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Fall Risk in Sedentary, Recreationally Active, and Masters Athlete Older Adults

Felicia Elizabeth Squires

University of Arkansas, Fayetteville

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Felicia Squires
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Michelle Gray, Ph.D.
Thesis Director

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Nicholas Greene, Ph.D.
Committee Member

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Tyrone Washington, Ph.D.
Committee Member

Abstract

The purpose of this study was to examine whether different habitual activity levels may affect balance ability in older adults. Balance must be studied as poor balance increases likelihood of falls. This study examined activity levels in older adults and effect on balance ability. Fifty-nine older adults aged 66.5 ± 9.5 participated. Three groups were separated by physical activity level. First group had 13 masters athletes, older adults performing least 150 minutes of aerobic activity a week and competing in nationally sanctioned event within the last six months. Twenty-seven older adults comprised recreationally active group performing at least 150 minutes of aerobic exercise per week but no competitive events within previous six months. The last group is sedentary older adults with 19 individuals performing less than 150 minutes of aerobic exercise per week. Postural stabilization was measured using Biodex Balance System SD. Using one-way ANOVA, no statistically significant differences were found between three activity groups in postural stabilization (p = .51). Groups were redefined for post hoc analysis using distance results from six-minute walk test as a measure of physical fitness. Results were divided into thirds and classified into physical function levels. Group one, walking the fewest meters, was least fit. Group 2 walked the next fewest meters with middle level of physical function. Group 3 completed most meters, therefore most physically fit. By comparing fitness groups using one-way ANOVA, no statistically significant differences were found in postural stability (p = .75). Subjects were divided into three groups to test for age effects. The young group consisted of 13 adults aged 54-59 years old. Twenty-one adults aged 60-69 were the middle group, while 17 adults aged 70-91 were the older group. No statistically significant difference was found in age groups (p = .48). Thirty-two females and 27 males were compared for sex differences. A significant difference was found (p = .001) with females exhibiting better postural stability. In conclusion, neither habitual activity level nor physical function level

influence postural stability in older adults. Age does not play a significant role in postural stability, but one’s sex may have an effect.

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Table of Contents

Introduction

Falls are a common occurrence among older adults. Each year, one in three adults over the age of 65 will experience a fall (Hausdorff, Rios, & Edelberg, 2001). For individuals over 80 years, 50% will be experience a fall (Inouye, Brown, & Tinetti, 2009). While roughly 30-50% of falls result in bruises or lesions, 5-10% of falls end in fractures (Goldacre, Roberts, & Yeates, 2002) or traumatic brain injuries (Rubenstein & Josephson, 2002). Falls without immediate injuries can still have grave consequences. Falls can result in a fear of falling limiting mobility (Rubenstein & Josephson, 2002) and activity (Tinetti & Powell, 1993). Furthermore, fear of falling can lead to deconditioning, depression, and feelings of isolation -creating an increased risk for future falls.

There are various risk factors for such falls. Age, chronic disease, gait impairment, and balance disorders are considered intrinsic risk factors (Sartini, Cristina, & Spagnolo, 2010). Environmental issues, including dim lighting, frayed rugs, and lack of grab rails, pose as extrinsic risk factors for falls (Axer, Axer, Sauer, Witte, & Hagemann, 2010). In a comprehensive review examining falls including 12 studies and 3,628 falls, 31% of falls were due to accidents, 17% were contributed to gait and balance disorders, and 13% were due to dizziness and vertigo (Rubenstein & Josephson, 2002). If such risk factors can be modified, the number or severity of falls could be reduced. Individuals who are impacted by these factors have a higher risk of falling than if the factors were not present. Fall risk is defined as is the likelihood of experiencing a fall. Therefore, individuals with more risk factors for falls have a higher fall risk. Fall risk can be evaluated by the number of risk factors one has in addition to measures from both clinical and field assessments. While there is a known relationship between increased fall risk and poor balance, the direction of the relationship is unknown. More research would need to be conducted to determine if an increased fall risk causes poor balance or if poor balance highlights an increased fall risk. Balance is defined as the state of an object when resultant forces acting upon the object is zero (Pollock, Durward, Rowe, & Paul, 2000). Balance in humans is a multidimensional concept with the primary goal of avoiding a fall. While there any many aspects of balance, fall risk is one aspect that can be measured and potentially used in fall prevention plans.

Postural control is the ability to stand upright or recover equilibrium after external perturbations (Lafond, Corriveau, Hebert, & Prince, 2004). Components of balance include visual, vestibular, and somatosensory systems. With aging, these systems become less efficient due to longer latency times and slower central integration (Perrin, Jeandel, Perrin, & Bene, 1997). Woollacott, Shumway-Cook, and Nashner (1986) tested balance in older and younger adults in various conditions to examine changes in sensory organization. The following conditions were utilized normal fixed support surface, normal support surface with eyes closed, normal support surface with a visual enclosure, support surface servoed with eyes open, support surface servoed with eyes closed, and support surface servoed with vision servoed. To examine the contributions of sensory inputs, a servo technique was used in which the input being tested was congruent with body sway. This technique nearly eliminated rotational changes in orientation of the body center of mass with respect to the support surface or visual enclosure. Specifically, in the support surface servoed with eyes open, the support surface rotated in proportion to the sway of body mass. With reduced or conflicting information from any one of the vestibular, visual, and somatosensory systems, the balance ability of older adults was compromised. Furthermore, while muscle coordination and sensory organization were related to age-related changes in postural control, no correlations between motor and sensory changes were detected suggesting that a deficiency in one area does not predict deficiency in the other.

While many fall prevention plans exist, various protocols often lead to contradicting results. Lord and Castell (1994) found significant improvements in quadriceps strength and body sway of an exercise group compared to a control group. The exercise group met twice a week for 20 weeks with sessions focusing on cardiovascular and aerobic exercises focusing on flexibility and muscular strength. Schlicht, Camaione, and Owen (2001) examined standing balance, walking speed, and sit to stand performance in older adults following an intense strength training program. The exercise group increased muscular strength, maximal walking speed, and five repetitions sit to stand significantly compared to the control group. However, the standing balance component of eyes closed single leg stance did not differ between the two groups. While fall prevention plans try to add components to improve balance and decrease fall risk, little research has examined the subjects' activity levels and fall risk without an intervention. The purpose of this study is to examine whether different habitual activity levels effect balance ability in older adults. Additionally, age and sex will be examined to determine if such factors influence balance ability.

