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The Effects of Arthritis Foundation's "Walk With Ease" Program on Cognitive Function

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Abstract

Physical activity (PA) is believed to improve cognitive function, particularly executive function, in older adults. However, few interventions in community settings have been performed to improve executive function through PA. The purpose of this study was to determine the effects of a community-based walking program on executive function in older adults (60+ years). Older adults from senior centers throughout Lexington County, SC were recruited for participation in this intervention. Exclusion criteria included currently exercising >30 minutes and exercising ≥2x/week or scoring ≤25 on the Mini-Mental State Exam. The intervention consisted of an evidenced-based community walking program, the *Arthritis Foundation's* "Walk With Ease", which met two times a week for 9 weeks. Participants were tested at baseline and follow-up on the following measures: executive function (Stroop Color-Word, Trail Making Test A and B, Semantic Fluency, and Phonetic Fluency), physical performance (Timed Up-and-Go, Gait Speed, Chair Stand), depressive symptoms, disease management self-efficacy, and PA levels. Participants also reported demographics and subjective health status. Paired t-tests and repeated measures ANOVA were conducted for all outcomes of interest, along with effect sizes. Participants (N=56) were predominantly female (80.4%) and overweight (BMI= 29.81 ± 5.92). No significant improvements for any cognitive function measure or physical performance measure were found following the intervention. Repeated measures ANOVA revealed a significant improvement following the intervention for both PA (B=17.79 ± 5.42 MET hours/week, p<0.01) and disease management self-efficacy (B=5.77 ± 2.53, p=0.03). The results of this community-based single group pretest-posttest study does not provide enough evidence that the WWE is associated with improvements in cognitive function or improvements in physical performance. This study indicates that WWE increases PA levels and disease management self-efficacy of older adults. Larger studies of longer duration may be needed to reveal impacts on cognitive function.

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List of Abbreviations

ADAS-Cog.......................... Alzheimer's Disease Assessment Scale – Cognitive Sub-Scale

BDNF .... Brain-derived neurotrophic factor

CDC .... Centers for Disease Control

CHAMPS................................. Community Health Activities Model Program for Seniors

Color-CW... Condition 2 - Condition 3

CS.. Chair Stand

GDS-15 .... Geriatric Depression Scale (short version)

GS.. Gait Speed

LCRAC .... Lexington County Recreation and Aging Commission

MMSE .... Mini-Mental State Exam

MVPA.. Moderate- to vigorous-intensity Physical Activity

ND .... Neurodegenerative disease

PA... Physical Activity

PARQ .... Physical Activity Readiness Questionnaire

PF... Phonetic Fluency

SCW... Stroop Color-Word

SF .... Semantic Fluency

TMT... Trail Making Test

TUT .... Timed Up-and-Go

WWE .... Arthritis Foundation's *Walk With Ease Arthritis Self-Management Program*

Chapter 1

Introduction

The population is rapidly getting older, creating new problems for public health to address (Olson, 2013). This increase in the population's age has caused certain diseases to have a greater effect on the population, such as dementia and Alzheimer's disease, which affect older adults more commonly. In 2010 alone the worldwide cost of dementia was $604 billion and that number is expected to continue to rise unless an effective treatment or prevention measure is found (Wimo et al., 2013).

One such preventive measure is increasing physical activity (PA) among older adults, a group that tends to be underactive (Schutzer & Graves, 2004). Interventions to increase PA among older adults have been shown to be effective (Conn, Minor, Burks, Rantz, & Pomeroy, 2003) and evidence suggests that increasing PA in older adults can help maintain and even improve cognitive function (Angevaren, Aufdemkapme, Verhaar, Aleman, & Vanhees, 2008). The greatest benefit to cognition from PA (especially aerobic activity) appears to be in improving executive function (Hall, Smith, & Keele, 2001), a broad term used to define planning and problem-solving, a function that also significantly declines in neurocognitive diseases (Perry & Hodges, 1999).

However, relatively few interventions have been performed to examine the relationship between PA and executive function. Questions still remain about the volume, duration, intensity, and even modality that will elicit a substantial improvement, or help maintain executive function. In addition, few community-based PA interventions have included measures of cognitive health. Community-based interventions among older adults have often been performed in samples with greater education and socio-economic status. The Arthritis Foundation's *Walk With Ease* arthritis self-management program (WWE) is one such community-based PA intervention that has not yet been evaluated for its ability to improve conditions other than arthritis, nor has it been tested in a predominantly rural setting among older adults with less education and lower socio-economic status. Therefore, it important to determine the effects of WWE on multiple health parameters.

Specific Aim 1: To determine if WWE is an effective program for improving the executive function of underactive older adults at senior centers located in Lexington County, South Carolina.

***Hypothesis*:** It was expected that the aerobic nature of the program, along with the expected increases in PA, would help improve the executive function of participants.

Specific Aim 2: To determine if changes in PA levels were associated with improved cognitive performance.

***Hypothesis*:** It was believed that greater improvements in PA would be associated with greater improvements in cognitive function.

Specific Aim 3: To determine if WWE improved PA levels, disease management self-efficacy, and physical performance measures.

***Hypothesis*:** WWE was expected to improve PA levels, disease management self-efficacy, and physical performance measures.

Specific Aim 4: To determine if greater attendance was associated with greater improvements in all major outcomes (i.e., executive function, PA levels, disease management self-efficacy, and physical performance measures).

***Hypothesis*:** Greater attendance levels were expected to be associated with greater improvements in all outcomes: executive function, PA levels, disease management self-efficacy, and physical performance measures.

Chapter 2

Background

Neurodegenerative diseases (ND), such as dementia and Alzheimer's, are debilitating diseases that are quickly becoming a major public health concern. Currently the incidence of ND is unknown because of differing diagnostic approaches, particularly with all-cause dementia (Launer, 2011). Estimates range between 2.6 and 5.2 million cases of Alzheimer's in the United States ("Centers for Disease Control and Prevention," 2011) and the risk of developing Alzheimer's increases with age. Given the aging of the population (Cohen, 2003), more people will be at risk for ND than ever before. Hebert and colleagues estimated that the number of individuals living with Alzheimer's will triple by 2050 unless new discoveries facilitate prevention (Herbert, Scherr, Bienias, Bennett, & Evans, 2003). Cognitive impairment, defined as confusion or memory loss that increases over a 12 month period, is estimated to have a prevalence of 11.9% according to a pilot study by the CDC (CDC, 2009).

ND have a serious impact on the economy as well as individuals and communities. The U.S. Department of Health and Human Services estimates that aggregate payments for health care and hospice care for individuals with ND will increase from $183 billion in 2011 to $1.1 trillion by the year 2050 (USDHHS, 2003). This growing burden on individuals, families and their communities has caused the Department of Health and Human Services to recognize ND as a major public health problem that severely impacts older adults and caregivers.

According to recent research, PA may slow the rate of cognitive decline (USDHHS, 2008). Many studies have been published on the benefits of PA as it pertains to cognitive health, particularly among older adults. While most studies have been observational in nature, there have been an increasing number of randomized trials that have been conducted.

The following details the current literature on the effects of PA on cognition with an emphasis on the effects of PA on executive function. Literature reviews that have described the effects of PA on cognition are presented first. In addition, individual studies (cross-sectional, cohort and randomized controlled trials) that have examined the effects of aerobic activity on executive function and brain health are also described.

Literature Reviews

A limited number of narrative and meta-analytic reviews have been conducted concerning the effects of PA on cognition in the past 15 years. Earlier reviews have primarily focused on the benefits of PA for cognitive health for all age groups and regardless of disease status. More recently published reviews have also looked primarily at the effects of PA on ND. In addition, more recent reviews have detailed the effects of PA interventions on cognitive health. For classification purposes, reviews published more than 5 years ago (before 2008) are considered *early reviews*, while those published within 5 years (after 2008) are considered *recent reviews*.

Early Reviews

While earlier reviews have generally been broad in their focus (including many different age groups and populations), PA has been positively associated with cognition. Two narrative reviews by Kramer et al. found that improved fitness can enhance the cognitive function of the older adult brain and even prevent cognitive decline (Kramer et al., 2003; Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005). The conclusions from this review were similar to those of Hillman and colleagues; who pointed out that there is converging evidence at the cellular, molecular, behavioral, and systematic levels that suggests that PA participation is beneficial to cognition across all age groups (Hillman, Erickson, & Kramer, 2007). In addition, Kramer and Erickson (Kramer & Erickson, 2007) indicated that aerobic exercise provides multiple routes to enhancing cognitive vitality throughout the lifespan; helping to reduce disease risk, as well as improve molecular, cellular and structural function in the brain. Both the Hillman et al. and the Kramer and Erickson review papers included both animal and human studies that examined the relationship between PA and cognition. In addition, all three of these reviews pointed out that most of the study designs from human trials involved aerobic exercise, with most studies showing a positive relationship between PA and cognitive function. In these review papers the authors pointed out that little was known on how to develop and design interventions that optimize cognitive health. In addition, questions also remained about what the best type of exercise training for brain health may be, as well as what are optimal frequencies, intensities and durations.

These reviews noted that it was unclear whether the molecular mechanisms of exercise are the same for both animals and humans. In addition, the authors pointed out the importance of studying how cognition can be affected by a variety of lifestyles and pharmacological treatments. Kramer and Erickson (2007) also noted that the benefits and limitations of aerobic exercise in preventing or reversing the cognitive and neural degradation associated with ND are not fully understood. This review concluded that the cognitive operations that are most affected by aerobic exercise are not fully known. Most importantly, all three reviews underscored that it is still unclear how the benefits of exercise seen in the laboratory translate to the outside world of aerobic exercise.

