MULTI-COMPONENT EXERCISE PROGRAM
IN A LIFE-CARE COMMUNITY:
FOR ADULTS 80 YEARS OF AGE AND OLDER

A dissertation submitted to the
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It is well established that health benefits can be derived from exercise training programs even for the oldest-old (age: 85+ yrs) populations. Much of the research on older adults has been conducted on younger groups and extrapolated to these oldest-old populations. The purpose of this investigation was to determine whether a 6-month multi-component structured exercise program of low-to-moderate intensity for 120 minutes/week plus habitual physical activities implemented in a life-care community of adults 80 years of age and older with mild cognitive impairment (MCI) could maintain or improve cardiovascular endurance, muscular strength, flexibility, balance/agility, and body composition. Additionally, the purpose was to determine whether changes in these physical performance measures were associated with changes in cognitive functioning.

A clinical group of 30 participants (age: 83.6±3.6; males: n = 12; females: n = 18) with very mild cognitive impairment completed the 6-month exercise program and pre- and post-intervention Senior Fitness Test. Paired-sample t-tests revealed significant increases in cardiovascular endurance (t(26) = -2.79, p = .01) and upper-body strength (t(29) = -2.01, p = .05); main effects for gender using ANOVAs demonstrated significant improvements for females in upper- (F(1,28) = 6.15, p = .01) and lower-body flexibility (F(1,28) = 12.59, p = .001); and no changes in lower-body strength and body composition. A significantly negative correlation (r = -.424; n = 25; p = .02) was found
between changes in cardiovascular endurance and cognitive functioning. Further analysis revealed this significantly negative correlation was evidenced for individuals with, but not for those without, 2 cardiovascular disease (CVD) risk factors. Although midlife CVD risk factors have previously been associated with declines in cognitive functioning, the effect of these risk factors is unclear in this study population. The results from this investigation suggest that adults in their ninth decade of life with very mild cognitive impairment can maintain or improve physical performance measures with a structured multi-component exercise program of low-to-moderate intensity. However, despite these improvements cognitive functioning continued to decline. These findings encourage further research of the relationship between physical performance measures and cognitive performance in this population.
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CHAPTER I

INTRODUCTION

In the United States the composition of older adults is dramatically changing as the “Baby Boomer” generation is aging and approaching 65 years of age. According to the U.S. Census Bureau (He, Sengupta, Velkoff, & DeBarros, 2005), this Baby Boomer population will begin turning 65 in 2011. These estimated projections indicate that the older population will expand from 35 million in 2000 to 72 million by 2030 and the oldest-old population, aged 85 and older, is expected to grow rapidly after that time. Furthermore, the number of centenarians (i.e., \( \geq 100 \) years of age) is projected to increase from 50,000 in 2000 to over a million by 2050 with women representing 80% of this population (U.S. National Institutes of Health – National Institute of Aging, 2008). The social and economic impact of this magnitude will focus attention on people living healthier lives with emphasis on quality of life as opposed to longevity.

The biological aging process results in declines in physiologic capacity (Kirkendall & Garrett, 1998). The hallmark of aging is a decrease in the cardiovascular, metabolic, respiratory and neuromuscular systems that contribute to weakness, fatigue and slowing of movement. Although aging is inevitable, the physiological and psychological effects of aging can be modified by individual lifestyle choices. The benefits of lifestyle choices, such as remaining physically active and maintaining a healthy body weight with proper nutrition, have been touted to the general public for the
past several decades on radio and television programs and in newspaper and magazine advertisements. Despite the emphasis placed on obtaining physical activity, many people remain sedentary, while others integrate physical activity including structured exercise programs into their habitual lifestyles.

The prevalence of chronic disease increases with age (Hardman & Stensel, 2003). In fact, the American Association of Retired Persons (2004) reports that the average person who reaches 75 years of age experiences a minimum of three chronic conditions that require medical attention and medication. Chronic diseases adversely affect an individual’s quality of life by inflicting illness, extensive pain, disability, and major limitations in daily living and can lead to physical inactivity. Individuals with disabilities have consistently been found to have higher rates of inactivity than those without disabilities (U.S. Department of Health and Human Services, 2006). Regardless of whether chronic conditions exist or not, older individuals are relatively physically inactive compared to younger individuals, and are more likely to be weak, easily fatigued, have impaired ability to walk, and suffer from frequent falls (Fiatrone & Evans, 2002). These debilitating results are sometimes accepted as normal aging; however, in reality they are a conglomerate of symptoms from disuse (Fiatrone & Evans, 1993; Freedman, Martin, & Schoeni, 2002).

Research involving older adults has shown that regular physical activity is an effective intervention for diminishing the risk factors and possibly avoiding functional deterioration associated with aging (Mazzeo & Tanaka, 2001). Healthy and chronically
ill individuals have both demonstrated that negative physiological and functional changes can be combated with exercise (Gill et al., 2002; Keysor & Jette, 2001; Spirduso & Cronin, 2001). Exercise can improve cardiovascular endurance, muscular strength and body composition, flexibility and range of motion, agility and balance, and cognitive function which may reduce pain and disability leading to increased walking, speed, distance and ability (Penninx et al., 2002). It may also increase psychological comfort and self-confidence in ability to live independently (Campbell & Aday, 2001) and improve quality of life (Mazzeo & Tanaka, 2001).

**Aerobic Capacity**

Maximal oxygen uptake (VO₂max) is considered the criterion for measuring the functional limits of the cardiorespiratory system (American College of Sports Medicine, 2009). It represents the maximal rate of oxygen utilized by working muscles from a maximal cardiac output. VO₂max is known to decline with age (Hollmann, Struder, Tagarakis, & King, 2007; Katzel, Sorkin, & Fleg, 2001). The age-related rate of decline in VO₂max differs among investigations and is highly variable among individuals within a population (Paterson, Cunningham, Koval, & St. Croix, 1999; Tanaka et al., 1997). Average predictions from cross-sectional studies indicate that the decline in VO₂max is approximately 1% per year after age 25 (Spirduso, Francis, & MacRae, 2005). This decrease in cardiorespiratory function along with the loss of muscular strength can significantly diminish an individual’s functional capacity. Many older individuals become so severely compromised that they struggle to perform the most basic activities...
of daily living. As such, the burden of chronic diseases and functional limitations can contribute to difficulties of even measuring VO$_2$max in older individuals (Gill, DiPietro, & Krumholz, 2000; Posner, Gorman, Klein, & Woldow, 1986). VO$_2$peak represents the level of oxygen consumption recorded at peak workloads and has therefore been used when VO$_2$max is unattainable (Hollenberg, Ngo, Turner, & Tager, 1998).

Research studies in older adults have been conducted to measure functional performance and the threshold of maximal voluntary performance during ordinary daily tasks (Arnett, Laity, Agrawal, & Cress, 2008; Cress & Meyer, 2003). Aerobic capacity or VO$_2$peak between 18 and 20 ml/kg/min (Cress & Meyer, 2003; Morey, Pieper, & Cornoni-Huntley, 1998a; Posner et al., 1995) has been defined as aerobic threshold below which there is a reduced probability of living independently (Cress & Meyer, 2003). For each 1 ml/kg/min of oxygen uptake below aerobic threshold, there is an associated 8-fold decline in physical function (Cress & Meyer, 2003). Aerobic reserve is the level of energy capacity above aerobic threshold that can serve as a safety margin for discretionary activities such as walking or gardening. Structured exercise programs can aid in elevating aerobic capacity that can provide an aerobic reserve or safety margin. Although few studies have shown increases in VO$_2$peak with aging, the ability for the elderly to maintain physical function may be obtained with a multi-component (i.e., aerobic, strength training, flexibility and balance) program (Hessert, Gugliucci, & Pierce, 2005).
Sarcopenia is the loss of muscle mass associated with a decline in muscle strength that occurs with aging (Spirduso et al., 2005). This hallmark of changing body composition includes a gradual accumulation of body fat and its redistribution to central and visceral depots during middle age and sarcopenia during middle and old age. It is due to a reduction in the size of the muscle mass contracting and may be influenced by the loss of motor units (Campbell, McComas, & Petito, 1973; Cederna et al., 2001; McComas, Fawcett, Campbell, & Sica, 1971) and changes in capillarity per muscle fiber (Cartee, 1994). The decline in muscle strength averages about 1 to 1.5% per year from ages 50 to 70 and then declines about 3% each year thereafter (Kallman, Plato, & Tobin, 1990; Vandervoort, 2002). This loss can have devastating effects on older individuals performing their activities of daily living. Although loss in strength occurs in both the upper and lower body, muscular power declines at a faster rate than muscular strength (Labarque, ‘T Eijnde, & Van Leemputte, 2002; Macaluso & De Vito, 2003) but both are associated with the onset of disabilities in later years (Cuoco et al., 2004; Hruda, Hicks, & McCartney, 2003; Rantanen, Guralnik, Foley, et al., 1999; Rantanen, Guralnik, Sakari-Rantala, et al., 1999). Structured exercise programs have been shown to substantially increase muscle strength in people of all ages (Fiatarone et al., 1994; Frontera, Meredith, O’Reilly, Knutgen, & Evans, 1988; Sipila, Multanen, Kallinen, Era, & Suominen 1996). Furthermore, resistance training is an effective and safe option for increasing muscle strength even in the frailest of populations.
Flexibility and Range of Motion

The importance of flexibility is augmented with aging. One of the most common and disabling chronic diseases associated with loss of flexibility and range of motion (ROM) is arthritis (National Institute on Aging, 2009, August). Flexibility or ROM can impair mobility (Felson et al., 2000), lower body (i.e., hip joint and hamstrings), and upper body (i.e., shoulder area) flexibility (Jette, Branch, & Berlin, 1990). Aging studies have reported that older populations lose up-to 50% in spinal flexion (Einkauf, Gohdes, Jensen, & Jewell, 1987) and 50% in women and 35% in men for ankle flexion (Vandervoort et al., 1992) when comparing flexibility between young (i.e., 20 to 29 years) and old (i.e., 55 to 85 years) age groups. This loss in ROM can result in back pain, risk of falls, and gait abnormalities. Few studies have compared the effects of specific ROM exercises on outcomes of flexibility. One such study (Rider & Daly, 1991) found significant improvements in hamstring flexibility and spinal extension in a group of 70 year olds while other documented evidence (Spirduso et al., 2005) described similar improvements in upper and lower body flexibility in older men. These findings suggest that flexibility can be increased in the major joints by ROM exercises in healthy people (Spirduso et al., 2005). Although the frequency and the type of ROM exercises for older adults are controversial.
Balance/Agility

Age-associated changes in sensory, motor and musculoskeletal function contribute to decline in balance and mobility even in older individuals with physically active lifestyles and no visible chronic diseases (Rose, 2005). Unstable balance is one of the major risk factors associated with falling which is the fifth leading cause of death in older adults (Rubenstein, 2009, November). Other common risk factors attributed to falling include lower extremity muscle weakness, slow reaction time, decreased lean body mass, impaired cognition, vision, syncope and overall impaired mobility (Gregg, Pereira, & Caspersen, 2000; Rubenstein & Josephson, 2002). In the United States, falling contributes to approximately 90% of hip fractures (Carter, Kannus, & Khan, 2001). It has been estimated that approximately 30% of community-dwelling older adults have fallen once annually, and 10-20% have fallen two or more times (Gregg et al., 2000). A fear of falling in older adults can lead to a reduction in physical activity, reduced ability to perform activities of daily living, and future falling episodes (Austin, Devine, Dick, Prince, & Bruce, 2007). Randomized, controlled trials studying fall prevention have shown both positive (Jensen, Lundin-Olsson, Nyberg, & Gustafson, 2002; Judge, Lindsey, Underwood, & Winsemissius, 1993) and negative (McMurdo, Millar, & Daly, 2000; Schlicht, Camaione, & Owen, 2001) results; however, difference in target groups, interventions, and outcome measures may explain the inconsistent results. Exercise programs that have shown positive effects on balance and falling were designed to include multiple modes of training compared to single-mode programs that resulted in
negative effects for balance and fall prevention. In addition, research from large prospective cohort studies linking activities such as walking with 30-50% reductions in risks for osteoporotic fractures have not provided evidence that walking, as the sole modality for balance training, can achieve adequate outcomes for the prevention of falls (Gillespie et al., 2003). Multi-component exercise programs focusing on muscle strength, flexibility, balance, and walking as well as tai chi programs have been shown to reduce risks of non-injurious and injurious falls.

**Cognitive Function**

In the course of normal aging, the human brain begins to lose brain tissue during the third decade of life (Raz, 2000). Between the ages of 30 and 90, disproportionately high losses occur in the frontal, parietal and temporal cortices (Raz, 2000) with a closely matched pattern of decline in cognitive performance during this period (Park, Polk, Mikels, Taylor, & Marshuetz, 2001). Cardiovascular exercise has been associated with improved cognitive functioning in aging humans (Colcombe & Kramer, 2003; Kramer et al., 1999). Instruments such as the mini-mental state examination (MMSE) (Folstein, Folstein, & McHugh, 1975) and the modified mini-mental state (3MS) (Teng & Chui, 1987) examination have been used in research and clinical settings for identifying individuals with an elevated probability of having cognitive impairment. Since regular physical activity and exercise have been linked to enhanced psychological and psychosocial health for older adults, are changes in physical performance measures associated with changes in cognitive function for the older-old and oldest-old adults?
Risk Factors Associated with Cognitive Status

There is growing evidence supporting a strong and likely causal association between cardiovascular disease (CVD) and its risk factors with the incidence of cognitive decline and Alzheimer’s disease (AD) (Stampfer, 2006). Several cardiovascular risk factors that are also risk factors for dementia include hypertension, high low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), diabetes mellitus (DM), and obesity. Although a single mechanism explaining the relationship of CVD to cognitive decline and AD has not been established, three possibilities are most commonly suggested to explain this relationship (Launer, 2002). First, CVD and AD share the same risk factors (i.e., similar risk factors independently increase the rates of CVD and AD). Secondly, an indirect influence of vascular disease damages the brain creating conditions which predispose one to neurodegeneration. Finally, vascular risk factors could directly affect the development of AD by causing neuronal death and accumulation of plaques and tangles in the brain. Consistent evidence from epidemiological studies has established a relationship between many CVD risk factors and cognitive decline and AD; however, it is not clear whether the relationship is from shared risk factors or a direct or indirect influence of the CVD risk factors on the pathological processes that cause AD. More research is needed to establish a fuller understanding of the effect of CVD risk factors on cognitive decline and AD.
Long-Term Care Facilities and Exercise Programs

In the mid-1980s assisted living emerged along the long-term care continuum between independent living and skilled nursing facilities with the primary objective of providing any level of care needed by residents in the assisted living setting so that residents would not have to leave what had become their home (National Center for Assisted Living, 2001). Assisted living facilities are known by other common names throughout the country such as residential care, community-based retirement facilities, and retirement residences. Assisted living is needed by individuals when chronic conditions, trauma, or illness limits their ability to carry out basic self-care tasks known as activities of daily living (ADLs) such as bathing, dressing, or eating or instrumental ADLs (IADLs) such as household chores, meal preparation, or money management (Family Caregiver Alliance, 2009). In addition, some older adults that do not need assistance but enjoy the benefits of being around others find assisted living communities to be a welcome alternative to maintaining a house, preparing meals, and coping with inclement weather (MetLife Mature Market Institute, 2009).

It is estimated that by 2050 the number of individuals using paid long-term care services in any setting (i.e., at home, assisted living, skilled nursing facilities) will likely double from 13 million using services in 2000 to 27 million people (Family Caregiver Alliance, 2009). Of the older population in the community with long-term needs, about 1.5 million people have substantial long-term care needs defined as 3 or more ADL limitations. Additionally, 25% of those with substantial long-term care needs are 85 and
older, 70% self-report they are in fair to poor health, 32% have moderate to severe memory impairment, and 40% are poor or near poor defined as incomes below 150% of the federal poverty level. Despite a common definition for assisted living making it difficult to pinpoint the number of residences in the U.S., the National Center for Assisted Living approximates that 29,500 facilities are in operation with one million residents (MetLife Mature Market Institute, 2009). The “typical” elderly assisted living resident is an 86-year-old female who is ambulatory but needs assistance with one or two ADLs, and may need or accept some assistance with IADLs (National Center for Assisted Living, 2009). In an assisted living survey, residents on average reported needing help with 1.7 ADLs, 89% needed or accepted help with housework, and 80% needed or accepted help with daily medication (National Center for Assisted Living, 1999). Little is known concerning assisted living residents possibility due to privacy rights and state government regulations that vary from state to state (MetLife Mature Market Institute, 2009).

The National Health Interview Survey for January through March 2009 showed that 36.4% of U.S. adults aged 65-74 engaged in regular leisure-time physical activity while only 16.3% of those aged 75 or older were regularly active (Centers for Disease Control and Prevention, September 2009). In addition, women were less likely than men to engage in regular leisure-time physical activity. Results from a meta-analysis found that long-term physical activity is related to postponed disability and independent living in the oldest-old participants, and even those with chronic conditions can enhance
physical function with systematic participation in physical activities (Spirduso and Cronin, 2001). Exercise training programs conducted in retirement community settings have demonstrated that improvements in aerobic capacity, muscular strength, flexibility, balance/agility, and self-esteem can be gained. One such study (Sung, 2009) demonstrated improvements in lower body strength, hip flexibility, and balance with a music exercise program for older women while another study (Baum, Jarjoura, Polen, Faur, & Rutecki, 2003) found improvements in balance and agility with a seated exercise program that incorporated upper- and lower-body strength training. Studies (Baker et al., 2007; Vaitkevicius et al., 2002) that focused on enhancing aerobic capacity were generally designed for participants to train on exercise machines such as treadmills, steppers, or cycle ergometers.

**Exercise Training Programs and Physical Activity**

It is well established that health benefits can be derived from exercise training programs even for the older-old (i.e., 75 to 84 yrs of age) and oldest-old (i.e., 85 yrs of age and older) populations, however, the benefits derived must extend beyond medical endpoints of morbidity and mortality and include quality of life aspects such as social functioning and emotional well-being (King, Taylor, Haskell, & DeBusk 1990; Sallis et al., 1992). Physical activity patterns appear to be strongly influenced by social interactions with friends and spouses throughout the life span (King et al., 1990; Sallis et al., 1992). Additionally, self-efficacy or confidence in one’s abilities is strongly associated with both adoption and adherence to physical activity in older adults.
(Dzewaltowski, 1994; McAuley & Jacobson, 1991). When quality of life aspects are considered in the design and running of exercise training programs, the focus shifts from simply performing an act of meeting specific criteria for frequency, intensity and duration to performing physical activities that aid in maintaining or improving independent physical functioning (Mazzeo et al., 1998).

Older adults engage in physical activity to boost health and functional capacity rather than for aerobic fitness (Mazzeo & Tanaka, 2001). Recommendations for all adults are to accumulate 150 minutes/week or more of moderate-intensity physical activity and should include endurance exercise, strength training, stretching and balance routines (ACSM position stand, 2009; Nelson et al., 2007). Because many older adults reside in retirement communities that cannot accommodate multiple-day exercise programs, the 150 minutes/week may need to be accumulated by combinations of structured group exercise classes as well as independent physical activity. Although most studies have demonstrated the benefits of exercise training, some studies have suggested that training programs may hinder (Goran & Poehlman, 1992; Meijer, Westerterp, & Verstappen, 1999; Morio et al., 1998) the amount of habitual physical activity performed throughout the day in elderly people. Studies reporting decreases in the amount of independent physical activity performed when elderly subjects participated in exercise training programs suggested that the intensity of the training program was too high and the reduction in physical activity was a compensatory response to save energy (Goran & Poehlman, 1992; Morio et al., 1998; Westerterp & Meijer, 2001). Despite the effects on
spontaneous physical activity, exercise training programs have demonstrated positive
effects in developing and maintaining strength, flexibility, and cardiovascular fitness that
contribute to performance of activities of daily living in elderly populations (Goran &

**Purpose and Hypothesis**

The purpose of this investigation was to determine 1) whether a 6-month multi-
component structured exercise program of low-to-moderate intensity conducted 2 days a
week for 60 minutes a session (i.e., 120 minutes/week) along with continued habitual
physical activities could maintain or improve cardiorespiratory fitness, muscular strength,
flexibility, balance/agility, and body composition in adults 80 years of age and older with
mild cognitive impairment residing in an adult life-care community; 2) whether the
amount of self-reported habitual physical activities changed with the implementation of
the exercise program; and 3) whether the changes in physical performance measures
were associated with changes in cognitive function for participants in the program. It
was hypothesized that

1. Cardiorespiratory function and body composition would be maintained with
   regular attendance and active participation in the multi-component exercise
   program between pre- and post-test measures.

2. There would be improvements in muscular strength, flexibility and balance/agility
   with regular attendance and active participation in the multi-component exercise
   program between pre- and post-test measures.
3. There would be no changes in the amount of habitual physical activities with the implementation of the exercise program.

4. Changes in physical performance measures would be associated with changes in cognitive function as measured by the modified mini-mental state (3MS) examination in the elderly between pre- and post-test measures.
CHAPTER II
LITERATURE REVIEW

Distinctions exist between exercise prescriptions for aerobic fitness and for health and quality of life (Mazzeo & Tanaka, 2001). The optimum exercise stimuli to alter these respective variables are quite different. For the elderly, it has become more important to engage in physical activity to promote health and functional capacity rather than aerobic fitness. It has been suggested that perceived control, overall satisfaction and enjoyment may be key variables that become primary outcomes for the elderly to participate in physical activities (Rejeski & Mihalko, 2001). One such outcome is continued independent physical functioning.

The consensus public health message from the Center for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) (Pate et al., 1995) recommends “every U.S. adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week”. This exercise prescription (i.e., frequency, duration, and intensity) may be an important stimulus on health and functioning for older adults. Evidence of moderate physical activity is associated with a substantial drop in all-cause mortality (Blair et al., 1989); however, growing epidemiologic literature shows significant relationships between low- and moderate-intensity activities and reduced all-cause mortality (Fried et al., 1998). Since older adults seem to prefer low-to-moderate intensity exercise, they may be more
compliant in exercise recommendations (King, Haskell, Taylor, Kraemer, & DeBusk, 1991). Although there is considerable evidence supporting the value of physical activity in later years, few studies have been completed concerning the optimum exercise prescriptions for different age cohorts or for people with various health and mobility conditions (Rikli, 2000).

**Physiological Effects of Aging**

A healthy life encompasses a full continuum of functional capacity at each stage of life progressing from infancy to old age (Cheitlin, 2003). Despite the fact that the aging process affects all individuals, it is genetically programmed and can be modified by environmental influences causing the rate of aging to vary widely among people. Some age-related changes involve gradual declines in functional capacities that are due to biological senescence. Processes associated with age-related functional capacity are generally characterized by a loss of performance capabilities involving cardiovascular endurance, muscular strength, flexibility, and coordination (Hollmann et al., 2007).

**Cardiovascular**

Maximal oxygen uptake (VO$_2$max) or functional aerobic capacity represents the maximal rate of oxygen utilization by exercising muscles that measures the functional limit of the cardiorespiratory system (Saltin & Strange, 1991; Siconolfi, Garber, Lasater, & Carleton, 1985). VO$_2$max is an objective measure useful in assessing physical functional capacity and developing an exercise prescription (White & Evans, 2001). As
such, it can identify individuals who may have difficulty performing various functional
tasks (Ainsworth et al., 1993; Morey, Pieper, & Cornoni-Huntley, 1998b). The oxygen
uptake in females and males in the North American and European latitudes reach its
maximum at ages 16 and between 18 and 19, respectively, and remains stable to ages 30
to 35 years. On average, after age 35, VO₂ max declines about 8% per decade (Hollmann
et al., 2007). The decrease in VO₂ max is primarily caused by the reduction in maximum
cardiac output related to a decline in maximal achievable heart rate (Hollmann et al.,
2007). Partial compensation for the diminished cardiac output during sub-maximal
workload is attributable to an increase in arteriovenous oxygen (a-v O₂) difference
(Hollmann, 1965).

The physical structure of the heart changes with age. The aorta and arterial
system becomes thicker and less compliant with age which contributes to increases in
systolic blood pressure and greater demands on the heart (Fleg, 1986). A rise in
myocardial O₂ demand corresponds to the increased product of heart rate and systolic
blood pressure. The left ventricular wall increases in thickness approximately 30%
between the ages of 25 and 80 (Fleg, 1986; Lakatta, 1990). This change may be a
compensation mechanism for the age-related increase in systolic blood pressure.

A contributing factor for the decrease in maximal achievable heart rate occurs as
the heart and vasculature become less sensitive to stimulation by the catecholamine
hormones (Lakatta, 1986). This loss of sensitivity is a primary limiting factor in
cardiovascular performance during physical stress that occurs with aging regardless of
cardiovascular disease. Total peripheral resistance increases about 1% a year and is attributable to the increased rigidity of the arterial system and decrease in biochemical mechanisms of vasodilation. There is a decrease in the number of β-receptors in the arterial smooth muscles with aging; therefore, sensitivity to the effects of the catecholamine hormones is reduced. A consequence of this decrease is a chronic increase in mean arterial pressure (Lakatta, 1986).

**Skeletal Muscle**

Muscle mass is a function of the mean volume of muscle fibers (i.e., fiber length X fiber cross-sectional area (CSA)) and the number of fibers present in a specific skeletal muscle (Faulkner, Larkin, Claflin, & Brooks, 2007). After maturation, fiber length only changes in conjunction with significant hypertrophy or atrophy of the fibers for conditions that initiate increases and decreases in fiber length, respectively (Maxwell, Faulkner, & Hyatt, 1974). In addition, the number of fibers in a muscle do not increase; therefore, a change in the muscle mass of a specific muscle is the result of either a change in the CSA of individual fibers or a loss in the number of fibers (Gollnick, Timson, Moore, & Riedy, 1981). The muscle cross-sectional area reduction amounts to approximately 40% between ages 15 to 83 years of age (Lexell, Taylor, & Sjorstrom, 1988). In humans, atrophy and loss in the number of fibers contribute to decreases in muscle mass with aging. The amount of decrease in muscle mass is dependent on heredity and habitual levels of physical activity. Prior to the age of 50, noticeable losses in muscle mass are attributable to the loss of CSA of individual fibers due to a sedentary
lifestyle. Research conducted on men between the ages of 50 and 80 found that the number of fibers in the vastus lateralis decreased by 50% from 600,000 to 323,000 fibers. Although the precise mechanisms for such changes in skeletal muscles remain unknown, the major underlying cause of muscle fiber loss appears to be the loss of motor units (Campbell et al., 1973).