Operational Definitions

Balance has no universal definition. For the current study, balance is defined as the state of an object when resultant forces acting upon the object is zero (Pollock, Durward, Rowe, & Paul, 2000) with the main goal of remaining upright to avoid a fall. Balance is closely related to postural control. Postural control is the ability to stand upright or recover equilibrium after external perturbations (Lafond, Corriveau, Hebert, & Prince, 2004). While postural control itself cannot be measured, it can be assessed through postural stabilization. Postural stabilization is defined as the amount an individual moves their center of mass while maintaining balance (Shumway-Cook, Woollacott, Kerns, & Baldwin, 1997). Fall risk is the likelihood that one will experience a fall. In the current study, fall risk often references the fall risk assessment by the Biodex Balance System SD in which the program assesses one's likelihood of experiencing a fall compared to age-related normative data. In the current study, sedentary individuals refer to those that do not get 150 minutes of aerobic exercise per week (ACSM, 2014). Recreationally active individuals refer to those individuals that perform at least 150 minutes of aerobic exercise each week (ACSM, 2014). Masters athletes refer to individuals that perform at least 150 minutes of aerobic exercise per week and have competed in a nationally sanctioned event within the last six months (Zhao et al., 2016). Physical function is defined as the ability to successfully complete basic actions and complex activities vital to independence and quality of life (Painter, Stewart, & Carey, 1999). The term servoed is used to describe a situation in which the variable being tested is manipulated so the subject has no frame of reference.

Literature Review

As balance is a multidimensional concept, various components play a role in maintaining one's balance. Vision, vestibular, somatosensory, cognitive and motor systems all contribute to maintaining balance (Horak, Shupert, & Mirka, 1989). Vision is the primary system in planning movement and avoiding obstacles. Visual acuity, contrast sensitivity, and area of visual field become impaired with age, increasing the risk of falls (Freeman, Muñoz, Rubin & West, 2007). The vestibular system senses motion, equilibrium, and spatial orientation in relation to movements of the head. Vertigo, an illusory sense of motion, along with vestibular imbalance increases the risk of falls with age (Agrawal, Carey, Della Santina, Schubert, & Minor, 2009). The somatosensory system provides information about the external environment. As the somatosensory system changes with age, older adults experience impaired proprioception, vibration and discriminative feeling (Shaffer & Harrison, 2007). Various aspects with cognition decline with age. Executive function which includes inhibition, working memory, and attentional capacity become impaired (Salthouse, Atkinson, & Berish, 2003). In examining center of foot pressure with cognitive tasks, subjects focused on cognitive tasks more than the balance task (Shumway-Cook, Woollacott, Kerns, & Baldwin, 1997). As cognition declines, older adults are not able to equally focus on multiple tasks resulting in impaired tasks, typically in balance. As with other aspects of balance, motor performance greatly influences fall risk. Motor performance is vital in response to the surrounding environmental and sensory information. Age-related decreases in muscle strength and nerve conduction speed along with increased area and speed of postural sway impairs balance, further increasing the risk of falls. While vision, vestibular, somatosensory, cognitive and motor systems all play a role in maintaining balance, motor performance will be the focus examined.

Few studies have been performed examining fall risk and activity levels in older adults. O'Loughlin, Robitaille, Boivin, and Suissa (1993) examined risk factors for falls. Frequent physical activity was associated with an increased number of falls, likely due to an increase in exposure of opportunities to experience falls. However, increased diversity of physical activity was found to be protective against falls as the activity could better maintain balance, flexibility, reflexes, muscle strength, coordination, and reaction time. Skelton (2001) stated in a review on physical activity and postural stability that increased physical activity can lead to an increased fall risk due to poor environmental conditions, acute fatigue, or unsafe practices. With care and proper technique, exercise and physical activity can lower fall risk in select groups.

Perrin, Gauchard, Perrot, and Jeandel (1999) examined the effects of physical and sporting activities on balance. Four groups were studied. The first group consisted of individuals who had always been physically active (AA). The second group became active after retirement (IA). The third group was active in youth, but stopped activity at least 30 years prior (AI). The last group had never been active (II). Physical and sporting activities practiced were primarily swimming, walking, cycling, tennis, and yoga. Dynamic and static balance tests were performed. The AA group performed best on the balance tests. The IA group had scores close to AA, where AI did not perform as well. The II group had the worst performance on the balance tests. Specifically sway path, sway area, and anterior-posterior sway were all high with a decrease in sports practice. Both short and long latency responses were delayed in those inactive individuals, particularly those II. However, no significant differences were detected in the amplitude of the short and long latency responses. These data suggest that engaging in physical and sporting activities more recently, rather than just early in life or not at all, improves balance measures.

In examining three different types of endurance activities and effects on balance, Buchner et al. (1997) found walking was the most beneficial in a comprehensive analysis. However, based on the balance measures, the aerobics grouped showed the most improvement. Subjects were assigned to an exercise group of low movement stationary cycling, medium movement walking, high level aerobics, or no exercise. Exercising groups met three times a week for three months. After three months, subjects were released from supervised classes and instructed to perform any exercise as desired. After three months of self-directed exercise, measures of strength, aerobic capacity, gait, balance, and health status were assessed. The distance walked on a 6 m narrow balance beam, which was used to measure balance, increased in a dose-response relationship between distance walked and the effect of training. The cycle group improved by 3%, walking by 7%, and aerobics by 18%. However, a dose-response relationship was not demonstrated in other measures. The VO_2max measure of aerobic capacity increased in the walking group by 18%, aerobic group by 10%, and in the cycling group by 8%. The walking group was the only group to improve gait speed which was increased by 5%. Furthermore, walking was the only group which experienced an improved score of the Medical Outcomes Study 36-Item Short Form Survey (SF-36) measure of role limitations due to physical health with an improvement of 24%. The SF-36 is a valid, reliable health-related quality of life survey covering eight domains including the role of limitations due to physical health which examines how one's physical status relates to limitations on quality of life (McHorney, Ware, & Raczek,1993). Walking was the sole exercise that improved at least one measure in each of the categories. Aerobic exercise also provided benefits, but not to the extent walking provided. Cycling had little effect on the measures, while the no exercise control group had no difference in baseline and final measures.

Balance is a unique process encompassing various components. While the components of vision, vestibular, somatosensory, and cognitive systems are vital, the motor system is the most imperative. The motor system translates the sensory and environmental information into a response to maintain balance. Current evidence suggests that active older adults are likely to have better balance performance scores than older adults that are not physically active. However due to limited research, the frequency and mode of physical activity that provide the most benefit for balance scores have yet to be determined.

