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Comparing Reaction Time and Postural Stabilization based on Activity Groups in Older Adults

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Comparing Reaction Time and Postural Stabilization based on Activity Groups in Older Adults

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Abstract

The purpose of this study was to compare reaction time and postural stabilization between activity groups in older adults. These variables are important because older adults are at a high fall risk and two major contributors to fall risk are postural stabilization and reaction time. This study examined if the activity group of an older adult had any influence on reaction time and postural stabilization. Fifty-nine older adults aged 66.46 ± 9.47 years old were used in the study. Thirteen subjects were in the master's athletes which are individuals over the age of 40 who competed in a nationally sanctioned event within the last 6 months and complete at least 150 minutes of aerobic exercise per week, 27 were in recreationally active, which are individuals who complete at least 150 minutes of aerobic exercise per week but do not compete, and 19 were in sedentary activity group, which are individuals who do not exercise at least 150 minutes per week of aerobic exercise. Choice and simple reaction time were measured to determined how quickly the individual could respond to a stimulus. Postural stabilization was measured using a Biodex Balance System. After comparing the activity groups using one-way ANOVA's, no statistically significant differences were found between activity groups in simple reaction time, $F(2, 56) = 2.77$, $p = .07$, choice reaction time $F(2, 56) = 2.29$, $p = .11$, or postural stabilization scores $F(2, 48) = .697$, $p = .51$. The cohen's f test found moderate effect sizes in the simple reaction time, $f = 0.31$, and choice reaction time, $f = 0.29$. The cohen's d test found the effect size was largest, $d > 0.50$ between sedentary and master's athletes activity groups and between recreationally active and master's athletes activity groups for all three variables. The main conclusion is that there were no significant differences between activity groups but that may be from the small number of subjects. The effect sizes showed a trend that master's athletes had the best scores overall for each variable.

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Introduction

In the United States, one in three individuals 65 years and older suffer from a fall each year (CDC, 2015b). Falls are extremely detrimental for an older individual and can lead to minor injuries such as bruising and decreased quality of life; and major injuries such as bone fractures or even death (Halvarsson, Dohrn, & Ståhle, 2015; Landers, Oscar, Sasaoka, & Vaughn, 2016; Pociask, DiZazzo-Miller, Goldberg, & Adamo, 2016). In 2013, 67.9 per 100,000 men and 49.1 per 100,000 women died from injuries sustained from a fall (CDC, 2015a). Falls are linked to many risk factors including dizziness (Titler, Shever, Kanak, Picone, & Qin, 2011), weakness in lower extremities (Seco et al., 2013), longer reaction time (Lord, Clark, & Webster, 1991), previous falls (Lajoie & Gallagher, 2004), impaired balance (Teeranut, Borwarnluck, & Prinya, 2015), unsteady gait pattern (Carty et al., 2015), impaired vision (de Boer et al., 2004), and medication usage (Titler et al., 2011). On average, after suffering a significant fall, an older adult will spend approximately 7.6 days in the hospital. This length of stay, along with treatments, puts increased financial burden on the patient and/or the patient's family. The average cost of a fall and all the therapies and treatments surrounding it is $17,483 (Landers et al., 2016) with annual costs estimated at $20 billion (Gelbard et al., 2014). Falls are problematic for individuals 65 years and older and lead to both physical and financial burdens.

Falls are costly, both emotionally and fiscally. With the knowledge of the adverse effects of a fall, older adults begin to fear falling. A growing problem with the staggering statistics of falls in older adults is the fear of falling (Boehm, Franklin, & King, 2014; Landers et al., 2016; Zijlstra et al., 2009). Fear of falling negatively influences older adults causing them to avoid activities lowering their regular participation in physical activity (Dattilo, Martire, Gottschall, & Weybright, 2014; Halvarsson et al., 2015; Landers et al., 2016). When physical activity is

avoided, there is a loss in bone mineral density, muscular strength, and muscular endurance (ACSM, 2014). All of these factors lead to a lower activity capacity and a frailer body resulting in increased falls and detrimental injuries (Halvarsson et al., 2015). As clinicians, the prevalence of falls and physical inactivity supports the need to be more focused on fall prevention and determining the role physical activity plays in improving fall risk factors.

There are three major groups of physical activity involvement for older adults, or adults aged 65 years and above. Those three groups are sedentary, recreationally active, and master's athletes. Sedentary older adults do not meet the American College of Sports Medicine (ACSM) guidelines of engagement in physical activity. The ACSM recommends that an individual should complete at least 30 minutes of moderate intensity aerobic exercise for five or more days a week, or 20 minutes of vigorous intensity aerobic exercise for three or more days a week (ACSM, 2014). Moderate intensity is 40-60% of heart rate reserve and vigorous intensity is 60-90% or more of heart rate reserve (ACSM, 2014). The recreationally active group meets or exceeds the minimum ACSM guidelines for physical activity frequency per week. The master's athletes group also meets or exceeds the minimum ACSM guidelines for physical activity frequency per week and also must have competed in a nationally sanctioned event within the last 6 months (Zhao, Tranovich, DeAngelo, Kontos, & Wright, 2016).

The cause of falls is multifactorial; however, two primary factors include reaction time (Lord et al., 1991) and postural stabilization (Carty et al., 2015). Reaction time is important to falls because the faster an individual's reaction time is, the faster the individual can react to a stimulus (Carty et al., 2015; Lord & Fitzpatrick, 2001). Research has shown that reaction time is faster among active older adults compared to their sedentary counterparts (Rotella & Bunker, 1978). In Rotella & Bunker's (1978) study, master's tennis players had their simple reaction time

measured using an Athletic Performance Analyzer (Model 631, Dekan Timing Devices). A light stimulas would appear and the analyzer would show how much time it took for the individual to hit the button. The master's athlete tennis players had a significantly faster speed of .242 seconds versus their sedentary counterpart that took an average of .294 seconds to respond. A gap in the literature is that reaction time is not compared between all three physical activity groups; only sedentary and master's athletes or sedentary and recreationally active. This is important to determine if involvement in competitive sport helps to influence reaction time in a beneficial way. Another major factor for the risk of falls is postural stabilization. The more movement of the center of pressure during postural stabilization, the worse the individual's balance, and the greater chance for a fall. Previous research has shown that active older adults have smaller movements of the center of pressure during postural stabilization and better balance than their sedentary counterparts (Victor et al., 2014). Research has focused primarily on comparing two activity groups but never all three. This is important to see how much physical activity is needed to help improve postural stabilization.