Due to the invasive nature investigating the mechanisms of age-related changes in skeletal muscles, rodent models (Brooks & Faulkner, 1988, 1991; Kadhiresan, Hassett, & Faulkner, 1996) have been used to provide evidence of such changes. In addition to the loss of motor units as a major factor in muscle atrophy, denervation atrophy of single fibers independent of the motor unit loss has been hypothesized (Andersson et al., 1993; Brown, Holland, & Hopkins, 1981). In rats, the loss of fast motor units leaves some fast fibers within a muscle denervated (Kadhiresan et al., 1996). These fibers get incorporated into the remaining slow motor units by axonal sprouting (Brown, Holland, & Hopkins, 1981) resulting in an increase in the innervation ratio (Kadhiresan et al., 1996). Fibers that do not become re-innervated undergo denervation atrophy and are eventually lost. The loss of motor units is roughly equal between rats (Cederna et al., 2001; Sugiura & Kanda, 2004) and human (Campbell et al., 1973; Doherty & Brown, 1993); however, the number of muscle fibers is not consistent. In humans, 50% of large limb muscles decrease by age 80 whereas hind limb muscles of rats show only a 5-10% loss of fibers of a comparable lifespan period (Daw, Starnes, & White, 1988; Larkin, Kuzon, & Halter, 2003).
The age-related reduction in muscular strength as measured by isometric, concentric and eccentric actions are dependent on the location within the body (i.e., upper vs. lower) (Spirduso et al., 2005). Significant reductions in static (i.e., isometric) muscle strength occur after age 60 (Doherty, 2003; Porter, Vandervoort, & Lexell, 1995) but then decline 1.0 to 1.5% per year up-to age 70 and 3.0% per year thereafter (Kallman et al., 1990; Vandervoort, 2002). Upper body extremities tend to change less with age than lower body extremities (Lynch et al., 1999). Concentric strength decreases with age in a manner similar to isometric strength, with the greatest losses occurring after age 70 (Spirduso et al., 2005). The loss of lower body strength below minimum strength thresholds places older adults in jeopardy of maintaining the ability to perform activities of daily living (Spirduso et al., 2005). Eccentric strength demands are substantially less affected by age-related strength loss than static and concentric muscle activities (Phillips, Brook, Siddle, Bruce, & Woledge, 1992; Vandervoort, Kramer, & Warran, 1990).

Sarcopenia is defined as age-related changes in skeletal muscle in the form of fat and connective tissue infiltration, reduction of muscular protein mass and cross-sectional area (Roubenoff, 2003). The major risk factor associated with sarcopenia is decreased physical activity, especially resistance training which has been associated with an accelerated loss of skeletal muscle mass with aging (Baumgartner et al., 1998; Walston & Fried, 1999; Zachwieja & Yarasheski, 1999). For most elderly people, the decrease in muscle mass (Lexell et al., 1988; Young, Stokes, & Crowe, 1985) accompanied by an equal or greater reduction in strength (Young, Stokes, & Crowe, 1985) and power
(Bassey et al., 1992) and an increase in muscle weakness (Brooks & Faulkner, 1994) and fatigue (Faulkner & Brooks, 1995) can significantly impact the activities of daily living.

The development of osteoporosis is favorable with the atrophy and loss of skeletal muscle mass since a nearly linear decline occurs between muscle strength and bone density (Hollmann et al., 2007). Pressure and tension as induced by strength training can positively influence bone, whereas endurance training such as running has proven to have little impact against osteoporosis (Seeman, 2003). Additionally, more than half of the bone fractures in the elderly could be avoided with regular strength training (Close et al., 1999; Tinetti, 2003).

**Endothelial Function**

The vascular endothelium is a single layer of cells that interact with circulating blood elements and various systems in the body (Vane, Anggard, & Botting, 1990). The endothelial function plays a vital role in vascular homeostasis by synthesizing and releasing a number of biologically active factors that regulate vascular tone, platelet aggregation, monocyte and leukocyte adhesion, thrombosis and smooth muscle. Vascular homeostasis is maintained through a critical balance between endothelial-derived relaxing and contracting factors (Laughlin, 1995; Moncada, Palmer, & Higgs, 1991). One such factor is nitric oxidize (NO) which plays a pivotal role in the regulation of vascular tone and in the sensitivity of the blood vessels. The endothelium is a primary target for injuries caused by mechanical strains and processes related to cardiovascular risk factors including the aging process (Celermajer et al., 1994), hypertension (Panza,
Quyyumi, Brush, & Epstein, 1990), dyslipidemia (Tawakol, Omland, Herhard, Wu, & Creager, 1997), carbohydrate metabolism disorders, and smoking (Celemajer et al., 1996). Vascular injury of the endothelial function results in reductions in the bioavailability of endothelial NO and induces endothelial dysfunction (Anderson, 1999). As a result, inflammation, vasoconstriction, blood vessel muscle cell proliferation, platelet activation, leukocyte adhesion, mitogenesis and thrombogenesis can occur (Cooke & Tsao, 1994; Libby, Ridker, & Maseri, 2002). There is accumulating evidence that endothelial dysfunction is the earliest events in the pathogenesis of cardiovascular disease (Gordon et al., 1989; Reddy, Nair, Sheehan, & Hodgson, 1994).

A non-pharmacological therapeutic measure to prevent the age-related changes of endothelial function is regular physical endurance training (Rinder, Spina, & Ehsani, 2000). In addition, a malfunctioning endothelial function related to atherosclerosis can be reversed with regular endurance training (Hambrecht et al., 1993). During dynamic muscular work, the increased blood flow enhances shear force and in conjunction with the metabolic effect of the erythrocytes, enhanced NO production results in increased vasodilation (Bloch & Schmidt, 2004). This also increases the mRNA expression of nitric-oxide synthase (NOS) which leads to enhanced synthesis and release of NO (Woodman, Muller, Laughlin, & Price, 1997).
Cognitive Function

The structure and function of the central nervous system is also affected by the aging process (Friedman, 2000; Haug et al., 1983; Haug & Eggers, 1991). The shrinkage of the frontal cortex and the hippocampus provokes the deterioration of brain performance with age (Albert, Duffy, & Naeser, 1987; Golomb et al., 1993; Squire, 1987). Of particular concern, is the decomposition of neurons, dendrites, spines and reductions in synapses. Spines which are stable structural extensions of the synapse are the areas involved in short-term memory. These reductions affect the quality of short-term memory which is the first functionally noticeable age modification of the brain. Furthermore, reduced blood flow to the brain due to narrowing of the arteries and less growth of new capillaries has been associated with the aging process (National Institute on Aging, 2009, May).

Animal models suggest that aerobic training in aging animals can increase levels of key neurochemicals that can improve plasticity and neuronal survival. The neurochemicals, brain-derived neurotrophin factor (BDNF) (Neeper, Gomez-Pinilla, Choi, & Cotman, 1995) and serotonin (Blomstrand, Perrett, Parry-Billings, & Newsholme, 1989) together with decreased levels of corticosteroid can increase cell proliferation rates in aged animals (Cameron and McKay, 1999). One study (Colcombe et al., 2003) on humans found that older adults with greater levels of cardiovascular fitness suffered significantly less loss of gray matter in the frontal, temporal, and parietal lobes and significantly less loss of tissue in the anterior and posterior white matter tracts.
The influence of age-related degenerative processes of the brain through physical and mental training is based on a multitude of factors (Tong, Shen, Perreau, Balazs, & Cotman, 2001). Studies examining 5000 genes in the hippocampus of rats established that a 3-week training program led to significant changes in the gene expressions of numerous genes. Many of these genes were involved in synaptic function and plasticity. Membrane and neurotrophic factors were involved as well as genes responsible for vesicle recycling or neuron and synaptic growth.

The function of the brain can be maintained at a high level into old age by the processes of neurogenesis and angiogenesis (Eriksson et al., 1998). Findings have demonstrated that physical activity predominantly influences the prefrontal cortex and the hippocampal regions although non-neuronal tissue reacts positively to training (Churchill et al., 2002).

**Studies of Age-Related Affects of Physical Inactivity**

The effects of physical inactivity were acknowledged as a major public health problem during the World War II era (Rice, Hutchinson, & Lee, 1958), although it was not recognized as a major risk factor for coronary heart disease until 1992 (Fletcher et al., 1992). Early studies that evaluated the effects of inactivity focused on demanding vs. sedentary occupational work (Paffenbarger, Laughlin, Gima, & Black, 1970; Salonen, Slater, Tuomilehto, & Rauramaa, 1988), high vs. low exercise intensity (Siscovick, Weiss, Fletcher, & Lasky, 1984; Slattery & Jacobs, 1988), and active vs. sedentary individuals (Kaplan, Strawbridge, Cohen, & Hungerford, 1996; Morris, Pollard, Everitt,
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& Chave, 1980; Paffenbarger et al., 1993). The results of such studies, as well as more recent studies (Hahn, Heath, & Chang, 1998; Hankey, Jamrozik, Broadhurst, Forbes, & Anderson, 2002; Hays & Clark, 1999; Hootman, Macera, Ham, Helmick, & Sniezek, 2003), have clearly demonstrated that physical inactivity is associated with increased risk for certain chronic diseases. Since the prevalence of chronic disease increases with age (Hardman & Stensel, 2003), physical activity may play a role in reducing the risk of many health problems associated with aging (Blair et al., 1996). The primary health problems associated with physical inactivity include cardiovascular disease (Hahn et al., 1998), stroke (Hankey et al., 2002), arthritis (Hootman et al., 2003), and diabetes (Hays & Clark, 1999). The average person will experience a minimum of three chronic conditions by age 75 that require medical attention and medication (American Association of Retired Persons, 2004). In addition, these chronic conditions can have adverse affects on the quality of life resulting in illness, disability, and major limitations in daily living (Ramey et al., 2008).

Chronic disease such as heart disease, cancer, and diabetes are leading causes of disability and death in the United States (Centers for Disease Control and Prevention, 2005, December). Every year, these diseases claim the lives of more than 1.7 million people. In addition, these chronic diseases result in major limitations in daily living for more than 25 million people. In a longitudinal study analyzing the impact of physical inactivity from middle age to early old age (i.e., 50 to 70 years of age, respectively) on functional ability at age 75, no relationship was found between inactivity at age 50 and
disability in a 25-year follow-up, no relationship was found at 60 years of age between inactivity and disability at age 75 except among persons with higher education (i.e., > 7 years), and a strong association between physical inactivity at age 70 and disability at age 75 was found (Christensen, Stovring, Schultz-Larsen, Schroll, & Avlund, 2006). This disability finding may be due to the reduction in muscle strength related to the effects of aging that accelerate after the age of 60 years (Porter et al., 1995).

The incidence of functional limitations can place older adults at risk of loss of independent physical functioning which is an important priority (Rejeski & Mihalko, 2001). Functional limitations are important risk factors for subsequent disability which can result in institutionalization and loss of independent living for older adults (McAuley et al., 2007). Physical activity plays an important role in the disablement process by offering a beneficial effect on functional limitations. Evidence from a pilot study on lifestyle interventions and independence in an elderly population suggests that physical activity can significantly reduce the incidence of functional limitations and disability (Morey et al., 2006). In addition, self-efficacy, which is the belief in the ability to successfully perform a specific task (Bandura, 1997), is an important social cognitive variable that can mediate the physical activity and functional limitation quandary (Keysor, 2003). In a longitudinal study designed to measure the role of self-efficacy and physical functional performance in older women with functional limitations, increases in physical activity over time were associated with greater improvements in self-efficacy,
which was associated with improved physical functional performance and fewer functional limitations (McAuley et al., 2007).

For most individuals, aging is accompanied with a general decline in cognitive function (Bugg, Zook, DeLosh, Davalos, & Davis, 2006; Salthouse, 2004). Another aspect of aging is the decline in physical activity (Taylor et al., 2004). From a “health-in-old age” perspective, this is an unfortunate choice of lifestyle since regular physical activity and exercise has been linked to enhanced physiological, psychological, and psychosocial health for older adults (Netz, Wu, Becker, & Tenenbaum, 2005; Taylor et al., 2004). Regular physical activity is important in an overall health promotion (Larson & Wang, 2004) and may also be an effective strategy for delayed cognitive decline and the possible onset of dementia (Pate et al, 1995). From a physiological view, physical activity and exercise may preserve brain function by improving cerebral blood flow and oxygen delivery (Rogers, Meyer, & Mortel, 1990) and inducing fibroblast growth factor in the hippocampus (Gomez-Pinilla, So, & Kesslak, 1998). Recent evidence on the aging brain suggests that reduced loss of hippocampal brain tissue is related to the level of physical fitness (Colcombe et al., 2003). Although reviews and recent studies suggest the notion that physical activity may be protective of future cognitive decline and risk of dementia (Fratiglioni, Paillard-Borg, & Winblad, 2004; Larson et al., 2006; Rovio et al., 2005) few studies have investigated the correlation between change in exercise status over time and cognitive function.
Despite the scientific evidence and recommendations to participate in physical activity, only 24.7% of adults ≥ 55 years of age are regularly physically active (Schoenborn, Vickerie, & Powell-Griner, 2006). Healthy People 2010 is a national objective to reduce the proportion of adults who engage in no leisure-time physical activity to 20% (U.S. Department of Health and Human Services, 2000). This objective aims to minimize age-related decreases in functional independence by increasing levels of physical activity even in later life that can improve lung capacity, bone density, muscle structure and function, and balance.

**Patterns of Physical Activity in Cross-Sectional Studies**

Despite evidence supporting the positive effects of exercise on health and quality of life, cross-sectional studies involving older adults, ethnic, and gender differences have found varying exercise patterns. Cross-sectional data in older adults have consistently shown exercise-related weekly energy expenditure to be significantly lower in older age groups when compared to younger groups for Caucasians (Siscovick et al., 1997; Stofan, DiPietro, Davis, Kohl, & Blair, 1998) and for African-Americans (Folsom et al., 1991). Data in a comprehensive descriptive analysis of participation in regular physical activity from the National Health Interview Survey 2002 (NHIS), Behavioral Risk Factor Surveillance System (1994-2004) (BRFSS), and National Health and Nutrition Examination Survey (1999-2004) (NHANES) have reported that only 36% of African-American men and 26% of African-American women meet the recommended amount of regular physical activity of 30 minutes of moderate-intensity activity 5 day/week or 20
minutes of vigorous-intensity activity 3 days/week with the older age groups reporting the lowest percentages (Whitt-Glover, Taylor, Heath, & Macera, 2007). Age-specific studies comparing racial/ethnic differences in leisure-time physical activity levels have shown men have higher energy expenditure than women, Caucasian men have higher mean energy expenditure compared to African-American men, and Caucasian women have greater energy expenditure than African-American women (Folsom et al., 1991). In a gender-specific study (Ransdell & Wells, 1998), it was found that only a small percentage of women of all ethnicities participate in the recommended level of physical activity and there was little difference between race/ethnicity (i.e., 8% African-American, 11% Mexican-American, 13% Caucasians).

**Studies on the Effects of Physical Activity in Older Adults**

With the surging growth of older people, government agencies; gerontology researchers; and health practitioners have been finding ways to extend people’s active life expectancies and reduce their disabilities (Rikli & Jones, 2001). Research studies have suggested that age-related loss in physical function could be prevented or reduced with emphasis on lifelong fitness (Fiatrone & Evans, 1993; Freedman et al., 2002). Even nonagenarians have experienced dramatic benefits from beginning exercise programs (Fiatrone & Evans, 2002). Over time the number of physical activity measurement techniques has expanded to include commonly used exercise equipment and testing protocols based on the populations being tested. Specific testing protocols have been developed to assess functional capacity of non-frail older adults who are living
independently but their declining fitness levels put them at risk of losing functional independence (Rikli & Jones, 2001). The following is a brief review of some common physical activity measurement techniques utilized in accessing aerobic capacity, muscular strength and endurance, flexibility and balance. In addition, epidemiological and longitudinal, field and clinical, energy expenditure, assisted living and retirement community, cognitive function and physical activity, and risk factors associated with cognitive status studies of older and elderly adult populations will be reviewed.

Measurement Modalities

A variety of modalities and protocols have been validated and accepted as reliable instruments to measure aerobic capacity, muscular strength and endurance, flexibility, balance, and body composition in clinical and research settings. Cardiovascular endurance has commonly been assessed with methods including the treadmill, bicycle ergometer, bench step tests, Cooper 12-minute or 1.5-mile running time tests, and the Rockport one-mile walking test (ACSM, 2009). In addition, muscular strength has commonly been evaluated with the 1-repetition maximum (1RM) strength test and flexibility has been assessed with the sit-and-reach test performed on the floor. These techniques were developed and validated for younger populations and may be inappropriate and unsafe for many older adults (Chandler & Hadley, 1996; Chodzko-Zajko, 1994; Fried et al., 1996; Rikli & Jones, 1997; Verbrugge & Jette, 1994). The burden of chronic conditions and physical limitations may preclude the use of these
techniques for older population. Furthermore, many of these modalities require expensive equipment and are not transportable for field testing.

The Senior Fitness Test (SFT) is a battery of performance tests designed to assess the major underlying physical parameters associated with functional mobility in independent older adults aged 60 to 90 and older (Rikli & Jones, 2001). This battery of test items includes aerobic endurance, upper- and lower-body strength, upper- and lower-body flexibility, and agility/dynamic balance. The SFT requires minimal equipment and space making it a very adaptable testing method in both clinical and community (i.e., non-laboratory) settings for older adults.

Exercise is frequently prescribed to the elderly to improve body composition, enhance energy expenditure, and increase functional independence (Goran & Poehlman, 1992). Westerterp (1998) reviewed studies on the effect of training programs on average daily metabolic rate measured using the doubly labeled water method on children, young adults and the elderly. In children (Blaak, Westerterp, Bar-Or, Wouters, & Saris, 1992) and young adults (Bingham, Goldberg, Coward, Prentice, & Cunnings, 1989; Van Etten, Westerterp, Verstappen, Boon, & Saris, 1997; Westerterp, Meijer, Janssen, Saris, & Ten Hoor, 1992) the size of the changes in energy expenditure associated with physical activity was on average twice the energy cost of the exercise training intervention. However, in the elderly the endurance training program did not change total energy expenditure. It was suggested that the intensity of the training program may have been
too high and resulted in a decline in non-training physical activity (Goran & Poehlman, 1992).

Clinical studies investigating cognitive screening tests began in the 1960s, and more than 10 instruments have been reported in English literature searches (LaMarre & Patten, 1991). The specific instrument used depends on the purpose of the evaluation. Two of the most commonly used instruments for evaluating cognitive status are the mini-mental state examination (MMSE; Folstein et al., 1975) which is used to serially measure change in cognitive status, and the modified mini-mental state (3MS) examination (Teng & Chui, 1987) which represents an extension of the MMSE that samples a broader variety of cognitive functions and covers a wider range of difficulties. Both examinations are valid and reliable; however, the reliability and validity of the 3MS was enhanced over that of the MMSE by the addition of four test items that assess a broader range of difficult levels and cognitive domains, increased range of possible scores (0-100), and the development of a standardized scoring system that permits partial credit on specific test items (Bravo & Hebert, 1997; Teng & Chui, 1987).

**Epidemiological and Longitudinal Studies**

Many studies initiated to evaluate a broad population base including young adults (age 40 to 64 years), young-old (age 65 to 74 years), older-old (age 75 to 84 years) and oldest-old (age 85+ years) adults have been conducted; however, older-old and oldest-old adults may be under-represented due to the modality used to measure physical
performance. Epidemiological and longitudinal studies will be reviewed in this section and summarized in Table 1.

In an epidemiological study, Hollenberg et al., (1998) demonstrated the feasibility of obtaining comprehensive cardiorespiratory measurements during exercise in a large number of elderly subjects. A linear age-related decline was found in both women and men for total duration of exercise, peak oxygen consumption, and peak heart rate. The difference in VO$_2$peak ml/kg·min$^{-1}$ between groups (i.e., 5-year age grouping 55-59, 60-64…>85 yrs) was greatest before age 65 years, narrowed with advancing age and disappeared after age 80 years. In women age groups from 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, >85 for total duration of exercise ranged from 13.61±4.1 to 7.92±4.0 minutes, VO$_2$peak normalized to total body mass ranged from 24.5±5.5 to 18.0±6.0 ml·O$_2$/kg total body mass/minute, and peak heart rate ranged from 159±17 to 131±13 beats per minute (bpm). For men age groups, total duration of exercise ranged from 16.79±4.1 to 7.50±3.0 minutes, VO$_2$peak normalized to total body mass ranged from 30.3±5.9 to 18.3±2.0 ml·O$_2$/kg total body mass/minute, and peak heart rate ranged from 161±15 to 122±5 bpm, respectively. Results from this study demonstrated decline in exercise duration, VO$_2$peak, and peak heart rate with aging. One major problem found in exercise testing elderly subjects was defining what is acceptable as a maximal or near maximal effort. Borg scores revealed that many of the subjects who stopped the treadmill test at low workloads did not feel that they were exerting themselves very hard at the point of test termination. Furthermore, 21% of women and 10% of men failed to
achieve a respiratory exchange ratio (RER $\geq 1.00$) despite exercising for considerable periods of time and only 33% of women and 53% of men achieved a RER $\geq 1.10$ which was considered a maximal effort.
Table 1

*Epidemiological and Longitudinal Studies in Older Adults*

<table>
<thead>
<tr>
<th>Reference</th>
<th>Test Method</th>
<th>Number of Subjects</th>
<th>Testing Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollenberg et al.,</td>
<td>Treadmill</td>
<td>N=1101</td>
<td>438 male &amp; 663 female subjects; ages 55-94</td>
</tr>
<tr>
<td>(1998)</td>
<td></td>
<td></td>
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<tr>
<td>Katzel et al.,</td>
<td>Treadmill</td>
<td>N=42 exercisers</td>
<td>42 male athletes - ages 63.4±1.0 at baseline; 71.4±1.1 at follow-up; 47 sedentary males - ages 61.1±0.9 at baseline; 70.4±0.9 at follow-up</td>
</tr>
<tr>
<td>(2001)</td>
<td></td>
<td>N=47 sedentary</td>
<td></td>
</tr>
<tr>
<td>Morey et al.,</td>
<td>Treadmill hand-held dynamometry &amp;</td>
<td>N=73 baseline</td>
<td>68 males and 5 females ages 64-90</td>
</tr>
<tr>
<td>(1996)</td>
<td>goniometry</td>
<td>N=36 follow-up</td>
<td></td>
</tr>
<tr>
<td>McCartney et al.,</td>
<td>1-RM cycle ergometer treadmill</td>
<td>N=142 baseline</td>
<td>Ages 60-70; male: 15 exercisers &amp; 14 controls female: 14 exercisers &amp; 15 controls</td>
</tr>
<tr>
<td>(1996)</td>
<td>stair climbing</td>
<td>N=113 follow-up</td>
<td>Ages 70-80; male: 14 &amp; 7 – female: 14 &amp; 20 respectively</td>
</tr>
<tr>
<td>Stevens et al.,</td>
<td>Side-by-side stand semi-tandem</td>
<td>N=998</td>
<td>Age groups: 65-69, 70-74, 75-79, 80+</td>
</tr>
<tr>
<td>(2008)</td>
<td>stand full-tandem stand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austin et al.,</td>
<td>Timed-up and go test</td>
<td>N=1,282</td>
<td>Females ages 70-85</td>
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<tr>
<td>(2007)</td>
<td></td>
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<tr>
<td>Reference</td>
<td>Test Method</td>
<td>Number of Subjects</td>
<td>Testing Population</td>
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<tr>
<td>Sternfeld et al., (2002)</td>
<td>BIA walking speed, handgrip</td>
<td>N=2,092</td>
<td>947 females and 708 males ages 69-70</td>
</tr>
<tr>
<td>Dey et al., (2009)</td>
<td>BIA handgrip, elbow flexion, knee &amp; trunk extension, trunk flexion</td>
<td>N=87</td>
<td>38 males and 49 females ages: 75 at baseline &amp; 80 at follow-up</td>
</tr>
<tr>
<td>Visser et al., (2002)</td>
<td>Timed-up and go test, chair-stand test</td>
<td>N=2,109</td>
<td>988 males and 1121 females 782 = age &lt; 65, 688 = age 65-74, 639 = age ≥ 75</td>
</tr>
</tbody>
</table>

1-RM = 1-repetition maximum

BIA = bioelectrical impedance
Katzel et al., (2001) compared the longitudinal changes in VO2max in healthy older athletes and sedentary men. The longitudinal decline in VO2max in older male endurance athletes (age: baseline 63.4±1.0; follow-up 71.4±1.1 years) was found to be highly dependent on the magnitude of continued training stimulus. Forty-two athletes were stratified into 4 groups (high, moderate, low, non-cardiac disease) based on training regimens and 47 sedentary men (age: baseline 61.1±0.9; follow-up 70.4±0.9 years) served as controls. The high training group reduced their running distance from 31 to 27 miles per week at a mean pace from 8.5 to 8.75 minutes per mile with an associated reduction in VO2max from 51.3 to 48.6 ml/kg·min\(^{-1}\) (.58% change in VO2max per year) over a 6 years follow-up. The moderate group decreased from 33 to 23 miles per week at a mean pace from 8.5 to 10.2 minutes per mile with a decrease in VO2max of 2.65% per year over 9 years of follow-up. The low group ran 34 miles per week at a mean pace of 8.7 minutes per mile at baseline and at follow-up none of the group ran any longer but did continue other physical activities and had a 4.1% per year decrease in VO2max. The non-cardiac group no longer trained and had a 4.7% per year decrease in VO2max at follow-up. The sedentary group resulted in a longitudinal decline in VO2max of 1.5% per year. The greatest longitudinal decline in VO2max was observed in individuals who were unable to maintain high training levels. Only 7 of the 42 individuals trained at a vigorous level at follow-up. These results underscore the difficulty of maintaining high levels of aerobic training and VO2max into their eight decade of life even for motivated older athletes.
In a five-year study, Morey et al., (1996) measured physical performance and the impact of disease on performance in cardiovascular fitness, musculoskeletal strength and flexibility in older adults (i.e., 69.0±4.4 years, range 64 to 90). It was found that older individuals could develop and maintain significant improvements in physical performance for at least 2 years. Individuals with a previous history of cardiovascular or musculoskeletal disease were found to have the same gains in performance as disease-free individuals. Participants improved in cardiovascular fitness until the second year and then declined. The results for musculoskeletal strength also increased for 3 years and then showed significant decline. Flexibility was evaluated using 2 range of motion (ROM) factors with ROM-1 focusing on ankle dorsiflexion, hip flexion and shoulder abduction and ROM-2 focusing on hamstring length. Participants disease-free or with cardiorespiratory disease demonstrated modest increases in ROM-1 flexibility for 2 to 3 years then gradually declined; however, participants with baseline musculoskeletal disease showed a significant decrease over the study period. All participants regardless of disease status demonstrated a significant increase in ROM-2; furthermore, participants with one or more baseline diseases, experienced continued gains in flexibility over the 5-year study period. These results demonstrated that older adults regardless of disease state can achieve significant gains in cardiovascular fitness, muscular strength and flexibility that can be sustained for 2 to 3 years before returning to baseline levels.