It has been suggested that factors such as age and sex play a role in the balance abilities. Hageman, Leibowitz, and Blanke (1995) proposed that balance decreases with age. This was determined by comparing the balance of younger adults aged 20 to 35 years along with an older group aged 60 to 75 years. Five measures were tested by way of force platform along with standing functional reach. Measures included sway area with eyes open, sway area with eyes closed, sway area with visual feedback, movement time, and path length. Age appeared to be a significant factor in every measure. The older group experienced greater sway area, longer latency times, greater path length, and shorter functional reach compared to the younger group. Likewise, in examining postural balance in adults aged 30 and older, postural balance was seen to decrease with age (Era et al., 2006). Postural balance was assessed using both laboratory and field measures. Field measures consisted of normal standing eyes open, normal standing eyes closed, semitandem, and tandem standing. Laboratory conditions were the same as the field assessments, but were performed on a force platform. The most drastic decreases in balance ability occurred in individuals older than 60 years. In conclusion while older adults appear to have decreased balance ability compared to their younger counterparts, more research needs to be performed further examining the decrease in older adults. While sex has been studied, conflicting results have been found. In the previously discussed postural control study, Hageman, Leibowitz, and Blanke (1995) found sex to have no significant effect on the six postural control variables. In the postural balance study, Era et al. (2006) also studied sex effects on postural balance. Men had significantly more pronounced sway in laboratory measures than women. Greater sway is suggestive of poorer balance. Regarding field measures, men were more likely to achieve the highest category of field tests which was 10 s of tandem stance. Furthermore, a significantly larger proportion of men were able to stand with feet side by side for 10 s than the proportion of women. While women fared better on the laboratory tests and men had more success with the field tests, more research is needed to determine what relationship, if any, exists between sex and balance.

The purpose of this study was to examine whether different habitual activity levels effect balance ability in older adults. Additionally, age and sex effects were analyzed with balance results. It is important to determine if individuals participating in competitive sports or an increased level of physical activity have better balance than the recreationally active and sedentary counterparts in order to provide guidance to our aging populations. The habitual activity groups in the current study include sedentary older adults, recreationally active older adults, and master athlete older adults. Based on existing research, it is hypothesized that balance ability will decrease with decreasing activity levels. Sedentary individuals will have the highest fall risk and masters athletes will have the lowest fall risk with the fall risk of recreationally active individuals between the two groups. For age groups, it is hypothesized that as age increases, the balance ability will decrease based on postural sway. Females are hypothesized to have lower postural sway than males due to a lower center of gravity.

Methodology

Research Design

This was a non-experimental approach to a comparative research design. This design was used compare postural stabilization between three activity level groups in older adults. The first independent variable was the activity group which consisted of three levels: sedentary, recreationally active, and masters athlete. This design was used to compare postural stabilization between three groups based on physical fitness. Physical fitness was another independent variable also consisting of three levels: low, medium, and high fitness. Age and sex were the last two independent variables tests. Postural stability was compared to age groups which consisted of three levels: young, middle, and old. In comparing sex and postural stability, sex was the independent variable with two levels being male and female. In all cases, the dependent variable was postural stability.

Subjects

A total of 59 subjects, aged at least 50 years, participated in the study. Following informed consent procedures as approved by the Institutional Review Board at the University of Arkansas, all subjects underwent physical activity screenings followed by balance assessments. Subjects were placed into one of three groups based on levels of physical activity. Nineteen subjects were sedentary individuals, 27 recreationally active, and 13 masters athletes. Subjects with uncontrolled cardiovascular disease, metabolic disease, or hypertension will be excluded. Subjects must have had no recent falls in the last 12 months. To be included in the study, subjects must be able to maintain a standing position without assistance and no knowledge of cognitive impairments. Subjects were recruited through a data base of a larger study, through flyers, and word of mouth of researchers.

Measures

Physical Activity Group. To determine the physical activity group of subjects, the subjects completed the Rapid Assessment of Physical Activity Questionnaire (RAPA). The RAPA is a valid and reliable measurement tool of self-reported physical activity in adults over 50 years (Topolski et al., 2006). The RAPA has seven items describing physical activity that the subject may participate in. If the question applies to the subject's activity level, "yes" is selected. Two other items were on the RAPA, one question pertaining to weight training and the other to flexibility training. Based on those results, subjects will be placed into one of three groups. 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 masters 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. By ACSM standards, a sedentary individual performs less than 150 min of moderate intensity exercise per week. To be recreationally active or masters athlete, an individual must perform 150 min of moderate intensity exercise per week with the distinction from aforementioned nationally sanctioned event.

Postural Stability. The Biodex Balance System SD (Biodex Inc., Shirley, NY) was used to measure balance and postural stability under dynamic stress. This system has been tested and shown to be valid and reliable for older adults (Parraca et al., 2011). The Biodex Balance System uses a circular platform free to move in the anterior-posterior and medial-lateral axes simultaneously. The stability of the platform can be varied by adjusting the level of resistance given by the springs under the platform. The platform stability ranges from 1–8, with 1 representing the greatest instability. The lower the resistance level the less stable the platform. In this study, the pre-set fall risk assessment was performed. Stability levels began at level six and progressively became less steady throughout the test and ending at level two. Before the test begins, the researcher recorded the subject's number, age, and height range. During the test subjects were instructed to maintain center of pressure in the smallest concentric rings (balance zones) of the monitor on the Biodex Balance System SD. To begin the assessment, subjects stand on the locked platform of the Biodex Balance System SD. In order to assess the foot position and establish the subjects' ideal foot positioning for testing, the stability platform will unlock to allow motion. Participants were instructed to adjust the position of the foot until they find a position at which they can maintain platform stability. The platform locked again. Foot position coordinates were constant throughout the test session. Testing began as the platform released starting a 20 second trial and participants were asked to maintain an upright standing position. During the test, subjects were instructed to not touch the handles for assistance. In order to maintain balance, a dot on the screen must stay in the center of concentric rings. To keep the dot centered, the subject must perform weight shifts. The objective of the test is to keep the dot centered and stable throughout the test. A 10 second break occurred between each trail. Three trials were performed. The result of the trials is given as a stability index along with standard deviation which compares the subject to age-dependent normative data. Scores higher than the normative values suggest poorer balance while scores below normative values suggest better balance.

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 that occurs is indicative of less postural stability. This value of the overall stability index is the value output by the Biodex Balance System SD. The overall stability index is compared to age-dependent normative data to determine if the individual is below, at, or above the fall risk levels for their age group. 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 occurs in the frontal plane. Equation 4 represents the mean deflection of the individual. The mean deflection of the individual 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 greater the standard deviations, the broader the range of values. The overall stability index score from Equation 1 is the greatest indicator of postural stability, and the focus of the current study.

