervision of the interventionist. Similar to
aerobic training, intensity of strength training was gradually increased over the first two to three weeks, building up to a 15-16 on the Borg RPE scale.

**Table 1**: PA Group Strength Training Exercises

<table>
<thead>
<tr>
<th>Group #1</th>
<th>Group #2</th>
<th>Group #3</th>
<th>Group #4</th>
<th>Group #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide leg squat</td>
<td>Standing leg curl</td>
<td>Knee extension</td>
<td>Side hip raise</td>
<td>Toe stand</td>
</tr>
<tr>
<td>Hip extension</td>
<td>Knee extension with ankle circles</td>
<td>Leg circles</td>
<td></td>
<td>Toe out calf raises</td>
</tr>
<tr>
<td>Hip flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bent leg raise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Strength training was followed by a short flexibility routine. Stretches targeting the hamstrings and calves, quadriceps, chest, and upper back were prescribed and held for 20-30 seconds. The flexibility routine was followed by 10 minutes of progressive balance exercises that ranged in difficulty rating from 1 (least difficult) to 5 (most difficult). An incremental variation pattern was applied to progress participants to exercises with higher difficulty ratings. First, arm support was decreased, followed by decreased base of support, and finally by increasing the complexity of the exercise. Each session was finished with a slow walk around the track which served as a cool down.

**Home based sessions**

The home based exercise sessions were divided into two phases: the Adoption Phase (AP; Weeks 1-52) and the Maintenance Phase (MP; 52 weeks - end of follow up). During the AP, participants were encouraged to perform the center based session
activities at home one time/week during the first four weeks, in addition to their two regularly scheduled sessions at the field center. Participants were given detailed instructions of the exercises completed at the center to make sure the transition to home-based activity was simple and generalizable to their home environment. Frequency of home based sessions progressively increased during the AP, moving up to two sessions/week (Weeks 4-8) and three to four sessions/week (Weeks 8-52). During the MP, participants were asked to continue attending the center based sessions twice per week and strive to accomplish three to four sessions/week at home. Throughout the entire intervention, participants were also encouraged to increase leisure time physical activity (LTPA) throughout the day. Newsletters regarding information about physical activity were sent quarterly to provide ongoing support and program adherence.

Measures

Modified Mini Mental State Exam

The Modified Mini Mental State Exam (3MSE), a revised version of the Mini-Mental State Examination (MMSE), is a measure of global cognition and is frequently used in identifying cognitive impairment and dementia in the elderly population (Teng & Chui, 1987). Scores range from 0-100, with higher scores indicating better performance. A score of 77/78 has been considered a cut point for classifying cognitive impairment and mild dementia (Bland & Newman, 2001). The LIFE-Main Trial utilized the 3MSE to screen for cognitive impairment.
Short Physical Performance Battery

The Short Physical Performance Battery (SPPB) was one of the primary measures for mobility assessment in the LIFE-Main Trial. There are three components to this task: 4 meter gait speed at usual pace, a timed repeated chair stand, and three balance tests that progressively increase in difficulty. Each component is scored on a scale from 0 to 4 and the SPPB total score is achieved by summing the three scores received for each component. Total scores range from 0 to 12 with higher scores indicating better physical functioning.

The Walking Decision Making Task

The Walking Decision Making Task (WDMT) is a complex walking task created at Wake Forest University and was developed to present a cognitive challenge while walking, specifically decision making. Preliminary evidence suggests that this task requires the use of several components of executive function, including shifting attention from walking to interpreting the directional message and inhibition of automatic processing in order to maintain efficient walking pace (Yamamoto, 2011). The decision challenge presented during the WDMT was chosen to represent a situation a person may encounter in everyday life and thus may have important implications for mobility in the real world.

The WDMT is a timed walking task through a T-shaped course that runs eight meters in length in both the left and right directions. During this task, participants were instructed to walk as quickly, but as safely as possible straight ahead for approximately four meters before deciding to turn left or right, where they continued to walk through
either finish line. The decision to turn left or right was based upon the stimuli presented on the computer screen that was placed atop a cart located just outside the boundary of the course straight ahead of the starting line. The computer screen remained blank until the participant reached the “decision line”, three meters from the start line, when the test administrator cued the computer to display the stimuli which provided instructions to turn left or right. Pairs of timers were placed along the perimeter of the course at seven different time points to capture the participants’ speed during different segments of the task, although only five timers were activated during each trial. Figure 1 illustrates the layout of the WDMT.

In Figure 1, the yellow triangles provide a basic outline of the course to assist the participants in visualizing the course they were about to navigate through. The solid red lines represent the start line and both finish lines, while the dotted red lines indicate the various split times that are taken throughout the task. The pairs of red rectangles illustrate the placement of the timers that use infrared light to sense movement between them. The timers are triggered when the participant passes between them and the start/stop/split time information is sent to a computer program that is managed by the test administrator.
Prior to the start, participants were instructed to make their decision to turn left or right based upon the instructions (stimuli) presented on the computer screen. The stimuli contained a single letter (L or R), a combination of a letter (L or R) and an arrow (← or →), or nothing at all, in which case the administrator verbally informed the participant which direction to turn prior to the start. Participants were told to follow the letter shown on the screen and to disregard which direction the arrows were pointing. Once those instructions were clear, the administrator demonstrated how to complete the task, walking from start to finish, reiterating the instructions during the demonstration and answering any remaining questions. Once the instructions were understood, the participant was asked to place their toes just behind the start line. The administrator then asked, “Are you ready?”, and if confirmed, gave the command, “You may begin.” Participants walked
straight ahead and upon approaching the “decision line”, the test administrator cued the computer to display the instructions for that trial. Upon deciding which way to turn, participants continued to walk through the finish line (the final two yellow cones). Time began and finished recording when the participant triggered the start and stop timers, respectively.

Eight trials were completed in succession, each with different instructions. The stimuli presented on the computer screen during each trial were classified as congruent (WDMT-C), incongruent (WDMT-I), or neutral (WDMT-N) and varied in the type of stimuli (none, visual, neutral), congruency (congruent, incongruent), and direction (left, right). See Table 2 for the details of each trial.

Neutral conditions served as a comparison for the congruent and incongruent conditions because they did not display conflicting stimuli. During these trials, only a visual stimulus was manipulated, displaying a letter (L or R) or a blank screen (no visual stimuli). Participants were told to make their turning decision according to the letter on the screen, either an L or an R. Prior to the start of the blank screen trials, participants were given verbal instructions to turn to the left (Blank L) or the right (Blank R) despite the screen remaining blank during the performance of the task.

Complexity of the task increased during the congruent conditions, where two variables were manipulated, visual stimuli and congruency. Congruent conditions displayed a letter and an arrow indicating the same direction, either a left facing arrow and the letter L (←L) or a right facing arrow and the letter R (→ R). Although the letter and arrow indicated the same direction, these two trials required more cognitive
processing that the neutral L and R trials because participants needed to process two separate stimuli to make their turning decision. Finally, the most complex trials were the incongruent conditions, which displayed a letter and an arrow indicating opposing directions. The two options were a left facing arrow and the letter R (← R) or a right facing arrow and the letter L (→ L). Once again, instructions to follow the letter for making a turning decision were given prior to the start.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Stimuli</th>
<th>Direction</th>
<th>Congruency</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral 1</td>
<td>None</td>
<td>Left</td>
<td>N/A</td>
<td>Blank</td>
</tr>
<tr>
<td>Neutral 2</td>
<td>None</td>
<td>Right</td>
<td>N/A</td>
<td>Blank</td>
</tr>
<tr>
<td>Neutral 3</td>
<td>Neutral</td>
<td>Left</td>
<td>N/A</td>
<td>L</td>
</tr>
<tr>
<td>Neutral 4</td>
<td>Neutral</td>
<td>Right</td>
<td>N/A</td>
<td>R</td>
</tr>
<tr>
<td>Visual 1</td>
<td>Visual</td>
<td>Left</td>
<td>Congruent</td>
<td>← L</td>
</tr>
<tr>
<td>Visual 2</td>
<td>Visual</td>
<td>Left</td>
<td>Incongruent</td>
<td>→ L</td>
</tr>
<tr>
<td>Visual 3</td>
<td>Visual</td>
<td>Right</td>
<td>Incongruent</td>
<td>← R</td>
</tr>
<tr>
<td>Visual 4</td>
<td>Visual</td>
<td>Right</td>
<td>Congruent</td>
<td>→ R</td>
</tr>
</tbody>
</table>

To minimize order effects, all eight trials were counterbalanced by the type of stimuli (visual or neutral) as well as the order in which the stimuli categories were
presented (Neutral followed by Visual or vice versa). There were four different combinations possible which were chronologically assigned to the first four participants tested (Table 3). The pattern repeated itself on every fifth participant. Once assigned a trial order at their baseline visit, the same trial order was used at subsequent testing visits.

