1-1-2012

Cardiovascular Effects and Enjoyment of Exer-Gaming in Older Adults

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Abstract

Background: A physically active lifestyle provides a variety of health benefits. However, physical activity may decline with age. Currently, there are 40 million older adults, representing 13.1% of the population in the United States. National surveys report that only 30% of older adults perform adequate amounts of physical activity. The lack of daily physical activity (PA) can lead to an increased risk of chronic disease. Exer-gaming (EG) has been successful in increasing PA in children and young adults in a fun and enjoyable manner, but the use of EG with older adults has not been well studied.

Purpose: To quantify the cardiovascular responses, the enjoyment, and the untoward physical discomforts to a 15 minute trial of EG (Nintendo Wii Tennis) in healthy, older adults.

Methods: A quasi-experimental design using a convenience sample of 34 self-reported healthy older adults from an independent living retirement community in Southeastern Pennsylvania completed the study. Serial measurements of heart rate, blood pressures (systolic, diastolic, and mean), rate-pressure product, and perceived exertion were taken at 5 minute intervals beginning at rest, standing, playing Wii tennis and post play recovery. Enjoyment was measured post Wii play and a 48 hour post questionnaire was provided. Analysis of the data included the use of descriptive statistics and general linear modeling of repeated measures.

Results: 15 minutes of exercise gaming (Nintendo Wii Tennis), moderately increased heart rate ($p<0.001$), blood pressures ($p<0.001$) and perceived exertion ($p<0.0001$) compared to rest. This level of activity corresponded to an age predicted maximum heart rate range of 64%. No differences in cardiovascular variables occurred between genders. Beta-blockade suppressed the heart rate and rate pressure product. All subjects completed EG tennis without reporting fatigue with 86% enjoying the experience with few physical discomforts and arrhythmias.

Conclusions: Nintendo Wii EG technology (tennis) induces a moderate intensity cardiovascular stress in an overall enjoyable manner among health, older adults.

Degree Type
Dissertation

Degree Name
Doctor of Philosophy (PhD)

Graduate Group
Nursing

First Advisor
Joseph R. Libonati

Keywords
Aging, Blood Pressure, Exercise, Physical Activity, Wii

Subject Categories
Nursing

CARDIOVASCULAR EFFECTS AND ENJOYMENT OF EXER-GAMING IN

OLDER ADULTS

Michael John Fachko

A DISSERTATION

in

Nursing

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2012

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DEDICATION

I dedicate this dissertation to my wonderful wife, Frances, who has put up with these many years of military assignments and then returning to school for research. I must also thank my loving mother Elizabeth, father Jack; my brother John and sister Lisa and Aunt Mary; as well as my wife's family for all of the support they have given us.

ACKNOWLEDGMENT

I would like to sincerely thank Dr. Joseph Libonati, Dr. Kathryn Bowles, and Dr. Keith Robinson for their excellent mentorship and guidance throughout the dissertation process. Their timely and succinct feedback, recommendations, and opinions have been invaluable for the initiation and completion of this work. I am forever grateful for their reassurance in me.

Also, I am eternally thankful for all of the support and professional guidance provided by my advisor Dr. Mary Naylor, director of the NewCourtland Center for Transitions and Health as well as all of the center members that have enriched my scholarly training.

In addition, I would like to express gratitude to the Center for Biobehavioral Research at the University of Pennsylvania's School of Nursing, Dr. Medoff-Cooper and Dr. Charlene Compher for providing the BioPac BioHarness and related software necessary to carry out this scientific inquiry.

This dissertation was directly supported by a generous scholarship from the Jonas Center of Nursing Excellence.

ABSTRACT

CARDIOVASCULAR EFFECTS AND ENJOYMENT OF EXER-GAMING IN OLDER ADULTS

Michael J. Fachko

Joseph Libonati, PhD

Background: A physically active lifestyle provides a variety of health benefits. However, physical activity may decline with age. Currently, there are 40 million older adults, representing 13.1% of the population in the United States. National surveys report that only 30% of older adults perform adequate amounts of physical activity. The lack of daily physical activity (PA) can lead to an increased risk of chronic disease. Exer-gaming (EG) has been successful in increasing PA in children and young adults in a fun and enjoyable manner, but the use of EG with older adults has not been well studied.

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CHAPTER I

Introduction

This chapter addresses the scope of the problem, the barriers to physical activity in older adults, the specific aims, the significance of the study, and the definition of terms used in this dissertation.

Scope of the Problem

Physical Activity

Physical activity is defined as any bodily movement induced by skeletal muscle contractions which results in energy expenditure (United States Department of Health and Human Services, 1996). A physically active lifestyle is associated with a number of health benefits and is critical in enhancing healthy living and maintaining a good quality of life among older adults (King & King, 2010; Nelson et al., 2007; United States Department of Health and Human Services, 1996). Regular participation in physical activity is associated with decreased age-related functional limitations (one's ability to accomplish their daily activities), a reduced risk of falling, and attenuation in the development of metabolic-related diseases (Lee & Park, 2006). Physically active older adults have a reduced risk of developing cognitive impairments (Williamson & Pahor, 2010), iterating the importance of physical activity in overall healthy aging (Nelson et al., 2007; Strawbridge, Deleger, Roberts, & Kaplan, 2002). Conversely, physical inactivity in older adults increases the risk of many chronic diseases and is costly to the health care system; with the projected annual costs directly attributable to physical inactivity in the

U.S. across all age groups estimated to be between $24 billion and $76 billion, or 2.4% to 5.0% of our total national health care expenditures.

Aging

Adults turning 60 years of age are an expanding segment of the total U. S. population (He, Sengupta, Velkoff, & DeBarros, 2005). Currently there are approximately 40 million older adults (over the age of 65 years) representing 13.1% of the population in the United States (Administration on Aging, 2011). The number of those in this age group is projected to increase to over 80 million people (U.S. Census Bureau, 2004; Wetle, 2008). A national survey found that as the mean age of the population increases, the mean amount of accrued physical activity decreased below the recommended levels of 30 minutes per day (Agency for Healthcare Research and Quality, 2002). One observational study reported that when older adults leave active paid work status, sedentary activities (like watching television) begin to replace prior physical activities performed in their paid work environments (Touvier et al., 2010). The lack of adequate physical activity has been shown to contribute to the development of chronic diseases such as heart disease, diabetes, cancer, and high blood pressure, of which are among the highest causes of mortality in older adults (Kramarow, Lubitz, Lentzner, & Gorina, 2007).

The World Health Organization (WHO, 2011) proposes that, depending on the country of origin, an older adult is someone over the age of 50 years. In the U. S., an older adult is defined by Medicare and Social Security laws as someone who is 65years of age and eligible for government retirement benefits. The age of 60 years has been used to identify those older adults who might start their transition from active work to an inactive or partial work status (Touvier et al., 2010). Additionally, many senior organizations start recruitment into their organizations earlier than 65 years of age. For example, the American Association of Retired Person's minimum membership age is 50 years. Thus, a variety of age ranges exist on how to categorize an older adult by their age in years. For the purpose of this dissertation, older adults will be defined as those individuals who are at least 60 years of age.

Older Adults and Physical Activity

In 1996, the Surgeon General (SG) of the United States issued a report which showed that as age increased, physical inactivity increased. The SG stated that only 30% of older individuals age 65 and older engaged in sufficient daily activity to promote healthy aging (United States Department of Health and Human Services, 1996). This low level of physical activity among older adults has been noted by several other prominent organizations and researchers (American College of Sports Medicine et al., 2009; Aoyagi, Park, Park, & Shephard, 2010; Baruth et al., 2010; Buchner, 2010; Buman et al., 2010; Chodzko-Zajko, Schwingel, & Park, 2009; Egerton, Brauer, & Cresswell, 2009; Elsawy & Higgins, 2010; Finucane et al., 2009; Hughes, Seymour, Campbell, Whitelaw, & Bazzarre, 2009; Katzmarzyk, 2010; King & King, 2010; Kruger, Buchner, & Prohaska, 2009; R. W. Motl & McAuley, 2010; National Institute on Aging, 2010; Richards et al., 2011; Shephard, 2009; Venturelli, Lanza, Muti, & Schena, 2010). While the exact reasons age-related physical inactivity remains unclear, one important finding by the WHO noted that levels of physical inactivity are higher in developed countries relative to non-developed countries (WHO, 2011). The WHO has identified several possible causes of physical inactivity that are manifested along with increases in environmental urbanization. In developing countries, as populations shift from rural to urban centers, the resulting increase in the urban center's population density may cause higher rates of poverty and crimes. Overcrowding can lead to a lack of secure public spaces for older adults to perform physical activity. In developed countries, the WHO notes that some of the causes of physical inactivity are linked to a lack of performing physically active leisure time activities (e.g., playing sports or exercising rather than watching TV.), increased sedentary work conditions, and the use of passive modes of transportation (e.g., using a car rather than walking). Despite the many potential beneficial attributes of performing frequent physical activity, people around the world, including the growing number of older adults, are not achieving enough daily physical activity to support good health.

A variety of physical activity programs already exist for older adults. These programs encompass various types of exercise modes with different levels of exertion intensities and durations, i.e., resistance training, balance training, walking, and treadmill training (Elsawy & Higgins, 2010; Martins, Neves, Coelho-Silva, Verissimo, & Teixeira, 2010; Sattelmair, Pertman, & Forman, 2009; Seals, Walker, Pierce, & Lesniewski, 2009; van Stralen, de Vries, Mudde, Bolman, & Lechner, 2009; Venturelli et al., 2010; Witham

& Avenell, 2010; Wurm, Tomasik, & Tesch-Romer, 2010). Data suggest that when these programs are performed regularly, they can be beneficial in aiding in the management of high blood pressure, diabetes, obesity, or high cholesterol. These programs have also shown improvements in physical function and have increased the ability of older individuals to live independently (Agency for Healthcare Research and Quality and the Centers for Disease Control, 2002). However, despite these reported benefits of physical activity, there remain barriers to physical activity in older adults.

Physical Activity Barriers in Older Adults

Older adults often do not begin to participate in physical activity programs due to perceived psychosocial (i.e., generational bias, gender bias, or low self-image or esteem) and physical barriers (i.e., poor physical environment, fear of injury, or lack of motivation) (Agency for Healthcare Research and Quality and the Centers for Disease Control, 2002). Moreover, it is estimated that 50% of older adults that start a new physical activity or exercise regimen drop out within 3 to 6 months (Cohen-Mansfield, Shmotkin, & Goldberg, 2010). Many older adults also erroneously believe that they are performing enough daily physical activity in their home sufficient to maintain adequate health status (Crombie et al., 2004). Other possible reasons include the lack of interest in physical activity, a reluctance to join group activities, or concerns with physical symptomology like difficulty in breathing and muscle/joint pain (Crombie et al., 2004). These barriers are of considerable concern since approximately one-third of persons age

65 or older lead a sedentary lifestyle, with older women being less physically active than older men (Haley & Andel, 2010).

Successful physical activity programs for older adults require some elements of fun and enjoyment, and need to encompass novel approaches to spark older individual's interest in participation (Alpert et al., 2009; Heath & Stuart, 2002; Leaf & Reuben, 1996; Nied & Franklin, 2002; Ross & Teasdale, 2005). For example, the new technology of exercise gaming (EG) may offer a potential enjoyable means to overcome barriers to participation in physical activity in older adults. EG is convenient to participate in and can be performed in the home. EG is not dependent on time of day, weather conditions, the need to travel to a recreational area (e.g., gym, tennis court), nor does it require a partner, a group of players or even a challenger. Instead, EG provides a fun and convenient mode of physical activity by allowing the older adult to re-experience activities that they might have enjoyed earlier in their lives, but are no longer able to fully participate in (e.g., playing virtual tennis instead of court tennis). The ability to participate in physical activities that meet older adults' current physical conditions and functional limitations may help to support adherence to EG physical activity routines. Furthermore, EG manufactures have produced hundreds of titles with a variety of games aimed toward sparking interest in play.

Exercise Gaming

EG has been successfully used in children and young adults as an innovative method to initiate, and maintain adherence to physical activity (Biddiss & Irwin, 2010;

Foley & Maddison, 2010; Lanningham-Foster et al., 2006; Lanningham-Foster et al., 2009; Maddison et al., 2007). EG combines enjoyable activities that rely on both aerobic and anaerobic metabolism (Siegel, L Haddock, Dubois, & Wilkin, 2009). Through the Internet and other media outlets (newsprint, magazine ads, etc.), EG manufacturers are now developing and promoting EG and virtual reality (VR) games as supportive and safe for overall health improvement across the age span (American Heart Association, 2011). However, given that EG was specifically developed for children and young adults who can safely endure wide variations in heart rate and blood pressure, the cardiovascular responses that occur in older adults during EG have not yet been adequately studied (Daley, 2009).

In children and young adults, heart rate and blood pressure changes have been shown to significantly increase from resting levels during the use of EG (Graf, Pratt, Hester, & Short, 2009; Graves, Stratton, Ridgers, & Cable, 2007; Graves, Ridgers, & Stratton, 2008; Graves et al., 2010; Lanningham-Foster et al., 2009; Levac et al., 2010; Penko & Barkley, 2010). It is not well studied if EG can cause rapid or sudden changes in the heart rate and blood pressure in older adults, of which may exceed age-related target heart rates or age-restricted blood pressure levels. Sudden cardiovascular changes could be potentially problematic for older individuals, especially those older adults who are physically inactive. It has been noted that participating in a vigorous exercise without the proper training might be challenging for sedentary individuals (Borjesson et al., 2010; Kohl, Powell, Gordon, Blair, & Paffenbarger, 1992; Marcera, 2006; Siscovick, Weiss, Fletcher, & Lasky, 1984; Thompson, Funk, Carleton, & Sturner, 1982; Whang et al., 2006).

While children and young adults who used EG as entertainment have increased their physical activity levels over traditional non-active computer games (Graf et al., 2009; Graves et al., 2007), there has been limited research studying the use of VR or EG in older adults (Chuang, Sung, & Lin, 2005; Sveistrup, 2004). Recently, Graves et. al., (2010) reported that some Nintendo Wii games significantly increased the metabolic costs (increased oxygen consumed, increased energy expenditure, and increased heart rate) in a small group (N=42) of adolescents (11-17 years; 4 female, 10 male), young adults (21-38 years, 8 female, 7 male) and older adults (45-70 years; 3 female, 10 male), when compared to traditional non-EG video games. Additionally, Graves et al., (2010) sought to determine the enjoyment of each activity by asking all subjects to rate enjoyment using questions derived from a modified physical activity enjoyment scale. Subjects rated the extent to which they agreed with each item on a 7-point Likert-type scale with highest scores stated as “I enjoyed it”, “I liked it”, “I feel good physically while doing it”. Graves et. al., then compared physiological responses and enjoyment derived during participation in Wii Fit activities (yoga, muscle conditioning, balance and aerobics) with young adults and adolescents during participation in hand held video games or brisk treadmill walking and jogging. For both groups, energy expenditure was greater and heart rate responses were higher during Wii Fit activities than during traditional handheld gaming ($P<0.001$), but lower than during treadmill exercise

($P \leq 0.001$). Each group's enjoyment rating was greater for Wii Fit balance and aerobics activities compared to treadmill walking and jogging ($P \leq 0.05$). This study also found that EG Wii Fit games were of light to moderate intensity. This study suggests that EG may well be suited for older adults who wish to engage in this type of exercise (Graves et al., 2010). Thus, on the basis of this small study, EG appears to have the potential to be more enjoyable than other leisure time physical activities for older adults.

For this dissertation, the Nintendo Wii tennis was selected as the exercise mode. This EG sport activity comes standardized with the many of the Wii consoles sold in the U.S. (the other games that come with Wii Sports are baseball, bowling, golf, and boxing). The physical effects of older adults playing this exercise game have not been robustly determined. Results from earlier adult studies were reviewed to determine the physiological effects on adults. Metabolic equivalent values (METS) for a physical activity are calculated by dividing VO_2 (oxygen consumption) by 1 MET (3.5 $mL \cdot kg^{-1} \cdot min^{-1}$). According to American College of Sports Medicine, older adult physical activity intensity categories are classified as light (≤3 METS), moderate (3–6 METS), or vigorous intensity (>6 METS) (American College of Sports Medicine, 2010). For example, one study determined that Wii tennis represented a medium or moderate metabolic equivalent (METS) cost of 3.0 ±0.8 METS versus Wii golf (2.0±0.3 METS), Wii bowling (2.7±0.6 METS) but lower than Wii boxing (4.2±0.9 METS) in 12 adult subjects (range 25-44 years) (Miyachi, Yamamoto, Ohkawara, & Tanaka, 2010). In another study in chronic stroke patients (3 men and 4 women ages 33-68 years), the mean

MET intensity of Wii tennis was 3.7±0.6 METS (METS±Standard Deviation) (Hurkmans, Ribbers, Streur-Kranenburg, Stam, & van den Berg-Emons, 2011). Both studies suggest that Nintendo Wii tennis may produce a moderate intensity physical activity (between 3-6 METS) for older adults.

Two additional studies used the Nintendo Wii successfully as either an enjoyment or distraction aid for stroke and burn patients during their course of rehabilitation (Celinder & Peoples, 2012; Fung et al., 2010). Therefore it is reasonable to hypothesize that a few of these reported qualities may help motivate healthy older adults to increase their overall physical activity.

Specific Aims

Before promoting the potential benefits of EG in older adults, it is imperative to further establish the physiological responses to EG in the aged population. Thus, the overall purpose of this dissertation is to describe the cardiovascular responses, the enjoyment, and the untoward physical responses from participating in a 15 minute trial of EG (Nintendo Wii Tennis) in healthy, older adults. The specific aims of this dissertation study are:

Specific Aim 1. To quantify changes in cardiovascular responses and perception of exertion from baseline to recovery with a 15 minute EG session in older adults.

Specific Aim 2. **To quantify the enjoyment and the 48 hour after effects of one 15 minute session of EG in older adults**.

A quasi-experimental design was utilized to execute the experiments in this dissertation. In the experiments, older adults were exposed to a continuous 15 minute trial of EG using the Nintendo Wii Tennis game. The gaming intensity was initially set to the beginner's skill level and advanced automatically as player skill level changed based on the Nintendo Wii's internal programming. Data was collected serially at resting (baseline), during EG play (activity), and after the EG gaming session (post-exercise recovery). Throughout the protocol, heart rate (HR), blood pressures (BP), rate pressure product (RPP) and the perception of exertion was recorded in five minute intervals.

Immediately following Wii tennis game play, overall enjoyment was measured. Untoward physical responses to EG tennis as well as several open ended survey questions were assessed after 48 hours after the experiment ended. This descriptive study will begin to systematically establish the cardiovascular responses and enjoyment levels of EG in older adults and provide the basis for tailoring future EG-based exercise interventions for older adults.

Significance

Physical activity has been shown to improve physical and mental health levels, improve functional capacity, and reduce the risk of disability among older adults (Elsawy & Higgins, 2010). As previously mentioned, there is an expected increase in the number of older adults to reach 80 million in the United States by 2030. Within this age group, attaining 30 minutes of daily physical activity is one of the most frequently recommended lifestyle habits that may help to attenuate a number of chronic diseases (Administration on Aging, 2011; Agency for Healthcare Research and Quality, 2002). Currently, the most popular EG system is the Nintendo Wii, which has been purchased by 30 million households (Video Games Blogger, 2010). In the U.S., approximately 33% of American households (112 million) own an EG compatible video game entertainment system. Since this EG technology can be viewed as commonplace and affordable (the Nintendo Wii manufacture's retail price is less than $170), EG may offer a novel and innovative approach to promote physical activity levels among older adults. Evaluating the cardiovascular effects of EG in older adults in a controlled manner is critical for determining whether untoward responses to EG exist in this population. Also, by describing the acute effects of EG on older adults, specific and tailored EG interventions may be developed, thereby bringing a low cost physical activity mode into the homes or community residences of older adults.

Definition of Terms and Variables

Dependent Variables

Cardiovascular (CV) Responses: The cardiovascular responses in this study are defined by HR, BP (systolic, diastolic, and mean), and rate pressure product (RPP) measured at baseline, during 15 minutes of EG gaming activity, and post EG recovery. The RPP is the product of heart rate multiplied by the systolic blood pressure. RPP indirectly approximates the oxygen demands of the heart (Gobel, Norstrom, Nelson, Jorgensen, & Wang, 1978).

Perceived Exertion (PE): This is an individualized and subjective measurement scale used to estimate one's physical activity intensity level on a numeric scale of 6 (no exertion) to 20 (maximum exertion) (Borg, 1998). Perceived Exertion is one of the preferred methods of determining an individual's physical activity intensity for those who take medications that affect heart rate, e.g., beta antagonists. Cardiovascular responses can be correlated to PE during exercise and has been used clinically in numerous exercise studies (Chen, Fan, & Moe, 2002; Eston & Connolly, 1996; Katsanos & Moffatt, 2005). Both heart rate (HR) and perceived exertion (PE) have a high correlation with myocardial oxygen demands (Lambrick, Faulkner, Rowlands, & Eston, 2009).

EG Enjoyment: This was assessed by the Physical Activity Enjoyment Scale (PACES) (Kendzierski & Decarlo, 1991). This tool is consists of 5 items with a point scale of 1-7 for each item. The sum of the items score (highest score is 35, lowest score is 5) describes the fun or enjoyment of the EG play. The higher the summed score of the PACES items relates to a higher level of fun or enjoyment the EG trial provided to the subject (Moore et al., 2009; R. W. Motl et al., 2001).

Forty Eight (48) Hours after effects of EG: The possible after-effects of a 15 minute trial of EG using the Nintendo Wii Tennis within 48 hours in older adults will be described using an open-ended questionnaire. Forty eight hours was chosen as the time interval for assessment given that delayed onset muscle soreness after an exercise activity peaks between 24 to 48 hours (Pettitt et al., 2010).

Independent Variables

Exer-gaming (EG): EG is a virtual reality video game that requires interactive physical activity (Graf et al., 2009). The average trial of Nintendo EG game play is approximately 15 minutes. (Graf et al., 2009; Graves et al., 2007; Graves et al., 2010; Lanningham-Foster et al., 2009; Miyachi et al., 2010; Worley, Rogers, & Kraemer, 2011). Exposure of older adults to 15 minutes of EG represents the typical exposure to a single trial of Nintendo Wii tennis, the EG mode used in this dissertation.

CHAPTER II

Review of Literature

Body System Response to Aging

This chapter describes the relationship between physical activity and aging. First, four major organ systems that support functional capacities in aged individuals will be reviewed. Second, classes of cardiovascular medications used by many older adults will be reviewed with respect to their impact on tolerance to physical activity. Third, the demographics of aging in relation to the hazards associated with a sedentary lifestyle, and aging-related chronic diseases will be addressed. Lastly, clinical applications and the usefulness of exercise gaming (EG) as a potential exercise intervention for older individuals will be reviewed.

Aging and the Organ Systems Used to Support Exercise

Aging is a process that can be measured in both chronological and physiological terms. Chronological age represents a person's quantity of life (Pirkl, 2009), whereas physiologic age reflects the homeostatic reserve of organ systems (Pu & Nelson, 1999). While heterogeneity of the aging process makes it difficult to predict how individual older adults age, several factors have been shown to contribute to the aging process. At the biological level, genetics acting in concert with post-translation cellular changes are postulated to be important regulators of cellular senescence (Rattan, 2006). Key environmental factors that influence post-translation cellular changes include both physical activity and nutrition. Both physical activity and nutrition are considered modifiable lifestyle behaviors (Costa, Casamassimi, & Ciccodicola, 2010; Fairweather-Tait, 2003) that have been shown to have significant impact on preventing or delaying the aging process. (Chodzko-Zajko et al., 2009). There is generally a decline of physiologic performance of most organ systems with aging that leads to reduction in the functional reserves of key organ systems contributing to exercise capacity. The main organ systems that limit functional capacity with aging are the neurological, musculoskeletal, cardiovascular, and pulmonary systems (discussed individually below).