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

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

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

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

$$|(X_n, Y_n)| = \sqrt{X_n^2 + Y_n^2}\ \text{(position vector magnitude)} \tag{5}$$

$$\text{A/P Mean Deflection} = \frac{\sum_n Y_n}{n} \qquad \begin{array}{l} n = \text{\# of samples} \\ Y_n = n\text{ th sample} \end{array} \tag{6}$$

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

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

Physical Function. A 6-minute walk test was performed to measure each individual's physical function (Enright et al., 2003). This test is a submaximal test which has been shown to be both valid and reliable for older adults (Forman et al., 2012). To perform this test, subjects were asked to walk as quickly and as safely as possible for six minutes. When the six minutes was up, the subject stopped walking wherever they were when time expired. The researchers then measured the distance the subject walked.

Procedures

Once IRB approval was obtained, the recruitment process for older adults to participate in the study began. A total of 59 older adults participated in the study. Thirteen masters athletes, 27 recreationally active, and 19 sedentary individuals were recruited for participation. Upon arrival to the laboratory, the subject was given the RAPA to complete which categorized the individual into the respective physical activity group. Once the RAPA was completed, the subject was tested on the Biodex Balance System SD to determine the subject's postural stability. The pre-programmed Fall Risk Assessment test was utilized for the study. During this assessment, the subject stood on a balance platform that was unstable for 20 seconds. In this 20 seconds, the already unstable balance platform became increasingly more unstable. The subject had a dot on the screen to keep in the middle of concentric rings. The dot stayed centered as long as the subject remained balanced on the platform. If the subject was unstable, the dot would leave the center circle until the subject regained balance. This test was performed three times with a ten second break between each trial. After the three tries ended, the Biodex Balance System SD presented two values. The first value was the overall stability index of the balance test which compares the postural stability of the subject to that of individuals of similar age. The second output value was the standard deviation which quantifies the extent of variation of the overall stability index. After the postural stabilization test, the subject completed the 6-minute walk test to gauge the subject's level of physical function. To perform the 6-minute walk test, two cones were set up 75 feet apart from one another. The subject walked from one cone to the other quickly and safely as many times as possible during the six minutes. Once the six minutes were up, the subject stopped in place where they were. The researcher then measured the total distance the subject walked in feet. The number of feet the subject walked was then converted to meters by the researcher.

Data analysis

Statistical tests were carried out using the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL). Data were analyzed using one-way analysis of variances (ANOVA). This study contained three levels of independent variable which were group determination (sedentary, recreationally active, masters athlete) as determined by RAPA. The dependent variable is fall risk as determined by BBS. The significance level was set at .05 for main effects and .017 for follow-up assessments to account for an inflated Type 1 error rate. Groups were then redefined for post hoc analysis using the results of distance walked from the six-minute walk test. The results were divided into thirds and classified into physical function levels. The group that walked the fewest meters was designated Group 1 and was the least physically fit. The group that walked the next fewest metes was deemed Group 2 and had the middle level of physical function. Group 3 walked the most meters in the six-minute walked and was the most physically fit. By comparing these three fitness groups using one-way ANOVA, no statistically significant differences were found in postural stability (p = .75).

For further analysis of age, subjects were separated into three age groups. Subjects were divided into three groups to test for age effects. The young group consisted of 13 adults aged 54 to 59 years old. Twenty-one adults aged 60-69 were in the middle group, while 17 adults aged 70-91 were in the older group. By comparing these groups using one-way ANOVA no statistically significant difference was found in comparing age groups (p = .48).

The last analysis conducted was an effect of sex difference. Postural stability of the 32 females and 27 males were compared to test for a sex difference. By comparing these groups using one-way ANOVA, a significant difference was found ($p = .001$) with females exhibiting better postural stability. This was demonstrated by a lower stability index value in women as compared to men.

Results

The means and standard deviations for the subjects' demographics are shown in Table 1. Overall, 59 subjects participated in the study. Thirteen subjects were masters athletes, 27 recreationally active, and 19 sedentary subjects. In this study, 59 subjects completed the six-minute walk test and 51 completed the Biodex Balance Test. The Biodex Balance Test was used to measure postural stability, an indicator of one's balance abilities. Postural stabilization which was measured by the movement of the center of pressure is shown in Table 1. The average overall postural stabilization score was 3.63 ± 2.28. The masters 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 ($p = .51$).

Another variable that is shown in Table 1 is the six-minute walk time which was used to measure physical function. The average for all subjects for the six-minute walk test was 587.63 ± 121.32 meters. The masters 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 six-minute walk test between groups ($p = .07$), yet there were no statistically significant differences between the groups. Figure 1 demonstrates the differences of the meters walked between the activity groups.

Table 1

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

	Overall	Masters Athletes	Recreationally Active	Sedentary	Significance (*p*)
N	59	13	27	19	
Age (years)	66.5 ± 9.5	59.2 ± 4.8	70.0 ± 9.8	66.4 ± 8.9	
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
PS	3.63 ± 2.28	2.75 ± 1.70	3.83 ± 2.10	3.73 ± 2.69	.51

Note. N=number of subjects; PS=postural stability

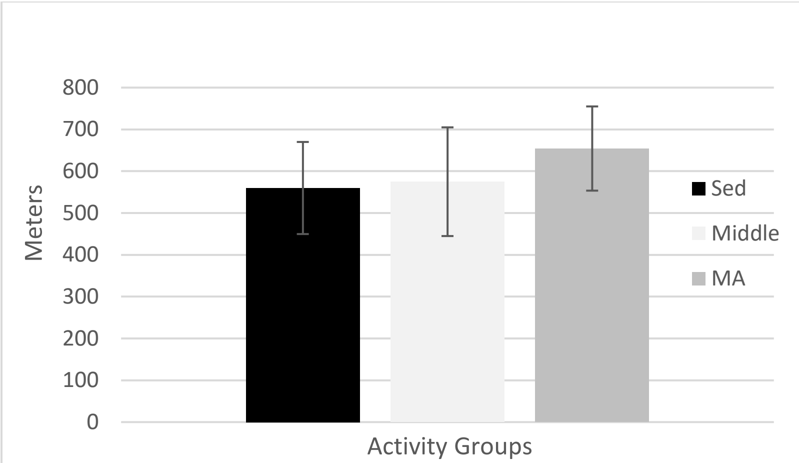

Figure 1. Average meters walked in the six-minute walk test for each activity group. Error bars represent standard deviation.

