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Feasibility and Preliminary Outcomes of a 6-Week Mindful Walking Program to Maintain and Improve Cognition in Adults at Risk for Alzheimer's Disease or Other Related Dementias

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FEASIBILITY AND PRELIMINARY OUTCOMES OF A 6-WEEK MINDFUL WALKING PROGRAM TO MAINTAIN AND IMPROVE CONGINTION IN ADULTS AT RISK FOR ALZHEIMER'S DISEASE OR OTHER RELATED DEMENTIAS

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DEDICATION

I would like to dedicate this thesis work to my family. Mom, Dad, and Abigayle, thank you for always believing me, providing encouragement, and reminding me that I can do it! I love you all. Thank you Grampy, for always reminding me that I can do anything I set my mind to. I know you would be proud.

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ABSTRACT

The present study examined the impact of a 6-week Mindful Walking intervention. Participants completed 30 minute walking sessions twice a week for 6 weeks. Ten older adults attended 100% of the supervised walking sessions. Pre-post comparison of the Montreal Cognitive Assessment and examination of subtests of the Montreal Cognitive Assessment did not reveal a significant change in mean scores ($p<.05$). Pre-post assessment of Ecological Momentary Assessment conducted with dedicated cell phones revealed pre-post improvement in speed of processing ($p < .003$). Physical measurement did not reveal a significant change in Timed Up and Go a measure of coordination, agility, and balance ($p > .05$, one-tailed). The number of steps accumulated as a result of Mindful Walking and other activities measured with the ActivPAL and change in MoCA total scores did not reach significance. Generally, the Mindful Walking program was well-liked (4 on a scale of 5) as indicated by participants' compliance with the program and an electronic survey sent at the end of the program. Future research may include longer sessions and a longer length of intervention.

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CHAPTER 1

INTRODUCTION

The United States currently has more than 46 million older adults over the age of 65. The U.S. Census Bureau projects that by 2035 there will be more older adults than children in the population (Nasser, 2021). The Alzheimer's Association projects that by 2050 nearly 13 million Americans will have an Alzheimer's diagnosis. They predict that this will cost the nation 1.1 trillion dollars. As the population ages, society needs to implement strategies to protect the aging population. Low social engagement (Seeman et al., 2001; Yun et al., 2020) and lack of physical activity (Beckett et al., 2015; Zhou et al., 2017) are risk factors for dementia and may impact the rate of decline associated with dementia ((Ahlskog, Geda, Graff- Radford, & Petersen, 2011). Supporting older adults by enhancing their social engagement (Zhou et al.,2020) and promoting physical activity (Dallmeyer, Wicker, & Breuer 2017) would likely reduce the social and economic burden associated with the increasing proportion of older adults in the United States in the coming years.

Even though the Center for Disease Control and Prevention has found that physical activity is essential for healthy aging, one in four Americans over the age of 50 years are not physically active beyond their daily routine (Center for Disease Control and Prevention, 2016). Furthermore, data from the ABC study in Columbia, SC indicated that 79 out of 88 participants 50 and older reported that they "never or seldom" participated in

a physical recreational activity (S. Newman-Norlund, Personal Communication, June 9, 2021). Physical Activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure; however exercise is physical activity that is planned, structured, repetitive, and is a subcategory of physical activity (Caspersen et al., 1985). Physical activity along with social engagement has been found to positively impact older adults' quality of life (Rosso, Taylor, Tabb, & Michael, 2013) and older adults' well-being (Livingston et al., 2017).

A recent survey conducted by the American Speech-Language-Hearing Association found that speech-language pathologists (SLP) who work in adult health care settings spend 14% of their time working with patients with dementia (ASHA, 2019). This study concluded that the majority of speech language pathologists who work in health care settings serve patients with dementia. As the United States continues to age, speech-language pathologists will spend more time educating and recommending interventions for cognition due to the increasing numbers of patients with dementia.

1.1 Cognition

Cognition is critical for functional independence as people age. It determines if someone can drive safely, manage finances and live independently (Murman, 2015). There is a wide variation in cognitive function during aging, both in performance and rate of change over time (Knopman et al. 2015). Cognition can be described as being on a continuum. Normal cognition at one end, dementia at the other, and mild cognitive impairment at the center. Where an older adult falls on the spectrum depends on their memory, attention, executive functioning, language, and visual-spatial domains (Knopman et al., 2014). Older adults shifting from normal cognition to age-related

cognitive decline is expected while aging. Once someone reaches the level of mild cognitive impairment it becomes a problem because they need greater support from family, friends and/or professionals; even more impactful is when an individual progresses from mild cognitive impairment to dementia and can no longer care for themselves in activities of daily living. As the United States population continues to age, more older adults will exceed age related cognitive decline and experience mild cognitive impairment and dementia, thus putting a burden on society.

Figure 1.1 The continuum of cognition and cognitive decline.

1.2 Aging

As someone gets older, cognitive changes are a normal process that occurs with healthy aging. Cognitive capacity remains intact, but encoding, storage, and retrieval become less efficient or are interrupted by reduced attention and working memory capacity (Fillit et al., 2002). Additionally, conceptual reasoning, memory, and processing speed decline gradually over time. Conversely, vocabulary continues to improve as the brain ages (Harada, Love, Triebel 2013). Normal age-related cognitive decline does not impair someone's ability to complete their daily activities. It is recommended that medical professionals should educate older adults on successful aging so they maintain the skills and abilities to remain in the healthy aging category (Dev et al., 2020).

Successful aging has a multitude of definitions in the literature. A more recent and respected definition states successful aging is a combination of physical, spiritual, social, and mental wellbeing (Kleineidam et al., 2019; Li et al., 2014; Stephens, Breheny, & Mansvelt, 2015; Topaz et al., 2014). Rowe and Kahn (1997) provided a theory that stated successful aging is made up of three components: reducing the risk of disease/disability, maintaining cognitive and physical function, and continuing engagement with life. Speech-language pathologists and other medical professionals can aid in healthy aging by educating the population on the importance of engagement and physical activity to reduce the risk of disease and cognitive impairment so members of society understand the factors of successful aging. More research and a greater focus on appropriate health promotion programs are needed to support the United States' aging population.

Figure 1.2 Rowe and Kahn's (1997) model of successful aging

1.3 Cognitive Impairment

Cognitive impairment (CI) may include a mild to severe difficulty in remembering, learning new things, concentration, or making decisions that affect daily life (Center for Disease Control and Prevention, 2011). Cognitive impairment leads to a

decrease in independence and a need for more assistance to complete activities of daily living. According to the Center for Disease Control and Prevention (2011), age is the primary risk factor for CI. Other risk factors include a family history of cognitive impairment, limited physical activity or inactivity, and other chronic conditions. A study by Kivipelto et al. (2008) reported advanced age, *APOE*-ε4 allele, family history and physical inactivity were all risk factors for dementia. This was used to establish the risk factors used for the current study. Although there is no definitive cure for cognitive impairment that is universally effective, medical professionals should strongly encourage older adults to remain socially, physically, and mentally active (Knopman and Petersen, 2014) because research suggests cognition can be maintained longer at the same level (Weaver & Jaeggi, 2021) or even improved in select cases (Zhu, et al., 2016).

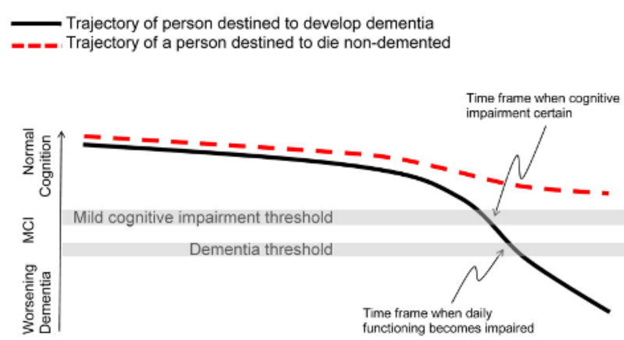

Figure 1.3 Knopman and Peterson's (2014) cognitive trajectories

1.4 Mild Cognitive Impairment (MCI)

Mild cognitive impairment is a related term and typically precedes dementia. The term is used to define the middle ground between cognitive changes related to healthy aging and early dementia (Peterson, 2004). At the stage of mild cognitive impairment, most still hold a job and complete all activities of daily living. Mild cognitive impairment

can be difficult to diagnose because individuals typically function independently or nearly in the same manner that they have in the past. A medical team diagnoses MCI using objective evidence of cognitive impairment that represents a decline in the individual's performance compared with past performance (Peterson, 2004). Although the adult can function independently at diagnosis, an MCI diagnosis makes a heightened risk for worsening and a predictor for the development of dementia (Roberts et al., 2014). In 2018 Petersen and Tangalos, published that the two main types of MCI are Amnestic MCI and Nonamnestic MCI. Amnestic MCI is more common, marked by memory impairments, and likely the precursor to Alzheimer's disease. Whereas nonamnestic MCI deficits tend to be associated with language, visual-spatial skills and executive functioning and lead to other types of neurodegenerative disease such as Lewy body dementia and primary progressive aphasia. Currently, there are limited treatment options and no FDA-approved medications for MCI. Some medical professionals are recommending drugs approved for Alzheimer's disease, however there is limited success (Weir, 2019). This has increased the drive for researchers to investigate strategies for prevention rather than treatment. A report published in 2017 by The National Institute on Aging and the National Academies of Sciences, Engineering, and Medicine, stated that physical activity and cognitive training aiming to enhance problem-solving, memory and speed of processing may slow cognitive decline and dementia. As the United States' population continues to age more adults will be living with MCI. Research is needed so professionals can advise those with mild cognitive impairment how to protect themselves from further decline that could result in dementia.

