DIFFERENCES IN FALL RISK ASSESSMENT SCORES BETWEEN WALKING AND CROSS-TRAINING EXERCISE GROUPS IN COMMUNITY DWELLING OLDER ADULTS

A Thesis
by
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Abstract

DIFFERENCES IN FALL RISK ASSESSMENT SCORES BETWEEN WALKING AND CROSS-TRAINING EXERCISE GROUPS IN COMMUNITY DWELLING OLDER ADULTS

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Falling is one of the most common accidents in the elderly (Yardley, Kirby, Ben-Shlomo, Gilbert, Whitehead, & Todd, 2008). Approximately 30% of people over the age of 65 fall at least once a year. Falls can lead to serious injuries such as hip and other fractures, soft-tissue damage, or even head injury (Tinetti, Speechley, & Ginter, 1988). Regular exercise can slow the biological aging process and minimize the effects of physical inactivity (Garber et al., 2011). However, when questioned, many older individuals are reluctant to join an exercise program to aid in fall prevention (Yardley et al., 2008). Clinical tests used to assess risk for falling examine strength, balance, and flexibility. In addition, clinical tests used to assess future falls might not be as effective when used with more active older individuals. Therefore, the purpose of this study is to examine if outcome scores from two fall risk assessment tests and one physical assessment test are different between two groups of exercisers: regular walkers and regular cross trainers. **Methods:** This is a cross sectional study, without intervention, in which community dwelling adults 60 years of age or older, participating in an exercise program for at least six weeks, volunteered to participate. Subjects were divided into a walking group or cross-training group based on the exercise description from a PASE questionnaire. Subjects underwent the Timed Up & Go test, Sitting-Rising Test, and postural sway balance test. **Results:** Differences were only observed between the two exercising groups during the

Sitting-Rising test ($p \leq 0.01$). We did not see differences in the Timed Up & Go test and the postural sway balance test between groups ($p \geq 0.05$). **Discussion:** Other studies have shown the Timed Up & Go test to be correlated with the balance test. However, in community dwelling adults who are active, the Timed Up and Go test is not recommended as the only test to be used when predicting future falls. To the best of our knowledge, this is the first study to compare the Sitting-Rising test to fall risk assessment tests. We did not follow up to assess future falls so we cannot say if the Sitting-Rising test can be useful in the assessment of future falls. Follow up studies are needed to elucidate whether the Sitting-Rising test can be used to assess risk for future falls. **Conclusion:** Older people are being encouraged to exercise now more than ever. Multiple studies highlight the benefits of exercise interventions on fall prevention. As we determined in this study, current fall risk assessment tests are useful with frail elderly, but they might not be the best at measuring risk for future falls in active older individuals.

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Chapter 1: Introduction

Falling is one of the most common accidents in the elderly (Yardley et al., 2008). Approximately 30% of people over the age of 65 fall at least once a year (Ambrose, Paul, & Hausdorff, 2013). Falls can lead to serious injuries such as hip and other fractures, soft-tissue damage, or even head injury (Tinetti et al., 1988). Some studies have shown falls to be one of the main causes of morbidity and mortality in an older population (Bradley, 2011). The difficulty in predicting future falls arises from the fact that falls can be multifactorial, having extrinsic factors, such as obstructed hallways and poor lighting, and to intrinsic factors like muscular strength, maintaining balance, and flexibility (Ambrose et al., 2013). However, the age related decline in strength, balance, and flexibility is often attributed to the increased risk of falling.

Regular exercise can slow the biological aging process and minimize the effects of physical inactivity (Garber et al., 2011). A study by Lord et al. (2006) showed that a general exercise program improved strength, balance, and reaction time in older women. Other forms of exercise such as Tai Chi and Pilates have also shown improvement in reducing future falls in older adults (Bird and Fell, 2014). Fall prevention exercise programs, implemented by physical therapists or health professionals trained specifically for that intervention, that focused on improving strength, balance, and mobility have also demonstrated a decrease in risk for future falls. However, these programs have not been as effective when used outside of research environments, such as in community settings (Kramer, Creekmur, Mitchell, Rose, Pynoos, & Rubenstein, 2014). Yardley et al. (2008) investigated the willingness of older people to participate in fall prevention exercise programs. Through surveys sent to general practice facilities, they found that only 22.6% of respondents said they would definitely participate in strength and balance training exercise session outside of their home. When asked if they would participate in the same program in their home, only 36.4% said they would definitely participate (Yardley et al., 2008). Despite the large number of studies identifying the benefit of exercise programs for fall prevention, it is still unclear as how to integrate evidence based research into community settings for fall prevention (Kramer et al., 2014).