Two meta-analyses have also found positive associations between PA and cognition in older adults. Colcombe and Kramer (S. Colcombe & Kramer, 2003) found in their meta-analysis, which included randomized controlled trials from 1966-2001 for adults over the age of 55, that aerobic fitness training has a robust and beneficial influence on the cognition of sedentary older adults. Fitness training increased cognitive performance significantly (effect size=0.48), regardless of the type of cognitive task, training method or characteristics of the participants. Furthermore, the cognitive benefits of fitness were greatest for tests of executive function (effect size=0.68). Etnier and colleagues found smaller, but still significant results in a meta-regression analysis (Etnier, Nowell, Landers, & Sibley, 2006), with an effect size of d=0.34.

Positive benefits of PA on cognition are even larger for older individuals with cognitive impairment or dementia (Heyn, Abreu, & Ottenbacher, 2004). A medium effect size (d=0.57) was found in a review of the effects of exercise training on cognition in older adults with ND or cognitive impairment. Although the effect size of this review appears extremely promising, only 12 studies were included in the review.

Recent reviews

While the few recent reviews have generally made similar conclusions regarding the association of PA and cognition (Ahlskog, 2011; Erickson, Weinstein, & Lopez, 2012), more of these reviews have examined the effects of PA on preventing and retarding ND. In addition, reviews published recently have also examined the effects of PA interventions on older adults to improve cognition.

A meta-analysis by Hamer and Chida found that increased levels of PA were associated with reduced risk of ND (Hamer & Chida, 2009). Specifically, they found that the relative risk of Alzheimer's disease and all-cause dementia were 0.55 and 0.72 (both statistically significant), respectively, when comparing the highest and lowest PA levels. In addition, PA lowered dementia and Alzheimer's disease risk by 28% and 45% respectively. While these findings provide strong evidence that PA can prevent ND, the authors note that it is not clear at what stage in an individual's life PA is most important for protection. Moreover, the timing of the PA assessment may be critical in relation to neurodegeneration. What is also unclear, say Hamer and Chida, is the optimal dose of PA for cognitive protection.

While Hamer and Chida's meta-analysis is the only recent one in the literature, several narrative reviews have examined the effects of PA on cognition in randomized trials. In a review of clinical trials of both animals and humans, Leckie and colleagues found that PA is effective at enhancing brain function by increasing gray matter and also influencing gene expression; although the genetic and physiological mechanisms still remain unclear (Leckie, Weinstein, Hodzic, & Erickson, 2012). In addition, many genetic and behavioral factors may attenuate or augment that result, such as diet or genetic levels of brain-derived neurotrophic factor (BDNF); both of which have been linked to cognition. Another recent review found that PA and cognitive enhancement exercises improve cognition in individuals with mild cognitive impairment (Teixeria et al., 2011). The majority of studies reviewed, however, were not randomized trials, but instead were prospective studies.

Despite the number of positive reviews and trials highlighted above, Snowden et al. stated, based on their review of the literature, that there is inadequate evidence at this time to conclude that PA and exercise interventions are effective at improving cognition in older adults (Snowden et al., 2011). It is important to note, however, that the inclusion and exclusion criteria for this review article were very rigorous, which limited many studies from eligibility for review. Furthermore, the authors did not perform a meta-analysis, but instead rated the quality and effectiveness of the studies. One of the main arguments of the authors is that overall the interventions were too short in duration; future studies and interventions should use longer study durations. Also, the authors argued that although many interventions have used valid and reliable measures of cognition, the measurement tools have often varied. They recommended a standard set of measurements to study the effects of PA on cognition.

Cross-Sectional Studies

Results from cross-sectional studies indicate that greater amounts of PA are associated with better brain health and greater levels of executive function. Colcombe and others found that while brain tissue loss does occur with age, higher levels of aerobic fitness are associated with greater levels of brain tissue (i.e., less loss over time)

(Colcombe et al., 2003). In addition, greater levels of PA are also associated with higher amounts of brain tissue and with higher levels of executive function (Benedict et al., 2013). Executive function is a broad term used to define planning and problem solving which occurs predominantly in the prefrontal cortex of the brain (Alvarez & Emory, 2006) and declines substantially with age, and even more with ND. Eggermont and others also found that executive function capability was associated with greater participation in PA in older, community-dwelling adults (Eggermont, Milberg, Lipsitz, Scherder, & Leveille, 2009).

While many of these findings have been observed with self-reported PA, Kimura and colleagues observed that significant differences existed in executive function between older adults who were more physically active, measured by accelerometers, in the three months prior to cognitive testing as compared to those who were less active (Kimura, Yasunaga, & Wang, 2012). Furthermore, there was a trend toward higher levels of moderate-intensity PA being positively associated with better simple reaction time.

Results from another study indicate a similar association between PA and executive function for older individuals (Boucard et al., 2012). Findings from this cross-sectional study indicated that PA status was associative with greater executive function capabilities only for adults over the age of 70, although the size of the sample for this age group was relatively small (n=30). In addition, an investigation led by Bixby, using a much larger sample, found that the relationship between better executive functioning and PA levels was apparent for adults over the age of 65 (Bixby et al., 2007).

While there appears to be an association between increased age and decreased executive function capability, there also appears to be a relationship between physical functioning and better executive function capability (Hirota et al., 2010). Faster trail making task time, a measure of executive function, was associated with increased walking speed, balance and obstacle negotiation.

Cohort Studies

Data from cohort (prospective) studies suggest that higher levels of PA throughout one's lifetime are associated with better brain health including better executive function. Using the 1914 Glostrup cohort, Gow and colleagues measured PA at age 50 and 60 with a single open-ended question that classified participants according to a 4-point scale (Gow, Mortensen, & Avlund, 2012). Participants were monitored for changes in cognitive ability from age 60 to 80, with cognitive ability scaled to age 50 norms. Greater levels of PA over the 30 years of follow-up were associated with higher levels of cognitive ability. However, this study may have been a conservative estimate, as noted by the authors, since it is likely that those with poor health or cognition were less likely to be followed.

Gow and colleagues measured PA and performed an MRI at age 70 in individuals from the Lothian Birth Cohort 1936, and then compared MRI results at age 73 (Gow, Bastin, et al., 2012). They examined normal white matter as compared to white matter lesions as well as atrophy, which are markers of cognitive decline. Results indicated that higher levels of PA were associated with higher levels of normal white matter, less atrophy and also lower levels of white matter lesions, suggesting PA is neuroprotective.

A recent study by Defina and colleagues measured incidence rates of dementia as compared to aerobic fitness levels (defined as VO_2 Max) (Defina et al., 2013). A total of

19,458 men and women were recruited in this study from the time of their midlife examination, at which time they underwent a single treadmill fitness test between 1971 and 2009. Participants were followed over time for incidence of all-cause dementia between 1999 and 2009. The authors found that higher level of fitness at the midlife examination was associated with a lowered risk of dementia later in life. This finding was constant even when adjusting for cerebral-vascular events. However, this study cannot offer advice on exercise prescription since it only measured aerobic fitness at the time of the midlife health check-up.

There is some evidence that even lower to moderate-intensity PA may be neuroprotective. Several studies point to an association between walking and higher levels of cognitive function. Vercambre et al. (Vercambre, Grodstein, Manson, Stampfer, & Kang, 2011) examined the association between PA and cognitive decline in the Women's Antioxidant Cardiovascular Study. Recreational PA was assessed at baseline and every two years thereafter from 1996 to 2000. Between 1998 and 2000, the participants underwent a cognitive battery by telephone including tests of global cognition, verbal memory and category fluency. Regular walking was strongly related to lower rates of cognitive decline. While it is important to note that women from this study had previously been diagnosed with a vascular condition, other publications have suggested similar findings (Etgen et al., 2009; Lautenschlager et al., 2008; Middleton, Mitnitski, Fallah, Kirkland, & Rockwood, 2008).

Yaffe and colleagues conducted an 8 year prospective study of community dwelling women with walking distance as the primary independent variable (Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001). Cognitive decline was defined as a 3+ point drop on the Mini-Mental State Exam at follow-up. After adjusting for age, educational level, co-morbid conditions, smoking status, estrogen use, and functional limitations, women with the highest levels of PA were 0.66 times as likely to experience cognitive decline as compared to the least physically active women. Similarly, Weuve et al. used data from the Nurses' Health Study to examine the relationship between self-reported PA levels and cognitive performance assessed via a telephone interview (Weuve et al., 2004). All participants at the beginning of the trial were 70 years or older. They found that women who participated in more PA, which consisted of predominantly walking, showed significantly better cognitive function over time.

Randomized Controlled Trials

There are a limited number of randomized controlled trials (RCT) that have examined the effects of exercise on cognitive health and executive function in older adults. Most of the RCT performed to increase executive function in older adults have used aerobic exercise as the treatment.

Kramer and colleagues compared a six-month aerobic fitness program to a stretching control program on measures of executive function in 124 previously sedentary older adults (Kramer et al., 1999). In this RCT, cardiorespiratory fitness and cognitive function were tested at baseline and at the completion of the 6-month programs. The aerobic fitness group exercise protocol consisted of walking (volume and duration not reported) whereas the attention control protocol consisted of stretching and toning exercises. The aerobic fitness intervention resulted in a significant increase in cardiovascular fitness as compared to the control group. Participants in the walking program also showed improvements in the three measures of executive function: task switching, reaction time, and response compatibility. This study suggests that even light to moderate forms of PA (i.e. walking) may have a positive effect on increasing cognitive ability and/or preventing cognitive decline in older adults, particularly in executive functioning.