The purpose of this study was to compare reaction time and postural stabilization between activity groups of older adults. The first hypothesis was that the reaction time will be the fastest in the master's athletes group, then recreationally active group, and slowest in sedentary group. The second hypothesis was that the least amount of movement of the center of pressure during postural stabilization will be in the master's athletes group, then recreationally active group, and largest in the sedentary group.

Operational Definitions

Balance is "a state of equilibrium, or equipoise; equal distribution of weight, and amount" (Ammer, 2016, p. Definition section). Postural control is "the act of maintaining or

achieving, or restoring a state of balance during any posture or activity" (Pollock, Durward, Rowe, & Paul, 2000, p. 402). Postural control can be measured through assessing an individual's postural stabilization. Postural stabilization is defined as how much an individual moves his or her center of mass while maintaining balance (Shumway-Cook, Woollacott, Kerns, & Baldwin, 1997). Sedentary individuals, in this study, refer to individuals who do not exercise at least 150 minutes per week (ACSM, 2014), recreationally active adults are the individuals who exercise at least 150 minutes per week (ACSM, 2014), and master's athletes achieve the 150 minutes of activity a week and compete in a nationally sanctioned event within the last 6 months (Zhao et al., 2016).

Literature Review

Introduction

Falls are detrimental to an older adult and may cause them to become dependent instead of independent. This lowers the quality of life for that individual so there has been a major focus on ways to prevent falls. While determining how to prevent a fall, researchers determined the factors that could lead to a fall. Some factors that can help a researcher predict the chance of a fall are an individual's postural stabilization and reaction time (Carty et al., 2015). These factors play some major roles on whether one is more likely to sustain a fall. Involvement in physical activity has been shown to reduce the risk of a fall (Gregg, Pereira, & Caspersen, 2000).

Physical Activity

Regular participation in physical activity and exercise is beneficial in all dimensions of health for aging adults (Smith et al., 2012). Older adults who engage in more physical activity and exercise are more resistant to disease, increase their functional capacity, keep an optimal

body composition, reduce the risk of physical disability, experience a better quality of life, and increase longevity of lifespan (ACSM, 2014; Seco et al., 2013). Yet, patterns show that as people age, they are more likely to become more sedentary and engage in activities such as reading, watching television, and other sedentary activities (Clark et al., 2010; Troiano et al., 2008).

There are three major categories of physical activity groups in older adults. There are master's athletes, recreationally active, and sedentary individuals. Master's athletes are over the age of 40 and regularly participate in high intensity aerobic and/or anaerobic training. They also compete regularly in the aerobic activity they train for such as running, swimming, and biking (Zhao et al., 2016). Recreationally active individuals follow the American College of Sports Medicine (ACSM) guidelines. The guidelines that the ACSM recommends state that an individual must do at least 30 minutes of moderate intensity aerobic exercise for five or more days a week, or 20 minutes of vigorous intensity aerobic exercise for three or more days a week (ACSM, 2014). Moderate intensity is 40 to 60 percent of heart rate reserve and vigorous intensity is 60 to 90 percent or more of heart rate reserve (ACSM, 2014). The major difference between master's athletes and recreationally active individuals is that master's athletes have competed in a nationally sanctioned event within the last 6 months; recreationally active individuals have not. Sedentary individuals do not meet the ACSM standards for recreationally active individuals. Older adults are the most sedentary age group (65 years or older) with only about 22% of the population participating in regular physical activity (ACSM, 2014). In order to improve the health and well-being of the aging population, the percentage of the population participating in regular physical activity must increase. Without regular exercise, older adults have a greater risk of developing health issues and also balance issues which can lead to a fall.

Physical Function

In older adults, the goal of physical activity and exercise programs is to increase an individual's physical function in order to improve health and maintain function (ACSM, 1998). In order to maintain independence, older adults must be able to perform activities of daily living. A major indicator for physical function is an individual's maximum volume of oxygen consumed (ACSM, 2014). This can be found through maximal and submaximal exercise testing (ACSM, 2014). In older adults, a test that is used frequently to determine one's maximum volume of oxygen consumed is through the 6-minute walk test (Forman et al., 2012). This is a submaximal test that has been determined as valid and reliable for older adults (Forman et al., 2012). The more distance traveled in the six minutes, the better the individual's functional capacity.

Postural Stabilization

Exceptional balance and high postural control is a key factor in reducing the risk of a fall for an individual (Overstall, Exton-Smith, Imms, & Johnson, 1977). Postural control can be defined as "the act of maintaining, achieving, or restoring a state of balance during any posture or activity" (Pollock et al., 2000, p. 402). Postural control is needed to perform almost every activity including sitting, walking, and performing activities of daily life. Postural control can be measured through assessing an individual's postural sway. Postural stabilization is defined as how much an individual moves his or her center of mass while maintaining balance (Shumway-Cook et al., 1997). If an individual has poor postural control, more movement of the center of pressure will occur to maintain postural stabilization and if the individual has good postural control, center of pressure will remain relatively still in order to maintain postural stabilization.

Postural stabilization is closely linked to balance. Balance is defined as "a state of equilibrium, or equipoise" (Ammer, 2016, p. Definition section). In order to be considered balanced, one must have the center of pressure within the base of support (Winter, 1995). To stay mobile, one must have adequate balance (Frank & Patla, 2003). Balance is used when walking, bending, standing, getting out of a chair or bed, and many other activities (Lajoie & Gallagher, 2004). Balance is affected by internal and external factors of the body and how it reacts to its environment. To start, vision is important for adequate balance because the individual can see clearly and react appropriately for external obstacles and provide feedback on the movement of the body and help keep an upright posture (Sturnieks, George, & Lord, 2008). It has been shown that, in general, after individuals reach age 50, the eyes decline in visual processes giving less accurate feedback to the brain causing balance to decline (Gittings & Fozard, 1986). Feedback from the vestibular system is also very important in postural control. The vestibular system uses three semi-circular canals to provide information on the angular acceleration of the head in any direction and the linear acceleration and head tilt are determined by the utricular and saccular organs of the otolithic system (Sturnieks, George, & Lord, 2008). The vestibular system is able to detect a perturbation and have the body react to correct the loss of balance experienced by providing feedback to the postural muscles (Sturnieks, George, & Lord, 2008). As individuals age, there is a natural decrease in vestibular functioning resulting in increased movement of the center of pressure during postural stabilization and decreased balance (Fife & Baloh, 1993; Herdman, Blatt, Schubert, & Tusa, 2000; Tian, Crane, Wiest, & Demer, 2002).