**Table 3: Trial Order Counterbalancing**

<table>
<thead>
<tr>
<th>Participant</th>
<th>Trial Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Neutral: 1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>Visual: 3, 1, 4, 2</td>
</tr>
<tr>
<td>2</td>
<td>Visual: 2, 4, 1, 3</td>
</tr>
<tr>
<td></td>
<td>Neutral: 4, 3, 2, 1</td>
</tr>
<tr>
<td>3</td>
<td>Neutral: 3, 1, 4, 2</td>
</tr>
<tr>
<td></td>
<td>Visual: 1, 2, 3, 4</td>
</tr>
<tr>
<td>4</td>
<td>Visual: 4, 3, 2, 1</td>
</tr>
<tr>
<td></td>
<td>Neutral: 2, 4, 1, 3</td>
</tr>
</tbody>
</table>
If the participant turned the incorrect way during a trial, we allowed them to finish the task in the chosen direction and continued with the trial order as planned. The incorrect trial condition was then repeated at the end of the trial sequence, acting as a 9th trial condition. Hand times were taken and recorded using a stopwatch in the event an infrared timer did not record the start or stop of the trial. All trial times were recorded along with any notes regarding performance (e.g. stopped at decision line, turned the wrong direction, turned wrong way but corrected half way through).

7 Meter Walk

This walking task is part of the Walking InCHIANTI Toolkit (WIT) (Shumway-Cook et al., 2007), which is a compilation of walking tasks of varying complexities. Its purpose is to assess the participants’ ability to adapt their walk when faced with an obstacle in the environment. Assessing a participant’s ability to overcome physical challenges in a research setting is an attempt to simulate a situation that could be encountered in their daily routine.

After the purpose of the task was explained, participants were instructed to walk as quickly but as safely as possible along the seven meter course while stepping over two obstacles they saw without touching them. The obstacles were triangular prisms made of foam and therefore, did not offer any resistance if they were unintentionally bumped by the participant. The obstacles were 6 cm and 30 cm in height and were placed two and four meters from the start, respectively. After confirmation that the instructions were clear to the participant, the test administrator demonstrated the task, further emphasizing the instructions and how to perform the task. Once ready, the participant placed their toes
just behind the start line and were asked if they were ready. Participants began walking upon hearing the command, “You may begin.” Time was recorded from start to finish with the same infrared timers used during the WDMT and a hand timer was again used as a backup. Refer to Figures 2 and 3 for an illustration of the obstacles and the layout of the course, respectively. In Figure 3, the red rectangles represent the pairs of start/stop timers and the long, orange rectangles illustrate the placement of the two obstacles.

**Figure 2:** Obstacles of 7 Meter Walk

![Figure 2: Obstacles of 7 Meter Walk](image)

**Figure 3:** 7 Meter Walk Layout

![Figure 3: 7 Meter Walk Layout](image)

If a walking device was brought to the assessment visit, the test administrator asked if the participant felt they could safely complete the task without the walking device. If the participant did not feel safe without it, they were allowed to use it during
the task. These same guidelines were also applied during the WDMT. For safety purposes, the test administrator walked at a reasonable pace and distance behind the participant in the event he/she felt unsteady and needed assistance overcoming the obstacles. Administrators recorded if the participant touched either obstacle or had any difficulty with task completion including, needing physical help to overcome obstacle; stumbling or appearing unstable; inability to perform the task; or putting his/her arms in the defensive position. If the start or finish timers did not record the time during the first trial, a second trial was completed. If the timers failed a second time, the hand time captured by the test administrator was recorded.

**Materials**

Performance times for the walking tasks were measured using TracTronix © TTU100 wireless infrared timers in combination with the Kronotrax timing computer program. For the WDMT, seven pairs of timers were used. The first pair was placed at the start and two pairs were placed at either finish line (left or right). The remaining four pairs were placed at different points between the start and both finish lines and served as split times to capture any changes in gait speed during the cognitively challenging part of the task just before and after the “decision line”. For the 7MW, only two pairs of timers were used at the start and finish lines.

**Procedures**

Participants were recruited from the 205 (PA=102; SA=103) LIFE study participants who were randomized to the Wake Forest University site. No additional eligibility criteria were applied. All LIFE participants randomized to the Wake Forest
University site were provided information about the CM study and offered the opportunity to participate by the LIFE clinic staff during their second screening visit (SV2). Willing participants signed an informed consent and, with participant approval, clinic staff forwarded contact information of the interested participants to the CM study staff. An additional clinic visit was then scheduled after LIFE SV2 (post randomization), but prior to the start of the intervention. The data collected at this visit served as baseline values.

The baseline visit was held in the Health and Exercise Science Functional Performance Laboratory located in Reynolds Gymnasium on Wake Forest University’s campus. The visit lasted for approximately one hour and included two cognitive measures, the Recollection Memory Assessment and the Self-Ordered Pointing Task (SOPT), that were completed prior to the two walking tasks, but were not included in the current study’s analyses. The cognitive measures took a total of 30-35 minutes to complete while the two walking tasks took approximately 20-25 minutes. Subsequent to the completion of both cognitive measures, baseline performance times for the 7MW were obtained, followed by the WDMT. During the WDMT, participants were allowed to take a break between trials as needed. Depending on walking ability, some participants took breaks frequently (every other trial) or none at all. The same test administrator collected data for both assessments and was blinded to intervention assignment. Bathroom and drink breaks were also offered on an as-needed basis. The same assessments were completed at 12 months and 24 months follow up. Participants were offered $5 gift cards to Target or Walmart for each clinic visit attended.
Analysis of Data

Descriptive statistics were used to describe the outcome variables (performance times on the WDMT and 7MW) and demographic characteristics of the sample. For all continuous variables, means and standard deviations were calculated, and for categorical variables, counts and percentages. The data were also checked for normality.

The mean performance times for each category of the WDMT (neutral, congruent, and incongruent) were calculated by averaging performance times of the trials within each category. Thus, there were three performance times for the WDMT. We then conducted a manipulation check using a mixed model using contrast statements for overall (PA and SA times combined) estimates in the differences between the performance times of the WDMT conditions at all time points (baseline, 12 month, and 24 month) to determine which condition had the slowest performance times.

To test the first hypothesis, an ANCOVA that controlled for baseline values of the dependent variable and total SPPB scores was used to test between group differences in change from baseline to 12 and 24 months in performance times on WDMT. The same analysis was performed to test the second hypothesis, but instead using 7MW performance times. All analyses were performed using SAS v9.3 assuming a Type I error rate of 0.05.
RESULTS

Participants

Seventy of the current LIFE study participants were recruited to be a part of LIFE-CM; 31 from the successful aging (SA) group and 39 from the physical activity group (PA). Twelve month follow up data was collected for 63 participants; 27 in the SA group and 36 in the PA group. Twenty-four month follow up data was collected for 60 participants; 26 in the SA group and 34 in the PA group. Figure 4 illustrates the recruitment flow and reasons for loss to follow up at 12 and 24 months. Demographic characteristics for the overall sample as well as each individual group are displayed in Table 4. The mean age of the sample was 78 years and the majority (70%) were female (n = 49). Approximately 77% were Caucasian and the sample was highly educated, with over 60% having at least a college degree. Additionally, the mean SPPB total score was 7.54 reflecting the group’s relatively low physical functioning. The mean 3MSE score of 91.94 for the sample indicated that the participants had average levels of global cognition. When comparing the demographic data between groups, it appears that the PA group had a greater number of females and people reporting having a college education, than the SA group.