In a randomized controlled trial, Maki and colleagues examined the effect of a three-month walking intervention (once/wk for 90 min, although participants were given pedometers and encouraged to increase their daily activity) vs. a control group on mental decline in 150 older adults (Maki et al., 2012). Several cognitive tests were performed at baseline and following the intervention. The walking group improved in verbal fluency, social interaction, and motor function as compared to the control group. These findings suggest that increasing walking activity may be related to improved executive function, in sedentary adults over 65 years old. Moreover, improvements were seen in a low-dose program that met only once a week.

Malliot and others also examined the effects of exercise on executive function in community dwelling older adults (Malliot, Perrot, & Hartley, 2012). Participants were randomly assigned to either an exercise video game group or to a no-treatment control group. The exercise group completed two 1 hour gaming sessions per week for 12 weeks. Neuropsychological function and fitness were assessed at baseline and at follow-up. They found that the exercise gaming group improved significantly in all measures of executive function, as well as physical functioning. While this study appears to be the only one available on the cognitive benefits of active video games, it appears to be a possible promising area of research.

Vreugdenhil and colleagues found that walking programs also have positive benefits for those already diagnosed with ND (Vreugdenhil, Cannell, Davies, & Razay, 2012). In a study of 40 community dwelling older adults (51-89 years old) diagnosed with Alzheimer's disease, a 4-month home-based exercise program resulted in increased MMSE scores and better cognitive scores according to the Alzheimer's Disease Assessment Scale – Cognitive Sub-Scale (ADAS-Cog). While the dose and type of exercise prescribed (i.e., resistance training vs. endurance training) was not clearly described, participants in the treatment group were required to include at least 30 min of walking in their exercise regime. Participants were asked to exercise daily, but were not monitored. Nonetheless, results from this trial appear positive since there was greater fitness as well as more favorable cognitive scores at post-intervention testing in the treatment group.

Finally, the benefit of exercise on cognition in older adults also applies to those with other medical issues besides ND, such as diabetes. Baker et al. found that after six months of aerobic exercise training, participants with glucose intolerance not only saw improvements in glucose tolerance, but also improvements on executive function tests (Baker, Frank, et al., 2010b).

Summary and Future Research

The literature on the effects of PA on cognition in individuals who have ND, as well as providing a protective effect for those who are disease free, appears very promising. Interventions to increase aerobic exercise and fitness have been consistently found to improve cognition in older adults, and also protect cognitive function (i.e., prevent decline). Research is still needed to study the effects of resistance training on cognition. Comparative studies on different forms of exercise must also be performed, such as differences in cognitive effects between aerobic and resistance exercise training; as it has been suggested that gross-motor cognitive training that occurs during total body resistance training may also have an effect on executive function capability (Pesce, 2012). Different types of exercise, exercise modalities, durations, and intensities should be examined to determine the effectiveness of different PA intervention programs.

Since PA should be one of the highest priorities for treating and preventing disease and disablement in older adults, effective interventions should be implemented and tested (Nelson et al., 2007). Many communities are implementing evidence-based PA programs. Efforts to evaluate these existing programs on a wide range of outcomes, including cognition, are important for reasons such as cost-effectiveness, feasibility, and sustainability. One such PA intervention program, WWE, was originally developed by the Arthritis Foundation for doctor-diagnosed and self-reported arthritis (Rizzo, 1999). This group-based walking program has the primary objectives of increasing PA, encouraging participants in the program to exercise, and educating participants about the benefits of PA. WWE is also designed to be affordable, easy to implement, and easily accessible. The Centers for Disease Control and Prevention's (CDC) Arthritis Program identified and now promotes WWE as one of six PA programs that have been proven safe and effective in this population (Hootman, Helmick, & Brady, 2012).

While only a few studies have evaluated the effectiveness of WWE, the initial results appear promising. Bruno and colleagues found that as compared to a pain management seminar, WWE participants reported being more confident, less depressed, less distressed about their health, and in less pain (Bruno, Cummins, Gaudino, Stoos, & Blanpied, 2006). In addition, participants in WWE showed significantly greater levels of PA at 6 weeks. Limitations of this study include that it used a quasi-experimental design, and very high attrition rates were seen at both 6 weeks (54.1%) and 4 months (73.0%).

Two other studies have evaluated WWE. In a quasi-experimental, pre-post study design, Callahan and colleagues found that both a self-directed program of WWE and a group format were equally effective at reducing self-reported arthritis pain and self-efficacy (Callahan et al., 2011). At 6 weeks, both groups had improvements in all self-reported measures as well as all performance measures.

The revised WWE program (a 9 week program meeting 2x/week), described by Schoster et al., decreased disability and improved arthritis symptoms, self-efficacy, perceived control, balance, strength, and walking pace in individuals with arthritis, regardless of the program format was group-based or self-directed (Schoster, Altpeter, Meier, & Callahan, 2012). At 1 year, some benefits were maintained, particularly among those in the self-directed program. WWE is a safe, easy, and inexpensive program to promote community-based PA among adults with arthritis.

WWE appears to be an effective intervention in older adults for increasing PA and may have potential for increasing cognition in community dwelling older adults. The purpose of this study was to examine whether WWE, in addition to improving arthritis symptoms and increasing PA, also improves cognitive function. Aside from testing whether WWE improved cognitive function, the study also examined if intervention attendance was associated with degree of change in cognition, and if changes in PA levels were associated with changes in cognitive performance. Finally, the study also set out to determine if the following secondary outcomes were improved by the intervention: PA levels, disease management self-efficacy, and physical performance measures.

Chapter 3

Methods

Study Design

The study was originally proposed as a 9-week randomized controlled trial consisting of an intervention group and a non-intervention control group to determine if a community based walking intervention could improve cognitive function (specifically, executive function) in healthy older adults at risk for arthritis. However, the program was modified to a single group pretest-posttest design in the third week of the trial; wherein, individuals who had initially been told that they would receive the WWE following the end of the study were allowed to participate in all remaining class sessions (these participants were marked as absent from classes they were excluded from). The study design was modified due to significant non-compliance to the program. Factors contributing to this non-compliance included: 1) the small size of the intervention group made program attendance less enjoyable; 2) participants felt discouraged from attending the WWE because they did not want to walk alone; and 3) contamination (control group participants joining WWE sessions) and non-compliance (intervention group participants refusing to participate in WWE sessions) were consistently occurring with participants assigned to the control group. While the change in study design reduces internal validity of the study, we believed that it would have been impossible to test our hypotheses given poor compliance in the intervention group and substantial contamination in the control group.

Participants

An *a priori* power calculation was conducted to determine sample size for the study using the G*Power 3.1.7 software (http://www.psycho.uni-duesseldorf.de, April 2013). However, when the study design was changed, the sample size for a pretest-posttest design was recalculated. Because we were unsure of how many seniors would participate in the program, the sample sizes needed for larger effect sizes (and thus smaller samples) were also calculated (see Table 3.1). With our actual enrollment of 48 participants who completed pretest and posttest measures, we were powered to detect an effect size of d= 0.41 (corresponding to a medium effect size).

Table 3.1 ***Total Sample Needed to Detect Various Effect Sizes for the Pretest-Posttest design (Paired t-test)***

Total Participants	Effect Size (d)
150	0.2302
120	0.2578
100	0.2829
80	0.3171
60	0.3677
40	0.4543

Participants were recruited from Lexington County Recreation and Aging Commission (LCRAC) associated Senior Centers at the following site locations: Lexington, Tri-City, Swansea, Gilbert, Pelion, and Batesburg-Leesville. Participating senior center directors actively recruited participants, and the researcher recruited through face-to-face contacts with older adults at participating centers.

Recruitment was targeted towards individuals who did not currently participate in senior center exercise activities. Records of older adults who participate in exercise classes at each senior center are kept by center directors and were used to exclude those individuals from participation in this program. Initially, each site was expected to have between 20-30 participants recruited who would then be randomized to either the intervention group or a delayed intervention control group in equal numbers. Larger sites (Tri-city, Lexington and Gilbert) were to have 30 participants recruited per site, while smaller sites (Pelion, Batesburg-Leesville, Swansea) would have 20 participants recruited at each site. However, due to lower than anticipated numbers of recruitment (N=56) and the other challenges described earlier, the study design was changed to a single group pre/post design. This change immediately increased participation in the study and allowed the trial to continue.

Sampling Procedure

After signing an informed consent form approved by the University of South Carolina Institutional Review Board, participants were screened to ensure they met criteria for participation in the study. In order to be eligible for this study, participants had to meet the following criteria: 60+ years of age, were currently not participating in an exercise program, were able to walk, lived independently, had a Mini-Mental-State Exam (MMSE) score of at least 25, and had not been diagnosed with a neurocognitive disease. MMSE scores lower than 25 are a sign of cognitive impairment (Crum, Anthony, Bassett, & Folstein, 1993).

Participants were excluded if they were a member of any group exercise class offered through the senior center, participated in regular exercise within the past month, or had previously had a stroke. The 2011 Behavioral Risk Factor Surveillance Survey was used for screening exercise behavior (Thompson, Nelson, Caldwell, & Harris, 1998). Participants were excluded from the study if they had regularly (>2x/week) participated in exercise of 30+ minutes. Finally, for safety reasons, participants were excluded if they endorsed any item on the Physical Activity Readiness Questionnaire (PAR-Q) (Cardinal & Cardinal, 2000; Cardinal, Esters, & Cardinal, 1996) ; however, participants who reported being on blood pressure medication (a question on the PAR-Q), and had a stable blood pressure (<140/90 mmHg), were still allowed to participate in this study.