Another physiological factor of balance is proprioception. Proprioception is when muscles provide feedback to central nervous system about positioning and angles of the body. The primary communicator for proprioception is the Golgi tendon, and with age, this declines in

function and causes a higher postural instability and higher chance of a fall in older adults (Lord, McLean, & Stathers, 1992). This decline in function of the Golgi tendon shows that as people age, they will inevitably lose functioning in key processes of balance. With that as a known factor, there has been research to find ways to slow down the decline in processes (Lord et al., 1992). Repeatedly, there has been research backing up the fact that if an individual is physically active, cognitive functioning and physiological functioning declines at a much slower rate than their sedentary counterpart (Seco et al., 2013). A study done by Victor et al. (2014) had 56 physically independent older adults, 28 were sedentary and 28 participated in a regular exercise program. The groups were determined using the Baecke questionnaire. The researcher had each individual stand on a force plate on one foot with eyes open and measured movement of center of pressure of the individual. It was found that there were significant differences between the active and sedentary group for both the area the center of pressure moved, $p = .02$ and the velocity of which the center of pressure moved, $p < .01$. The active group's area of center of pressure was 10.02 centimeters squared and the sedentary's was 19.33 centimeters squared. The velocity of the anterior-posterior movements for the active group were 3.09 centimeters per second and the sedentary group was 5.82 centimeters per second. This further shows the amount of movement the center of mass has in active versus sedentary individuals. With respect to postural stabilization there are a few important factors that play major roles in reducing the risk of a fall and a major way to avoid a fall is by becoming physically active.

Reaction Time

In addition to postural stabilization, reaction time is another component that plays a major role in determining the risk of a fall in an individual (Lord & Fitzpatrick, 2001; Morrison, Colberg, Parson, & Vinik, 2014). As one ages, reaction time becomes slower (Dascal & Teixeira,

2016; Lord & Fitzpatrick, 2001; Morrison et al., 2014). This is concerning because research has shown the slower the reaction time, the less time to recover from a loss of balance, resulting in a higher chance of a fall (Lord & Fitzpatrick, 2001). Reaction time is influenced by an individual's cognitive motor responses and how quickly an individual can react to a stimulus. As a person ages, cognition declines causing slowed neuron firing and slower response time (Fozard, Vercryssen, Reynolds, Hancock, & Quilter, 1994). Fozard et al. (1994) recruited 1,265 individuals from ages 17 to 96 and conducted repeated measures using simple reaction time. Fozard et al. (1994) found that older individuals had slower reaction times and had more errors in order to try to get a faster reaction time than the younger age groups. Since reaction time is so important in the reduction of falls, it is important to find ways to find ways to slow the process of increases in reaction time in older adults.

As people age, reaction time increases, but research shows that an active individual has a faster reaction time compared to their sedentary counterparts (Rotella & Bunker, 1978). Rotella and Bunker (1978) compared older adults that were master's athletes who played tennis and older adults who were sedentary. This was done with an Athletic Performance Analyzer which measured the time it took an individual to see a light stimulus and respond to it by pressing a response button. They found there was a significantly faster reaction time among the master's athletes (.242 seconds) versus the sedentary individuals (.294 seconds), $p < .05$. Faster reaction time has to do with the increased ability of executive cognitive functioning. Research found that exercise changes the way the brain processes information and those processes will remain more youth-like in movements for signaling throughout the brain and better cognitive functioning (Hyodo et al., 2016). In young adults, the brain recruits the right prefrontal and parietal cortices and in older adults the brain recruits more bilaterally (Hyodo et al., 2016). This change in

recruitment and movement patterns within the brain slows the processing and signaling of the nervous system and the body causing a longer reaction time within the individual (Hyodo et al., 2016). Exercise also increases cerebral blood flow (Swain et al., 2003), which is great for brain health and can help improve cognitive functioning (Filipe Marmeleira, Soares de Melo, Tlemcani, & Godinho, 2011). Overall, exercise increases executive functioning in older adults, causing faster response times and faster reaction times than sedentary older adults.

Conclusion

In conclusion, postural stabilization and reaction time are two major contributors to determining an individual's fall risk. Falls are extremely detrimental for older adults and can lead to injuries, loss of independence, and death. Postural stabilization directly measures postural control which translates to balance and reaction time measures how quickly an individual can react to a change in stimuli. Research has shown exercise improves an individual's postural stability (Teeranut et al., 2015) and reaction time (Filipe Marmeleira et al., 2011; Swain et al., 2003), but gaps remain in the literature. There have been limited studies examining different exercise groups on postural stability and reaction time among master's athletes, recreationally active, and sedentary older adults. The reason this is important is to determine if an individual engaged in competitive sports or an increased involvement in physical activity can have even better balance than the recreationally active and sedentary individuals.

Methodology

Research Design

This was a non-experimental approach to a comparative research design. This design was used to compare reaction time and postural stabilization between three activity level groups for

older adults. The independent variable was the activity group which consisted of three levels: sedentary, recreationally active, and master's athlete. The dependent variables were postural stability and simple and choice reaction time.

Participants

A total of 59 subjects, 55 years old and above, participated in the study. The subjects were stratified by activity groups. Thirteen subjects were master's athletes, 27 recreationally active, and 19 sedentary individuals. The subjects had to maintain a standing position without assistance and have no known cognitive impairments. The subjects were recruited through a data base of a larger study, through flyers, and by word of mouth of researchers.