In a two-year longitudinal study, McCartney, Hicks, Martin, & Webber (1996) examined the effects of a consecutive 42 week/year progressive weight-training program
with a 2-month break between years on a population of 60 to 80 year olds. The 2-day/week weight-training program initially consisted of 2 sets at 50% of 1-RM for each exercise and progressed in a few weeks to 3 sets at 80% of 1-RM. In addition to measuring weight training capacity, peak power output using a cycle ergometer, and cardiovascular capacity using a treadmill and stair climbing equipment was also assessed. Training groups demonstrated substantial gains in arm curl, military press, bench press, and leg press. In all exercises males were significantly stronger than females; older decade subjects were weaker than younger subjects, and no effect for age was found for power output and treadmill capacity. After the 2 month weight training break, there was an overall decrease of 8% in 1-RM which remained for the second year of the program. Significant increases were found in treadmill capacity and stair climbing endurance between the weight-training group vs. the control group. Overall increases in cross-sectional area of the knee extensors confirmed the effectiveness of the weight training program. These results suggest that ongoing weight training in the elderly may be an excellent method of counteracting the losses in strength normally associated with aging. The added benefit of weight training in the elderly may increase endurance in functional tasks involving the trained muscles.

In an epidemiology study, Stevens, Lang, Guralnik, & Melzer (2008) identified factors specifically associated with poor performance in well-validated balance tests, or with self-reported problems with dizziness, in disability-free older adults 65 and older. Static balance was evaluated in three separate and progressively more difficult tests.
including side-by-side stand, semi-tandem stand, and full-tandem stand. Dizziness was evaluated as a self-reported problem. The prevalence of poor balance and dizziness was higher in women than men; but the prevalence rates rose with age only for balance impairment. There was a strong association between increasing age and poor balance for those 80 and older compared to those 65 to 69 years of age. For poor balance, heightened risk was associated with increasing age, having diabetes, arthritis, poor vision, low grip strength, low socio-economic status, and light (i.e., 7.9 grams of alcohol or < 1 drink/week) or none drinkers. In contrast to poor balance, dizziness was not associated with increasing age. These findings suggest a connection between poor balance with age and age-related physiological changes and the need for interventions to address the prevention of falling.

In a longitudinal investigation, Austin et al., (2007) studied the incidence and predictors of new and persistent fear of falling (FOF) in ambulatory women aged 70 to 85 over a 3 year period. Women with persistent FOF were older, had higher body mass index (BMI), higher consumption of medication for depression and hypertension, higher prevalence of cognitive impairment and depression, a greater likelihood of living alone, slower timed-up and go times, worse balance scores, less physical activity, more reported falls, and more walking aid use. Only the baseline characteristics, obesity (BMI 28.2±5.0) and poor performance on the timed-up and go (baseline: quintile 4: 9.9-11.3 seconds; quintile 5: >11.4 seconds) test, which is a composite measure of balance and mobility, were predictors of the new onset of FOF. This study suggests that FOF is the
initial consequence of mobility impairment and that early intervention is needed for prevention.

In another epidemiological study, Sternfeld, Ngo, Satariano, & Tager (2002) assessed the cross-sectional associations of physical function with levels of fat and lean mass independent of each other and explored the relation of fat distribution to physical performance and functional limitations in a group of men and women 69 to 70 years of age. In both men and women higher fat mass and waist circumference were associated with slower walking speeds and a greater likelihood of functional limitations. These observations are consistent with the Framingham Heart Study (Visser, Harris, et al., 1998a) and Cardiovascular Heart Study cohort (Visser, Langlois, et al., 1998b) which found a higher percentage of body fat, but not lean mass, associated with an increased risk of self-reported disability. Additionally, lean mass was directly associated with strength although the magnitude of the association decreased as fat mass increased in women and increased as age increased in men. The findings from this study, along with other studies (Visser, Harris, et al., 1998a; Visser, Langlois, et al., 1998b) suggest that the accumulation of body fat may be more predictive of poor physical performance, functional limitations and subsequent disability and mortality than loss of muscle mass. Fat distribution, measured as waist circumference, was associated with decreased walking speed and an increased likelihood of self-reported limitations and with decreased grip strength in leaner women and older men. This finding implies that central adiposity negatively impacts physical functioning independent of levels of lean mass and fat mass.
In a 5-year study, Dey, Bosaeus, Lissner, & Steen (2009) explored the longitudinal changes in body composition and isometric muscle strength in baseline 75 year old men and women with follow-up after 5-years at age 80. Body composition was assessed using BIA, height, body weight, and waist circumference. Isometric muscle strength was measured using handgrip, arm flexion, knee extension, trunk flexion and extension. Body fat increased and fat-free mass (FFM) and total body water significantly decreased in both genders. Maximal isometric muscle strength decreased for handgrip, elbow flexion, knee extension, trunk flexion and extension with more prominent declines in men compared to women. The maximal isometric muscle strength significantly decreased in both genders over the 5-year follow-up with more prominent declines in lower extremity and trunk muscle strength. The decrease in lower body muscle strength (i.e., knee extension) was significantly correlated with baseline FFM index suggesting that the change in leg strength is directly related to change in muscle mass.

In a 3-year longitudinal study, Visser, Pluijm, Stel, Bosscher, & Deeg (2002) examined whether physical activity (i.e., total physical activity, sports activity and daily activity such as walking and household activities) was a determinant of future changes in mobility performance in men and women 55 to 85 years of age. The 3-year change in physical activity declined from baseline to follow-up with 29% of the study population reducing more than 1 hour/day and 14.6% decreasing more than 2 hour/day. Only 53.4% of the participants that reported sports activity at baseline continued to participate at follow-up. The study population experienced a 45.6% decrease in mobility performance.
Individuals that had a steady activity pattern during follow-up (change in total physical activity 0 to 1.0 hour/day) demonstrated the smallest decline in mobility performance. Changes in mobility performance were not different for healthy participants compared to those with one or more chronic diseases at baseline. Overall, higher physical activity levels were associated with smaller declines in mobility performance. Furthermore, participants who spent more time on daily activities such as walking and household activities experienced smaller declines in mobility performance. Thus, older individuals who are unable to participate in vigorous activities can achieve benefits from less intensive activities that may aid to slow down mobility decline.

**Field and Clinical Studies**

Several studies that have utilized the Senior Fitness Test (SFT) for older adults will be reviewed in this section and are summarized in Table 2.

Cavani, Mier, Musto, & Tummers (2002) assessed the effectiveness of a 6-week combined stretching and moderate volume (i.e., one set of 12-15 repetitions) resistance training program on the performance of functional fitness in males and females aged 60 to 79. The training program resulted in significant improvements in the arm curl, back scratch, chair stand, chair sit-and-reach, and 8-foot up-and-go tests but no significance was found for the 6-minute walk. The number of arm curl repetitions increased 24% in the training group compared to 5% for controls. Likewise, increases for chair stand (30% vs. 4%), 8-foot up-and-go (15% vs.1%), back scratch (1.3 vs. -0.1 inches) and chair sit-and-reach (2.28 vs. -0.5 inches) tests, respectively, were demonstrated. In addition to the
increases in individual functional fitness, improvements in agility and walking velocity were observed in the 8-foot-up-and-go which could be due to the crossover effects from training in other domains. The results from this study suggest that resistance training does not need to be high intensity and can be one single set of 12-15 repetitions of moderate resistance to improve functional fitness in relatively healthy older adults.

Toraman, Erman, & Agyar (2004) compared the effects of a 9-week multi-component exercise program on functional fitness and body composition on an exercise group versus a control group of males and females 65 to 80 years of age with MMSE scores ≥ 20. At baseline, all participants were classified as having intermediate functional ability, and low levels of physical activity although the exercise group had significantly greater distances in the 6-minute walk compared to the control group. The exercise group demonstrated a 32% increase in the arm curl versus 0.03% decrease in the control group. The chair stand was 89% increase versus 16%, 8-foot up-and-go was 26% increase versus 7%, and 6-minute walk was 14% increase versus 2%, respectively. The training program did not significantly affect the back scratch, chair sit-and-reach, BMI, body fat percentage, fat-free mass, and waist-to-hip ratio suggesting the program may have been too short in duration. The results of this study suggest that older, low-to-sedentary adults with or without chronic diseases can improve their functional fitness primarily in upper and lower extremity strength, aerobic endurance, and balance.
### Table 2

*Field and Clinical Studies in Older Adults*

<table>
<thead>
<tr>
<th>Reference</th>
<th>Test Method</th>
<th>Number of Subjects</th>
<th>Testing Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavani et al., (2002)</td>
<td>SFT</td>
<td>N=22 exercise</td>
<td>Exercise group: 8 males, 14 females ages 60-79 (69±1 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=15 control</td>
<td>Control group: 6 males, 9 females ages 60-75 (70±4 yrs)</td>
</tr>
<tr>
<td>Toraman et al., (2004)</td>
<td>SFT, waist-to-hip ratio BMI</td>
<td>N=21 exercise</td>
<td>Exercise group: 17 males, 4 females ages 65-80 (72.5±7.4 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=21 control</td>
<td>Control group: 18 males, 3 females ages 66-79 (72.3±6.0 yrs)</td>
</tr>
<tr>
<td>DiBrezzo et al., (2005)</td>
<td>SFT, BMI, MMSE</td>
<td>N=16 exercise</td>
<td>Exercise group: 3 males, 13 females ages 60-92 (74.9±8.8 yr)</td>
</tr>
<tr>
<td>Takeshima et al., (2007)</td>
<td>SFT, waist-to-hip ratio BMI</td>
<td>N=92 exercise</td>
<td>Total participants: 64 males, 49 females ages 64-81 (73±6 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=25 control</td>
<td></td>
</tr>
<tr>
<td>Cyarto et al., (2008)</td>
<td>SFT</td>
<td>N=167</td>
<td>Exercise group: 35 males, 132 females ages 65-96 (78.8±6.4 yr)</td>
</tr>
</tbody>
</table>

SFT = Senior Fitness Test  
BMI = Body Mass Index  
MMSE = Mini-Mental State Examination
In a 10-week exercise intervention, DiBrezzo, Shadden, Raybon, & Powers (2005) evaluated the effectiveness of a muscular strength, flexibility and balance program for older men and women aged 66 to 84. Significant improvements were observed in the 8-foot up-and-go, chair stand, arm curl, and back scratch tests. It was suggested that strength training both the anterior and posterior leg muscles may have contributed to improvements on the 8-foot up-and-go test which measures dynamic balance and agility and chair stand which measures lower body strength. No significant improvements were demonstrated in the 6-minute walk and chair sit-and-reach tests. The program was designed to increase range of motion and improvements were observed in both upper and lower body flexibility although only upper body gains were significant. No statistical difference was found between pre- and post-test scores on the MMSE and scores reported for both pre- and post-tests were ≥ 25. Although no measurable improvements in cognitive skills were observed, participant’s altitude about exercise in general improved which can lead to benefits associated with social interaction.

In a 12-week field study, Takeshima et al., (2007) compared the pre- and post-test effects of participants assigned to one of five exercise groups including aerobics, resistance training, balance, flexibility, or Tai Chi or assigned to a control group on functional fitness in older males and females aged 64 to 80. Improvements were found in the arm curl, chair stand, 8-foot up-and-go, functional reach and 12-minute walk tests for the exercise groups compared to the control group. Cardiorespiratory fitness, tested with the 12-minute walk, significantly improved only in the aerobics group (16%) compared
to all other groups. Upper-body strength, measured by the arm curl test, was significantly improved in the resistance training (31%), balance (20%), and Tai Chi (25%) groups compared to the other groups. Lower-body strength, assessed by the chair stand test, was significantly improved with the greatest improvements in the balance group (40%), and no difference between the resistance (33%) and Tai Chi (34%) groups. The resistance training (10%), balance (10%), and Tai Chi (12%) groups significantly improved in the 8-foot up-and-go test which measured balance/agility. The functional reach test which also measured balance/agility was significantly improved for the aerobics (13%), balance (16%) and resistance training (15%) groups. No significant improvements were found for upper- and lower- body flexibility which used the back scratch and sit-and-reach tests, respectively. The results from this study suggest that the components of training can crossover into domains not specifically targeted for their design.

In a 20-week investigation, Cyarto, Brown, Marshall, & Trost (2008) evaluated and compared the effectiveness of home-based versus group-based resistance training (RT) programs compared to walking groups in nine retirement communities for males and females aged 65 to 96 years. No significant differences were found across the three groups for baseline data. Attendances for the programs were 63% for home-based RT, 66% for group-based RT, and 53% for walking groups. A significant group-by-time interaction was found for the sit-and-reach test with the group-based RT increasing by 3.0 centimeters, no change for the home-based RT, and a significant decline in the walking group by -3.8 centimeters. Significant improvements were found over time for the
group-based RT in the chair-stand, arm curl, sit-and-reach and 8-foot up-and-go tests. The home-based RT showed improvements in the chair-stand, arm curl, and back scratch tests; however, no significant improvements were observed in the walking group. The results from this study suggest that both the home- and group-based resistance programs may be effective in maintaining strength and functional ability in retirement village residents.

**Energy Expenditure Studies**

Studies measuring the impact of exercise training programs and their effect on non-training physical activity in older adults will be reviewed in this section.

In a 12-week study, Meijer et al., (1999) examined the effect of regular exercise training on daily physical activity in healthy elderly men and women aged 55 to 62. Exercise training and physical activity were measured using a tri-axial accelerometer. The training program consisted of 1-day/week of various aerobic exercises in a group setting and 1-day/week of individual cardio- and weight- machine training. Mean physical activity was calculated by subtracting output from the accelerometer during training sessions from total accelerometer output. The difference in mean physical activity was significantly greater at week 6 compared to week 12 and exercise intensity was greater at week 12. These results suggest that elderly subjects will compensate for the addition in workload by reducing non-training physical activity even when the exercise intensity is moderate.
Goran & Poehlman (1992) evaluated the effects of an endurance training program on the amount of physical activity during the remainder of the day in older men and women aged 56 to 78. Total energy expenditure was measured using the doubly-labeled water technique before and during the exercise program. There was no change in total energy expenditure after 8 weeks of endurance training despite an increase in resting metabolic rate and average daily energy cost of endurance training. Furthermore, the energy expenditure of physical activity during non-exercise training was significantly reduced compared to pre-training levels. These results suggest that the significant decrease in energy expended in non-training physical activity during the remainder of the day negate the increase in energy expenditure from the higher resting metabolic rate and cost of energy during endurance training. Although the reduction in non-training physical activity for the remaining of the day may be a compensation mechanism for the energy required for the high-intensity (85% of VO_{2max}) training program.

Assisted Living and Retirement Community Studies

Several studies developed for residents in assisted living facilities or retirement communities will be reviewed in this section.

Sung (2009) assessed the effectiveness of a 16-week exercise program on physical function and mental health in 11 older-old (75 to 84 years of age) women and 9 young-old (65 to 74 years of age) women compared to control groups (n = 17) in an assisted living facility. All participants were older than 65 years of age, able to ambulate alone, not participating in any regular exercise program within the previous 6 months,
and scored > 23 on the mini-mental state examination Korean version. The exercise program consisted of a warm-up of walking and stretching, low-to-moderate intensity dance exercises, upper- and lower-body strength training, and a cool-down with stretching, walking, and breathing 40 minutes/day 3 times a week. The health education program consisted of describing the benefits of exercise, promoting safety issues to avoid falls, and discussing health issues such as nutrition and sleep. Heart rate monitors were worn to confirm and maintain 50 to 55% maximum heart rate. Pre- and post-testing consisted of lower-body strength using the chair stand test, lower-body flexibility using the sit-and-reach test, and balance using the one-legged standing tests for physical functioning and instruments for self-esteem and depressive symptoms were administered for the mental health testing. At baseline and after the exercise program, there were no differences between the intervention age groups. After the exercise program, the intervention groups showed a significant improvement in lower-body strength and flexibility, balance, and self-esteem compared to the control group. There was no change in the depressive symptoms after training. The results from this study suggest that older women living in long-term assisted living facilities can physically benefit from a group exercise program of low-to-moderate intensity.

Baum et al., (2003) designed and piloted a low-cost, 6-month strength and flexibility training program for residents in an assisted living facility that included some residents from the nursing care facility. A total of 20 residents including 5 from nursing care and 15 from assisted living participated in this study and 11 participants (75 to 96
years of age) were assigned to the exercise group while 9 participants (78 to 99 years of age) were assigned to the control group. The exercise program consisted of a warm-up, upper- and lower-body strength training, stretching, and a cool-down which was conducted in a group guided manner with all exercises performed in a seated position due to participants’ frailty. Equipment used for the program included soft weights, weighted hand-sized balls, beach balls, and resistance bands. Pre- and post-testing included the timed up-and-go, physical performance test (PPT), Berg balance scale (Berg, Wood-Dauphinee, Williams, & Maki, 1992), and mini-mental state examination (MMSE). The overall effects of the exercise intervention resulted in 18 seconds faster for the timed up-and-go, 1.3 better score for the PPT, 4.8 better score for the Berg balance scale, and 3.1 better score for the MMSE compared to the control group. These results suggest that frail elderly in a long-term assisted living facility can benefit from a strength and flexibility training program that can be designed using low-cost equipment.

Vaitkevicius et al., (2002) investigated the effects of an aerobic exercise training program on VO2peak in 11 men and 11 women with a mean age of 84±4 years and numerous chronic diseases residing in a retirement community consisting of independent living, assisted living and convalescent care residence. Each participant completed a treadmill test using the modified Balke protocol where initial walking speeds varied from 1.6 to 4.0 km/h depending on individual ability at both baseline and follow-up. In addition, participants completed a survey assessing their ability to perform specific activities of daily living (ADLs) and instrumental ADLs (IADLs). After baseline
training, participants completed a six-month exercise training program that included a 5 to 10 minute warm-up, stretching exercises, 20 to 30 minutes on the treadmill or stationary bike, and a 5 minute cool-down. Participants were supervised on the use of the treadmill and stationary bike for the first 3 to 5 sessions and then instructed to continue training on their own with minimal input from the instructor. Exercise intensity was prescribed at 60 to 80% of maximal heart rate and adjusted monthly. Participants exercised an average of 2 days/week for 21 minutes/session (i.e., 11.4±4.0 min/session on treadmill and 9.3±2.9 min/session on bike) at an average exercise intensity of 76% on the bike and 75% on the treadmill. The exercise training program resulted in a significant increase in exercise duration from 11.9 to 15.9 min/session, lower heart rate during exercise testing, and an increase in VO$_2$peak and O$_2$ pulse (i.e., VO$_2$peak/HR) at exhaustion. Total exercise time in minutes and baseline VO$_2$peak (ml/min/kg) were independent predictors of the increase VO$_2$peak with exercise training. Although no significant change was found with participants’ ability to perform ADLs and IADLs as reported in the survey, a trend for improvement in overall functional status was observed. It was noted in the investigation that although frequency and duration of the exercise sessions were lower than expected, improvements in VO$_2$peak were achieved suggesting that the functional decline often accompanied with aging and sedentary behavior may be attenuated with such an exercise program. Participants aged 80 and older can achieve significant improvements in aerobic capacity from moderate-intensity, low-frequency exercise training.
Baker et al., (2007) examined the hypotheses that exercise adoption and adherence would be high and that significant improvements would be demonstrated in the areas of muscular strength, balance, and endurance in a retirement community involving 14 men and 24 women between 70 and 85 years of age. Baseline and follow-up testing consisted of a 6-minute walk for endurance; one-repetition maximum (1RM) exercises involving various muscle groups for strength; progressive stances for balance; and gait velocity, chair stand, stair climb, and a short physical performance battery. In addition, questionnaires were completed for depression, physical activity scale and self-efficacy. A 10-week exercise program was designed for 2 days/week of aerobic training, 3 days/week of strength training and 1 day/week of balance conditioning. Overall strength gains tended to be higher in the exercise group compared to controls with significantly greater improvements in hip flexion, hip abduction and chest press in the exercise group. Significant improvements occurred in both groups in the stair climb and chair stand time. There were no significant changes in 6-minute walk performance and depression scores. Exercise self-efficacy was low for all categories except walking. Two control and four exercise participants dropped-out within the first two weeks of the program. The results from this study suggest that physical and psychological adaptations to exercise are linked although volumes and intensities of multiple exercise modalities sufficient to cause significant adaptation appear difficult to prescribe and adhere to simultaneously in older adults.
Cognitive Function and Physical Activity Studies

Physical activity has been implicated in the improvement of cognitive function therefore it is important for the well-being and quality of life of older adults. Cross-sectional evidence has suggested that physically active older adults have better cognitive functioning than their sedentary counterparts in the areas of memory, reaction time and visuospatial skills (Clarkson-Smith & Hartley, 1989; Colcombe, Kramer, McAuley, Erickson, & Scalf, 2004; Dustman, Emmerson, & Shearer, 1994; Roth, Goode, Clay, & Ball, 2003). In addition, prospective and longitudinal findings have suggested that physical inactivity is predictive of subsequent cognitive decline and that changes in patterns of physical activity over time are associated with changes in cognitive function (Barnes, Yaffe, Satariano, & Tager, 2003; Pignatti, Rozzini, & Trabucchi, 2002; Van Gelder et al., 2004; Weuve et al., 2004; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001).

Generally, exercise training programs for older adults have shown improvements in cognitive function, particularly on measures of information processing speed and executive function (Dustman et al., 1984; Kramer et al., 1999; Moul, Goldman, & Warren, 1995). However, some experimental studies have been less conclusive (Blumenthal et al., 1991; Blumenthal & Madden, 1988; Hill, Storandt, & Malley, 1993). The discrepancies between these studies are possibly attributable to methodological differences including duration, intensity, frequency, control groups, exclusion criteria, and cognitive outcome measures. Colcombe & Kramer (2003) conducted a meta-analysis and found that generally exercise interventions do have the potential to improve cognitive
function primarily, mental speed and executive functioning. In addition, they found that most benefits were gained from exercise programs that were greater than 30 minutes in duration and consisted of aerobic and strength training components targeted at adults 65 to 70 years of age.

Lindwall, Rennemark, & Berggren, (2008) investigated the relationship of light and strenuous exercise, and self-reported change in exercise status, with components of cognitive function and gender differences in older men and women 60 to 96 years of age. Age was significantly and negatively related to test scores for MMSE and other cognitive tests. Post-hoc analyses on the effects of light exercise on MMSE scores showed that the several-times-a-week exercise group had significantly higher scores than the every-day exercise group and the inactive group. The effects of light exercise were significant for men but not for women and the effects of strenuous exercise on MMSE scores were not significant. A negative significant effect for change in exercise status was associated with lower MMSE scores for males but not females. Individuals exercising with light intensity several times a week had the highest cognitive test and MMSE scores while the inactive group had the lowest scores. The results from this study not only demonstrated the positive link between physical activity and cognitive function in older adults, but also, clearly advocate for the use of light-to-moderate levels of exercise rather than strenuous intensity exercise for the benefits of cognitive function.

Lam et al., (2009) evaluated the association between modality of physical exercise and the number of years performing exercise and cognitive function in a
population of men and women 63 to 82 years of age. Three modes of exercise were measured by questionnaire including stretching, aerobics and mind-body exercise (i.e., Tai Chi forms). The aerobics and mind-body exercise groups that reported exercising for over 5 years achieved significantly higher scores on the MMSE and other cognitive tests compared to the stretching group and these effects were more prominent in the 65 to 74 age group. Regression analysis revealed that the MMSE and other cognitive test scores were influenced by age and educational levels. The effects of the mind-body exercise group on cognitive function were comparable to that of the aerobics group. The results of this study suggest that mind-body exercise as a health intervention for cognitive decline may have the same possible effects as an aerobic exercise program and may have the added benefits of being low stress and user-friendly.

In summary, because research to-date has been equivocal on whether a relationship exists between exercise training and cognitive function, it is important that experimental research include analysis for determining whether an association is found for the effects of exercise training on cognitive function in elderly populations. Furthermore the modality, duration and frequency of the exercise as it relates to the specific population are key factors in determining the effects of the relationship.

Risk Factors Associated with Cognitive Status Studies

There has been increasing evidence suggesting that cardiovascular disease (CVD) risk factors such as hypertension, dyslipidemia, and diabetes mellitus (DM) are also risk factors for dementia (Breteler, 2000a, 2000b; De la Torre, 2002; Elias, Wolf, D’Agostino,
Cobb, & White, 1993; Gorelick, 2004; Iadecola & Gorelick, 2003; Papademetriou, 2005). These CVD risk factors along with coronary and carotid artery diseases can lead to cerebrovascular disease, hypoperfusion, and ischemia (Gorelick, 2004). If damage occurs in areas of the brain responsible for cognition, dementia can transpire. The rate of decline in the central nervous system differs for individuals although potential genetic susceptibility may predispose these individuals to certain disease states. For example an individual with the apolipoprotein E4 (ApoE4) allele may be predisposed to Alzheimer’s disease (Kuusisto et al., 1994; Saunders et al., 1993). Because there are distinct differences between decline in cognition in normal aging, mild cognitive impairment (MCI) and dementias including Alzheimer’s disease (AD), vascular dementia (VaD) and post-stroke dementia (PSD); it is important to recognize the relationship of each cognitive classification when discussing these CVD risk factors.