1.5 Dementia

Dementia is a term used in the literature to describe the syndrome of cognitive, functional, and behavioral consequences associated with various diseases. (Lanzi, Ellison & Cohen, 2021). The term *major neurocognitive disorder* can be used to describe the same condition. It is used instead of dementia in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, DSM-5 Task Force, 2013). Dementia is described as a subjective and objective decline in cognitive skills from a previous level that overwhelms the individual's ability to compensate and restricts their ability to live independently. The American Speech-Language-Hearing-Association uses a similar definition. They define dementia as a syndrome caused by acquired brain disease that results in a progressive decline of memory and cognitive functioning to the degree that independent living is negatively affected. ("Dementia", n.d.)

Alzheimer's Disease is the most common pathological cause of the symptoms that make up dementia. The Alzheimer's Association estimates 6.2 million Americans age 65 and older are living with Alzheimer's disease dementia in 2021. That means one in nine people age 65 and older have Alzheimer's dementia. More recent research has shown that a variety of types of brain pathology contribute to dementia; in addition to plagues and tangles associated with Alzheimer's disease, microvascular pathology and Lewy bodies are commonly found in post mortem analysis(Auzoff & Libard, 2020). Alzheimer's dementia is projected to increase to 12.7 million Americans by 2050. These projections mean medical professionals as a whole will spend more time diagnosing, educating, and treating older adults with dementia. Research is being conducted to evaluate prevention and treatment methods for dementia. Currently, the research emphasizes the benefit of

physical activity and social engagement as interventions for individuals with dementia as well as those at risk for dementia (Ahlskog, Geda, Graff- Radford, & Petersen, 2011). More research on programs to combat social isolation and physical inactivity are needed to provide older adults with evidence-based interventions.

1.6 Nonpharmacological Interventions

In recent years public health professionals have been advocating for nonpharmacological interventions to prevent cognitive decline associated with aging. Several pharmacological interventions have been examined and suggest minimal results of altering or slowing progression of dementia (Birks and Flicker, 2006; Farina et al., 2012; Russ, 2014; Yue et al., 2012). Additionally pharmacological interventions for Alzheimer's disease dementia and or cognitive impairment have been shown to result in gastrointestinal complaints (Mohammad et al., 2017) and a greater incidence of falls (Epstein et al., 2014). Older adults may prefer nonpharmacological interventions because of low risk and no side effects (Rodakowski et al., 2016). Speech-language pathologists and other health professionals and public health initiatives can educate their patients about nonpharmacological interventions (Lanzi, Ellison & Cohen, 2021).

1.7 Physical Activity

Several older studies found a correlation between regular participation in physical activity and positive changes to brain structure volume, such as an increase in white matter and parietal lobe gray matter volume (Benedict et al., 2013) and hippocampal and basal ganglia volume (Erickson et al., 2009; Niemann et al., 2014). A more recent study in 2019 found that effect of exercise on brain volume is in conclusive (Tarumi et al., 2019). Although brain volume change is controversial, a multitude of studies have

reported that adults who exercise are less likely than sedentary people to experience cognitive decline and dementia as older adults (Lautenschlager, Cox, & Flicker, 2008). A 2019 meta-analysis, that included 1 moderate-to-high intensity interventions and 12 moderate intensity interventions, found that physical activity can aid in delaying progress of AD, and that high frequency interventions (exercising more than 3 times a week) are not characterized with greater effects on cognition opposed to lower frequency physical activity (Jia et al. 2019). However, one in four adults over the age of 50 are not physically active beyond their daily routine (Centers for Disease Control and Prevention, 2016). Physical Activity is a protective factor for noncommunicable diseases such as cardiovascular disease, stroke, diabetes, and some types of cancer (World Health Organization, n.d.) as well as possibly delaying the onset of dementia (Livingston et al., 2017). Exercise does not prevent all cases of dementia, however, may help prevent some cases of dementia (Wang et al., 2021) and or delay the onset (Sander, 2007). The most benefit is seen with regular long-term exercise (Ahlskog, Geda, Graff- Radford, & Petersen, 2011).

Medical professionals should encourage physical activity because it can promote brain health and could slow the decline of cognition (Chen et al., 2019; Livingston et al., 2017; Wang et al., 2021). Although some medical conditions may limit some forms of exercise, a wide variety of aerobic exercises have been found to have a positive impact on cognition such as rowing, exercise bikes, and walking (Ahlskog, Geda, Graff- Radford, & Petersen, 2011). For the current study, participants had to walk independently for thirty minutes at a comfortable pace. The participants walked while completing mindfulness meditations. The participants walked for 30 minutes sessions twice a week for six weeks.

1.8 Mindfulness

The history of mindfulness practice dates back thousands of years. Mindfulness is broadly defined as the cultivation of sustained attention in a framework of non-reactivity and acceptance (Kabat-Zinn, 1990). Mindfulness training involves the direction of attention to one or more phenomena as they arise. Engagement in mindfulness requires the utilization of narrowly focused attention or broadly receptive attention (Fountain-Zaragoza & Prakash, 2017). An immediate benefit of mindfulness is a sense of peace and calm because the past and anxiety toward the future cannot exist while focusing on the present (Fredrickson et al., 2008; Sharma & Rush, 2014). In addition to immediate benefits, research has shown that long-term practice can alter the brain's structure and function thereby improving attentional skills, cognitive capacity, and emotional regulation (Hölzel et al., 2011).

For this study, the participants utilized focused attention while reflecting on breath awareness and body scan practices. Recently there has been growing research that cognitive training programs such as mindfulness could counteract the decline of cognitive functioning in older adults (Gard, Hölzel, & Lazar, 2014). Mindfulness is considered a special form of attention however current research falls far behind the extent of pertinent clinical research (Chiesa et al., 2011).

Current research supports that mindfulness meditation-based interventions can be associated with increased performance in attention, memory, executive function, processing speed, as well as general cognition (Chiesa et al., 2011; Cásedas et al., 2020; Sevinc et al., 2021) Although most studies have shown a positive association between improvement in older adult cognition and mindfulness meditation training, a few studies

have found limitations and no association or benefit plausibly reflecting differences in study design, study duration and patients' populations (Chiesa et al., 2011; Lao et al., 2016). Small research studies and anecdotal therapy reports of the use of mindfulness in speech-language therapy of various types suggest that it may be incorporated in all of the major domains of speech-language pathology for clientele of all ages (Medina & Mead, 2021). However, further research is needed to fully understand the relationship between mindfulness meditation and its potential impact on cognition.

1.9 Ambulatory Cognitive Assessments

Technology is being increasingly used to measure cognitive function outside of traditional clinic and laboratory settings. Traditional testing, tests individuals in a clinical setting and usually on one occasion (Sliwinski et al., 2018). Health and social scientists share concerns that the snapshot of cognitive ability in the clinic setting may not be representative of everyday functioning. Ecological momentary assessment (EMA) is a method of studying an individual's physical symptoms, psychological state, and behavior in real-time and in a natural environment such as their home (Shiffman, Stone, & Hufford, 2008; Smyth & Stone, 2003). A primary motivation for ambulatory assessment is to enhance ecological validity, especially for the world of neuropsychology focused on understanding the relationship between the results and real-world cognitive function (Spooner & Pachana, 2006). The thesis data obtained in the current study included ambulatory measures of cognition to support traditional cognitive assessments used.