Fall risk assessment tests are typically part of a fall prevention program and assess strength, balance, and mobility, often through physical tests that identify any risk factors that indicate the risk for future falls. Force platforms and other biomechanical tests have been used in a laboratory setting to measure balance and mobility; however, a lack of portability of this equipment has limited the use of these tests (Thapa, Gideon, Brockman, Fought, & Ray, 1996). Therefore, fall risk assessment tests were developed to be simple and easy to conduct in a variety of clinical settings. These easy and safe to perform tests give valuable information for prescribing exercise to individuals for the prevention of future falls.

One of the simplest fall risk assessments to perform is the Timed Up and Go test (TUG). It requires the participant to rise from a chair, walk three meters to a cone or tape on the floor, turn around, and return to the chair in a seated position. Due to good inter-rated reliability and high intra-class correlation of .80, the TUG test has been used to predict falls in elderly populations (Beauchet, Fantino, Allali, Muir, Montero-Odasso, & Annweiler, 2011). However, many studies have questioned the ability of these tests to predict future falls when using these tests in older adults of varying functional ability. A systematic review by Beauchet et al. (2011) found that in retrospective studies, the time to complete the TUG test was positively associated with history of falls. As time to complete the test increased, so did the number of falls. From this review, only one prospective study found a positive association with time to the complete the test and occurrence of future falls.

Measuring one's balance, by measuring postural sway, or the ability to maintain an upright posture is another assessment test commonly used, albeit, more often in a research setting (Thapa et al., 1996). The amount the body sways in a static position often indicates poor balance. Postural sway measures are known to correlate well with other fall risk assessment measures such as Tinetti's Performance Mobility Assessment, functional reach, TUG, and the ability to sit and rise from a chair (Thapa et al., 1996). The previously mentioned tests are sometimes used in combination in fall prevention programs in order to assess one's muscular strength and/or power, balance, and flexibility. Clinical settings would benefit from a fall risk assessment test that would be able to measure all of those aspects in one single test. One test might currently exist, but it has only been used to measure mortality risk.

A study by de Brito, Ricardo, de Araujo, Ramos, Myers, and de Araujo (2012) found that a simple task, such as sitting on the ground and rising again, was able to asses muscular strength/power, coordination, balance, and flexibility, characteristics needed for activities of daily living and ability to transition from seated to standing positions. Although not measuring risk for falling, they found that the amount of support needed to perform the sitting-rising test (SRT) was significantly related to all cause mortality risk in subjects 51-80 years of age (de Brito et al., 2012). Because hip fractures from falling can increase mortality within 1 year by 25%, it could be possible that this SRT test could be used to predict future falls in older adults (Bradley, 2011). To the best of our knowledge, a study has yet to examine the potential of the dynamic SRT to be used as a fall risk assessment test.

The purpose of this study is to determine if differences in outcome scores of traditional fall risk assessment tests, Timed Up and Go test and postural sway test, and a non-traditional fall risk assessment test, the Sitting-Rising Test, will exist between two groups of exercisers: regular walkers (W) and regular cross trainers (XT). We hypothesize we will only see differences between groups in the postural sway test and Sitting-Rising test and no group differences in the Timed Up and Go test.