Cognitive decline in normal aging tends to affect mental-processing speed and leads to delayed retrieval (Feldman & Jacova, 2005), whereas individuals with MCI experience short-term memory loss without an overall decline in cognitive function or normal daily functioning although they are at increased risk of dementia (Bruscoli & Lovestone, 2004; Knopman et al., 2003). Dementia is defined as a global cognitive impairment in memory, learning, language, visuospatial function, executive function, and other aspects of cognition that severely affect daily functioning (Fillit, Nash, Rundek, & Zuckerman, 2008). The CVD risk factors with strong associations with risk of cognitive decline and dementia are hypertension, dyslipidemia, and DM.
**Hypertension.** Midlife hypertension is a significant predictor of impaired cognitive functioning in 10 to 20 years (Knopman et al., 2001; Swan et al., 1998) and may be associated with an increased risk of developing dementia (Kivipelto, Helkala, Laakso, et al., 2001; Whitmer, Sidney, Selby, Johnston, & Yaffe, 2005). Although research is sparse on whether individuals with MCI and hypertension are at greater risk of dementia than normotensive individuals, hypertension increases the risk of stroke (Rashid, Leonardi-Bee, & Bath, 2003), VaD (Desmond, Moroney, Sano, & Stern, 2002) and AD (Honig et al., 2003).

In the Honolulu-Asia Aging Study a strong correlation between the risk of dementia and midlife hypertension was found in a cohort of 3703 Japanese-American men (Launer et al., 2000). The relative risk of dementia was 4 times higher in patients with untreated systolic blood pressure (SBP) $\geq 160$ mm Hg compared to those with SBP between 110 and 139 mm Hg.

In a 3-year follow-up of the Kungsholmen Project, 1270 non-demented participants 75+ years of age were evaluated for the influence of blood pressure on the incidence of dementia (Guo et al., 2001). The relative risk of dementia was 1.6 times higher for individuals with baseline SBP $>180$ mm Hg compared to SBP of 141-160 mm Hg which supports the association of high SBP and increased risk of dementia.

**Dyslipidemia.** Epidemiological studies have demonstrated a strong relationship between elevated low-density lipoprotein cholesterol (LDL-C) levels and CVD risks (Kivipelto & Solomon, 2006; Stamler, Wentworth, & Neaton, 1986). Although a
relationship between cholesterol levels and the risk of cognitive decline and AD has been conflicting, elevated LDL-C levels have been observed in patients with VaD and are associated with an increased risk of developing stroke-related dementia (Kivipelto, Helkala, Hanninen, et al., 2001; Kivipelto, Helkala, Laakso, et al., 2001; Kivipelto & Solomon, 2006).

In the Women’s Health Study 4081 women participated in a randomized trial of low-dose aspirin and vitamin E (Devore, Buring & Grodstein, 2004). Baseline LDL-C levels were modestly associated with decreased cognitive performance five years later, while HDL-C levels were strongly related to higher cognitive test scores. A strong trend was demonstrated in decreasing the risk of cognitive impairment with increasing HDL-C levels and a modest association for LDL-C levels.

Various relationships between elevated cholesterol levels and AD pathogenesis have been suggested. The accumulation of β-amyloid in neuritic plaques is a key feature of AD (Hardy & Selkoe, 2002). β-amyloid production is the result of abnormal cleavage of the amyloid precursor protein by the enzymes β- and γ-secretase, and evidence suggests that the enzymes function best in a high-cholesterol environment (Wolozin, 2004). Apolipoprotein E modulates lipid transport and the ApoE4 allele of this gene raises levels of total and LDL-C which increase CVD and cognitive impairment risk (Stampfer, 2006). Increased cholesterol affects both phosphorylation of the tau protein and the formation of neurofibrillary tangles through its effect on β-amyloid production. Autopsies have found high midlife cholesterol levels have been associated with β-
Amyloid deposition (Pappolla et al., 2003) and the formation of neuritic plaques (Launer, White, Petrovitch, Ross, & Curb, 2001).

**Diabetes mellitus.** Clinical evidence has suggested a link between DM and cognitive impairment and dementia (Crooks, Buckwalter, & Petitti, 2003; Grodstein, Chen, Wilson, & Manson, 2001; Yaffe et al., 2004). Epidemiological studies observed that type 2 DM was associated with cognitive impairment, and a meta-analysis revealed similar findings for type 1 DM (Brands, Biessels, de Haan, Kappelle, & Kessels, 2005). In addition, episodes of acute hyper- and hypoglycemia are associated with impaired cognitive function that increase the risk of dementia in DM individuals (Auer, 2004; Sheetz & King, 2002).

The Rotterdam Study found a strong correlation between DM and dementia where 6370 elderly patients with DM almost doubled the relative risk of dementia compared to non-diabetic patients (Ott et al., 1999).

In a prospective investigation women with diabetes performed more poorly on cognitive tests and had greater 4-year cognitive decline compared to impaired fasting glucose (IFG) and non-diabetic participants (Yaffe et al., 2004). In addition, IFG participants had cognitive scores lower than non-diabetic individuals. These findings suggest that abnormal glucose metabolism is linked to cognition and increased risk of developing cognitive impairment and dementia in older women.
**Obesity.** Various studies have indicated obesity per se as an independent cardiovascular risk factor predisposing to type 2 DM, hypertension and dyslipidemia (Wellman & Friedberg, 2002; Wing, Mathews, Kuller, Meilahn, & Plantinga, 1991). Although hypertension, atherosclerosis, DM, and aging may contribute to the secondary complications of obesity, a direct deleterious effect of obesity on the cardiovascular system has been evidenced (Duflou et al., 1995). Almost all animal and clinical studies evaluating vascular function in obesity have found some degree of vascular abnormalities at the endothelial and smooth muscle levels (Creager et al., 1990; Fatani et al., 2007; Naderali & Fatani, 2005). Therefore, it is has been hypothesized that vascular disease at the level of the brain may affect memory function.

Midlife obesity has been associated with an increased risk of dementia and AD in aged individuals (Kivipelto et al., 2005). In the Cardiovascular Health Study, an increased risk of dementia was found for participants with midlife (i.e., 50 years of age) obesity BMI > 30 compared to normal BMI 20 to 25 after adjusting for demographics and cardiovascular risk factors (Fitzpatrick et al., 2009). The study also found that in late-life being underweight BMI < 20 was associated with an increased risk of dementia, having a BMI between 25 and 30 was not associated with an increased risk of dementia, and being obese (i.e., BMI > 30) reduced the risk of dementia compared to normal BMI individuals. These data demonstrate the bimodal effect of total adiposity on cognitive function in later life where being obese at midlife has a negative effect and being obese at later life has a positive effect (Naderali, Ratcliffe, & Dale, 2009).
**Other risk factors.** Evidence has indicated that management of lifestyle risk factors such as smoking, and alcohol consumption may reduce the risk of cognitive impairment, dementia, and AD in older age as well as reduce the risk of CVD (Juan et al., 2004; Tyas et al., 2003). Studies evaluating the link between smoking and cognitive impairment or smoking and the risk of AD have provided contradictory results; therefore, the relationship between smoking, cognitive decline and dementia has not been definitively established (Broe et al., 1990; Shalat, Seltzer, Pidcock, & Baker, 1987). Research suggests moderate alcohol consumption (i.e., 8-16 drinks/week) may provide a protect effect against cognitive decline and dementia (Elias, Elias, D’Agostino, Silbershatz, & Wolf, 1999; Galanis et al., 2000), whereas excessive alcohol intake may lead to dementia, stroke, VaD, and AD.

From these data the relationships found between CVD risk factors (i.e., hypertension, dyslipidemia, DM, and midlife obesity) and cognitive impairment, VaD, and AD suggest that individuals affected with these risk factors could be at higher risk of cognitive impairment.

**Summary of Literature Review**

Evidence obtained from studies of physical inactivity clearly demonstrates the beneficial effects of exercise in attenuating chronic diseases, and enhancing functional limitations, functional independence, self-efficacy, and cognitive function in older adults. It is also demonstrated from cross-sectional studies that despite the positive effects that exercise has on health and quality of life, most individuals are not regularly physically
active. Regardless of age, ethnicity, and gender, patterns of physical activity demonstrate that older adults are less active than younger adults, women are less active than men, and African-Americans have lower energy expenditure than their Caucasian counterparts.

Epidemiological and longitudinal studies have demonstrated the effects of exercise and physical activity on cardiovascular fitness, muscular strength, flexibility, balance/agility and body composition. In general, these studies demonstrate that VO₂max declines with age even in master athletes that continue to train. Exercise programs that focus on muscular strength provide crossover effects in other domains such as cardiovascular fitness, flexibility, balance/agility, and body composition. It is obvious from these studies that aging has an effect on physical and functional performance and these effects are more evident with the older-old (i.e., 75 to 84 years) and oldest-old (i.e., ≥ 85 years) populations. While research on the positive influence of physical active and exercise has been studied for more than three-quarters of a century, the effects have predominantly focused on young adults and young-old adults (i.e., 65 to 74 years of age). Over the next twenty years, our older adult population (i.e., young-old, older-old, oldest-old) will increase in size. Many of these older-old and oldest-old populations will be living with chronic diseases, mobility limitations, and a cognitive decline that may restrict their access and abilities to exercise independently. In addition, many of these individuals will be living in retirement communities that may have limited space for physical activity and exercise programs.
Studies evaluating the effects of exercise training programs on energy expenditure utilized during habitual physical activity have clearly demonstrated that the age-related decline in physical activity occurs when exercise programs are designed for moderate-to-vigorous intensity levels. Little is known whether low-to-moderate or independently established intensity levels have any effect on non-training physical activity. Despite the influence exercise training has on habitual physical activity, the positive benefits derived from multi-component exercise programs in endurance, muscular strength, flexibility, and balance must be considered.

Field and clinical studies clearly demonstrated that older populations could benefit from exercise programs that were low-to-moderate intensity using evaluation techniques (i.e., SFT) designed to measure physical capacity for this population. In addition, the benefits gained from these programs demonstrated crossover effects into other domains than the programs were designed to address such as a strength training program providing cardiovascular improvements. Contrary to findings from epidemiological and longitudinal studies, field and clinical investigations reported improvements in aerobic capacity. These findings may be due to the increases from initially low levels of aerobic capacity of these groups. Low-to-moderate exercise programs designed to address older populations have the ability to maintain or improve physical functional performance thereby allowing individuals to perform activities of daily living independently.
Investigations in assisted living facilities clearly demonstrate that improvements in aerobic capacity, muscular strength and flexibility can be achieved in elderly adults. These improvements can be achieved with low-to-moderate intensity, low-frequency training programs that can possibly extend independent living. Although improvements in physical function can be achieved in older adults, non-participation and drop-out rates indicate that adoption and adherence of exercise programs might be better accepted with a gradual progressive exercise approach.

Studies evaluating the effects of physical activity on cognitive function demonstrated that positive results as measured by the MMSE could be gained from programs of low intensity exercises. Improvements in cognition could be achieved with exercise programs of several days a week. Furthermore, benefits from exercise programs may go beyond psychological well-being and into the psychosocial area thereby improving the individual’s quality of life.

Increasing evidence suggests that CVD risk factors including hypertension, dyslipidemia, and DM parallel the risk for dementia as well. In addition, midlife obesity has been associated with increased risk of late-life dementia. Management of lifestyle factors such as staying physically active and maintaining a normal body weight not only can reduce the risk of CVD but also reduce the risk of cognitive decline.

Information is lacking as to the optimal amount of structured exercise together with routine physical activity to elicit positive health benefits for the older-old and oldest-old populations. Older adults in the United States are more likely to report lower-
intensity activities such as walking, gardening or golfing. Furthermore, studies have demonstrated the relationships between low-to-moderate physical activity and functional performance and cognitive function. Although all adults should accumulate 30 minutes or more of moderate-intensity physical activity on most or all days of the week (ACSM position stand, 2009), is it possible for the older-old and oldest-old to achieve improvements in physical capacity as assessed with the Senior Fitness Test with 120-minute/week, low-to-moderate, multi-component exercise program.
CHAPTER III
METHODOLOGY

This research project evaluated whether a multi-component structured exercise program implemented in an adult life-care community of adults 80 years of age and older with mild cognitive impairment could show beneficial improvements in the areas of cardiovascular endurance, muscular strength, flexibility, balance/agility, and body composition; whether this exercise program changed the amount of habitual physical activity performed throughout 6-month period; and whether these changes in physical performance measures were associated with changes in cognitive function for participants in the program. This investigation evaluated the effects of a 6-month exercise program consisting of aerobics, resistance training, stretching, and balance routines administered to a population of older adults 2 days a week for 60 minute sessions or 120 minutes/week. Performance measures involved a series of functional tests that have been validated for community-dwelling older adults to measure cardiovascular endurance, upper- and lower-body strength and flexibility, balance/agility, hand eye coordination, and performance of activities of daily living. Self-reported amounts of habitual physical activity were compared to determine whether implementing an exercise program affected the amount of physical activity performed during the period of the exercise program. In addition, the modified mini-mental state (3MS) examination was used to serially measure changes in cognitive status to determine whether the changes in physical performance measures were associated with changes in cognitive function.
Study Design

This study was intended to be a pilot project with the primary objective of designing and developing a multi-component structured exercise program that could be utilized in many adult life-care communities therefore, one particular facility was sought out to serve as a primary site for developing this program. The exercise program was structured to facilitate persons with mild cognitive impairment (MCI), in need of assistance with activities of daily living (ADLs) or instrumental ADLs (IADLs), chronic diseases, and mobility and other range-of-motion limitations, as well as healthy individuals. The various phases of this project consisted of recruiting, screening, testing, exercise program, and statistical analysis.

Recruiting

Announcements were made and flyers were distributed to individuals within the community selected for the exercise program. The experimental procedures and possible risks were verbally explained to each volunteer. All volunteers signed the consent form (Appendix A) that was approved by the Kent State University Human Subjects Review Board and the Summa Health Systems Institutional Review Board. In addition, all volunteers completed a medical history form (Appendix B). The completed medical history was reviewed with each volunteer prior to screening. Each volunteer initially met the participant health requirements for further consideration for this study.
Participant Health Requirements

A total of thirty residents within an adult life-care community that were 80 years of age or older and spoke English were eligible for the study. Exclusion criteria included a history of neurological disorders such as stroke, seizures or severe head injury and significant psychological problems such as schizophrenia or bipolar disorder. In addition, residents were ineligible for participating in the exercise program for any of the following absolute contraindications prescribed by the American College of Sports Medicine (2009): recent change in the resting ECG (electrocardiogram) suggesting ischemia, recent myocardial infarction within 2 days or other acute cardiac event; unstable angina; uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise; severe aortic stenosis; uncontrolled symptomatic heart failure; acute pulmonary embolus or pulmonary infarction; acute myocarditis; suspected or known dissecting aneurysm; or acute infections. Participants consulted and were advised by their physicians whether to engage in the structured exercise program if they had been diagnosed with any of the following relative contraindications prescribed by the American College of Sports Medicine (2009): left main cardiac stenosis; moderate stenotic valvular heart disease; electrolyte abnormalities; severe arterial hypertension; tachyarrhythmias or bradyarrhythmias; hypertrophic cardiomyopathy; neuromuscular, musculoskeletal, or rheumatoid disorders that are exacerbated by exercise; high degree atrio-ventricular block; ventricular aneurysm; uncontrolled metabolic diseases; or chronic infection.
Screening

Each volunteer was initially evaluated by trained psychologists to determine whether the person could comprehend and follow instructions in completing questionnaires related to memory and cognition. The goal of the memory and cognitive evaluation was to exclude individuals who have been diagnosed with Alzheimer’s disease and identify those with mild cognitive impairment that may benefit from a structured exercise program. In addition, participants completed a questionnaire to assess their performance of basic activities of daily living (ADLs) and instrumental activities of daily living (IADLs). The goal of this evaluation was to determine whether a participant needed assistance with 2 or more ADLs and/or IADLs, thus labeling them as an “assisted living participant”. If deemed eligible for participant health requirements, mental capacity, and assisted living participant, the individual completed a series of anthropometric, physical fitness, and physiological tests prior to commencement of the 6-month exercise program.

Testing

The following tests were conducted prior to beginning the exercise program and immediately following the 6-month exercise program. All information was recorded on the data collection sheets (Appendix C), 3MS examinations (Appendix D), Lawton-Brody IADL/ADL questionnaires (Appendix E), and the rapid assessment of physical activity (RAPA) questionnaires (Appendix F).
Mental capacity test. The 3MS examination (Teng & Chui, 1987) was administered to volunteers to determine if there was a relationship between changes in cognitive function and changes in physical performance measures based on outcomes assessed using the Senior Fitness Test.

The 3MS is an extension of the MMSE (Crum, Anthony, Bassett, & Folstein, 1993; Kase et al, 1998); therefore, the 3MS contains all of the items on the MMSE and four new items (LaMarre & Patten, 1991). As such, the primary function of the MMSE is to serially measure change in cognitive status (Tombaugh & McIntyre, 1992). Repeated administration of the MMSE has been utilized to differentiate between normal age-associated cognitive decline and the pathological cognitive decline that occurs in dementia, track progress of dementia, and assess the effects of rehabilitation. The 3MS was developed to include the primary functions of the MMSE and the modifications were instituted to sample a broader variety of cognitive functions and cover a wider range of difficulties thereby enhancing the reliability and validity of the test. Four subsets were added that included date and place of birth, word fluency, similarities, and delayed recall of words. The upgraded scoring increased the total achievable score to 100 and a test score of 79 will be used as the cut-off score for identification of mild cognitive impairment. One advantage of the 3MS examination is that both the 3MS and MMSE scores can be derived from a single administration (Tombaugh, McDowell, Kristjansson, & Hubley, 1996).
**IADL/ADL questionnaire.** The IADL/ADL questionnaire (Lawton & Brody, 1969) was administered to volunteers as a tool to identify eligible individuals for the exercise program that met the criteria for needing assistance with 2 or more IADLs/ADLs. The IADL/ADL questionnaire is divided into two levels ranging from the more basic ADLs to the more advanced IADLs. ADLs include dressing, feeding, ambulating, toileting, grooming and bathing. Normally these activities are performed independently but as the individual become progressively frailer and unable to do these tasks, more caregiving assistance may be necessary. IADLs include telephone use, shopping, food preparation, housekeeping, laundry, mode of transportation, responsibility for own medications, and ability to handle finances. These tasks are necessary for independent functioning in the community and changes may uncover subtle disabilities. The IADL/ADL questionnaire has practical utility in widely diverse settings with a range of aged populations, and a variety of goals. The use of this instrument allows for a quick systematic review of the older person’s current functioning and provides some basis for preliminary judgments and directions to consider for facilities or treatment options.

**Anthropometric tests.** Each participant was assessed using anthropometric tests including height, body weight, waist and hip circumferences, and 3-site skinfold measurements. In addition, body mass index was calculated using the assessed height and body weight measurement and waist-to-hip ratio was calculated using the waist and hip measurements from each participant.
Height was assessed by affixing an 8 foot measuring tape to the wall, having the participant stand erect with shoes on and back against the wall and placing a ruler atop the head perpendicular to the measuring tape while the participant took a deep breath and held it.

Body weight was assessed using a Healthometer- model 320KL Digital Scale (Health-o-meter, Inc, Bridgeview, IL). Participants with shoes on were assessed by standing erect on the digital scale platform. The digital read-out provided body weight in pounds and kilograms.

Body mass index (BMI) (ACSM, 2009) was calculated using the height and weight measurements. BMI is used to assess weight relative to height and is calculated by dividing body weight in kilograms by height in meters squared (i.e., BMI = kg/m²). One purpose of BMI is to determine obesity-related health problems associated with indexes greater than 25.0. BMIs of 25.0 to 29.9 kg/m² are defined as overweight and BMIs equal to or greater than 30.0 kg/m² are defined as obese (Panel E, 1998).

Waist and hip circumference (ACSM, 2009) were assessed with a Gulick tape measure (Gulick Country Technology, Gays Mill, WI). The waist circumference was assessed at the narrowest part of the torso above the umbilicus and below the xyphoid process. The hip circumference was assessed with feet together at the widest part of the buttock. Duplicate measures were assessed and agreed within 0.5 cm or 0.2 inches and averages of the measures were used.
The waist-to-hip ratio (WHR) (ACSM, 2009) was calculated by dividing the waist by hip measurements. The pattern of body fat distribution is associated with predictable health risks of obesity (Van Itallie, 1988). Individuals with more fat on the trunk, especially abdominal fat, are at increased risk for hypertension, type 2 diabetes, hyperlipidemia, coronary artery disease, and premature death compared to individuals with equal amounts of fat on their extremities. Health risks are associated with age and individuals 60 to 69 years old with WHR values greater than 1.03 for men and 0.90 for women are at very high disease risk.

A 3-site skinfold measurement (ACSM, 2009) was assessed using Lange Calipers (Beta Technology, Santa Cruz, CA). The principle behind this technique is that the amount of subcutaneous fat is proportional to the total amount of body fat. This study used a 3-site gender-specific measurement that included tricep, suprailiac and thigh for women and chest, abdomen, and thigh for men. Triceps sites were measured with a vertical fold assessed at the midline of the arm halfway between the acromion and olecranon process. Suprailiac sites were measured using a diagonal fold taken above the ilium at the spot where an imaginary line would come down from the mid-axillary line. Thigh sites were assessed with a vertical fold taken on the front of the thigh, midway between the hip and the nearest border of the patella. Chest sites were measured on a diagonal fold taken with its long axis directed to the nipple just next to the anterior axillary fold. Abdominal sites were assessed with a horizontal fold picked up slightly more than one inch to the side of the naval and one half inch below the naval. The 3-site
gender-specific skinfold measurements were assessed in millimeters (mm) and each participant’s 3-site total measurement was entered into the appropriate body density formula (adapted from Jackson & Pollock, 1985; Pollock, Schmidt, & Jackson, 1980):

Men: sum of 3-site skinfold – chest, abdomen, thigh

\[ \text{Body Density} = 1.10938 - 0.0008267 \times \text{(sum of 3-site skinfolds)} + 0.0000016 \times \text{(sum of 3-site skinfolds)}^2 - 0.0002574 \times \text{(Age)} \]

Women: sum of 3 skinfolds – tricep, suprailiac, thigh

\[ \text{Body Density} = 1.099421 - 0.0009929 \times \text{(sum of 3-site skinfolds)} + 0.0000023 \times \text{(sum of 3-site skinfolds)}^2 - 0.0001392 \times \text{(Age)} \]

The body density results were then used to calculate percent body fat from the following gender-specific body fat formula (adapted from Heyward & Stolarczyk, 1996):

Men: % Body fat = \( \frac{4.95}{\text{Body Density}} - 4.50 \)

Women: % Body fat = \( \frac{5.01}{\text{Body Density}} - 4.57 \)

**Physical fitness tests.** One of the more recent and best validated field tests is the Senior Fitness Test (SFT) (Rikli & Jones, 2001). This battery of performance tests is suitable for assessing the major underlying physical parameters associated with functional mobility in independent older adults aged 60 to 90 and older. A cross section of the major fitness components associated with independent functioning in later years is reflected in this battery of test items which include aerobic endurance,
upper- and lower-body strength, upper- and lower-body flexibility, and dynamic balance/agility. The SFT requires minimal equipment and space making it a very adaptable testing method in both clinical and community (i.e., non-laboratory) settings for older adults. The SFT method has been utilized in studies of older and elderly populations.

Each participant performed a series of functional exercise tests that were validated for community-residing older adults and are reliable measures of cardiovascular endurance, upper- and lower-body strength and flexibility, dynamic balance/agility, hand-eye coordination, and activities of daily living.

**Cardiovascular endurance.** Cardiovascular endurance was measured by having the participant perform a 2-minute step test (Rikli & Jones, 1999). The 2-minute step test has been validated against 1-mile walk test (Dugas, 1996) and treadmill performance time to 85% of predicted maximum heart rate using a modified Balke-graded exercise protocol (Johnston, 1998). To perform the 2-minute step test, the appropriate stepping height for each participant was determined by placing a measuring tape between the middle of the patella and hip bone and then doubling over the tape to mark the midpoint. The midpoint between the participant’s kneecap and iliac crest was marked with masking tape. The masking tape was transferred to a wall and used as the guide for the proper stepping height. The participant was instructed to step with each knee reaching the height of the masking tape. The participant was signaled to begin. The score represents the number of full
steps (i.e., each time the right knee reached the target height) completed in 2 minutes.

**Upper-body strength.** Upper-body strength was measured by having the participant perform an arm curl test for 30 seconds (Rikli & Jones, 1999). The arm curl test has been validated against the 1RM bicep curl, 1RM chest-press, and 1RM seated row which found the arm curl test to be a good indicator of overall upper body strength that is needed when performing household chores or carrying groceries (James, Rikli, & Jones, 1998). The arm curl test was performed by having the participant sit in a straight-back chair with feet flat on the floor. Participant held a free-weight (i.e., 5 lb weight for females and 8 lb weight for males) in a handshake grip perpendicular to the floor. The participant curled the weight through a full range of motion with the palm rotating up during the concentric phase and returning to the handshake position during the eccentric phase while the upper arm remained steady during the test. Participant performed one or two practice trials and then was signaled to begin. The score indicates the number of full curls (i.e., one concentric and one eccentric rotation) in 30 seconds; however, if the arm was more than halfway at the end of 30 seconds, it was counted as a full curl.

**Lower-body strength.** Lower-body strength was assessed by having the participant perform the chair stand test for 30 seconds (Rikli & Jones, 1999). The chair stand has been validated against the 1RM leg-press. The leg-press involves multiple-joints including hip extension, knee extension and ankle plantar flexion that
is considered a good criterion for measuring lower body strength resembling common daily activities of older adults such as rising from a chair, bathtub or car (Jones, Rikli, & Beam, 1999). The chair stand test was performed by having the participant sit in the middle of a straight-back chair with feet flat on the floor and arms across the chest. Participant rose to a full standing position and returned to a fully seated position. The participant performed one or two practice trials and was signaled to begin. The score represents the number of full stands (i.e., one stand and one seated action) in 30 seconds; however, if the participant was more than half-way at the end of 30 seconds, it was counted as a full stand.