Histograms illustrating the distribution of performance times on the neutral (WDMT-N), congruent (WDMT-C), incongruent (WDMT-I) conditions of the WDMT, as well as the 7 meter walk (7MW), and total SPPB scores for both groups at each follow up period are displayed in Figures 5-9. It is evident from the diagrams that there is wider distribution of times on the complex mobility tasks in the PA group compared to the SA group, particularly at 24 month follow up. When comparing the distributions of total
SPPB scores, the PA group has much more variation than the SA group. Additionally, the PA group has several participants, approximately 13%, with scores of 4 or 5 while the SA group did not. Although there was a slight decrease in the proportion of participants scoring in this range on the SPPB over 12 and 24 month follow up, approximately 8%, it is clear that the PA group had a larger number of participants with extremely low physical functioning.
Figure 4: Flow Diagram of Recruitment and Follow up

Participants at Wake Forest Site of LIFE-Main Trial
(n = 205)

Successful Aging Group of LIFE-Main
(n = 102)

Physical Activity Group of LIFE-Main
(n = 103)

Successful Aging Group of LIFE-CM
(n = 31)

Physical Activity Group of LIFE-CM
(n = 39)

Participants with 12 month data
(n = 27)
- 2 deceased
- 1 moved away
- 1 dropped

Participants with 24 month data
(n = 26)
- 1 moved away

Participants with 12 month data
(n = 36)
- 2 deceased
- 1 dropped

Participants with 24 month data
(n = 34)
- 2 deceased
Table 4: Demographic Characteristics

<table>
<thead>
<tr>
<th>Description</th>
<th>SA (n=31)</th>
<th>PA (n=39)</th>
<th>Overall (n=70)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%) or Mean ± SD</td>
<td>N (%) or Mean ± SD</td>
<td>N (%) or Mean ± SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>78.71 ± 6.22</td>
<td>77.56 ± 5.22</td>
<td>78.07 ± 5.67</td>
</tr>
<tr>
<td>Female</td>
<td>20 (64.52%)</td>
<td>29 (74.36%)</td>
<td>49 (70%)</td>
</tr>
<tr>
<td>White</td>
<td>22 (70.97%)</td>
<td>32 (82.05%)</td>
<td>54 (77.14%)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; High School</td>
<td>0</td>
<td>1 (2.56%)</td>
<td>1 (1.43%)</td>
</tr>
<tr>
<td>High School</td>
<td>14 (45.16%)</td>
<td>10 (25.64%)</td>
<td>24 (34.29%)</td>
</tr>
<tr>
<td>College</td>
<td>7 (22.58%)</td>
<td>23 (58.97%)</td>
<td>30 (42.86%)</td>
</tr>
<tr>
<td>Post Graduate</td>
<td>9 (29.03%)</td>
<td>4 (10.26%)</td>
<td>13 (18.57%)</td>
</tr>
<tr>
<td>Other</td>
<td>1 (3.23%)</td>
<td>1 (2.56%)</td>
<td>2 (2.86%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>23 (74.19%)</td>
<td>26 (66.67%)</td>
<td>49 (70%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>8 (25.81%)</td>
<td>10 (25.64%)</td>
<td>18 (25.71%)</td>
</tr>
<tr>
<td>SPPB Total Score</td>
<td>7.68 ± 1.05</td>
<td>7.44 ± 1.55</td>
<td>7.54 ± 1.35</td>
</tr>
<tr>
<td>7 Meter Walk Time</td>
<td>9.17 ± 3.56</td>
<td>10.17 ± 4.35</td>
<td>9.72 ± 4.02</td>
</tr>
<tr>
<td>WDMT Neutral</td>
<td>9.53 ± 1.92</td>
<td>10.11 ± 2.50</td>
<td>9.85 ± 2.26</td>
</tr>
<tr>
<td>WDMT Congruent</td>
<td>9.59 ± 1.80</td>
<td>10.01 ± 2.37</td>
<td>9.82 ± 2.13</td>
</tr>
<tr>
<td>WDMT Incongruent</td>
<td>9.95 ± 1.77</td>
<td>10.62 ± 2.71</td>
<td>10.32 ± 2.35</td>
</tr>
<tr>
<td>3MSE</td>
<td>92.61 ± 4.57</td>
<td>91.41 ± 5.59</td>
<td>91.94 ± 5.16</td>
</tr>
</tbody>
</table>

Abbreviations: WDMT (Walking Decision Making Task); 3MSE (Modified Mini Mental State Exam)
Figure 5: Distribution of Performance Times on WDMT-Neutral
Figure 8: Distribution of Performance Times on 7 Meter Walk

Time (s)
Figure 9: Distribution of Total SPPB Scores
Baseline Performance Times

The results of the manipulation check for differences between performance times on each condition of the WDMT over all time points for all subjects are presented in Table 5. As expected, the neutral condition performance times were significantly faster than those observed in both the congruent ($p = 0.0174$) and incongruent conditions ($p < 0.0001$). Additionally, the incongruent performance times were significantly slower than the congruent condition ($p < 0.001$), suggesting that the incongruent condition was the most difficult. These results provide further validation for the WDMT as they represent our successful manipulation of the independent variable, which in this case is the cognitive demand/complexity of the task.

Between group comparisons of baseline performance times on the 7 meter walk (7MW) and each of the WDMT conditions are displayed in Table 6. Between group differences in performance times at baseline were not statistically significant (all $p > 0.05$).

|                  | Difference | SE  | DF | $t$ Value | $Pr > |t|$ | Alpha | 95% CI     |
|------------------|------------|-----|----|-----------|-------|-------|------------|
| Neutral-Congruent| -0.205     | 0.084 | 70  | -2.44     | 0.0174 | 0.05  | -0.373, -0.037 |
| Neutral-Incongruent| -0.675   | 0.149 | 70  | -4.53     | <.0001 |       | -0.973, -0.378 |
| Congruent-Incongruent| -0.497   | 0.111 | 70  | -4.46     | <.0001 |       | -0.720, -0.275 |
Table 6: Between Group Differences of Baseline Values on Complex Mobility Tasks

<table>
<thead>
<tr>
<th>Variable</th>
<th>SA (n=31)</th>
<th>PA (n=39)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>95% CI</td>
<td>p</td>
</tr>
<tr>
<td></td>
<td>SA SD</td>
<td>PA SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>WDMT Neutral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.53 1.92</td>
<td>10.11 2.50</td>
<td>-0.58 -1.66</td>
</tr>
<tr>
<td>WDMT Congruent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.59 1.80</td>
<td>10.01 2.37</td>
<td>-0.41 -1.44</td>
</tr>
<tr>
<td>WDMT Incongruent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.95 1.77</td>
<td>10.62 2.71</td>
<td>-0.67 -1.80</td>
</tr>
<tr>
<td>7 Meter Walk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.17 3.56</td>
<td>10.17 4.35</td>
<td>-1.00 -2.93</td>
</tr>
</tbody>
</table>

Follow up Performance Times

Means and standard deviations for performance times for both complex walking tasks at baseline, 12 month, and 24 month follow up time points are displayed by group assignment in Table 7. Tables 8-11 include the least squared means of the change values in performance times from baseline to 12 and 24 month follow up on each complex mobility task to assess differences in change scores between the intervention groups.

Table 7: Follow up Performance Times on Complex Mobility Tasks

<table>
<thead>
<tr>
<th>Variable</th>
<th>WDMT Neutral</th>
<th>WDMT Congruent</th>
<th>WDMT Incongruent</th>
<th>7 Meter Walk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td></td>
<td>SA</td>
<td>PA</td>
<td>SA</td>
<td>PA</td>
</tr>
<tr>
<td>Baseline</td>
<td>9.53 (1.92)</td>
<td>10.11 (2.50)</td>
<td>9.59 (1.80)</td>
<td>10.01 (2.37)</td>
</tr>
<tr>
<td>12 month</td>
<td>10.22 (2.35)</td>
<td>10.92 (2.68)</td>
<td>10.51 (2.22)</td>
<td>11.09 (2.62)</td>
</tr>
<tr>
<td>24 month</td>
<td>10.79 (2.82)</td>
<td>11.24 (3.43)</td>
<td>11.28 (2.82)</td>
<td>11.47 (3.87)</td>
</tr>
</tbody>
</table>
**WDMT-Neutral**

Changes in performance time over 12 and 24 month follow up in the WDMT-N condition are presented in Table 8. Both groups experienced increasing performance times over the follow up period. However, the between groups difference in change scores was not significant at 12 ($p = 0.83$) or 24 ($p = 0.91$) month follow up. See Figure 10 for an illustration of change over time between groups in the WDMT-N condition.