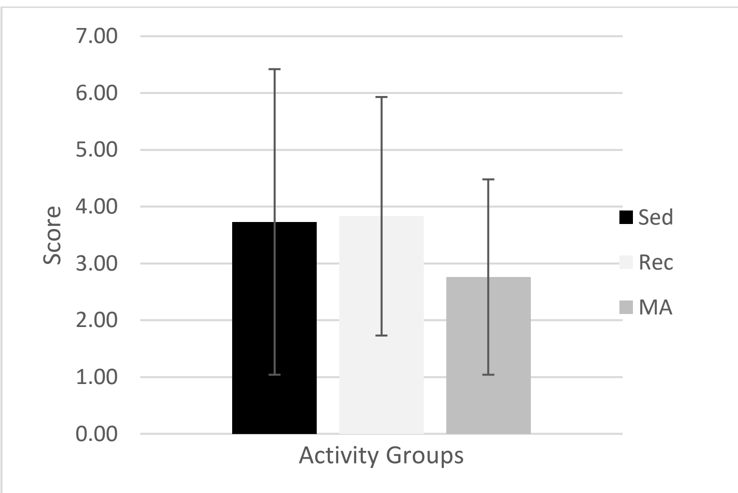

Figure 2. Average postural stability for each activity group. Error bars represent standard deviation.

After comparing the activity level analysis for this study, the researcher divided the subjects based on physical function. These physical function levels were determined by the number of meters walked during the six-minute walk test. The distances walked were divided into three groups. These groups consisted of the top third of the results from the six-minute walk, middle third in the six-minute walk, and the bottom third in the six-minute walk. The group that walked the least number of meters in six minutes was named Group 1, the low physical function group. The group that walked the second least number of meters was called Group 2, the middle physical function group. The group that walked the greatest number of meters in the six minutes was noted Group 3, indicating the high physical function group. Upon analysis, it was found there was a significant difference in distance walked between groups during the six- minute walk test ($p < .00$). A post hoc test was performed to see where the differences occurred and a significant difference in meters walked between each physical function group was discovered with all groups having a significance ($p < .00$). Postural stabilization was then compared between these three groups. As shown in Table 2, physical function did not influence postural stability ($p = .51$).

Table 2

Means and standard deviations for six-minute walk

	Overall	Group 1	Group 2	Group 3	Significance (p)
N	59	19	20	20	
6 min walk (m)	587.83 ± 121.32	449.76 ± 77.09	598.38 ± 19.17	708.96 ± 59.63	.00
PS	3.63 ± 2.28	3.92 ± 2.27	3.35 ± 2.17	3.75 ± 2.56	.75

Note. N=number of subjects; PS=postural stability

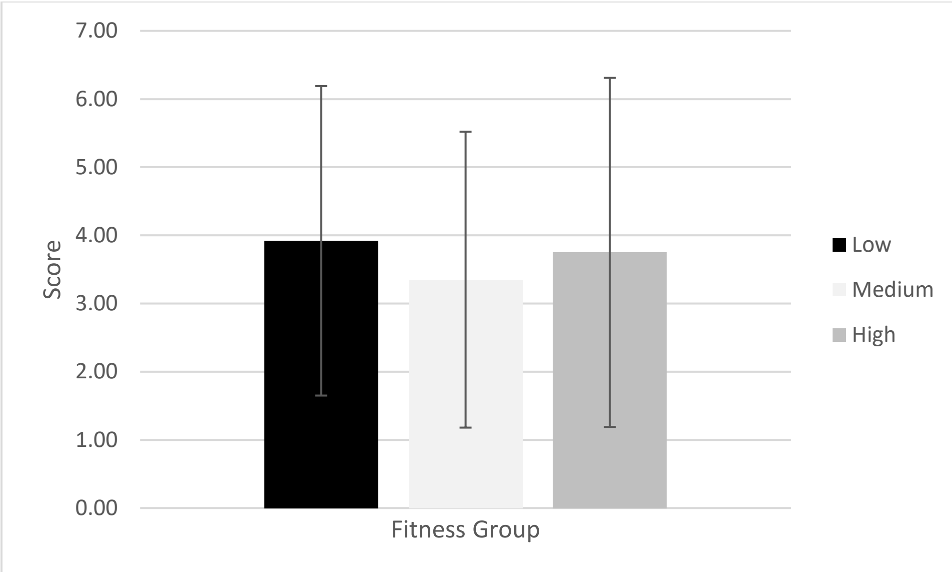

Figure 3 Average balance score for each fitness group. Error bars represent standard deviation

Upon further data analysis, age was examined as a possible indictor of balance ability. As there were 51 subjects with complete data, subjects were divided into three groups of based on age. Group 1, the young group, consisted of 13 older adults aged 54 to 59 years old. Twenty-one adults aged 60 to 69 years were in the middle group denoted Group 2. Group 3 was the oldest group which was made up of seventeen adults aged 70-91 years. A one-way ANOVA was used to compare the postural stability of the different age groups. Overall, the average postural stability of all subjects was 3.63 ± 2.28. Group 1 had a stability index of 2.96 ± 1.62. The postural stability index of Group 2 was 3.81 ± 2.52. Group 3 presented a stability index of 3.91 ± 2.42. As seen in Table 3, no significant difference was found between age groups and postural ability (p = .48). Figure 4 displays the stability index for all three groups along with standard deviations. A correlation was run to determine the Pearson correlation coefficient between age and balance ability. The Pearson correlation coefficient was determined to have no correlation (r = .12). This low correlation coefficient suggests that, in the current study, age has no relationship to postural ability.

Table 3

Summary of means and standard deviations for age comparison

	Overall	Group 1 (young)	Group 2 (middle)	Group 3 (old)	Significance (*p*)
N	51	13	21	17	
PS	3.63 ± 2.28	2.96 ± 1.62	3.81 ± 2.52	3.91 ± 2.42	.48

Note. N=number of subjects; PS=postural stability

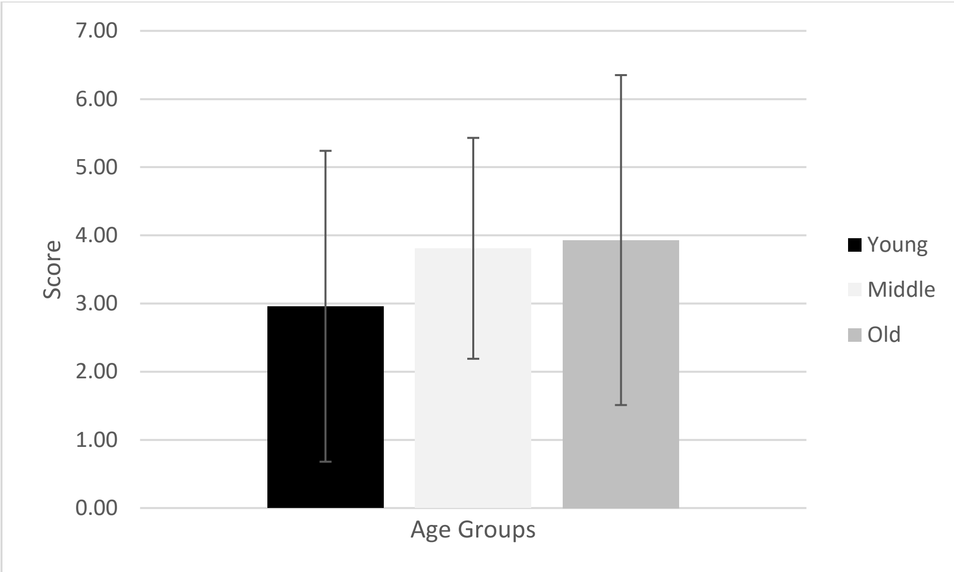

Figure 4. Average balance score for each age group. Error bars represent standard deviation.