Neurological System:

Several significant changes in the neurological system occur with aging. For example, the brain's weight decreases over one's lifespan, an effect secondary to a net loss of neurons in both the white and grey matter (Seidler et al., 2010). Also, with increasing age, sensory motor control and peripheral nervous system functioning diminishes. Declines in this area of the nervous system translate into decreased fine motor control, dexterity, reduced gait function and balance stability. These motor deficits in combination with corresponding cognitive declines may affect the ability of older adults to live independently. Electrophysiological studies have also demonstrated a decrease in the amplitude of both action potential and conduction velocities in the brain and the peripheral nervous system. These neurological changes may underlie the less efficient and slower neural processing observed in aged individuals (Salami, Eriksson, Nilsson, & Nyberg, 2011). Also, with the loss of neurons within the cerebral cortex of aged individuals, the ventricles of the brain enlarge (Fjell & Walhovd, 2010). Abnormal protein accumulation in the brain can also occur with aging, thereby inducing "neurofibriallary tangles", indicating decaying dendrites or projections off of the neural cell bodies (Bi, 2010), and "senile plaques" or hard clusters of damaged or dying neurons (Dickson, 1997). In some individuals, these aging-related pathological findings have been associated with cognitive impairments, and even dementia. In other individuals, these structural changes in the brain are non-symptomatic. The neural reserve theory (having an increased number of neurons in the brain) postulates that some people have larger neuron reserves, so that the brain can compensate for neuron loss over time or injury (Stern, 2009). With more neurons, the brain is able to overcome tangles and plaques, and the individual is less likely to develop cognitive impairments or dementia (Stern, 2009). Physical activity is believed to be one of several factors that are "neuroprotective", thereby contributing to increasing the brain's neural reserve (Archer, 2010). The exact mechanism in which exercise can be neuroprotective during aging is unknown, but one report has noted that exercise training protects against neuron apoptosis (Kaliman et al., 2011). Moreover, exercise elicited neurogenesis has been shown to decrease neural aging and may sustain cognition during aging in mice (Lazarov, Mattson, Peterson, Pimplikar, & van Praag, 2010). Participation in regular exercise is hypothesized to increase neurogenesis during one's lifetime, even within the context of age-induced down regulation (Erickson et al., 2011; Lazarov et al., 2010). Evidence suggests that exercise may attenuate or even reverse age-related declines in the brain, nervous system, as well as improve motor functioning in older adults (Seidler et al., 2010).

Musculoskeletal System:

Muscle strength and muscle mass decrease as age increases and has tremendous influence over age-related declines in functional capacity. Generally, muscle strength peaks at age 30 and declines at a rate of about 10-15% per decade in those individuals who are not regularly physically active (Doherty, 2001). Muscle strength and mass during aging can be maintained in older adults who perform physical activity regularly. Resistance training (the use of weights, elastic bands or other actions that cause contraction of muscles greater than the forces of gravity) is quite effective in allowing the maintenance of muscle mass and bone density (Roubenoff & Hughes, 2000). Inactive older adults typically show muscle atrophy and strength loss, but this muscle disuse is reversible when weight bearing or resistance type exercises are resumed (Little & Phillips, 2009). Some studies have even shown significant gains in muscular strength, performance, and changes in body composition from exercise regimes that were performed as little as once a week (Galvao & Taaffe, 2005; Seguin & Nelson, 2003; Taaffe, Duret, Wheeler, & Marcus, 1999). Resistance training can lead to functional improvements in older adults, even if strength was lost due to injury (Hollmann, Struder, Tagarakis, & King, 2007).

As muscle strength and mass change as a function of aging, posture and balance are also affected. Posture reflects how the body stays upright against gravity. Postural control is the control of the body's position in space to maintain balance and spatial orientation (Pollock, Durward, Rowe, & Paul, 2000). Balance encompasses postural control, but additionally entails how the body sustains an upright position in response to internal and external sensory feedback based on "on-line" demands of the body and the environment, respectively. Postural changes may be the combined result of changes in the neurological and musculoskeletal systems, as well as, lifestyle habits. Postural changes with aging increase kyphosis of the thoracic spine, increase lordosis of the lumbar spine, and increase risks of falling (Ostrowska, Giemza, Wojna, & Skrzek, 2008). As the central nervous system degrades over time, maintaining one's balance becomes more challenging. With the degradation of the efficiency of afferent and sensory systems, particularly proprioception and vision, the musculoskeletal structures used to maintain the body upright against gravity becomes less precise. The integrity of muscle strength and mass are an essential component the sensory-motor feedback system that control balance. Older adults demonstrate increased swaying during balance testing, have increased reaction times during movement, and demonstrate a decreased ability to participate in higher level balance activities such as standing on one unsupported leg (Laughton et al., 2003). These decrements in balance often cause older individuals to take smaller steps and induce difficulty in climbing stairs. As postural control and balance decrease in older adults, the risks and prevalence of falling increases. About 35% of adults over the age of 65 years have sustained a fall due to loss of postural control or balance, and the risk of falling increases to 56% per year in older adults who are 90 to

99 years of age (Blake et al., 1988). Physical activity and exercise can improve both muscular strength and balance and tend to mitigate falling in older adults (Granacher, Muehlbauer, Gollhofer, Kressig, & Zahner, 2010).

Cardiovascular System:

Aging causes both structural and physiological changes in the cardiovascular system. One of the most common structural changes in the aging heart is left ventricular hypertrophy, or a thickening of the ventricular wall which is typically secondary to aging-induced hypertension. It is estimated that 90% of individuals who are normotensive at age 55 years are at risk for developing hypertension during the remainder of their lifetime (Chobanian et al., 2003). Other structural changes that influence cardiac function are valvular disease. Aortic stenosis, aortic regurgitation, and mitral valve calcification have been shown to increase with age (Karavidas, Lazaros, Tsiachris, & Pyrgakis, 2010). All of these conditions increase the load on the heart and induce myocardial growth. Left ventricular diastolic function is also altered in older adults due to increased systolic pressure and left ventricular hypertrophy, which predisposes the heart to have increased left ventricular filling pressures, the development of fibrosis, decreased pumping efficiency, decreased stroke volume and increased end systolic volume (Cheitlin, 2003). These events then increase the pressure in the left atrium and pulmonary veins, contributing to the potential development of atrial arrhythmias and heart failure in older adults (Karavidas et al., 2010).

Peripheral vessels also undergo changes during aging resulting in the stiffening of the arteries and veins and their inability to properly dilate in response to stress, thereby affecting systolic blood pressure and venous return (Karavidas et al, 2010.). Aging is a primary risk factor for the development for peripheral arterial and venous dysfunction (Lloyd-Jones et al., 2010). Some of the causes associated with blood vessel dysfunction during aging are related to impaired endothelial dilation possibly caused by the reduced bioavailability of nitric oxide (NO) (Seals, Jablonski, & Donato, 2011). NO is needed at the molecular level for normal blood vessel function, but is inhibited by excessive levels of oxidative stress, prostaglandins and inflammation with age (Seals et al., 2009). Additional factors that can inhibit normal vascular functions are a lack of exercise, poor diet, and obesity (Sjogren et al., 2010).

Regular physical activity in older adults can achieve some physiological remodeling of the left ventricle and reverse some of the negative cardiovascular effects of aging, thereby making the left ventricle more efficient (Fujimoto et al., 2010). Exercise training can also improve arterial and venous vascular physiology in older adults over time (DeSouza et al., 2000). Activities such as walking at a moderate rate can be sufficient to improve vascular function to include reducing carotid artery stiffness (Moreau, Donato, Seals, DeSouza, & Tanaka, 2003; Tanaka et al., 2000). Nitric oxide released during moderate exercise has been noted as one potential mechanism that is protective against vascular damage (d'Alessio, 2004). Exercise has been shown to increase NO bioavailability (Kingwell, 2000). This protection may be the result of nitric oxide's ability to counter inflammation throughout the vascular system (Harrison et al., 2006).

To ensure that a specific intensity or exertion level is attained during physical activity, a maximum heart rate and percent ranges of intensity can be calculated. One of the most common ways to do this is to establish an age predicted maximum heart rate (APMHR) which is commonly calculated as 220 minus the age in years (American College of Sports Medicine, 2010; Fletcher, 1997). For example, a 60 year old individual's APMHR is 160 beats per minute. From the APMHR, exercise intensity ranges are calculated as a percentage on the APMHR. Moderate physical intensity levels for older adults range from 50% to 75% of APMHR for 15 to 30 minutes daily; this is the recommended intensity and duration found in many physical activity and exercise guidelines (Centers for Disease Control and Prevention, 2010c). Therefore, a 60 year old individual's target heart rate for performing in the moderate intensity range should reach at least 80 bpm or 50% of APMHR and stay elevated below 120 bpm or 75% of APMHR for at least 15 minutes of duration (Haskell, Montoye, & Orenstein, 1985). Sedentary older adults should start physical activity on the lower end of the APMRH of 50% and then increase their intensity gradually over time to 75%, in order to prevent overexertion or adverse events (i.e., heart attack or stroke).

If older adults use a beta-blocker as part of their anti-hypertension therapy, a perceived exertion scale could be used in conjunction with monitoring heart rate to determine exercise intensity (Eston & Connolly, 1996). For example, Borg's Rating of

Perceived Exertion scale (RPE) can be used along with heart rate monitoring to determine physical activity or exercise intensity for those individuals using beta-blockers (Borg, 1998). Borg's RPE is an individualized subjective rating scale from 6 (equaling a low or resting intensity) to 20 (equaling maximum intensity). The RPE scale allows the individual to use a subjective fatigue level rather than just their heart rate to determine their exertion level. A moderate level of intensity (60% of peak aerobic capacity) using this RPE scale is reached when the individual considers their exertion to be a 13 or "somewhat hard" (Tanaka, Monahan, & Seals, 2001).

Pulmonary System

Aging of the pulmonary system is also associated with declines in the structure and function of the lungs (Janssens, Pache, & Nicod, 1999; Johnson, Badr, & Dempsey, 1994; Levitzky, 1984; Sheel, Foster, & Romer, 2011; B. J. Taylor & Johnson, 2010). Both chest wall compliance and elastic recoil of the lungs are decreased with aging. These changes lead to increased functional residual capacity within the lungs (Janssens et al., 1999; Levitzky, 1984). Age related functional declines in the pulmonary system leads to decreased gas exchanges of oxygen and carbon dioxide. Ventilation as well as perfusion mismatches may also occur because of structural deficits causing a decrease in oxygen/carbon dioxide gas exchange, decreased pulmonary blood volume, and reduced lung perfusion (Janssens et al., 1999; Johnson et al., 1994; B. J. Taylor & Johnson, 2010). Even with these pulmonary system declines incurred from aging, the exercise capacity of older adults is generally not limited by these pulmonary changes (Rossi, Ganassini, Tantucci, & Grassi, 1996; B. J. Taylor & Johnson, 2010). During mild to moderate exercise, a healthy older adult's pulmonary reserve capacity (the ability to maintain arterial blood gases within normal parameters) is able to meet elevated metabolic demands. (B. J. Taylor & Johnson, 2010). In less active or sedentary older adults, physical activity has been shown to increase pulmonary ventilation/perfusion matching (Janssens et al., 1999). Increasing aerobic fitness in older adults may increase pulmonary blood flow which promotes increased pulmonary gas exchange, increases exercise capacity and reduces exertional dyspnea (Sheel et al., 2011; B. J. Taylor & Johnson, 2010). In older adults with chronic obstructive pulmonary disease, performing regular aerobic physical exercise can increase pulmonary function efficiency (Anagnostakou et al., 2011; Antunes-Correa et al., 2011; Downing & Balady, 2011; Duiverman et al., 2011; Estrella-Holder, 2011; Guimaraes, Carvalho, Bocchi, & d'Avila, 2011; Isaksen, Morken, Munk, & Larsen, 2011; Rammaert, Leroy, Cavestri, Wallaert, & Grosbois, 2011; Sindhwani, Verma, Biswas, Srivastava, & Rawat, 2011; S. Singh, Harrison, Houchen, & Wagg, 2011).

Medications and Exercise in Older Adults

Data from the National Health and Nutrition Examination Survey (NHANES) has indicated that 50 million Americans have hypertension, yet only 59% percent of adults receive treatment for this (Chobanian et al., 2003). Additionally, 46% of older adults with hypertension are taking some type of cardiovascular medication (Gu, Dillon, & Burt, 2010). The American Medical Association's "The Seventh Report of the Joint

National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure" (JNC7) provides the current guidelines for hypertension prevention and management in the United States (Chobanian et al., 2003).

The JNC7 report advocates for lifestyle modifications and non-pharmacological treatment of pre-hypertensive individuals. Major lifestyle modifications that have been demonstrated to prevent or lower high blood pressure include weight reduction in those who are overweight; using diet to increase the intake of potassium and calcium rich foods while reducing salt intake; increasing physical activity; and consuming alcohol in moderation. While these lifestyle habits have been individually successful in lowering the blood pressure, they are more effective when used in combination (Chobanian et al., 2003).

If these lifestyle interventions are unsuccessful, the JNC7 report suggests the use of antihypertensive therapy. The recommended classifications of medications used in the treatment of high blood pressure are: thiazide-type diuretics, beta-blockers (BB), angiotensin-converting enzyme (ACE) inhibitors, angiotensin-receptor blockers (ARBs), and calcium channel blockers (CCBs). These medications can be used alone or in combination. It is important to consider each individual class of anti-hypertensive medication with regard to the side effect that may occur in older adults. Although there is no specific literature that prohibits physical activity of older adults who are on anti-hypertensive medications, a few precautions and warnings are noteworthy. **Table 2.1** below summarizes of some of the common exercise concerns of older adults who are taking anti-hypertensive medications as highlighted in the JNC7 and in other source materials such as the Michigan Governor's Council on Physical Fitness, Health and Sports (Chobanian et al., 2003; Lampman, 2002).

Table 2.1: Exercise Concerns For Older Adults Who Take Anti-Hypertensive Medications

Anti-hypertensive medication classification:	Prescribed for:	Exercise considerations:
Diuretics	First line agent for initial treatment	Older adults should not exercise in extreme heat; check potassium level regularly; may increase risk for life threatening arrhythmia; encourage water intake while exercising to replace water loss through perspiration.
Beta-blockers(BB)	Atrial fibrillation, hypertension, long Q-T syndrome, arrhythmia prophylaxis, and/or angina	Their effects include: reduced resting heart rate; reduced maximal heart rate, reduced myocardial contractility, and blood pressure during exercise. If exercise produces weight loss or increase in fitness, medication adjustments may be needed to prevent hypotension. Limited endurance times may be noted.
Angiotensin-converting enzyme (ACE) inhibitors	Used with diuretics in patients whose blood pressure has not decreased sufficiently with diuretics alone	Older adults might develop lower blood pressures within the first few weeks of initial treatment. These have the same exercise considerations as diuretics.
Angiotensin-receptor blockers (ARBs)	Used with diuretics in patients whose blood pressure has not decreased sufficiently with diuretics alone	Older adults might develop lower blood pressures within the first few weeks of initial treatment. These have the same exercise considerations as diuretics.
Calcium channel blockers (CCBs)	Used with diuretics in patients whose blood pressure has not decreased sufficiently with diuretics alone	May cause worsening angina and acute myocardial infarction in those with severe coronary artery disease.

Overall, older adults who are physically active and are taking any anti-hypertensive medications should communicate with their healthcare provider to determine the best way for them to tolerate their anti-hypertension agents without adverse side effects. Ideally, with proper medical supervision, an older adult who increases their level of physical activity may achieve blood pressure control with fewer medications (Cocco & Pandolfi, 2011).

The blunting effects of cardiovascular medications may affect the heart rate and blood pressure responses, as well as modify arterial/venous blood vessel responses during exercise. Therefore, heart rate, blood pressures and rate pressure product may be blunted in adults on anti-hypertensive therapy. To overcome this problem, heart rate, blood pressure and rate pressure product responses during exercise should be supplemented with a measure of perceived exertion, for example, the Borg's RPE (Borg, 1998). Perceived exertion is the subjective response of the intensity of the activity reported by the subject (Centers for Disease Control and Prevention, 2010b). This self-determined perception of exertion grounds the older adult's participation in their individual experience of exercise while providing a valid measurement of exercise intensity and cardiovascular demands during exercise.

Demographics of Aging, and Hazards and Chronic Diseases Related Sedentary Lifestyles

Demographics of Aging: The oldest persons born in the "baby boomer" generation from 1945 to 1964 turned 65 around the year 2011 (Schutzer & Graves, 2004).

The generation of those born from 1925 to 1945, at 65 years had an adjusted life expectancy of 12.2 additional years, while the baby boomer generation adjusted life expectancy at age 65 years has increased to 13.8 additional years. This correlates to a 12% increase in their lifespan (Arias, 2006). Along with the increase in life expectancy, the increase in aging-related chronic medical conditions is also expected to rise (Christ & Diawan, 2008). Most of the chronic diseases that occur in older adults can be discussed in terms of a physical activity component that may contribute to their respective disease severities. The increased survival of older adults with chronic diseases will have increased economic (e.g., Medicare expenditures) and social costs (e.g., caregiver participation). Increasing physical activity among older adults is proposed as a socioeconomic solution to reduce both the economic and caregiver burden costs. Regularly performed daily physical activity for 30 minutes or more can help to reduce the risk of chronic diseases and may increase functional independence in older adults compared to older adults who are sedentary (Lampman, 2002).

Hazards and Chronic Diseases Related to Sedentary Lifestyles: Despite the growing evidence that having an active lifestyle provides many health benefits, many older adults remain sedentary. A sedentary lifestyle contains little-to-no leisure time physical activity (Centers for Disease Control and Prevention (CDC), 1993). Regular physical activity has been shown to reduce the morbidity and mortality of many chronic diseases (U.S. Department of Health and Human Services, 2002). Millions of Americans needlessly suffer from chronic illnesses that can be prevented by regularly performing moderate intensity physical activities (Centers for Disease Control and Prevention, 2009). The most prevalent chronic diseases among adults aged 65 years or older are arthritis, hypertension, heart disease, diabetes, cancer, and respiratory disorders (He et al., 2005). All of these disease processes are to some degree preventable, or greatly mitigated in older adults who participate in daily physical activity (Christmas & Andersen, 2000; M. A. Singh, 2004). The total annual economic impact of preventable chronic diseases on the U.S. economy exceeded $1 trillion in 2007 and is expected to reach $6 trillion by 2050 (DeVol et al., 2007). The rate of increase in chronic diseases in the U.S. associated with having a sedentary or inactive lifestyle is expected to triple by 2049 (Agency for Healthcare Research and Quality, 2002).

In 1996, the Surgeon General of the U.S. recognized the alarming trend of physical inactivity of all adults (United States Department of Health and Human Services, 1996). In 2002, the U.S. Department of Health and Human Services specifically reported that "fifty-four percent of men and sixty-six percent of women aged 75 and older engage in no leisure-time physical activity" (U.S. Department of Health and Human Services, 2002). This trend of physical inactivity among older adults is growing. Moreover, there is a difference in the amount of physical inactivity between men and women, with older women being more physically inactive than older men (U.S. Department of Health and Human Services, 2002). To reverse or mitigate some of the negative health effects incurred from a sedentary lifestyle, the Surgeon General recommended that sedentary individuals of all ages should participate in regular physical activity for at least 30 minutes at a moderate activity rate for at least five days per week, or 20 minutes of vigorous physical activity at least three times per week. More recently, position statements from scientific and national organizations have recommended similar physical activity guidelines (Agency for Healthcare Research and Quality and the Centers for Disease Control, 2002; American College of Sports Medicine, 2007; American College of Sports Medicine et al., 2009; American Heart Association, 2011; Centers for Disease Control and Prevention, 2010a; Elsawy & Higgins, 2010; National Institute on Aging, 2010; Nelson et al., 2007), (**Appendix A**). To quantify a moderate or vigorous physical activity level, the "Talk Test" was developed so that a person could self-determine their physical intensity level in a simple manner (Foster et al., 2009; Jeans, Foster, Porcari, Gibson, & Doberstein, 2011). The "Talk Test" identifies the relative intensity of the physical activity by assessing how much you can talk during physical activity. Moderate-intensity activity infers that an individual can talk, but not sing, during the physical activity. For a vigorous-intensity physical activity, an individual will not be able to say more than a few words without pausing for a breath. Moderate and vigorous levels of physical activity are essential to sustaining good health, and to help reduce the risk of developing heart disease, diabetes, hypertension, and, some types of cancers. Physical activity helps to lessen the negative impact (e.g., lower quality of life) of chronic diseases in one's life (Coberley, Rula, & Pope, 2011). For older adults with cardiovascular diseases, high blood pressure, high cholesterol, chronic lung diseases, diabetes, obesity, and osteoarthritis, any physical activity can be an effective part of their treatment regimens to reduce the sequela of these diseases (Agency for Healthcare Research and Quality and the Centers for Disease Control, 2002). By keeping physically active, older adults can achieve a healthy weight, reduce the risk of falls, reduce depression and improve their overall psychological wellbeing (United States Department of Health and Human Services, 1996).

Applications and Usefulness of Exercise Gaming as an Exercise Intervention

The first home video gaming systems introduced in the U.S. were the Magnavox Odyssey in 1972 and the Atari Pong in 1975 (Winter, 2010). As video gaming technology advanced with the development of higher resolution graphics and more streamlined user interfaces, the popularity of video gaming increased. The first home video gaming applications with EG appeared in the U.S. marketplace between 1982 and 1989. The first EG systems, which were add-ons to the home video gaming console, consisted of a floor mat in which the individual interacted with the EG system. The floor mat allowed individuals to simulate dancing or running scenarios that appeared on the television, that is, the interface. Although this was an innovative step to engage the individual to be more physically active, sales declined due to its poor quality interface and unrefined graphics. Starting in 1992, software driven interactive cycle and stair steppers were introduced as an attachment to the home video gaming console, but these peripheral devices obtained marginal success due to the difficulty in operating the devices and high dollar costs (WorldLingo, 2011).

The first major breakthrough in EG occurred when the game manufacture Konami released Dance Dance Revolution (DDR) in 1998. DDR is considered the first successful EG system that instituted the EG era we see today (Lazarus, 2010). EG systems thereafter have had sustained sales in the U.S. and the world. The Nintendo Wii system was introduced in 2006; the Wii Fit and specialized balance board and Wii Sport software was introduced in 2008 (Lazarus, 2010). The success of the Nintendo Wii system, in both worldwide sales and popularity, is attributed to this EG system's ability to deliver interactive, fun, exercises in the home environment as an alternative to traditional gym based exercises (Fit Day, 2009). The success of the Wii in motivating children and adolescents to become more active has prompted a number of researchers to investigate if EG may become the solution to stem the tide of childhood obesity (Graves et al., 2008; Lanningham-Foster et al., 2009; Levac et al., 2010; Penko & Barkley, 2010; White, Schofield, & Kilding, 2010)

EG systems provide individuals with repetitive, motivating, and safe exercises which offer continuous visual and physical feedback in real time (Flynn, Palma, & Bender, 2007). This "real-time feedback" provided by EG "interactive environments" is understandable to individuals of all age; modulates the user's inputs to determine success or failure of their game play; and motivates the user to correct a failed scenario with repetition. EG users can develop a tolerance for extended periods of game play activity that may be perceived as fun (Holden, 2005).

Enjoying the activity is reported as a strong reason for continuing a physical activity program (Leaf & Reuben, 1996; Nied & Franklin, 2002; Ross & Teasdale, 2005). Enjoyment in an activity program is an important component of motivating older adults to continue participating in the physical activity (Alpert et al., 2009). EG may provide a motivating and enjoyable way of continuing physical activity by EG's ability to be tailored to the physical and mental needs in older adults. EG has the potential to be used as a recreation-based physical activity or a regularly scheduled exercise program in older adults.

Summary

Aging causes an overall reduction in the performance of several major organ systems. Regular daily exercise may decrease these declines that occur with aging. With the expanding elderly population, reducing the negative effects of sedentary lifestyles is paramount to promote quality of life and reduce healthcare costs. EG potentially offers an effective form of exercise/physical activity for older people. Generally, EG is inexpensive, convenient, portable, fun, and easy to operate. However, further studies are required before EG can be recognized and promoted as an exercise intervention for older adults.

CHAPTER III

Research Design and Methods

This chapter describes the study design, the subjects, inclusion criteria, exclusion criteria, sample size, data analysis, enrollment procedures including screening, consent, and data collection, experimental procedures including treatment environment, the specific instruments and equipment used, and human subjects considerations (risks, protection from risks, safety, important knowledge to be gained from the study, inclusion of women, minorities and children, and database management).

Study Design

The overall purpose of this dissertation is to quantify the cardiovascular responses, the enjoyment, and the untoward physical responses from participating in a 15 minute trial of EG (Nintendo Wii Tennis) in healthy, older adults. The specific aims of this dissertation study are:

Specific Aim 1. To quantify changes in cardiovascular responses and perception of exertion from baseline to recovery with a 15 minute EG session in older adults.

Specific Aim 2. **To quantify the enjoyment and the 48 hour after effects of one 15 minute session of EG in older adults.**

In these experiments, older adults were exposed to a continuous 15 minute trial of EG using the Nintendo Wii Tennis game. The gaming intensity was initially set to the beginner's skill level and advanced automatically as player skill level changed based on the Nintendo Wii's internal programming. Data was collected serially at rest baseline, during, and after the EG gaming session. Throughout the protocol, heart rate (HR), blood pressure (BP), rate pressure product (RPP) and the perception of exertion were recorded in five minute intervals. Immediately following the Wii tennis game play, overall subject's enjoyment was measured. Untoward physical responses and additional qualitative responses to this single EG experience were collected using a 48 hours post EG gaming session questionnaire.