1.10 The Current Study

The purpose of this study is to evaluate if a six-week urban outdoor mindful walking program would help improve or maintain cognition for adults that are at risk for

Alzheimer's disease dementia or other related dementias. This study seeks to answer the following questions:

1. Based on ambulatory and traditional cognitive measures, to what extent does the mindful walking program improve or maintain cognition?
    i. It is hypothesized that the mindful walking program will help participants' cognition remain the same or improve based on the results from the cognitive testing completed at pre and post-testing.
2. Is physical activity sampling at weeks 5 and 6 of intervention related to change in MoCA scores over the 6 week intervention?
    i. It is hypothesized that physical activity during the 5th and 6th week intervention will have a positive correlation to positive change in MoCA scores.
3. Using the results from cognitive measurements, which domain(s) showed more change compared to the others by the mindful walking program?
    i. It is hypothesized that attention and memory will show significant improvements because mindfulness has an attentional component and memory is the most vulnerable cognitive domain to the negative effects of brain changes in aging.

CHAPTER 2

METHODS

2.1 Participants

Study participants were older adults recruited from the local community around the Midlands region of South Carolina that met the inclusion criteria.

2.1.1 Inclusion Criteria. The target population were generally healthy adults aged 60 and over who did not have disabilities and were not currently medicated for a mental illness.

At the beginning of the screening participants were screened to determine if they met one of the four Alzheimer’s Dementia Risk Factors. To participate in the study, they had to have at least 1 of the 4 factors. These factors are: (1) Having a family history of Alzheimer's disease and related dementias (any first-degree relative/family member who was diagnosed by a medical professional), (2) Has experienced confusion or memory loss that has happened more frequently or gotten worse during the last 12 months, (3) Have a BMI greater than 25, (4) Exercises less than 150 minutes a week.

Once a participant met one of the four Alzheimer dementia risk factors the research assistant continued to screening to make sure the older adult had to meet the following criteria (1) Ages 60 and above, (2) completed first two doses of the COVID

vaccination (3) have at least one risk factor for Alzheimer's disease and related dementias: family history of Alzheimer's disease and related dementias (minimum of one first-degree relative), or subjective cognitive decline, or currently obese/overweight, or physically inactive (based on the 2018 physical activity guidelines), (4) adequate hearing and visual ability to complete study tasks and assessments, (5) able to read and write in English, (6) medically stable with or without medication, (7) capable of providing informed consent.

2.1.2 Exclusion Criteria: (1) Clinical diagnosis of brain abnormalities (i.e., strokes, epilepsy, Parkinson’s disease), (2) currently medicated for mental disorders (i.e., depression, post-traumatic stress disorder, bipolar disorder), (3) inability to complete smartphone-based surveys and cognitive tasks on the smartphones (i.e., due to arthritis or other reasons), (4) unable to walk without other people's assistance, (5) plan to have surgery or relocate within five months.

2.2 Procedure

2.2.1 Participant Recruitment. Participants were recruited from the local community around the midlands region of South Carolina. The procedures for the study were modeled based on a preliminary study conducted in State College, PA (Yang & Conroy, 2018). Participants were first recruited by flyers and posters in the community and a recruitment table in the lobby of a local senior center.

Once a potential participant showed interest in the study, a screening interview was conducted using the script (Appendix A) by one of the lab staff members in person

or over the phone. To qualify for the study the participant needed to qualify for at least one of the 4 Alzheimer's and Dementia Risk Factors listed above. Once a potential participant met 1 of the 4 risk factors, the interviewer queried all inclusionary criteria.

After determining that the participant qualified for the study, the research staff set an appointment for visit 1. The study consisted of 3 visits at the Aging Gracefully Lab at the University of South Carolina Close Hipp building and 12 scheduled walks with lab member supervision at a predetermined paved path around the South Carolina State House.

Lab Visit 1:

Participants completed an in-person visit on campus with the research staff to provide informed consent, completed the baseline measures (See table 1 for a description of measures), and learned about the study protocol by watching a training video with the research staff. **For the purpose of this thesis only select measures were analyzed and discussed**. The baseline measures included height and weight, blood pressure test, the mobility functioning assessment (grip strength; rapid walk test; get up and walk test), and performance-based cognitive tasks using a paper-pencil format and a smartphone touch screen (more details about these tools are available in the Measurement section below). Participants scheduled their 12-session mindful walking sessions with the staff (2 sessions maximum per week with at least one day in between sessions). At the visit, participants were provided with a map that shows the location of the walking trail by the South Carolina State House (figure 4). At the end of the first visit, the participants completed an online survey. The first visit took about 90 minutes to complete.

Table 2.1 Testing Measures

Concept	Variable Type/Aims	Measure	Data Collection	Time
Cognition	Objectively measured pre and post intervention	MoCA	In person assessment	10 mins.
Cognition	- Objectively measured pre and post Intervention	Trails Test	In-person assessment	5 mins.
Cognition	Objectively measured pre and post intervention	Maze Test	In-person assessment	5 mins.
Repeated ambulatory Cognitive Assessments	Objectively measured pre and post intervention	Visual attention, inhibition, and memory	Delivered to participants remotely using study cell phone	5 mins. At pre and post testing, before and after each walking session and 3 times per day for 14 day monitoring period.
Physical Health	Objectively measured pre and post intervention	Timed Up and Go	In-person assessment	5 mins.
Physical Health	Objectively measured pre and post intervention	Height-Weight (BMI); shoes off	In-person assessment	5 mins.
Physical Health	Objectively measured pre and post intervention	Blood Pressure	In-person assessment	5 mins.
Physical Health	Objectively measured pre and post intervention	Grip Strength	In-person assessment	5 mins.
Physical Activity	Objectively measured week 5 and 6 of the intervention.	Minutes/week of activity	ActivPAL worn on thigh for 14 days (week 5 & 6) of intervention	Training 5 mins. Placed independently by participant
Adherence	Post test	Participation logs collected by the Interventionists/RA		
Demographic, Health Status, and perceived cognition	Objectively measured pre and post intervention	demographic questions, modified SF-36 Questionnaire, modified Pittsburgh sleep quality index, modified physical limitation questions, modified Community Healthy Activities Model Program for Seniors (CHAMPS) Questionnaire, modified positive and negative affect schedule survey, modified the mindful attention awareness scale, modified Duke Social Support Index (DSSI), modified five facet mindfulness questionnaire, modified perceived stress scale, modified CERAD neuropsychological battery, and modified geriatric depression scale.	In-person assessment on computer of completed at home.	30-45 mins.
Perception on Intervention	Questionnaire	-Program evaluation	-Qualitative feedback on program	5 mins.

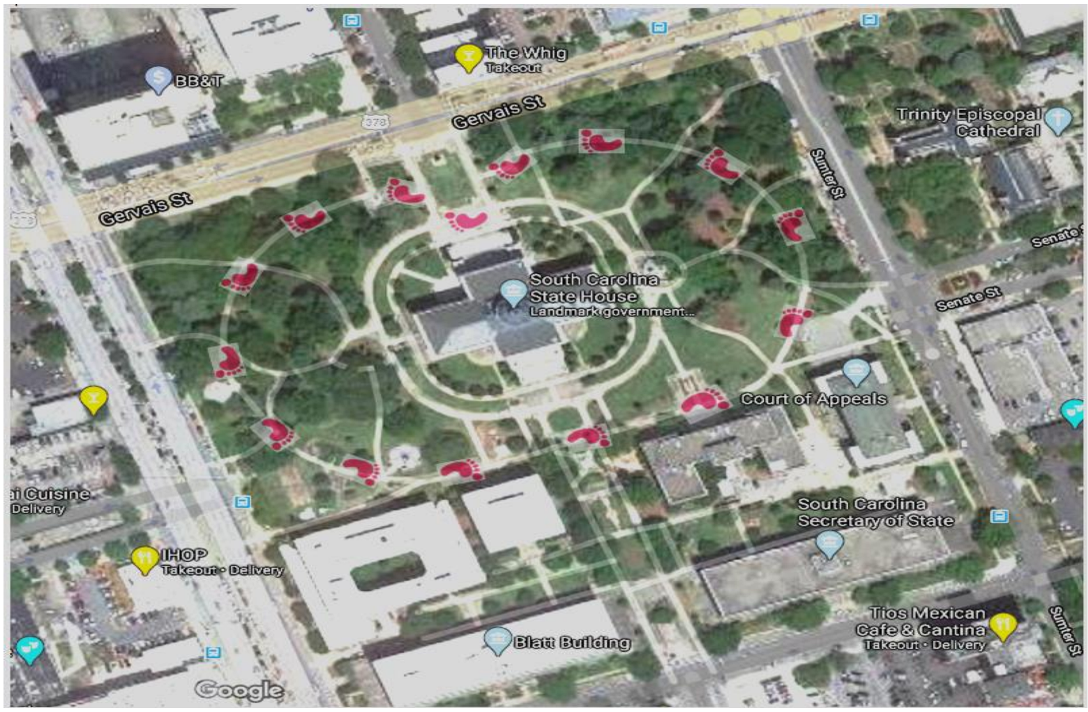

Figure 2.1 The paved walking trail located at the South Carolina State House

Walking session #1:

At the first walking session, participants completed smartphone measures before and after the walk. The smartphone measures included 3 questions about the participants sleep the previous night and 3 short ambulatory cognitive assessments looking at processing speed (symbol search), working memory (memory dots), and inhibition (go/no-go). These mobile cognitive tests have been validated in age- and demographically-diverse samples (Sliwinski et al., 2018). The entire smartphone measure took approximately 5 minutes. Once the participant completed smartphone measures (including ambulatory cognitive assessment), the research assistant read the walk session #1 script to the participant (Appendix B). After the instructions, the participant was asked to walk for 30 minutes on the pre-planned trail. They were told to walk at a comfortable-

pace or roughly a walking speed of 1 step per second. The research participant followed at a distance to help familiarize the participant with the walking path. Once the walk was completed, the participant completed the same smartphone measures. Lastly, the staff reminded them of their next walking session date and time before they left. This walking session and the brief measures took about 45 minutes to complete.

Walking session #2:

Before starting the second mindful walking session, participants completed smartphone measures and then were read instructions (Appendix B) detailing the mindful walking skills they would be using. The participants were told to walk the same circle for 30 minutes at a comfortable pace. They were then told to practice the breath-focused mindful walking for the first 5 minutes. After the walk participants completed smartphone measures. Next, the research staff asked " Were you able to pay attention to your walking? Were you able to pay attention to your breath? What distractions did you encounter? How did you feel?". Lastly, the staff reminded them of their next walking session date and time before they left. This walking session and the brief measures/interview took about 45 minutes to complete.

Walking session #3-4:

In the third and the fourth mindful walking sessions, participants first completed smartphone measures. Next participants were instructed (Appendix B) to extend the breath-focused comfortable pace walking (instructed from the first session) for the first 10 minutes of the mindful walking session. Once the walk was completed participants completed smartphone measures and answered the following questions: "Were you able to pay attention to your walking? Were you able to pay attention to your breath? What

distractions did you encounter? How do you feel?" Lastly, the staff reminded them of their next walking session date and time before they left. This walking session and the brief measures/interview took about 45 minutes to complete.

Walking session #5-6:

During the fifth and the sixth mindful walking sessions, participants first completed smartphone measures and were instructed (Appendix B) on how to walk at a comfortable pace by sustaining their attention on the rhythm of their breath (paying attention to every inhale and exhale) and the sensation of their steps (focus on your steps. How do they feel when they hit the ground? What about your socks and shoes, how do they feel? Do you feel connected to the ground?) Once the walk was completed participants completed smartphone measures. Then the participants were asked the following questions: Were you able to pay attention to your walking? Were you able to pay attention to your breath? Were you able to pay attention to your steps? What distractions did you encounter? How did you feel? Lastly, the staff reminded them of their next walking session date and time before they left. This walking session and the brief measures/interview took about 45 minutes to complete.

Walking session #7-8:

Before the seventh and the eighth mindful walking sessions, participants completed smartphone measures and were instructed (Appendix B) to " practice paying attention to their breath, their steps, and scan their body for the entire 30-minute session." Once the walk was completed participants completed smartphone measures. They then answered the following questions: Were you able to pay attention to your walking? Were you able to pay attention to your breath? Were you able to pay attention to your steps?

What did you notice about your body? What distractions did you encounter? How did you feel? Lastly, the staff reminded them of their next walking session date and time before they left. This walking session and the brief measures/interview took about 45 minutes to complete.

Lab Visit 2 in the lab or home:

One month after participants finished their first visit and completed 8 walking sessions, they met with the research staff again for instruction on how to put on the activity monitor (more details about the activity monitor (ActivPal) available in the Measurement section below) and were instructed on how to use the smartphone-based surveys for the next two weeks. Each participant was loaned an activity monitor and a study smartphone with a survey app installed.

14-day monitoring:

Starting from the day after the training, participants completed two brief daily surveys using the study phone during the 14-day period. They also responded to 4 randomly delivered smartphone prompts each day during waking hours for 14 consecutive days. When participants heard the prompt (audio signal and vibration), participants were instructed to complete a brief survey about their in-situ subjective experiences, contexts, and primary behavior/activity. Following each survey, they completed a short battery of “brain games” on the screen. The brain games were the same smartphone measures collected before and after every walk. These brain games included brief and validated cognitive tests to assess participants' attention, memory, and processing speed in their everyday settings. The 14-day protocol was completed during

the 5th and the 6th week after their first visit. Walking sessions #9-12 were carried out during this 2-week period for the intervention group.

Walking session #9-12

The first eight sessions of mindful walking were designed as the skill-building period for participants to familiarize themselves with the three mindful walking skills (attention to breath, steps, and body scan). The last four mindful walking sessions (9-12 across two weeks) were considered the skill-acquisition period. At the start of sessions 9 through 12, participants completed smartphone measures and were instructed (Appendix B) to " practice paying attention to their breath, their steps, and scan their body for the entire 30-minute session." Once the walk was completed participants completed smartphone measures. They then answered the following questions: Were you able to pay attention to your walking? Were you able to pay attention to your breath? Were you able to pay attention to your steps? What did you notice about your body? What distractions did you encounter? How did you feel? Lastly, the staff reminded them of their next walking session date and time before they left. This walking session and the brief measures/interview took about 45 minutes to complete.

Lab Visit 3:

Within 7 days of completing their 2-week smartphone survey period, participants met with the research staff for their final visit. During the visit, participants returned the study devices and completed the same set of cognitive measures/tasks they did during visit 1. At this time, participants were encouraged to provide any feedback or concerns they had about the study. Ten out of 10 participants were compliant with the required number of days for activity monitor to be worn and therefore received monetary

compensation based on meeting the compliance rate (10 days). At the end of the third lab visit following the 12th walking session, participants completed a set of self-report questionnaires. This final lab visit took about 90 minutes to complete. The entire intervention was 6 weeks. The timeline is illustrated in *Figure 5*.

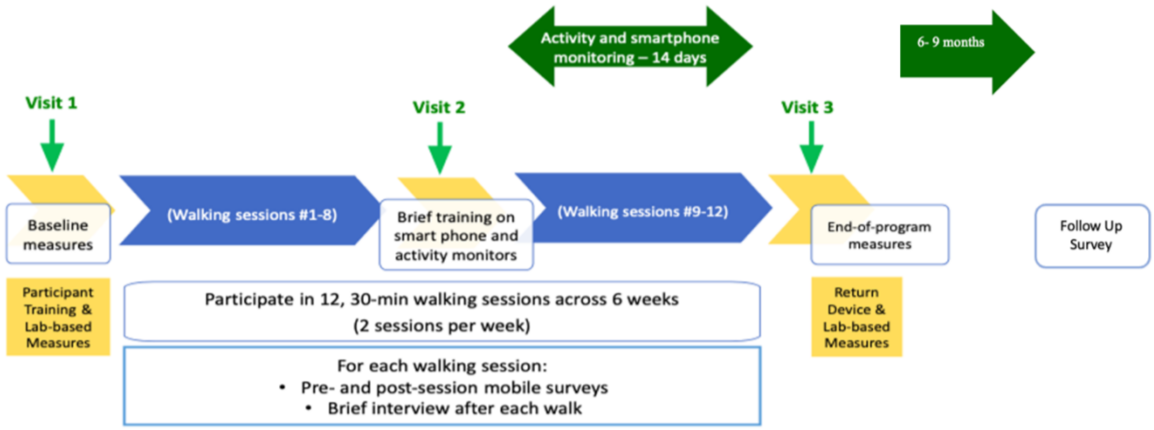

Figure 2.2 A schematic diagram outlining the timeline of the study

2.3 Measures

During the first and third visit physical and cognitive measures were collected by trained research staff using instructions.

2.3.1 Physical measures

Timed Up & Go Test (TUG)

The Timed Up and Go test is a general physical performance test used to assess balance, mobility and locomotor performance in older adults. Participants start sitting in a chair, stand up and walk around a cone placed 3 meters from the chair and then sit down. A trained staff member told them to go and timed it. Each participant completed this 3 times and an average was calculated. The Timed up and Go test was published by Podsiadlo and Richardson in 1991. This test incorporated time as the measuring

component to assess general balance and function at a comfortable walking pace. Lower scores at post-test indicate faster performance, which indicates better physical control.