The last variable analyzed was sex. Thirty-two females participated in the study while 27 males volunteered. Results were analyzed using a one-way ANOVA. Again, the overall stability index was 3.63 ± 2.28 as shown in Figure 4. The stability index for females was 2.69 ± 1.71. For males, the stability index was 4.77 ± 2.40. As the stability index is indicative of movement that occurred during the fall risk assessment, the lower the stability index indicates better balance. As seen in Table 4, females have a lower stability index which is a significant difference (p = .001).

Table 4

Means and standard deviations for sex differences

	Overall	Female	Male	Significance (p)
N	59	32	27	
PS	3.63 ± 2.28	2.69 ± 1.71	4.77 ± 2.40	.001

Note. N=number; PS= postural stability

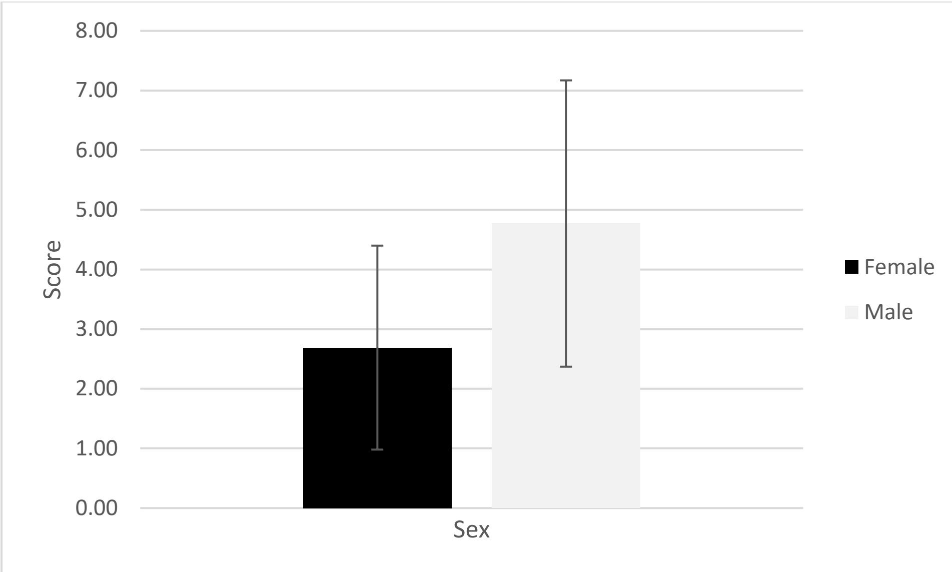

Figure 5. Average balance score for each group based on sex. Error bars represent standard deviation.

Discussion

In the current study, older adults were tested to examine the relationship between activity levels and balance. Balance can be evaluated in many ways. For this study, balance was determined by the movement of the center of pressure during postural stabilization. It was hypothesized that as activity levels increase, the balance ability would improve as well. The masters athletes would have the best balance, represented by the least center of pressure movement. Following the masters athletes, the recreationally active adults would have poorer balance than masters athletes, shown by more movement of center of pressure. Sedentary adults were hypothesized to have the poorest balance which is characterized by the most center of pressure movement. Based on statistics, this hypothesis was unsupported (p =.51). These results do not agree with previous research performed by Marques et al. (2011). Immediately following an 8-month long multicomponent training program, balance measures among older women aged 60-95 years was improved. At baseline and post-training, balance was measured using a similar force platform as used in the current study. Subjects were instructed to balance on one foot.

Subjects in the multicomponent exercise group experienced an increase time of performance, decrease in mean velocity, along with a decrease in sway area compared to the control group. Such differences in results could be attributed to the type of exercises performed. In the current study, any general aerobic exercise was included. In Marques et al. (2001), a multicomponent program was utilized creating a more thorough program which could affect balance scores. However, work by Seco et al. (2013) suggests that the age and sex of subjects could impact the improvements in balance. A total of 227 subjects completed a 9-month training period consisting of three sessions per week followed by a detraining period of three months. Both male and female subjects older than 65 years of age were included in the study. The program was a multicomponent training program focusing on strength, flexibility, cardiovascular fitness, and balance. Measures were taken at baseline, immediately post-training, and immediately post-detraining. Balance was measured by standing on a force platform in closed and partially closed kinetic chain position with eyes open and then eyes closed. In post-training measures, balance scores improved in all subjects. Following detraining, it was determined the beneficial effect of the training program on balance tended to be lost. Specifically, further examination found this loss to occur to in male subjects and those subjects aged 75 years and older with values mimicking baseline levels. Female subjects and those subjects aged 65-74 years old were able to maintain balance improvements from the training period, suggesting sex or age may play a role in balance abilities. Based on such results, age and sex were analyzed in the current study.

Based on those age and sex balance results from Seco et al. (2013), the variables of both age and sex were further examined in the current study. Subjects were divided into three groups based on age with a young, middle, and old age group. The current study did not support the results of Seco and colleagues (2013), demonstrating no relation between age differences and stability (p = .48). The differences in age results between the current study and those of Seco et al. (2013) could be attributed to the age criteria differences in groups. The current study included those over age 50 years, while the Seco et al. (2013) was more exclusive only allowing those aged 65 years and older to participate. A correlation was performed to see if any association existed between age and stability. No such association was found between age and balance ability (r = .12). Using a one-way ANOVA, a sex comparison was made between female and male subjects. Like Seco and colleagues, a significant difference was found between female and male subjects (p = .001). Females had a stability index of 2.69 ± 1.71, while males had a stability index of 4.77 ± 2.40. As a lower stability index is indicative of better balance, females have a significantly better stability index and therefore better balance than men. These results agree with those of Seco et al. (2013), who found females were able to maintain improvements in balance better than males following a period of detraining.