To achieve **Specific Aim 1**, data was collected by serially recording heart rate (HR), blood pressures [(BP), SBP=Systolic BP, DBP=Diastolic BP, and MBP=Mean BP)], rate pressure product (RPP=HR*SBP) and perceived exertion (PE) levels (using the Borg Rated Perceived Exertion Scale) at baseline, upon standing, during EG activity at the 5, 10, and 15 minute intervals, and at 5 and 10 minutes post activity while the subject rested in the seated position. To achieve **Specific Aim 2**, overall enjoyment of EG was collected using the Physical Activity Enjoyment Scale (PACES), (**Appendix B**). Also, a 48 hours post-exercise follow-up questionnaire was completed to describe the EG experience (**Appendix C**).

While the primary dependent physiological variables were cardiovascular responses (heart rate, blood pressures, rate pressure product), and perceived exertion, there are several covariates that require analysis to adequately achieve the primary aim. Thus, gender and cardiac medication use were also assessed. The dependent study variables and demographic/baseline covariates are listed and defined in **Appendix D**.

Subjects

Residents of one independent adult living community in Southeastern Pennsylvania were enrolled in this study. The location's approval authority conducted its own internal review of this proposal. Their support was contingent on approval by the Institutional Review Board (IRB) at the University of Pennsylvania. Upon IRB approval (**Appendix E**), the Principle Investigator (PI) coordinated with the site's point of contact to establish informational and study recruitment sessions, reserved the testing rooms, ensured that the necessary equipment was on-hand, and the experiment began. Approved flyers were posted in common areas and bulletin boards; this site also had a four channel closed circuit television station where activities and other information were posted for 24 hour access. Recruitment was supplemented by the point of contact person acting as an on-site recruiter, whose role was to inform the PI of interested individuals.

Those agreeing to be recruited had the study carefully explained to them in person by the PI. Screening for vital signs was conducted (**Appendix F**) and inclusion/exclusion criteria covered (**Appendix G**). Written informed consent (**Appendix H**) was obtained at the first meeting. During this first meeting, the PI answered questions and made sure that the procedures to be used were fully understood by the subjects. Subjects were told during enrollment and reminded at each meeting that they had the option to terminate participation early or to participate at another time. Recruitment began on 19 December 2011. All study subjects were enrolled, consented, scheduled, and tested by 29 January 2012.

Inclusion criteria: subjects in this study were; (1) age 60 or older; (2) living independently; (3) cognitively intact as determined by the 60 second animal word retrieval screening (Canning, Leach, Stuss, Ngo, & Black, 2004) with a score of greater than 14; (4) able to stand and ambulate without the aid of assistive devices (i.e., walker or cane) for at least 30 minutes; (5) able to read, write, and communicate in English at a conversational level; (6) capable of adequate functional visual acuity and hearing acuity at levels to participate in everyday tasks and conversation; (7) having a resting heart rate of less than 120 beats per minute (bpm) with a resting blood pressure of less than 180/110 at the time of consent/screening and before the experiment began, and (8) without any serious and/or acute illness (see Inclusion and Exclusion Study Criteria, in **Appendix F and G**). Since it would have been difficult to recruit older adult subjects who were not on any cardiovascular medications, subjects that were taking cardiovascular medications to manage hypertension and other cardiovascular diseases were included. Cardiovascular medication use was included in the statistical analysis. Furthermore, inclusion of older adult subjects who take cardiovascular medications lends to the real world generalizability of the study's results.

Exclusion Criteria: Subjects were excluded from this study if he/she (1) had an implanted cardiac pacemaker or defibrillator (Both the Nintendo Wii and the BioPac BioHarness warn against the use of their products with implanted cardiac medical devices due the possibility of interference or malfunction from these devices); (2) unable to stand unsupported for at least 30 minutes; (3) taking any anti-anginal medication for any reason (e.g., nitroglycerin as needed for chest pain during an activity or daily scheduled nitroglycerin dose); (4) hospitalized for an acute or chronic illness in the past three months or receiving permanent long term care for physical incapacity; or (5) uncontrolled hypertension (above set screening parameters of 180/110 mmHg or heart rate greater than 120 bmp), orthopedic or neurological disease that results in instability upon standing and walking as well as history of known cardiac arrhythmias or sudden cardiac arrest.

Sample Size

The study was an observational, one-sample, repeated measures study that observed heart rate, blood pressures, rate pressure product, and perceived exertion among older adults in a community living environment. The primary objective of the study was to describe cardiovascular parameters over time in response to Nintendo Wii Tennis activity. Specifically, the goal of this study was to obtain estimates of average group variables, with the primary outcome measure of cardiovascular responses (HR, BP's and RPP) at eight different time points (baseline at 5 and 10 minutes, and standing; during activity at 5, 10 and 15 minutes, and 5 and 10 minutes after stopping the Wii Tennis activity).

Power in a descriptive study relies on the report of confidence intervals (CI) and ensuring adequate precision for mean estimates of outcome variables at various time points. A narrow confidence interval with a high confidence level (95%) is more likely to include the true population mean value in a descriptive study (Browner, Black, & Newman, 1988). A narrow confidence interval implies that the data points will fall between the upper and lower limit of the expected confidence interval 95% of the time with high confidence even if a study were to be repeated an infinite number of times. Using a narrow interval for this experiment is an attempt to establish a stable estimation of the cardiovascular responses in this population. In contrast, using a wider confidence interval could give us a larger interpretation of the population mean estimation resulting in less “confidence” that the future heart rate results are unusual compared to previously results. For example, if the narrow CI produces a mean heart rate of 85 with a CI of ±10 BPM in 20 subjects and the 21st subject is found to have a heart rate of 125, this could indicate that the subject is different than the other subject in the study.

For this dissertation a sample of 25 subjects produced a two sided 95% CI with a distance from the mean to the upper and lower limits equal to 4.953 heart beats per minute when the estimated standard deviation is 12 heart beats per minute of the most vigorous Nintendo Wii aerobics program based on observations from a previous study (Graves et al., 2010). To account for various attrition scenarios, we added 40% (Dissertation Committee recommended) to the calculated sample size of 25 to bring the final sample size to 35.

Enrollment and Experimental Procedures

Following IRB and treatment site approval, the following quasi-experimental procedure was implemented in two phases. The two phases were: 1) consent, data collection, and enrollment, (with screening); and 2) the experimental procedure.

Consent, Data Collection and Enrollment: **Figure 3.1** illustrates the consent and enrollment process. A group or individual meeting between the PI and potential subjects was offered weekly to provide general information about the study, demonstrate

Figure 3.1: Meetings I&II: Consent & Enrollment; Experimental Procedures	
Meeting I	**Provide/Offer Information session** **Obtain Informed Consent** **Screening, reviewed inclusion/exclusion** **Complete forms & data collection** **Set up date/time for Meeting II**
Meeting II	**Review completed data collection and forms** **Conduct Experiment**

the equipment, and answer any questions about the study. Printed advertisement flyers were posted at various locations in the facility. Individuals were allowed to interact with the equipment on hand. The goal of these meetings was to develop a rapport with the potential subjects and to pre-screen them using the inclusion and exclusion criteria. It was considered ethically acceptable to screen potential research subjects by using general questions to gauge their interest without delving into detailed medical questions before going through the formal written consenting process (J. Karlawish, personal communication, April 28, 2011).

Data Collection: To maintain privacy and confidentiality during the consent, screening, enrollment, and the experiment, a private office or classroom was used and the experiment took place in a classroom size space approximately 10 foot by 12 foot or larger. After determining interest and eligibility, the PI consented and enrolled the subjects immediately. Data collection began immediately after each subject was consented. The consent contains a description of the study to include all of the necessary informed consent and Health Insurance Portability and Accountability Act (HIPPA) information as required for IRB approval (**Appendix H**).

Specific Instrumentation

This section will cover the specific instruments used during this study to determine cognitive status, physical activity, the gaming system, biometrics (BP's, HR, etc.), physical exertion, post experiment follow-up, and enjoyment (**Appendix I**).

60 Second Animal Word Retrieval Screening: This screening tool was used to screen subjects for cognitive impairment. The 60 second animal word retrieval screening has been shown to have good sensitivity and specificity for detecting the semantic memory and verbal fluency impairments that occur in Alzheimer's disease and several other dementias. In one study, the animal naming test was determined to be superior compared to the Controlled Oral Word Association Test (COWAT) in discriminating the patients with Alzheimer Disease (n=98) from normal controls (n=46) (Canning et al., 2004). Both the 60 second animal word retrieval screening and COWAT were administered by a trained psychometrist. All patients were asked to verbally to respond within 60 seconds and the verbatim responses were record for analysis. Positive likelihood ratios demonstrated that animal naming scores of less than 15 were 20 times more likely to occur in a patient with Alzheimer's disease group than those in the normal cognition control group (sensitivity = 0.88; specificity = 0.96) (Canning et al., 2004).

The Rapid Assessment of Physical Activity Among Older Adults (RAPA): This assessment tool was used to determine the older adult's baseline level of physical activity during the screening and enrollment phase of the research protocol. The RAPA is readable at the sixth grade reading level. When compared to other physical activity questionnaires, such as the Behavioral Risk Factor Surveillance System (BRFSS), Patient-centered Assessment and Counseling for Exercise (PACE), and the Community Healthy Activities Model Program for Seniors (CHAMPS), the RAPA showed good or better sensitivity (81%), positive predictive value (77%), and negative predictive value (75%) compared to the other tools (Topolski et al., 2006). The RAPA is an easy to use, valid measure of physical activity in older adults and is well received by geriatricians (Topolski et al., 2006).

Nintendo Wii Gaming System: Nintendo introduced a new style of VR gaming and EG in 2006 that uses a wireless controller that interacts with the player via a motion detection system. The hand controllers use embedded sensors responsive to changes in three directions, speed, and acceleration that enable subjects to interact with the games while performing upper and lower body movements. A two-point infrared light sensor, mounted either on top or lower edge of a television, captures the movement from the controller and replicates the actions performed by subjects on the screen. The feedback provided by the television screen image, as well as the opportunity to observe their own movements in real time, generates positive reinforcement for players, thus facilitating training and task improvement. Several distinctive features of the Nintendo Wii favored its selection over other VR systems with EG. The Wii combines its novel 3D effects gaming technology to enhance simulations with low cost affordability. Combined with real-time feedback enhancements, the Wii is easily adaptable for patient use in a number of clinical areas. Many of the games enable skill level adjustment to the reduce speed or accuracy, thus making it suitable for patients with cognitive impairments or impaired eye-hand coordination. The direct multimodal sensory feedback (vision, touch, and auditory) features allow the player to make adjustments during the game. The software game, Wii Tennis, comes bundled with the computer console unit with all Nintendo Wii systems sold in the United States since 2006 (Saposnik et al., 2010). The Nintendo Wii carries a warning that the Wii remote emits radio frequencies that may interference with the normal operation of pacemakers or other implanted medical devises. Those who have these devices should consult their doctor or manufacture of the device before playing the Nintendo Wii system (Nintendo, 2011).

Zephyr BioPac BioHarness Portable Measurement System: Physiological status monitoring (BioPac BioHarness, BioPac Systems Inc., CA) was used to monitor the cardiovascular responses during EG activities. This system gives real time visibility into the physical status of subjects during physical activity. The BioHarness, provides a single device to collect a number of physiological variables data (**Appendix D**). The BioHarness measures both physiological and accelerometer data and then transmits it wirelessly to a laptop computer. This device is worn around the chest across the lower part of the sternum by a single strap that is adjustable with Velcro for chest sizes ranging from 22 to 52 inches (for pictures of how the BioHarness and how it is positioned on the chest, see **Appendix J**). The strap has built in skin contacts (which must directly touch the skin for electrocardiographic recording and transmission) and sensors to capture, record and then transmits the data wirelessly through the built in antenna to the receiving computer. The advantage of this device is that time is saved compared to utilizing separate devices to collect this data and then perform post data collection synchronization. The BioHarness can be worn in almost any environment and it maintains performance under extreme activity with fast, accurate collection and analysis of data. The BioHarness can operate in two modes, real time data collection and transmission, or recording mode, which stores data for up to 30 days and then downloads to a computer to be analyzed at a later time. For the experimental procedure, the real time data transmission mode was utilized to monitor cardiac physiological parameters for nearly instantaneous real time viewing. The BioHarness was tested and certified by the National Safety Foundation (NSF) as safe electronic monitoring device for use in life scientific research (the International Organization for Standardization (ISO) certificate of registration is located in **Appendix K**). For both men and women who might participate in this experiment, confidentiality and privacy was respected in helping them put on the BioHarness. No subject stated that they were uncomfortable with the PI helping them to put on the BioHarness, the PI first demonstrated to them how to wear harness was to be worn. Women did not have to remove their bras, but the BioHarness must be placed high enough on the chest at the bottom of the sternum to obtain a strong and clear signal. If the subject did not have the dexterity to put the harness on, the PI, a veteran nurse, assisted them. No subject requested an on-site female to assist them put on the

BioHarness. Respect for privacy is the one of the highest priorities in conducting research at this facility. The BioHarness straps were rinsed in clean water between each use. The manufacture recommends that the Bioharness strap can be machined washed on a monthly basis or up to 25 machine washings without harming the electronics contained in the strap. Multiple straps in a variety of sizes were available so that a “snug” for the appropriate pressure level for a clean transmission signal is obtained. During the recording of the experiment, the unique identification number was used as the file name and the BioHarness recording device were erased between recording sessions.

Life Source UA-767 One Step Auto-Inflation Blood Pressure Monitor: The Life Source UA-767 is described by the manufacture as a state-of-the-art blood pressure monitor and one of the most technologically advanced, yet easy to use auto-inflation blood pressure monitor available in today’s marketplace. This monitoring device is specifically designed for high accuracy and ease of use. Blood pressure reading is based on the “oscillometric method”. This method of noninvasive blood pressure determination was initially developed in 1876 (Balestrieri & Rapuano, 2010). One advantage of using this technique is that a transducer does not need to be placed directly over the brachial artery; this means it is easier to use in the clinical setting (Pickering et al., 2005). The term “oscillation” refers to any measure of vibrations caused by the arterial pulse. The cuff is fully inflated until the artery is blocked. Then, measurements are taken while the cuff deflates. This blood pressure monitor examines the pulsatile pressure generated by the arterial wall as it expands and contracts against the cuff with each heartbeat. Blood pressure measurements determined by the UA-767 are equivalent to those obtained by a trained observer using the cuff/stethoscope auscultation method within the limits prescribed by the American National Standards Institute for electronic or automated sphygmomanometers. Measurement of blood pressure range from 20 mmHg to 280 mmHg, the pulse measurements range from 40 pulses to 200 pulses per minute. The accuracy of the UA-767 for blood pressure is ±3 mmHg or 2%, whichever is greater and pulse accuracy is ±5% (A&D Lifesource, 2009).

Borg Rating of Perceived Exertion Scale (RPE): This scale provides a way of measuring physical activity intensity levels. An individual's perceived exertion state relates to the physical sensations that a person experiences during physical activity, including increased heart rate, increased respiration rate, increased sweating, and muscle fatigue (Centers for Disease Control and Prevention, 2010b). The Borg 20 point scale ranges from 6 to 20, where 6 suggests "no exertion at all" and 20 suggests "maximal exertion". A perceived exertion rating of a physical activity from 12 to 14 is considered a moderate level or middle level of intensity during physical activities. The RPE has been suggested as the preferred method to assess physical activity intensity among individuals who take medications that affect the heart rate response to stress (Borg, 1998).

48 Hour Post-Wii Tennis Follow-Up Questionnaire: This survey was developed to illuminate potential post-Wii tennis hazards that might arise after the experiment (Dissertation Committee guided). A 48 hours post physical activity timeframe was chosen because it is associated delayed onset muscle soreness which peaks between 24 to 48 hours after the physical activity is stopped (Pettitt et al., 2010).

Primarily, this questionnaire was used to record whether the experiment caused any untoward physical responses (i.e., soreness, pain, extreme fatigue, or muscle/joint discomfort) and level of this response after 48 hours of the experiment on a 0 to 10 scale, with 0 meaning no pain/discomfort and 10 meaning extreme pain/discomfort. If the subject responded with any discomfort due to the experiment, the PI asked them to identify the site on their body and describe the discomfort in detail.

Additional questions in this questionnaire sought the subject's opinion to recount if this technology is interesting to older adults by asking them several open ended questions such as if they would use the Wii again, if the Wii could be part of a physical activity plan, if the Wii was difficult to use, and if they had any specific comments that they felt were important. These descriptive responses will enrich the results and discussion section of this experiment by robustly describing the older adult's perceptions on how this type of technology interfaces with them.

The Physical Activity Enjoyment Scale (PACES): This tool assessed the physical enjoyment of the Wii Tennis experiment. This tool consists of 5 items with a point scale of 1-7 for each item. The sum of the items score (highest score is 35, lowest score is 5) describes the fun or enjoyment of the EG play. The higher the summed score of the PACES items relates to a higher level of fun or enjoyment the EG trial provided to the subject (Moore et al., 2009; R. W. Motl et al., 2001).

Screening

The 60 second animal word retrieval screening was used to screen for cognitive impairment. The subject was asked to name 14 or more animals within 60 seconds. The PI recorded the responses on the case report form. If the potential subject could not name at least 14 animals within 60 seconds, they were excluded from the study and the site coordinator was notified to encourage appropriate follow-up care.

To determine readiness to participate in this study, the subject's vital signs were screened at the time of consent, and the Modified Physical Activity Readiness Questionnaire developed by the American College of Sports Medicine's (ACSM) guidelines for exercise testing and prescription was given (American College of Sports Medicine, 2010). This pre-physical activity and exercise screening questionnaire provides the researcher with accepted vital signs (heart rate and blood pressure limits) before a subject participates in an exercise experiment as well as the finding from direct health questions. Since older women may experience atypical prodromal chest pain or discomfort before a heart attack, two questions were modified in order to be sensitive to this phenomenon as an additional level of protection to all subjects (McSweeney et al., 2003; McSweeney et al., 2010). If the subject answered "yes" to any of the seven questions or their heart rate or blood pressure was greater than the set maximum levels, the subject was not allowed to participate in the exercise experiment. The PI also encouraged them to see their primary care provider for further guidance and treatment (**Appendix F**).

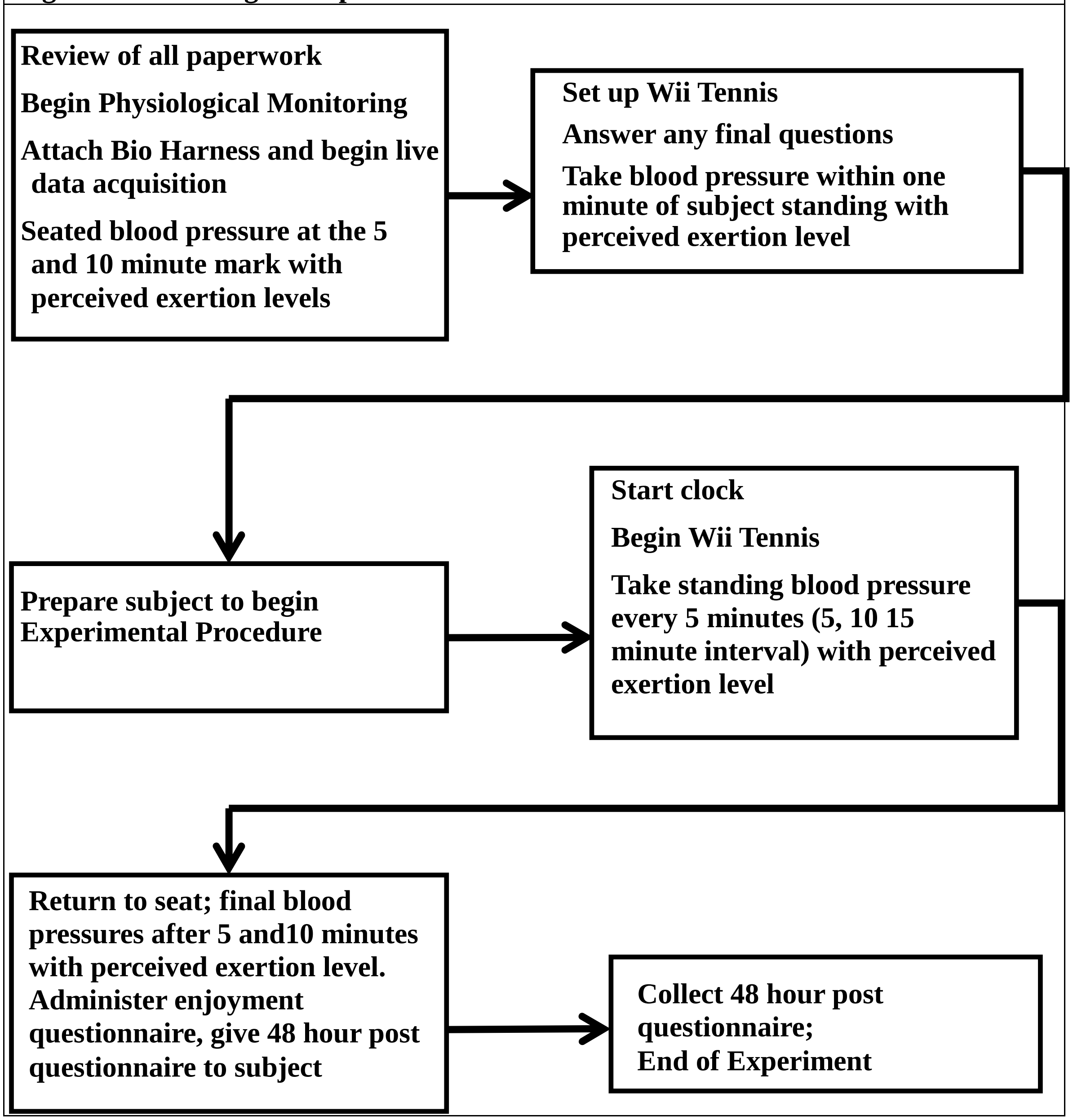
Additional self-reported background information collected during consenting and enrolling meeting included the number of current medical diagnosis, number of medications taken daily and number of supplements taken daily was collected.

If the subject was not familiar with the Nintendo Wii, a 15 minute hands-on introduction and interaction with Nintendo Wii Tennis was arranged prior to the experiment. Proficiency in playing the EG is not the intent of this study; it was important that the subject keeps moving during the length of the experiment.

At the end of the first meeting, the subjects were asked to abstain from eating a large meal, smoking, exercising and using caffeine for a period of at least two hours prior to their second meeting, which was the experimental procedure appointment. The abstinence period for at least 2 hours prior to the experimental procedure was a methodological control to help minimize the possible confounding effects of digestion, nicotine, fatigue from earlier exercise and caffeine on heart rate, blood pressure and rate pressure product. For subject comfort, the PI asked subjects to wear loose fitting and comfortable clothing (i.e., a T-shirt and sweat pants) as well as comfortable foot gear (i.e., tennis shoes or sneakers) for the experimental procedure.

Experimental Procedure: The experimental procedure was scheduled in agreement with the study subject at a date and time that was convenient for them between Monday to Friday and between the hours of 10am and 4pm (other days of the week (i.e., Saturday or Sunday) and earlier or later times were made available, if needed or requested). The PI greeted the subject and reviewed their consent, study paperwork for completeness, and verified that the study subject had abstained from eating, smoking, exercise, and caffeine for a period of at least 2 hours prior to the experimental procedure. The subject was fitted with the appropriately sized BioHarness and instructed on how to report exertion levels during rest, Wii tennis play, and post exercise recovery using the Borg Rated Perceived Exertion (RPE) scale. When the experiment began, the subject remained seated for approximately 10 minutes to become accustomed to the harness and to establish CV baseline readings, **Figure 3.2**. After the subject remained seated for 5 minutes, the first heart rate, blood pressure and perceived exertion level was taken. After an additional 5 minutes (at the 10 minute seated mark, baseline), another sitting resting baseline blood pressure was taken from the subject. With every blood pressure, the subject was asked to rate their perceived exertion based on the Borg RPE scale between 6-20. During this stabilization period, the PI ensured that the Nintendo Wii Tennis was set up for the subject to begin the experimental procedure.

Figure 3.2: Meeting II: Experimental Procedure



Upon standing, another resting blood pressure was taken as well as perceived exertion. Then the subject played Wii Tennis for 15 minutes in 5 minute intervals. After 5 minutes, the subject briefly stopped game play and stood as still as possible while the PI took their standing blood pressure in their dominant arm with a manually applied automatic blood pressure cuff. The Borg scale was also administered at this time. This procedure was repeated at the 10 and 15 minute time intervals of play. Heart rate was monitored and automatically recorded by the BioHarness. Subjects were instructed that at any time during the experimental protocol, they could state that they felt fatigued or if they did not want to participate any longer or withdraw from the experiment. The PI constantly monitored the subjects regarding how they felt or if they were in any distress as well as monitoring their vital signs. The PI also informed them how much longer they needed to keep active until the end of the experiment time segment. Upon completion of the experiment, the subject was seated for vital sign stabilization and was asked the PACES enjoyment questionnaire. The final blood pressures and perceived exertion ratings were taken at the 5 and 10 minutes after completion of EG play. Before leaving the subject was instructed to complete the 48 hour Post-Wii Tennis Follow-Up Questionnaire forty eight hours later and return them to the PI or the on-site recruiter.