Thigh-worn activity monitor

The research-grade activPAL micro4 accelerometers (PAL Technologies, UK) was used to measure daily activities during the 14-day monitoring period. ActivPAL is a valid and reliable thigh-worn device for measuring posture (e.g., sitting, standing), movement (e.g., stepping), activity intensity/levels (e.g., number of steps, metabolic equivalents [METs]) in older adults under free-living contexts. Participants wore the activPAL for 24 hours a day, including sleep time during the 14-day period. Participants can switch legs for wearing the monitor (e.g., after a shower) and will not impact data quality.

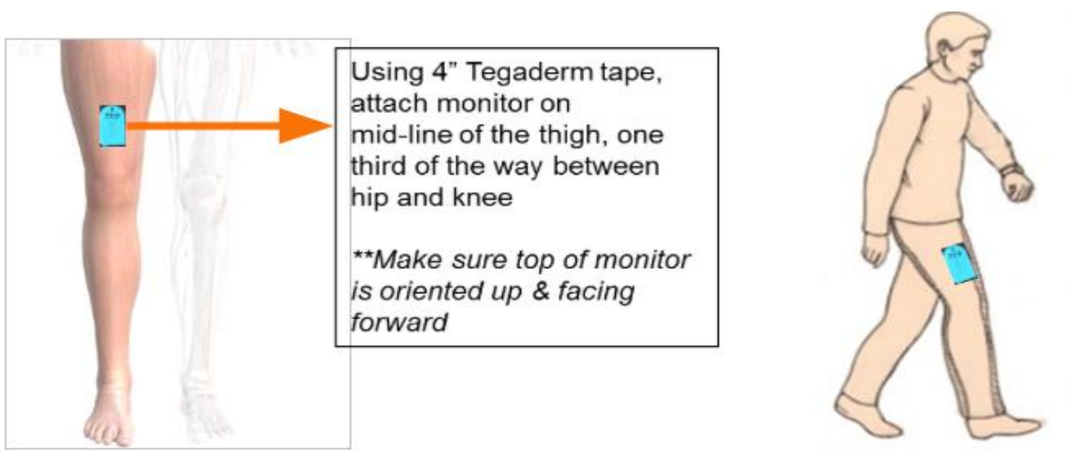

Figure 2.3 Activpal placement.

2.3.2 Cognitive Data Measures

The Montreal Cognitive Assessment (MoCA)

The MoCA is a sensitive cognitive measure created by Ziad Nasreddine and colleagues used to measure cognition and risk for mild cognitive impairment and dementia. For the study the participants completed version 7.1 at visit 1 (baseline) and

7.2 at the visit 3 (post testing). All research assistants who administered the MoCA were trained and certified by the MoCA test company. The cut-off score of 18 is usually considered to separate MCI from AD but there is overlap in the scores since, by definition, AD is determined by the presence of cognitive impairment in addition to loss of autonomy. The average MoCA score for MCI is 22 (range 19-25) and the average MoCA score for mild AD is 16 (11-21). Although it should be noted that a gradual progression that includes difficulty with everyday activities without other known causes is needed for the diagnosis of AD. For more information, please see the Normative Data section of the MoCA website https://www.mocatest.org.

Baseline, post-test and follow-up surveys

Participants completed a baseline survey online on the day they completed their visit 1 (baseline testing). Participants also completed the same survey at the Visit 3 (post testing visit). The survey asked their demographics, psychological states, perceived cognition, physical activity levels, and their overall health status. Participants completed the survey in one hour. A follow up survey was completed 6 to 9 months after participating in the intervention. This survey included questions about their enjoyment of the study. For the purpose of this study, only questions related to evaluation of enjoyment will be reported.

Smartphone-based measures

The NIH-funded M2C2 (Mobile Monitoring of Cognitive Change) smartphone app was used to assess older adults' psychological and cognitive states in real time. This smartphone-based survey was applied on three different occasions: during in-person visits, before and after the comfortable pace walking sessions (for intervention group),

and during the 14-day monitoring period (up to 4 times per day). Each smartphone survey included a total of 15 questions measuring older adults' real-time in-situ experiences of incidental affect, state mindfulness, perceived cognitive function, social context, physical context, and behavior. The smartphone surveys delivered three ultra-brief "brain games" following the self-report survey. These "brain games" measure critical domains sensitive to cognitive aging, including processing speed (symbol search), working memory (memory dots), and inhibition (go/no-go). The current study will analyze processing speed (Symbol Search). These mobile cognitive tests have been validated in age- and demographically diverse samples. Each smartphone-based survey can be finished within 5 minutes.

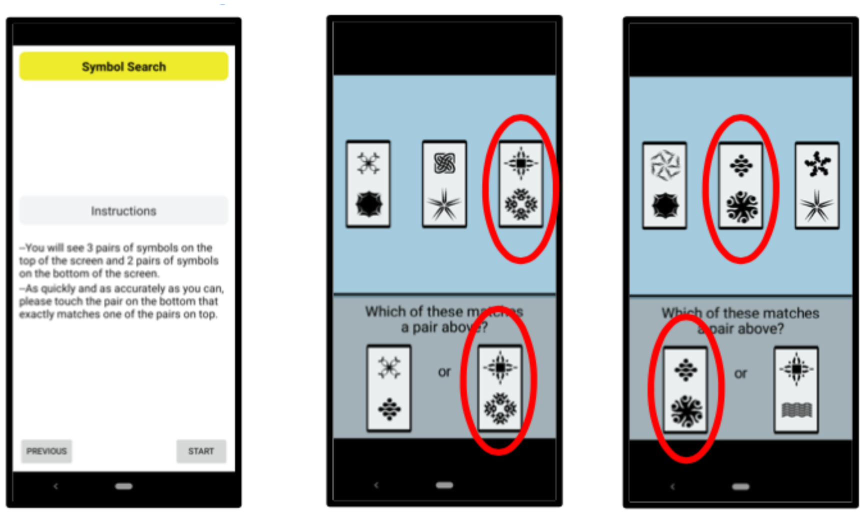

Figure 2.4 Symbol Search one of the 3 "brain games" participants will complete during smartphone measures.

CHAPTER 3

RESULTS

3.1 Sample Descriptive

Sample descriptive statistics were analyzed in order to determine participant demographic information regarding participant characteristics including age, gender, education level. Participants reported biographical information during the initial screening and when completing the questionnaire at their first visit. Participants reported information about their age, gender, cognition, social engagement, overall health and exercise(Table 2). The Sample included 9 females and 1 male ranging from 61 to 85 years of age. Three of the 10 reported that in the last 6 months they have had increased confusion and memory loss. All participants rated their general health to be fair to excellent.

Table 3.1 Participant Demographic Information

Participant number	Currently taking medication for depression?	During the past 4 weeks to what extend has your physical or emotional problems interfered with normal social activity with family, friends, neighbors, or groups?	Perceived concerns with cognition?	Physical activity level: I intend to engage in at least 150 minutes of moderate to vigorous physical activity per week for the next two weeks	Perceived Health status: In general, would you say your health is:	Risk factors for ADRD reported
1	No	Slightly	No concerns	Disagree	Very Good	1. Family History
2	No	Not at all	No concerns	Agree	Very Good	1.Family history 2.BMI > 25, 3.<150 minutes of high intensity PA
3	No	Moderately	In the last 6 months has had increased confusion or memory loss	Strongly Disagree	Good	1. Family History 2.Recent confusion or memory loss 3. BMI>25 4. <150 minutes of high intensity PA
4	No	Not at all	In the last 6 months has had increased confusion or memory loss	Agree	Very Good	1. Recent confusion or memory loss
5	No	Not at all	No concerns	Strongly Agree	Excellent	1. Family History
6	No	Not at all	No concerns	Agree	Good	1. Family History
7	No	Not at all	No concerns	Somewhat Disagree	Very Good	1.BMI.25
8	No	Not at all	In the last 6 months has had increased confusion or memory loss	Neither Agree or Disagree	Fair	1.family history 2.Recent confusion or memory loss
9	No	Not at all	No concerns	Somewhat Disagree	Good	1.BMI.25
10	No	Not at all	No concerns	Disagree	Good	1. Family History

3.2 Results

This study enrolled 10 participants with one or more risk factors for Alzheimer's disease and Related Dementias in a 6-week mindful walking program. The study addressed the following questions and related hypotheses:

1. Based on ambulatory and standard cognitive measures, to what extent does the mindful walking program improve or maintain cognition? To answer this question comparison of pre and post total MoCA scores and speed of processing measures were analyzed.
    - i It was hypothesized that participants in the mindful walking program will show no change or improvement in MoCA scores.