After initial analysis based on activity level was performed, further analysis was utilized to determine if physical function influences postural stability. Physical function was determined by the results of the six-minute walk test. The results were divided into thirds. The lowest third, which walked the fewest meters and represented the lowest physical function was named Group 1. Group 2 walked the middle number of meters and was indicative of the middle group of physical function. The group that walked the greatest number of meters and therefore represented the highest level of physical function was Group 3. A one-way ANOVA was utilized to determine if a significant difference between groups for postural stabilization was present. The one-way ANOVA found no significantly different results. Again, this lack of difference could be attributed to subjects' possible balance training which could result in better Biodex Balance Test scores as opposed to better scores deriving from one's level of physical function.

While subjects in the current study were asked about exercise habits, subjects were not asked about balance classes or specific exercises aimed at improving balance. There is a possibility some subjects partake in balance classes which could result in balance scores being skewed.

In the current study, there were 59 subjects. Of the 59 subjects, 51 completed the Biodex Balance Test. The approval for the Biodex Balance System was not granted by the IRB until after the greater study had begun. As a result of this delayed start, only eight of the 13 masters athletes were able to complete the Biodex Balance Test. Once again, this limited number of masters athlete subject data for the Biodex Balance Test could cause a difference in the balance scores.

Overall, there were no statistically significant differences in groups and postural stability. In grouping subjects by activity level and also by physical function level, no significant differences in postural stability were shown. These results suggest that simply living a more active lifestyle or being more physically fit does not necessarily mean one's balance will benefit. It is important to note that the means used to gauge balance, measuring postural stability on a Biodex Balance System SD, is a unique method of testing. Such method does not mimic any activities of daily living which could influence the balance scores.

Threats to Internal/External Validity

One potential threat to internal validity was the new lab setting. Subjects were exposed to new methods of testing in addition to a researcher supervising. Such new experiences may have influenced performance of the subject. Another potential threat to internal validity is the self-reported RAPA. This questionnaire categorized subjects into groups based on their estimated activity level. While this is a quick and reliable method, some subjects may overestimate or underestimate activity levels resulting in incorrect placement in activity level.

A potential threat to external validity could be the participation of subjects in a balance class or balance type training program. It is possible that sedentary subjects only engage in balance training, but no aerobic training. Such a lifestyle could make it possible for subjects of sedentary group and/or low physical function to outperform aerobically active subjects on balance performance tests. Another potential threat to external validity is the method of subject recruitment. This study was part of a greater follow up study and therefore, many subjects were recruited from the previous study. As a result, the subjects were of a convenience sample rather than a random sample which would have been more representative of the population. Another threat to external validity was the ecological validity. Tests were performed in a laboratory which was unfamiliar to subjects. Additionally, many of the tests utilized were not representative of activities of daily living which could influence results of the tests. Lastly, a threat to external validity was difference in the mean age of the groups. The recreationally active group was the oldest group, sedentary group was the middle group, followed by masters athletes which was the youngest group. This distribution could have influenced the test scores of the groups.

Assumptions

One assumption made was that subjects were able to complete the tasks to the best of their ability. It was assumed subjects were truthful in completing the RAPA. It was also assumed that subjects performed the postural stability and six-minute walk test with the best effort. Another assumption was that equipment was working properly. It was assumed that researchers were consistent in providing feedback and answering questions of the subjects during the testing period. The last assumption was that no known cognitive impairment existed which was screened for by the Mini-Mental State Examination.

Limitations

A limitation to the current study was the self-report questionnaire used to classify the subjects into physical activity groups. Another limitation was the small sample size of 59 subjects. A final limitation was that only eight of 13 masters athletes were able to complete the Biodex Balance Test.

Delimitations

The following are delimitations of the current study. A total of 59 subjects participated in the study. Subjects were divided into three groups based on physical activity levels. The sedentary group had 19 subjects, recreationally active group have 27 subjects while the masters athlete group have 13 subjects. Postural stabilization was measured by the Biodex Balance System SD using the fall risk assessment test. Postural stability was compared between the three physical activity groups. Physical function was measured using the six-minute walk test with distance walked. Three physical function groups were created and used to compare postural stability. All aspects of this study were conducted at the University of Arkansas in the Human Performance Laboratory.

Conclusion

When activity groups were based off self-reported physical activity questionnaire, no significant differences were seen in postural stability. Likewise, when physical function groups were determined by meters walked in the six-minute walk test, no significant differences were seen in postural stability. In examining age and postural stability, no significant relationship was found. However, an effect seemed to exist when it came to sex. Men did not have significant relationship between sex and postural ability, but a significant relationship between sex and postural stability did exist for women. Therefore, it is unlikely that activity levels, physical function levels, or even age play a role in balance ability. While more research is needed, it is suggested that women may have better postural stability than their male peers.

References

ACSM. (1998). Exercise and physical activity for older adults: Position stand. *Medicine and Science in Sport and Exercise, 30*(6), 992-1008.

ACSM. (2014). *ACSM's guidelines for exercise testing and prescription* (9 ed.).

Agrawal, Y., Carey, J. P., Della Santina, C. C., Schubert, M. C., & Minor, L. B. (2009) Disorders of balance and vestibular function in US adults: data from the National Health and Nutrition Examination Survey, 2001-2004. *Archives of internal medicine*, *169*(10), 938 -944.

Axer, H., Axer, M., Sauer, H., Witte O.W., & Hagemann, G. (2010). Falls and gait disorders in geriatric neurology. *Clinical Neurology and Neurosurgery,* 112, 265–74.

Buchner, D. M., Cress, M. E., De Lateur, B. J., Esselman, P. C., Margherita, A. J., Price, R., & Wagner, E. H. (1997). A comparison of the effects of three types of endurance training on balance and other fall risk factors in older adults. *Aging Clinical and Experimental Research*, 9(1-2), 112-119.

Enright, P. L., McBurnie, M. A., Bittner, V., Tracy, R. P., McNamara, R., Arnold, A., & Newman, A. B. (2003). The 6-min walk test: a quick measure of functional status in elderly adults. *Chest*, *123*(2), 387-398.

Era, P., Sainio, P., Koskinen, S., Haavisto, P., Vaara, M., & Aromaa, A. (2006). Postural balance in a random sample of 7,979 subjects aged 30 years and over. *Gerontology*, *52*(4), 204 -213.

Forman, D. E., Fleg, J. L., Kitzman, D. W., Brawner, C. A., Swank, A. M., McKelvie, R. S., . . . Bittner, V. (2012). 6-min walk test provides prognostic utility comparable to cardiopulmonary exercise testing in ambulatory outpatients with systolic heart failure. *Journal of the American College of Cardiology, 60*(25), 26532661 \doi:10.1016/j.jacc.2012.08.1010.

Freeman, E.E., Muñoz, B., Rubin, R., & West, S.K. (2007). Visual field loss increases the risk of falls in older adults: the salisbury eye evaluation. *Ophthalmology & Visual Science,* 48(10), 4445-4450.