**Upper-body flexibility.** Upper-body flexibility was assessed by having the participant perform the back scratch test (Rikli & Jones, 1999). No single criterion measure exists; however, experts in the field consider it a valid assessment of overall shoulder range of motion (Gross, Fetto, & Rosen, 1996; Hoppenfeld, 1976; Starkey & Ryan, 1996). The motion of reaching behind the head and over the shoulder reflects shoulder flexion, abduction, and external rotation; while the behind-the-back position involves extension, adduction, and internal rotation. The back scratch test was performed by having the participant raise the right arm straight up over the shoulder and then down the back. The left arm was positioned behind and up the middle of the back. The participant practiced this test as described and then practiced with the opposite arms over head and around the back. The arm with the most flexibility was used. Two practice measures were scored to the nearest half
inch measuring the distance between the middle fingers. A minus score represents the distance short of touching the middle fingers and a plus score indicates the degree of overlap. The best score was used for upper body flexibility.

**Lower-body flexibility.** Lower-body flexibility was assessed by having the participant perform the chair sit-and-reach test (Rikli & Jones, 1999). The chair sit-and-reach test was validated against the two-leg floor sit-and-reach and a one-leg back-saver sit-and-reach using a goniometer to measure hamstring flexibility (Jones, Rikli, Max, & Noffal, 1998). The chair sit-and-reach test was performed by having the participant sit on the edge of a straight-back chair with the crease of the leg even with the chair. The preferred leg was extended straight out in front of the hip, heel on the floor and ankle flexed 90º. The opposite leg was bent at the knee with foot resting on the floor and off to the side. The participant overlapped hands with middle fingers even and reached toward toes as far as possible while keeping the extended knee straight. The participant was given two practice tests and then two test trials were measured to the nearest half inch. A minus score was given if the reach was short of the toes and a plus score if the reach was beyond the toes. The score for lower body flexibility indicates the best of the two test scores.

**Balance/agility.** Dynamic balance and agility was assessed by timing the participant performing the 8-foot up-and-go test (Rikli & Jones, 1999). Although no one “gold standard” criterion exists for this test, it has been found to be significantly related to the Berg balance scale, to gait speed, and the Barthel index of ADLs which
represents a composite measure involving transfer actions (e.g., getting in and out of the tub), walking and stair climbing (Podsiadlo & Richardson, 1991). The 8-foot up-and-go test was performed by having the participant sit in the middle of a straight-back chair with feet flat on the floor with one foot slightly in front of the other and hands on thighs. The participant got up from the chair and walked as quickly as possible around a cone that was placed 8 feet away and returned to the chair. Participant performed one practice trial and then was signaled to begin two additional test trials. A complete trial began when the participant was signaled to go and finished when back in the seated position in the chair. The score indicates the better of the two test trials measured to the nearest second.

**Hand eye coordination.** Hand eye coordination was assessed by timing the participant performing the soda pop test (Osness et al., 1996). This test was performed by placing 6 strips of masking tape 3 inches apart and placing unopened cans of pop in squares 1, 3, and 5 if right handed or squares 6, 4, and 2 if left handed. When signaled to begin, the participant turned the first pop can into the next empty square, the second pop can into the next empty square, and the third pop can into the last empty square and then returned the cans to the original squares. The participant performed two test trials. The score represents the better of the two test trials.

**Activities of daily living.** Activities of daily living were assessed by having the participant perform three timed performance tests (Loudon, Bell, & Johnston, 1998). The participant picked-up a book and placed it on a shelf for the first test.
For the second test the participant put on a jacket and removed it. The third test required the participant to pick up a pencil from the floor. The participant was signaled to begin each of these tests. The score was measured in seconds.

**Physiological measures.** Physiological measures were assessed on each participant and included resting blood pressure and resting heart rate.

Resting blood pressure was assessed to quantitatively evaluate the exercise tolerance and maximal aerobic power for each participant. Participants were seated quietly for at least 5 minutes in a chair with feet flat on the floor and arm supported at heart level. Blood pressure measurements were assessed with a random-zero sphygmomanometer and stethoscope (NASCO International Inc., Inc. Fort Atkinson, WI). An appropriate-sized cuff (i.e., cuff bladder encircling at least 80% of the arm) that ensures accuracy was used. Standard Korotkoff procedures were followed where systolic blood pressure was measured as the point at which the first of 2 sounds were heard (phase I), and diastolic blood pressure were measured at the point of disappearance of sounds (phase V) (Chobanian et al., 2003).

Resting heart rate (HRrest) was measured by pulse rate using the ventral aspect of the wrist on the side of the thumb (i.e., radial artery). Participants were seated quietly for at least 5 minutes in a chair with feet flat on the floor and arm supported at heart level. Pulse rate was palpitated for 30 seconds and then multiplied by 2 for the number of beats per minute (Nieman, 1999).
Exercise Program

All exercise classes were guided by an exercise physiologist trained in the area of exercise programs for older adults. Exercise classes met 2 days a week for 60 minutes sessions or 120 minutes/week for 6 months. Each session included a warm-up consisting of 10-15 minutes of non-strenuous stretching and flexibility exercises; an interval phase consisting of aerobic movements with intermittent strength training using free-weights for 30 minutes; a resistance band phase consisting of strength training focusing on the upper and lower body for 5-10 minutes; and a cool-down phase consisting of 10 minutes of gentle stretching and relaxation designed to return the heart rate to pre-exercise levels. Exercises were randomly selected for each exercise class that allowed for variety and conditioning of all the major muscle groups. Since participants were plagued by chronic diseases and mobility and other range-of-motion limitations, they performed the exercises while sitting or standing depending on their individual abilities. Routines were chosen from the list of exercises provided in Appendix G. This list of exercises was compiled from recommendations set forth by the National Institute of Aging (U.S. Department of Health and Human Services, 2001) and the American Council on Exercise (Cotton, Ekeroth, & Yancy, 1998), as well as the experience of the instructors. Each exercise was performed for one set of 12 repetitions with progression to two sets. Exercise equipment available for this program included dumbbells (1-5 lbs), resistance bands ranging from least to greatest (red, yellow, and green) strength, tennis balls, and medium-sized nerf balls.
All participants wore a Polar FS1/FS2/FS3™ fitness heart rate monitor (Polar Electro Inc., Lake Success, NY) for each class session. Heart rate monitors consisted of a chest strap with electrodes that transmitted a signal to a wrist receiver for display. The wrist receivers were programmed with target heart rate ranges for each participant. Target heart rates (THR) were computed based on the heart rate reserve (HRR) method (Swain & Leutholtz, 1997). The formula for the HRR method is:

\[ \text{THR} = [(\text{HR}_{\text{max}} - \text{HR}_{\text{rest}}) \times \% \text{ intensity desired}] + \text{HR}_{\text{rest}}. \]

The calculation was performed twice to determine the upper and lower target heart rate range. \( \text{HR}_{\text{max}} \) was based on the formula 220 – age, and \% intensity desired was determined by using 40 to 60\% which corresponds to a moderate intensity of exercise (Mazzeo & Tanaka, 2001). Heart rates were obtained 3 times during each class session (i.e., beginning, mid-class, and end) with the beginning HR corresponding to \( \text{HR}_{\text{rest}} \), mid-class meaning \( \text{HR}_{\text{peak}} \), and end corresponding to recovery HR. In addition, ratings of perceived exertion (RPE) were obtained along with the heart rate. RPE is a valuable and reliable indicator in monitoring an individual’s exercise tolerance. RPE correlates highly with exercise heart rates (HR) and work rates (ACSM, 2009; Borg, 1998). Borg’s modified RPE scale allowed the exerciser to subjectively rate his or her feelings during exercise, taking into account personal fitness level, environmental conditions, and general fatigue levels (Borg, 1998; Noble, Borg, Jacobs, Ceci, & Kaiser, 1983).
Progression was individualized. Whenever participants felt that the last three repetitions of a set were “easy”, they were encouraged to increase the amount of resistance by using the next-size-heavier dumbbell or the next thicker resistance band.

Exercises were designed to facilitate learning and behavioral changes while relying on cognitive skills. Complex behaviors were broken into small steps, and, as each step was mastered, the next one was added. Participants were encouraged to verbally participate while the twelve repetitions were counted by varying methods such as numerically by 7s or alphabetically starting with z. Individuals were encouraged to maintain or increase their exercise or physical activity programs on their own between group sessions.

Physical activity patterns were monitored by use of the rapid assessment of physical activity (RAPA) questionnaire. This questionnaire has been shown to be a reliable and valid instrument for assessing levels of physical activity for adults older than 50 years of age (Topolski et al., 2006). The RAPA questionnaire categorizes activity patterns by sedentary, underactive, underactive regular – light activities, underactive regular, and active.

After completing the 6-month program, participants were re-tested using all the same tests used prior to the exercise program.
Statistical Analysis

This research study consisted of 3 designs including 1) a mixed model analysis of variance (ANOVA) for physical performance measures with repeated measures, 2) ANOVA for physical activity measures with repeated measures, and 3) correlation for changes on the 3MS and each performance measure. The criterion for statistical significance was set a priori at 0.05 for all tests. All statistical analyses were performed utilizing the SPSS 18.0 grad pack (SPSS, Inc., Chicago, IL).

Performance measures. This research design consisted of a two (group) by two (time point) mixed model ANOVA for performance measures with repeated measures on the second factor. Tests of significance were used to determine the effects of group (male and female), time (pre- and post-testing), and their interaction. The paired-sample t-tests were used to further evaluate significant group and interaction effects. If effects of group or interactions were not found, the data was pooled and paired-sample t-tests were used to analyze the data. The dependent variables consisted of functional performance test battery items including aerobic endurance (# of steps), upper body strength (# of arm curls), lower body strength (# of chair raises), upper body flexibility (inches in back scratch), lower body flexibility (inches in chair sit-and-reach), and balance (seconds in 8-foot up-and-go); timed items including hand eye coordination and ADLs tests; and physiological items including resting heart rate (beats per minute (bpm)) and blood pressure (systolic and
diastolic (SBP & DBP)). Means and standard error means were computed on physical performance dependent variables at both pre- and post-testing time points.

**Physical activity.** A two (group) by two (time point) mixed model ANOVA with repeated measures on the second factor was used for physical activity. Tests of significance were used to determine the effects of group (male and female), time point (pre and post), and their interaction. Paired-sample t-tests were used to further evaluate significant group effects. Since effects of group or interactions were not found, the data was pooled and paired-sample t-tests were used to analyze the data. The dependent variables included no physical activity (PA), light PA some but not all weeks, light PA every week, moderate PA < 30 minutes/day 5 days/week, vigorous PA < 20 minutes/day 3 days/week, moderate PA ≥ 30 minutes/day 5 days/week, vigorous PA ≥ 20 minutes/day 3 days/week, muscle strength training ≥ once a week, and flexibility training ≥ once a week. Percentage and standard deviations of “yes” responses were computed on dependent variables at pre- and post-testing time points.

**3MS examination.** A relationship was evaluated using product moment correlations between changes in physical performance variables and changes in the cognitive test scores for the 3MS examination. Analysis of covariance (ANCOVA) was used to adjust for any group differences which significantly correlated with changes in the test scores.
CHAPTER IV

RESULTS

The purpose of the present investigation was to determine whether a 6-month multi-component structured exercise program implemented in an adult life-care community of adults 80 years of age and older demonstrated changes in the areas of cardiovascular endurance, muscular strength, flexibility, balance/agility, and body composition; whether this exercise program changed the amount of habitual physical activity performed throughout the 6-month period; and whether the changes in these physical performance measures were associated with the changes in cognitive function for the participants in the program. A medical history and physician clearance when necessary was obtained and all participants were deemed to participate in low-to-moderate intensity exercise. A clinical group of 30 males and females with health issues and medication use typical of an older population and meeting the criteria on the Clinical Dementia Rating Scale (Morris, 1994) for very mild dementia completed the 6-month exercise program and pre- and post-intervention performance tests. The pre-test data was collected within a week prior to intervention and post-test data was collected within a week after the intervention. The results of this study will be presented in multiple sections: participant characteristics, physical performance/timed/physiological measures,
anthropometric measures, habitual physical activity, and correlations of changes in physical performance measures and cognitive function.

**Participant Characteristics**

Participant characteristics are presented in Table 3. Independent t-tests were used to analyze gender differences for participant variables. There were significant group differences at pre-testing between males (n=12) and females (n=18) in height (p < .001), weight (p < .001), and education (p = .03) but not for age (p ≥ .49), BMI (p ≥ .17), modified mini-mental state (3MS) examination scores (p ≥ .29), 2-minute step test (p ≥ .35), 30-second arm curl test (p ≥ .41), 30-second chair stand test (p ≥ .68), back scratch test (p ≥ .15), 8-foot up-and-go test (p ≥ .54), soda pop test (p ≥ .32), placing book on shelf (p ≥ .25), putting jacket on then off (p ≥ .91), picking up pencil from floor (p ≥ .51), systolic blood pressure (p ≥ .18), diastolic blood pressure (p ≥ .16) and resting heart rate (p ≥ .90). Gender differences were found where females demonstrated significantly more flexibility in the chair sit-and-reach test (p = .006) compared to males at pre-testing. The number of female participants was lower for the 2-minute step, chair stand, and 8-foot up-and-go tests due to physical limitations. Cardiovascular risk factors and average incidence identified included high blood pressure (15), high cholesterol (14), diabetes mellitus (2), stroke (2), heart attack (4), bypass surgery (3), obesity defined as BMI ≥ 30 kg/m² (7), overweight defined as BMI > 25.0 kg/m² (11), and problems with alcohol/drugs (1).
Table 3

*Participant Characteristics for Males and Females at Pre-Testing*

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Participants (n = 30)</th>
<th>Males (n = 12)</th>
<th>Females (n = 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>83.6±3.6</td>
<td>84.2±2.9</td>
<td>83.2±4.0</td>
</tr>
<tr>
<td>Height (cm)*</td>
<td>163.6±12.4</td>
<td>173.7±13.3</td>
<td>156.9±5.4</td>
</tr>
<tr>
<td>Weight (kg)*</td>
<td>71.9±16.1</td>
<td>85.0±14.9</td>
<td>63.2±9.7</td>
</tr>
<tr>
<td>BMI</td>
<td>26.8±4.9</td>
<td>28.3±4.7</td>
<td>25.8±4.8</td>
</tr>
<tr>
<td>Education (years)*</td>
<td>15.8±3.4</td>
<td>17.3±3.9</td>
<td>14.7±2.5</td>
</tr>
<tr>
<td>3MS (score)</td>
<td>90.0±7.1</td>
<td>91.8±3.2</td>
<td>88.9±8.8</td>
</tr>
<tr>
<td>2-minute step</td>
<td>76±17.9</td>
<td>79±21.4</td>
<td>73±14.6 (n=15)</td>
</tr>
<tr>
<td>Arm curl (30 sec)</td>
<td>16±3.4</td>
<td>16±3.0</td>
<td>17±3.6</td>
</tr>
<tr>
<td>Chair stand (30 sec)</td>
<td>11±3.8</td>
<td>12±3.1</td>
<td>11±4.3 (n=16)</td>
</tr>
<tr>
<td>Back scratch (in)</td>
<td>-5.3±5.4</td>
<td>-7.1±4.8</td>
<td>-4.2±5.6</td>
</tr>
<tr>
<td>Chair sit-and-reach (in)*</td>
<td>-2.3±6.1</td>
<td>-5.9±6.4</td>
<td>0.1±4.7</td>
</tr>
<tr>
<td>8-foot up-and-go (sec)</td>
<td>8.9±3.5</td>
<td>8.5±3.1</td>
<td>9.3±3.9 (n=17)</td>
</tr>
<tr>
<td>Soda pop test (sec)</td>
<td>9.5±3.7</td>
<td>10.3±3.6</td>
<td>8.9±3.7</td>
</tr>
<tr>
<td>Place book on shelf (sec)</td>
<td>1.6±0.7</td>
<td>1.4±0.5</td>
<td>1.7±0.8</td>
</tr>
<tr>
<td>Put jacket on then off (sec)</td>
<td>12.3±5.1</td>
<td>12.5±6.1</td>
<td>12.2±4.5</td>
</tr>
</tbody>
</table>
Variables

All Participants (n = 30)  |  Males (n = 12)  |  Females (n = 18)
---|---|---
Pick up pencil from floor (sec)  | 2.1±1.3  | 2.3±0.9  | 2.0±1.6
SBP (mm Hg)  | 127±15.7  | 132±15.4  | 124±15.5
DBP (mm Hg)  | 70±8.0  | 72±7.9  | 68±7.8
RHR (bpm)  | 71±9.8  | 70±9.9  | 71±10.1

Values are mean ± standard deviation

* Indicates significant differences by gender at pre-testing

**Physical Performance Measures**

The physical performance measures consisted of tests for cardiovascular endurance using the 2-minute step test, upper-body strength using the arm curl test, lower-body strength using the chair stand test, upper-body flexibility using the back scratch test, lower-body flexibility using the chair sit-and-reach test, and balance/agility using the 8-foot up-and-go test. Measurements for hand eye coordination and activities of daily living were assessed for speed of task performance. Additionally, physiological measures for systolic (SBP) and diastolic blood pressure (DBP), resting heart rate (RHR), exercise heart rate (EHR), and rate of perceived exertion (RPE) were assessed. All physical performance dependent variables were originally analyzed using a 2-way group
x time ANOVA with repeated measures. Variables that demonstrated a significant main effect for gender and/or interaction for time by gender are depicted by use of ANOVA. All other physical performance variables were pooled and evaluated by paired-sample t-tests. Since timed and physiological measures were used as secondary variables in relation to cardiovascular endurance, balance/agility, and cognitive function, these dependent variables were pooled and evaluated by paired-sample t-tests. The results from these tests are presented in Table 4.
### Table 4

**Physical, Timed, and Physiological Performance Measures**

<table>
<thead>
<tr>
<th>Test Measure</th>
<th>Number of Participants</th>
<th>All</th>
<th>Males (n=12)</th>
<th>Females (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-minute step *</td>
<td>Pre n = 27</td>
<td>76±3.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 27</td>
<td>85±3.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Arm curl (30 sec) *</td>
<td>Pre n = 30</td>
<td>16±0.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 30</td>
<td>18±0.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chair stand (30 sec)</td>
<td>Pre n = 27</td>
<td>12±0.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 27</td>
<td>12±0.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Back scratch (in)**</td>
<td>Pre n = 30</td>
<td>-5.6±0.9</td>
<td>-7.1±1.5†</td>
<td>-4.2±1.2†</td>
</tr>
<tr>
<td></td>
<td>Post n = 30</td>
<td>-4.9±0.6</td>
<td>-7.2±1.0</td>
<td>-2.5±0.8**</td>
</tr>
<tr>
<td>Chair sit-and-reach (in)† **</td>
<td>Pre n = 30</td>
<td>-2.9±1.0</td>
<td>-5.9±1.5†</td>
<td>0.1±1.2†</td>
</tr>
<tr>
<td></td>
<td>Post n = 30</td>
<td>-2.0±0.6</td>
<td>-4.3±1.0</td>
<td>0.3±0.8**</td>
</tr>
<tr>
<td>8-foot up-and-go (sec) *</td>
<td>Pre n = 28</td>
<td>8.6±0.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 28</td>
<td>18.4±1.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Timed Performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soda pop test (sec) *</td>
<td>Pre n = 30</td>
<td>9.5±0.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 30</td>
<td>7.8±0.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Place book on shelf (sec) *</td>
<td>Pre n = 30</td>
<td>1.6±0.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 30</td>
<td>2.5±0.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Put jacket on &amp; off (sec)</td>
<td>Pre n = 30</td>
<td>12.3±1.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 30</td>
<td>14.2±1.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Test Measure</td>
<td>Number of Participants</td>
<td>All Participants</td>
<td>Males (n=12)</td>
<td>Females (n=18)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------</td>
<td>------------------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Pick up pencil from floor (sec)</td>
<td>Pre n = 30</td>
<td>2.0±0.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Post n = 30</td>
<td>2.3±0.4</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Physiological Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre n = 30</th>
<th>Post n = 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP (mm Hg)</td>
<td>127±2.9</td>
<td>129±2.6</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>70±1.5</td>
<td>72±1.6</td>
</tr>
<tr>
<td>RHR (bpm)</td>
<td>71±1.8</td>
<td>67±1.9</td>
</tr>
</tbody>
</table>

Paired-sample t-tests were used for test measures without gender reporting

ANOVBAs were used for test measures with gender reporting

Values are mean ± standard error mean

† indicates significant difference between gender at pre-testing

* indicates significant differences between pre- and post-testing

** indicates significant main effect for gender
Cardiovascular Endurance

The changes in cardiovascular endurance were measured using a paired-sample t-test for the number of completed steps in 2-minutes and is presented in Figure 1 and Table 4. The overall number of completed steps significantly increased between pre- and post-intervention ($t(26) = -2.79, p = .01$). The effect size for cardiovascular endurance using Cohen d is .54 which represents a medium effect.

![Bar chart showing comparison between pre-test and post-test for steps completed, with * indicating significance.](image)

*Figure 1. Cardiovascular endurance 2-minute step test, * indicates significance. Mean ± SEM for the number of completed steps ($p = .01$).*

Upper-Body Strength

The number of arm curls performed in 30-seconds was analyzed using a paired-sample t-test and is presented in Figure 2 and Table 4. There was a significant change in upper-body strength where the overall number of arm curls in 30-seconds significantly
increased between pre- and post-intervention ($t(29) = -2.01$, $p = .05$). The effect size for upper-body strength using Cohen $d$ is .37 which represents a small effect.

**Figure 2.** Upper-body strength arm curl test, * indicates significance. Mean ± SEM for the number of arm curls in 30-seconds ($p = .05$).

**Lower-Body Strength**

A paired-sample t-test was used to analyze the number of chair stands completed in 30 seconds to measure lower-body strength. The results are presented in Table 4. The overall number of chair stands remained constant between pre- and post-intervention ($t(26) = -.73$, $p > .05$). The effect size for lower-body strength using Cohen $d$ is .14 which represents a very small effect.
Upper-Body Flexibility

The changes in upper-body flexibility were assessed using a 2-way group x time ANOVA with repeated measures and demonstrated a significant main effect for gender ($F(1,28) = 6.15, p = .01$). The results are presented in Figure 3 and Table 4. Independent t-tests showed that females were more flexible than males at pre-testing, and the overall back scratch distance significantly improved during post-intervention testing for females but not males. There was no significant main effect for time ($p \geq .25$) or interaction for time by gender ($p \geq .16$). The effect size for upper-body flexibility using Cohen $d$ is .18 which represents a very small effect.
Figure 3. Upper-body flexibility back scratch test, * indicates significance. Mean ± SEM for gender where distance between middle fingers significantly improved for females (p = .01) but not males at post-intervention testing. Minus scores represent distance short of touching the middle fingers (i.e., less flexible) and plus scores indicate overlapping fingers (i.e., more flexible).

Lower-Body Flexibility

A 2-way group x time ANOVA with repeated measures demonstrated a significant main effect for gender (F(1,28) = 12.59, p = .001) for changes in lower-body flexibility and are presented in Figure 4 and Table 4. Independent t-tests showed females were significantly more flexible (p = .006) than males at pre-testing, and the overall chair sit-and-reach distance significantly improved during post-intervention testing for females but not males. There was no significant main effect for time (p ≥ .23) or interaction for
time by gender (p ≥ .36). The effect size for lower-body flexibility using Cohen d is .31 which represents a small effect.

Figure 4. Lower-body flexibility chair sit-and-reach test, * indicates significance. Mean ± SEM for gender where distance to touch toes significantly improved for females (p <.01) but not males during post-intervention testing. Minus scores represent the distance short of the toes (i.e., less flexible) and plus scores are beyond the toes (i.e., more flexible).

**Balance/Agility**

The changes in balance/agility were assessed using a paired-sample t-test for the 8-foot up-and-go test. The results are presented in Figure 5 and Table 4. The overall time for the 8-foot up-and-go test, measured in seconds, significantly increased (i.e., took
longer to perform) between pre- and post-intervention testing \((t(27) = -8.72, p < .001)\).

The effect size for balance/agility using Cohen d is 1.64 which represents a large effect.

![Figure 5. Balance/agility 8-foot up-and-go test, * indicates significance. Mean ± SEM for the number of seconds to perform 8-foot up-and-go (p < .001).](image)

**Hand Eye Coordination and Activities of Daily Living**

A paired-sample t-test showed a significant change \((t(29) = 2.21, p = .03)\) for hand eye coordination using the soda pop test. The results are presented in Figure 6 and Table 4. The overall time in seconds significantly decreased for the soda pop test between pre- and post-intervention.
Figure 6. Hand eye coordination soda pop test, * indicates significance. Mean ± SEM for the number of seconds to perform soda pop test (p < .03).

The changes in ADLs for placing a book on the shelf were assessed using a paired-sample t-test and demonstrated a significant change (t(29) = -4.79, p < .001). The results are presented in Figure 7 and Table 4. The overall time to place a book on the shelf took longer to perform during post-testing compared to pre-testing.
The changes in ADLs using paired-sample t-tests demonstrated no significant changes for putting a jacket on then off ($t(28) = -1.48$, $p > .05$) and picking up a pencil from the floor ($t(26) = -0.93$, $p > .05$). The results are presented in Table 4. The time for both measures slightly increased during post-testing compared to pre-testing.

**Blood Pressure**

Systolic and diastolic blood pressures were assessed to determine the physiological effects of the exercise training program. Paired-sample t-tests were used to analyze the changes in systolic and diastolic blood pressure between pre- and post-testing. There were no significant changes in systolic ($t(29) = -7.52$, $p > .05$) and
diastolic \((t(29) = -1.40, p > .05)\) blood pressures although slight increases were reported. The results are presented in Table 4.