Table 3.2 Total MoCA Scores

Participant ID	Pre-test total score (30)	Post-test total score (30)
1	28	28
2	25	27
3	29	29
4	24	25
5	25	28
6	27	26
7	21	29
8	21	19
9	25	21
10	27	27

MoCA pre-post testing indicated that 4 participants performed better on the MoCA, 3 participants performed the same and 3 participants performed worse. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in MoCA score from pre to post intervention were observed for the intervention group ($t(9) = -0.684$, $p=0.255$) The pretesting MoCA mean score was M= 25.2 with a SD of 2.69. The post testing MoCA mean score was M=25.9 with a SD of 3.381. Data analysis was completed via data analysis using Microsoft Excel. According to the Normative data provided on the assessment's website a score between 18 and 25 indicates MCI. 6 participants scored in the MCI category at pre-testing whereas only 3 of those 6 scored in the MCI category at the post-test. Although a comparison of MoCA scores pre and posttest did not show significant change, the participant number was too small to reach any conclusions.

ii It was hypothesized that participants would show improvement in Speed of Processing based on an average of Speed of Processing scores from pre to post intervention testing.

Table 3.3 Speed of Processing

Participant ID	Pre-test	Post-test
1	2212.78	1235.11
2	2383.56	2416.33
3	4924.33	1795.56
4	3947.67	2390.33
5	N/A	N/A
6	4684.44	2800.89
7	2637	2160.78
8	2322.63	1607.56
9	3733.63	3296.89
10	3551.67	1870.44

Processing Speed pre-post testing using the symbol search ambulatory cognitive measure indicated that out of 9 participants 8 decreased their processing speed and 1 participant increased their processing speed. A paired t-test indicated that scores on average did significantly decrease in processing speed from pre to post intervention were observed for the intervention group according to a one-tail t-test ($t(8)= 3.736$, $p= 0.002$). One participant was not included in the t-test because the pretest data was not saved properly.

2. Is physical activity sampling at weeks 5 and 6 of intervention related to change in MoCA scores over the 6 week intervention? To answer this question a Pearson Product Moment test was analyzed.

   i It was hypothesized that participants' physical activity for week 5 and 6 of the intervention would positively correlate to the change in MoCA scores from pre to post test.

Table 3.4 MoCA scores and Average Steps per Day

Participant ID	Pre-test total score (30)	Post-test total score (30)	Change in MoCA score	Average Steps per day for week 5 and 6
1	28	28	0	8833.7
2	25	27	+2	11852.8
3	29	29	0	3203.2
4	24	25	+1	6262.4
5	25	28	+3	4300
6	27	26	-1	3304.3
7	21	29	+8	7387.1
8	21	19	-2	3124.9
9	25	21	-4	4564.6
10	27	27	0	8844.1

A Pearson Produce Moment Test was calculated by first adding 10 to all of the changes in MoCA scores so that all values were positive and then calculating the score. The correlation was calculated to be a positive medium strength correlation r=.356 (p=.313) This means that there was a positive relationship between the participants' average step count for week 5-6 and their change in MoCA score from pre to post intervention testing. However with a p value of =.313 we cannot conclude the correlation is significant. While there was a positive correlation in the expected direction of greater change in MoCA score with steps, it did not reach significance. Additionally the Timed Up and Go (TUG) pre and posttest were compared.

Table 3.5 Timed Up and GO Test

Participant ID	Pre-test	Post-test
1	10.66	9.45
2	14.09	11.26
3	10	9.57
4	9.12	7.6
5	10.89	10.53
6	9.71	9.77
7	9.3	8.83
8	6.55	6.77
9	9.04	9.87
10	12.73	12.71

The mean TUG time was calculated to be M=10.209 seconds for the pre-test and M=9.636 seconds at the post-test. From pre-test to post-test 7 participants improved and 3 participants regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post intervention however the result approached significance with a one-trailed test ($t(9) = 1.738$, $p=0.058$). It was also observed that the 3 participants that performed worse on the MoCA were the same 3 participants that performed worse on the TUG.

3. Using the results from cognitive measurements, which domain(s) showed more change compared to the others by the mindful walking program? To answer this question comparison of pre and post MoCA subtest scores were analyzed.

    i. It is hypothesized that attention and memory will show significant improvements because mindfulness has an attentional component and memory is the most vulnerable cognitive domain to the negative effects of brain changes in aging.

Table 3.6 Visual MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Visual Score	5	3	5	5	4	3	3	2	4	5
Post Visual Score	5	3	5	5	4	3	4	2	3	5

The mean visual MoCA subtest score was calculated to be M=3.9 for the pre-test and post-test. From pre-test to post-test 8 participants performed the same, 1 improved, and 1 participant regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in the visual MoCA subtest score from pre to post intervention were observed for the intervention ($t(9) = 0.5$, $p=1.833$).

Table 3.7 Naming MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Naming Score	3	3	3	3	2	3	2	3	3	3
Post Naming Score	3	3	3	3	3	3	3	3	2	3

The mean naming MoCA subtest score was calculated to be M=2.8 for the pre-test and M=2.9 at the post-test. From pre-test to post-test 7 participants performed the same, 2 improved, and 1 participant regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in the naming MoCA subtest score from pre to post intervention were observed for the intervention ($t(9) = -0.55$, $p=0.295$).

Table 3.8 Digit Attention MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Digit Attention Score	2	2	2	2	2	2	2	2	2	2
Post Digit Attention Score	2	2	2	2	2	2	2	1	2	2

The mean digit attention MoCA subtest score was calculated to be M=2 for the pre-test and M=1.9 at the post-test. From pre-test to post-test 9 participants performed the same and 1 participant regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in the digit attention MoCA subtest score from pre to post intervention were observed for the intervention ($t(9) = 1$, $p=0.172$).

Table 3.9 Letter Attention MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Letter Attention Score	1	1	1	1	1	1	1	1	1	1
Post Letter Attention Score	1	1	1	1	1	1	1	1	1	1

The mean letter attention MoCA subtest score was calculated to be M=1 for the pre-test and post-test. From pre-test to post-test all participants performed the same. No T-test could be calculated since there was no change in any participants score.

Table 3.10 Subtraction Attention MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Subtraction Attention Score	3	3	3	0	2	3	2	3	2	3
Post Subtraction Attention Score	3	3	3	3	3	2	3	1	1	2

The mean subtraction attention MoCA subtest score was calculated to be M=2.4 for the pre-test and M=1.9 at the post-test. From pre-test to post-test 3 participants performed the same, 3 improved, and 4 participants regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing.

Paired sample t-tests indicated no significant increases in the Subtraction Attention MoCA subtest score from pre to post intervention were observed for the intervention (t(9) = 0, p=0.5).

Table 3.11 Language Repeat MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Language Repeat Score	2	2	2	1	2	1	1	1	2	2
Post Language Repeat Score	2	2	2	1	2	2	2	1	2	2

The mean Language Repeat MoCA subtest score was calculated to be M=1.6 for the pre-test and M=1.8 at the post-test. From pre-test to post-test 8 participants performed the same and 2 improved. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in the Language Repeat MoCA subtest score from pre to post intervention were observed for the intervention (t(9) = -1.5, p=0.084).

Table 3.12 Language Fluency MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Language Fluency Score	0	1	1	1	0	1	0	1	1	0
Post Language Fluency Score	0	1	1	0	0	1	1	1	1	1

The mean Language Fluency MoCA subtest score was calculated to be M= 0.6 for the pre-test and M=0.7 at the post-test. From pre-test to post-test 7 participants performed the same, 2 improved, and 1 participant regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in the Language Fluency

MoCA subtest score from pre to post intervention were observed for the intervention (t(9) = -0.557, p=0.295).

Table 3.13 Abstraction MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Abstraction Score	2	1	2	1	2	2	1	2	0	2
Post Abstraction Score	2	2	2	1	2	2	2	1	1	2

The mean Abstraction MoCA subtest score was calculated to be M= 1.5 for the pre-test and M=1.7 at the post-test. From pre-test to post-test 6 participants performed the same, 3 improved, and 1 participant regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in the Abstraction MoCA subtest score from pre to post intervention were observed for the intervention (t(9) = -1, p=0.171).