**WDMT-Congruent**

Changes in performance time over 12 and 24 month follow up in the WDMT-C condition are presented in Table 9. Similar to the WDMT-N condition, both groups experienced increased performance times on the walking tasks over time. The baseline to 12 month difference in change scores between groups (SA: $M=0.98$, $SE=0.05$; PA: $M=1.21$, $SE=0.04$) were not statistically significant ($p = 0.55$). Similarly, the baseline to 24 month change scores (SA: $M=1.63$, $SE=0.09$; PA: $M=1.69$, $SE=0.07$) were also not statistically different between groups ($p = 0.93$). See Figure 11 for an illustration of change over time between groups in the WDMT-C condition.

**WDMT-Incongruent**

Change in performance times over 12 and 24 month follow up in the WDMT-I condition are presented in Table 10. As can be seen from the table, although there was a general trend for increasing performance times over the follow up period in both groups, the between group difference in change was not statistically significant at 12 ($p = 0.65$) or 24 months ($p = 0.48$). See Figure 12 for an illustration of change over time between groups in the WDMT-I condition.
7 Meter Walk

Change in performance times over 12 and 24 months in the 7MW are presented in Table 11. Similar to the WDMT, the data demonstrate a trend for increasing performance times on this task in both groups over the course of follow up but, the between group difference in change was not statistically significant at 12 ($p = 0.79$) or 24 months ($p = 0.73$). See Figure 13 for an illustration of change over time between groups in the 7MW task.
### Table 8: Between Group Differences at Follow up for WDMT- Neutral

<table>
<thead>
<tr>
<th></th>
<th>( \Delta BL-12 )</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>( p^* )</th>
<th>( \Delta BL-24 )</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>( p^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>0.72</td>
<td>0.06</td>
<td>0.09</td>
<td>-0.78, 0.97</td>
<td>0.83</td>
<td>1.19</td>
<td>0.08</td>
<td>0.06</td>
<td>-1.09, 1.22</td>
<td>0.91</td>
</tr>
<tr>
<td>PA</td>
<td>0.81</td>
<td>0.05</td>
<td>0.26</td>
<td>-1.26, 1.26</td>
<td>0.07</td>
<td>0.06</td>
<td>1.26</td>
<td>0.07</td>
<td>-1.09, 1.22</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Adjusted for baseline values on complex mobility measures and SPPB total scores
CIs correspond to the difference in adjusted change scores
* indicates the \( p \) value for difference between groups’ change scores

### Table 9: Between Group Differences Follow up for WDMT- Congruent

<table>
<thead>
<tr>
<th></th>
<th>( \Delta BL-12 )</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>( p^* )</th>
<th>( \Delta BL-24 )</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>( p^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>0.98</td>
<td>0.05</td>
<td>0.23</td>
<td>-0.53, 0.98</td>
<td>0.55</td>
<td>1.63</td>
<td>0.09</td>
<td>0.05</td>
<td>-1.14, 1.25</td>
<td>0.93</td>
</tr>
<tr>
<td>PA</td>
<td>1.21</td>
<td>0.04</td>
<td>0.39</td>
<td>0.69, 0.98</td>
<td>0.07</td>
<td>1.69</td>
<td>0.07</td>
<td>0.05</td>
<td>-1.14, 1.25</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Adjusted for baseline values on complex mobility measures and SPPB total scores
CIs correspond to the difference in adjusted change scores
* indicates the \( p \) value for difference between groups’ change scores
Table 10: Between Group Differences at Follow up for WDMT-Incongruent

<table>
<thead>
<tr>
<th></th>
<th>∆BL-12</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>p*</th>
<th>∆BL-24</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>1.66</td>
<td>0.11</td>
<td>-0.34</td>
<td>-1.84, 1.16</td>
<td>0.65</td>
<td>1.46</td>
<td>0.09</td>
<td>-0.41</td>
<td>-1.65, 0.84</td>
<td>0.51</td>
</tr>
<tr>
<td>PA</td>
<td>1.32</td>
<td>0.08</td>
<td>-0.08</td>
<td>-1.16, 1.16</td>
<td>1.05</td>
<td>0.07</td>
<td></td>
<td>-0.41</td>
<td>-1.65, 0.84</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Adjusted for baseline values on complex mobility measures and SPPB total scores
CIs correspond to the difference in adjusted change scores
* indicates the p value for difference between groups’ change scores

Table 11: Between Group Differences at Follow up for 7 Meter Walk

<table>
<thead>
<tr>
<th></th>
<th>∆BL-12</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>p*</th>
<th>∆BL-24</th>
<th>SE</th>
<th>Difference Score</th>
<th>95% CI</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>1.90</td>
<td>0.13</td>
<td>-0.25</td>
<td>-2.11, 1.61</td>
<td>0.79</td>
<td>2.36</td>
<td>0.19</td>
<td>-0.50</td>
<td>-3.15, 2.14</td>
<td>0.71</td>
</tr>
<tr>
<td>PA</td>
<td>1.65</td>
<td>0.10</td>
<td>-0.25</td>
<td>-1.86, 1.61</td>
<td>1.86</td>
<td>0.15</td>
<td></td>
<td>-0.50</td>
<td>-3.15, 2.14</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Adjusted for baseline values on complex mobility measures and SPPB total scores
CIs correspond to the difference in adjusted change scores
* indicates the p value for difference between groups’ change scores
**Figure 10:** WDMT-Neutral Performance Times

**Figure 11:** WDMT-Congruent Performance Times
**Figure 12:** WDMT-Incongruent Performance Times

**Figure 13:** 7 Meter Walk Performance Times
DISCUSSION

Summary of Findings

The purpose of this study was to determine if a multimodal physical activity intervention had an effect on measures of complex mobility in older adults. The two measures of complex mobility used in the present study, the Walking Decision Making Task (WDMT) and the 7 meter walk (7MW), may provide an assessment of mobility that more closely resembles mobility encountered in everyday life, as they involve more than one physiological subsystem. There is currently no previous studies examining the impact of physical activity on complex mobility measures, but due to the positive association of physical activity with other simple mobility measures (Pahor et al., 2006; Rejeski et al., 2011) and cognition, one system with significant support for its role in walking (Ble et al., 2005), there is reason to believe physical activity can also improve complex mobility performance.

The hypotheses were that compared to the successful aging (SA) control group, the physical activity (PA) group would experience greater decreases in performance times on the WDMT-I and 7MW at 12 and 24 month follow up. The results revealed that performance times on all measures increased over time, but there were no significant between group difference in change in performance times on the WDMT and 7MW from baseline to 12 months or 24 months. This is the first study to date to examine the impact of a physical activity intervention on measures of complex mobility in older adults with low physical functioning, as the current literature has only focused on simple mobility outcomes thus far.
Interpretation of Results

Although this is the first RCT to examine the impact of physical activity on complex mobility, numerous other studies have found that physical activity interventions can improve several measures of mobility, such as 400MWT times (Rejeski et al., 2011). Thus, the findings of the present study are unexpected. There are several potential explanations for why the hypotheses were not supported. First, the dose of the intervention (frequency, intensity and duration) may not have been enough to produce changes in complex mobility. That is, it is possible that the participants in the present study did not exercise at a sufficient level during each component of the intervention to produce improvements in complex mobility. As the strength and balance/coordination training were supplementary to the aerobic training, they may have been too low of intensity to produce additional benefits. Unfortunately, we do not have access to adherence data at this point. Similarly, we also do not have information regarding medical leave (frequency and duration of leave), and therefore did not factor these in to our analyses. These variables are especially important to consider in this older age group since unplanned interruptions of the intervention can result in a period of detraining, which can lead to decreases in physical function (Kalapotharakos, Diamantopoulos, & Tokmakidis, 2010).