Measures

Physical Activity Group. To determine the physical activity group of the participants, a survey called Rapid Assessment of Physical Activity (RAPA) was completed by the subject. This survey was found to be a valid and reliable test to measure the level of participation in physical activity for an individual who is 50 years old or more (Topolski et al., 2006). This survey has seven items that describe physical activity that the subject may participate in. The subject chose "yes" for the statement that the individual felt best represented his or her activity level. There were two additional items, one asking about weight training frequency and the other on flexibility training frequency. Following survey completion, the subject's physical activity group was established as well as subject's participation in strength and flexibility exercises. To be categorized as sedentary the individual had to answer "yes" to a statement from items one through five, all of these items describe being physically active less than the ASCM guidelines. To be recreationally active, the individual had to choose either statement six or seven, both of

these statements said that the individual is at least, if not more, active than the ACSM guidelines. Finally, to be considered a master's athlete the individual had to select either statement six or seven and note to the researcher that they have competed in a nationally sanctioned event within the last 6 months.

Reaction Time. Reaction time was recorded using the MoART Reaction Time System (Lafayette Instruments, Lafayette, IN). The subject performed three sets of 10 repetitions with a 15 second break in between each set. The subject completed simple and choice reaction time tests. The first reaction test conducted was the simple reaction test. The subject started with index fingers on the bottom of the board on the tape that marked out the start location. There was only one sensor that the subject had to focus on. Each time the light above the sensor turned on the subject had to move the dominant hand's index finger to hit the black sensor under the light as soon as possible. There was a random time interval of one to three seconds between each repetition. Once the subject hit the sensor, the subject replaced the index fingers back onto the tape. Once the 10 repetitions and three sets were completed, the average time was recorded. The second test proctored was the choice reaction test. The subject started the same way as the simple reaction test with both pointer fingers on the marked tape. In choice reaction there were eight potential lights that could go off and each had a black sensor underneath. There were four sensors on the left side and four on the right. The subject had to use the left pointer finger for the left side and the right pointer finger for the right side. The cue, which was a red light, went off with a randomized time interval that ranged from one to three seconds. The subject hit the correct sensor and then placed both pointer fingers back on to the pieces of tape on the table. Once the 10 repetitions and three sets were completed the average time was recorded.

Postural Stability. The Biodex Balance System SD was used for balance assessment. This system has been tested and shown to be valid and reliable for older adults (Parraca et al., 2011). The pre-set test fall risk assessment was used for measuring the individual's postural stability. For this test the first thing the researcher did was recorded the subject's number, age, and height range. After these data were entered, the subject was asked to step onto the balance platform with feet about shoulder width apart. The platform started off stable. The researcher then asked the subject to hold onto the handles and as the platform was released and became unstable. After the subject felt comfortable on the unstable platform, the subject shifted his or her weight until the dot on the screen on the Biodex Balance System SD was stable and centered. Once the dot was centered, the researcher started the test. In this assessment, the balance platform was unstable for 30 seconds and throughout the 30 seconds the balance platform became increasingly unstable. The objective of the subject was to keep the dot on the screen centered and still. The subject could do that by remaining balanced and centered on the platform without touching the handles for assistance. The researcher recorded the amount of touches per trial. The platform setting started at level six and progressively became less steady throughout the test until it finished at a level two. This test was repeated three times with a 10-second break between each set. Once the test was over, the results showed the score of the balance test and standard deviation.

The Biodex Balance System created reports for the test mode and the results were used to measure and record the subject's ability to maintain postural stability in a bilateral position. The data was sampled at a rate of 20Hz. The Y component represented the degree of movement in the anterior/posterior direction of the center of pressure and the X component represents the degree of movement in the medial/lateral direction of the center of pressure. In a perfectly balanced state

the center of pressure was at the coordinates of (0,0). Equation 1 shows how to solve for the individual's overall stability, which was the overall angular movement of the subject's center of pressure. The more movement is indicative of less postural stability. Equation 2 represents the degree of movement in the anterior/posterior direction which occurs in the sagittal plane. Equation 3 represents the degree of movement in the medial/lateral direction which occured in

the frontal plane. Equation 4 represents the mean deflection of the individual which is the average position in all motions throughout the test. Equation 5 represents the anterior/posterior deflection which was the average position of the individual in the sagittal plane throughout the test. Equation 6 represents the medial/lateral deflection which is the average position of the individual in the frontal plane throughout the test. Equation 7 represents the standard deviation which accounts for the variability in the statistical measure. The lower the standard deviation, the range of values were closer together. The larger the overall stability index score, the worse postural stabilization.

$$(DI) = \sqrt{\frac{\Sigma\,(0 - X)^2 + \Sigma\,(0 - Y)^2}{\text{number of samples}}} \tag{1}$$

$$DIy = \sqrt{\frac{\Sigma\,(0 - Y)^2}{\text{number of samples}}} \tag{2}$$

$$DI_x = \sqrt{\frac{\Sigma\,(0 - X)^2}{\text{number of samples}}} \tag{3}$$

$$\text{Mean Deflection} = \frac{\underset{n}{\Sigma}\,|(X_n,\,Y_n)|}{n} \tag{4}$$

$$|(X_n,\,Y_n)| = \sqrt{X_n^2 + Y_n^2}\ \text{(position vector magnitude)}$$

$$\text{A/P Mean Deflection} = \frac{\underset{n}{\Sigma}\,Y_n}{n} \qquad \begin{array}{l} n = \text{\# of samples} \\ Y_n = n\text{ th sample} \end{array} \tag{5}$$

$$\text{M/L Mean Deflection} = \frac{\underset{n}{\Sigma}\,X_n}{n} \qquad \begin{array}{l} n = \text{\# of samples} \\ X_n = n\text{ th sample} \end{array} \tag{6}$$

$$\text{Standard Deviation} = \frac{\underset{n}{\Sigma}\,\sqrt{(X_n - \bar{X})^2}}{n} \qquad \begin{array}{l} n = \text{\# of samples} \\ X_n = n\text{ th sample} \\ \bar{X} = \text{mean deflection} \end{array} \tag{7}$$

Physical Function. The 6-minute walk test was used to measure each individual's physical function. This submaximal test has been shown to be valid and reliable for older adults (Forman et al., 2012). In this test, the subjects were asked to walk as quickly and as safely as

possible for six minutes. Once the time was up, the researcher had the subject stop wherever they were at six minutes and measured the distance the individual walked.