**Resting and Exercise Heart Rate**

Resting heart rate was assessed to determine the physiological effects of the exercise training program and the results are presented in Table 4. A paired-sample t-test was used to evaluate the non-significant change in resting heart rate \((t(29) = 1.88, p > .05)\). There was a slight decline observed in resting heart rate between pre- and post-testing.

Exercise heart rate (EHR) and rate of perceived exertion (RPE) were assessed 3 times at the start, middle and end of each exercise session. EHR and RPE were assessed to determine each individual’s exercise intensity during the class. The averages for attendance, EHR, and RPE are presented in Table 5.

Attendance was recorded for each class session. Bivariate correlations were performed to determine whether the change (i.e., post-testing minus pre-testing score) in each of the physical performance measures including cardiovascular endurance, upper- and lower-body strength and flexibility, and balance/agility were associated with the number of sessions attended. No relationships were found for attendance and physical performance measures.
Table 5

*Attendance and Exercise Intensities*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Class Time</th>
<th>All Participants (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td># of days</td>
<td>18.9±6.3</td>
</tr>
<tr>
<td></td>
<td>range</td>
<td>3-28</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>Start</td>
<td>74.3±18.0</td>
</tr>
<tr>
<td></td>
<td>Mid</td>
<td>81.0±20.3</td>
</tr>
<tr>
<td></td>
<td>End</td>
<td>73.1±17.7</td>
</tr>
<tr>
<td>RPE (scale 1-10)</td>
<td>Start</td>
<td>1.4±0.8</td>
</tr>
<tr>
<td></td>
<td>Mid</td>
<td>2.8±0.8</td>
</tr>
<tr>
<td></td>
<td>End</td>
<td>2.9±0.8</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation

**Anthropometric Measures**

The anthropometric measures consisted of height, body weight, BMI, waist and hip circumferences, waist-to-hip ratio, and 3-site skinfold measurement. The changes in body composition were measured using 2-way group x time ANOVAs with repeated measures. There was a significant interaction for time by gender for waist-to-hip ratio (F(1,28) = 5.42, p = .02) between pre- and post-intervention. Significant gender
differences were found in hip circumference and waist-to-hip ratio (both $p = .02$) for males compared to females ($p \geq .72$) and ($p \geq .51$), respectively. The hip circumference for males significantly decreased which resulted in a larger waist-to-hip ratio for males between pre- and post-intervention. No significant main effect for time or interaction for time by gender differences were found for height ($p \geq .94$), body weight ($p \geq .82$), BMI ($p \geq .82$), and waist circumference ($p \geq .72$). The data for the skinfold measurement was unusable due to personal privacy issues. Table 6 shows the results.
### Table 6

**Anthropometric Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>All</th>
<th>Males (n=12)</th>
<th>Females (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height (cm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>163.6±12.2</td>
<td>173.6±13.3</td>
<td>156.9±5.3</td>
</tr>
<tr>
<td>Post</td>
<td>163.6±11.9</td>
<td>173.4±11.8</td>
<td>157.1±6.3</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>71.9±16.0</td>
<td>85.0±14.9</td>
<td>63.1±9.6</td>
</tr>
<tr>
<td>Post</td>
<td>71.9±16.1</td>
<td>84.7±15.2</td>
<td>63.3±9.9</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>26.8±4.8</td>
<td>28.3±4.6</td>
<td>25.8±4.8</td>
</tr>
<tr>
<td>Post</td>
<td>26.8±4.8</td>
<td>28.3±4.4</td>
<td>25.8±4.9</td>
</tr>
<tr>
<td><strong>Waist circumference (cm)</strong></td>
<td>92.1±15.0</td>
<td>105.2±11.3</td>
<td>83.4±9.9</td>
</tr>
<tr>
<td>Post</td>
<td>91.8±16.0</td>
<td>105.3±12.6</td>
<td>82.7±11.0</td>
</tr>
<tr>
<td><strong>Hip circumference (cm)</strong></td>
<td>106±12.2</td>
<td>111.7±10.8*</td>
<td>103.2±12.0</td>
</tr>
<tr>
<td>Post</td>
<td>105.1±11.3</td>
<td>108.6±10.4*</td>
<td>102.9±11.5</td>
</tr>
<tr>
<td><strong>Waist-to-hip ratio</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>.86±.09</td>
<td>.94±.04*</td>
<td>.81±.05</td>
</tr>
<tr>
<td>Post</td>
<td>.87±.10</td>
<td>.96±.05*</td>
<td>.80±.05</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation

* Indicates significant differences between pre- and post-intervention
Habitual Physical Activity

The amount of habitual physical activity was assessed by administering the rapid assessment of physical activity (RAPA) questionnaire. There were no significant main effects for gender or interaction for time by gender; therefore the data was pooled and paired-sample t-tests were used to analyze the scores of the RAPA. The categories for determining changes in physical activity consisted of questions: (a) no physical activity (PA) \( t(29) = .00, p > .05 \), (b) light PA some but not all weeks \( t(29) = -1.00, p > .05 \), (c) light PA every week \( t(29) = .63, p > .05 \), (d) moderate PA < 30 minutes/day 5 days/week \( t(29) = 1.54, p > .05 \), (e) vigorous PA < 20 minutes/day 3 days/week \( t(29) = -1.36, p > .05 \), (f) moderate PA ≥ 30 minutes/day 5 days/week \( t(29) = 1.14, p > .05 \), (g) vigorous PA ≥ 20 minutes/day 3 days/week \( t(29) = -5.71, p > .05 \), (h) muscle strength training ≥ once a week \( t(29) = -1.16, p > .05 \), and (i) flexibility training ≥ once a week \( t(29) = -.63, p > .05 \). Scoring for the RAPA indicates that 50% of participants were categorized as active at pre-testing but decreased to 40% at post-testing for question 6; while 46% of participants were categorized as underactive regular at pre-testing but declined to 30% at post-testing for question 4. As indicated by questions 8 and 9, the percentage of participants performing muscular strength and flexibility training increased at post-testing compared to pre-testing. The percentage of participants that responded “Yes” to this questionnaire is presented in Table 7.
### Table 7

**Responses from RAPA Questionnaire for Amount of Habitual Physical Activity**

<table>
<thead>
<tr>
<th>Question</th>
<th>Total (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I rarely or never do any physical activity</td>
<td>Pre 3% ±0.03</td>
</tr>
<tr>
<td></td>
<td>Post 3% ±0.03</td>
</tr>
<tr>
<td>2. I do some light or moderate physical activity, but not every week</td>
<td>Pre 10% ±0.05</td>
</tr>
<tr>
<td></td>
<td>Post 20% ±0.07</td>
</tr>
<tr>
<td>3. I do some light physical activity every week</td>
<td>Pre 80% ±0.07</td>
</tr>
<tr>
<td></td>
<td>Post 73% ±0.08</td>
</tr>
<tr>
<td>4. I do moderate physical activities every week, but less than 30 minutes per day, 5 days/week</td>
<td>Pre 46% ±0.09</td>
</tr>
<tr>
<td></td>
<td>Post 30% ±0.08</td>
</tr>
<tr>
<td>5. I do vigorous physical activities every week, but less than 20 minutes per day, 3 days/week</td>
<td>Pre 3% ±0.03</td>
</tr>
<tr>
<td></td>
<td>Post 13% ±0.06</td>
</tr>
<tr>
<td>6. I do 30 minutes or more per day of moderate physical activities, 5 or more days per week</td>
<td>Pre 50% ±0.09</td>
</tr>
<tr>
<td></td>
<td>Post 40% ±0.09</td>
</tr>
<tr>
<td>7. I do 20 minutes or more per day of vigorous physical activities, 3 or more days per week</td>
<td>Pre 3% ±0.03</td>
</tr>
<tr>
<td></td>
<td>Post 6% ±0.04</td>
</tr>
<tr>
<td>8. I do activities to increase muscle strength, such as lifting weights or calisthenics, once a week or more</td>
<td>Pre 56% ±0.09</td>
</tr>
<tr>
<td></td>
<td>Post 70% ±0.09</td>
</tr>
<tr>
<td>9. I do activities to improve flexibility, such as stretching or yoga, once a week or more</td>
<td>Pre 66% ±0.08</td>
</tr>
<tr>
<td></td>
<td>Post 73% ±0.08</td>
</tr>
</tbody>
</table>

Values are mean ± standard error mean of “Yes” responses
Correlations of Changes in Cognitive Function and Physical Performance Measures

Bivariate correlations were performed to determine the relationship between the changes in cognitive function using the 3MS examination and the changes in each physical performance measure which consisted of the 2-minute step for cardiovascular endurance, arm curls for upper-body strength, chair stands for lower-body strength, back scratch for upper-body flexibility, chair sit-and-reach for lower-body flexibility, and 8-foot up-and-go for balance/agility. The post-testing mean score for the 3MS examination was 88.0±1.6. Changes were determined by calculating the difference between post- and pre-test scores. There was a significant negative correlation (r = -.424, n = 25, p = .02) for changes in the 3MS examination scores and 2-minute step test which is depicted in Figure 8. The bivariate correlation indicates that cardiovascular fitness measured by the 2-minute step test improved while cognitive function assessed by the 3MS examination declined. The effect size for the changes in 3MS examination scores and 2-minute step test was .17 which represents a small effect (i.e., Cohen d). There were no significant relationships for the 3MS examination scores and arm curls, chair stands, back scratch, chair sit-and-reach, and 8-foot up-and-go tests. The results are presented in Table 8.

When the participants were stratified by those with two cardiovascular disease (CVD) risk factors and those without, there was a significant negative correlation (r = -.708, n = 10, p = .02) for individuals with two CVD risk factors for changes in cognitive function and cardiovascular endurance which is depicted in Figure 9. The correlation indicates that as cardiovascular endurance improves cognitive function declines for
individuals with two CVD risk factors. For individuals without two CVD risk factors, there was no significant correlation found.

*Figure 8.* Bivariate correlation for changes in cognitive function and cardiovascular endurance. Mean±SEM where significant negative correlation ($r = -.424; n = 25; p = .02$) for changes in the 2-minute step test and 3MS examination scores.
Table 8

Correlations for Changes in Physical Performance Measures and 3MS Examination Scores

<table>
<thead>
<tr>
<th>Variables – to 3MS examination scores</th>
<th>R value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-minute step *</td>
<td>-.424</td>
<td>.02</td>
</tr>
<tr>
<td>Arm curls</td>
<td>.119</td>
<td>.53</td>
</tr>
<tr>
<td>Chair stands</td>
<td>.232</td>
<td>.24</td>
</tr>
<tr>
<td>Back scratch</td>
<td>-.092</td>
<td>.62</td>
</tr>
<tr>
<td>Chair sit-and-reach</td>
<td>-.130</td>
<td>.49</td>
</tr>
<tr>
<td>8-foot up-and-go</td>
<td>.084</td>
<td>.67</td>
</tr>
</tbody>
</table>

* Indicates significance
Figure 9. Bivariate correlation for individuals with 2 CVD risk factors for the changes in cognitive function and cardiovascular endurance. Mean±SEM where significant negative correlation \((r = -0.708; n = 10; p = .02)\) for changes in the 2-minute step test and 3MS examination scores.

**Summary of Results**

In summary, there were significant improvements in cardiovascular endurance and upper-body strength while no significant changes were demonstrated for lower-body strength. Significant main effects for gender were found for upper- and lower-body flexibility for females but not males. A significant decrease in performance time was demonstrated for the soda pop test. The performance time for ADLs resulted in a significant increase for placing a book on a shelf and non-significant increases for putting a jacket on then off and picking up a pencil from the floor. No correlations were found between attendance and the physical performance measures.
There was a significant interaction for time by gender for waist-to-hip ratio between pre- and post-intervention. There was a significant main effect for gender for hip circumference for males which resulted in a significant increase in the waist-to-hip ratio for males but not for females. No significant main effect for time or interaction for time by gender was found for height, body weight, BMI, and waist circumference.

There were no significant changes for the amount of habitual physical activity as assessed by the RAPA questionnaire between pre- and post-intervention.

A significantly negative relationship was found between cardiovascular endurance and the 3MS examination scores but no relationships were found for upper- and lower-body strength and flexibility, and balance/agility. When stratifying the group by two CVD risk factors, this relationship was significantly negative for individuals with but not for those without risk factors.
CHAPTER V

DISCUSSION

Evidence obtained from inactivity, epidemiological, longitudinal and field studies clearly have demonstrated the beneficial effects of exercise in attenuating chronic diseases and functional limitations, and enhancing functional independence, self-efficacy, and cognitive function in older adults. However, information is lacking as to the optimal amount of structured exercise together with routine physical activity to elicit positive health benefits for the older-old (i.e., 75 to 84 yrs of age) and oldest-old (i.e., 85+ yrs of age) populations. The purpose of the present investigation was to determine whether a multi-component structured exercise program of low-to-moderate intensity conducted 2 days a week for 60 minutes a session (i.e., 120 min/wk) along with continued habitual physical activities could maintain or improve physical performance measures when implemented in an adult life-care community for adults 80 years of age and older with mild cognitive impairment. In addition, to determine whether implementing the exercise program changed the amount of continued habitual physical activity and whether there was a relationship between the changes in physical performance measures and cognitive functioning. The findings from this investigation will be discussed by hypotheses.
Cardiovascular Endurance and Body Composition

The results of the present investigation do not support the hypothesis that participants actively engaged in the multi-component exercise program would maintain cardiovascular endurance but does support the hypothesis that body composition would be maintained. Research on aerobic capacity or VO2peak is well documented and known to decline with aging (Hollmann et al., 2007; Katzel et al., 2001). However, this age-related decline in VO2peak is highly variable among individuals within populations (Paterson et al., 1999; Tanaka et al., 1997). Hessert et al. (2005) demonstrated the importance of integrating the various exercise components including aerobic fitness, strength training, flexibility, and balance into a multi-component exercise program to maintain physical performance in the elderly. Presently, this 6-month multi-component exercise program elicited significant improvements in cardiovascular endurance measured using the 2-minute step test. These findings are similar to those of previous investigators (Takeshima et al., 2007; Toraman et al., 2004; Vaitkevicius et al., 2002) who found improvements in VO2peak with multi-component and/or walking exercise programs. These studies, as well as the present investigation, emphasize the principle of specificity of exercise for the development of a particular body part. Presently, the exercise program involved a 10-minute warm-up followed by a thirty-minute aerobic-strength training interval segment. At the inception of the program, most participants were unable to stand for durations of thirty minutes, therefore the design of the program allowed for gradual progression (i.e., increments of 5 min/wk) permitting participants to
develop cardiovascular strength and endurance over time. Most participants were able to remain standing throughout the thirty-minute training segment within four to six weeks from commencement of the program. The program included a variety of marching and stepping movements that focused on single and complex routines, not only designed to increase aerobic capacity, but also to facilitate learning and behavioral changes that rely on cognitive skill. In contrast, Cavani et al., (2002) and DiBrezzo et al., (2005) found no change in aerobic endurance with 6-weeks and 10-weeks stretching, strengthening, and balance training programs, respectively. The failure of these studies to induce improvements in cardiovascular endurance was suggested to be attributable to the limited effects of combining strength and flexibility training without the aerobic fitness component. The improvements in the 2-minute step test demonstrated in the present investigation support the importance of specificity of exercise (i.e., aerobic training) for cardiovascular endurance.

It was hypothesized that cardiovascular endurance would be maintained with regular attendance and active participation in the multi-component exercise program. In an investigation by Baker et al. (2007) attempting to simultaneously prescribe doses and intensities of training levels, low enrollment and high drop-out rates occurred with disinterest and perceived lack of time cited as the dominant reasons for not participating. Presently, compliance to the exercise program ranged from 3 to 100% with over half of the participants attending 75% or more of the sessions. Fifty percent of participants were ranked active (i.e., 30 minutes/day or more of moderate physical activity 5 days/wk or
more) and forty-six percent ranked under-active regular (i.e., moderate physical activity every week but less than 30 minutes/day or 5 days/week) according to the self-reported RAPA questionnaire at pre-intervention. Despite the low attendance rate of several participants, significant improvements in cardiovascular fitness were observed.

Since chronic diseases, mobility and other range-of-motion limitations plagued the participants, training intensity levels were based on their individual abilities. Heart rates (HR) and ratings of perceived exertion (RPE) were obtained at the beginning, middle, and end of each exercise session. The middle HR and RPE were used to represent the group’s target HR during the aerobic-strength training interval segment of the program. The average HR ranged from 60 to 109 beats per minute which was lower than the calculated target HR using the heart rate reserve method with 40 to 60% exercise intensity. The lower HR achieved was possibly due to the use of beta-blockers, anti-hypertension, and other heart medication prescribed for two-thirds of the participants. The Borg CR10 RPE scale (Borg, 1998) was used to allow the participants to subjectively rate their feelings concerning exercise tolerance during the program. The average RPE corresponding to the average HR ranged from 1 to 4 on the Borg CR10 scale with 63% reporting moderate to somewhat strong ratings during the middle portion of the exercise program.

Physiological measures were assessed at pre- and post-testing to determine the effects of the 6-month multi-component exercise program on resting heart rate and blood pressure. One of the hallmarks of cardiovascular training is the dominant vagal control
of the heart and resting bradycardia effect in younger adults (Shi, Stevens, Foresman, Stern, & Raven, 1995; Smith, Hudson, Graitzer, & Raven, 1989). Studies in older populations have had less definitive results regarding changes in resting heart rate as a result of aerobic training. Presently, a non-significant decrease (i.e., -3 bpm) in resting heart rate was demonstrated between pre- and post-testing. These findings are similar to those reported by Huang, Shi, Davis-Brezette, and Osness (2005) in a meta-analysis where 13 studies were assessed and demonstrated that aerobic training had a statistically significant effect on enhancing vagal control of the heart and reducing resting heart rate by an average of 6 beats per minute (bpm) (ranging from -2 to -12 bpm) in older adults over 60 years of age that engaged in longer length (i.e., possibly 30 weeks or more) training programs. It is possible that reductions in resting heart rates in adults in their ninth decade of life can be achieved.

Cardiovascular endurance training generally improves peripheral blood flow regardless of age and gender. Presently, there was no significant difference in resting systolic and diastolic blood pressures. These findings are not consistent with the results reported by Murphy, Nevill, Murtagh, and Holder (2007) in a meta-analysis where nine studies involving walking interventions found no significant change in resting systolic blood pressure but did find a significant reduction in resting diastolic blood pressure representing a 2% change. In the present study, due to the age and physical limitations of the population, instructional exercises were guided at a low-to-moderate intensity allowing participants to perform the exercises based on their own abilities. One plausible
explanation for the discrepancies in blood pressure results may be attributable to the intensity of the training used in these studies which was 50 to 86% of predicted maximum heart rate vs. less than 40 to 60% of heart rate reserve in the present study.

It was hypothesized that body composition would be maintained with regular attendance and active participation in the multi-component exercise program. As hypothesized, body composition was maintained with no significant changes as assessed by body weight, BMI, and waist circumference. These findings are similar to results by Takeshima et al. (2007) and Toraman et al. (2004) that reported no significant differences in body composition assessments for body fat percentage, fat-free mass, body weight, and BMI following a 12-week and 9-week intervention, respectively. Presently, significant reductions in hip circumference and significant interactions for time by gender for waist-to-hip ratio in males were found. However, these changes in circumferences and ratios were not reflected in changes in body weight and are suspect to possible error. As noted in the results section for the 3-site skinfold measurement, personal privacy issues were cited. These issues involved the lack of cooperation by the participants to remove clothing to properly assess 3-sites for the skinfold measurement. This issue could also have contributed to the difference in hip circumference changes in males. Another possibility for the reduction in hip circumference may have been the improper stance of the male participants during assessment due to osteoporosis and physical limitations. Therefore, the reliance on hip circumference and waist-to-hip ratio is equivocal. Overall, the lack of changes in body composition following the 6-month exercise program may
have been due to the low-to-moderate intensity of the exercises which failed to produce a strong enough stimuli to combat the age-related effects on body composition. The diet regimen of the participants which was not controlled or monitored may have had an effect on body composition as well.

**Muscular Strength, Flexibility and Balance/Agility**

The results of the present investigation do no support the hypothesis that participants actively engaged in the multi-component exercise program would improve in muscular strength, flexibility, and balance.

**Muscular Strength**

Investigations by Fiatrone et al. (1994), Frontera et al. (1988), and Sipila et al. (1996) found that people of all ages could substantially increase muscular strength with structured exercise programs. In the present investigation, upper-body strength using the arm curl test significantly improved while lower-body strength assessed with the chair stand test was not significantly different following the 6-month multi-component exercise program. These results were similar for upper-body strength but contrasted the findings for lower-body strength from investigators (Cavani et al., 2002; Cyarto et al., 2008; DiBrezzo et al., 2005; Takeshima et al., 2007; Toraman et al., 2004) who found changes in both upper- and lower-body strength following strength and/or resistance training programs. These studies consisted of durations from 6 to 20 weeks in length, frequencies of training from 2 to 3 days a week, and exercise methods including resistance machines.
and bands, dumbbells, and body weight as resistance. Table 2 highlights the testing
method and the ages of the participants in these investigations. The present investigation
was 26 weeks in duration, 2 days a week, employing a multi-component program using
resistance bands, dumbbells, and body weight as resistance and testing method consisting
of the Senior Fitness Test which was used by all aforementioned studies. Muscular
strength training was performed in an interval fashion with aerobic fitness to allow the
participants respiratory recovery while keeping their heart rates elevated. Twelve
repetitions of each exercise were performed with incremental progression to 2 sets.
During the interval segment, dumbbells were used while performing exercises such as
shoulder presses and squats. Following the interval segment, resistance bands were used
for exercises that not only focused on strength but also emphasized flexibility. Presently,
the average age (i.e., males 84.2±2.9; females 83.2±4.0) of participants was older than the
average age of participants in these investigations. It is possible that the age-related
changes of the participants played a role in the lack of improvement in lower-body
strength. Significant reductions in muscular strength are estimated to decline after age 60
(Doherty, 2003; Porter et al., 1995) with rates of 1.0 to 1.5% per year up-to age 70 and
then at increased rates of 3% per year thereafter (Kallman et al., 1990; Vandervoort,
2002). Another possibility is that the training stimulus (i.e., weight of dumbbells) was
not sufficient to create positive changes due to the low-to-moderate intensity of the
exercise program.
Flexibility

The results of the present investigation do not support the hypothesis that participants actively engaged in the multi-component exercise program would improve in flexibility. The loss in flexibility is generally attributed to inactivity although the loss in flexibility does not occur at the same rate in all joints (Bell & Hoshizaki, 1981). The decline is similar in men and women; however, women are more flexible than men throughout life (Holland, Tanaka, Shigematsu, & Nakagaichi, 2002; Rikli & Jones, 1999). Presently, this 6-month multi-component exercise program elicited significant improvements in upper- and lower-body flexibility in women but not men when measured with the back scratch and chair sit-and-reach tests, respectively. These findings are similar to those of previous investigators (Cyarto et al., 2008; DiBrezzo et al., 2005) who found improvements in upper- and lower-body flexibility primarily in older women. These investigations as well as the present study used similar methods for stretching exercises with resistance bands, balls, and body weight for resistance. In the present study, the first ten to fifteen minutes of each session began with stretches involving the neck, shoulders, torso, and appendages which focused on slow, static movements aimed at loosening joints throughout the body. After the warm-up, the program followed with a thirty-minute aerobic-strength training interval segment, and then finished with balance and stretching routines focusing on the hamstrings, hips, back, and shoulders. During every session, all primary joints were stretched in the warm-up or cool-down segment. The significant improvements in upper- and lower-body flexibility in women but not men
contrasted the findings from investigators (Takeshima et al., 2007; Toraman et al., 2004) who found no improvements in flexibility and Cavani et al. (2002) who found improvements in both men and women in upper- and lower-body flexibility with a 6-week stretching and moderate-intensity resistance training program. Canvani et al. (2002) attributed improvements in range of motion solely to a 20-minute stretching session before the resistance training 3 days per week. It is unclear why improvements in flexibility for females but not males were found when performing the same stretching movements. One plausible explanation may be that since females are more flexible than men throughout life, the improvements in females may be the result of regained flexibility that was lost from disuse over the years.

**Balance/Agility**

Unstable balance is one of the major risk factors associated with falling which is the fifth leading cause of death in older adults (Rubenstein, 2009, November). Multi-component exercise programs focusing on muscular strength, flexibility, balance, and walking as well as tai chi have been shown to reduce risks of non-injurious and injurious falls (Gillespie et al., 2003). In the present investigation, balance/agility measured using the 8-foot up-and-go test significantly declined following the 6-month multi-component exercise program. It appears that the decline in balance/agility that occurred may be the result of the testing technician’s misjudgment. Investigators (Cavani et al., 2002; Cyarto et al., 2008; DiBrezzo et al., 2005; Takeshima et al., 2007; Toraman et al., 2004) found significant improvements in balance/agility. The exercise interventions employed by
investigators Cavani et al. (2002), Cyarto et al. (2008), DiBrezzo et al. (2005), and Takeshima et al. (2007) consisted of combinations of strength and resistance training, stretching, and balance routines. Presently, balance routines were integrated into the strength training and cool-down segments of the program. Participants would perform exercises such as stand on one foot with eyes open then closed, stand on toes and hold for fifteen seconds. Routines were performed at least one session per week. Therefore, the significant decline in balance following the 6-month training program makes it suspect to testing misjudgment by the technician.

In the only previous study that used a multi-component intervention, Toraman et al. (2004) observed a 26% increase by the exercise group in the 8-foot up-and-go performance compared to 7% increase by the control group. This significant finding in the 8-foot up-and-go test was the first study to report improvements after a multi-component or aerobic training intervention. It was suggested that work is needed to determine whether additive effects could be gained by using different training protocols that specifically focus on balance in older adults. Because results from the 8-foot up-and-go test in the present study may have been flawed, additional studies are necessary to determine whether a multi-component exercise program can produce beneficial improvements in balance.