Participants were initially randomized after signing a consent form and completing all baseline measures. However, as previously mentioned, in the third week of the trial all participants in the study were invited to participate in the intervention.

Intervention

The WWE walking program was run according to the guidelines set forth by the Arthritis Foundation. In order to effectively measure all sites, three senior centers (*Group A*) underwent baseline testing the week before the other three senior centers underwent baseline testing (*Group B*). *Group A* (Lexington, Pelion, and Gilbert) began the WWE program during the week that *Group B* was undergoing baseline testing. *Group B* (Swansea, Tri-City, and Batesburg-Leesville) then began the WWE program the week following completion of baseline testing.

All classes were led by a trained and certified instructor of the Arthritis Foundation. Each class lasted 50-95 minutes. Class structure followed the procedure outlined in Table 3.2. Since walking times and intensities are self-selected by participants, who may rest at any time during the walking period, the class duration varied. According to the Arthritis Foundation, the time initially spent walking was brief, but gradually built up to 30 minutes of PA. However, because each site had a different instructor and participant characteristics varied by location, time spent walking varied from location to location and also from session to session.

Table 3.2 ***WWE Typical Class Schedule***

Activity	**Time**
Pre-class socializing & Attendance	10 minutes
Welcome & Announcements	2-5 minutes
Health Education – Lecturettes	5-10 minutes
Walking Warm-Up	3-5 minutes
Warm-Up Stretches	4-5 minutes
Walking Activity	5-30 minutes
Walking Cool-down	3-5 minutes
Cool-down Stretches	7-9 minutes
Closing	5 minutes
After-class socializing	10 minutes
Total Time	**Approximately 50-95 minutes**

During each class participants also took part in Health Education Lecturettes designed to increase knowledge and elicit behavior change using strategies consistent with the Transtheoretical Model (Prochaska & Velicer, 1997) and Social Cognitive Theory (Bandura, 1997). Knowledge of arthritis, the relationship between arthritis and exercise, how to exercise safely and comfortably, and additional programs and resources were all targeted to help move adults towards the preparation stage of change. In addition, the action stage was targeted by teaching goal setting and problem-solving for PA, addressing how to overcome barriers to exercise, and also creating a personal walking plan.

Participants had access to the WWE program workbook which contained a detailed schedule of chapters to be covered for each week's classes. Copies were made available for purchase at participating senior centers ($5), but participants could also access free copies found at each of the senior centers. Table 3.3 outlines the chapters covered and recommended program schedule according to the program guidebook.

Class attendance was recorded by the instructor for each participant.

Table 3.3 ***WWE Weekly Program Schedule and Reading List***

Activity	*Week 1*	*Week 2*	*Week 3*	*Week 4*	*Week 5*	*Week 6*	*Week 7*	*Week 8*	*Week 9*
Read Chapter 1, 2 & 3	X	X							
Do your Starting Point Self-test (Chapter 1)	X								
Set-up your Walking Plan (Chapter 2 & 3)		X							
Walk! Try to Walk at least 3 days a week.	X	X	X	X	X	X	X	X	X
Do the 5 Step Basic Walking Pattern each time you walk (Chapter 5)			X	X	X	X	X	X	X
Follow the FITT principles each time you walk (Chapter 3 & 5)		X	X	X	X	X	X	X	X
Keep your walking dairy each time you walk (Chapter 3)		X	X	X	X	X	X	X	X
Read Chapter 4,5 & 6		X	X	X	X	X	X	X	
Measure your fitness level periodically, and also after the program ends			X			X		X	X
Monitor your walking intensity and walking progress (distance, time). (Chapter 3, 4 & 5)			X			X		X	X
Do a midway program assessment of your progress using your walking diary, walking plan and monitoring techniques (Chapter 3, 4, 5, & 6)						X			
Do your Ending Point Self-test and set up your future walking plan. (Chapter 6)								X	
Maintain your walking plan							X	X	X

Measures

Baseline data were collected during the first week of the study at each of the senior centers. The baseline assessment included measures of: demographics, cognitive tests, PA, depressive symptoms, disease management self-efficacy, and physical performance. All measures, excluding demographics, were assessed at the following times: baseline and one week after the program ended (Week 10).

Sociodemographics and Health

Participants were surveyed at baseline for sociodemographic information. Participants reported their age, sex, race, ethnicity, height and weight (used to calculate BMI), tobacco use, marital status, living status (e.g., independent, under supervision), health status and education level. Additionally, participants self-reported any current or previous health conditions such as diabetes, hypertension, osteoporosis, arthritis, and cancer. Participants also reported if they used a cane or other ambulatory device.

Cognitive Tests

Executive function tests included *trail-making test*, *Stroop Color-Word*, and *verbal fluency*. These measures have all been shown to be positively influenced by exercise (Emery, Schein, Hauck, & MacIntyre, 1998; Hyodo et al., 2012).

Trail-making test

The trail-making test (TMT) assesses executive function, and has been shown to be highly correlated with other tests of executive function (Sanchez-Cubillo et al., 2009). Normative data, by age and education level, also exist for time to complete this task as shown in Table 3.4 (Tombaugh, 2004). In addition, both the trail-making test A and trail-making test B have been shown to be sensitive to change over time (Chen et al., 2001). Trail-making test A consists of 25 numbers and participants are asked to connect the numbers in order (e.g., 1 to 2, 2 to 3, etc.). Trail-making test B consists of both numbers (1-13) and letters (A-L) and participants are asked to connect the numbers to the letters in sequential order (e.g., 1 to A, 2 to B, etc.). Trail-making test B is more complex and requires response-set switches.

Trail-making tests A and B were administered according to the guidelines of Strauss and colleagues (Strauss, Sherman, & Spreen, 2006). Briefly, after each test was explained and a practice attempted, participants were instructed to complete each test as quickly as possible. If an error was made, participants were asked to go back to the "circle" where the error occurred and continue. Time to complete each test was recorded by the test administrator. The difference in task completion time between test B and A (i.e, B-A) was calculated. Greater differences between times indicate poorer executive function. Each test takes anywhere from 5 minutes to 15 minutes to administer.

Table 3.4 ***Normative Data for Mean Trail Making Task Times Stratified by Age and Education Level***

Age group	Education level	Mean Trails A Time (SD)	Mean Trails B Time (SD)
65-69			
	0-12 years	39.14 (11.84)	91.32 (28.89)
	12+ years	33.84 (6.69)	67.12 (9.31)
70-74			
	0-12 years	42.47 (15.15)	109.95 (35.15)
	12+ years	40.13 (14.48)	86.27 (24.07)
75-79			
	0-12 years	50.81 (17.44)	130.61 (45.74)
	12+ years	41.74 (15.32)	100.68 (44.16)
80-84			
	0-12 years	58.19 (23.31)	152.74 (65.68)
	12+ years	55.32 (21.28)	132.15 (42.95)
85-89			
	0-12 years	57.56 (21.54)	167.69 (78.50)
	12+ years	63.46 (29.22)	140.54 (75.38)

Stroop Color-Word Test

The Stroop Color-Word (SCW) test is another measure of executive function. It has shown to have high test-retest reliability, although a practice effect may exist with this test for older adults (ICC=0.47) (Lemay, Bedard, Rouleau, & Tremblay, 2004). SCW was administered as defined by Golden (Golden, 1975). Normative data based on age, sex and education level is also available, as shown in Table 3.5 (Seo et al., 2008). This test includes three conditions:

1) 100 words (Red, Green, Blue) are printed in black ink. Participants are asked to read the words (from top to bottom of each of the five columns) as quickly as possible for 45 seconds.

2) 100 colors (Written as XXXX) are printed in either red, green or blue ink. Participants read the color names as quickly as possible for 45 seconds.

3) 100 words (Red, Green, Blue) are printed in either red, green or blue ink. Participants are asked to name the color of the ink that the word is printed in as quickly as possible for 45 seconds.

Table 3.5 ***Normative Data for Stroop Color-Word Scores Stratified by Age, Sex and Education Level***

Age group	Sex	Education Level	Mean Color-Word Score (SD)
60-69	Male	Low	30.58 (9.08)
		Average	32.13 (10.02)
		High	35.19 (10.19)
	Female	Low	34.87 (10.97)
		Average	34.56 (11.50)
		High	40.31 (11.47)
70-74	Male	Low	29.60 (8.64)
		Average	32.70 (9.87)
		High	35.37 (10.51)
	Female	Low	33.18 (10.99)
		Average	34.21 (11.96)
		High	38.77 (10.64)
75-79	Male	Low	26.31 (7.09)
		Average	29.79 (10.18)
		High	35.89 (10.79)
	Female	Low	32.86 (10.71)
		Average	33.14 (11.60)
		High	37.90 (9.60)
80-90	Male	Low	25.50 (8.05)
		Average	29.91 (10.52)
		High	35.57 (12.07)
	Female	Low	30.97 (10.40)
		Average	32.18 (10.78)
		High	38.82 (10.21)

One practice line was completed at the beginning of each condition, and the same Stroop version was administered at each testing session. Each participant was asked to read aloud what was required for each condition as quickly as possible. If an error was made, than the participant was asked to go back and correct their mistake before continuing. The number of stimuli completed was recorded. Interference scores (Condition 2- Condition 3 [Color-CW]) were recorded and used as the measure of executive function, as per the Golden protocol. Greater interference scores indicated poorer executive function. Participants who reported color blindness or could not read the print were excluded from statistical analysis of SCW. The test takes 5-10 minutes to administer.