Experimental Environment: The room sizes met the minimum of 10 feet by 12 feet dimensions to allow free movements of the subject during EG play. The lighting was bright enough for the PI and the subjects to complete case report forms and adjustable so that the gaming image was easily viewable. Ambient temperature was set between 66 degrees and 74 degrees Fahrenheit. The same size 26 inch television (TV) and identical cart for Nintendo Wii Tennis was used for all subjects to maintain consistency. Distance from the 26 inch television screen was set with a line of tape on the floor approximately five and a half feet away from the base of the TV cart. This viewing distance corresponded to industry recommendations viewing distances for this TV screen size (Kindig, 2010) (**Appendix L**). The Wii tennis game volume was initially set to moderate or middle of the volume setting on the television. The television volume was adjusted to a comfortable level for each subject's preference, if requested. The skill setting for the Wii Tennis was set to the lowest level for all subjects. As the game was played, the degree of difficulty automatically changed based on the subjects' skill in playing the game and the Nintendo Wii's programming.

Since there was no set configuration standards available for testing older adults using the Nintendo Wii, the insight and knowledge gathered during this experiment was invaluable for future experiments using this technology. Modifications to the experimental environment during and between subjects were kept to a minimum.

Data Analysis

Descriptive statistics were used to characterize the subject population and their responses during the EG trial including mean values, standard deviations, and median values for continuous variables. All data from the case report forms and Bioharness heart rates were entered into a statistical software package SPSS 20.0 for Windows or compatible file type. SPSS statistical software was utilized for all statistical analyses and data plots for graphs. All study variables were summarized using appropriate descriptive statistics. A complete list of variables can be found in **Appendix D**.

Statistical Analysis Procedures

A repeated measures analysis of variance (ANOVA) for the six cardiovascular variables exploring for within subject variations over time was conducted. Data was tested for sphericity with Mauchly's Test of Sphericity (Mauchly's W). Sphericity is the condition where the variances of the differences between all combinations of related groups (levels) are equal. Thus, violation of sphericity occurs when the variances of the differences between all combinations of related groups are not equal. The violation of sphericity is common for the repeated measures ANOVA. A sphericity violation causes the ANOVA test level of significance to become too generous (i.e., an increase in the Type I error rate), therefore, a Greenhouse-Geisser correction was used to adjust each F-value variable over time. If the ANOVA resulted in significant differences for any of the six variables, then pair-wise comparisons with a Bonferroni adjustment was used for multiple comparisons. For independent t-tests, equality of variances was determined by the Levene's test.

Human Subjects Consideration

Hazardous Procedures and Precautions: There were no hazardous chemical or materials used in this study. No invasive body fluid sampling was conducted on the subjects. Subjects were monitored to prevent them from exceeding recommended limits for heart rate and blood pressure of 80% of age predicted maximum heart rate (220-age in years multiplied by .80) or > 50% deviation from their baseline blood pressures for both systolic and diastolic readings for more than 60 seconds.

Introduced into the U.S. Market in 2006, the Nintendo Wii's has developed some popularity with older adults. A recent survey of adults (age 42 to 51) found that 43% of them said that they own video game consoles and play video games (Glovin, Fiorentins, de Lussante, & Wilkos, 2008). Also in the same survey report, 22% of adults (age 52 to 62) owned and played Xbox, PlayStation or Nintendo Wii. The Nintendo Wii has earned the distinction of receiving an endorsement for off-the-shelf entertainment/gaming system to promote heart health. The American Heart Association has labeled the Nintendo Wii as being a "heart healthy" activity to participate in among the general population (American Heart Association, 2011). This potentially attractive way to increase physical activity in all age groups has not been adequately studied in the older adult population. Therefore, having older adults play the Nintendo Wii without medical evaluation or supervision involves a small degree of risk.

Human Subjects Involvement, Characteristics and Protection From Risks: Prior to conducting this research, approval was obtained from the IRB of the University of Pennsylvania. The study design is expected to impart the lowest possible risk to research subjects. The proposed study is designed to begin at a low or resting heart rate and proceed to a moderate heart rate level, which is considered a safe transition method for healthy older adults when they begin to exercise (Elsawy & Higgins, 2010). Unique identifiers were applied to each subject to assure anonymity and accountability. The researcher has received and will continue to receive training on the ethical conduct of research through various resources available at the University of Pennsylvania. The researcher maintained HIPAA certification throughout the research project and had completed the required online training and certification program entitled Collaborative Institutional Training Initiative (CITI) Protection of Human Research Subjects-Biomedical. Completed by the researcher on January 19, 2010, this course satisfied the university's requirement for human subject's research training in the biomedical sciences. In addition to the above requirement, the researcher regularly attended and actively participated in both the NewCourtland Center for Transitions and Health directed by Mary Naylor, PhD, FAAN, RN and the John A. Hartford Center of Geriatric Nursing Excellence directed by Eileen M. Sullivan-Marx, PhD, CRNP, FAAN. Both of these prestigious centers of nursing excellence provided rich and substantial continuing education seminars on ethics. These seminars were presented by center members who were biomedical ethics experts or by experts from the University of Pennsylvania's School of Medicine.

Potential Risks: There were risks involved in this proposed study to all subjects. To protect privacy, the subjects were assigned a unique identifier to reduce the risk of a recognizable link between any individual subject and the experiment. The physical risks, however small, included: heart attack, stroke, and possibly death. More common physical risks for any physical activity were: injuries or soreness to the bones, joints, tendons, and muscles, which would require very little medical treatment or just a period of reduced activity until the discomfort subsides. Subjects were monitored to prevent them from exceeding recommended limits for heart rate (greater than 80% of the maximal age predicted target heart rate) for more than 60 seconds and blood pressure (greater than 180/110 mmHg) at every 5 minute interval of Wii Tennis activity. The PI collected all of the data in this study and was trained in basic life support (BLS) as a healthcare provider with 16 years of nursing experience at community, large regional and military hospitals. The BLS training included how to use generic automated external defibrillator (AED) with emphasis on alerting the site's emergency response system.

Adequacy of Protection Against Risks

Data Security: The security of the data was protected by a firewall and password with a secure backup mechanism in place. The data were stored on a research-dedicated, secured, firewall-protected server maintained by the University of Pennsylvania, School of Nursing. The data were accessed through a password-protected desktop computer. All data for this dissertation proposal were stored and analyzed at the University of Pennsylvania on the School of Nursing server maintained by the Office of Technology and Information Systems. The data were secured on the protected health information server and was accessed only by authorized individuals required to analyze the data. All files were password protected. The health information server was routinely backed up and had weekly backups stored in an off-site location for added protection. Since this information and server were designated a critical host by the University of Pennsylvania, additional protective security measures were in place. These security measures included firewalls, access controls, scans for data infection from viruses and potential failures, and software management with updates.

Injury: Each subject was at risk for physical injury during the experiment due to disease or conditions unknown to either the researcher or the subject. Steps taken to minimize injury were outlined in the inclusion and exclusion criteria. All subjects had their blood pressure and heart rate assessed at each meeting. In addition, they were asked questions from the Pre-Screening Questionnaire located in **Appendix F**. As stated in **Appendix G**, only subjects who had been stable over the last 3 months and were able to perform physical activities were consented and enrolled. Those who had experienced a serious or acute illness or hospitalization within the 3 months prior to enrolling in this study were excluded, as well as potential subjects with uncontrolled hypertension, orthopedic and/or neurological limitations that require the use of a cane or other device for stability and freedom of movement, or a history of uncontrolled arrhythmias or sudden cardiac arrest.

Fatigue: To minimize risk of fatigue during the first meeting, surveys were chosen that were as short as possible. The completion of the self-report demographic and health survey form took less than an hour to complete and required that the subject sat and talked with the PI during this phase of the experiment. The experiment was scheduled at a time that was convenient for subjects between the hours of 10am and 4pm, unless otherwise preferred by the subject.

Potential Benefit: There were no direct benefits to the subjects in this study, although all subjects received assessments of a variety of biomarkers and participated in an experiment that may have been enjoyable or beneficial. A possible benefit of participation in this study was that the subject may receive a sense of satisfaction for their generosity in advancing nursing science. Their participation in this proposed study will guide future research in developing new EG or other activities that may improve healthy aging by increasing physical activities in older adults.

Importance of the Knowledge to be Gained

Physical inactivity was a major contributing factor for older adults developing arthritis, hypertension, heart disease, diabetes, respiratory disorders and many other chronic diseases. These diseases contribute to older adults having reduced physical independence. The impact of these preventable diseases can be influenced by older adult's participating in physical activity on a daily basis. Regular physical activity has been shown to reduce high blood pressure, diabetes, obesity, or high cholesterol, depression and anxiety; control weight; maintain bone density; strengthen muscles and protect joints, as well as reduces the risk of falls (Agency for Healthcare Research and Quality and the Centers for Disease Control, 2002; Nelson et al., 2007; U.S. Department of Health and Human Services, 2002; United States Department of Health and Human Services, 1996; United States Department of Health and Human Services, 1996). Physical activity promotes an overall sense of well-being in older adults (Buman et al., 2010). However, in spite of the preponderance of research and clinical evidence that supports physical activity as an important part of healthy aging, only 1 in 3 older adults are achieving the daily and weekly recommended amount of physical activity (U.S. Department of Health and Human Services, 2002). A recent survey of older adult's physical activities found that only 26% of all older adults participate in the light intensity physical activity and 46% had no leisure time physical activity as recommended by national guidelines (Kruger, Carlson, & Buchner, 2007). Older adults report numerous barriers that prevent their participation in individual or group physical activities. In addition to previously mentioned barriers to older adult physical activity, other situations may act as barriers such as: unsafe neighborhoods, lack of reliable and affordable transportation to senior recreation programs, lack of time, no caregiver relief support, pain or difficulty in ambulation. EG offers a potential and innovative avenue to reduce or eliminate many of the older adult's barriers to participate in physical activities by providing in-household physical activity opportunities that do not require outside of the home support or coordination.

Inclusion of Women and Minorities

According to the 2000 U.S. Census Report, nearly 60% of older adults are women. As older adults continue to age, the percentage of women older than 85 years will grow to more than 70% of the U.S. population. While the majority of study subjects were women, an attempt to balance the number of men during recruitment of study subjects was a priority. The researcher attempted to maintain a representative balance of demographic variables between all study subjects.

Inclusion of Children

Children were not be enrolled in the proposed study. The main focus and inclusion criteria include only older adults.

Data Monitoring

Because the study was not a clinical trial, a Data and Safety Monitoring Board was not required. However, the dissertation committee chair, Dr. Joseph Libonati, PhD as well as the committee members exercised methodological and ethical oversight of the entire study.

CHAPTER IV

Results

Subjects and Recruitment Results

Thirty nine subjects (12 males and 27 females) from an independent living retirement community in Southeastern Pennsylvania were recruited and granted written informed consent to participate in the study. Three female subjects voluntarily withdrew after enrollment. These three subjects stated that they did not desire to continue to participate in the study; i.e., two female subjects said that they felt that playing of the Nintendo Wii tennis was too physically demanding and one female subject stated that she did not like the game of tennis. Two additional male subjects were withdrawn by the PI. One male subject was withdrawn because of hypertension. He stated that his antihypertensive medications were changed by his healthcare provider a few days prior to testing. The second male subject was withdrawn from the study because of his daily use of nitroglycerin. One hundred percent of the final sample (n=34) completed the entire experimental protocol and the 48 hour post experiment questionnaire.

Demographics

The subject demographics and descriptive characteristics (n= 34) subjects are shown in **Table 4.1**.

Table 4.1: Subject Demographic and Other Characteristics (n=34)	
Variables	**Mean±SD (Range)**
Age (years)	**80.97±4.54 (69-91)**
Sex, *n* (%)	
Male	**10 (29.4)**
Female	**24 (70.6)**
Race, *n* (%):	
White	**33 (97.1)**
Black/Multiracial/Other	**1 (2.9)**
Education (*years)**	**13.59±2.44 (9-21)**
Weight (kg)*	**71.40±13.19 (40.91-98.88)**
Height (cm)*	**165.43±12.09 (142.24-193.04)**
Body Mass Index (BMI)	**25.98±3.13 (19.92-31.66)**
# of Medical Diagnosis	**2.38±1.23 (0-5)**
# of Medication taken daily	**3.26±1.96 (0-8)**
# of Supplements taken daily	**2.24±2.16 (0-10)**
#Subjects on no CV Medication	**17**
#Subjects on any CV Medication	**17**
#Subjects on CV Medication, beta-blockers	**8**
RAPA Score	**5.85±0.74 (4-7)**
***n*=number of subjects, #=number, kg=kilograms, cm=centimeters, CV=Cardiovascular, RAPA=Rapid Assessment of Physical Activity. All continuous variables reported with mean±sd (range); *=Significant differences between males and females (p<0.05)**	

Subjects ranged in age from 69 to 91 years, with a mean age of 80.97±4.54 years. The sample was composed of 24 female subjects (70.6%) and 10 male subjects (29.4%). The majority of subjects self-reported their race as white or Caucasian (n=33, 97.1%), with the remaining subject reporting race as non-white. Education in years (with completion of high school equaling 12 years of education) ranged from 9 to 21 years, with a mean of 13.59±2.44 years. Subject's weights ranged from 40.91 to 98.88 kilograms, with a mean weight of 71.40±13.19 kg. Heights ranged from 142.24 to

193.04 centimeters, with a mean height of 165.43±12.09 cm. Body mass index (BMI) was calculated using the formula: weight in kilograms/height in meters^2. Group BMI ranged from 19.92 to 31.66, with a group BMI mean of 25.98 and standard deviation (SD) of ±3.13. The number of self-reported medical diagnosis ranged from 0-5 with a mean of 2.38 with a SD of ±1.23. The number of medications taken daily ranged from 0 to 8, with a mean medication number of 3.26 ±1.96, and the number of supplements taken daily ranged from 0-10, with a mean of 2.24 ±2.16. In addition, 17 subjects reported that they did not take cardiovascular medications of any type, while 9 subjects took a combination of different cardiovascular medications that did not include beta-blockers, and 8 subjects took a combination of cardiovascular medications that included a beta-blocker.

Rapid Assessment of Physical Activity (RAPA)

The RAPA assessment tool was used to determine the subject's baseline level of physical activity. Twelve percent of the sample reported that they performed some moderate physical activity every week, but for a time of less than 30 minutes a day and for a frequency of less than 5 days a week (n=4), corresponding to a RAPA score of 4. Seventy nine percent of subjects reported that they

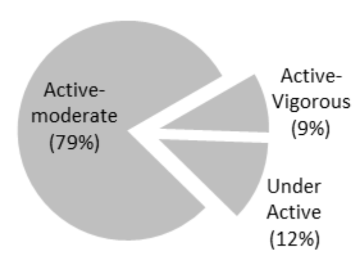


Figure 4.1. Rapid Assessment of Physical Activity. The subject's physical activity score by RAPA group total score expressed as a percentage for each group category.

regularly performed moderate physical activity for more than 30 minutes daily for at least 5 days a week or more (active with moderate physical activity) (n=27); this elicited a RAPA score of 6. Nine percent of subjects self-reported that they performed 20 minutes or more of vigorous physical activity for 3 or more days a week (active with vigorous physical activity) (n=3), which corresponded to a RAPA score of 7, **Figure 4.1**. Thus the RAPA assessment suggests that the majority (88%) of subjects in this study regularly performed moderate or vigorous physical activity as denoted by a score of 6. Refer to **Appendix M** for descriptions and examples of the RAPA's physical activity intensity levels.

Specific Aim 1

Specific Aim 1. To quantify changes in cardiovascular responses and perception of exertion from baseline to recovery with a 15 minute EG session in older adults.

Cardiovascular Responses To EG (Nintendo Wii Tennis): With-In Group Comparisons Over Time

Data are summarized on the F-table below (**Table 4.2)**. The ANOVA's showed significant differences for all six of the measured cardiovascular variables. Within group pair-wise comparisons were performed between resting and activity states, and between resting state and post exercise recovery.

Table 4.2
ANOVA Table Summary of Group Cardiovascular Variables over 8 Time Points

	SS	df (error)	MS	F	p-value
Heart Rate	10139	4(124)	2704	29	<0.0001*
Systolic Blood Pressure	13604	3(106)	4248	14	<0.0001*
Diastolic Blood Pressure	3547	4(119)	983	10	<0.0001*
Mean Blood Pressure	5448	4(137)	1313	18	<0.0001*
Rate Pressure Product	566081716	3(98)	190782958	36	<0.0001*
Perceived Exertion	1215	3(89)	450	94	<0.0001*

ANOVA=Analysis of Variance; CV=Cardiovascular Variables; SS=Sum of Squares; df=Degrees of Freedom; MS=Mean Square; F=F statistic; *= significant difference between resting baseline over time at the 0.05 level

The time point of resting for 10 minutes was used to represent baseline. Exercise values at 5, 10, and 15 minutes; and during post exercise recovery at 5 and 10 minutes were also assessed. The group cardiovascular variables were plotted over the eight time points, **Figure 4.2**. The findings observed during the within group pair-wise comparisons for the cardiovascular variables are located in **Appendix N**.

For average group heart rate, there were no significant differences between 5 and 10 minutes resting during sitting (p = NS), nor between 10 minutes of sitting and standing (p = NS). The mean heart rates during exercise at 5, 10, and 15 minutes were significantly increased relative to baseline (p=<0.0001) and returned to pre-exercise levels at 5 and 10 minutes of post exercise recovery (p = NS). See **Figure 4.2(A)** and **Appendix N**.

For systolic blood pressure, there were no significant changes between 5 and 10 minutes resting during sitting (p = NS), nor between 10 minutes of rest and standing (p = NS). Systolic blood pressure was significantly elevated at 5, 10, and 15 minutes (p=<0.0001, p=<0.0001, p=0.014, respectively) relative to baseline and returned to resting baseline levels at 5 and 10 minutes of post exercise recovery (p=NS). See **Figure 4.2(B)** and **Appendix N**.

During the within group comparisons for diastolic blood pressure, there were no significant differences between the two resting time points at 5 and 10 minutes (p = NS), nor between resting at 10 minutes and standing (p=0.484). Diastolic pressure increased significantly during Wii tennis play at 5, 10, and 15 minutes compared to baseline (p=0.002, p<0.0001, p=0.010, respectively) and returned to baseline levels at 5 and 10 minutes of post exercise recovery (p = NS). See **Figure 4.2(C)** and **Appendix N**.

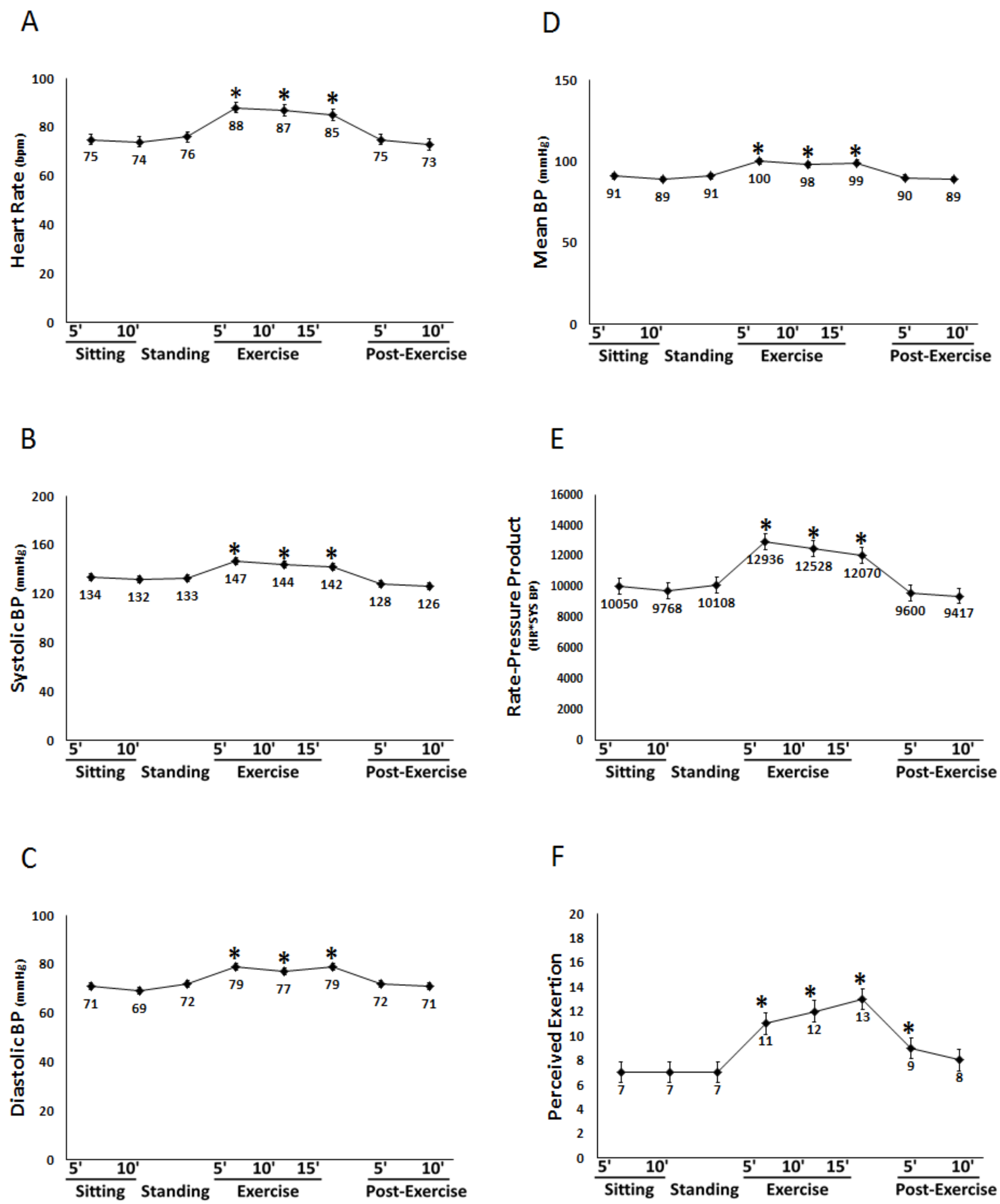


Figure 4.2: Levels of heart rate (A), systolic blood pressure (B), diastolic blood pressure (C), mean blood pressure (D), rate-pressure product (E) and perceived exertion (F). Significance is noted by *p≤0.05 for intragroup comparisons. All data expressed as mean ± standard error of the mean (SEM).

For mean blood pressure, there were no significant differences between the two resting time points during sitting at 5 and 10 minutes (p = NS), nor between resting at 10 minutes and standing (p = NS). Relative to baseline, mean blood pressure increased significantly with exercise ($p<0.0001$, $p<0.0001$, $p=0.002$, respectively) and then returned to pre exercise baseline values at 5 and 10 minutes of post exercise recovery (p = NS). See **Figure 4.2(D)** and **Appendix N**.

During the within group comparisons for rate pressure product, there were no significant differences between 5 and 10 minutes of sitting rest nor between resting at 10 minutes and standing (p = NS). The mean rate pressure product was significantly elevated at all exercise intervals ($p<0.0001$) and returned to pre exercise baseline levels at 5 and 10 minutes of post exercise recovery (p = NS). See **Figure 4.2(E)** and **Appendix N**.

For the within group comparisons for perceived exertion, there were no significant changes between perceived exertion between 5 and 10 minutes resting during sitting nor between baseline and standing ($p=0.482$). Perceived exertion increased during exercise at 5, 10, and 15 minutes relative to baseline ($p<0.0001$) and remained significantly elevated at 5 minutes post exercise recovery, but decreasing when compared to perceived exertion during exercise. By 10 minutes of post exercise recovery, perceived exertion was similar to baseline ($p=0.466$). See **Figure 4.2(F)** and **Appendix N**.

The CV variables for the within group comparisons followed similar patterns by increasing significantly from resting values during exercise (Wii tennis play for 15 minutes) and then returning to resting values within 10 minutes post-exercise recovery time. All 34 subjects completed 15 minute of Wii tennis play without experiencing fatigue or injury.

Between Group Comparisons Over Time by Gender

ANOVA with repeated measures for each of the six cardiovascular variables exploring for between subject variations over time by gender were also performed. The gender comparisons included 24 females and 10 males. None of the ANOVAs were significant for any of the six measured cardiovascular variables, indicating no gender differences in the Wii response, **Table 4.3**.