**Habitual Physical Activities**

The results of the present investigation support the hypothesis that there would be no changes in the amount of habitual physical activities with the implementation of the 6-
month multi-component exercise program. Exercise is frequently prescribed to the elderly to enhance energy expenditure, improve body composition and increase functional independence (Goran & Poehlman, 1992). Because of the decline in VO₂max with aging, activities of daily living represent a greater portion of total energy expenditure thereby limiting the energy reserved for leisure physical activities in older adults. Most research studies have demonstrated the benefits of exercise training, although some studies (Goran & Poehlman, 1992; Meijer et al., 1999; Morio et al., 1998) have suggested that training programs may hinder the amount of habitual physical activity performed throughout the day in the elderly. Presently, although not significant, a downward trend in the amount of physical activity was reported with the implementation of the 6-month multi-component exercise program. During pre- and post-testing, participants completed the RAPA questionnaire that monitors physical activity patterns but was not specifically designed to capture physical activity information on the days of training. This trend showed that the percentage of participants that were categorized as active (i.e., reported performing moderate physical activities thirty minutes or more 5 days/week or more, pre-testing: 50%; post-testing: 40%) and underactive-regular (i.e., moderate physical activities every week but less than thirty minutes/day or 5 days/week, pre-testing: 46%; posting: 30%) (Table 9) declined following the exercise program. The findings from previous investigators (Goran & Poehlman, 1992; Meijer et al., 1999; Morio et al., 1998) found that the energy expenditure of physical activity during training days assessed using doubly-labeled water, tri-axial accelerometer, and self-reported activity logs, respectively, were significantly deceased. It was suggested
that these decreases in physical activities may have been a compensation mechanism for the energy required for the high- and moderate-intensity training programs. One explanation for not finding significant changes in the amount of physical activity may have been due to use of the RAPA questionnaire that assessed activity at pre- and post-intervention instead of measuring the activity levels on the days of the exercise training program.

**Correlations of Changes in Cognitive Function and Physical Performance Measures**

Cardiovascular exercise has been associated with improvements in cognitive functioning in aging humans (Colcombe & Kramer, 2003; Kramer et al., 1999). The Study of Osteoporotic Fractures reported activity level was linked to changes in the mini-mental state examination (MMSE) score (Yaffe et al., 2001) and the Canadian Study of Health and Aging demonstrated that physical activity was associated with a lower risk of cognitive impairment and dementia based on scores from the 3MS examination (Laurin, Verreault, Lindsay, MacPherson, & Rockwood, 2001). The results of the present investigation do not support the hypothesis that changes in physical performance measures would be associated with changes in cognitive function using the 3MS examination in the elderly between pre- and post-testing. Presently, the changes in cardiovascular endurance using the 2-minute step test and the 3MS examination demonstrated a significantly negative correlation indicating that as cardiovascular endurance improved cognitive functioning declined. These findings are counter-intuitive. In the present study, participants were encouraged to verbally recite the various
movements while performing the aerobic/muscular strength interval training segment. As the aerobic segment was conducted participants would recite their actions such as right foot forward right foot back; two-steps forward one step back, etc. Twelve repetitions of each strength training exercise would be counted by a variety of methods such as numerically by 3s or alphabetically starting with o. In a meta-analysis conducted by Heyn, Abreu, & Ottenbacher (2004) exercise training resulted in improvements in cardiovascular endurance, muscular strength, flexibility, BMI, and cognitive function. The study found that for the cognitively impaired, exercise training had a significantly positive effect on physical performance measures compared to controls, strength training effects improved substantially more compared to controls and comparison groups, and cognitive tasks showed improvement compared to controls. These findings were based on 30 studies that included participants 80±6.1 years of age, 72% women and 28% men, with MMSE scores categorizing the participants with mild, moderate, or severe cognitive impairment, or with cognitive impairment such as Alzheimer’s disease, dementia, etc. The training programs consisted of a variety of combinations of aerobic fitness, muscular strength, flexibility, and balance exercises.

Increasing evidence has suggested that many cardiovascular disease (CVD) risk factors such as hypertension, dyslipidemia, diabetes mellitus (DM), and mid-life but not late-life obesity are risk factors for dementia. In the present investigation all participants met the criteria on the Clinical Dementia Rating Scale (Morris, 1994) for very mild dementia. The medical history completed at pre- and post-intervention indicated that
many participants presented with CVD risk factors that are associated with cognitive impairment. High blood pressure and high cholesterol were among the highest reported risk factors present in nearly half of the participants and sixty percent of the population was overweight or obese with BMI > 25. After stratifying the individuals by those with two CVD risk factors and those without, it is apparent from the significantly negative correlation depicted in Figure 9 between the changes in cardiovascular endurance and cognitive function that individuals with at least two CVD risk factors did not have the same response to the 2-minute step test and 3MS examination as those without risk factors. For individuals without two CVD risk factors, no association was found for changes in the 2-minute step test and the score on the 3MS examination. Evidence from studies evaluating the relationship of midlife high blood pressure (Guo et al., 2001; Launer et al., 2000), high cholesterol (Devore et al., 2004), DM (Ott et al., 1999; Yaffe et al., 2004), and midlife obesity (Fitzpatrick et al., 2009; Kivipelto et al., 2005) to the increased risk of dementia found strong correlations between these CVD risk factors and increased risk of late life dementia. Presently it is impossible to determine the effect of CVD risk factors on cognitive functioning due to the cross-sectional design of this investigation, although evidence suggests that the incidence of high blood pressure, high cholesterol, DM and being overweight or obese may play a role in the decline in cognitive functioning. Additional research may provide evidence of the mechanism(s) involved in the influence of these CVD risk factors on the increased risk of dementia and AD. It is not clear whether the relationship is due to a sharing of risk factors or to direct or indirect influence of CVD on the pathological processes that cause cognitive decline.
One investigation that found the influence of CVD risk factors on cognitive decline demonstrated that individuals with elevated BMI > 25 exhibited poorer executive function test performance compared to individuals with normal body weight at any age (Gunstad et al., 2007). These findings provide evidence of the relationship between elevated BMI and reduced cognitive performance regardless of age. It is plausible from these findings to suggest that the decline in cognitive functioning may be influenced by the negative effects of the CVD risk factors.

It has been suggested that slower speed of task performance could be an early marker of functional change in mild cognitive impairment (MCI). In the present investigation participants were timed while performing activities of daily living including placing a book on the shelf, putting a jacket on then off, and picking-up a pencil from the floor and the hand eye coordination task of turning soda pop cans. The performance time for each of these cognitive tasks with the exception of the turning of soda pop cans increased (i.e., took longer to perform) during post-testing compared to pre-testing. Wadley, Okonkwo, Crowe, and Ross-Meadows (2008) demonstrated that participants with MCI took significantly longer to complete timed instrumental activities of daily living (IADLs) including telephone use, locating nutrition information on food labels, financial abilities, grocery shopping, and medication management compared to cognitively normal participants. Although no relationship between the aforementioned timed tasks and 3MS examination score was found, the decline in the speed of performing these tasks may be signs of decline in cognitive functioning.
To further analyze the significantly negative correlation between cardiovascular endurance and the 3MS examination score, study participants were stratified into 2 categories based on the number of training sessions attended. Category 1 represented the high attendance group that attended 75% or more sessions and category 2 was the low attendance group representing less than 75% of the sessions. The negative relationship for the changes in cardiovascular endurance and cognitive functioning remained for both high- and low-attendance groups. Although it is unclear how the low-attendance group demonstrated improvements in cardiovascular endurance without training, the negative changes in cognitive functioning were present in both high and low attendance groups.

Presently, except for the association between changes in cardiovascular endurance and the 3MS examination, there were no relationships found between the changes in upper- and lower-body strength and flexibility, and balance and the changes in the 3MS examination.

**Conclusions**

The results of the present investigation build upon the limited body of literature on elderly adults over the age of 80 in several ways. First the improvements in cardiovascular endurance in the older-old (i.e., 75 to 84 years of age) and oldest-old (i.e., 85+ years of age) adults that are physically active supports the current body of literature especially for those over 80 years of age. However, the negative association between the changes in cardiovascular endurance and cognitive functioning for participants with very mild dementia is timely since the current literature has generally demonstrated positive or
no associations. This negative association may support the findings for CVD risk factors (i.e., high blood pressure, high cholesterol, DM and BMI $\geq 30$) associated with cognitive decline. Improvements in upper-body strength can occur with strength training in individuals well into their ninth decade of life. The maintaining of lower-body muscular strength should be viewed as an important finding since normal muscle mass deterioration after 70 years of age is so prevalent that simply preserving muscle tissue is a benefit. Improvements in upper- and lower-body flexibility are possible with exercise programs that focus on stretching and may highlight the return of flexibility due to disuse. Changes in body composition were not demonstrated which may further add to the current literature that have found little to no change in body composition following exercise programs in elderly adults over the age of 80. Finally, although not significant, there was a downward trend in physical activity at post-intervention compared to pre-intervention that may be a result of the implementation of the exercise program. These findings clearly demonstrate the beneficial effects in attenuating functional limitations and enhancing functional independence with a multi-component exercise program.

**Limitations**

The present investigation is not without limitations. As part of the study design, one adult life-care community was selected which employed a fairly homogeneous population that makes generalizing these findings to the general public more difficult. This study involved elderly adults over 80 years of age, most physically active every week, able to exercise and/or cleared by physician, Caucasian, high socio-economic
status, highly educated, needing assistance with 2 or more IADLs or ADLs, and all with very mild dementia. Individuals that participated in this investigation have been more active than the general population at this age. Body composition measures including the 3-site skinfold and hip circumference were compromised due to limited cooperation by the participants in removing clothing for proper assessment. The number of class sessions was limited to 2 days/week for a total of 120 minutes/week due to accommodations at the facility. Recommendations for all adults are to accumulate 150 minutes/week or more of moderate-intensity physical activity and should include endurance exercise, strength training, stretching and balance routines (ACSM position stand, 2009; Nelson et al., 2007). In an effect to account for the 150 minutes per week, participants were encouraged to continue their habitual physical activities. Dispute the encouragement to continue physical activities, the self-reported RAPA questionnaire showed a downward trend in physical activities at post-testing compared to pre-testing. The use of the RAPA questionnaire for measuring physical activity patterns in lieu of the doubly-labeled water method or wearing accelerometers by the participants limited direct measurement of the amount of physical activity on the days of the exercise program. The Senior Fitness Test (Rikli & Jones, 2001) was used as the primary assessment method for determining differences between pre- and post-intervention changes. The 8-foot up-and-go test may have been jeopardized due to the testing technician’s misjudgment. During the exercise program participants were not receptive of individual assistance due to impaired hearing and range-of-motion limitations which may have jeopardized maximal benefits of the exercise. Due to the cross-sectional design of the study, data is lacking
concerning the influence of midlife CVD risk factors to the increased risk of cognitive decline. Finally, the age of the participants allows much needed data for research, however, the safety and respect of the participants creates unique challenges when conducting such an investigation. Most research on older adults has been conducted on populations 79 years of age or younger and then extrapolated to adults in their ninth and ten decades. Because the composition of older adults in the U.S. is dramatically changing with people living longer, the findings with these limitations provide current literature for adults over 80 years of age with some form of cognitive impairment.

**Future Directions**

Based on the findings from the present investigation, future methodologies can be expanded to include the following recommendations while using the Senior Fitness Test (Rikli & Jones, 2001) assessment method:

1. The inclusion of elderly adults over 80 years of age of different ethnic backgrounds, lower socio-economic status, less education and no cognitive impairment could improve generalization.

2. The inclusion of sedentary adults in their ninth decade of life and older could provide information about participation and adherence to a structured exercise program.

3. The inclusion of elderly adults over 80 years of age not living in a life-care adult community could provide generalization to a larger population of elderly adults.
4. The inclusion of elderly adults in their ninth decade of life and older in a multi-component exercise program that meets 3 days/week for 150 minutes could examine whether similar results are found or greater benefits could be sought.

5. The inclusion of adults over 80 years of age wearing accelerometers during the course of the multi-component exercise program may provide better information about the physical activity patterns of the participants on the days of the training program.
APPENDICES
APPENDIX A

Consent Form
Appendix A
Consent Form

Cognitive Benefits of Exercise

Principal Investigator: John Gunstad, Ph.D.

CONSENT FORM

Benefits of Exercise For Cognition

Full Project Title: Attenuating the Cognitive Decline in MCI Individuals with Exercise in an Assisted Living Facility

Principle Investigator: Investigators: John Gunstad, Ph.D.
Co-Investigators: Mary Beth Spitznagel, Ph.D. and Ellen Glickman, Ph.D.

We are asking you to be in a research study which will include up to 100 participants. The following information is provided to inform you about the study and your participation in it. Please read it carefully and feel free to ask any questions.

PURPOSE OF STUDY: You are being asked to participate in a research study. The purpose of this study is to gain information that may help us better understand the relationship between exercise and problems with memory and other thinking skills. To do this, we are asking people to participate in an exercise program and following them over time. We will look at how memory and other thinking skills change over time and how participation in the exercise program may affect these changes.

PROCEDURES: If you decide to take part in this study you will first be asked to complete a series of tests. These evaluations will include:

Tests of memory and other thinking skills: You will be asked to complete a short set of pen/paper and question/answer tests that assess your ability to focus and sustain your attention, learn and remember new information, and other types of thinking skills. These tests will take about 45-60 minutes. You will be asked to do these tests now, 6 months from now, and in 12 months at the end of the study.

Questionnaires: You will also be asked to complete paper-and-pencil questionnaires. The questions ask about your personal characteristics (such as gender) as well as your eating and exercise habits, ways you deal with stress, and interactions with others. You will also be reading a message about exercise and some questionnaires will ask you to provide feedback about that message. The questionnaires will take about 30 minutes to finish. You will be asked to do these tests now, 3, 6, 9 months from now, and in 12 months at the end of the study.

Physiological Testing: Baseline levels of your height, weight, waist to hip ratio, skinfold, resting heart rate and blood pressure measurements will be recorded. Your blood pressure and resting heart rate will be measured every two weeks throughout the study. Your weight and height will be measured now. 3. 6. 9.
and 12 months from now. Your skinfold and waist to hip ratio will be assessed now, and at 6 and 12 months.

**Functional Testing:** You will be asked to perform some functional testing to determine your fitness level. These tests will assess your cardiopulmonary capacity, muscular strength and endurance, flexibility, balance and physical performance ability. This testing will be conducted now, 3, 6, 9, and 12 months from now.

**Blood Draw:** You will be asked to give a small sample of your blood at the baseline assessment and 12 month follow-up. Levels of chemicals in your blood that may influence memory and other thinking abilities will be analyzed. We will also store your blood to conduct additional analyses on it in the future. The blood will be drawn by a licensed medical technologist using sterile, disposable equipment from a space in your forearm (antecubital space: the inside portion of your elbow). You should refrain from eating or drinking anything except water for 10-12 hours prior to the collection of blood. You are permitted to take your medications and drink as much water as you wish. You should recognize that you may experience some discomfort at the site on your arm where the sample will be taken. You will then be given a brief break and a snack.

Once you have completed the evaluations, you will be asked to sign up for exercise sessions that fit your schedule. The sessions are 90 minutes twice a week for 12 months. The exercise program will be structured as follows:

**Warm up/Flexibility/Balance (10-15 mins):** This will consist of a series of non-strenuous stretching and flexibility exercises designed to prepare the individual for more strenuous exercise. Exercises to improve balance will also be incorporated.

**Aerobic activities (20-30 minutes):** These activities will consist of a structured program of walking, jogging, dancing or similar aerobic activities. Aerobic exercise improves heart and lung function and helps to give individuals more energy. The specific type and intensity of activity will depend upon your age and fitness level and will be prescribed by the Principal Investigator and administered by certified exercise physiologists. Target heart rates will be used in the determination of exercise intensity. Your heart rate during exercise will be monitored by wearing a Polar heart rate monitor. Intensity will also be monitored using the 15 point Borg scale where you will rate how hard you feel that you are working. You will not be allowed to exercise to exhaustion.

**Resistance training (10-15 minutes):** These activities will consist of a structured program of resistance/strength training. You may be using free weights, weight machines, resistance bands or body weight for the training. You will be performing 8-10 exercises involving major large muscle groups. The specific type and intensity of activity will depend upon your age and fitness level.
Cognitive Benefits of Exercise

and will be prescribed by the Principal Investigator and administered by certified exercise physiologists. Rating of perceived exertion will be used to determine exercise intensity.

Cool down (10-15 mins): These activities will consist of a series of gentle stretching and relaxation exercise designed to cool an individual down after exercise and bring your heart rate down close to your pre-exercise level. Your progress in these activities will be closely monitored and you will receive regular feedback with regard to your progress.

In addition to the activities described above, we also request that you give permission for the research team to review your Laurel Lake medical chart to help us keep track of your medications, medical problems and symptoms, allergies, hospitalizations, and surgeries.

All results will be kept confidential. We will store all study materials in a locked filing cabinet in a locked room at Kent State University. As soon as possible, your personal identifying information such as your name and date of birth will be removed from your file.

YOUR RIGHTS AS A PARTICIPANT: Your participation in this study is strictly voluntary and confidential. You may refuse to participate in this study or withdraw consent to participate at any time without penalty or loss of benefits. You may also refuse any aspect of this study (for example, refusing to allow the research team access to medical records) without penalty. If you refuse to participate or withdraw from the study, it will not affect your treatment at Laurel Lake.

RISKS AND DISCOMFORTS: We believe that the risks of this study are minimal. One risk is possible distress caused by completing the tests of memory or other thinking skills and the questionnaires. If you experience distress during the memory testing, please understand that you can stop at any time and rest until you are ready to continue, or decide not to continue. If you experience distress while completing the questionnaires, please understand that you can choose not to answer any questions that you do not want to answer. One of the investigators will be available during these times to meet with any participant, upon request, to discuss any concerns. You can also ask to meet with a member of the research team by calling Dr. John Gunstad at 330 672-2589 (office phone).

In addition, there is also an extremely small risk of more serious medical complications, including heart attack and sudden death. However, these risks are extremely small in healthy individuals. Furthermore, participation in a well organized and individualized exercise program greatly reduces these already small risks.
Please inform a research team member if you should wish to stop, experience some failure of exercise equipment, or happen to experience any of the following during this study: chest pain, shortness of breath, pallor, fainting, wheezing, leg cramps, light-headedness, confusion, nausea, cold/clammy skin, noticeable change in heart rhythm, severe fatigue, or any other discomfort.

Additionally, if findings emerge during this research that might affect your willingness to continue to participate, this information will be provided to you so that you can make an informed decision about your participation.

We will provide feedback on your memory performance after each assessment. If it becomes apparent during the course of the study that you are having significant difficulties with your memory or other thinking skills, we will discuss this with you and may request evaluation by neuropsychology or psychiatry service to ensure your safety. Similarly, if you report intentions to hurt yourself or others, we will contact the psychiatry service to evaluate you to ensure your safety. Members from the psychiatry service will talk with you about these concerns and identify the most appropriate course of action.

In the unlikely event that you experience any psychological distress or medical problem during the course of this study, medical care and mental health services are available at Summa Health System. Medical care and mental health services are also available outside the Summa Health System. However, you would have to make arrangements to pay for any services. Any medical or mental health care would not be provided for free because you were in this research project.

POTENTIAL BENEFITS: This research study is being conducted to better learn how a structured exercise program might benefit cognitive skills, such as memory, in older adults. Previous research shows that routine exercise can prevent or slow cognitive decline, so your involvement in this study may provide cognitive benefits to you. We will provide you with feedback regarding your memory performance after you have completed testing. We will also give everyone information on memory problems in older adults, and it is possible that you will find this information helpful. We also expect you may experience the benefits typically associated with regular exercise, such as improved fitness, health, and quality of life. The outcome of the research will provide important information on the relationship between exercise and memory and other thinking skills.

CRITERIA FOR INCLUSION/EXCLUSION FROM PARTICIPATION:
Inclusion: To be included in this study, you must be older than 55 years of age, able to communicate in English, and a Laurel Lake resident.

Exclusion: You will not be eligible if you have a history of significant neurological disorders, such as stroke, seizures, or severe head injury. You will not be eligible.
Cognitive Benefits of Exercise  Principal Investigator: John Gunstad, Ph.D.

if you have a history of significant psychological problems, such as schizophrenia or bipolar disorder. In addition, this study will adhere to the “Contraindications to Exercise Testing” (American College of Sports Medicine Guidelines for Exercise Testing and Prescription, 7th Edition 2006, p.50). If you have any of the conditions in the below list of “Absolute Contraindications,” you may not participate in this study:

**Absolute Contraindications**

If you have been diagnosed by your doctor to have any of the following medical conditions, we will ask you NOT to participate in this study.

- A recent change in the resting ECG (electrocardiogram) suggesting ischemia, recent myocardial infarction (within 2 days) or other acute cardiac event.
  - Decreased blood flow to organs, recent heart attack
- Unstable angina
  - Unexplained recurrent chest pain
- Uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise
  - Abnormal rhythms or sequence of heartbeats that causes poor blood circulation
- Severe aortic stenosis
  - Narrowing or stiffening of the aortic valve
- Uncontrolled symptomatic heart failure
  - Symptoms of heart failure including, but limited to, decreased blood flow to organs, swollen legs, shortness of breath
- Acute pulmonary embolism or pulmonary infarction
  - Blood clot in the lung
- Acute myocarditis
  - Inflammation of the heart muscle
- Suspected or known dissecting aneurysm
  - Rupturing of the blood vessel walls
- Acute infections

If you have been diagnosed with any of the following “Relative Contraindications,” it is unadvisable for you to participate without consulting with your doctor.

**Relative Contraindications**

- Left main cardiac stenosis
  - Blockage in the left main coronary valve of your heart
- Moderate stenotic valvular heart disease
Cognitive Benefits of Exercise

Principal Investigator: John Gunstad, Ph.D.

- Heart valve with impaired function
- Electrolyte abnormalities (hypokalemia, hypomagnesemia)
  - Low potassium or magnesium levels
- Severe arterial hypertension (SBP > 200 mmHg and/or DBP > 100 mmHg at rest)
  - High blood pressure; systolic blood pressure greater than 200 mmHg and/or diastolic blood pressure greater than 100 mmHg at rest
- Tachyarrhythmias or bradyarrhythmias
  - Fast and/or irregular heart rhythm; or slow heart rhythms
- Hypertrophic cardiomyopathy
  - Enlarged heart with compromised contractions
- Neuromuscular, musculoskeletal, or rheumatoid disorders that are exacerbated by exercise
- High degree atrio-ventricular block
  - Compromised electrical conduction of impulses through heart; usually requires pacemaker
- Ventricular aneurysm
  - Defect in the ventricle wall of your heart
- Uncontrolled metabolic diseases (e.g., diabetes, kidney disease)
- Chronic infection (e.g., mononucleosis)

Relative contraindications can be superseded if benefits outweigh risk of exercise. In some instances these individuals can be exercised with caution and/or using low-level end points, especially if they are symptomatic at rest.

CONFIDENTIALITY: All research records will be kept in a locked office at Kent State University and confidentiality of your records will be maintained within the limits of the law; however, Federal law authorizes representatives from the Office of Human Research Protection, Kent State University, and the Summa Health Systems Institutional Review Board to inspect the research records. The information you provide will be identified only by a number.

SPONSORS: This research is being supported financially by the Extendicare Foundation and involves collaboration between researchers at Summa Health System and researchers at Kent State University. We plan to recruit 100 participants in this study.

QUESTIONS: If you want to know more about this research project, please call Dr. John Gunstad at (330) 672-2589 (office phone). The procedures for this project have been reviewed by the Human Subjects Committee at Kent State University. If
you have questions about Kent State University's rules for research, please call Dr. John West, Dean, Division of Research and Graduate Studies (Tel. 330-672-0700).

By signing this consent form you agree that you are willing to be contacted in the future by the investigators to see how you are doing. At that time you may choose to participate or to decline to participate in any new procedures (such as a telephone interview or questionnaire).

You will get a signed copy of this consent form.

By signing this form I acknowledge that I have read it, understand it, and have had any questions regarding the risks and benefits of this study satisfactorily answered, and I am voluntarily consenting to participate in this study. Further, I realize that by signing this form I do not waive any of my legal rights, and that I can choose to terminate my participation at any time.

________________________________________________________________________ Date: _____________
Participant Signature

________________________________________________________________________ Date: _____________
Witness Signature

________________________________________________________________________ Date: _____________
Person obtaining consent

________________________________________________________________________ Date: _____________
Investigator
Tell me in your own words what participation in this study involves:
(Correct answer should include some detail about the baseline testing process, as well as the commitment to participate in twice weekly exercise sessions for the duration of the study).

What risks and benefits might be involved in this study?
(Correct answer could include anything listed in informed consent as a risk/benefit, or any other statement that accurately reflects a risk or benefit).

What should you do if you experience distress or discomfort at any time during the study?
(Correct answer is to inform the researcher immediately).