Verbal Fluency

Verbal fluency, another measure of executive function, can be measured accurately by short semantic and phonetic tests (Harrison, Buxton, Husain, & Wise, 2000). Verbal fluency has also been shown to be sensitive to change, especially with exercise in older adults (Baker, Frank, et al., 2010a). Both semantic and phonetic fluency have established normative data based on age and education as shown in Table 3.6 (Tombaugh, Kozak, & Rees, 1999).

Table 3.6 ***Normative Data for Verbal Fluency Scores Stratified by Age and Education Level***

Age group	Education Level	Phonetic Fluency Score (SD)	Semantic Fluency Score (SD)
60-79			
	Low	25.3 (11.1)	14.4 (3.4)
	Average	35.6 (12.5)	16.4 (4.3)
	High	42.0 (12.1)	18.2 (4.2)
80-95			
	Low	22.4 (8.2)	13.1 (3.8)
	Average	29.8 (11.4)	13.9 (3.4)
	High	37.0 (11.2)	16.3 (4.3)

Phonetic fluency (PF) was tested by asking each participant to name as many words as possible for one minute starting with the letter “T”. Participants without cognitive impairment should be able to generate between 10-15 words, according to age predicted norms. The letter used was not changed from pretest to posttest. Semantic fluency (SF) was tested by having the participant generate as many examples of the category “animals” within 1.5 minutes. The category used was not changed from pretest to posttest. Both tests take no more than 5 minutes to administer.

Physical Activity

PA was measured using the Community Health Activities Model Program for Seniors (CHAMPS) questionnaire. The measure provides valid and reliable estimates of PA in older adults and has also been shown to be sensitive to change in PA intervention studies (Giles & Marshall, 2009; Harada, Chiu, King, & Stewart, 2001; Hekler et al., 2012; Stewart, Mills, et al., 2001).

The questionnaire usually takes 10-15 minutes to complete. Participants reported whether they engaged in each of 40 activities (yes or no) “in a typical week in the past four weeks,” and if yes, the number of times per week and the duration each week, ranging from “less than 1 hour” to “more than 9 hours.” Activities range from daily household chores, to recreational sports and leisure activities. MET hours per week for total activity as well as moderate- to vigorous-intensity PA (MVPA) MET hours per week were calculated (Stewart, Mills, et al., 2001). Previous research indicates that increases in MVPA have had positive effects on executive function capability in both chronic and acute conditions (Kashihara, Maruyama, Murota, & Nakahara, 2009; Taylor et al., 2004).

Depressive Symptoms

Depressive symptoms were measured with the short version of the Geriatric Depression Scale (GDS-15) (Yesavage et al., 1983). The GDS-15 has been shown to be a valid and reliable self-administered measure (α=0.81) (Almeida & Almeida, 1999).

The GDS-15 is composed of 15 questions that require a yes or no to each. The survey takes no more than 5 minutes to complete. Scores can range from 0-15 with higher scores indicating greater depressive symptoms.

Disease Management Self-Efficacy

Self-efficacy is a central construct in both the Transtheoretical model (Prochaska & Velicer, 1997) and Social Cognitive Theory (Bandura, 1997), the two theories that guided WWE. The 11-item Arthritis Self-Efficacy Scale is a validated questionnaire (α = 0.85) that measures the participant's confidence to control or manage arthritis symptoms (i.e., pain or fatigue) (Barlow, Williams, & Wright, 1997; Gonzalez, Stewart, Ritter, & Lorig, 1995; Mueller, Hartmann, Mueller, & Eich, 2003). Barlow and colleagues (Barlow, Turner, & Wright, 2000) also found that this scale was sensitive to change after implementing an intervention.

The Arthritis Self-Efficacy Scale asks participants to rank their certainty that they can manage various symptoms of arthritis on a Likert scale from 1 (very uncertain) to 10 (very certain). Items are summed and scores can range from 11 to 110, with higher scores indicating greater disease management self-efficacy. The survey takes 5-10 minutes to complete.

Physical Performance

Physical performances measures included *Gait Speed*, *Timed Up-and-Go Test*, and the *Chair Stand Test.* All three of these measures are commonly used for assessing physical capabilities of older adults (Guralnik, Branch, Cummings, & Curb, 1989) and normative data is available for older adults (Bohannon, 2006; Rikli & Jones, 1999).

Gait Speed

Usual gait speed (GS) can be assessed with high reliability and validity (Steffen, Hacker, & Mollinger, 2002). Faster GS is indicative of greater physical function. Slower walking speed has also been shown to be associated with hospitalization, dependence, institutionalization, cognitive impairment and mortality (Abellan Van Kan et al., 2009; Fritz & Lusardi, 2009; Studenski et al., 2011). Improvement in walking speed has also been linked to decreases in mortality risk (Hardy, Perera, Roumani, Chandler, & Studenski, 2007).

Two consecutive trials of GS were conducted as each participant walked on a marked 30 ft walkway at a normal comfortable speed. The fastest trial was used. Times were then converted into speed vectors (feet/s), which can be compared to normative values (Table 3.7). This test takes approximately 5 minutes to complete.

Table 3.7 ***Normative data for usual Gait Speed (feet/sec) by sex and age group***

Sex/Age	*Mean*	*SD*
Male		
60-69	4.46	0.67
70-79	4.36	0.64
Female		
60-69	4.25	0.69
70-79	4.17	0.69

Timed Up-and-Go

The Timed Up-and-Go Test (TUT) has been shown to be a highly reliable and valid measure for assessing basic mobility and balance skills in older adults (Steffen et al., 2002). Faster times (i.e., lower score) are associated with greater physical performance ability and can be compared to normative values (Table 3.8).

Table 3.8 ***Normative values for Timed Up and Go (sec) by age group***

Age	*Mean*	*95% CI*
60-69	8.1	7.1-9.0
70-79	9.2	8.2-10.2
80-99	11.3	10.0-12.7

The test measures the time it takes a participant to stand up from a chair, walk a distance of 10 ft, turn, walk back to the chair, and sit down. Two consecutive trials were performed. The fastest trial was used. The test takes 5 minutes to complete.

Chair Stand Test

The Chair Stand Test (CS) has also been shown to be a highly reliable measure (α=0.76) and predictive of disability and morbidity (Guralnik et al., 2000). The test measures lower body strength, has clear cut-off values for what is considered to be a below average performance (Lusardi, Pellechia, & Schulman, 2003), and is also sensitive to changes over time from an exercise intervention (Weiss, Suzuki, Bean, & Fielding, 2000).

Participants were asked to fold their arms across their chest and stand up once out of a chair. If successful, participants were then asked to sit down and stand up out of the chair as quickly as possible for 30 seconds. If unable to stand out of the chair, a score of 0 was given. The examiner stood by the participant for safety and also to count the number of successful sit-to-stands during the testing period. Higher scores indicate greater lower body strength, which can be compared to normative values (Table 3.9). The test takes approximately 5 minutes to complete.

Table 3.9 ***Normative data for Chair Stand Test (stands in 30 seconds) by age group and sex***

Age	*Female Mean (SD)*	*Male Mean (SD)*
60-64	14.5 (4.0)	16.4 (4.3)
65-69	13.5 (3.5)	15.2 (4.5)
70-74	12.9 (3.6)	14.5 (4.2)
75-79	12.5 (3.8)	14.0 (4.3)
80-84	11.3 (4.2)	12.4 (3.9)
85-89	10.3 (4.0)	11.1 (4.6)
90-94	8.0 (5.1)	9.7 (3.8)

Statistical Analysis

Survey results, cognitive tests and physical performance tests were scored according to recommended procedures.

Changes in Cognitive Function

Paired t-tests comparing pretest and posttest scores were performed for each cognitive measure (SCW, TMT, SF, PF). Significant differences between means indicate changes in executive function.

Differences over time in executive function were also assessed using repeated measures ANOVA generated from *SAS 9.3*. A time effect, when controlling for covariates, indicated a change in cognitive function following the intervention. Covariates were age, sex, BMI, race, tobacco use, cane use and a standardized performance test score at pretest (CS + TUT + GS). Differences in executive function test scores have been previously found between men and women, as well as for different age groups (Brennan, Welsh, & Fisher, 1997; Jurado & Rosselli, 2007). High BMI has been associated with executive dysfunction in otherwise healthy adults (Gunstad et al., 2007). Tobacco use has also been correlated with harmful cognitive effects (Swan & Lessov-Schlaggar, 2007). Finally, better cognitive performance has been positively associated with better physical function (Carlson et al., 1999). Four models were tested- one for each of the cognitive tests (SCW, TMT, SF, PF).

Changes in Physical Performance

Paired t-tests comparing pretest and posttest scores were performed for each physical performance measure (CS, TUT, GS) with significant differences between means indicating changes in physical performance.

Differences over time in physical performance were also assessed using repeated measures ANOVA. When controlling for appropriate covariates, a time effect indicated a change in physical performance following the intervention. Age, sex, BMI, race and use of a cane at pretest were covariates used for the three physical performance measures; differences in performance have been associated with age, BMI and cane use (Studenski et al., 2003).

Changes in Disease Management Self-Efficacy

Paired t-tests were also performed for changes in disease management self-efficacy. Significant differences between means indicated a change in disease management self-efficacy.

Differences over time in disease management self-efficacy were then assessed using repeated measures ANOVA. A time effect indicated a change in disease management self-efficacy following the intervention. Covariates used for disease management self-efficacy were age, depression and physical performance at pretest (standardized score of all three performance tests summated); all of these factors have been found to influence disease management self-efficacy (Turner, Ersek, & Kemp, 2005).