Procedures

Once the University IRB approved this study to be conducted, 59 older adults were recruited to participate in the study. Researchers recruited 13 master's athletes, 27 recreationally active, and 19 sedentary individuals. The researchers started by giving the subjects the RAPA to be able to identify the physical activity group of the individual. Then the individual started the reaction time tests. The subject performed simple and then choice reaction time tests. Each test had 3 sets of 10 repetitions. Between each repetition there was a randomized one to three second interval. Between each set there was a 15 second break. Once the subject completed the RAPA and reaction time tests, the subject was tested on the Biodex Balance System SD to find the subject's postural stability. The pre-set test, Fall Risk Assessment was used for this study. In this assessment, the balance platform was unstable for 30 seconds and throughout the 30 seconds the balance platform became increasingly unstable. The objective of the subject was to keep the dot on the screen centered and still. The subject could do that by remaining balanced and centered on the platform without touching the handles for assistance. The researcher recorded the amount of touches per trial. The platform setting started at level six and progressively became less steady throughout the test until it finished at a level two. This test was repeated three times with a 10-second break between each set. Once the test was over, the results showed the score of the balance test and standard deviation. After the postural stabilization test, the subject performed the 6-minute walk test to find the subject's level of physical function. For the 6-minute walk test, two cones were set up 75 feet away from each other. The subject walked from cone to cone as quickly and as safely as they could in six minutes. When the six minutes were up, the subject had

to stop and the researcher recorded the amount of feet the subject walked. Once the amount of feet was measured, the researcher converted that distance into meters.

Statistical Analysis

To compare the simple and choice reaction time and the postural stability between each physical activity group three one-way analysis of variances (ANOVA) were performed. An additional one-way analysis of variances was performed in order to compare the physical function level between the three activity groups. In this study, there were four levels of dependent variables and those were six-minute walk test, simple reaction time, choice reaction time, and postural stability. This study contained three levels of independent variables and those were master's athletes, recreationally active, and sedentary activity groups. For hypothesis one, simple and choice reaction time will be the dependent variables and the activity groups will be the independent variables in the one-way ANOVA. For hypothesis two, postural stabilization will be the dependent variable and the activity groups will be the independent variables in the one-way ANOVA. The results were significant if the p-value was less than .05. SPSS was used to perform the data analysis. To determine effect sizes, Cohen's f and Cohen's d tests were also performed.

Results

The means and standard deviations for multiple variables are shown in Table 1. Overall there were 59 subjects in the study. Thirteen were master's athletes, 26 recreationally active, and 19 sedentary subjects. In this study, 58 subjects completed the six-minute walk test, 59 completed the simple and choice reaction tests, and 51 completed the Biodex Balance Test. The average for all subjects for the 6 minute walk test was 587.63 ± 121.32 meters. The master's

athletes walked 654.29 ± 100.68 meters, the recreationally active walked 575.01 ± 129.99 meters, and the sedentary group walked 559.89 ± 110.13 meters. There was a trend occurring for the 6 minute walk test between groups, $F(2, 55) = 2.76$, $p = .07$, yet there were no statistically significant differences between the groups. After running a cohen's f test, a moderate effect size $f = 0.32$ was found, which is shown on Table 1. A cohen's d test was run to compare the effect sizes between each activity group. A moderate effect size of $d = 0.78$ was found between the sedentary group and the master's athletes and a moderate effect size of $d = 0.65$ between the recreationally active and master's athletes groups shown on Table 2. There was a small effect size of $d = 0.12$ found between the sedentary and recreationally active activity groups. Figure 1 depicts the differences of the meters walked between the activity groups.

As seen in Table 1, the average simple reaction time was 570.63 ± 126.01 milliseconds. Master's athletes had a simple reaction time of 504.00 ± 71.60 milliseconds, recreationally active had a simple reaction time of 601.11 ± 126.09 milliseconds, and the sedentary group had a simple reaction time of 572.89 ± 142.04 milliseconds. A trend occured for the simple reaction test between activity groups, $F(2, 56) = 2.77$, $p = .07$, showing there were differences between the groups, yet none were statistically significant. After running a cohen's f test, a moderate effect size of $f = .31$ was found between the activity groups. Table 2 shows that there was a moderate effect size between sedentary and master's athletes $d = 0.55$ and between recreationally active and master's athletes $d = 0.77$. Figure 2 displays the differences between activity groups for simple reaction time. The overall average of choice reaction time was 893.12 ± 225.79 milliseconds. Master's athletes had an average of 781.85 ± 156.16 milliseconds, recreationally active had an average of 940.85 ± 229.79 milliseconds, and the sedentary activity group had an average of 901.42 ± 243.53 milliseconds in choice reaction time as shown on Table 1. Table 1

shows that there were no significant differences $F(2, 56) = 2.29$, $p = .11$, but there was a moderate effect size of $f = .29$. Table 2 shows that there was a moderate effect size between sedentary and master's athletes of $d = .53$ and recreationally active and master's athletes of $d = .70$, for choice reaction time. Sedentary and recreationally active activity groups had a small effect size of $d = 0.17$. Figure 2 depicts the differences in choice reaction time between the three activity groups.

Another variable that is shown on Table 1 is postural stabilization which was measured by the movement of the center of pressure. The average overall postural stabilization score was 3.62 ± 2.28. The master's athletes had an average sway of 2.75 ± 1.70, recreationally active had a sway of 3.83 ± 2.10, and the sedentary activity group had an average sway of 3.73 ± 2.69. As shown in Table 2, there were no significant differences between the groups, $F(2, 48) = .70$, $p = .51$. There was also a small effect size between the groups of $f = .17$. There were small effect sizes between all three activity groups as well.

After running the original tests in this study, the researcher split the subjects up based on the amount of meters walked during the six minute walk test. The three groups were the top third in the six minute walk, middle third in the six minute walk test, and the bottom third in the six minute walk test. The group who walked the least amount of meters was Group 1 and they had an average of 449.76 ± 77.09 meters, the group who walked the second least amount of meters was Group 2 and they had an average of 598.38 ± 19.17 meters, and Group 3 was the group who walked the most meters in six minutes with an average of 708.96 ± 59.63 meters. Postural stabilization and simple and choice reaction time were compared between these three groups. It was found that there was a significant difference between groups during the six minute walk test $F(2, 55) = 99.86$, $p < .001$. There was a post hoc test to see where the differences lie and it was

found that there was a significant difference in meters walked between each group and all of the groups had a significance of $p < .001$.