Table 4.3

ANOVA Table Summary of Cardiovascular Variables over 8 Time Points Exploring Men Versus Women Differences

	SS	df(error)	MS	F	p-value
Heart Rate	249	4(121)	66	0.704	0.583
Systolic Blood Pressure	268	3(102)	84	0.265	0.861
Diastolic Blood Pressure	189	4(116)	52	0.504	0.716
Mean Blood Pressure	142	4(133)	34	0.452	0.778
Rate Pressure Product	15454467	3(96)	5126197	0.993	0.400
Perceived Exertion	10	3(86)	4	0.780	0.495

ANOVA=Analysis of Variance; CV=Cardiovascular Variables; SS=Sum of Squares; df=Degrees of Freedom; MS=Mean Square; F=F statistic

The group cardiovascular variables between genders were plotted over the eight time points, **Figure 4.3**.

Between Group Comparisons Over Time by Cardiovascular Medication

The cardiovascular responses of subjects were compared between those not taking cardiovascular medications (N=17) and those subjects taking any combination of cardiovascular medications (N=17), **Table 4.4**.

A repeated measures ANOVA for the six cardiovascular variables exploring for whether there were between group differences for subjects not taking cardiovascular medications vs. those subjects taking any combination of cardiovascular medications demonstrated no significant differences across all six cardiovascular variables. The group cardiovascular variables between subjects taking no cardiovascular medication compared to subjects taking any combination of cardiovascular medication were plotted over the eight time points, **Figure 4.4**.

The comparisons of those subjects taking no CV medication compared to those subjects taking any CV medication resulted in no statistically significant differences between these two group over time.

Between Group Comparisons Over Time by Beta-Blocker Medication Use

The mean cardiovascular responses of subjects taking no cardiovascular medications (N=17) versus those subjects taking any beta-blocker (N=8) was also explored, **Table 4.5**.

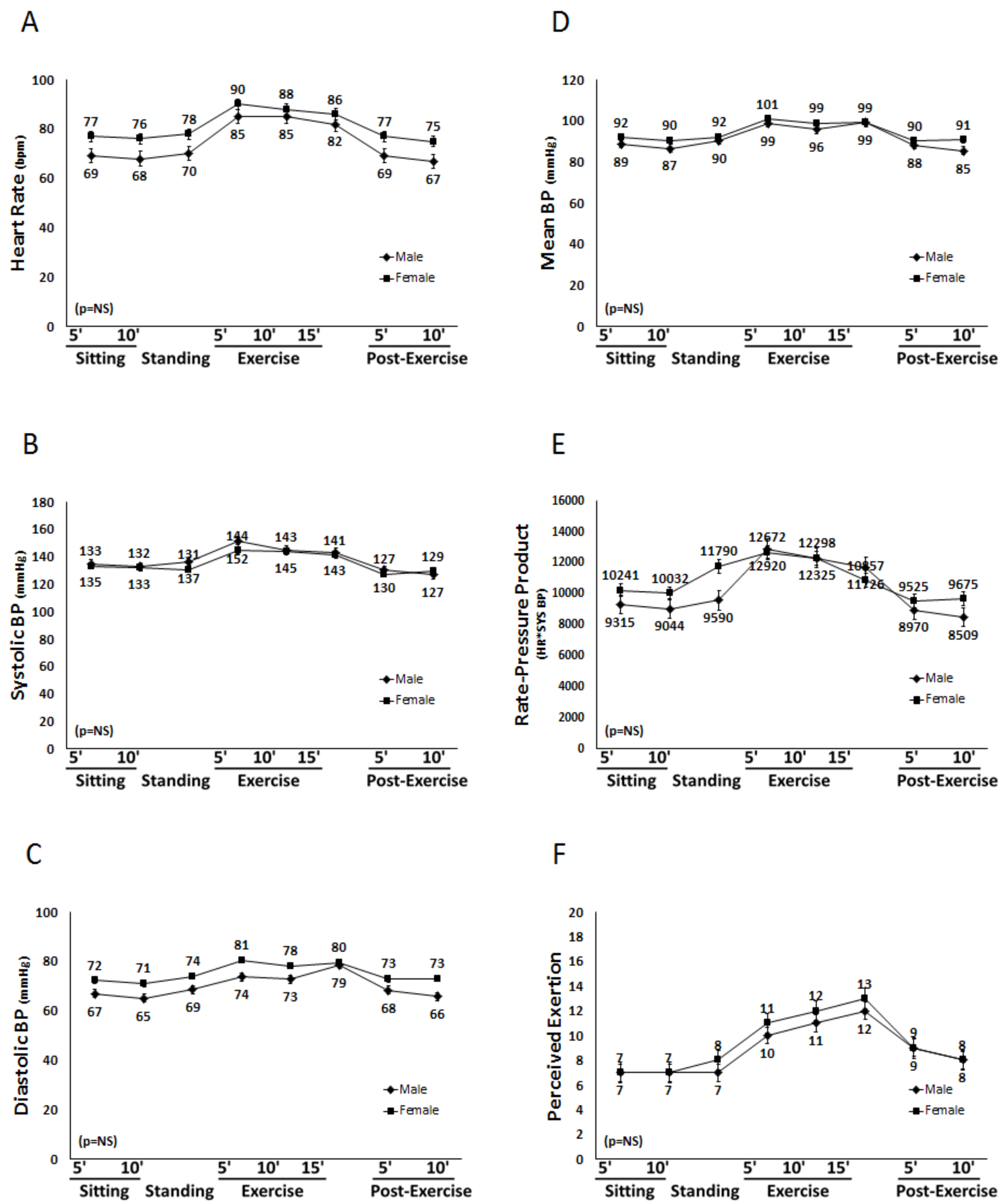


Figure 4.3. Levels of heart rate (A), systolic blood pressure (B), diastolic blood pressure (C), mean blood pressure (D), rate-pressure product (E) and perceived exertion (F). All data expressed as mean ± standard error of the mean (SEM). (p=NS) between gender groups (Males compared to Females).

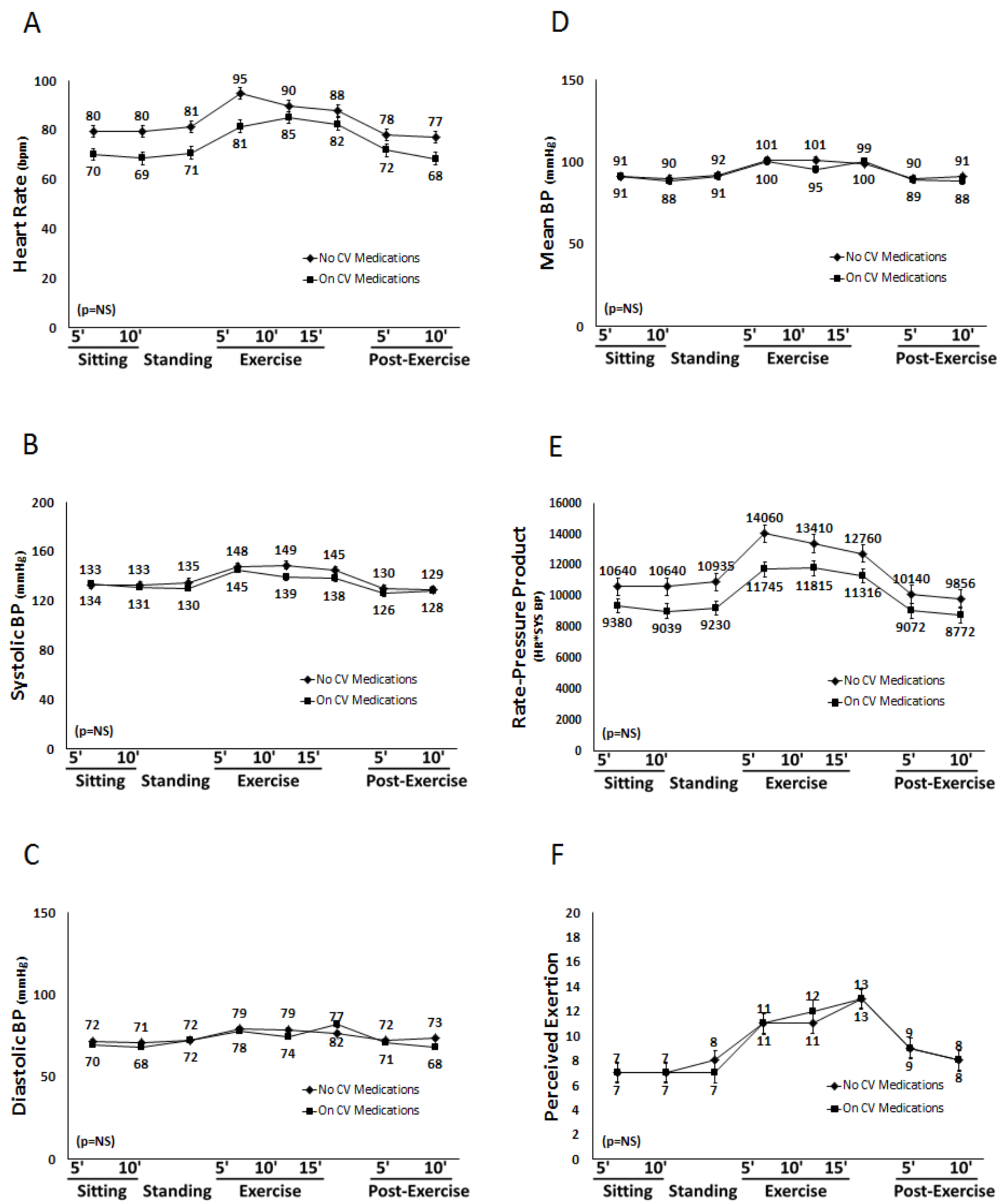


Figure 4.4. Levels of heart rate (A), systolic blood pressure (B), diastolic blood pressure (C), mean blood pressure (D), rate-pressure product (E) and perceived exertion (F). All data expressed as mean ± standard error of the mean (SEM). (p=NS) between medication groups.

Table 4.4					
ANOVA Table Summary of Cardiovascular Medications Compared To No Cardiovascular Medications by Cardiovascular Variables over 8 Time Points					
	SS	df(error)	MS	F	p-value
Heart Rate	555	4(122)	146	1.611	0.179
Systolic Blood Pressure	1186	3(104)	364	1.209	0.311
Diastolic Blood Pressure	559	4(116)	154	1.537	0.201
Mean Blood Pressure	215	4(131)	53	0.690	0.603
Rate Pressure Product	13891301	3(96)	4648610	0.890	0.449
Perceived Exertion	3	3(86)	1	0.228	0.855
ANOVA=Analysis of Variance; CV=Cardiovascular Variables; SS=Sum of Squares; df=Degrees of Freedom; MS=Mean Square; F=F statistic; *= The mean difference is significant at the 0.05 level					

Table 4.5					
ANOVA Table Summary of No Cardiovascular Medications Compared To Beta-Blockers by Cardiovascular Variables over 8 Time Points					
	SS	df(error)	MS	F	p-value
Heart Rate	9781	1(23)	9781	6.432	0.018*
Systolic Blood Pressure	2390	1(23)	2390	0.676	0.419
Diastolic Blood Pressure	23	1(23)	23	0.051	0.824
Mean Blood Pressure	420	1(23)	420	0.496	0.488
Rate Pressure Product	260777215	1(23)	260777215	7.014	0.014*
Perceived Exertion	20	1(23)	20	1.129	0.299
ANOVA=Analysis of Variance; CV=Cardiovascular Variables; SS=Sum of Squares; df=Degrees of Freedom; MS=Mean Square; F=F statistic; *= The mean difference is significant at the 0.05 level					

A repeated measures ANOVA for the six cardiovascular variables exploring for within subject variations over time by beta-blocker cardiovascular medication was completed. As summarized on the F-table above, the ANOVAs showed significant between group differences for heart rate and rate pressure product, **Table 4.5**. Unpaired t-Tests with equal variances not assumed, were performed comparing heart rate and rate pressure product, **Table 4.6**. The group cardiovascular variables between subjects taking no cardiovascular medications compared to subjects taking beta-blockers were plotted over the eight time points **Figure 4.5**.

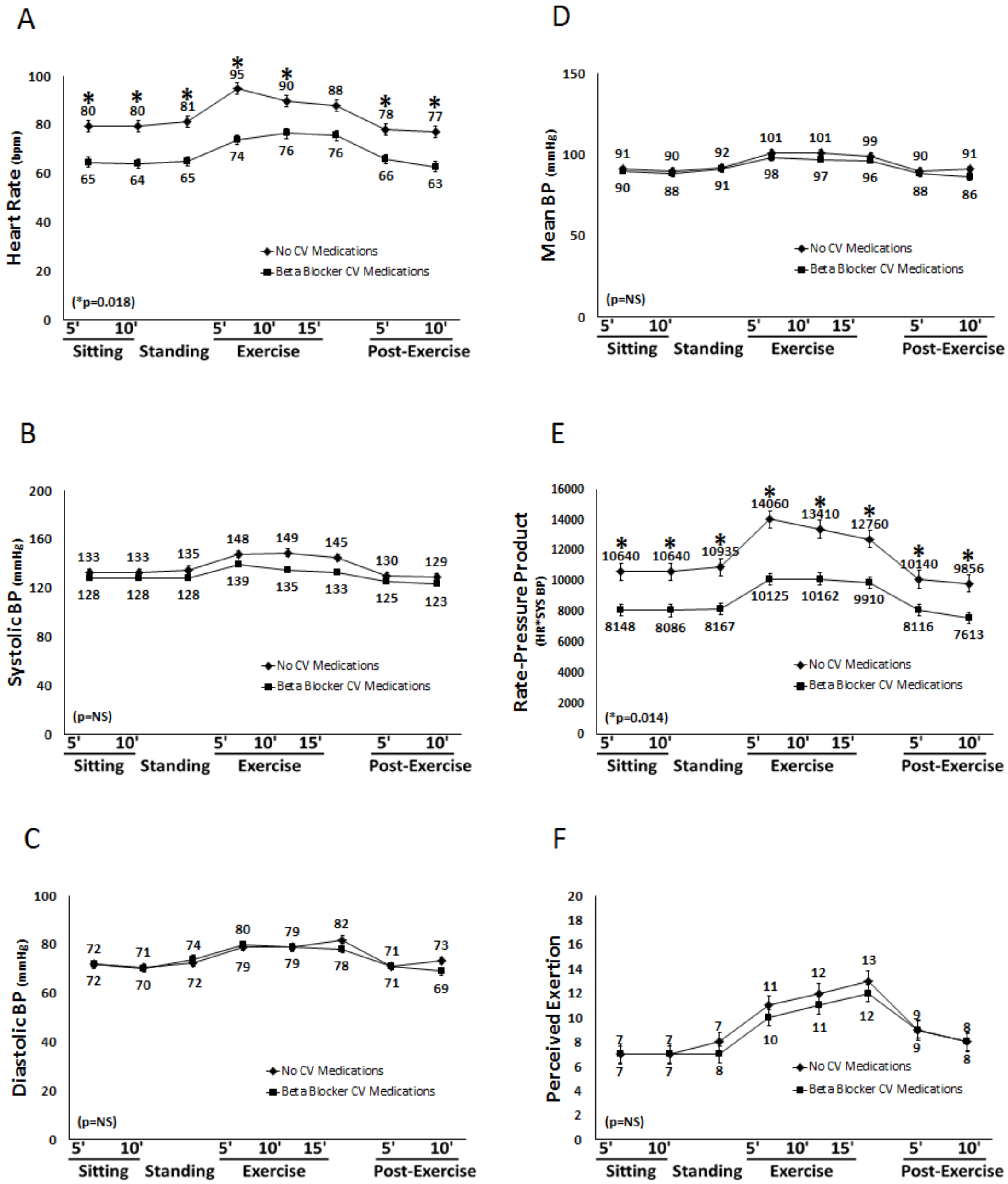


Figure 4.5. Levels of heart rate (A), systolic blood pressure (B), diastolic blood pressure (C), mean blood pressure (D), rate-pressure product (E) and perceived exertion (F). Significance is noted by *p≤0.05 for between group comparisons between subjects on No CV medications compared to subjects on beta-blockers. All data expressed as mean ± standard error of the mean (SEM).

Table 4.6
Between Group (No Cardiovascular Medications and Beta Blockers) Comparison t-test

	Heart Rate		**Systolic Blood Pressure**		**Rate Pressure Product**		**Perceived Exertion**	
	t(df)	P-value	t(df)	P-value	t(df)	P-value	t(df)	P-value
5 minutes Resting	2.4(23)	0.025*	0.6(23)	0.554	3.1(23)	0.006*	0.77(23)	0.452
10 minutes Resting	3.2(22.9)	0.004*	0.6(23)	0.557	3.9(23)	0.001*	1.2(23)	0.245
Standing	3.2(22.9)	0.004*	0.8(23)	0.458	4.1(22.4)	<0.0001*	1.6(23)	0.118
5 minutes Wii Tennis Play	2.9(23)	0.009*	1.0(23)	0.333	3.8(19.7)	0.001*	1.0(23)	0.322
10 minutes Wii Tennis Play	2.3(19.1)	0.031*	1.4(23)	0.184	3.3(22.3)	0.003*	0.7(23)	0.499
15 minutes Wii Tennis Play	1.6(23)	0.132	1.1(23)	0.268	2.2(23)	0.039*	0.7(23)	0.499
5 minutes recovery	2.2(23)	0.041*	0.6(23)	0.584	2.6(23)	0.017*	0.7(23)	0.483
10 minutes recovery	3.2(22.4)	0.004*	0.4(23)	0.973	2.8(23)	0.010*	0.2(23)	0.868

t=Student t-test; df=Degrees of Freedom; *= The mean difference is significant at the 0.05 level

The overall cardiovascular responses of subjects taking no cardiovascular medications compared to those subjects taking any beta-blocker resulted in the following findings. In these between groups comparisons, heart rates were significantly lower with beta blockade in seven out of the eight ANOVA results, except at 15 minutes of Wii tennis play (p=0.132). Rate pressure products were also significantly lower with beta blockade throughout the protocol as resulted by the ANOVA (p=0.014), despite similar systolic blood pressure and perceived exertions ANOVA results (p=0.419; p=0.299, respectively) (**Table 4.5**).

Specific Aim 1 Summary

The significant findings for aim 1 found that all 6 CV variables significantly increased from rest and returned to resting values after 10 minutes of post Nintendo Wii tennis recovery. No significant differences were found between genders and between those subjects taking no CV medications compared to those take any type of CV medications. A further sub-analysis comparing those subjects not taking any CV medications compared to those subjects taking a beta-blocker medication was performed. This analysis found that those subjects taking a beta-blocker had a lower heart rate and rate pressure product. No significant differences in the remaining CV variables (systolic, diastolic, and mean blood pressures as well as perceived exertion) were determined.

Specific Aim 2. **To quantify the enjoyment and the 48 hour after effects of one 15 minute session of EG in older adults**.

Enjoyment

Immediately post-exercise, subjects were asked to complete Physical Activity Enjoyment Scale (PACES) questions. Higher PACES scores represent greater enjoyment with the maximum PACES score being 35. This sample of subjects had an overall mean group PACES score of 29. The majority of subjects (n= 32, 94%) scored the Nintendo Wii tennis greater than the PACES median score of 20. Two subjects, however, scored Wii tennis as not enjoyable reporting PACES scores of 13 and 20, respectively. Moreover, a t-test determined that there were no significant differences for PACES enjoyment ratings between men and women (p=0.622), **Table 4.7**. Additionally, enjoyment was not significantly influenced in those subjects who were not on any cardiovascular medication compared to those on any combination of cardiovascular medications or beta-blockers (p=0.808, p=0.933, respectively) **Tables 4.8** and **4.9**.

Table 4.7

PACES Enjoyment Men compared to Women

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper
PACES	Equal variances assumed	.011	.916	.487	32	.630	1.025	2.106	-3.264	5.314

Table 4.8

PACES Enjoyment between Subjects taking No CV medications compared to Subjects taking CV Medications

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper
PACES	Equal variances assumed	.006	.939	-.245	32	.808	-.471	1.924	-4.390	3.449

Table 4.9										
PACES Enjoyment between subjects taking No CV medications compared to Subjects taking Beta-blockers										
Independent Samples Test										
	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F		Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
PACES	Equal variances assumed	.250	.622	.086	23	.933	.191	2.234	-4.430	4.813

No significant differences in the enjoyment of playing 15 minutes of Nintendo Wii tennis between men and women, based on PACES, was found. Additionally, no significant differences in the enjoyment of playing 15 minutes of Nintendo Wii tennis was established between subjects taking no CV medications and those subjects taking any CV medication or beta-blocker CV medication.

48 Hour Post Nintendo Wii Tennis Questionnaire Results

One hundred percent of 48 hour post Wii Tennis follow-up questionnaires were returned for analysis. The primary focus of this post-exercise survey was to ascertain if any untoward physical discomforts occurred by the subjects who played the Nintendo Wii Tennis for 15 minutes after a post recovery period of 48 hours. Additionally, six open ended subjective questions were posed, as well as a single “any other comments?” question to provide a qualitative description of the subject’s EG Wii tennis experience. All responses to all eight questions are presented in **Appendix O**.

Question #1: Are you experiencing any discomfort from playing the Nintendo Wii tennis?

The majority of subjects (91%) reported no discomfort (31/34). Three subjects reported discomfort or pain. Two female subjects reported dominate arm and shoulder discomfort of 2/10, and one female subject reported dominate shoulder and rib pain of 8/10 (based on a scale of 0-10 with 0 = not pain and 10 = greatest pain ever experienced) following their Nintendo EG Wii Tennis trial. In addition, after reviewing the BioHarness heart rate rhythm, two subjects were found to have an irregular atrial rhythm. Subjects that were found to have an irregular atrial rhythm were promptly contacted by the PI for follow-up and encouraged by the PI to meet with their primary care providers for medical evaluation. The three subjects that reported discomfort/pain stated that they symptoms resolved within an additional 24 to 48 hours, and they did not seek medical care.

The 48 hour post Nintendo Wii Tennis follow up survey also offered the subjects additional chances to response to 6 questions and 1 open ended question.

Questions #2 through #8

Questions 2 asked “Would you play Nintendo Wii tennis less or more than 15 minutes? Why?”. Twenty one subjects (62%) stated that they would play for more than 15 minutes while 10 subjects stated (29%) would play less than 15 minutes. Three subjects (9%) provided no response to this question

Question 3 asked if the subjects would use the Nintendo Wii Tennis as a part of a plan to keep physically active. Thirty eight percent of the subjects (13/34) stated that they would include the Wii Tennis as part of their plan to keep physically active. Fifty percent of subjects (17/34) reported that they would not use the Wii Tennis as part of their plan. Twelve percent of the subjects provided no response to this question (4/34).

Question 4 asked how frequently the subjects would use the Nintendo Wii Tennis, **Table 4.10**. Sixty five percent of the subjects (22/34) stated that they would use the Nintendo Wii Tennis either occasionally (50%), often (12%), or daily (3%). Two subjects reported that they would infrequently use the Nintendo Wii Tennis (6%), while 9 subjects (26%) stated that they would never use the Nintendo Wii Tennis again. One subject provided no response to this question (3%). These responses are summarized in **Table 4.10**.

Table 4.10	
Question #4: How often you think you will use the Nintendo Wii Tennis?	
Every Day	**n=1; 3%**
Often	**n=4; 12%**
Occasionally	**n=17; 50%**
Infrequently	**n=2; 6%**
Never	**n=9; 26%**
1 subject (3%) had no comments to this follow-up question.	

Question 5 asked the subjects if using the Nintendo Wii Tennis was easy or difficult to play. Forty seven percent (16/34) stated it was easy to use; 9% (3/34) remarked that it was difficult for them to play. Forty four percent of subjects (15/34) provided no response to this question.

Question 6 asked the subjects about what they liked the most during their exposure to Nintendo Wii Tennis. Question 7 asked the subjects what they did not like about Nintendo Wii Tennis play. There were 30/34 positive comments (88%) in response to what the subjects liked (question 6), and 23/34 negative comments (68%) in response to what the subjects did not like (question 7). Four subjects out of 34 (12%) had no response for questions 6, and 11 subjects had no response for question 7. See **table 4.11** below for summarized individual responses to question 6 and 7.

Table: 4.11 Nintendo Wii Play

Question #6: What did you like the most to Nintendo Wii Tennis, 30 Responses	**Question #7:What did you not like about Nintendo Wii Tennis , 23 Responses**
It was fun (6 comments)	**Nothing (10 comments)**
Challenging (6 comments)	**Frustrating (2 comments)**
The experience(3)	**I did not like it**
I could keep a volley going (2)	**No knowledge of the game**
Competition (2)	**The ball was too fast for me (2)**
Different	**Made me look bad**
The chance to improve	**My backhand needs work**
First time playing Wii tennis	**Not my game**
Nothing	**Scoring (2)**
A lot of movement in Wii tennis	**It was all good**
The activity for good fitness	**It was tiring**
Entertaining	
Privacy	
Remembering again the game of tennis	
It was pleasurable	

The final 48 hour post Wii Tennis follow-up was Question 8 asked subjects for any additional comments they would like to communicate to the PI about their experience playing the Nintendo Wii Tennis game. Fourteen of 34 subjects (41%) provided comments and 20 subjects did not respond to this final question. See **Table 4.12** for responses to question 8 below.