Changes in Physical Activity

Paired t-tests comparing pretest and posttest scores were performed for changes in MET hours per week in PA and MVPA. Significant differences between means indicated a change in total PA or MVPA following the intervention.

Differences over time in PA and MVPA were then assessed using repeated measures ANOVA. A time effect indicated a change in total PA or MVPA following the intervention. Covariates used included: age, sex, BMI, and cane use.

The Relationship between Attendance and Outcomes

Analyses of WWE attendance in relation to the outcomes of cognition, physical performance, disease management self-efficacy, total PA, and MVPA were conducted using repeated measures ANOVA analyses generated from *SAS 9.3*. Separate ANOVA models were conducted for each of the outcomes using the covariates previously described. Each model also contained time, number of sessions attended, and the time x attendance interaction. A significant interaction indicated differential change in the outcome over time according to attendance level.

Predicting Changes in Cognition from Changes in Physical Activity

In order to test whether changes in PA were associated with changes in cognitive function, residualized change scores were created for total PA, MVPA and each cognitive measure. Multiple linear regression analyses were then performed to predict residualized changes in cognitive function from residualized changes in total PA and MVPA. Covariates for analysis of changes in executive function tests included age, sex, and BMI. Significance indicated that improvements in PA were associated with improvements in cognitive function.

Effect size calculations

In addition to conducting the analyses proposed above, the observed effect size (Cohen's d) was also computed for each outcome of interest using the following formula: (mean posttest - mean baseline) / (baseline standard deviation). These calculations helped to determine the clinical meaningfulness of the results in addition to statistical significance. Conventions of small (d = 0.20), medium (d = 0.50), and large (d = 0.80) were used (Cohen, 1988).

Chapter 4

Results

Participant Characteristics and Baseline Values

Participant characteristics are shown in Table 4.1. Baseline and post-program values for all outcome variables are shown in Table 4.2. Participants (N=56) were predominantly female and overweight. The average participant was over 70 years of age. A majority of participants were either married or widowed and lived independently. Additionally, most of the older adults had not gone to college. Over 80% had some form of arthritis and more than 80% also reported having hypertension. More than half the participants used a cane for daily mobility and support and more than half of the participants also reported being in fair or poor health.

Baseline values for most major outcomes were also lower than normative values. Mean SCW scores and TMT times were lower than normative values for the average age of the sample. Mean PF scores were also lower than normative values for the average age of the sample, however mean SF scores were similar to normative values. All mean baseline values for the physical performance tests (i.e., CS, TUT, GS) were also less than normative values for the average age of the sample.

Follow-up values for most major outcomes were still lower than normative values following the intervention. Mean SCW scores, TMT, and PF were lower than normative values for the average of the sample; however, SF scores were still similar to normative values. Additionally, all physical performance tests were still less than normative values for the average age of the sample.

Table 4.1 ***Participant Characteristics (N=56)***

Characteristic	Mean (SD) or %
Age (years)	74.22 (8.02)
Sex	
Male	19.6%
Female	80.4%
Race	
White	64.71%
Black	33.33%
Other	1.96%
BMI (kg/m^2)	29.81 (5.92)
Depressive Symptoms (GSD-15 Score)	2.41 (2.42)
Education	
Some College or Higher	19.61%
High School	41.18%
Some High School	25.49%
Grade School	13.73%
Marital Status	
Married	21.57%
Widowed	45.10%
Divorced	15.69%
Separated	3.92%
Never Married	13.73%
Living Status	
Independent	74%
With Children	18%
Community Home	4%
Under Supervision	4%
Self-Rated Health Status	
Excellent	6.25%
Good	22.92%
Fair	39.58%
Poor	31.25%
Presence of Comorbidities	
Diabetes	27.45%
Myocardial Infarction	7.84%
Hypertension	80.39%
Angina	88.24%
Smoker	41.18%
Asthma	21.57%
Osteoporosis	15.69%
Arthritis	80.39%
Hyperlipidemia	56.86%
Cancer	15.69%
Cane Use	50.98%
Physical Problems	41.18%

Table 4.2 ***Baseline and Post-Program Outcome Values***

Outcome Variable	Mean (SD)	Post-Program Mean (SD)
Cognitive Function		
CW (words)	25.74 (9.68)	25.39 (9.51)
Color-CW (words)	31.08 (9.92)	30.64 (10.10)
Trails A (sec)	48.25 (20.27)	52.31 (31.77)
Trails B (sec)	163.58 (103.28)	140.35 (94.28)
Trails B- Trails A (sec)	115.30 (91.21)	88.04 (69.89)
Semantic Fluency (words)	19.84 (6.51)	19.54 (7.08)
Phonetic Fluency (words)	10.16 (5.10)	10.58 (4.85)
Physical Performance		
Chair Stand	8.42 (5.04)	9.00 (5.52)
Timed Up and Go (sec)	13.53 (6.87)	13.52 (7.18)
Gait Speed (ft/sec)	3.41 (1.15)	3.98 (1.21)
Disease Management Self-Efficacy	50.37 (19.22)	60.51 (15.46))
Physical Activity (MET hours/week)	24.16 (22.58)	41.56 (30.14)
Moderate-Vigorous Physical Activity (MET hours/week)	23.61 (23.73)	18.42 (21.10)

Attendance and Follow-up Values for Outcomes

Mean session attendance was 6.39 ± 4.95 sessions out of 18 possible (35.5% of available sessions), with a range of 0 to 16 sessions (Table 4.3). Of the 56 participants, 9 (16%) attended no sessions, 20 (36%) attended 1-6 sessions, 19 (34%) attended 7-12 sessions, and 8 (14%) attended 13-18 sessions. Attendance decreased over the course of the intervention from 58% at the first session to 33% at the last session. This decrease over time can be seen in Figure 4.1.

Table 4.3 ***Participant Adherence Rates***

Attendance Level	Sessions Attended	N	Mean Session Attendance	SD Session Attendance	Range
None	0 sessions	9	N/A	N/A	N/A
Low	1-6 sessions	20	3.4	1.729	1-6
Medium	7-12 sessions	19	9.05	1.58	7-12
High	13-18 sessions	8	14.75	0.8864	14-16
Mean Session Attendance (Sessions) = 6.39 ± 4.95					

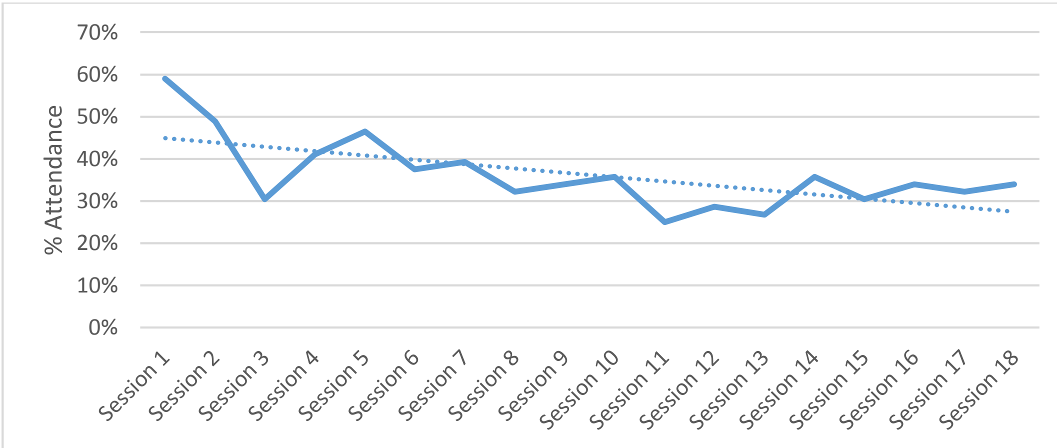

Figure 4.1 ***Percent Session Attendance Over Time***

Changes in Cognitive Function

T-tests revealed no significant changes in means following the intervention (Table 4.4). Following the intervention, a small effect size was found for improvement in TMT time (d=0.24). All other effect sizes were found to be extremely small. Repeated measures ANOVA for main effects also revealed no significant changes following the intervention (Table 4.5).

Table 4.4 ***T-test results with expected mean differences and p-values for Executive Function Tests***

Outcome	Mean Difference (SD) *Pre-test vs. Post-test*	t-Value	p-value	Cohen's d
Color-CW (words)	1.07 (9.91)	-0.51	0.61	-0.11
Trails B - Trails A (sec)	15.84 (67.28)	-1.08	0.28	-0.24
Phonetic Fluency (words)	.13 (4.94)	0.12	0.79	-0.03
Semantic Fluency (words)	-0.21 (6.82)	-0.15	0.88	0.01

Table 4.5 ***Main Effects of Time for Repeated Measures ANOVA for Executive Function Tests***

Outcome	B (SD) for time	F-Value for time	p-value for time
Color – CW	-1.62 (1.58)	1.05	0.31
Trails B - Trails A (sec)	-3.23 (13.01)	0.06	0.81
Semantic Fluency (words)	-0.14 (0.77)	0.03	0.88
Phonetic Fluency (words)	-0.71 (0.51)	1.94	0.18

Note: Models controlled for age, sex, BMI, race, tobacco use, cane use, and physical performance at baseline

Changes in Physical Performance

Paired t-tests revealed no significant changes in means following the intervention (Table 4.6). Effect sizes for all physical performance tests were very small. Repeated measures ANOVA for main effects also revealed no significant changes following (Table 4.7).