Chapter 2: Literature Review

Falling is multifactorial, but the age related decline in strength, balance, and flexibility is often attributed to the increased risk of falling. Exercise interventions that challenge postural balance, as well as general exercise programs, are known to decrease this risk of falling (Bird & Fell, 2014). Many studies show that regular exercise can slow the biological aging process and minimize effects associated with physical inactivity (Garber et al., 2011). A study by Lord et al. (2006) showed that a general exercise program improved strength, balance, and reaction time in older women. Other forms of exercise such as Tai Chi and Pilates have also shown improvement in fall risk assessments in older adults (Bird & Fell, 2014). Exercise programs for an older population focus on improving strength, balance, and mobility, but often come in many forms. More research needs to be conducted to elucidate the components of an exercise program and how they affect fall risk assessment outcome measures.

The purpose of this literature review is to discuss fall risk assessments commonly used in clinical and biomechanical settings, introduce a potential new fall risk assessment test, and review current exercise interventions to reduce the risk for future falls.

Measuring Fall Risk

Studies investigating falls in elderly populations have shown approximately one in three individuals are at risk for falling (Tinetti et al., 1988). The aging process is natural and is commonly associated with changes that lead to decreases in functional capacity and physical activity levels (Fernandez-Arguelles, Rodriguez-Mansilla, Antunez, Garrido-Ardila, & Munoz, 2015). The elderly population can get trapped into a cycle of inactivity and disuse due to the association falling has with morbidity and mortality. Moreover, this can instill a fear of falling that can cause individuals to reduce the amount of physical activity or mobility (Simmons & Hansen, 1996). Voluntarily limiting movement will lead to more disuse and loss of functional mobility, in turn, further contributing to functional decline (Vellas, Cayla, Bocquet, de Pemille, & Albarede, 1987).

Majority of fall risk assessments measure strength, balance, or flexibility to assess whether someone is at risk of falling. Some common clinical fall risk assessment tests include Performance Oriented Mobility Assessment test, Berg Balance test, Four square step test, Timed Up & Go test, and various dual task tests (Ambrose et al., 2013). Furthermore, biomechanical assessments, typically performed in a laboratory or research setting, are used to measure static and dynamic balance to give an indirect measurement for the risk of falling (Thapa et al., 1996).

Timed Up & Go Test. The Timed Up & Go test (TUG) is a simple tool used for fall risk assessment in community settings (Schoene et al., 2013). Due to its requirement of performing multiple tasks, such as standing up, walking, turning around 180 degrees, and sitting down (Schoene et al., 2013), it is a commonly used measure of functional mobility and can predict the future risk of falling (Granacher, Muehlbauer, & Gruber, 2012). The TUG test requires subjects to stand up from a chair, walk three meters to a cone or tape on the floor, turn around, walk back to the chair, and sit down. The speed at which this is done can vary between administers, but typically, it is the fastest speed at which the individual is comfortable doing, without increasing the risk for injury. Poor scores on the TUG test are associated with known risk factors for falling: poor muscle strength, poor balance, slow gait speed, fear of falling, physical inactivity, and reduced ability to perform basic and complex activities of daily living (Schoene et al., 2013). Given the factors associated with poor TUG scores, it would be expected that these are useful for predicting future falls. However, a systematic review by Schoene et al. (2013) found that average TUG times have large variability within groups of fallers and non-fallers. Healthier elderly showed smaller differences, while frail elderly had larger differences. Another systematic review stated that all retrospective studies found a significant relationship with time to complete the test and previous history of falls (Beauchet et al., 2011). This is in agreement with the findings from Schoene et al. (2013) in which both systematic reviews mentioned that the TUG test is not the best test for predicting future falls in a higher functioning elderly population; however, it can be useful in a less healthy, frail elderly population. Due to the inability to predict future falls, it is recommended that the TUG test be used in conjunction with other fall risk assessment tests (Schoene et al., 2013; Barry, Galvin, Keogh, Horgan, & Fahey, 2014).