Table 4.12

Question #8: Additional Comments (N=14/34)

I enjoyed the game; challenging (2)	**Not interested in Wii tennis**
I like Wii Bowling (2)	**The chance to improve**
Fun, but I still enjoy bowling more	**Fun experience**
There are other more efficient ways of exercising and cheaper too	**I prefer Wii bowling and walking for exercise**
I liked playing the game because it was an activity, but I do not have one	**I would like to play Wii tennis as well as bowling**
I hope they organize a group to play Wii Tennis	**Different**
20 subjects did not respond to this question.	

Specific Aim 2 Summary

Wii tennis was reported as enjoyable for 94% of the subjects. Sixty five percent of the subjects stated that they would play Wii tennis more than occasionally. Thirty eight percent would use the Wii as part of their plan to keep physically active, and there were few minor untoward physical discomforts (9%). **Figure 4.6**.

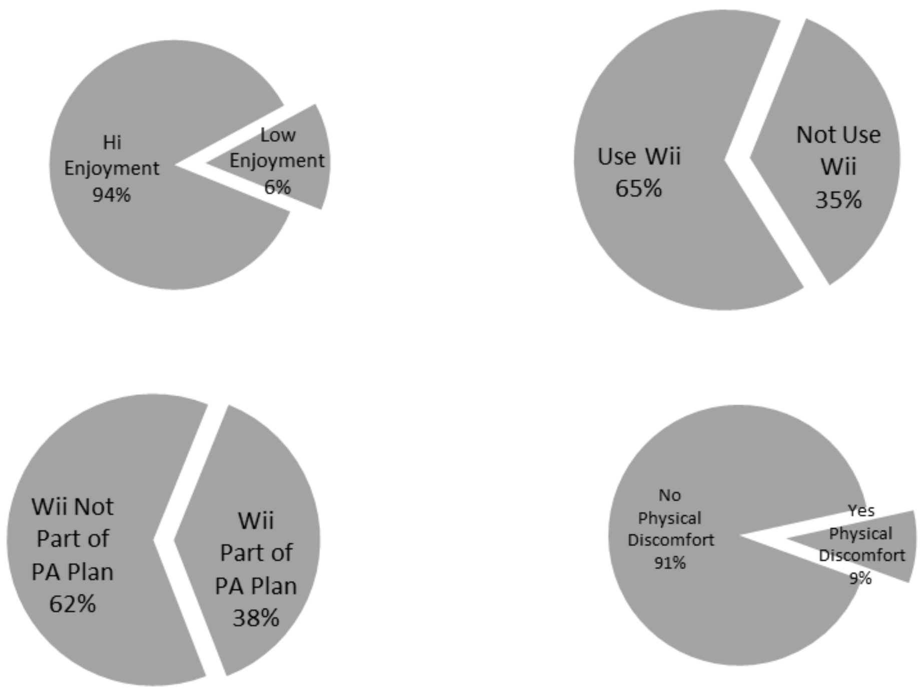


Figure 4.6. Summary: 48 hour Post-Exercise Nintendo Wii Questions: Enjoyment was high (86% rated this physical experience above the mean score of 29), 65% would use the Wii more than occasionally, 38% would use the Wii as part of their plan to keep physically active, and there were few minor complaints (9%) of post-exercise discomfort.

Specific Aim 1 and 2 Summary

In healthy older adults, 15 minutes of exercise gaming (Nintendo Wii Tennis), induces a moderate cardiovascular response. This can be accomplished in an overall enjoyable manner with few untoward physical discomforts which included 2 subjects with irregular atrial rhythms.

CHAPTER V

Discussion and Conclusion

Introduction

The purpose of this study was to quantify older adults' cardiovascular responses and perceptions of exertion in response to fifteen minutes of an exercise-gaming trial (Nintendo Wii Tennis). Additionally, this study sought to describe the enjoyment of the activity and to determine whether there were any untoward physical after effects following Wii tennis play. If any physical after-effects occurred (discomfort or pain after playing Wii tennis), the severity of the after-effects were quantified on a numeric scale. Lastly, the subject's qualitative responses from a series of questions were examined. A quasi-experimental design using repeated measures over time was utilized to describe the cardiovascular changes in a convenience sample of 34 older adults from an independent living retirement community in Southeastern Pennsylvania. This chapter summarizes the findings; how they relate to use of exercise-gaming as a means of physical activity in older adults; limitations; conclusions; and future directions.

Main Findings

Overall, 15 minutes of exercise gaming (Nintendo Wii Tennis) stimulated moderate increases (between 50% -70% of APMHR from resting values during Nintendo Wii tennis play) in heart rate, blood pressures (systolic, diastolic and mean) and rate pressure product in this study sample of healthy, older adults. The cardiovascular responses increase from rest during Nintendo Wii tennis play, and then returned pre-exercise resting values after 10 minutes, in an overall enjoyable manner with relatively few untoward physical discomforts or after-effects.

The findings in this small study suggest that using the Nintendo Wii tennis module is a practical mode of exercise for healthy older adults. Similar to the current study, Nintendo Wii tennis has been previously reported to represent a moderate level of exercise in adults, see **Table 5.1** below (Graves et al., 2010; Hurkmans et al., 2011; Miyachi et al., 2010). The rationale for selecting the Nintendo Wii tennis EG for this study was based on tennis demonstrating a moderate exertion level. Also, tennis is a standard game packaged with the Nintendo Wii gaming console, or it may be purchased at an additional cost based on manufacturing packaging and promotions.

Table 5.1: Previous studies having adults playing Nintendo Wii

	Nintendo Wii Game	Males	Females	Total	Age Mean ±(SD) or (range)
Graves, et al.	Wii Fit	3	7	13	57.6±6.7
Hurkmans, et al.	Wii Tennis	3	4	7	48(33-68) SD was not reported
Miyachi, et al.	Wii Tennis	7	5	12	34±6

SD = Standard Deviation

Heart Rate

Heart rate is commonly used as to estimate a target exercise intensity range by age (Karvonen & Vuorimaa, 1988), as it increases linearly with oxygen consumption during exercise (Wang et al., 2009). During this fifteen minute trial of exercise gaming using the Nintendo Wii Tennis, the mean group heart rate increased from a resting heart rate of 75 beats per minute (bpm) to a peak heart rate of 88 bpm during Wii tennis play. The age predicted heart rate was calculated using this peak heart rate during exercise and the group's mean age of 81 years using the formula (Age Predicted Maximal Heart Rate= 220-Age in years). This resulted in an age predicted maximum heart rate (APMHR) of 64% achieved in our sample. The CDC recommends that a heart rate between 50% and 70% of maximum age predicted maximum heart rate be reached and maintained for a duration of at least 10 minutes during an exercise episode at a moderate exertion level to provide overall health benefits (Centers for Disease Control and Prevention (CDC), 2011). Thus, based upon the HR achieved in this study, and reports from the literature, it appears that Wii tennis represents a moderate exercise challenge in healthy, older adults, and it may also be a useful exercise modality to meet the CDC's physical activity goals of 30 minutes of moderate physical activity daily.

By the five minute post-exercise recovery period, the group's heart rate returned to pre-exercise levels. Older physically active adults typically show prompt heart rate recovery rate in the absence of cardiovascular disease (Giallauria et al., 2006; MacMillan, Davis, Durham, & Matteson, 2006; Tiukinhoy, Beohar, & Hsie, 2003). A slow heart rate recovery (i.e., having the heart rate return to pre physical activity baseline longer than five minutes after a physical activity has stopped) has been noted as an independent predictor of mortality and an increased risk of cardiovascular disease (Cole, Blackstone, Pashkow, Snader, & Lauer, 1999).

Blood Pressures

All of the average group blood pressure responses (systolic, diastolic, and mean) increased from rest to a maximum value after the first five minutes during the EG period, and then returned to pre-exercise levels in the post-exercise after the experiment was terminated, see **Figures 4.2 B, C, and D**.

Systolic Blood Pressure

During the systolic contraction phase of the heart (the systolic phase), peak arterial blood pressure is produced. The increase in systolic blood pressure during exercise results from an augmentation in cardiac output that is driven by hormonal and neural feedback loops. During exercise these feedback loops cause the heart rate and force of the heart's contractions to meet the increased metabolic demands of skeletal muscle.

In this experiment, the systolic blood pressure increased to 147 mmHg after the first five minutes of Nintendo Wii tennis play compared to resting values and then leveled off (subsequent average systolic blood pressures decreased over the next two five minute intervals of play to 144 mmHg, then to 142mmHg), See **Figure 4.2, B**. After five minutes of seated rest, post-exercise systolic blood pressure decreased to an average of 128 mmHg. Systolic blood pressure generally returns to pre-exercise values within five minutes of terminating exercise (Amon, Richards, & Crawford, 1984). A delay in the return of the systolic blood pressure may be considered an abnormal response, and has been found to occur in patients with coronary artery disease (both myocardial ischemia and previous myocardial infarction) (A. J. Taylor & Beller, 1998). In addition, changes in an older adult's ability to regulate blood pressures based on positional changes may be the result of reduced baroreflex sensitivity, particularly in older adults with hypertension (James & Potter, 1999).

The rise of systolic blood pressure during exercise is a result of an increased heart rate, stroke volume, and thus cardiac output. The demand for oxygen by the organs as well as the need for metabolic waste removal throughout the body is increased during exercise. The parasympathetic nervous system is overridden by the sympathetic nervous system to act as the "fight or flight" mediator which speeds up most metabolic process (i.e., heart and respiratory rate) and slows down other systems that are not activated during stress (i.e., digestion). After the exercise is completed, the systolic blood pressure normally recovers to pre-exercise levels with a decrease in the heart rate and an attenuation of sympathetic nervous activation. Due to various individual levels of physical conditioning, peripheral vasodilatation, or vascular resistance, systolic blood pressure normally may fall below pre-exercise values and remain at that level for up to several hours before recovering to pre-exercise values (Laukkanen et al., 2004). Having an abnormal systolic blood pressure (lower than 90 mmHg) at rest, during physical activity, or its delayed return to pre-activity baseline is related to adverse events (National Heart, Lung, and Blood Institute, 2010). In the long term, having elevated systolic blood pressure could lead to kidney damage and arteriosclerosis among other diseases (Izzo & Shykoff, 2001).

It has also been noted that the magnitude of the systolic blood pressure decrease after exercise has been shown to vary greatly across studies. Aerobic-type physical activity can produce an acute blood pressure lowering effect in older adults, i.e., a relative hypotension. One study found that daily physical activity of moderate intensity for at least 10 minutes a day reduced systolic blood pressure by 4% mmHg (Kelley, Kelley, & Tran, 2001), as well as lowering the risk of developing cardiovascular diseases (Centers for Disease Control and Prevention (CDC), 2011).

In the present study, overall average group systolic blood pressures were maintained within exercise testing values as set by the ACSM and showed typical responses, i.e., systolic blood pressure increased from rest, peaked during 15 minutes of Wii tennis play, and then promptly returned to resting values.

Diastolic Blood Pressure

In this experiment, the group's diastolic blood pressure increased from a mean resting value of 70 mmHg to a maximum of 79 mmHg during Wii tennis play and then returned to a post -exercise value of 71 mmHg, see **Figure 4.2 C**. The diastolic blood pressure responses from resting to maximum value during exercise were considered normal for an adult (below 90 mmHg in older adults) (Chobanian et al., 2003).

Diastolic blood pressure is an indication of the residual blood's pressure pressing against the arterial walls when the heart is at rest. Central and peripheral arteries undergo changes during aging resulting in the stiffening of the arteries which reduce their ability to properly dilate in response to stress (Karavidas et al, 2010.). Diastolic blood pressure changes resulting from the seated to the standing position before exercise may be explained by older adults having an altered cardiac or baroreceptor reflex response (Luukinen, Koski, Laippala, & Kivela, 1999; Montain, Jilka, Ehsani, & Hagberg, 1988). Regardless of exercise intensity or duration, there should be little or no change in diastolic blood pressure with exercise (Akhras, Upward, & Jackson, 1985; Rowell, 1974). Changes in diastolic blood pressure greater than 15 mmHg are considered an abnormal response to exercise, and it is suggested that the exercise should be terminated before this occurs (Akhras et al., 1985). Elevated diastolic blood pressure, i.e., greater than 90mmHg, can develop with increasing age as the arteries and heart muscle walls become stiffer. Although some loss of arterial compliance is considered a normal part of the aging process, abnormal stiffness of the heart wall and arteries can lead to increased risk for heart failure and stroke (Chobanian et al., 2003).

In this group of self-reported healthy older adults, overall group diastolic blood pressure was maintained within exercise testing values as set by the ACSM (American College of Sports Medicine, 2010). Their diastolic blood pressure did vary between the time points from rest, increased during 15 minutes of Wii tennis play, and then returned to resting values (maximum variation was 10 mmHg). The variation in the diastolic blood pressure might be attributed to vascular changes that occur during the aging process.

Mean Blood Pressure

The mean blood pressure represents the average arterial pressure throughout the entire cardiac cycle. It is the mean force that drives blood through the vasculature system within the body. With increased age, arteriosclerosis may affect mean blood pressure. As blood vessel walls stiffen, mean blood pressure alterations reflect reduced elasticity and compliance (Izzo & Shykoff, 2001). In this study, mean blood pressure was calculated (using the formula 1/3 systolic blood pressure + 2/3 diastolic blood pressure) for each time point. Mean blood pressure represents the combined average pressures exerted on the arterial wall as a proportion of the time the systolic and diastolic phases of the cardiac cycle (Rowell, 1974). Since mean blood pressure is a calculation of portions of systolic and diastolic blood pressures, ACSM has produced blood pressure guidelines subjects should be screened against before any type of exercise testing. ACSM's recommended pre-exercise testing screening values for systolic and diastolic blood pressures should be less than 180/110 mmHg (American College of Sports Medicine, 2010). However, there were limited recommendations of what the minimum or maximum blood pressures during exercise testing were prudent to follow (Sieira, Ricart, & Estrany, 2010). Suggested systolic and diastolic blood pressures to closely monitor during exercise testing and should be kept below 210/190 mmHg, or diastolic blood pressure below 105 mmHg or an increase greater than 10 mmHg at any time during testing, or a drop in systolic blood pressure greater than 20 mmHg below initial value, or an increase of less than 20 mmHg during the exercise testing (Sieira et al., 2010). All subjects that participated in the exercise testing during this experiment were screened and monitored to ensure that they maintained before, during and post-exercise blood pressure values.

In this experiment, the group's average mean blood pressures at rest were approximately 90 mmHg. After five minutes of exercise, the mean blood pressure increased to a maximum value of 100 mmHg and remained elevated compared to baseline mean for the next two five minute periods of exercise (98 mmHg and 99 mmHg respectively). The mean blood pressure then returned to the pre-exercise value of 90 mmHg after five minutes post-exercise and dipped one unit lower to 89 mmHg after 10 minutes post-exercise.

A relative post-exercise hypotension was shown by a significant decrease in systolic, diastolic and mean blood pressures following the 15 minutes of Nintendo Wii play. A similar hypotensive response following other exercise protocols has been reported (Kenney & Seals, 1993; Nickel, Acree, & Gardner, 2011; Taylor-Tolbert et al., 2000). These as well as other studies support that both acute and chronic exercise of moderate intensity for 15-30 minutes daily may prove beneficial in reducing blood pressures by 5% mmHg of their diastolic blood pressure (Kelley et al., 2001).

In this group of self-reported healthy older adults, overall group mean blood pressure increased from rest, peaked during 15 minutes of Wii tennis play, and then returned to pre-exercise resting values without any apparent difficulties.

Rate Pressure Product

Rate pressure product is the value determined by multiplying heart rate by the systolic blood pressure. This “product” is an indirect surrogate marker well correlated to myocardial oxygen demand (Gobel et al., 1978). Exercise testing guidelines by the American Heart Association (AHA) provides guidance on the range of RRP in healthy males ages 25 to 54 years. During AHA submaximal and maximal treadmill testing, the RPP varied from the lowest 10^{th} percentile of 25,000 to the 90^{th} percentile value of 40,000. On average, the subjects in this study achieved an increased rate pressure product after five minutes of Wii tennis play of 13016 or 24% above baseline RPP. Although heart rate and systolic blood pressure slightly decreased during the remaining 10 minutes of Wii tennis play, in the last five minute period of Wii tennis play, the rate pressure product increase from baseline levels by 18%.

This finding supports that using EG Nintendo Wii tennis is useful in raising the heart rate and blood pressure of healthy older adults in a controlled manner. Also, EG Nintendo Wii tennis meets the appropriate age considerations of staying below 85% of age predicted maximum heart rate in healthy, older adults.

Perceived Exertion

The subjective rating of the intensity of exertion perceived by the person exercising is generally accepted as an indicator of overall fatigue (i.e., a decreased response to perform work at a sustained intensity by the cardiorespiratory, muscular, as well as central nervous systems) (Fletcher et al., 1995). One recognized method of rating exertion intensity is by using the Borg rating of perceived exertion (RPE). The Borg RPE scale begins at a resting level of 6 and increased to a maximum of 20. Commonly, as one's heart rate increases their perceived exertion of the workload intensity will also increase (as well as increases in their respirations, body temperature, and feelings of muscle fatigue). This scale is a recommended method to assess exercise intensity among those who take medications that affect their natural heart rate response during exercise (Borg, 1998). Using RPE intensities (on a scale of 6-20) in conjunction with target heart rates is useful in understanding the heart rate and exertion responses during exercise in those taking cardiovascular medications that controls their heart rate during aerobic exercise. Myocardial oxygenation during moderate intensity exercise has been reported to differ by 5-15% in those taking cardiovascular medications that affects heart rate compared to those not taking these medications. In addition, fatigue or breathlessness may occur at lower calculated target heart rates based on age in those who take cardiovascular medications that affects their resting heart rate and reduce their maximum heart rate during exertion (American College of Sports Medicine, 1998). Therefore, individuals on medications that suppress their heart rate should base their target exercise intensities (i.e., pushing yourself to a "moderate" level) base on their perceived exertion levels (Borg RPE scale of 12-14) as well as their heart rate (i.e., attaining 50% to 70% of their age predicted maximum heart rates as a "moderate" intensity level) to prevent overexertion or injury.

During this experiment, mean perceived exertion was statistically different when the subjects changed from 10 minutes of sitting to exercise. PE peaked at the end of 15 minutes of EG tennis and returned to nearly pre-exercise levels after 10 minute post-exercise recovery, Although PE is a subjective measure, as a group, the mean peak perceived exertion did not exceed a level of 13 (on a scale of 6-20) representing a “Somewhat Hard” rating on Borg’s RPE scale. This exertion intensity scale has been used as a surrogate for heart rate estimation during physical activity (Borg, 1998), but its approximation of the subject’s actual heart rate during a physical activity can vary based on the subject’s age and baseline physical conditioning (Fletcher et al., 1995). Perceived exertion ratings may change as maximum heart rates decrease due to aging. Therefore, the correlation between perceived exertion levels and heart rates may become less linear as individuals age (Aminoff, Smolander, Korhonen, & Louhevaara, 1996). Perceived exertion is also a valuable marker of exercise intensity in patients on cardiovascular medications (i.e., beta blockers) that alter heart rate and blood pressure responses to exercise to provide the individual with a numeric intensity to reach or maintain during exercise (Hansen, Stevens, Eijnde, & Dendale, 2012).

During this experiment, there were no significant differences of perceived exertion after 15 minutes of Nintendo Wii tennis play expressed by those subjects who were not taking any cardiovascular medications, those taking one or more cardiovascular medications or those who were taking beta-blockers ($p=0.998$, $p=0.524$ respectively). This might be explained because the group’s maximum age predicted heart rate did not reach 85% of maximum level to produce a perceived exertion consistent with a perceived exertion rating of 13 “Somewhat Hard” as reported in a previous study with younger subjects (49.3 ±11.9 years) (Pinkstaff, Peberdy, Kontos, Finucane, & Arena, 2010). Thus, in this group of self-reported healthy older adults, overall group perceived exertion increased from rest, peaked during 15 minutes of Wii tennis play, and then returned to slightly higher resting values without any apparent difficulties. It is postulated that if the subject’s perceived exertion was monitored for a longer post-exercise time interval (i.e., more than 10 minutes and up to 1 hour), their perceived exertion level would have numerically returned to their resting value.

Gender

Women have smaller lung volumes and pulmonary capillary volumes than men (Harik-Khan, Wise, & Fleg, 2001), as well as lower hemoglobin concentrations, hematocrits and total blood volume (Cureton et al., 1986). Women also have a smaller heart mass, which is related to lower filling volumes, lower stroke volumes and decreased cardiac output (Astrand, 1960). These physiological differences potentially affect the transport of oxygen to skeletal muscle during exercise, and often result in higher heart rates during exercise relative to men (Mier, Domenick, Turner, & Wilmore, 1996). However, gender differences become less significant when cardiovascular parameters (heart rate and oxygen uptake) are expressed relative to lean body mass (Uth, 2005). In addition, exercise studies suggest that there appears to be little to no differences between genders (within the same age group) for similar performed workloads or exertion levels

(American College of Sports Medicine, 1998; Green, Crews, Bosak, & Peveler, 2003; Hunter, Critchlow, & Enoka, 2004; Kohrt et al., 1991; Wilmore, 1974).

In the current study, there were differences in the physical characteristics between men and women were noted; men were heavier ($p=0.016$) and taller ($p<0.0001$) relative to women. The BMI between genders was not significantly different. The workload or intensity of the Nintendo Wii tennis (as measured by heart rate and perceived exertion) remained relatively constant among the gender groups and the maximum reported perceived exertion between the gender groups was not statistically different at rest, during exercise or during post-exercise resting values. In this study sample of healthy older adults playing the Nintendo Wii tennis for 15 minutes, no significant perceived exertion differences between men and women subjects with the same average BMI was observed.

Cardiovascular Medication

Most medications prescribed for the treatment of various cardiovascular diseases either have a direct or indirect effect on the heart or the peripheral vasculature. Cardiovascular medications typically alter exercise capacity by blunting heart rate and blood pressure shifts during exercise (Wenger, 1983; Wenger, 1985). In general, the cardiovascular response to exercise causes an increase in the cardiac output and myocardial oxygen consumption with more blood flow to the active skeletal muscles and skin in order to dissipate body heat (Fortney & Vroman, 1985; Gleeson, 1998). The rating of perceived exertion during a physical activity provides an additional measure of the subject's perception of the difficulty or intensity of the activity. Perceived exertion combines both the subjective intensity perceptions of heart rate and blood pressures in those who take cardiovascular medication during exercise to provide a personal intensity level to train to instead of using a target heart rate based on age (Dunbar, Glickman-Weiss, Edwards, Conley, & Quiroz, 1996; Squires, 2011). Overall, older adults who have blood pressure controlled on anti-hypertensive therapies (i.e., diuretics, ACE, ARB, CCB or BB) were shown to tolerate exercise without excessive fatigue or lack of endurance compared to normotensive older adults (de Vries et al., 1995; Dunselman, 2001; Finimundi, Caramori, & Parker, 2007; Hasija, Karloopia, Shahi, & Chauhan, 1998; Parthasarathy et al., 2009; Poelzl et al., 2006; Riegger, 1991).

In this study, there were no group differences in heart rate, blood pressures or perceived exertion between subjects taking various combinations of cardiovascular medications compared to those who were not prescribed any cardiovascular medications. Also, no symptoms of overexertion (i.e., complaints of shortness of breath or statements of fatigue) during the physical activity time intervals occurred.

Cardiovascular Medication: beta-blockers

Further sub-analysis showed that those subjects that took beta-blockers did have significantly reduced mean heart rate and rate pressure product at rest, as well as during and following exercise compared to those subjects that were not taking any cardiovascular medications. Beta-blockers suppress the heart rate and blood pressures during exercise (Peel & Mossberg, 1995). The effect of beta-blockers in this sample of older adults resulted in a significantly lower heart rate and rate-pressure product relative to those subjects who were not prescribed beta-blockers. Also, use of beta-blockers did not produce statistical differences in systolic, diastolic, mean blood pressures, or perceived exertion values during the 15 minute trial of EG between those subjects who were prescribe beta-blockers compared to those subject not on any cardiovascular medications. Also, it is unclear which subjects were taking selective versus non-selective beta-blockers as their effects on submaximal exercise capacity and physiological responses has been reported to be different (Eston & Connolly, 1996; Peel & Mossberg, 1995). Contrary to the literature, it might be expected that subjects with lower resting heart rates caused by beta-blockers would report greater perceived exertion at lower workload intensities (Tesch, 1985), and have an increased perceived exertion with a lower magnitude of heart rate increase over time (Westhoff et al., 2007). The phenomenon of beta blocker medications inducing increased perceived exertion in this sample of older adults was not observed in this study.