Second, the study sample had a wide range of lower extremity functioning at baseline with a large proportion of the sample having SPPB scores ≤ 7, and several scoring five or less. Although we controlled for baseline SPPB scores, this does not eliminate the possibility that a portion of the sample were not capable of exercising at a level sufficient to significantly impact complex mobility. Moreover, although there were
no statistically significant differences in baseline measures of mobility, the PA group had several participants with SPPB scores of four or five whereas the lowest score observed in the SA group was six. This group of individuals may have too severe of mobility impairment to benefit from a regular physical activity intervention, which comes back to questions of whether they received the correct dose of the intervention and their adherence. It has been suggested that exercise interventions in older adults with compromised mobility may need to be tailored in order to produce significant changes in mobility outcomes (Marsh et al., 2009). For example, when comparing the effects of an aerobic training intervention involving only moderate intensity walking (WALK) to the same walking intervention with the additional of mental and physical obstacles throughout (WALK+), individuals with low physical functioning experienced significant improvement in mobility only in the WALK+ group (Marsh et al., 2009). These results suggest that to observe changes in mobility in older adults with lower physical functioning, physical activity programs need to be tailored to include additional functional training exercises such as dynamic and static balance and those involving multisensory integration training. Mobility encompasses much more than just the ability to walk, but also lateral mobility, the ability to climb stairs, and fall risk (Buchner, 2008), so taking this multi-dimensional, tailored approach to physical activity interventions addresses the various skills needed to for independent mobility.

Third, in light of the high variability in physical functioning, our study may have also lacked the statistical power required to detect differences between groups due to its small sample size. There is no single explanation for the variability we observed in our outcome measures. Working with a population of older individuals that are so
functionally impaired is very challenging because it is difficult to predict their behavior, health status, or response to the intervention. Performance at both the intervention sessions and at the follow up assessments is largely dependent on how the participant felt on that particular day and this is likely to fluctuate frequently due to their age and poor physical functioning. This wide range of variability is difficult to account for, especially with our sample size of 70. Therefore, it is reasonable to suggest that the sample size of the present study resulted in a lack of statistical power and it is possible that a larger sample size would allow us to detect statistically significant between group differences in change.

Fourth, the follow up time points that we chose to assess changes in performance on the complex mobility tasks may have impacted our results. It is possible that greater improvements would have been observed during the first few months of the intervention, that then began to plateau or decline by the time we assessed their progress at 12 months, a trajectory of change that has been observed previously (Rejeski et al., 2011). Unfortunately, our follow up assessments did not allow us to assess changes in mobility during the initial months of the intervention. Additionally, our measures of complex mobility may not be sensitive enough to detect small changes in performance over time. As described earlier, the WDMT has previously been reported to be a valid measure of mobility, due to its correlations with other measures of mobility and physical function and several measures of global cognition and executive function (Yamamoto, 2011). This task was also deemed reliable over one week, although it was suggested that there may have been a learning effect. However, this is the first study to examine change in WDMT resulting from a physical activity intervention as well as to use the WDMT for
long term assessments. This is also the first study to examine effects of physical activity on 7MW performance. It is unknown whether these measures possess ceiling or floor effects that might impact their ability to detect changes over time.

Finally, physical activity may not have any effect on measures of complex mobility. No other study to date has specifically examined the impact of physical activity on complex mobility, so it is hard to make comparisons to previous studies. However, numerous studies have found that physical activity positively impacts simple mobility measures such as 400 MWT (Pahor et al., 2006; Rejeski et al., 2011), SPPB (Pahor et al., 2006), and habitual (Chandler et al., 1998; Malatesta et al., 2010) and maximum walking speeds (Schlicht et al., 2001). Therefore, this explanation seems unlikely, but is an option that cannot be ruled out.

Limitations

In addition to the aforementioned small sample size and measurement issues, there were several limitations that may have contributed to our results. First, potential moderators of this relationship have not been addressed. Although the role of cognition in walking has been well established, the present study did not examine the impact of cognitive functioning on complex mobility performance. It is unknown whether there were any changes in cognitive status throughout the intervention and if these changes were associated with changes in mobility, an association that has been observed in previous longitudinal studies (Atkinson et al., 2007; Buchman et al., 2011). Unfortunately, we did not include measures of cognition in the current analyses, which limits our understanding of the relationship between physical activity and mobility.
Although baseline total scores on the SPPB were controlled for in our analyses that tested the difference in change between groups, it is unknown whether baseline physical functioning status would moderate the effects of physical activity on complex mobility. The current literature suggests that, initially, people of lower physical functioning benefit more from a physical activity intervention (Lord et al., 1996; Rejeski et al., 2011), while those with higher levels of functioning need a greater stimulus to see similar benefits (Mian et al., 2007). However, there may be a lower limit to the level of impairment a person can have to be able to actively engage in a physical activity intervention.

As noted above, the small sample size may have limited our power for detecting change. We did not start recruitment for LIFE-CM until six months after the start of randomization of the LIFE-Main trial, thus limiting the number of participants we were able to recruit from the pool of 205. Despite reaching our recruitment goal of 70 participants to detect effect sizes of 15-20%, our power estimates were based on data from the SHARP-P study (Legault et al., 2011), which included participants with higher and more homogenous levels of lower extremity functioning and may have underestimated the power needed for the present study. Additionally, the LIFE Study mandated that we recruit participants at the end of a very long baseline testing visit (approximately three hours) and following randomization. This may have limited the number of people that volunteered for this study.
Future Directions

The current study sought to gain a better understanding about the impact of physical activity on complex mobility. Although our results did not provide support for the beneficial effects of physical activity on measures of complex mobility, this does not imply that the relationship does not exist because this only one study and it is well known that numerous studies are needed to confirm or reject a relationship. To further examine this relationship, cognition needs to be assessed at baseline and all follow up points in order to determine if cognitive functioning is maintained or reduced over the duration of the physical activity intervention. Then, changes in cognition need to be compared to changes in performance on each condition of the WDMT and the 7MW to give us a better understanding of the moderating role cognition may have on the impact of physical activity on complex mobility. Additionally, it is important to design an intervention that challenges and trains the body to more efficiently integrate multiple sensory systems, as walking in the real world is believed to require various systems of the body to work together simultaneously.

This study is one of the first regarding this topic and there is a need for more studies that address the numerous moderators and mediators that may play a role in this process. In the future, it would be beneficial to have a larger sample size to address the issue of power. With more participants, there is a better chance that the variability observed in performance times will be overcome. Recruiting participants with better physical functioning for the same type of intervention as conducted presently, may shed some light onto whether having such a severe level of mobility dysfunction has an inhibitory effect on the benefits to be gained from physical activity.
If the complex mobility measures were shown to be sensitive to change, future studies should also consider a study design with four intervention arms: multimodal training, aerobic training, strength training, and successful aging control. This would provide a better understanding of which training component has the biggest role in affecting complex mobility. Having more frequent follow up assessments (e.g., 3, 6, 12, 18, 24 months) would provide a more detailed illustration of the trajectory of change throughout the intervention. The addition of measures of executive function at each follow up assessment would again allow researchers to determine if executive function plays a role in the relationship between changes in cognition and changes in complex mobility performance time.