Sitting-Rising Test. The Sitting-Rising test is a simple, functional task that is required for independence, and the inability to perform similar tasks is related to falling (de Brito et al., 2012). The study by de Brito et al. (2012) investigated whether the inability to perform the simple task of sitting on the floor from a standing position and getting up again, predicts all cause mortality in individuals 51-80 years old. Subjects performed the SRT and had a median follow up 6.3 years later. To perform the test, subjects stood barefoot in a 2x2 foot square, were instructed to try to sit on the floor and then rise from the floor, using the minimal amount of support needed (de Brito et al., 2012). The use of each arm or kneeling on one or both knees count as using support throughout the movement. In addition, test administrators did not want the subjects to worry about the speed of the movement. The findings from this study showed that the lower the score, indicative of using more support to sit down and stand up, was related to higher all cause mortality rate. A combination of musculoskeletal strength, coordination, and flexibility is needed to achieve a high score on the SRT.

The same components are needed during locomotion, activities of daily living, and exercise programs. There is potential the SRT could be a future screening tool for fall risk assessment. To the best of our knowledge, we have not found any studies examining whether the SRT is a valid test to predict future falls in an elderly population.

Postural sway. Balance measurements can be broken down into two categories: clinical measures and biomechanical measures (Thapa et al., 1996). The Performance Oriented Mobility Assessment test and Berg Balance test are examples of clinical measurements. Biomechanical measures use either a force platform or sway meter to measure postural sway. More recent studies that measure postural sway use a force platform. Postural sway is typically measured in an upright stance and is indicative of the body's effort to maintain the upright posture. A larger area of sway indicates more of an effort to maintain the stance, therefore, lesser ability to maintain balance. Forces applied to the force platform through the feet to maintain balance provide a path of movement, called center of pressure (COP). The area covered by the path of COP is what is evaluated in the measurement of postural sway (Thapa et al., 1996). A study by Campbell, Borrie, and Spears (1989) found that individuals with increased body sway were considered to have a higher risk of falling. This study also examined a variety of health variables in men and women, 70 years of age and older, living in a rural community in New Zealand. Other factors associated with the risk for falling were loss of muscle strength, poor stability, and lack of physical activity.

Exercise as a fall prevention strategy

Different exercise interventions are employed to investigate the efficacy various interventions may have on reducing or preventing falls in an older population. Research investigating the positive impacts physical activity has in older adults has shown physical exercise as a viable intervention to prevent and reduce the risk of falling (Church, Goodall, Norman, & Hass, 2012). Currently, there is not a clear answer to what exercise intervention is best at preventing or reducing future falls (Rose, 2008). The effectiveness of a fall prevention program to reduce falls is often the largest factor for older individuals in deciding in which program to participate (Hill, Day, & Haines, 2014). A study that explored the factors that influence older individuals intent to participate in a falls prevention program found that only a small portion believed fall prevention would reduce the risk of falling (Hill et al., 2014). This was in subjects who have previously fallen or thought they were at a high risk for future falls. Hale, Waters, and Herbison (2012) examined subject's perception of a 12-week, water-based exercise program in individuals with osteoarthritis in their lower extremities. They found that subjects who shared their opinions in the focus group spoke highly of the water exercise program but stated that they would not have gone if it were not in a group setting (Hale et al., 2012). Most participants reported less fear for pain or adverse effects from the exercise in the water, largely due to less pressure on joints from water's buoyancy. However, some participants noted temperature of the water and the classes being too difficult as barriers to participation in the water-based exercise program (Hale et al., 2012). Based on studies investigating fear of falling, land-based exercise programs to improve physical fitness are not suitable for the entire elderly population (Lord et al., 2006) and could possibly explain why water exercise is popular among older adults. Its popularity is possibly due to the water characteristics (buoyancy) that can reduce the fear and risk of falling during the activity (Sanders, Takeshima, Rogers, Colado, & Borreani, 2013).