Enjoyment

Immediately post-exercise, subjects were asked to complete Physical Activity Enjoyment Scale (PACES) questions. Higher PACES scores represented greater enjoyment with the maximum PACES score being 35. Subjects in this study had an overall mean group PACES score of 29. The percentage enjoyment score of 83% is consistent with a similar study involving older adults using Nintendo Wii Fit exercises (Graves et al., 2010). There were no significant differences for the enjoyment ratings between men and women. Additionally, enjoyment was not significantly influenced in by those subjects who were on cardiovascular medications. Many factors can affect the enjoyment of physical activity including being overweight, having a sedentary life style, fearing pain or having exercise induced symptoms (Buttery & Martin, 2009; Sallinen et al., 2009). These additional factors were not assessed in the current study.

Muscle Soreness and Arrhythmias

After 48 hours the subjects were asked to complete a follow up questionnaire to notify the PI if any subject experienced any untoward discomfort. All questionnaires (34 responses) were returned for analysis. Of the 34 subjects, three subjects reported that they experienced some level of discomfort or pain resulting from their EG play. Two reported pain score of 2 on a 10 point pain scale (0 = no pain; 10 = extreme pain) in their dominate arm or shoulder. The third subject reported back and rib pain that was scored at 8 out of 10 on the 10 point pain scale. Also, two subjects were suspected of having atrial fibrillation during exercise. Within the United States, the incidence of atrial fibrillation (AF) in older adults is common, and has been reported to be around 0.1% in adults aged 55 years and younger, and increases to 9.0% in those aged 80 years and older (Go et al., 2001). In this sample of older adults, approximately 6% of the sample was found to have AF, and is consistent with the expected rate of AF in older adults in the general U.S. population.

All subjects that complained of pain or were suspected of having arrhythmias were contacted by the PI. The two subjects with suspected arrhythmias were encouraged to discuss this with their primary healthcare provider as soon as possible. None of the subject's complaints for pain required any medical intervention as they all stated that they achieved complete relief after an additional 24-48 hours. Muscle soreness from atypical physical activity starts within the first 24 hours after the event and peaks in intensity after 48 hours (Rahnama, Rahmani-Nia, & Ebrahim, 2005). This muscle soreness may be caused by different or unusual movements that require different use of muscle groups than accustomed to during usual daily routines. Muscle soreness may be associated with warmth, swelling, tenderness and even overt pain. These symptoms generally resolve during the post exercise recovery period (Nosaka, 2008). In EG, the small incidence of pain or discomfort from overuse injuries in older adults has been reported to be fairly low and can be minimized by limiting play to 10-20 minutes per event (Mouawad, Doust, Max, & McNulty, 2011).

In general, this study found that Nintendo Wii tennis, an example of an EG, is not without the potential for the occurrence of muscle soreness in sample of self-reported healthy older adults when played for 15 minutes. The soreness was temporary and no subject sought emergency or immediate medical treatments. Moreover, there were arrhythmias observed in our sample at rates in accord with the general population.

Subjective Assessment of the Wii Experience

Many of the subjects reported that they would play the EG longer than the tested 15 minutes. A few of the comments stated that this episode of EG was "fun". Other positive comments were "I liked it" and "I enjoyed it". The literature suggests that older adults who find enjoyment in physical activities will perform them longer (Ginis et al., 2006; Paxton, Browing, & O'Connell, 1997).

These remarks suggest that older adults are amendable to playing Wii tennis for at least 15 minutes or longer. When asked whether the Nintendo Wii Tennis could be used as part their physical activity plan to stay healthy, one third of the subjects stated that they would include it into their overall routine because they enjoyed it or found it fun. Based upon responses collected in this small sample, it is reasonable to suggest that older adults would use EG to overcome barriers to physical activity such as lack of time, weather conditions, transportation or monetary costs associated with other types of physical activities (Salmon, Owen, Crawford, Bauman, & Sallis, 2003).

Although very few subjects stated that they would play Wii tennis "daily", the majority stated that they would prefer to play other Wii games such as bowling. Conversely, 25% of the subjects stated that they would "never" play Nintendo Wii in the future. The frequency of playing a particular EG game may be dependent on how much physical activity or exertion is required as well as the level of enjoyment. It has been noted that children who played high exertion video games have found them less enjoyable compared to lower exertion video games and therefore played them less frequently (Lyons et al., 2011). In this study, it was difficult to determine the future frequency of Nintendo Wii EG play from a single observation.

All subjects were able to play the Nintendo Wii Tennis after minimal instructions and a brief demonstration by the PI. Although many of the subjects had previous exposure to the Wii hand controller through a social Wii bowling league, those without any Nintendo Wii gaming experience were not deterred from completing the 15 minutes of play. Thus, Nintendo Wii has an easily learned interface to introduce older adults to this type of technology. While some subjects expressed frustration early in the game in serving the tennis ball or returning the computer's tennis serves, this frustration diminished as tennis play progressed. Overall, exercise gaming is designed for ease of its use and fun, and was viewed as such by the current study sample. EG allows for older adults to physically participate in virtual games, such as tennis, that they may not be able to actually play in their real life. (Graves et al., 2007; Graves et al., 2010; Shubert, 2010; Wollersheim et al., 2010).

Limitations

Limitations of this study include a small sample size comprised of convenience sampling of the subjects that were socially connected with previous exposure to the Wii system and its general use (many of the subjects were already playing Nintendo Wii bowling, 78%). A level of bias may have affected the magnitude of the cardiovascular measures, perceived exertion as well as enjoyment, since many subjects were familiar with EG. Also, this study was a descriptive, single observation, of a single period of play and no formal scientific conclusions may be generated beyond the description of what occurred between gender and cardiovascular medication groups. This descriptive research does provide new data for informing future exercise intervention trials involving older adults and EG. The PACES questionnaire for enjoyment was developed for young adults, mainly girls, playing college sports, therefore it application to evaluate enjoyment after EG play may require further evaluations (Kendzierski & Decarlo, 1991). Although this has been used in quantifying enjoyment in other Nintendo Wii activities (Graves et al., 2010), the validity, specificity or reliability has not been robustly determined for its use in determining enjoyment in video games or in the older adult population. Although many subjects in this study self-reported themselves as being “healthy”, a more detailed medical assessment is necessary to aid in determining the cardiovascular benefits of this technology. Larger prospective longitudinal studies with more diverse subject sample are needed to confirm the findings that older adults are able to safely play EG for a period of 15 minutes without adverse events.

Conclusions and Future Direction

Overall, in healthy older adults, 15 minutes of exercise gaming (Nintendo Wii Tennis), stimulates moderate cardiovascular responses resulting in increased HR, BP’s, RPP, and PE. The APMHR was reached and maintained within the recommended moderate physical activity range of 50% to 75% for the 15 minutes of play in these older adults. This was accomplished in an overall enjoyable manner with few temporary untoward physical discomforts. This study has important clinical applications to inform primary health care providers on how to promote physical activity in their older adults patients with the use of this popular technology irrespective of gender or medications.

Although some older adults may shy away from new technology (Selwyn, Gorard, Furlong, & Madden, 2003), limited aversion to this technology was found among the older adults participating in this the study. This study was able to provide 15 minutes of low to moderate level physical activity equivalent to at least 3 METS during the play of Wii tennis (Miyachi et al., 2010). Also, the use of EG for 15 minutes daily can accomplish 50% of the 30 minute daily recommended requirement for moderate intensity physical activity among older adults as prescribed by the government and fitness organizations.

The knowledge gained from this study supports the use of technology developed for home video gaming for use in a new and innovative manner to safely increase older adult's physical activity. This EG technology has the ability to be tailored for use by individuals in their home or for group activities (i.e., at a senior center). There is evidence that the location of the exercise program (exercising at home for convenience and low cost compared to a professional "center" program that requires travel, scheduling and possible costs) can influence adherence to physical activity programs over time (Ashworth, Chad, Harrison, Reeder, & Marshall, 2005). Some evidence shows that people tend to continue exercising longer in their home environments, but some exercise regimes requiring professional supervision, instructions, and evaluations of progress (i.e., cardiac rehabilitation) are best conducted at a "center" outside the home.

This study also supports that moderate levels of physical activity in older adults while playing EG is also enjoyable among older adults, although older adults might like other EG games better than Nintendo Wii tennis. It has been reported that even low levels of daily physical activity can provide health benefits such as reducing mortality and increasing life expectancy by three years with a physical activity duration of 15 minutes at a low to moderate exertion level (2.5 METS or greater) (Wen et al., 2011).

EG supports the growing trend that older adults are aware of their need to maintain their health by being more physically active. Since older adults responded in this study that EG play were fun and enjoyable, this technology has the ability to increase daily physical activity compliance in older adults by minimizing some of the barriers such as boredom or lack of motivation. Older adults who choose to use EG as part of their physical activity plan will be able to attain a portion of the required daily amount of physical activity that provides some overall health benefits as well as protection from diseases associated with sedentary lifestyles (Blair, Kohl, Gordon, & Paffenbarger, 1992; DiPietro, 2001). Consequently, older adults can derive at least 50% of the daily dose of physical activity from 15 minutes of continuous play at a moderate level as recommended by the AHA and ACSM (Haskell et al., 2007).

EG has emerged as innovative and engaging ways for older adults to overcome traditional sedentary habits and increase their physical activity while promoting their overall health status. Healthcare providers should offer EG activities to older adults so that they can implement daily physical activities to promote health and independence. Findings from this study support the recommendation of using the Wii EG video game of tennis as a physical activity that offers a feasible alternative to traditional physical activities for older adults.

Using Wii EG game tennis can meet half of the ACSM and government guidelines for improving and maintaining cardio-respiratory health by performing 15 minutes of moderate level physical activity daily. Additionally, decreased physical activity contributes to a reduction in manifestation of sedentary diseases that can eventually result in loss of physical independence. Generally, these findings are clinically important to clinicians as well as for fitness instructors, physical therapists, and others who advise older adults to exercise more to promote their overall health.

APPENDICES

Appendix A

Older Adult Physical Activity or Exercise Guidelines

Agency	Recommendations	Date Published & Website
American College of Sport Medicine	Participate in moderately intense aerobic exercise 30 minutes a day, five days a week **Or** vigorously intense aerobic exercise 20 minutes a day, 3 days a week. Additionally, perform eight to 10 strength-training exercises of 10-15 repetitions of each twice to three times per week. If at risk of falling, perform balance exercises and have a physical activity plan with your healthcare provider.	2007 http://www.acsm.org/AM/Template.cfm?Section=Home_Page&TEMPLATE=CM/HTMLDisplay.cfm&CONTENTID=7764
American Heart Association	Same as American College of Sport Medicine	2007 http://circ.ahajournals.org/cgi/reprint/CIRCULATIONAHA.107.185649
Centers for Disease Control (CDC)	150 minutes of moderate-intensity aerobic activity every week and muscle-strengthening activities on 2 or more days a week that work all major muscle groups. **Or**, 75 minutes of vigorous-intensity aerobic activity every week **and** muscle-strengthening activities on 2 or more days a week that work all major muscle groups. **Or**, an equivalent mix of moderate- and vigorous-intensity aerobic activity **and** muscle-strengthening activities on 2 or more days a week that work all major muscle groups.	2010 http://www.cdc.gov/physicalactivity/everyone/guidelines/olderadults.html
U.S, Department of Health and Human Services	Same as the CDC	2008 http://www.health.gov/paguidelines/factsheetprof.aspx
Agency for Healthcare Research and Quality	Strive to achieve a moderate amount of activity at least 30 minutes daily on 5 or more days of the week and participate in strength training activities that improve and maintain muscular strength and endurance at least 2 days a week.	2002 http://www.ahrq.gov/ppip/activity.htm
American Academy of Family Physicians	Same as the CDC	2010 http://www.ncbi.nlm.nih.gov/pubmed/20052963
National Institute on Aging	At least 30 minutes of moderate-intensity endurance activity on most or all days of the week	2009 http://www.nia.nih.gov/HealthInformation/Publications/ExerciseGuide/04b_endurance.htm

Appendix B

Physical Activity Enjoyment Scale (PACES)

Physical Activity Enjoyment Scale (PACES)

Please rate how you feel at the moment about the physical activity you have been doing

1	2	3	4	5	6	7
I hate it						I enjoy it
1	2	3	4	5	6	7
I dislike it						I like it
1	2	3	4	5	6	7
It's no fun at all						It's a lot of fun
1	2	3	4	5	6	7
I feel bad physically while doing it						I feel good physically while doing it
1	2	3	4	5	6	7
I am very frustrated by it						I am not at all frustrated by it

Appendix C

48 hours post Wii Tennis follow-up questions

1. Are you experiencing any discomfort from playing the Nintendo Wii tennis?
    a. If yes: where was the discomfort?
    b. If you were feeling discomfort from the Wii game rate the level on a scale of 0-10 with 0 meaning no discomfort to 10 meaning extreme discomfort?

0 1 2 3 4 5 6 7 8 9 10

No Discomfort Moderate Extreme

2. Would you play Nintendo Wii tennis less or more than 15 minutes? Why?
3. Would you use the Nintendo Wii Tennis as a part of your overall plan to keep physically active? Why or why not?
4. Please rate how often you think you will use the Nintendo Wii Tennis?

    Never infrequently occasionally often everyday

5. Was using the Nintendo Wii Tennis easy or difficult for you to use? Easy

    Difficult: Why?

6. What did you like the most during your exposure to Nintendo Wii Tennis?
7. What did you not like about your exposure to Nintendo Wii Tennis?
8. Any other comments?

Appendix D
Demographic, Dependent Variables and Sources

Demographic variables	**Definition**	**Source**
Age	Years	Self-report
Gender	Male or female	Self-report
Income	In U.S. dollars per year	Self-report
Education	In years completed	Self-report
Race or ethnicity	Self-Identification in a group	Self-report
Residence	Where subject is living	Self-report
Marital status	Current status	Self-report
Employment status	Current status	Self-report
Height	Meters	Self-report or PI measured
Weight	Kilograms	Self-report or PI measured
BMI	Per formula pg. 58	PI calculation
Wii status	Novice played Wii less than 5 times or expert played Wii more than 5 times	Self-report
RAPA	As per tool; establishes baseline for activity	Self-report
Pill count	Number of pills taken daily or weekly	Self-report
Medical conditions	Number of current medical conditions	Self-report
Dependent variables	**Definition**	**Source**
Heart Rate (D)	Number of beats per minute based on R-R interval	Continuous; Bio-Harness
Blood pressure(D)	Indirect automated ambulatory systolic and diastolic via oscillation method and measured in millimeters of Mercury or mmHg.	Intermittent; Life Source UA-767 Manual
Perceived exertion (D)	A rating of between 6 and 20	Intermittent Borg RPE
Nintendo Wii Games Tennis (I)	Wii Tennis is included in all Nintendo Wii's sold in the U.S. since 2006.	

(D) Dependent Variable, (I) Independent Variable, (U.S.) United States, BMI = Body Mass Index, RAPA = Rapid Assessment of Physical Activity, RPE = Rate of perceived Exertion

Appendix E

Institution Review Board Approval Letter

University of Pennsylvania
Office of Regulatory Affairs
3624 Market St., Suite 301 S
Philadelphia, PA 19104-6006
Ph: 215-573-2540/ Fax: 215-573-9438
INSTITUTIONAL REVIEW BOARD
(Federalwide Assurance # 00004028)

06-Dec-2011

Joseph R Libonati
Jlibonat@Nursing.Upenn.Edu
Claire M. Fagin Hall
418 Curie Blvd
135 Claire Fagin Hall
Philadelphia, PA 19104-4217
Attn: Michael J Fachko
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PRINCIPAL INVESTIGATOR	: Joseph R Libonati
TITLE	: Cardiovascular Effects and Enjoyment of Exer-Gaming on Older Adults
SPONSORING AGENCY	: No Sponsor Number
PROTOCOL #	: 814694
REVIEW BOARD	: IRB #7

Dear Dr. Joseph Libonati:

The above referenced protocol and was reviewed and approved by the Executive Chair (or her authorized designee) using the expedited procedure set forth in 45 CFR 46.110, category 4, 7, on 05-Dec-2011. This study will be due for continuing review on or before 04-Dec-2012.

Approval by the IRB does not necessarily constitute authorization to initiate the conduct of a human subject research study. Principal investigators are responsible for assuring final approval from other applicable school, department, center or institute review committee(s) or boards has been obtained. This includes, but is not limited to, the University of Pennsylvania Cancer Center Clinical Trials Scientific Review and Monitoring Committee (CTSRMC), Clinical and Translational Research Center (CTRC) review committee, CAMRIS committee, Institutional Bio-safety Committee (IBC), Environmental Health and Radiation Safety Committee (EHRS), and Standing Conflict of Interest (COI) Committee. Principal investigators are also responsible for assuring final approval has been obtained from the FDA as applicable, and a valid contract has been signed between the sponsor and the Trustees of the University of Pennsylvania. If any of these committees require changes to the IRB-approved protocol and informed consent/assent document(s), the changes must be submitted to and approved by the IRB prior to beginning the research study.

If this protocol involves cancer research with human subjects, biospecimens, or data, you may not begin the research until you have obtained approval or proof of exemption from the Cancer Center's Clinical Trials Review and Monitoring Committee.

The following documents were included in this review:
- HS-ERA Application (Confirmation Code: hefjhaa), submitted 11/30/2011
- Response Letter to IRB, dated 11/30/2011
- Informed Consent and HIPAA Authorization Form, uploaded 11/30/2011
- Appendices A – L, uploaded 11/1/2011
- Recruitment Flyer, uploaded 11/30/2011
- Dissertation Proposal, uploaded 11/30/2011
- Letter of Support from Ann's Choice, dated 11/17/2011
- CITI Completion Report for Keith Robinson, dated 2/3/2011
- Biopac Systems Inc Certificate of Registration, uploaded 11/30/2011

When enrolling subjects at a site covered by the University of Pennsylvania's IRB, a copy of the IRB approved informed consent form with the IRB approved from/to stamp must be used unless a waiver of written documentation of consent has been granted.

If you have any questions about the information in this letter, please contact the IRB administrative staff. Contact information is available at our website: http://www.upenn.edu/regulatoryaffairs.

Thank you for your cooperation.

Sincerely,

IRB Administrator

Appendix F

Pre experiments screening questions and vital signs

Screening Criteria	**Values**	**Reference**
Modified Physical Activity Readiness Questionnaire		Adapted from ACSM's Guidelines for Exercise Testing and Prescription, 8th edition
Has your doctor ever said that you have a heart condition **AND/OR** that you should only do physical activity recommended by a doctor?	If yes: refer to Health Care Provider (HCP), exclude from study If no: OK to participate in physical activity	
Do you feel discomfort or pain anywhere in your chest or upper back when you do physical activity*? *Physical activity relates to any activity such as: walking to the mailbox or climbing up and down stairs or any other activity not just a program of exercise.	If yes: refer to HCP, exclude from study If no: OK to participate in physical activity	
In the past month, have you had discomfort or pain anywhere in your chest or upper back when you were not doing physical activity?	If yes: refer to HCP, exclude from study If no: OK to participate in physical activity	
Do you lose your balance because of dizziness or do you ever lose consciousness?	If yes: refer to HCP, exclude from study If no: OK to participate in physical activity	
Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?	If yes: refer to HCP, exclude from study If no: OK to participate in physical activity	
Do you know of any other reason why you should not do physical activity?	If yes: refer to HCP, exclude from study If no: OK to participate in physical activity	
Vital Signs: Resting If greater than value listed: refer to HCP, exclude from study	**Values**	**Reference**
Blood Pressure: Systolic	≥180 refer to HCP, exclude from study	AHA
Blood Pressure: Diastolic	≥110 refer to HCP, exclude from study	AHA
Heart Rate	≥120 refer to HCP, exclude from study	AHA

AHA: American Heart Association; ACSM: American College of Sports Medicine

Appendix G

Inclusion and Exclusion Study Criteria

Inclusion	**Defined As**	**Rational**
Age	Chronological age 60 year old or older in the current year.	This study is looking at the cardiovascular response to EG in older adults age 60 and older.
Living Independently	Not meeting the requirements for Assisted Living or Nursing Home Care. In general, anyone who is generally healthy and not living at a state-licensed that provides assistance with Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs).	This basic study seeks to observe the cardiovascular changes in independently living older adults.
Cognitively Intact	Determined by naming 15 animals as stated by the 60 second animal word retrieval screening	The PI requires that subjects be cognitively intact for physical safety and consent to participate
Lack of Use of Assistive Devices	The use of a walker or cane. Also, the participant must be able to stand unassisted for 30 minutes.	This basic study seeks to observe the cardiovascular changes in independently living older adults who do not use assistive devices.
Able to communicate in English	The subject must be able to read, write and speak in English. This is important for obtaining consent and the participant's ability to follow verbal instructions from the PI, as well as respond to the written and verbal questions.	This study will include English speaking older adults who can also read, write and converse in this language.
Functional Visual & Hearing Acuity	Subject participants must have corrected vision acuity and hearing acuity to participate in everyday tasks and conversation.	Participants without adequate visual and hearing acuity, might may have the reduced ability to follow commands from the EG during the experiment
Lack of Serious	A serious health condition is	This study seeks to observe the

and/or Acute Illness	defined as an illness, injury, impairment, or physical/mental condition that meets any one of the following: 1. Involves inpatient care in a hospital, hospice, or residential medical care facility, including any period of incapacity or any subsequent treatment in connection with such inpatient care for 3 months prior to enrollment. 2. Continuing treatment by a health care provider that consists of a period of incapacity for more than three consecutive days that also involves treatment two or more times by a health care provider, or treatment at least once by a health care provider which results in a regimen of continuing treatment. 3. Chronic conditions-episodic incapacity (e.g., diabetes, epilepsy), permanent/long-term conditions (e.g., Alzheimer's, terminal cancer), or multiple treatments (e.g., chemotherapy, dialysis) (The Ohio State University, Office of Human Resources, 2009).	cardiovascular changes in independently living older adults. Serious or acute medical conditions or illness will lead to outliers in the data. This study seeks a homogeneous sample for both statistical analysis and generalizability of the results
Heart Rate and Blood Pressure	Subjects must having a resting heart rate less than 120 beats per minute and/or a resting blood pressure of less than 180/110 at the time of consent/screening or before the experiment begins	American College of Sport Medicine has establish these limits to protect subject from injury before they participate in a physical experiment of any intensity
Exclusion	**Defined As**	**Rational**
Cardiac Pacemaker or Defibrillator	The subject participants must not have any type of cardiac pacemaker or defibrillator, either implanted or external.	Both the Nintendo Wii and the BioPac BioHarness technical specifications prohibit the use of their devices with persons who have either a cardiac pacemaker or defibrillator because the hand controller

		may cause interference in these devices.
Use of Antianginal agents during physical activity or as a preventative daily dose	An antianginal is any drug used in the treatment of angina pectoris, a symptom of ischemic heart disease that results in chest pain or discomfort. The most common fast acting antianginal is nitroglycerin delivered by sublingual tabulate, sub-lingual or buccal mucosa spray or patch.	Excluding those on antianginal medications, for this study, would add a level of safety to protect the subject. Those on antianginal medication should be supervised in a cardiac rehabilitation program (J. McSweeney, personal communication, May 31, 2011.
Unable to Consent	If the subject participant is not able to be assessed or refused to submit for mental competency screening prior to consent, they will be excluded from this study.	General subject participation requires informed consent for the ethical rigorous demanded by the Institutional Review Board and other Federal guidelines.

Appendix H

Informed Consent and HIPPA Authorization Form
UNIVERSITY OF PENNSYLVANIA RESEARCH SUBJECT INFORMED CONSENT AND HIPPA AUTHORIZATION FORM

Protocol Title:	CARDIOVASCULAR EFFECTS AND ENJOYMENT OF EXER-GAMING ON OLDER ADULTS
Principal Investigator:	Michael Fachko, RN, MSN School of Nursing University of Pennsylvania 215-573-1214, 215-573-4176
Emergency Contact:	Michael Fachko, RN 215-805-2607

Why am I being asked to volunteer?
You are being invited to participate in a research study because you are a healthy volunteer. This is not a form of treatment or therapy. It is not supposed to detect a disease or find something wrong. Your participation is voluntary which means you can choose whether or not you want to participate. If you choose not to participate, there will be no loss of benefits to which you are otherwise entitled. Before you can make your decision, you will need to know what the study is about, the possible risks and benefits of being in this study, and what you will have to do in this study. The primary researcher (PI) is going to talk to you about the research study, and will give you this consent form to read. You may ask to have this form read to you. You may also decide to discuss it with your family, friends, or family doctor. You may find some of the medical language difficult to understand. Please ask the PI about this form. If you decide to participate, you will be asked to sign this form.