Further research addressing the many questions regarding the relationship between physical activity and complex mobility is needed to enhance our understanding of complex mobility and how it can be improved in older adults. It is important to continue to explore the finer details and the complexity of mobility in the real world because loss of mobility is becoming more prevalent in older adults and the consequences, most notably loss of independence, are devastating. Our current methods of assessing mobility do not address the challenging conditions that an older adult must navigate through in order to live an independent lifestyle. Complex mobility measures offer unique insight as to how gait is related to the manifestation of mobility loss and how cognition moderates this relationship. Utilizing a more ecologically valid assessment of mobility can help identify older adults at highest risk for mobility disability that may not be classified as such if a more simple measure was used. Discovering a way to improve complex mobility in this population, whether through physical activity or another type of
multisensory intervention, could drastically improve the quality of life of many older adults.
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APPENDIX A: Informed Consent

Complex Mobility and Executive Functioning

Informed Consent Form to Participate in Research

Jeffrey A. Katula, PhD, Principal Investigator

INTRODUCTION
You are invited to be in a research study. Research studies are designed to gain scientific knowledge that may help other people in the future. You are being asked to take part in this study because you are participating in the LIFE study. Your participation is voluntary. You do not have to take part in this study and if you chose not to, you can continue to participate in the LIFE study. Please take your time in making your decision as to whether or not you wish to participate. Ask your study doctor or the study staff to explain any words or information contained in this informed consent document that you do not understand. You may also discuss the study with your friends and family.

WHY IS THIS STUDY BEING DONE?
The purpose of this research study is to study the influence of physical activity on your ability to walk over obstacles while making decisions. We are also interested in studying how your memory and attention influence your walking ability.

HOW MANY PEOPLE WILL TAKE PART IN THE STUDY?
70 people at this research site will take part in this study.

WHAT IS INVOLVED IN THE STUDY?
If you agree to participate in this study by signing this consent form, your contact information will be provided to the coordinators at Wake Forest University who are conducting this study. They will contact you within a few days to schedule your first visit. You will be asked to come to the Reynolds Gym on the Reynolda Campus at Wake Forest University. You will be asked to complete two memory tasks and two walking
tasks. During the first memory task you will be given a list of 30 words to try and remember. Then you will be read a different list of words and you will be asked which words were off of the original list. The second memory task will be done on the computer and you will be asked to select shapes one at a time until all shapes have been selected. For the first walking task you will be asked to walk as fast as you can for 7 meters (about 21 feet) and there will be 2 small obstacles that you must step over. The second walking task is called the walking decision making task (WDMT). This involves following directions presented on a computer screen regarding which direction to turn while you are walking.

We anticipate that each visit will take approximately 35 minutes. You will be asked to return to complete the same the tasks after your 12 and 24 month follow up visit for the LIFE study.

**HOW LONG WILL I BE IN THE STUDY?**
You will be in the study for about 2 years.

You can stop participating at any time. If you decide to stop participating in the study we encourage you to talk to the investigators or study staff first to learn about any potential health or safety consequences.

**WHAT ARE THE RISKS OF THE STUDY?**
Being in this study involves some risk to you. You should discuss the risk of being in this study with the study staff. Risks and side effects related to the walking tasks include a small risk of injury such as muscle strains or pulls, falling, tripping, or joint injury. This will be minimized by having trained staff conduct these tasks will they will give you adequate instructions on how to complete the tasks.

There also may be other side effects that we cannot predict. You should tell the research staff about all the medications, vitamins and supplements you take and any medical conditions you have. This may help avoid side effects, interactions and other risks.

Taking part in this research study may involve providing information that you consider confidential or private. Efforts, such as coding research records, keeping research records secure and allowing only authorized people to have access to research records, will be made to keep your information safe.

**ARE THERE BENEFITS TO TAKING PART IN THE STUDY?**
You are not expected to receive any direct benefit from taking part in this research study. We hope the information learned from this study will benefit other people in the future.
WHAT OTHER CHOICES ARE THERE?
This is not a treatment study. Your alternative is to not participate in this study.

WHAT ABOUT THE USE, DISCLOSURE AND CONFIDENTIALITY OF HEALTH INFORMATION?
By taking part in this research study, your personal health information, as well as information that directly identifies you, may be used and disclosed. Information that identifies you includes, but is not limited to, such things as your name, address, telephone number, and date of birth. Your personal health information includes all information about you which is collected or created during the study for research purposes. It also includes your personal health information that is related to this study and that is maintained in your medical records at this institution and at other places such as other hospitals and clinics where you may have received medical care. Examples of your personal health information include your health history, your family health history, how you respond to study activities or procedures, laboratory and other test results, medical images, photographs/ videotapes/audiotapes and information from study visits, phone calls, surveys, and physical examinations.

Your personal health information and information that identifies you (“your health information”) may be given to others during and after the study. This is for reasons such as to carry out the study, to determine the results of the study, to make sure the study is being done correctly, to provide required reports and to get approval for new products.

Some of the people, agencies and businesses that may receive and use your health information are the research sponsor; representatives of the sponsor assisting with the research; investigators at other sites who are assisting with the research; central laboratories, reading centers or analysis centers; the Institutional Review Board; representatives of Wake Forest University Health Sciences and North Carolina Baptist Hospital; representatives from government agencies such as the Food and Drug Administration (FDA), the Department of Health and Human Services (DHHS) and similar agencies in other countries.

Some of these people, agencies and businesses may further disclose your health information. If disclosed by them, your health information may no longer be covered by federal or state privacy regulations. Your health information may be disclosed if required by law. Your health information may be used to create information that does not directly identify you. This information may be used by other researchers. You will not be directly identified in any publication or presentation that may result from this study unless there are photographs or recorded media which are identifiable.
If this research study involves the treatment or diagnosis of a medical condition, then information collected or created as part of the study may be placed in your medical record and discussed with individuals caring for you who are not part of the study. This will help in providing you with appropriate medical care. In addition, all or part of your research related health information may be used or disclosed for treatment, payment, or healthcare operations purposes related to providing you with medical care.

When you sign this consent and authorization form you authorize or give permission for the use of your health information as described in the consent form. You can revoke or take away your authorization to use and disclose your health information at any time. You do this by sending a written notice to the investigator in charge of the study at the following address:

Jeffrey A. Katula, PhD
Wake Forest University
PO Box 7868
Winston-Salem, NC  27109

If you withdraw your authorization you will not be able to be in this study. If you withdraw your authorization, no new health information that identifies you will be gathered after that date. Your health information that has already been gathered may still be used and disclosed to others. This would be done if it were necessary for the research to be reliable. You will not have access to your health information that is included in the research study records until the end of the study.

This authorization is valid for six years or five years after the completion of the study, whichever is longer.

WHAT ARE THE COSTS?
There are no costs to you for taking part in this study. All study costs, including any study medications and procedures related directly to the study, will be paid for by the study. Costs for your regular medical care, which are not related to this study, will be your own responsibility.
WILL YOU BE PAID FOR PARTICIPATING?
You will receive a $5 gift card for each study visit that you complete ($15 total). If you withdraw for any reason from the study before it is completed you will still receive a $5 gift card for each study visit that you completed.

WHO IS SPONSORING THIS STUDY?
This study is being sponsored by the Department of Health & Exercise Science at Wake Forest University. The sponsor is providing money or other support to Wake Forest University Health Sciences to help conduct this study. The researchers do not, however, hold a direct financial interest in the sponsor or the product being studied.

WHAT HAPPENS IF YOU EXPERIENCE AN INJURY OR ILLNESS AS A RESULT OF PARTICIPATING IN THIS STUDY?
Should you experience a physical injury or illness as a direct result of your participation in this study, Wake Forest University School of Medicine maintains limited research insurance coverage for the usual and customary medical fees for reasonable and necessary treatment of such injuries or illnesses. To the extent research insurance coverage is available under this policy the reasonable costs of these necessary medical services will be paid, up to a maximum of $25,000. Wake Forest University Baptist Medical Center holds the insurance policy for this coverage. It provides a maximum of $25,000 coverage for each claim and is limited to a total of $250,000 for all claims in any one year. The Wake Forest University School of Medicine, and the North Carolina Baptist Hospitals, Incorporated do not assume responsibility to pay for these medical services or to provide any other compensation for such injury or illness. Additional information may be obtained from the Medical Center’s Director of Risk and Insurance Management, at (336) 716-3467.

You do not give up any legal rights as a research participant by signing this consent form. For more information on medical treatment for research related injuries or to report a study related illness, adverse event, or injury you should call Jeffrey Katula at 336-758-3612 during normal business hours or 336-409-4899 after hours.