Table 3.14 Delayed Recall MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Delayed Recall Score	4	3	4	4	4	5	3	0	4	3
Post Delayed Recall Score	4	4	5	3	5	4	5	2	3	3

The mean Delayed Recall MoCA subtest score was calculated to be M= 3.4 for the pre-test and M=3.8 at the post-test. From pre-test to post-test 2 participants performed the same, 5 improved, and 3 participants regressed. A paired t-test indicated that scores on average did not significantly differ from pretesting to post testing. Paired sample t-tests indicated no significant increases in the Delayed Recall MoCA subtest score from pre to post intervention were observed for the intervention (t(9) = -1.08, p=0.154).

Table 3.15 Orientation MoCA Subtest

	1	2	3	4	5	6	7	8	9	10
Pre Orientation Score	6	6	6	6	6	6	6	6	6	6
Post Orientation Score	6	6	5	6	6	6	6	6	5	6

The mean Orientation MoCA subtest score was calculated to be M= 6 for the pre-test and M=5.8 at the post-test. From pre-test to post-test 8 participants performed the same, 1 improved, and 1 participant regressed. A paired t-test indicated that scores on average did not significantly differ Orientation MoCA subtest score from pre to post intervention were observed for the intervention ($t(9) = 1.5$, $p=0.083$).

CHAPTER 4

DISCUSSION

The principal aim of this study was to evaluate if a six-week mindful walking program would help improve or maintain cognition for adults that are at risk for Alzheimer's dementia or other related dementias. A secondary aim is to see if physical activity from week 5 and 6 correlated to maintenance or change in cognition over the 6-week (about 1 and a half months) program. Lastly a third aim was to determine which domains of cognition showed the most change after the intervention. We hypothesized that the intervention would result in participants' cognitive performance improving or maintaining. It was hypothesized that mindful walking would have the greatest impact on memory and attention because of the frequency of amnestic MCI and the mindfulness practice's attentional component. Overall, results from the intervention suggest that (a) there was no significant statistical difference when comparing MoCA scores pre and post intervention. (b) Ambulatory measures showed a significant decrease in processing speed from pre to post intervention. (c) There was a positive medium strength association between change in MoCA scores and average daily steps for week 5 and 6 of the intervention, however it did not reach significance. (d) No domain of cognition showed significant statistical improvement from pre to post testing.

4.1 Intervention Outcomes

Analysis of preliminary intervention outcomes did support that participants' physical activity could impact cognition. This is consistent with the broader literature base documenting physical activity can promote brain health and may slow the decline of cognition (Chen et al., 2019; Livingston et al., 2017; Wang et al., 2021). Ambulatory measures showed improvement in processing speed. The improvement in processing speed supports current literature that mindfulness-based interventions are associated with increased performance in attention, memory, executive function, and processing speed (Chiesa et al., 2011; Cásedas et al., 2020; Sevinc et al., 2021). Additionally, a meta-analysis published in 2018 by Gomes-Osman and colleagues found an association between change in processing speed and exercise of various types. Their analysis suggested that 52 hours of exercise was the optimal dose. However, it is hard to make a comparison because mindful walking interventions and exercise have different intensities.

Contrary to our hypothesis, the preliminary outcomes did not confirm maintenance and/or improvement of MoCA scores with the 6 week mindful walking intervention. Although not formally diagnosed, we did observe that several of the participants fell within the range of MCI. These participants were able to function independently in the community. However, a diagnosis increases the risk for worsening cognition and is a predictor for the development of dementia (Roberts et al., 2014). Exercise does not prevent all cases of dementia (Wang et al., 2021). Some participants did decline over the intervention we are unable to measure if the rate of decline was slowed by the intervention. Overall, results from this study did not suggest that a 6 week

mindful walking intervention had a strong correlation to improved or maintained cognition. However, preliminary data showed that the intervention had some benefit and was enjoyable.

4.2 Intervention Feasibility

Multiple past studies have shown that physical activity may help delay (Sander, 2007; Livingston et al., 2017) and potentially prevent (Wang et al., 2021) cognitive decline and dementia. The primary purpose of the current study was to implement a mindful walking intervention in Columbia, SC for older adults at risk for Alzheimer's or other related dementias. This study and procedures were modeled after a previous study by Yang and Conroy in 2018. The procedures and intervention was modified to reflect recent literature on physical activity and mindfulness intervention and include additional cognitive measures. The study was feasible to carry-out according to the methods employed in the study. Participants were adherent to the study protocol and all 10 participants attended all 12 of the mindful walking sessions.

4.3 Implications and Recommendations

Further research is needed to evaluate the mindful walking intervention and its impact on older adult's cognition. The current study included 6 black participants and 4 white participants. Black men are at high risk for dementia (Weuve et al. 2018) and cardiovascular disease (Carnethon et al., 2017). Identification of exercise programs that are preferred by this population has public health significance for reducing the incidence of dementia and stroke. Research studies could promote more group discussion by scheduling set times for mindful walking in the morning and in the evening such that participants have more discussion time with others. This could also further improve the

enjoyment of the activity, which was positive but not perfect. Research has suggested that social support and social engagement play a role in the most effective way to encourage physical activity in older adults (Lindsay Smith et al., 2017). Having set times for exercise may also allow improved recruitment and larger study groups.

4.4 Study Strengths, Limitations, and future directions

This study included multiple strengths and limitations that can inform future researchers about the carryout of a mindful walking program. First, this study's sample size, although small, included a diverse group of participants. The sample included 9 females and 1 male ranging from 61 to 85 years of age. The sample included 6 participants that identified as African American and 4 that identified as white/Caucasian. A sample size of 10 made it difficult to find statistically significant conclusions. Additionally, another strength was that participants' positive appraisal of the Mindful Walking program. This helps illustrate that implementing a walking program would be enjoyable to the participants.

Table 4.1 Enjoyment Questionnaire

	1	2	3	4	5	6	7	8	9	10
I found the mindful walking program enjoyable.	5	3	4	5	4	5	5	5	5	4
I use the skills I learned during the mindful walking program often.	5	4	4	5	3	4	4	5	5	3
I am likely to recommend the program to a family member, friend, or peer.	5	4	4	5	4	4	4	5	5	4

A Follow-up survey was sent to participants approximately 6 to 9 months after they completed the intervention. The participants were asked to score 3 questions about the study on a scale from 1=strongly disagree to 5=strongly agree. The mean score for "I found the mindful walking program enjoyable" was found to be M= 4.5. The mean score of " I use the skills I learned during the mindfulness walking program often was found to be M=4.2. The mean score of " I am likely to recommend the program to a family member, friend, or peer" was found to be M=4.4. In conclusion of the survey results, the program was enjoyable but not perfect. This information can help aid in the development of other exercise programs or future directions for this program. Lastly, one of the biggest strengths was that the study included highly respected and used measures of cognition to evaluate the benefit of the program. A limitation of the study was that the program was

over 6 weeks a longer intervention might have yielded different results. A second limitation was that the walking trail was outside. The heat and inclement weather made scheduling sessions more difficult. Future research should take these strengths and limitations into consideration when developing further studies.

4.5 Conclusion

In conclusion, this study provides limited evidence into the effectiveness of a six-week mindful walking program improving and or maintaining cognition for adults that are at risk for Alzheimer's dementia or other related dementias. This study had a small sample size which made it difficult to find statistically significant conclusions. Although a small sample size, the program did impact processing speed and find a positive moderate association between participants steps in week 5 and 6 of the intervention and MoCA score changes although it did not reach significance. This small sample size did not find statistically significant correlations when comparing pre and post intervention MoCA scores. More research is needed to determine how a 6-week mindful walking program impacts older adults cognition and if a mindful walking program is an effective nonpharmacological interventions for prevention of dementia.

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APPENDIX A

RECRUITMENT SCRIPT

The Recruitment Script for Slow walking for better health study

Principal Investigator Name: Chih-Hsiang "Jason" Yang

Verbal Recruitment Script in the initial lab visit

READ: "Hi Carol, this is Caroline calling from the Aging Gracefully Lab at the University of South Carolina. Thank you for your interest in the Aging Gracefully Study. Are you able to talk right now for 5 minutes?

No □ Alright, that's fine. Is there any time that we can call you back?