Table 4.6 ***T-test Results with Expected Mean Differences and p-values for Physical Performance***

Outcome	Mean Difference (SD) *Pre-test vs. Post-test*	tValue	p-value	Cohen's d
Chair Stand	0.64 (5.38)	0.55	0.59	0.12
Gait Speed (ft/sec)	-0.04 (1.17)	-0.16	0.87	-0.03
Timed Up and Go (sec)	0.02 (7.13)	0.01	0.99	<0.01

Table 4.7 ***Main Effects of Time for Repeated Measures ANOVA for Physical Performance***

Outcome	B (SD) for time	F-Value for time	p-value for time
Chair-Stand	0.12 (0.09)	1.52	0.23
Timed Up and Go (sec)	0.02 (0.09)	0.03	0.87
Gait Speed (ft/sec)	-0.05 (0.10)	0.21	0.65

Note: Models controlled for age, sex, race, BMI, and cane use

Changes in Disease Management Self-Efficacy

Paired t-tests revealed a trend in improvement of disease management self-efficacy following the intervention (p=0.08) as seen in Table 4.8. Additionally, small to medium effect size was found for disease management self-efficacy (d=0.43). Repeated measures ANOVA also showed a significant improvement in disease management self-efficacy over time (B=5.77 points) after controlling for covariates, as shown in Table 4.9.

Table 4.8 ***T-test Results with Expected Mean Differences and p-values for Disease Management Self-Efficacy***

Outcome	Mean Difference (SD) *Pre-test vs. Post-test*	tValue	p-value	Cohen's d
Disease Management Self-Efficacy	7.29 (15.36)	1.8	0.08	0.43

Table 4.9 ***Main Effects of Time for Repeated Measures ANOVA for Disease Management Self-Efficacy***

Outcome	B (SD) for time	F-Value for time	p-value for time
Disease Management Self-Efficacy	5.77 (2.53)	5.21	**0.03**

Note: Models controlled for age, depression score, and physical performance score

Changes in Physical Activity

Paired t-tests revealed a significant improvement in mean MET hours/week of total PA (p<0.01) following the intervention. No significant changes were observed for MET hours/week of MVPA (Table 4.10). A medium effect size was observed for changes in total PA (d=0.60). Additionally, a small negative effect size was observed for changes in MVPA (d=-0.23). Repeated measures ANOVA showed the same relationships after controlling for covariates. There was a significant improvement in total PA following the intervention (B=17.79 MET hours/week; p<0.01), but not in MVPA (Table 4.11).

Table 4.10 ***T-test Results with Expected Mean Differences and p-values for Physical Activity***

Outcome	Mean Difference (SD) *Pre-test vs. Post-test*	tValue	p-value	Cohen's d
Physical Activity (MET hours/week)	16.48 (27.35)	2.79	**< 0.01**	**0.60**
Moderate-Vigorous Physical Activity (MET hours/week)	-5.26 (22.74)	1.07	0.37	-0.23

Table 4.11 ***Main Effects of Time for Repeated Measures ANOVA for Physical Activity***

Outcome	B (SD) for time	F-Value for time	p-value for time
Physical Activity (MET hours/week)	17.79 (5.42)	10.78	**< 0.01**
Moderate-Vigorous Physical Activity (MET hours/week)	-5.31 (5.24)	1.03	0.32

Note: Models controlled for age, sex, race, BMI and cane use

The Relationship between Attendance and Changes in Outcomes

No significant time x attendance interactions were seen for any of the measures of cognitive function, indicating that those that attended more sessions did not show greater improvements in cognitive function (Table 4.12). However, the time x attendance interaction was significant for CS (B=0.05 stands, p=0.018), indicating that those who attended more sessions showed greater improvements in CS over time. A trend was also seen for an improvement in gait speed with greater intervention attendance (Table 4.13). However, no significant time x attendance interaction was observed for PA, MVPA or disease management self-efficacy (Table 4.14).

Table 4.12: ***Results of Repeated Measures Analyses Examining Time x Attendance Interaction for Tests of Executive Function***

Outcome	B (SD) of time x attendance interaction	F-Value of time x attendance interaction	p-value of time x attendance interaction
Color - CW (words)	-0.43 (0.37)	1.37	0.25
Trails B - Trails A (sec)	0.42 (2.83)	0.02	0.88
Semantic Fluency (words)	0.02 (0.17)	0.01	0.93
Phonetic Fluency (words)	0.02 (0.12)	0.02	0.89

Note: Models controlled for age, sex, race, BMI, tobacco use, cane use and total intervention attendance

Table 4.13 ***Results of Repeated Measures Analyses Examining Time x Attendance Interaction for Physical Performance Tests***

Outcome	B (SD) of time x attendance interaction	F-Value of time x attendance interaction	p-value of time x attendance interaction
Chair Stand	0.05 (0.02)	6.31	**0.018**
Timed Up and Go (sec)	-0.01 (0.018)	0.57	0.46
Gait Speed (ft/sec)	0.03 (0.02)	2.64	0.11

Note: Models controlled for age, sex, race, BMI, cane use and total intervention attendance

Table 4.14 ***Results of Repeated Measures Analyses Examining Time x Attendance Interaction for Physical Activity and Moderate-Vigorous Physical Activity, and Disease Management Self-Efficacy***

Outcome	B (SD) of time x attendance interaction	F-Value of time x attendance interaction	p-value of time x attendance interaction
Physical Activity (MET hours/week)	-0.01 (1.17)	0.00	0.99
Moderate-Vigorous Physical Activity (MET hours/week)	0.06 (1.10)	0.00	0.96
Disease Management Self-Efficacy	0.25 (0.60)	0.17	0.68

Note: Models for PA and MVPA controlled for age, sex, BMI, race, cane use and total intervention attendance: Model for Disease Management Self-Efficacy controlled for age, depression score, physical performance score and total intervention attendance

Associations between Changes in Cognition and Changes in Physical Activity

When controlling for appropriate covariates, increases in total PA levels were associated with significant improvements in SF (p=0.03), but were unrelated to changes in the other three executive function tests (Table 4.15). The association between increases in MVPA and improvements in executive function capability for both TMT and also SF approached statistical significance (Table 4.16), however no significant improvements were seen for either SCW or PF.

Table 4.15 ***Associations between Changes in Cognition and Changes in Physical Activity***

Outcome	F-test of residualized PA	Model R^2	p-value for PA
Stroop Color-Word	0.59	0.07	0.67
Trails B - Trails A (sec)	1.10	0.13	0.38
Semantic Fluency (words)	2.96	0.25	**0.03**
Phonetic Fluency (words)	0.86	0.09	0.50

Note: Models controlled for age, sex, BMI, race and cane use

Table 4.16 ***Associations between Changes in Cognition and Changes in Moderate-Vigorous Physical Activity***

Outcome	F-test of residualized MVPA	Model R^2	p-value for PA
Stroop Color-Word	0.77	0.09	0.55
Trails B - Trails A (sec)	1.79	0.19	0.16
Semantic Fluency (words)	1.90	0.18	0.13
Phonetic Fluency (words)	0.14	0.02	0.97

Note: Models controlled for age, sex, BMI, race and cane use

Chapter 5

Discussion

Previous research has suggested that engagement in PA may lead to the maintenance and even improvement of the cognitive function of older adults (Teixeria et al., 2011), however few community-based PA interventions have measured changes in cognitive health. The purpose of this study was to determine if the WWE program, a community-based PA intervention, improved the executive function of underactive older adults at senior centers located throughout Lexington County, South Carolina. Additionally, the study examined if greater intervention attendance was associated with improved outcomes and if increases in PA levels were associated with improved cognitive performance. The study also measured if involvement in the intervention improved any of the following: PA levels, disease management self-efficacy, and physical performance.

This community based single group pretest-posttest study had little significant impact on improvements in cognitive function and physical performance. Improvements in executive function were small and not statistically significant and there was no evidence of improvements in executive function with greater program attendance. Similarly, improvements in physical performance were limited to small and not statistically significant effects, but there did appear to be a small but significant interaction between greater attendance and improved physical performance.

One key reason that the findings did not support the hypotheses could have been the short duration of the intervention combined with an inadequate dose of PA. Although the WWE program was effective at increasing self-reported total PA levels of participants, these increases in PA were not significantly associated with the improvements in cognitive performance. Additionally, the WWE program appears to be effective at improving disease management self-efficacy among older adults following the program. However increases in PA and disease management self-efficacy levels were not related to increased attendance, contrary to hypotheses. These findings, that the program can increase total PA levels and also improve disease management self-efficacy and physical performance, are in line with previous research on the WWE (Bruno et al., 2006; Callahan et al., 2011).

In contrast to the generally null findings of this study in regards to cognition, much of the literature on interventions to improve cognitive function through PA in older adults has been positive (Baker et al., 2010; Kramer et al., 1999) . However, Snowden and colleagues in a panel review of older adult interventions for cognitive health found that while there have been some studies that have found positive results, most of the literature is inconsistent (Snowden et al., 2011). Nonetheless, in an early meta-analysis of randomized controlled trials, it was found that PA was associated with significant gains in cognitive ability, particularly executive function (Colcombe & Kramer, 2003). Other reviews have also found a similar positive effect, particularly with aerobic activity (Hillman et al., 2007; Kramer et al., 2003). These positive findings, however, have generally come from 3-6 month interventions and it has been suggested that improvements in cognition might require an intervention duration of at least 3 months (Kramer & Erickson, 2007).