WHAT ARE MY RIGHTS AS A RESEARCH STUDY PARTICIPANT?
Taking part in this study is voluntary. You may choose not to take part or you may leave the study at any time. Refusing to participate or leaving the study will not result in any penalty or loss of benefits to which you are entitled. If you decide to stop participating in the study we encourage you to talk to the investigators or study staff first to learn about any potential health or safety consequences. The investigators also have the right to stop your participation in the study at any time. This could be because it is in your best medical interest, your condition worsened, new information becomes available, you had
an unexpected reaction, you failed to follow instructions, or because the entire study has been stopped.

You will be given any new information we become aware of that would affect your willingness to continue to participate in the study.

**Whom Do I Call if I Have Questions or Problems?**

For questions about the study or in the event of a research-related injury, contact the study investigator, Jeffrey Katula at 336-758-3612 during normal business hours or at 336-409-4899 after hours.

The Institutional Review Board (IRB) is a group of people who review the research to protect your rights. If you have a question about your rights as a research participant, or you would like to discuss problems or concerns, have questions or want to offer input, or you want to obtain additional information, you should contact the Chairman of the IRB at (336) 716-4542.

You will be given a copy of this signed consent form.

**SIGNATURES**

I agree to take part in this study. I authorize the use and disclosure of my health information as described in this consent and authorization form. If I have not already received a copy of the Privacy Notice, I may request one or one will be made available to me. I have had a chance to ask questions about being in this study and have those questions answered. By signing this consent and authorization form, I am not releasing or agreeing to release the investigator, the sponsor, the institution or its agents from liability for negligence.

___________________________________________  _________________________  _________________________
Subject Name (Printed)

___________________________________________  _________________________
Subject Signature                          Date

___________________________________________  _________________________
Person Obtaining Consent                     Date
APPENDIX B: LIFE Study Eligibility Criteria

Table 1. Inclusion or Exclusion Criteria

Inclusion criteria

- Age 70–89 years
- Summary score ≤10 on the Short Physical Performance Battery (score ranges from 0 [poorest performance] to 12 [best])
- Sedentary lifestyle defined by ≤120 min of activity per week on the CHAMPS-18 questionnaire
- Able to complete the 400-m walk test within 15 minutes at baseline without sitting, leaning, using a walker, or the help of another person
- Willingness to be randomized to either intervention group

Exclusion criteria

- Unable or unwilling to give informed consent or accept randomization in either study group
- Current diagnosis of schizophrenia, other psychotic disorders, or bipolar disorder
- Consumption of more than 14 alcoholic drinks per week
- Plans to relocate out of the study area within the next 2 years or plans to be out of the study area for more than six consecutive weeks in the next year
- Self-reported inability to walk across a room
- Another member of the household is a participant in the LIFE Study
- Nursing home residence
- Difficulty communicating with study personnel due to speech or language or hearing problems
- Modified Mini-Mental State Examination (3MSE) below 2 SDs of education- and race-specific norms
- Participation in LIFE Pilot study
- Severe arthritis, such as awaiting joint replacement, that would interfere with the ability to participate fully in either study arm
- Cancer requiring treatment in the past 3 years, except for nonmelanoma skin cancers or cancers that have an excellent prognosis (e.g., early-stage breast or prostate cancer)
- Lung disease requiring regular use of corticosteroids or of supplemental oxygen
- Cardiovascular disease (including NYHA Class III or IV congestive heart failure, clinically significant valvular disease, history of cardiac arrest, presence of an implantable cardiac defibrillator, or uncontrolled angina)
- Parkinson’s disease or other progressive neurological disorder
- Renal disease requiring dialysis
- Chest pain, severe shortness of breath, or occurrence of other safety concerns during the baseline 400-m walk test
- Other medical, psychiatric, or behavioral factors that in the judgment of the principal investigator may interfere with study participation or the ability to follow either the intervention or the successful aging protocol
- Other illness of such severity that life expectancy is less than 12 months
- Clinical judgment concerning safety or noncompliance

Temporary exclusion criteria

- Uncontrolled hypertension (systolic blood pressure > 140 mmHg or diastolic blood pressure > 90 mmHg)
- Uncontrolled diabetes with recent weight loss, diabetic coma, or frequent hypoglycemia
- Stroke, hip fracture, hip or knee replacement, or spinal surgery in the past 6 months
- Serious conduction disorder (eg, third-degree heart block), uncontrolled arrhythmia, new Q waves within the past 6 months or ST-segment depressions (>3 mm) on the ECG
- Myocardial infarction, major heart surgery (ie, valve replacement or bypass surgery), stroke, deep vein thrombosis, or pulmonary embolus in the past 6 months
- Current participation in physical therapy or cardiopulmonary rehabilitation
- Current enrollment in another randomized trial involving lifestyle or pharmaceutical interventions

Note: ECG = electrocardiogram; LIFE = Lifestyle Interventions and Independence for Elders.
Walking Decision Making Task Instructions

- Overview

  o **Begin WDMT**: This task will test your ability to make decisions while you are walking. I would like you to walk as quickly, but safely, as you can through this course. You will walk straight ahead and then decide to turn left or right based upon the instructions presented to you on the computer screen. After you turn, you will continue to walk as quickly as you can through the finish line. Your time will be recorded from start to finish.

  o Your decision to turn left or right will be based upon the instructions presented to you. What you will see is a letter. If you see an “R” you should turn right; if you see an “L” you should turn left. You may see some arrows. Don’t pay any attention to the arrows or which way they are pointing, just follow the letter.

  o I will demonstrate for you. You’ll start with your toes behind the yellow line. I will say ready, begin and you will walk forward. Instructions will pop up, you will decide to turn right, or left, but continue walking as fast as you can and cross the finish line.
Life Ancillary Study

Visit: ______

Trial Condition: _______________________

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APPENDIX D: 7 Meter Walk Instructions and Data Collection Form

7 Meter Walk Test

- **Overview**
  
  - Walking with obstacles assesses the ability of the subject to adapt his walk to the environment, programming the most appropriate motor response to overcome the obstacle faced.
  
  - Description of the test: The subject is invited to walk a route of 7 meters on which two obstacles of foam rubber are placed; they are 6 cm and 30 cm high, respectively. The obstacles are paced at the 2nd and 4th meter of the route, respectively. The test is performed in a well-lighted environment. The subject to be tested can use an aid that he/she uses daily, if he/she thinks it necessary.

- **Instructions/Script**
  
  - “This test has the purpose of understanding how you behave when you meet an obstacle on your street. Walk along this route and try to get past the obstacles you see without touching them. Try to adapt your walk so as to overcome the obstacles without needing to stop or slow down. The obstacles are of different height, are made of foam rubber, and therefore are light and do not offer resistance when bumped. Therefore, you should not be afraid of falling if you bump against these objects. I will stay near you during your performance of the test. It is not a competition, but it is important that you walk at a steady pace. Try not to speak during the test. If you have doubts, tell them to me now and I will try to resolve them”.
  
  - The subject is shown the test, but is not granted a practice session.

- **Performance of the Test**
  
  - When the examiner says GO, the subject walks the route. The test will be timed by two IRT (timers): Start timer and End Timer. A stopwatch will be used for backup. If the timers do not work properly on the first trial, a second trial will be performed. If the timers do not work properly on the second trial, the stopwatch time will be recorded.
o Start the stopwatch when the subject takes their first step. For safety purposes, examiner should follow subject as a reasonable distance during test. Examiner should be close enough to subject to be able to provide help should the subject falter during the test, but not so close as to dictate the pace of the test.

- **Measurements Taken**
  
o The time recorded;
o Begin unable to perform the test;
o Stumbling or appearing unstable;
o Moving the obstacle and which one;
o Putting his/her arms in a defensive position;
o The subject needing physical help to overcome the obstacle.