A one-way ANOVA was run for simple reaction time it was found that there was a signficiant difference between groups, $F(2, 55) = 9.31$, $p < .001$. Group 1 had an average simple reaction time of 653.68 ± 170.05 miliseconds, Group 2 was 535.63 ± 67.18 miliseconds, and Group 3 was 513.35 ± 48.83 miliseconds. A post hoc Bonferroni test was run to find the difference between the groups and there was a significant difference between Group 1 and Group 3, $p = .001$ and Group 1 and Group 2, $p = .004$. There were no significant difference between the Group 3 and Group 2, $p = 1.00$. Another one-way ANOVA was performed to find if there was a difference between groups in choice reaction. In choice reaction time Group 1 had an average of 1052.84 ± 275.47 miliseconds, Group 2 was 847.84 ± 144.79 miliseconds, and Group 3 was 765.00 ± 105.43 miliseconds. There was a statistically significant difference between groups in the choice reaction time $F(2, 55) = 11.95$, $p < .001$. A post hoc analysis was completed to see the differences between each group and it was found that choice reaction time was significantly different between Group 1 and Group 2 , $p < .004$ and Group 1 and Group 3, $p < .001$. There was no significant difference between Group 2 and Group 3, $p = .527$.

In order to compare postural stabilization between the groups a one-way ANOVA was used. There were no statistically significant differences between the groups, $F(2, 47) = .293$, $p = .75$. Group 1 had a balance score of 3.92 ± 2.27, Group 2 had a balance score of 3.35 ± 2.17, and Group 3 had a balance score of 3.75 ± 2.56. A post hoc test was performed and between each group there were no significant differences.

Table 1

Summary of means and standard deviations of multiple variables for each activity group

	Overall	Master's Athletes	Recreationally Active	Sedentary	Signfigance (p)	Cohen's f
N	59	13	27	19		
Age (years)	66.46 ± 9.47	59.23 ± 4.80	69.96 ± 9.82	66.42 ± 8.85		
Height (cm)	169.24 ± 8.69	166.95 ± 9.34	170.65 ± 9.24	168.79 ± 7.42		
Weight (kg)	74.80 ± 16.30	67.62 ± 14.58	76.06 ± 14.10	77.93 ± 19.43		
6 min walk (m)	587.83 ± 121.32	654.29 ± 100.68	575.01 ± 129.99	559.89 ± 110.13	.07	.32
SRT (ms)	570.63 ± 126.01	504.00 ± 71.60	601.11 ± 126.09	572.89 ± 142.04	.07	.31
CRT (ms)	893.12 ± 225.79	781.85 ± 156.16	940.85 ± 229.79	901.42 ± 243.53	.11	.29
PS	3.62 ± 2.28	2.75 ± 1.70	3.83 ± 2.10	3.73 ± 2.69	.51	.17

Note. n = number of subjects; SRT = simple reaction time; CRT = choice reaction time; PS = postural stabilization.

Table 2

Effect size between each group for each variable tested

	Effect Size (Cohen's *d*)			
	Reaction Time			
	6 min walk	Simple	Choice	Balance
Sed vs. Rec	0.12	0.22	0.17	0.04
Sed vs. MA	0.78	0.55	0.53	0.43
Rec vs. MA	0.65	0.77	0.70	0.47

Note. Sed = sedentary; Rec = Recreationally active; MA = Master's athlete.
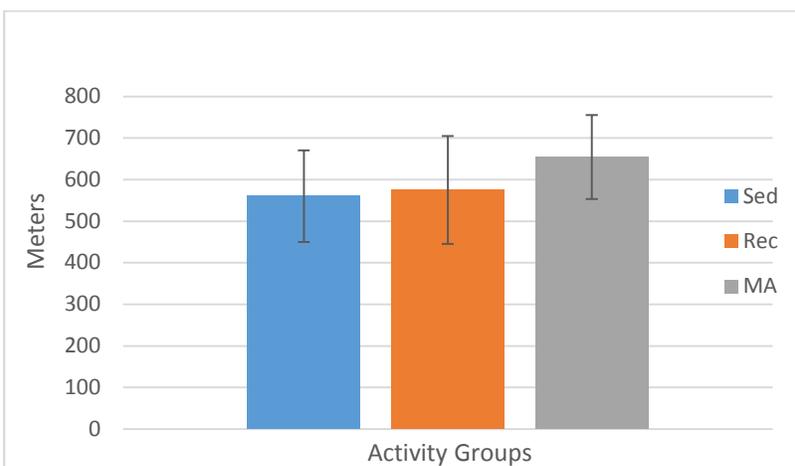