Goldacre, M.J., Roberts, S.E., & Yeates, D. (2002). Mortality after admission to hospital with fractured neck of femur: database study. *British Medical Journal,* 325(7369), 868–9.

Hageman, P. A., Leibowitz, J. M., & Blanke, D. (1995). Age and gender effects on postural control measures. *Archives of physical medicine and rehabilitation*, *76*(10), 961-965

Hausdorff, J.M., Rios, D.A., & Edelberg, H. K. (2001). Gait variability and fall risk in community-living older adults: a 1-year prospective study. *Archives of Physical Medicine and Rehabilitation*, *82*(8):1050–6.

Horak, F. B., Shupert, C. L., & Mirkla, A. (1989). Components of postural dyscontrol in the elderly: a review. *Neurobiology of aging, 10*(6), 727-738.

Inouye, S.K., Brown, C.J., & Tinetti, M.E. (2009). Medicare nonpayment, hospital falls, and unintended consequences. *The New England Journal of Medicine, 360*(23), 2390–3.

Lafond, D., Corriveau, H., Hebert, R., & Prince, F. (2004). Intrasession reliability of center of pressure measures of postural steadiness in healthy elderly people. *Archives of Physical Medicine and Rehabilitation,* 85:896-901.

Lord, S., & Castell, S. (1994). Effect of exercise on balance, strength, and reaction time in older adults. *Australian Physiotherapy*, 40(2), 83-88.

Marques, E. A., Mota, J., Machado, L., Sousa, F., Coelho, M., Moreira, P., & Carvalho, J. (2011). Multicomponent training program with weight-bearing exercises elicits favorable bone density, muscle strength, and balance adaptations in older women. *Calcified Tissue International*, *88*(2), 117-129.

McHorney, C. A., Ware, J. E., & Raczek, A. E. (1993). The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Medical Care*, 31 (3), 247-263.

O'Loughlin, J. L., Robitaille, Y., Boivin, J. F., & Suissa, S. (1993). Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. *American Journal of Epidemiology*, *137*(3), 342-354.

Painter, P., Stewart, A. L., & Carey, S. (1999). Physical functioning: definitions, measurement, and expectations. *Advances in renal replacement therapy*, *6*(2), 110-123.

Parraca, J., Olivares, P., Carbonell-Baeza, A., Aparicio, V., Adsuar, J., & Gusi, N. (2011). Test-Retest reliability of Biodex Balance SD on physically active old people. *Journal of Human Sport & Exercise, 6*(2), 444-451. doi:10.4100/jhse.2011.62.25.

Perrin, P. P., Gauchard, G. C., Perrot, C., & Jeandel, C. (1999). Effects of physical and sporting activities on balance control in elderly people. *British journal of sports medicine*, *33*(2),121-126.

Perrin, P.P., Jeandel, C., Perrin, C.A., & Bene, M.C. (1997). Influence of visual control, conduction, and central integration on static and dynamic balance in healthy older adults. *Gerontology*, 43(4): 223.

Pollock, A., Durward, B., Rowe, P., & Paul, J. (2000). What is balance? *Clinical Rehabilitation, 14*, 402-406.

Rubenstein, L.Z., & Josephson, K.R. (2002). The epidemiology of falls and syncope. *Clinics in Geriatric Medicine*, 1 8(2):141–58.

Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *Journal of Experimental Psychology: General*, *132*(4), 566.

Sartini, M., Cristina, M. L., Spagnolo, A. M., Cremonesi, P., Costaguta, C., Monacelli, F., ... & Odetti, P. (2010). The epidemiology of domestic injurious falls in a community dwelling elderly population: an outgrowing economic burden. *The European Journal of Public Health*, *20*(5), 604-606.

Schlicht, J., Camaione, D. N., & Owen, S. V. (2001). Effect of intense strength training on standing balance, walking speed, and sit-to-stand performance in older adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *56*(5), M281-M286.

Seco, J., Abecia, L. C., Echevarría, E., Barbero, I., Torres-Unda, J., Rodriguez, V., & Calvo, J. I. (2013). A long-term physical activity training program increases strength and flexibility, and improves balance in older adults. *Rehabilitation Nursing*, *38*(1), 37-47.

Shaffer, S. W., & Harrison, A. L. (2007). Aging of the somatosensory system: a translational perspective. *Physical therapy*, *87*(2), 193.

Shumway-Cook, A., Woollacott, M., Kerns, K. A., & Baldwin, M. (1997). The effects of two types of cognitive tasks on postural stability in older adults with and without a history of falls. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *52*(4), M232-M240.

Skelton, D. A. (2001). Effects of physical activity on postural stability. *Age and ageing*, *30*, 33 -40.

Tinetti, M.E, Powell, L. (1993). Fear of falling and low self-efficacy: a case of dependence in elderly persons. *Journal of Gerontology*, 48:35–38.

Topolski T.D., LoGerfo J., Patrick D.L., Williams B., Walwick J., & Patrick M.B. (2006). The Rapid Assessment of Physical Activity (RAPA) among older adults. *Preventing Chronic Disease*, 3 (4), 1-8.

Woollacott, M. H., Shumway-Cook, A., & Nashner, L. M. (1986), Aging and Posture Control: Changes in Sensory Organization and Muscular Coordination. *The International Journal of Aging and Human Development*, 23(2), 97-114.

Zhao, E., Tranovich, M. J., DeAngelo, R., Kontos, A. P., & Wright, V. J. (2016). Chronic exercise preserves brain function in masters athletes when compared to sedentary counterparts. *The Physician and Sports Medicine, 44*(1), 8-13. doi:10.1080/00913847.2016.1103641.

UNIVERSITY OF ARKANSAS

February 14, 2017

Office of Research Compliance
Institutional Review Board

MEMORANDUM

TO:	Michelle Gray Katherine Adams Ashley Binns Felicia Squires	Jennifer Vincenzo Whitney Freeman Matthew Stone
FROM:	Ro Windwalker IRB Coordinator	
RE:	PROJECT CONTINUATION	
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	
Previous Approval Period:	Start Date: 02/08/2016 Expiration Date: 02/07/2017	
New Expiration Date:	02/07/2018	

Your request to extend the referenced protocol has been approved by the IRB. If at the end of this period you wish to continue the project, you must submit a request using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. Failure to obtain approval for a continuation on or prior to this new 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.

This protocol has been approved for 150 total participants. If you wish to make *any* 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.

The IRB determined and documented that the risk is no greater than minimal and this protocol may be reviewed under expedited review procedure for future continuing reviews.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.

T210 Administration • Fayetteville, Arkansas 72701 • (479) 575-2208 • (479) 575-3846 (FAX)
Email: irb@uark.edu