Time:	Time:	Time:	Time:

Yes □ Great. First, we need to establish some basic requirements for our study. (Begin asking questions below)

General Screening Questions

VarName	**Question**	**Decision Criteria**
Age	How old are you? **( ) years old.**	Age 60+ □ eligible proceed to next question Else □ not eligible
Covid Vaccine?	Have you received the Covid-19 vaccine? (both doses? if applicable)	Yes □ eligible proceed to next question Else □ not eligible

ADRD risk factor 1	Do you have a family history of Alzheimer's disease and related dementias? (any first-degree relative/family member who was diagnosed)	Yes eligible, proceed to next question No proceed to next question
ADRD risk factor 2	During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?	Yes eligible, proceed to next question No proceed to next question
ADRD risk factor 3	What is your height? What is your weight? BMI calculations: If they know their weight in pounds, use: Weight (lbs) x 703 / height (in^2) _____ lbs. X 703/ _____ (in2) = ______ If they know their weight in kilograms, use: Weight (kg) / height (m^2) _____ kg / _____ (m^2) = _________	BMI ≥ 25 eligible, proceed to next question No proceed to next question
ADRD risk factor 4	How many minutes of exercise (higher intensity of physical activity) do you participate within a week?	More than 150 minutes per week Not eligible Less than 150 mins eligible, proceed to next question
Participant needs to fulfill at least one of the four ADRD risk factors to enroll		

Hearing and vision	Do you have adequate hearing and visual ability to use a cell phone?	Yes eligible proceed to next question No not eligible
English proficiency	Do you speak and read English fluently?	No not eligible Yes eligible proceed to next question
Medically stable	Currently, do you need any medical treatment beyond routine medical care for any acute or chronic health problems?	Yes not eligible No eligible proceed to next question
Brain abnormalities	Have you been diagnosed with any brain abnormalities, such as strokes, epilepsy, Parkinson's disease, memory impairment by a doctor or dementia?	Yes not eligible No eligible proceed to next question
Mental disorders	Have you been diagnosed with any mental or emotional disorders, such as depression, post-traumatic stress disorder, bipolar disorder?(And take medication)	Yes not eligible No eligible proceed to next question
Arthritis/hand injury	Do you have arthritis, hand injuries, other reasons that limit your ability to use the touchscreen on a smartphone?	Yes not eligible No eligible proceed to next question
Mobility	Can you walk without other people's assistance for 30 mins at a time? (using a walker or walking stick is fine)	Yes eligible proceed to next question No not eligible
Relocate/surgery	Do you plan to have surgery, have an extended vacation, or move in the next three months?	Yes not eligible No eligible

Start study time	If you are enrolled, are you able to start in the next 7 days?	Yes eligible No not eligible

NOT ELIGIBLE: "I'm sorry but you do not meet the requirements to participate in this study. Thank you for your interest in the study. Would you be interested in contacting by our staff for future study opportunities?
Either Yes or NO Thank you again have a great day!

ELIGIBLE: "Great**.** In order to begin your involvement, we need some contact information from you to schedule your visits.

May I please get your full name?	
Do you have an email address? Okay, what is your email address?	
What is the phone number which you can be reached at?	
What is the best way to get in touch with you? (phone/email)	

The first part of the research study will be a meeting with our research staff for a review of the study procedure and completing some baseline measurements and survey questionnaires. Can we schedule your meeting time now?"

No **"**Alright that's fine. You can either schedule your training sessions by calling (803-777-1088, emailing (uofscslowwalk@gmail.com), or we will call you again at a later time. If you have questions or concerns at any time feel free to call us. Thank you for your interest in participating in this research study, we hope to hear from you soon."

Yes "Great. Now just a reminder the initial meeting may last for about an hour and fifteen minutes.What days and what time periods will you be able to meet with us this week or next week?

Date (dd/mm)	Time (i.e., 2:00 – 4:00 pm)	Note
1/11	12:30 EST/ 10:30 MST	Example
/		
/		
/		
/		

Thank you! We will contact you when your meeting is scheduled, we will contact you again before your scheduled time in order to remind you of the date and time. If you need to reschedule your appointment or have any questions or concerns, please feel free to call us at 803-777-1088 We look forward to seeing you soon, have a great day."

Text and Phone Script for Appointment/ Walking Session Reminders:
Hello this is (name) from the Aging Gracefully Lab at University of South Carolina calling to remind you of your appointment is on (date/time). You if are not able to make this appointment / walking session, please email us back(uofscslowwalk@gmail.com) contact us at (803-777-1088, and we will schedule another time with you. We appreciate your involvement in our research and will see you on (date/time). Have a great day!

For Parking:

Directions to the Aging Gracefully Lab

(Close-Hipp Building, Room 214, 1705 College St, Columbia, SC 29208)

The Close Hipp building is located at the corner of Barnwell St. and Pendleton St.

APPENDIX B

MINDFULNESS INSTRUCTIONS SCRIPT

Session 1:

Research Assistant : "Today we are going to get comfortable with the trail. You will walk on the circular paved path for 30 minutes. Walk at a comfortable pace. You are asked to walk alone and not talk with others or on the phone during the mindful walking. If at any time you feel too tired to continue, feel free to take a break. "

Session 2:

Research Assistant : You will walk the same circle today for 30 minutes. At the beginning of your walk, you will practice paying attention to your breath for 5 mins. Walk at a comfortable pace. You are asked to walk alone and not talk with others or on the phone during the mindful walking. If at any time you feel too tired to continue, feel free to take a break. "

Let's try it now. Take 3 slow breaths in and out. Focus on your breath. (Research assistant will demonstrate 3 slow breaths inhaling through the nose, exhaling through the mouth.) I will remind you to start the breaths for 5 mins at the beginning of the walk.

Notice if your mind wanders. Refocus on the present moment. Notice thoughts that cause stress; if they occur refocus your thoughts on practicing mindful walking skill(s).

If you have any problems, call or text me. Otherwise, I will be right here. If you go around the path 1 time and you finish in less than 30 minutes, you should keep going so that you walk exactly 30 minutes.

Session 3 and 4:

Researcher: You will walk the same circle today for 30 minutes. You will begin your walk by practicing paying attention to your breath for 10 mins. Walk at a comfortable pace. You are asked to walk alone and not talk with others or on the phone during the mindful walking. If at any time you feel too tired to continue, feel free to take a break. "

Notice if your mind wanders. Refocus on the present moment. Notice thoughts that cause stress; if they occur refocus your thoughts on practicing mindful walking skill(s).

If you have any problems, call or text me. Otherwise, I will be right here. If you go around the path 1 time and you finish in less than 30 minutes, you should keep going so that you walk exactly 30 minutes.

Session 5 and 6:

Researcher: You will walk the same circle today for 30 minutes. You will practice paying attention to your breath for 10 mins. Walk at a comfortable pace. You are asked to walk alone and not talk with others or on the phone during the mindful walking. If at any time you feel too tired to continue, feel free to take a break. "

Let's try it now. Take 3 slow breaths in and out. (Research assistant will demonstrate 3 slow breaths inhaling through the nose, exhaling through the mouth.) Focus on your breaths.

For the next 10 minutes, I want you to also focus on your steps. Take a few steps. What do you notice? How do your feet feel when they hit the ground? What about your socks and shoes, how do they feel? Do you feel connected to the ground?

Now think about your steps. Are you taking long steps or short steps?

Now as you walk, I want you to continue to reflect on your breaths and steps for the first 20 minutes.

Notice if your mind wanders. Refocus on the present moment. Notice thoughts that cause stress; if they occur refocus your thoughts on practicing mindful walking skill(s).

If you have any problems, call or text me. Otherwise, I will be right here. If you go around the path 1 time and you finish in less than 30 minutes, you should keep going so that you walk exactly 30 minutes

Session 7 and beyond:

Researcher: You will walk the same circle today for 30 minutes. You will practice paying attention to your breath, your steps, and scan your body. Walk at a comfortable pace. You are asked to walk alone and not talk with others or on the phone during the mindful walking. If at any time you feel too tired to continue, feel free to take a break. "

Let's try it now. Take 3 slow breaths in and out. (Research assistant will demonstrate 3 slow breaths inhaling through the nose, exhaling through the mouth.) Focus on your breaths.

You will also focus on your steps. How do your feet feel when they hit the ground? What about your socks and shoes, how do they feel? Do you feel connected to the ground?

Now think about your steps. Are you taking long steps or short steps?

For the last 10 minutes of your walk I want you to scan your body. Start with your feet. Think about how they feel. Slowly work your way up. How do your ankles feel? Slowly move from your legs to your back to your arms. How do they feel?

Reflect on your breaths, steps, and body scan for the whole 30 minutes.

Notice if your mind wanders. Refocus on the present moment. Notice thoughts that cause stress; if they occur refocus your thoughts on practicing mindful walking skill(s).

If you have any problems, call or text me. Otherwise, I will be right here. If you go around the path 1 time and you finish in less than 30 minutes, you should keep going so that you walk exactly 30 minutes