Figure 1. Average meters walked in the six-minute walk test for each activity group.
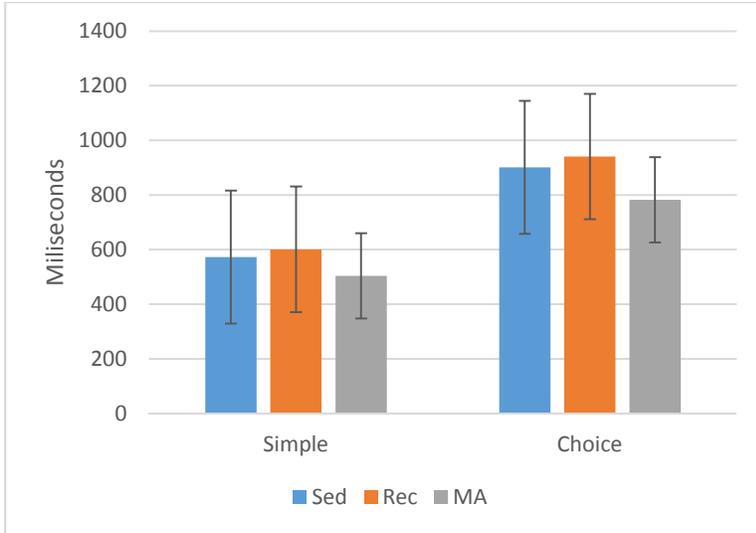
Figure 2. Average simple and choice reaction times in milliseconds for each activity group. Error bars represent standard deviation.
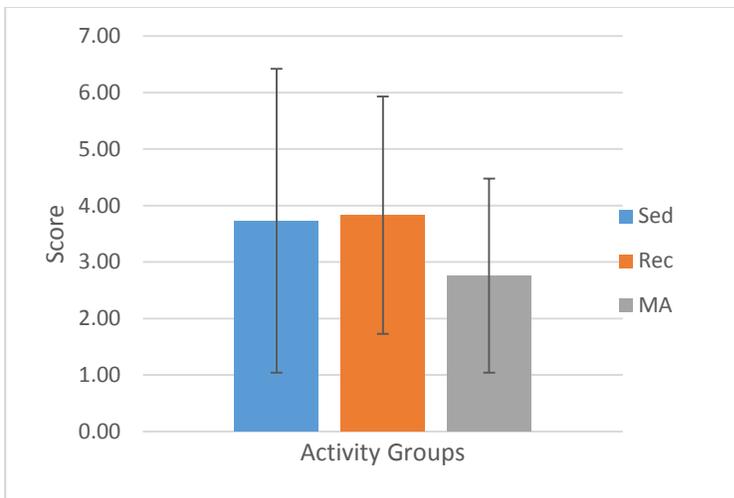

Figure 3. Average balance score for each activity group. Error bars represent standard deviation.

Table 3

Post hoc overall means and ANOVA variables for each group

	Overall	Group 1	Group 2	Group 3	Signfigance (*p*)
n	58	19	19	20	
6 min walk (m)	587.83 ± 121.32	449.76 ± 77.09	598.38 ± 19.17	708.96 ± 59.63	.00*
SRT (ms)	566.62 ± 123.26	653.68 ± 170.05	535.63 ± 67.18	513.35 ± 48.83	.00*
CRT (ms)	886.43 ± 221.79	1052.84 ± 275.47	847.84 ± 144.79	765.00 ± 105.43	.00*
PS	3.67 ± 2.28	3.92 ± 2.27	3.35 ± 2.17	3.75 ± 2.56	.75

Note. n = number of subjects; SRT = simple reaction time; CRT = choice reaction time; PS = postural stabilization. Statistical significance, *p* < .05, is signified by *.

Discussion

The results show that the first hypothesis which stated, the reaction time will be the fastest in the master's athletes group, then recreationally active group, and slowest in sedentary group, was not statisitcially supported. Yet, there was a trend in simple reaction time, $F(2, 56) = 2.77$, $p = .07$ showing that differences could potentially be present between the groups. Choice reaction had a slightly lower trend with $F(2, 56) = 2.29$, $p = .11$. A cohen's f test was run to see the effect size between the three activity groups. There was a moderate effect size for both simple, $f = 0.31$ and choice reaction, $f = 0.29$ times. A cohen's d test was run to determine which groups had the largest effect size and it was found that between the master's athlete group and recreationally active group and between the master's athlete group and the sedentary group there was the largest effect size. Both were moderate effect sizes, $d > 0.50$. This trend agreed with Rotella and Bunker (1978) that found that there was a significantly faster simple reaction time in master's athletes versus their sedentary counterparts. Rotella and Bunker used master's athletes who were tennis players and found sedentary individuals who were the same age and compare their simple reaction times. Their study showed that there was a difference in reaction time between groups and since they were tennis players, reaction time is extremely important to move and react the the ball. In this study, the master's athletes were mostly distance runners or triathathletes so reaction time was not as critical in these individuals sports. So this study differs by also comparing active individuals who do not focus on reaction time versus sedentary individuals. Yet there was still a small effect size between recreationally active and sedentary groups in simple reaction time, $d = .22$ and choice reaction time, $d = .17$ may be because there was not a significant difference in physical function levels for those two groups, $d = .12$. This conclusion is inferred from Swain et al. (2003), who found that an increase in exercise leads to

an increase in blood flow to the brain which causes an improvement in cognitive functioning such as executive functioning (Filipe Marmeleira et al., 2011). There may not have been a significant difference between activity groups for simple or choice reaction time, but there is a trend and a moderate effect size trending to master's athletes having a faster simple and choice reaction time compared to the recreationally active and sedentary activity groups. Filipe Marmeleira et al. (2011) looked at both simple and choice reaction timein older adults who drove to look at movement and decision making time which are both extremely important in driving. He had 26 subjects assigned to either exercise or control group. The exercise group had an exercise program that occurred three times a week for an hour for eigth weeks. The subject was in one car and the researcher was in another car. As soon as the researcher put his foot on the break and the light went off the subject had to slam on the brake as quickly as possible. Filipe Marmeleira (2011) found that the exercise group had a significantly faster reaction time for both choice, $p = .004$ and simple reaction time, $p = .015$ versus the control group. Although there is not statistical difference between the groups in this study, the moderate effect size of the master's athletes is trending in the same direction as the conclusions from Filipe Marmeleira (2011). The results may have been different for this study because of how the activity groups were determined. Activity groups were determined based off of the RAPA, a self-reported recall of an individual's physical activity involvement. This is important to note because the some individuals that were classified in the sedentary group could have potentially been in the recreationally active group and vice versa. The six-minute walk test was used to assess physical function in order to see if there truly was a difference in physical function between exercise groups. The only activity group that had a moderate effect size, $d > 0.50$, compared to the other two groups in the 6 minute walk test was the master's athlete group. These results show that

there may not have been a large difference in physical functioning, or aerobic capacity, between sedentary and recreationally active individuals.