It therefore seems that a possible reason for the null findings of this study, in regards to changes in cognitive function, might be due to the short duration of the study. Moreover, the self-selected frequency and duration of walking times within WWE might also have led to insufficient levels of PA to have an effect on cognitive function. In support of this idea, MVPA did not significantly increase whereas total PA did significantly increase, suggesting that perhaps the intensity of the PA was inadequate to yield improved cognition. Other variables such as cerebral vascular health have been previously shown to be associated with the executive function capability of older adults (Jacobs et al., 2013), suggesting that executive function could potentially be mediated by numerous other factors besides PA which were outside the scope of this study.

In contrast to the findings on the effects of WWE on physical performance, many studies have also determined that PA is associated with improvements in physical function and quality of life for older adults (King, Rejeski, & Buchner, 1998; Motl & McAuley, 2010). Additionally, PA interventions are moderately successful at improving quality of life and also improving the physical functioning of older adults (Nelson et al., 2007). Nonetheless, certain performance measures might be difficult to improve through PA increases or exercise training for frail older adults. A recent meta-analysis found that interventions to improve physical performance in frail older adults failed to yield significant effects for TUT, but did improve GS (Chou, Hwang, & Wu, 2012). Instead, it appears that the greatest improvements from exercise and PA for frail older adults were seen in measures of activities of daily living. Because the sample used in the present study was both very old and also frail, the small improvements seen in regards to changes in physical performance appears to be in line with previous literature. Rather, if the present study had measured changes in activities of daily living, more significant effect sizes might have been seen. Additionally, a younger and healthier sample then the current one might have seen greater benefits in physical performance capabilities from increases in PA.

Walking based PA interventions do appear to be conducive to significant increases in PA, like what was seen in this study. Conn and colleagues found that four of six walking-focused PA interventions reviewed increased walking activity in the intervention group, however these interventions were no more effective at increasing total PA than any other intervention strategy (Conn et al., 2003). A meta-analysis by Conn, Valentine, & Cooper revealed only small effect sizes ($d=0.26 \pm 0.05$) for interventions to increase PA amongst older adults (Conn, Valentine, & Cooper, 2002). Furthermore, theory based interventions (like WWE) had a small effect size, although an insufficient number of studies that were not theory based existed to make comparisons.

Many studies have determined that group-based PA interventions that focus on individual change, such as the WWE program, may be well suited for older adults (Cress et al., 2005; King, 2001). Belza and colleagues found that a community-based group-exercise class significantly improved physical performance measures and also self-rated health status in older adults (Belza, Shumway-Cook, Phelan, Williams, & Snyder, 2006). In a randomized controlled trial by Stewart and colleagues, older adults (65+ years) who underwent a 1 year individual-change based intervention saw significant increase in total energy expenditure following the intervention, as compared to controls (Stewart et al., 2001). However, this trial had limited group delivery (once a month), and was mostly based on trying to promote individual change. Another community based trial by Barnett and colleagues found that a group based intervention significantly increased physical performance and decreased falls risk in frail older adults (Barnett, Smith, Lord, Williams, & Baumand, 2003). Much like the WWE, these programs allowed for self-selected exercise length, duration, and attendance.

Walking interventions to improve older adult quality of life have also been previously shown to be effective. A recent meta-analysis by Kassavou, Turner, & French found that walking based PA interventions, targeting all age groups, caused a medium-to-large ($d= 0.52 \pm 0.19$) increase in total PA (Kassavou, Turner, & French, 2013). The walking interventions that only targeted older adults (60+ years) also were found to have medium-to-large effect on total PA ($d=0.57 \pm 0.40$). Additionally, a study of a neighborhood based walking intervention found that there were significant improvements in walking activity, quality of life, and physical function (Fisher & Li, 2004). Talbot and colleagues also found that a combination of a walking program with an arthritis self-management program caused significant improvements in daily step count, walking efficiency, strength and functional performance as compared to just the self-management program alone (Talbot, Gaines, Huynh, & Metter, 2003). These findings suggest that a walking program can improve multiple can improve the physical function of older adults, and cause greater improvements than just an educational intervention alone. Moreover, the findings of the current study are in line with previous research on the extent to which a walking based intervention can improve PA in older adults. Programs like WWE deliver both an exercise component and also an educational component which appears to make it ideal for improving physical activity, physical function and also quality of life.

Limitations

This study, however, was not without limitations. First, the study was initially planned as a randomized trial, but had to be altered to a single group pretest-posttest design midway through the trial. While the reasons for this alteration have already been discussed, this change does limit the internal validity of the study. Participants who had been randomized to the control group may have chosen not to participate at all due to their placement or only received a part of the intervention which may have reduced the likelihood of behavior or performance change. Additionally, the single group design limits the ability of the intervention to determine a causality of the changes seen at posttest, which may have been a matter of chance.

A major limitation of our research was that we did not record and account for the duration of the walking activity in our analysis. Program leaders did not keep detailed class logs and it would not have been feasible for them to record time spent walking for each participant given participants self-selected their walking duration.

Another major limitation to this study is the poor adherence to the intervention by the participants. Participants did not attend a majority of the sessions which may have limited their improvements in outcomes. The lack of attendance may have also made it difficult to measure a dose-response relationship to the intervention since most of the participants did not attend more than half the intervention. However, it was not feasible to provide an incentive to participate more frequently in the intervention and the purpose of this intervention was to determine the effects of the WWE program in a real-life setting.

The study also was limited by its measures, particularly the lack of objective measures of PA. While the CHAMPS survey has been previously shown to be a reliable measure of PA, there are still issues with recall of PA that may have hampered the validity of the findings in this study. A review of PA self-report measures for older adults found that there was a weak agreement between self-report measures of PA (r=0.29), suggesting that different self-report measures may lead to different results (Kowalski, Rhodes, Naylor, Tuokko, & MacDonald, 2012). Studies of the validity of CHAMPS have found similar relationships to more objective measures. Hekler and others found a significant but modest agreement between CHAMPS and accelerometer measured PA (r=0.38) in a sample of 870 older adults (Hekler et al., 2012). These findings were similar to those of a previous study of the validity of CHAMPS that found a significant but modest agreement between CHAMPS and accelerometer measured PA (r=0.36). However, due to budget restrictions and lack of staff it would have been extremely difficult to monitor participant PA via objective measurement. Additional measurement limitations may have existed for cognitive function tests, given that they were performed in the field under less than ideal conditions. More profound differences in cognition may have existed had the threat of measurement error for cognitive testing not been omnipresent throughout this study.

Given the small number of participants that were recruited for this study, some of the null findings (i.e., improvements in cognitive function or physical performance) may have been caused by lack of sample size. As previously mentioned, a large body of evidence has suggested that increases in PA are associated with increases in executive function and physical function. However, the findings of this study were inconclusive for both changes in cognition and also physical performance.

The inconclusive findings of this study may have also been due to the poor performance of this sample on both cognitive and physical performance tests at baseline. Collectively, the sample scored below normative values for all cognitive and physical performance outcomes, and this poor performance at baseline could have made it more difficult for the participants to improve enough to reach statistical significance, although one would also assume that these participants would have more room for improvement given their initial low test scores. However, improvement in outcome scores may have been limited due to the nature of the intervention. The sample was composed of a large number of participants who were not highly educated which may have made it exceedingly difficult for full comprehension of the intervention. A lack of literacy may have made it difficult for participants to actually comprehend the material and change their behavior, thus allowing improvements in outcome measures.

A final limitation was the short duration of the intervention and unknown dose of PA participation. The WWE intervention does not last longer than 9 weeks, however a continuation of the program might have yielded larger effects, given that participants might still be participating in greater amounts of PA. Nonetheless, the dose of PA participation was still unmeasured during this study. The lack of measurement of individual amount of PA participation received in the intervention, however, was deemed to be unavoidable due to budget restraints and a lack of staff to accurately measure PA participation.

Strengths and Future Research

This study is unique, however, because it involves a hard to reach population of older adults from a rural area. Few interventions have been performed on these types of communities to increase PA. The findings that are presented from this study show that the WWE program may be suitable to increase PA in this type of population. Additionally, this study has participants from numerous different racial, ethnic, and educational backgrounds which indicates that the program is effective at improving PA and disease management self-efficacy for many different types of older adults. To date, this is the first known study on the effects of the WWE in a rural population of older adults.

Future research should continue to examine the effects of the WWE on a variety of outcomes, as well as other community based interventions to improve PA in older adults. Future studies should use objective measures of PA such as pedometers and accelerometers. Other variations of the WWE, such as the self-directed version and performing the intervention as a 3 day/week intervention should also be compared to the 2 day/week protocol used in this study. Future research should also determine if differences in performance and behavior exist following either protocol. Additionally, large sample sizes should be used for community based interventions to allow for greater statistical power and more conclusive findings, particularly when measuring changes in cognition and physical performance which can be expected to yield small effect sizes. More accurate and precise methods of test administration should be utilized in future study designs rather than using field based testing, which is open to greater amounts of measurement error. Finally, a longer program duration would allow for more adequate study of the effects of the program on cognitive performance.

Conclusion

The results of this community-based single group pretest-posttest study indicate that there does not appear to be enough evidence to indicate that the WWE is capable of improving the cognitive function or physical performance of older adults. The WWE program does appear to improve PA levels of older adults as well as increase their quality of life, but these improvements do not mediate improvements in cognition. However the improvements in PA and quality of life do not appear to be related to the attendance to the intervention, which indicates the lack of a dose-response relationship between the intervention and improvements in PA or disease management self-efficacy. Future researchers should measure changes in PA objectively, as well as utilize greater sample sizes.

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