How would you withdraw from the study, if you decided you no longer want to participate?
(Correct answer is to inform the researcher, either in writing or verbally).
APPENDIX B

Medical History Form
Appendix B
Medical History Form

Medical History Form

Date: 

Name: 

Sex: Male Female

Address: 

Date of Birth: 
Age: 
Yrs of Education: 

Phone #: 

Emergency Contact (Name and number): 

Medical History: (circle all that apply)
1. High blood pressure
2. Heart Attack
3. Bypass surgery or Valve Replacement surgery
4. High Cholesterol
5. Diabetes
6. Thyroid Problems
7. Stroke
8. Seizures
9. Head injury
10. Sleep Apnea
11. Depression
12. Anxiety
13. Other psychological problems If yes, please list 
14. Problems with Alcohol/Drugs If yes, please list 
15. Past Surgery If yes, please list 
16. Arthritis If yes, please list 
17. Current Medication If yes, please list 
18. Other medical problems If yes, please list 

Primary language:
1. English
2. Other

Handedness: 1 Right 2 Left 3 Mixed

Marital Status:
1. Married
2. Divorced
3. Widow(er)
4. Single/Never Married

Race/Ethnicity:
1. Caucasian
2. Hispanic/Latino
3. Asian-American
4. African-American
5. Native American/Alaskan Eskimo
6. Other
APPENDIX C

Data Collection Sheet
## Appendix C

### Data Collection Sheet

<table>
<thead>
<tr>
<th>FUNCTIONAL TEST</th>
<th>PRETEST</th>
<th>Date</th>
<th>Initials</th>
<th>MIDTEST</th>
<th>Date</th>
<th>Initials</th>
<th>POSTTEST</th>
<th>Date</th>
<th>Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Minute Step Test (# Steps completed)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(# full ROM curls in 30 sec)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chair Stand (# stand in 30 sec)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Back Scratch (Distance btw middle fingers in cm)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chair Sit and Reach (2 trials-distance in cm)</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8 Foot Up and Go (2 trials measured in sec)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Soda Pop Can (in sec)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>PHYSICAL PERFORMANCE</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Place Book on shelf</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Put on and remove jacket</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pick up pencil from floor</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Height (mm)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Tricep Skinfold -females (mm)</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Suprailiac -females (mm)</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Thigh -males &amp; females (mm)</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chest -males (mm)</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Abdomen -males (mm)</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Waist (cm)</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hip (cm)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Waist/Hip ratio</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Blood Pressure (mm Hg)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All spaces must be completed*
Appendix D
Modified Mini-Mental State (3MS) Examination

**Modified Mini Mental State Examination (3MS)**

<table>
<thead>
<tr>
<th>Handedness:</th>
<th>R</th>
<th>L</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital Status:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pt. Initials:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3MS MMSE

**DATE AND PLACE OF BIRTH**

- Date Month: __________ Date Year: __________
- Place: City: __________ State: __________

**REGISTRATION** (if presentations)

- SHIRT: BROWN, HONESTY
- (or: SHOES: BLACK, MODESTY)
- (or: SOCKS: BLUE, CHARITY)

**MENTAL REVERSAL**

- 5 to 1
  - Accurate: 2
  - 1-2 errors/misses: 0 1
  - DLROW: 0 1 2 3 4 5

**FIRST RECALL**

- Spontaneous recall: 3
  - After "Something to wear": 2
    - "SHOES, SHIRT, SOCKS": 0 1
  - After "A color": 2
    - "BLUE, BLACK, BROWN": 0 1
  - After "A good personal quality": 2
    - "HONESTY, CHARITY, MODESTY": 0 1

**TEMPORAL ORIENTATION**

- Year: __________
  - Accurate: 4
  - Missed by 1 year: 0 2
- Season: __________
  - Accurate/within 1 mo.: 0 1
- Month: __________
  - Accurate/within 5 days: 0 1
  - Missed by 1 month: 0 1
- Day of Month: __________
  - Accurate: 3
  - Missed by 1-2 days: 2
  - Missed by 3-5 days: 0 1
- Day of Week: __________
  - Accurate: 0 1

**SPATIAL ORIENTATION**

- State: __________
- City: __________
- County: __________
- HOSPITAL/OFFICE/HOME: __________

**NAMING (MMSE: Pencil Watch)**

- Forehead: __________
- Chin: __________
- Shoulder: __________
- Elbow: __________
- Knuckle: __________

**FOUR-LEGGED ANIMALS**

<table>
<thead>
<tr>
<th>SIMILARITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ans. - Leg</td>
</tr>
<tr>
<td>Body part, limb, etc.: 2</td>
</tr>
<tr>
<td>Less correct answer: 0 1</td>
</tr>
<tr>
<td>Laughing - Crying</td>
</tr>
<tr>
<td>Feeling, emotion: 2</td>
</tr>
<tr>
<td>Other correct answer: 0 1</td>
</tr>
<tr>
<td>Eating - Sleeping</td>
</tr>
<tr>
<td>Essential for life: 2</td>
</tr>
<tr>
<td>Other correct answer: 0 1</td>
</tr>
</tbody>
</table>

**REPEITION**

- "I WOULD LIKE TO GO OUT."
  - 1 or 2 missed words: 2
  - "NO IF___ AND___ OR BUT___": 0 1

**READ AND OBEY "CLOSE YOUR EYES"**

- Obey without prompting: 3
- Obey after prompting: 2
- Reads aloud only (spontaneously or by request): 0 1

**WRITING** (1 minute)

<table>
<thead>
<tr>
<th>MMSE: Spontaneous sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) WOULD LIKE TO GO OUT.</td>
</tr>
</tbody>
</table>

**COPYING PENTAGONS** (1 minute)

<table>
<thead>
<tr>
<th>Pentagon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each Pentagon</td>
</tr>
<tr>
<td>5 approximately equal sides: 4 4</td>
</tr>
<tr>
<td>5 unequal (&gt;2.1) sides: 3 3</td>
</tr>
<tr>
<td>Other enclosed figure: 2 2</td>
</tr>
<tr>
<td>2 or more lines: 0 1 0 1</td>
</tr>
<tr>
<td>Intersection</td>
</tr>
<tr>
<td>4 corners: 2</td>
</tr>
<tr>
<td>Not 4-corner enclosure: 0 1</td>
</tr>
</tbody>
</table>

**THREE-STAGE COMMAND**

| TAKE THIS PAPER WITH YOUR (non-dominant) HAND, FOLD IT IN HALF, AND HAND IT BACK TO ME |

**SECOND RECALL**

| 0 1 2 3 |
| (something to wear) |
| (color) |
| (good personal quality) |

**TOTALS:**

- **3MS:** 100
- **MMSE:** 30
CLOSE YOUR EYES
APPENDIX E

Lawton-Brody IADL/ADL Questionnaire
Appendix E
Lawton-Brody IADL/ADL Questionnaire

Lawton-Brody IADL/ADL Questionnaire

Instructions: The following questions are designed to provide us with information concerning your abilities in the various areas of daily living skills. For each of the items 1 through 14 on the following pages, circle only one statement that best describes your behavior. Please answer the questions honestly and completely. Thank you for your cooperation.

Your Age
Your Education (in years)
Your Ethnicity (circle one) Caucasian African-American Asian Other

What is your living situation? (check one):
  o Live alone in own house/apt.
  o Live in supervised housing.
  o Live with family.
  o Live in nursing home.
  o Live in own apartment but in the same building as family (e.g., duplex)

How much formal or informal assistance/care do you receive each week?
  o None
  o Less than 20 hours
  o 20-39 hours
  o 40+ hours

IADL

1. Telephone use:
   A. You operate a telephone on your own initiative -- looks up and dials numbers, etc.
   B. You dial only a few well-known numbers.
   C. You answer the telephone but do not dial.
   D. You do not use the telephone at all.

2. Shopping:
   A. You take care of all shopping needs independently.
   B. You shop independently for only small purchases.
   C. You need to be accompanied on any shopping trip.
   D. You are completely unable to shop.

3. Food preparation:
   A. You plan, prepare, and serve adequate meals independently.
   B. You prepare adequate meals if supplied with ingredients.
   C. You heat and serve prepared meals, or prepare meals but do not maintain an adequate diet.
   D. You need to have meals prepared and served for you.
1. **Housekeeping:**
   A. You maintain your house alone or with occasional assistance.
   B. You perform light daily tasks such as dishwashing, bedmaking.
   C. You perform light daily tasks but cannot maintain an acceptable level of cleanliness.
   D. You need help with all home maintenance tasks.
   E. You do not participate in any housekeeping tasks.

5. **Laundry:**
   A. You do personal laundry completely on your own.
   B. You launder small items only on your own—rinses socks, stockings, etc.
   C. All of your laundry must be done by others.

6. **Mode of transportation:**
   A. You travel independently on public transportation or drive your own car.
   B. You arrange your own travel via taxi, but do not otherwise use public transportation.
   C. You travel on public transportation when assisted or accompanied by another.
   D. Your travel is limited to taxi or automobile only with assistance of another.
   E. You do not travel at all.

7. **Responsibility for own medications:**
   A. You are responsible for taking medication in correct dosages at correct time.
   B. You take responsibility if medication is prepared in advance in separate dosages.
   C. You are not capable of dispensing your own medication.

8. **Ability to handle finances:**
   A. You manage financial matters independently (budget, write checks, pay rent, go to bank, collect and keep track of income).
   B. You manage day-to-day purchases, but need help with banking, major purchases, etc.
   C. You are incapable of handling money.

**ADL**

9. **Toileting:**
   A. You care for yourself at the toilet, no incontinence.
   B. You need to be reminded, or need help in cleaning yourself, or have rare (weekly at most) accidents.
   C. You soil or wet yourself while asleep more than once a week.
   D. You soil or wet yourself while awake more than once a week.
   E. You have no control of your bowels or bladder.

10. **Feeding:**
    A. You eat without assistance.
    B. You eat with minor assistance at meal times and/or with special preparation of food, or help in cleaning up after meals.
    C. You feed yourself with moderate assistance and are untidy.
    D. You require extensive assistance for all meals.
    E. You do not feed yourself at all and resist efforts of others to feed you.

11. **Dressing:**
    A. You dress, undress, and select clothing from your own wardrobe.
B. You dress and undress yourself with minor assistance.
C. You need moderate assistance in dressing or selection of clothes.
D. You need major assistance in dressing, but cooperate with efforts of others to help.
E. You are completely unable to dress yourself and resist efforts of others to help.

12. Grooming (neatness, hair, nails, hands, face, clothing):
   A. You are always neatly dressed and well groomed without assistance.
   B. You groom yourself adequately with occasional minor assistance, e.g. shaving.
   C. You need moderate and regular assistance or supervision in grooming.
   D. You need total grooming care, but can remain well groomed after help from others.
   E. You actively negate all efforts of others to maintain your grooming.

13. Physical Ambulation:
   A. You go about grounds or city.
   B. You ambulate within your residence or about one block distant.
   C. You ambulate with assistance of (check one) ( ) another person ( ) railing
      ( ) cane ( ) walker ( ) wheelchair.
      1. _____ Get in and out of wheelchair without help.
      2. _____ Need help in getting in and out of wheelchair.
   D. You sit unsupported in a chair or wheelchair, but cannot propel yourself without help.
   E. You are bedridden more than half the time.

14. Bathing:
   A. You bathe yourself (tub, shower, sponge bath) without help.
   B. You bathe yourself with help in getting in and out of tub.
   C. You wash your face and hands only, but cannot bathe the rest of your body alone.
   D. You do not wash yourself, but are cooperative with those who bathe you.
   E. You do not try to wash yourself and resists effort of others to keep you clean.

PADL Total______
APPENDIX F

Rapid Assessment of Physical Activity (RAPA) Questionnaire
Appendix F
Rapid Assessment of Physical Activity (RAPA) Questionnaire

RAPA

Physical Activities are activities where you move and increase your heart rate above its resting rate, whether you do them for pleasure, work, or transportation.

The following questions ask about the amount and intensity of physical activity you usually do. The intensity of the activity is related to the amount of energy you use to do these activities.

Examples of physical activity intensity levels:

<table>
<thead>
<tr>
<th>Light activities</th>
<th>Moderate activities</th>
<th>Vigorous activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• your heart beats slightly faster than normal</td>
<td>• your heart beats faster than normal</td>
<td>• your heart rate increases a lot</td>
</tr>
<tr>
<td>• you can talk and sing</td>
<td>• you can talk but not sing</td>
<td>• you can't talk or your talking is broken up by large breaths</td>
</tr>
<tr>
<td>Walking Leisurely</td>
<td>Fast Walking</td>
<td>Stair Machine</td>
</tr>
<tr>
<td>Stretching</td>
<td>Aerobics Class</td>
<td>Jogging or Running</td>
</tr>
<tr>
<td>Vacuuming or Light Yard Work</td>
<td>Strength Training</td>
<td>Tennis, Racquetball, Pickleball or Badminton</td>
</tr>
<tr>
<td>Description</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>I rarely or never do any physical activities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do some <strong>light</strong> or <strong>moderate</strong> physical activities, but not every week.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do <strong>light</strong> physical activity every week.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do <strong>moderate</strong> physical activities every week, but less than 30 minutes per day, 5 days a week.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do <strong>vigorous</strong> physical activities every week, but less than 20 minutes per day, 3 days a week.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do 30 minutes or more per day of <strong>moderate</strong> physical activities, 5 or more days per week.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do 20 minutes or more per day of <strong>vigorous</strong> physical activities, 3 or more days per week.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do activities to increase muscle <strong>strength</strong>, such as lifting weights or calisthenics, once a week or more.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do activities to improve <strong>flexibility</strong>, such as stretching or yoga, once a week or more.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(Check one answer on each line)*
APPENDIX G

List of Exercises
Appendix G
List of Exercises

EXERCISE INTERVENTION PROGRAM

Physical activity guidelines for adults > age 65 by the American College of Sports Medicine (Nelson et al., 2007) are as follows:

Aerobic capacity

Moderately intense aerobic exercise for 30 minutes a day, five days/week

Or

Vigorous aerobic activity for 20 minutes a day, three days/week

Muscle strengthening activity

Perform 8-10 strength training exercises, 10-15 repetitions, two to three times per week on non-consecutive days. As program continues exercises should be progressive, increasing weight as tolerated.

Flexibility

Stretch major muscle and tendon groups at least 2 days/week for about 10 minutes. Hold each stretch for 10-30 seconds. Repeat each stretch three to four times.

Balance

Perform exercises that improve balance. Individuals that are at risk for falls are especially in need of this requirement.

These are the minimum requirements for health and fitness benefits. For goals such as weight loss or disease maintenance, frequency needs to be increased. Care must be taken to tailor exercise prescription to each individual's needs and capabilities.
The exercise intervention followed the American College of Sports Medicine guidelines recommendation of the FITT principle, frequency, intensity, type and time as well as progression.

**Frequency**

Due to logistics the exercise intervention at life-care adult community was performed two days per week. Participants were free to participate in other activities that were available at the facility. The RAPA (Rapid Assessment Physical Activity) questionnaire was used periodically throughout the study to assess physical activity patterns of participants outside of the study exercise intervention.

**Intensity**

Participant intensity was monitored through the use of Polar heart rate monitors as well as Modified Borg Scale Rating of Perceived Exertion. Participants were encouraged to modify their intensity according to their functional abilities and how they felt during the class.

**Type**

The exercise intervention consists of a warm-up, aerobic portion, strength or resistance training, balance training and a cool-down. Occasionally, the aerobic and strength portions were combined in an interval or circuit format in an effort to promote increases in participant endurance.

Equipment used during the class consisted of tennis balls, free weights, resistance bands, paper plates, small balls and beach balls. Not all equipment was used in every class. Music chosen was age appropriate and kept at a level such that it did not inhibit participant ability to hear instructions.
Time

All classes were 60 minutes in length. The breakdown was as follows:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-up</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Aerobic</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Resistance</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Balance</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Flexibility/Cool-down</td>
<td>15 minutes</td>
</tr>
</tbody>
</table>

Progression

Different levels of each activity were demonstrated so that participants were able to begin at a level that they felt comfortable with. Over the course of the intervention they were encouraged to progress to the next level as tolerated. Participants were encouraged to increase the amount of resistance when appropriate. During the aerobic portion of the class, if participants began seated they were encouraged to stand for some part of the class as tolerated. This occurred with the balance and flexibility training as well.

**WARMUP**

The purpose of the warm-up is to prepare the body for exercise by gradually increasing circulation and heart rate as well as increasing blood flow and oxygen to working muscles. The warm-up lasts for approximately 15 minutes. All major muscle groups are engaged, with progressive continuous rhythmic movements. Intense static stretching is performed during the cool-down portion of the class.

In our intervention the warm-up was performed with participants seated in chairs, preferably without arms, to provide greater range of motion. A tennis ball was used as well. We began exercises warming up from head to toe.

Participants should be seated with proper alignment and feet flat on the floor. As a safety precaution, any equipment (such as weights, bands) not being used should be placed under the participants chairs while not in use to prevent injury.
Any of the warm-up activities may be performed standing depending upon participants' functional abilities.

- Deep breathing
- Head turns
- Head tilts
- Head nods
- Neck extension and retraction
- Shoulder rolls
- Large arm circles
- Tennis ball pitch
- Tennis ball circle
- Tennis ball squeeze
- Wrist circles
- Wrist shakes
- Hand and forearm rotation
- Finger stretches
- Back squeeze
- Hug a tree
- Stir the pot (arms and shoulders)*hand mixer
- Stir the pot (torso)*Kitchen aid mixer
- Rag doll
- Spine twists
- Torso twists
- Saw
- Leg extensions
- Ankle circles
- Ankle flexion and extension – feet on floor
- Ankle flexion and extension with legs extended
- Leg circles
- Alphabet or number drawing
- Leg Inversion and eversion
- Toe taps
- Ankle flexion and extension with feet in floor
- Knee lifts
- Leg abduction and adduction
AEROBIC TRAINING

The goal of this portion of the class is to increase aerobic capacity and endurance that will allow participants the ability to perform their activities of daily living. It also assists in caloric consumption and promoting weight control. Another goal is to allow participants to "multi-task", perform multiple movements at the same time and in more rapid succession. This can be done by switching sides, adding arm movements or combining multiple movements. To accomplish this goal a move such as a heel press was introduced leading with the right leg for a total of 8 times. Then the move was repeated for 8 times on the left leg. This sequence was repeated multiple times to allow participants the ability to master switching lead legs. Next an arm movement was added to the leg movements, again switching lead legs until the participants mastered the combination moves. The next step was to decrease the amount of repetitions on each lead leg, such as 6 times on each side, then to 4 times and so on down to alternate heel presses, if desired. Once the participants were comfortable with the movement, a new movement, such as a “V” step was introduced following the same design. The third step was to incorporate linking the two patterns together – For example, perform 4 sets of alternate heel presses leading with right leg and then 4 “V” steps with right lead, followed by 4 sets of alternate heel presses leading with left leg and then 4 “V” steps with left lead.

Prior to performing these activities, safety precautions must be taken ensuring that all equipment is placed under the chair to prevent injury. It is important as well to make sure that participants are not too far away from their chairs so that they may return to a seated position if necessary. Modifications of most of the movements can be made for seated participants.

* As the number of participants in the class was rather large, and space was limited, we were limited in the types of movements that were used while ensuring participant safety was maintained. We did at all times have at least three instructors moving throughout the space to correct form, assist participants and help with motivation.

Some of the movements that were performed include:

- **Lower body movements**
  - Marching in place
  - Multiple sidesteps in either direction
  - Walking forward and back
  - Walking around the chair
  - Turn and walk to the right
Turn and walk to the left
Step touch side to side
“V” steps
Standing knee lifts
Standing leg kicks
Front lunges
Side lunges
Back lunges
Low impact jacks
Heel presses
Toe taps (front only, front and back, front side back, front side back side front)
Heel raises
Side squats
Upper body movements
Claps
Elevate arms overhead (unilaterally or bilaterally)
Elevate arms overhead in a “V” shape (unilaterally or bilaterally)
Elevate arms in front shoulder height (unilaterally or bilaterally)
Elevate arms to the side shoulder height (unilaterally or bilaterally)
Arms bent (unilaterally or bilaterally)
Bicep curls (unilaterally or bilaterally)
Tricep kickbacks (unilaterally or bilaterally)
Chest presses
Diagonal arms
Clap front and back
Combinations:
When teaching combinations, teach leg movements first, then incorporate the
arm movements stressing to participants that the arm movements are optional and that
unless they are moving in an unsafe manner the whole purpose is movement, not
perfection. Use the repetition reduction method if desired; otherwise just add on moves
as tolerated.
### Sample combination #1

<table>
<thead>
<tr>
<th>Legs</th>
<th>Arms</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>March in place – right leg leading</td>
<td>Swing arms</td>
<td></td>
</tr>
<tr>
<td>V-step – right leg leading, switch to left lead</td>
<td>Unilateral forearm adduction and abduction</td>
<td>Perform multiple repetitions on one side before moving to other side</td>
</tr>
<tr>
<td>Right leg out to right side switch to left lead</td>
<td>Unilateral or bilateral bicep curls</td>
<td>Perform multiple repetitions on one side before moving to other side</td>
</tr>
<tr>
<td>Heel raises</td>
<td>Arms up overhead with each heel raise</td>
<td></td>
</tr>
</tbody>
</table>

### Sample combination #2

<table>
<thead>
<tr>
<th>Legs</th>
<th>Arms</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step touch right and left</td>
<td>Clap hands</td>
<td></td>
</tr>
<tr>
<td>Alternate knee lifts</td>
<td>Chest presses</td>
<td>Perform slowly to ensure participants switch legs safely Option – If balance or mobility is an issue, perform alternate heel lifts</td>
</tr>
<tr>
<td>Toe presses front, right leg leading, switch to left lead</td>
<td>Unilateral or bilateral tricep kickbacks</td>
<td>Perform multiple repetitions on one side before moving to other side</td>
</tr>
<tr>
<td>Heel presses back, right leg leading, switch to left lead</td>
<td>Unilateral or bilateral frontal raise arms to shoulder height</td>
<td>Perform multiple repetitions on one side before moving to other side</td>
</tr>
</tbody>
</table>
Sample combination #3

<table>
<thead>
<tr>
<th>Legs</th>
<th>Arms</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk forward right, left, right and tap left. Walk back left, right, left and tap right.</td>
<td>Clap on tap.</td>
<td>Have participants say “right, left, right, tap left; left, right, left, tap right”</td>
</tr>
<tr>
<td>Right leg forward and back, slowly</td>
<td>Opposition arms – Left arm forward, right arm back when right leg forward, right arm forward, left arm back when right leg is back</td>
<td>Teach leg movement first, then just arm movement and then combine. Must do very slowly at first as these movements together require much neural input to co-ordinate</td>
</tr>
<tr>
<td>Heel raises up and down</td>
<td>Arms clap front waist height when heels raised, clap behind back when heels on floor</td>
<td>Perform slowly and stress to participants that their ROM may limit clapping behind back</td>
</tr>
<tr>
<td>Repeat above starting all with left leg leading</td>
<td>Reverse all applicable arm movements when indicated</td>
<td>Eventually, goal is to alternate movements between right and left leads</td>
</tr>
</tbody>
</table>
Sample combination #4

<table>
<thead>
<tr>
<th>Legs</th>
<th>Arms</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn and face right wall, walking to the right – right, left, right left.</td>
<td>Move naturally with the walk</td>
<td>Participants will need to stand behind their chairs to allow room for this move</td>
</tr>
<tr>
<td>Turn and face front and march in place</td>
<td>Swing arms</td>
<td></td>
</tr>
<tr>
<td>Turn and face left wall, walking to the left – left, right, left, right.</td>
<td>Move naturally with the walk</td>
<td>Participants should now be behind their own chairs</td>
</tr>
<tr>
<td>Slow low kick front with right leg return to starting position, repeat for a total of no more than 8 times. Repeat series using the left leg</td>
<td>Arms either in guard position or at waist</td>
<td>Watch participants carefully on this move as it requires balance, core stability and leg strength to maintain. Option – Alternate right and left leg kicks so that body weight is shifted</td>
</tr>
</tbody>
</table>

**RESISTANCE TRAINING**

The purpose of resistance training is to improve muscular strength and endurance. This in turn assists participants maintaining independence in performing activities of daily living. It also assists in the preservation of lean body mass which in turn aids in increasing resting metabolic rate.

In our intervention the goal was to complete 1 to 2 sets of 12 repetitions of 8-10 different resistance exercises incorporating both upper and lower body movements. This was accomplished by using free weights, resistance bands and body resistance. Exercises may be performed either standing or in a seated position depending on participants’ functional abilities.

The following guidelines should be followed with each resistance exercise:

a. Maintain proper spinal alignment whether standing or sitting
b. Inhale on easy portion of exercise
c. Exhale upon exertion
d. Do not hold breath at any time (Have participants count with you when performing repetitions)
e. Proper form should be maintained at all times to prevent injury and to ensure effectiveness of the exercise
f. Watch participants and correct form when necessary
g. Use appropriate resistance level and either increase or decrease depending on tolerance
h. Stress to participants progression to increase resistance when current resistance level is becoming too easy (i.e. – if they can perform more than the 12 repetitions with good form using the resistance, it is time to increase resistance)
i. When introducing a new exercise, take time to teach the proper form, first without weight or resistance
j. Visually show participants where they should be feeling the exercise action
k. Use visual cues to ensure proper body part placement and orientation
l. When adding the resistance, cue how to hold or place the resistance equipment
m. Perform repetitions in a slow and controlled manner, having participants visualize the working muscle or muscle group
n. When holding free weights or resistance band handles, hold securely, but not so tight as to exert stress into shoulders
o. Work opposing muscle groups, such as biceps-triceps, quadriceps-hamstrings.
p. If performing multiple sets of the same exercise, or exercising the same muscle group, rest for 1-2 minutes between sets or same exercises. Alternately, move to another exercise while resting one muscle group and then return and repeat original exercise if multiple sets are to be performed.
q. Ensure neutral wrists when performing the exercises
r. Ensure resistance bands are securely under feet before applying resistance
s. Inspect bands each time before use for tears or damage
Upper body

Bicep curls – free weights
Hammer curls – free weights
Side bicep curls – free weights
Bicep curls – resistance bands
Hammer curls – resistance bands
Side bicep curls – resistance bands
Tricep kickbacks – free weights
Overhead tricep press – free weights (*May not be suitable for all due to limited ROM of some participants)
Wiperblade
Tricep kickbacks – resistance band
Overhead tricep press – resistance band (*May not be suitable for all due to limited ROM of some participants)
Overhead press – free weights
Overhead press – resistance band
Frontal raises – free weights
Lateral raises – free weights
Lateral raises – resistance band
Snow angels – free weights
Rotator cuff – free weights
Rows – free weights
Rows – resistance band
Low rows – free weights
Low rows – resistance band
Front punches – free weights
Front punches – resistance band
Hug a tree – free weights
Chest press – resistance band

Lower body

Squat
Plié squat
Leg abduction
Leg adduction
Back leg extension
Standing leg curl
Standing knee lift with knee extension
Seated knee lift with knee extension
Seated leg curl
Seated leg abduction
Seated leg adduction
Seated ball squeeze
Chair stand
Tibialis anterior strengthener

Abdominal exercises
Abdominal vacuum
Reverse curls
Abdominal twists
Side bends

Balance exercises
Heel raises
Rock heel to toe
Stand on one leg
Stances – feet together (eyes open then closed)
Stances – feet semi-tandem (eyes open then closed)
Stances – feet tandem (eyes open then closed)

Flexibility and cool-down
Hamstring stretch
Calf stretch
Quadriceps stretch
Knee cross over with spinal rotation
Figure 4 stretch
Knee hugs
Side bend
Shoulder stretch
Hugs
Tricep stretch
Bicep stretch
Neck stretch
Deep breathing
REFERENCES


*Blickpunkt Der Mann, 3*, 13-18.