- **Scoring**
  
o At the end of the walk, the examiner assesses the test qualitatively and decides if the subject has passes the walk. The subject must not have stumbled or shown himself/herself unstable, moved the obstacle, put his/her arms in a defensive position, or required help.
7-Meters Walk Test

OBSERVATIONS OF 7-Meters Walk Test

Accompany the subject to the starting line of the 7-meters Walk Test with script and stop watch. Describe the 7-meters Walk Test:

Script: “This test has the purpose of understanding how you behave when you meet an obstacle on your street. Walk along this route and try to get past the obstacles you see without touching them. Try to adapt your walk so as to overcome the obstacles without needing to stop or slow down. The obstacles are of different height, are made of foam rubber, and therefore are light and do not offer resistance when bumped. Therefore, you should not be afraid of falling if you bump against these objects. I will stay near you during your performance of the test. It is not a competition, but it is important that you walk at a steady pace. Try not to speak during the test. If you have doubts, tell them to me now and I will try to resolve them.”
Life Ancillary Study

If subject uses cane or other assistive device: "I would like you to attempt this test without your cane (or other walking device)."

1. Do you feel it would be safe to try and walk through this course?
   - Yes
   - D/K
   - No

2. Would you be willing to try it and see how you feel?
   - Yes
   - No

3. Did participant bring a cane [walking device to the clinic?
   - Yes
   - No

4. Do you feel it would be safe if you could use your cane [or other device]?
   - Yes
   - No

Script: "I will demonstrate how to walk through the course." After completing demonstration, ask: "Do you have any questions?"

When subject indicates they feel ready to begin, the test may proceed:

Script: "I will walk behind you. When I say 'GO', start walking through the course at a steady pace. Ready, Go."

Start the stop watch when the subject takes their first step. For safety purposes, examiner should follow subject at a reasonable distance during test. Examiner should be close enough to subject to be able to provide help should subject falter during test, but not so close as to dictate the pace of the test.

5. Did the participant use an assistive walking device during the test?  
   - Yes
   - No

6. Did the participant complete the 7-m walk?  
   (Record time that first foot crosses the finish line)  
   - Yes
   - No

7. TIME to walk 7-m course:  
   - Seconds

   7a. Number of trials:

   7b. Time was recorded with:  
      - IRT (Timer)
      - Stopwatch

   7c. If stopwatch was used, what was the reason?  
      - Start Timer did not work
      - End Timer did not work
8. If unable to perform test, “Why did you feel you could not continue”?

- Shortness of Breath
- Chest Pain
- Leg Pain
- Feeling Faint or Dizzy
- Fatigue
- Other: (Specify)

9. Did the participant move the obstacle?

- Yes
- No

9a. (6cm obstacle):
- Yes
- No

9b. (30 cm obstacle):
- Yes
- No

10. Observed Symptoms at end of walk: (X all that apply)

- Stumbling
- Appeared Unstable
- Put arms in defensive position
- Subject needed physical help to overcome the obstacle
- No symptoms observed

11. Comments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Page 3 of 3
Erika L. Griffith
Health and Exercise Science MS student

Personal Information
Name: Erika Lynn Griffith
Address: 520-R Park Ridge Court, Winston-Salem, NC 27104
Email: eg124305@yahoo.com (personal)
Email: grifel12@wfu.edu (school)

Education
Graduate
Wake Forest University, M.S. (Health and Exercise Science)
2012-2014 Winston-Salem, NC

Undergraduate
Towson University, B.S. (Major: Exercise Science; Minor: Psychology)
2008-2012 Towson, MD

Research Experience

2013 to present
Wake Forest School of Medicine
Department of Public Health Sciences
Research Assistant
Dr. Jeffery A. Katula, Supervisor

LIFT Study
Lifestyle Intervention For the Treatment of Diabetes

The purpose of this study is to determine if a 12 month community-based weight loss intervention in overweight adults with Type II Diabetes can decrease cardiovascular disease risk by decreasing caloric intake and increasing physical activity.

Responsibilities: Acting physical activity expert at various intervention sessions; development of materials; record meeting minutes; assist with participant management; assist with training of new interventionists.

2013 to present
Wake Forest Baptist Health
Department of Rheumatology and Immunology
Lead Interventionist
Dr. Jeffery A. Katula and Dr. Dennis Ang, Supervisors
**Fibromyalgia Study**

Community based therapy for fibromyalgia: A feasibility study

The purpose of this study is to test the feasibility of establishing a community based physical activity (PA) intervention administered in combination with cognitive behavioral therapy (CBT) by a trained physical activity interventionist for fibromyalgia patients.

**Responsibilities:** Lead interventionist (PA and CBT); development of materials; participant management.

---

**2012-present**

**Wake Forest University Behavioral Medicine Research Laboratory**

**Department of Health and Exercise Science**

Research Assistant
Dr. Jeffrey A. Katula, Supervisor

**LIFE-Ancillary Study**

Complex Mobility and Cognitive Functioning

The purpose of this study is to examine the impact of a long-term structured physical activity program on cognitive functioning and mobility as assessed using complex walking tasks.

**Responsibilities:** Scheduling of assessments; data collection and management; data query management.

---

**Summer 2011**

**Johns Hopkins Cardiology Research Suite**

**Bayview Medical Center**

Research Intern
Dr. Devon Dobrosielski, Supervisor

Several studies were going on within the department with topics ranging from sleep apnea to heart disease. My assistance was utilized where I was needed.

**Responsibilities:** observed and assisted with health and fitness tests; organized packets for participants; critiqued unpublished manuscripts; reviewed the literature on cardiorespiratory fitness and composed an outline for book chapter to be updated; composed research paper examining effect of a 3 month diet and exercise intervention on sleep apnea symptoms.
Professional Experience

2013 to present  
**Wake Forest Healthy Exercise and Lifestyle Programs (HELPS)**  
New Participant Coordinator

**Responsibilities**: introduce prospective participants to the program and tour the facility; obtain medical history and informed consent; schedule the health and fitness assessment; keep track of new participants and address concerns/changes in health status; assemble patient charts.

Exercise Testing Lab Assistant

**Responsibilities**: take resting and exercise blood pressures during stress tests; place electrodes and connect ECG wires; ask participants RPE during test.

Teaching Experience

2012 to present  
**Wake Forest University Department of Health and Exercise Science**  
*HES 101: Exercise for Health* required undergraduate course  
Graduate Instructor

2010-2012  
**Towson University Athletic Department**  
*BIOL 213/214: Anatomy and Physiology I & II* undergraduate course  
Tutor for other student-athletes

2010-2011  
**Mount Laurel, New Jersey School District**  
Kindergarten – 8th grade  
Certified Substitute Teacher

2010-2011  
**Towson University Department of Kinesiology**  
*KNES 369: Clinical Competencies and Fieldwork in Exercise Science* undergraduate course  
Teaching Assistant
Presentations

2014

2014

2013

Volunteer Experience

2013
Crazy Running - Training Group; Winston-Salem, NC
Robyn Holland, Coordinator
Helped 5-7 year olds through an 8 week training program of running drills and activities to prepare them for a 1 mile fun run.

2012/2013
Liberty Community Development Cooperation (CDC) 5k
Winston-Salem, NC
Assisted with registration, food set-up and distribution of awards.

Brenner FIT Challenge – Fighting Childhood Obesity Race
Brenner Children’s Hospital; Winston, Salem, NC
Assisted with directing participants on the course and activity set-up.

96
2010  **Breakthru Physical Therapy; Moorestown, NJ**  
Kevin Schnitzer, P.T., Supervisor  
Observed and assisted with physical therapy programs and activities.

**Certifications**

2014  American College of Sports Medicine – Clinical Exercise Specialist (ACSM-CES)

2013  SilverSneakers Muscular Strength and Range of Movement (MSROM) Instructor, Healthways

2012  CPR and AED certified, American Heart Association

**Memberships**

2014-2015  American College of Sports Medicine (ACSM)

2013-2014  Society of Behavioral Medicine (SBM)

2012-2014  Southeast American College of Sports Medicine (SEACSM)

**Awards**

2014  Gordon A. Melson Outstanding Master’s Student Award  
Graduate School of Arts and Sciences  
Wake Forest University

2013  Alumni Student Travel Award  
Wake Forest University

2012  Outstanding Student in Exercise Science  
Towson University

Leadership Award – Cross Country Representative  
Towson University Athletic Department

2011  Donald I. Minnegan Scholarship Endowment  
Towson University  
*Awarded to one athlete each year who achieved excellence both athletically and academically.*