What is the purpose of this research study?
The purpose of this study is to determine how virtual reality, specifically exercise gaming (EG) play may change the cardiovascular responses in healthy older adult volunteers. Virtual reality is an electronic device with a computer to simulate real activities that require interaction between the device and the person. Virtual reality tries to simulate the real world environment around us to give the perception that we are actually somewhere we are not. We are performing this study to describe the virtual reality effects in healthy older adults and their cardiovascular responses. Additionally, we wish to describe your overall satisfaction and how you feel after 48 hours of interacting with this technology.

How long will I be in the study? How many other people will be in the study?
Your participation in this study will last approximately one or two hours over the course of one or two separate days. The total length of the study is about 1 year. A total number of 35 subjects are expected to be enrolled in this study.

<u>What am I being asked to do?</u>
You will be asked to play the Nintendo Wii Tennis game for 15 minutes while we take measurements of how your heart and body is reacting to playing EG Nintendo Wii Tennis, your enjoyment of this experiment and answer a few questions on how you felt about this activity after 48 hours. Your participation in this research study will last approximately one to two hours.

<u>What information and what activities will I doing in this study?</u>
If you agree to be a part of this study, you will be:

- Asked several questions about your age, race, education background, marital status, your medical condition(s), physical activity level and medication use.
- You will be asked to participate in an interview and examination for the following:
  - Answer questions regarding your physical activities (10 minutes)
    Be examined for uncontrolled blood pressure and heart rate (10 minutes)
    Participate in an interview discussing the use of technologies (30 Minutes)
    Answer questions about your exertion level (5 minutes) and how you enjoyed game (5 minutes), a fill out a questionnaire of how you feel 48 hours after playing the tennis game (5 minutes).
- The investigator will gather information about your medical history from an interview with you (30 minutes).

<u>Meeting 1 (Consent and Enrollment):</u> The purpose of this visit is to explain the study to you and see if you meet the requirements to be in the study. This visit will last about one hour. After the study has been explained to you and you have agreed to participate (signed the consent form), the meeting will continue. This research requires for us to measure your blood pressure, heart rate, and height/weight and ask you questions about your daily activities, medical conditions and a short memory screening. Once all clinical data has been reviewed, the PI will let you know if you qualify for the study. If you do not qualify for this study, some of the data collected from the screening visit may be used to answer the research questions. If you are enrolled in this study, you will be asked to not start any new medications (includes over-the-counter and prescription) or dietary supplements until you complete the experiment visit if possible. You will be asked to not participate in any form of physical activity that would be considered “exercise” (such as jogging, playing sports, “going to the gym”) for a least two hours prior to the experiment visit. Also, you will be reminded to refrain from or abstained from eating, smoking, exercising and taking any form of caffeine for a period of 2 hours prior to your next meeting. Please wear comfortable exercise or physical activity clothes and footwear (i.e., T-shirt or light sweatshirt, sweat pants, and tennis shoes or sneakers).

<u>Meeting 2 (Experimental Procedure):</u> The experiment day begins on the date and time arranged at the end of previous meeting. You will be greeted and the PI will review your consent, all study paperwork for completeness, and verify that you have abstained from

eating, smoking, exercise and caffeine for a period of two hour prior to the experiment. The PI will ask you to put on the BioHarness (a strap that goes around your chest) and describe to you the Borg RPE scale (a way to measure how much exertion you feel when you are actively moving about) will be discussed. Your blood pressure, heart rate and exertion level will be closely monitored. You will guided by the PI during all steps in the experimental procedure. You will play the Nintendo Wii Tennis for about 15 minutes. You will be stopped at regular intervals so that your blood pressure and exertion level can be recorded. It is important to keep moving as comfortable as possible, you do not need to win the tennis match.

<u>What are the possible risks or discomforts?</u>
There are some potential risks and discomforts that *you may* reasonably expect as part of the study.

The testing protocol will impose a minimal level of stress on your arms and legs. You will be shown the Nintendo Wii and be allowed to practice to become familiar with this technology. Different people respond differently virtual reality. Some people experience dizziness, eye strain, fatigue or nausea. These symptoms generally subside once they remove themselves from the virtual reality environment. There are no known long term side effects or lasting effects from being exposed to virtual reality. The risk of injury when performing the testing and familiarization is minimal. Appropriate rest will be provided during the test if needed.

In addition to possible risks, the research study may involve risks that are currently unforeseeable: If you experience any illness or injury while you are in the study, please inform the PI immediately.

In a published report, Nintendo Wii self-reported injuries have been tracked over a 2 year period from November 2006 to November 2008. The results of the study show us that 39 injuries have been reported while using this type of virtual reality gaming system. There are no reports of death due to the use of this virtual reality gaming system used in this study. The most commonly occurring Nintendo Wii related injury is trauma to the hand. The Wii relate injuries are: epistaxis (nose bleed)(1), periorbital hematoma (black eye) (5), clavicular fracture (1), patellar dislocation (knee pain)(2), lip laceration (cut)(1), forehead bruise (3), chin laceration (cut) (1), tooth avulsion (lost tooth) (1), quadriceps sprain (thigh) (1), metacarpal fracture (hand) (2), hand laceration (cut) or bruise (17), wrist strap injury (1), ankle sprain or fracture (2) and metatarsal (foot) fracture (1). These self-reported injuries were cited in Sparks, D., Chase, D., & Coughlin, L. (2009). Nintendo Wii have a problem: A review of self-reported Nintendo Wii related injuries. *Informatics in Primary Care, 17*(1), 55-57.

At any time during the experimental protocol, you feel fatigued or you do not want to play anymore, you may withdraw from the experiment. You can request a rest break if you are feeling fatigue, the experiment will stopped immediately and you will be monitored until you

no longer feel fatigued. If your fatigue continues you may be allowed to reschedule the experiment after 48 hours if were unable to complete the first experimental attempt.
If your fatigue does not go away and you do not feel well, medical attention will be provided to by the staff at Ann's Choice. If the medical care your require is above the medical care that they provide, you will be taken by ambulance to a hospital for further evaluation and possible treatment.

What if new information becomes available about the study?
During the course of this study, we may find more information that could be important to you.

This includes information that, once learned, might cause you to change your mind about continuing in this study. We will notify you as soon as possible if such information becomes available.

What are the possible benefits of the study?
You are not expected to get any benefit from being in this research study while there may be no specific therapeutic benefit to you in this study, you may experience improvements in functional movements, reaction time, balance, muscle strength, flexibility, pain and mood. Participation in this study may provide new information about physical activity and fitness in older adults and the way your body responds to intervention.

What other choices do I have if I do not participate?
The alternative to this study is not to participate.

Will I be paid for being in this study?
There is no compensation offered for your participation in this study.
Will I have to pay for anything?

There will be no cost to you for the costs of your medical care during this study.

What happens if I am injured or hurt during the study?
If you have a medical emergency during the study you be transported to the nearest emergency room. You may contact the PI, who is also the Emergency contact listed on page one of this form. You may also contact your own doctor, or seek treatment outside of the University of Pennsylvania. Be sure to tell the doctor or his/her staff that you are in a research study being conducted at the University of Pennsylvania. Ask them to call the telephone numbers on the first page of this consent form for further instructions or information about your care. In the event of any physical injury resulting from research procedures, medical treatment will be provided without cost to you, but financial compensation is not otherwise offered from the University of Pennsylvania. If you have an illness or injury during this research study that is not directly related to your participation in this study, you and/or your insurance will be responsible for the cost of the medical care of that illness or injury.

If you have an illness or injury during this research trial that is not directly related to your participation in this study, you and/or your insurance will be responsible for the cost of the medical care of that illness or injury.

When is the Study over? Can I leave the Study before it ends?
The overall study is expected to end in about one year. This study may also be stopped at any time by the study doctor, the study Sponsor, or the Food and Drug Administration (FDA) without your consent because:
• The Primary Investigator feels it is necessary for your health or safety. Such an action would not require your consent, but you will be informed if such a decision is made and the reason for this decision.
• You have not followed the research/study instructions
• The Principal Investigator, or the Food and Drug Administration (FDA) has decided to stop the study.

If you decide not to participate, you are free to leave the study at any time. Withdrawal will not interfere with your future care.

Who can see or use my information? How will my personal information be protected?
The PI and other key personnel involved with this study will keep your personal health information collected for the study strictly confidential. This is the "HIPAA Privacy Authorization" document that explains specifically how your personal information will be protected.

Who can I call with questions, complaints or if I'm concerned about my rights as a research subject?
If you have questions, concerns or complaints regarding your participation in this research study, you should speak with the Principal Investigator listed on page one of this form. If the PI cannot be reached, or you want to talk to someone other than those working on the study, you may contact the Office of Regulatory Affairs with any concerns or complaints at the University of Pennsylvania by calling (215) 898-2614.

What information about me may be collected, used or shared with others?
In order to maintain accurate separation of each individual who participates in this study, we need to have certain information to ensure your individuality. This information will be held in the strictest of confidence and only used to positively identify you in obtaining supporting documentation required in this research project. It is possible that the data collected on you as an individual subject will be subjected to other analyses in the future; however this will be done in a manner that will protect you from being individually identified. This may include, for example, information you tell us that is in your medical record, results of physical examinations, medical history, or protected health information such as name, address or social security number, e.g.,

- Name, address, telephone number, date of birth
- Social Security number
- Personal and family medical history
- Results from prior physical examinations, tests or procedures

Why is my information being used?
Your information is used by the PI to contact you during the study. Your information and results of tests and procedures are used to:
- Do the research
- Oversee the research
- To see if the research was done right.

Who may use and share information about me?
The following individuals may use or share your information for this research study:
- The investigator for the study and the study personnel
- Other authorized personnel at Penn

Who, outside of the School of Nursing, might receive my information?
- All research centers participating in the study, even if they are not part of the School of Nursing
- The funding sponsor and organizations supporting the sponsor, if applicable

Oversight organizations
- The Food and Drug Administration
- The Office of Human Research Protections
- The researcher's Dissertation Committee

Once your personal health information is disclosed to others outside the School of Nursing, it may no longer be covered by federal privacy protection regulations.

The Principal Investigator or study staff will inform you if there are any additions to the list above during your active participation in the trial. Any additions will be subject to University of Pennsylvania procedures developed to protect your privacy.

How long may the School of Nursing use or disclose my personal health information?
Your authorization for use of your personal health information for this specific study does not expire.
Your information may be held in a research database. However, it is possible that the group data will be subjected to further analyses not proposed here, however the data will be completely de-identified and remain secure to exclude the possibility of violating the privacy of individual subjects in any way unless:
- You have given written notice that the information cannot be reused
- The University of Pennsylvania's Institutional Review Board grants permission

- As permitted by law

<u>Can I change my mind about giving permission for use of my information?</u>
Yes. You may withdraw or take away your permission to use and disclose your health information at any time. You do this by sending written notice to the investigator for the study. If you withdraw your permission, you will not be able to stay in this study.

<u>What if I decide not to give permission to use and give out my health information?</u>
Then you will not be able to be in this research study.
You will be given a copy of this Research Subject HIPAA Authorization describing your confidentiality and privacy rights for this study.
By signing this document you are permitting the School of Nursing to use and disclose personal health information collected about you for research purposes as described above.

When you sign this form, you are agreeing to take part in this research study. This means that you have read the consent form, your questions have been answered, and you have decided to volunteer. Your signature also means that you are permitting the PI to use your personal health information collected about you for research purposes.

A copy of this consent form will be given to you.

______________________________ ______________________________________
Name of Subject (Please Print) Signature Date

______________________________ ______________________________________
Name of Person Obtaining Consent (Please Print) Signature Date

Appendix I
Assessment Instruments

Instrument or Tool	Description	How used in study
Physical Activity Level in Older Adults (RAPA) Source: via interview or self-assessment	Physical activity is conceptualized as performing the appropriate activity in one of five categories: sedentary, underactive, regular underactive (light activities), regular underactive, and regular active and performing either strength or flexibility training or both (Topolski et al., 2006).	Ordinal variable. 1 = sedentary, 2 = underactive, 3 = regular underactive (light activities), 4 = regular underactive, and 5 = regular active; strength training = 1, flexibility = 2, or both = 3. This tool sets the baseline of physical activity for comparison against cardiovascular parameters
Borg Rating of Perceived Exertion Scale (RPE) Source: subject's verbal response to EG gaming	Physical exertion is a subjective measure in older adult due often due to their use of cardiac medications. Direct measures of heart rate, blood pressure and muscle workload does not generally correlate well in the older adult. The RPE preferred method to assess physical activity intensity among individuals who take medications that affect the heart rate and pulse (Borg, 1998).	Ordinal variable. The exertion scale ranges from 6 to 20, where 6 means "no exertion at all" to 20 which means "maximal exertion". This tool elicits a subject response of the VR activity for comparison against cardiovascular responses measured by the BioHarness
Physical Activity Enjoyment Scale (PACES) Source: subject's verbal response to EG gaming	Enjoyment is based on the individual perception of the experience. Bipolar questions in this scale seek to understand if the physical activity truly reflects their lived experience (Kendzierski & Decarlo, 1991).	Ordinal variable. 7-point Likert scale items include "I find it energizing"/"I find it tiring" and "I enjoy it"/"I hate it. This tool will aid in determining if this technology is enjoyable with older adults to use an a physical activity
60 second animal word retrieval screening	The participant will name > 14 animal names in 60 seconds. If less than 14 animals are named the participant will encouraged to seek their primary health care provider for further evaluation.	Used in this study to screen for cognitive impairment for study consent.
48 Hour Post-Wii Tennis Follow-Up Questionnaire	This a priori survey was developed to illuminate potential post-Wii tennis hazards that might arise after the experiment	To assess and describe any untoward physical responses (i.e., soreness, pain, extreme fatigue or muscle/joint discomfort) after 48 hours based on a 0 to 10 scale, with 0 meaning no pain/discomfort and 10 meaning extreme pain/discomfort.

Appendix J

BioHarness Pictures

Appendix K

BioHarness ISO Certificate of Registration

789 North Dixboro Road, Ann Arbor, Michigan 48105
(888) NSF-9000

Certificate of Registration

This certifies that the Quality Management System of

BIOPAC SYSTEMS, INC.

42 Aero Camino
Goleta, California, 93117, United States

has been assessed by NSF-ISR and found to be in conformance to the following standard(s):

ISO 9001:2008

Scope of Registration:

Design and manufacture of educational and research computerized recording data and analysis systems including transducers, electrodes, amplifiers, recording accessories, software and curriculum materials for life science research communities such as universities, hospital facilities, pharmaceutical companies and research institutes.

Exclusions: None

Industrial Classification:

SIC: 3571
IAF - QMS: 19
NACE: DL 30

Certificate Number: 45311-IS1
Certificate Issue Date: 08-DEC-2009
Registration Date: 07-DEC-2009
Expiration Date *: 06-DEC-2012

Christian B. Lupo, General Manager
NSF-ISR, Ltd.

Authorized Registration and /or Accreditation Marks. This certificate is property of NSF-ISR and must be returned upon request *Company is audited for conformance at regular intervals. To verify registration call (888) NSF-9000 or visit our web site at www.nsf-isr.org

Appendix L

TV Viewing Size and Distance

CRUTCHFIELD	
Screen Size	**Recommended Range**
26”	3.25’ – 5.5’
32”	4.0’ – 6.66’
37”	4.63’ – 7.71’
40”	5.0’ – 8.33’
42”	5.25’ – 8.75’
46”	5.75’ – 9.5’
50”	6.25’ – 10.5’
52”	6.5’ – 10.8’
55”	6.9’ – 11.5’
58”	7.25’ – 12.0’
65”	8.13’ – 13.5’
70”	8.75’ – 14.75’

Available: http://www.crutchfield.com/S-vDUHiL7nMgW/learn/learningcenter/home/tv_faq.html#size

Appendix M

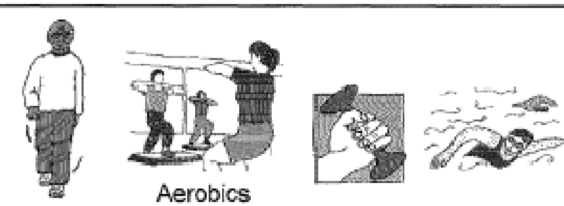
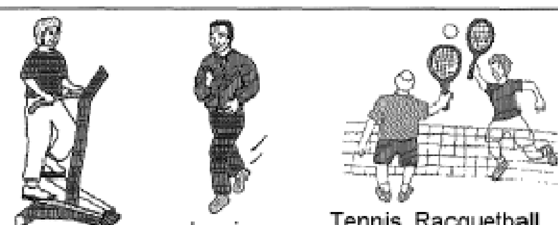
Rapid Assessment of Physical Activity (RAPA)

Rapid Assessment of Physical Activity

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:

Light activities • your heart beats slightly faster than normal • you can talk and sing	 Walking Leisurely · Stretching · Vacuuming or Light Yard Work
Moderate activities • your heart beats faster than normal • you can talk but not sing	 Fast Walking · Aerobics Class · Strength Training · Swimming Gently
Vigorous activities • your heart rate increases a lot • you can't talk or your talking is broken up by large breaths	 Stair Machine · Jogging or Running · Tennis, Racquetball, Pickleball or Badminton

How physically active are you? *(Check one answer on each line)*

			Does this accurately describe you?	
			Yes	No
RAPA 1	1	I rarely or never do any physical activities.	☐	☐
	2	I do some **light** or **moderate** physical activities, but not every week.	☐	☐
	3	I do some **light** physical activity every week.	☐	☐
	4	I do **moderate** physical activities every week, but less than 30 minutes a day or 5 days a week.	☐	☐
	5	I do **vigorous** physical activities every week, but less than 20 minutes a day or 3 days a week.	☐	☐
	6	I do 30 minutes or more a day of **moderate** physical activities, 5 or more days a week.	☐	☐
	7	I do 20 minutes or more a day of **vigorous** physical activities, 3 or more days a week.	☐	☐
RAPA 2 (3 = Both 1 & 2)	1	I do activities to increase muscle **strength**, such as lifting weights or calisthenics, once a week or more.	☐	☐
	2	I do activities to improve **flexibility**, such as stretching or yoga, once a week or more.	☐	☐

ID # ______________________________

Today's Date ______________________

Scoring Instructions

RAPA 1: Aerobic

To score, choose the question with the highest score with an affirmative response. Any number less than 6 is suboptimal.

For scoring or summarizing categorically:

Score as sedentary:

1. I rarely or never do any physical activities.

Score as under-active:

2. I do some light or moderate physical activities, but not every week.

Score as under-active regular – light activities:

3. I do some light physical activity every week.

Score as under-active regular:

4. I do moderate physical activities every week, but less than 30 minutes a day or 5 days a weel
5. I do vigorous physical activities every week, but less than 20 minutes a day or 3 days a week.

Score as active:

6. I do 30 minutes or more a day of moderate physical activities, 5 or more days a week.
7. I do 20 minutes or more a day of vigorous physical activities, 3 or more days a week.

RAPA 2: Strength & Flexibility

I do activities to increase muscle strength, such as lifting weights or calisthenics, once a week or more. (1)

I do activities to improve flexibility, such as stretching or yoga, once a week or more. (2)

Both. (3)

None (0)

Appendix N

Pair-Wise Comparisons; Group Heart Rate Compared Time

Within Group Across Time Pairwise Comparisons For Each Cardiovascular Variable										
Resting			**Standing**	**Wii Tennis Play**				**Recovery**		
Heart Rate		5 Min.			5 Min.	10 Min.	15 Min.		5 Min.	10 Min.
10 Minutes	Mean Diff.	.647	1.882		14.088*	13.353*	10.971*		0.882	1.294
	Std. Error	.755	0.991		1.835	1.81	1.948		1.615	0.943
	p-value	1.000	1.000		0.000	0.000	0.000		1.000	1.000
Systolic BP										
10 Minutes	Mean Diff.	1.735	0.559		14.588*	11.912*	9.735*		3.765	6.029
	Std. Error	1.468	1.92		2.742	2.354	2.517		1.843	3.914
	p-value	1.000	1.000		0.000	0.000	0.000		1.000	1.000
Diastolic BP										
10 Minutes	Mean Diff.	1.529	3.118		9.265*	7.294*	9.941*		2.294	1.588
	Std. Error	1.085	1.244		2.037	1.361	2.505		1.348	1.259
	p-value	1.000	0.484		0.002	0.000	0.010		1.000	1.000
Mean BP										
10 Minutes	Mean Diff.	1.647	2.206		11.000 *	8.794 *	9.824 *		0.294	0.029
	Std. Error	0.923	1.083		1.9	1.294	2.153		1.246	1.266
	p-value	1.000	1.000		0.000	0.000	0.002		1.000	1.000
RPP										
10 Minutes	Mean Diff.	233.5	314.0		3462.3*	2919.4*	2419.9*		80.382	330.706
	Std. Error	167.12	206.364		492.768	349.6	362.689		279.897	207.069
	p-value	1.000	1.000		0.000	0.000	0.000		1.000	1.000
PE										
10 Minutes	Mean Diff.	.118	0.206		3.559 *	4.647 *	5.794 *		2.029 *	0.853
	Std. Error	0.07	0.082		0.287	0.365	0.409		0.367	0.338
	p-value	1.000	0.482		0.000	0.000	0.000		0.000	0.466
Based on estimated marginal means; Mean Diff.=Mean Difference; Std Error=Standard Error; *= The mean difference is significant at the 0.05 level										

Appendix O

48 hours Post Wii Tennis Follow-Up Questions Responses

Question #1: Are you experiencing any discomfort from playing the Nintendo Wii tennis?	
No=31	**Yes=3**
No Discomfort	**8/10 Back & Rib pain; upon follow up phone call subject stated discomfort fully resolved, no medical treatment required**
	2/10 R Arm pain; upon follow up phone call subject stated discomfort fully resolved, no medical treatment required
	2/10 shoulder pain; upon follow up phone call subject stated discomfort fully resolved, no medical treatment required

Question #2: Would you play Nintendo Wii tennis less or more that 15 minutes?	
More=21	**Less=10**
More-I enjoyed it (9)	**No (3)**
Fun (8)	**I did not like the game (2)**
A form of exercise (2)	**Not interesting**
Love it	**Boring**
15 minutes would be long enough	**No-I played poorly**
	I would be overtired
	Less-I don't need it
3 subjects had no comments to this follow-up question.	

Question #3: Would you use the Nintendo Wii Tennis as a part of your overall plan to keep physically active?	
Yes=13	**No=17**
It's a fun activity (2)	**I do not enjoy tennis(4)**
I enjoyed it (2)	**No, not physical enough (4)**
Love to play it	**I have a plan that works well (2)**
To stay active	**Wii is not readily available (2)**
Physical fitness	**Boring (2)**
For a moving activity	**I walk and go to the gym**
It is a good brain activity	**Too much coordination, the game is too fast for me**
Yes, I would participate	**No, my shoulder needs replacement**
A good exercise for coordination	
Building strength and good stretch	
It would be better to play against someone	
4 subjects had no comments to this follow-up question.	

Question #4: How often you think you will use the Nintendo Wii Tennis?	
Every Day	**N=1; 3%**
Often	**N=4; 12%**
Occasionally	**N=17; 50%**
Infrequently	**N=2; 6%**
Never	**N=9; 26%**
1 subject (3%) had no comments to this follow-up question.	

Question #5: Was the Nintendo Wii tennis easy or difficult for you to use?	
Easy comments=14	**Difficult comments=3**
I was not too difficult (5)	**I don’t like tennis**
Easy to use the equipment(3)	**Difficult to learn how to play**
Good exercise(2)	**Difficult to hit the ball**
I play Wii Bowling(2)	
It was fun and challenging	
It was enjoyable	
15 subjects had no comments to this follow-up question.	

Question #6: What did you like the most during your exposure to Nintendo Wii Tennis?	
It was fun (6)	Entertaining
Challenging (6)	A lot of movement in Wii tennis
The experience(2)	The chance to improve
Competition (2)	The activity for good fitness
I could keep a volley going (2)	Remembering the game of tennis
First time playing Wii tennis	Different
It was pleasurable	Nothing
4 subjects had no comments to this follow-up question.	

Question #7: What did you not like about your exposure to Nintendo Wii Tennis?	
Nothing (10)	Not my game
Frustrating (2)	My backhand needs work
The ball was too fast for me (2)	Made me look bad
Scoring (2)	It was all good
No knowledge of the game	It was tiring
I did not like it	
11 subjects had no comments to this follow-up question.	

Question #8: Additional Comments	
I enjoyed the game; challenging (2)	**Not interested in Wii tennis**
I like Wii Bowling (2)	**The chance to improve**
Fun, but I still enjoy bowling more	**Fun experience**
There are other more efficient ways of exercising and cheaper too	**I prefer Wii bowling and walking for exercise**
I liked playing the game because it was an activity, but I do not have one	**I would like to play Wii tennis as well as bowling**
I hope they organize a group to play Wii Tennis	**Different**
21 subjects had no comments to this follow-up question.	

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