The second hypothesis was that the least amount of movement of the center of pressure during postural stabilization will be in the master's athletes group, then recreationally active group, and largest in the sedentary group and this was also statistically unsupported, $F(2, 48) = .697$, $p = .51$. These results do not agree with Seco et al. (2013) who found conducted a study that 247 subjects all of which had a baseline test done for balance, a nine month intervention that was two sessions a week of walking and balance and strength exercises, a post test balance test, and finally a three month follow up. With that said, these individuals were trained specifically for balance and had a repeated measures test which could lead to learning how to perform the tests better. It was found that there was an improvement in balance after the training program but these changes were lost in the three month follow-up. Further showing that exercise, especially balance specific exercise can help with one's balance scores or decrease their movement of center of mass. The subjects in this study were not asked if they were in balance classes and that can play a role in differences in balance scores. In this study there were only 51 subjects that completed the Biodex Balance Test and only eight out of the 13 master's athletes completed the balance test. The reason there were fewer subjects in this assessment was because IRB approval for the Biodex Balance System was granted after the start of the larger study. A power analysis was run and it was found that if there was a sample size of 540 individuals there would be an actual power of 0.95. This test had a very small effect size of $f = .17$ and all effects sizes between activity groups were small. Another reason for that may be because of how close the physical function was between sedentary and recreationally active groups.

Once the testing and statistics were run, post hoc analyises were run to see if there may be a difference in reaction time and postural stability based on functional fitness. The groups were determined based off of the six-minute walk test results. The first group was the lower third of meters walked in the six-minute walk test, the second group was the middle amount of meters walked, and the third group was top third of most meters walked. After running a one-way ANOVA for both simple and choice reaction, it was found that there was a significant difference between the groups, $p < .001$. This agrees with all the research stated above. The more aerobically trained the individuals were, the better their reaction times. A post hoc data analysis was run after the ANOVA to find where the differences lie and the largest differences between groups are between Group 1 and Group 2 and between Group 1 and Group 3. Another one-way ANOVA was run to see if there was a significant difference between groups for postural stabilization. It was found that there were no significantly different results, $p =.75$. These results show there were no differences between activity levels for postural stabilization. This may be due to the fact that these subjects could be trained in balance and have a good score from balance training not because they are aerobically fit and vice versa.

Overall, there were no statistically significant differences between any of the groups for any of the variables. There was a moderate effect size for both simple and choice reaction times and the groups that differed the greatest were between master's athletes and sedentary and between master's athletes and recreationally active activity groups. A major reason there were small effect sizes between sedentary and recreationaly active activity groups most likely came from the fact that their physical function capacity was about the same. A reason this could have happened was because there could be error included in the self-reported amount of physical activity that was performed.

Threats to Internal/External Validity

A potential threat to internal validity was that the subject was in a new lab setting and may not have had a top performance because of fear of failure while researcher was in the room. Another threat to internal validity was that the RAPA was a self-reported amount of exercise the subject feels they participated in. This survey determined which activity group the individual was a part of and an individual could easily over or under estimate their activity level. An external threat to validity may be that some of the subjects could be participating in balance classes offered through their fitness facilities. This is a threat to external validity because it can cause activity groups that are considered sedentary could be avoiding aerobic activity but taking balance classes. With the specific balance training that individual could out perform a fellow activity group member because of training specificity. Another threat to external validity was that majority of the subjects were recruited from a previous study. This is a threat to validity because it is a convience sample and not truly a random sample. Another threat to external validity was ecological validity because the tests were not in natural settings/conditions so not all results can be directly applied to real life situations. A final threat to validity was that the groups were not all homogeneous in their ages.

Assumptions

It was assumed that the subjects answered the RAPA to the best of his or her knowledge and completed the postural stability and reaction time tests to the best of his or her ability. It was also assumed that all equipment used were calibrated and operating correctly. The researcher also assumed the individuals had no known cognitive impairment.

Limitations

Limitations to this study are that the physical activity group was determined through self-reported physical activity involvement, sample size was small, and the measure of variables accuracy may not have been precise enough especially in the physical function test.

Delimitations

This study had 59 subjects. Nineteen were sedentary, 27 recreationally active, and 13 master's athletes were in the study. To be a part of the study the subject had to be 55 years or older. Postural stabilization was measured using the Biodex Balance System SD and postural stability was compared between physical activity groups (master's athlete, recreationally active, and sedentary individuals). Reaction time was measured by MoART and compared between physical activity groups. Physical function was measured through the 6-minute walk test and compared between physical activity groups. This study took place in University of Arkansas Human Performance Lab.

Conclusion

There were no significant differences between activity groups based off of a self-reported physical activity questionnaire. But when the groups were separated based off of the six-minute walk performance, there was a significant difference between groups for simple and choice reaction. Still no statiscially significant difference between groups in postural stabilization.

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Appendix

IRB Aproval Form

UNIVERSITY OF
ARKANSAS

Office of Research Compliance
Institutional Review Board

November 3, 2016

MEMORANDUM

TO: Michelle Gray   Jennifer Vincenzo
                             Katherine Adams   Whitney Freeman
                             Ashley Binns   Matthew Stone
                             Felicia Squires

FROM: Ro Windwalker
                             IRB Coordinator

RE: PROJECT MODIFICATION

IRB Protocol #:   16-01-488

Protocol Title: *A Follow-Up Study on Differences in Physical Function, Dual and Single-Task Gait, Anthropometric Measures, and Lower-Body Power Among Late-Middle Aged and Older Sedentary, Recreationally Active, Masters Athletes*

Review Type: ☐ EXEMPT   ☒ EXPEDITED   ☐ FULL IRB

Approved Project Period: Start Date: 10/31/2016 Expiration Date: 02/07/2017

Your request to modify the referenced protocol has been approved by the IRB. **This protocol is currently approved for 150 total participants.** If you wish to make any further modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

Please note that this approval does not extend the Approved Project Period. Should you wish to extend your project beyond the current expiration date, you must submit a request for continuation using the UAF IRB form "Continuing Review for IRB Approved Projects." The request should be sent to the IRB Coordinator, 109 MLKG Building.

For protocols requiring FULL IRB review, please submit your request at least one month prior to the current expiration date. (High-risk protocols may require even more time for approval.) For protocols requiring an EXPEDITED or EXEMPT review, submit your request at least two weeks prior to the current expiration date. Failure to obtain approval for a continuation *on or prior to* the currently approved expiration date will result in termination of the protocol and you will be required to submit a new protocol to the IRB before continuing the project. Data collected past the protocol expiration date may need to be eliminated from the dataset should you wish to publish. Only data collected under a currently approved protocol can be certified by the IRB for any purpose.

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