Many studies examining differences between land-based and water-based exercises have measured one aspect of fall risk assessment, balance. A more recent study by Alikhajeh, Hosseini, and Moghaddam (2012) used the TUG test and Sharpened Romberg test to investigate static and dynamic balance in elderly men following eight weeks of water-exercise training program compared to a control group. Results showed significant increases for the experimental group during the eyes open and eyes closed Sharpened Romberg balance test and TUG test. According to the researchers, fall risk was indirectly measured using the previously mentioned tests. All subjects in this study scored, on average, approximately 10.83 seconds in the TUG test. Most studies using the TUG test indicate 10 seconds as a time considered to be normal for healthy adults. Interestingly, subjects in the water-exercise group significantly improved their scores by lowering the average to 7.29 ± 1.33 seconds. This shows that although a ceiling for performance might exist in the TUG test, improvement is still possible even if one is classified in a healthy, low risk category. A study by Geirsdottir et al. (2012) found the TUG to improve significantly with 12 weeks of whole body strength training. Subjects in this study performed three sets of 6-8 repetitions at 75-80% of 1 repetition maximum, three times per week. Subjects also improved leg and grip strength following the strength-training program (Geirsdottir et al., 2012). In contrast, Yamada, Higuchi, Nishiguchi, Yoshimura, Kajiwara, and Aoyama (2013) found a multi-target stepping program resulted in better TUG scores and 10 meter walking time, compared to a control group who participated in a walking program, similar in duration to the stepping program. The multi-target stepping program required the subjects to step on square targets of different colors that were evenly spaced along a 10x1 meter mat twice per week for 24 weeks. The number of square targets over the 10x1 meter mat increased every six weeks to increase the difficulty of the task. The respective color of the square targets subjects had to step on was chosen at random. Interestingly, all subjects, independent of exercise groups, participated in strength training twice a week throughout the 24-week intervention. After a one year follow-up, subjects in the stepping group had fewer reported falls and decreased fear of falling. No significant differences were observed when assessing strength measurements and functional reach. Although improvements were observed in the TUG, post intervention, for the stepping group, mean times of 12.2 ± 5.3 (s) is above the cutoff score separating fallers from non-fallers. This is supportive of their findings as the stepping group, although showing improvement in time to complete the TUG, did report falls within a year of completing the intervention. Since both groups performed the same strength program, it might suggest that the multi-target stepping program resulted in the improvement in TUG scores and 10-meter walk times. It is possible the multi-directional movements of the stepping program contributed to these improvements.

More recent studies have been investigating exercise programs that challenge the sensorimotor system and possibly improve postural control, in turn, reducing the risk for falling (Seco et al., 2014). A study by de Oliveira, da Silva, Dascal, and Teixeira (2014) examined the effect mini trampoline, aquatics gymnastics, and general land gymnastics programs have on different postural tests using a force platform. The training programs were designed to focus on four areas: 1) neuromuscular adaptations from balance exercises and reaction time, 2) muscular strength and endurance of lower limbs and trunk, 3) flexibility of upper and lower limbs using static stretching, and 4) aerobic exercises performed for the aquatics group and gymnastics group. The postural sways tests analyzed double stance and tandem stance during eyes opened and eyes closed conditions. After 12 weeks of training, the researchers found improvements in postural balance from all three interventions but no significant difference between interventions (de Oliveira et al., 2014). These findings show that the exercise interventions, albeit all different, resulted in improvements in postural sway. In addition, the interventions were structured to be nearly identical in duration and types of movement, independent of the specific intervention. Furthermore, the interventions in this study were types of exercise in which an elderly population might be willing to participate. This study did not follow up to see if falls were observed for the different exercise groups.

Conclusion

Individuals who are at high-risk for falls are typically the targets for fall prevention programs, but age related loss of function can affect all older adults (Elbar, Tzedek, Vered, Shvarth, Friger, & Melzer, 2013). Moreover, fall prevention programs are not one-size fits all and individuals who have a fear of falling might be reluctant to participate in certain exercise programs (Hill et al., 2014). However, exercise programs that challenge postural control through changes in base of support throughout the exercise, involve whole body strength training, and required multi-directional movement showed to improve outcome scores in tests assessing risk for future falls. In some cases, falls were reported to decrease following the intervention. However, compliance in such programs continues to remain low in an elderly population.

Chapter 3: Methods

Subjects

Independent, community-dwelling adults (older than age 60) were recruited from staff and faculty at Appalachian State University and the local communities to participate in this study. Participants were included in the study if they were healthy, without an uncontrolled metabolic or cardiovascular disease, free of neuromuscular and musculoskeletal disorders, had not fallen within the previous six months, and had participated in an exercise program at least 1 day a week for the previous six weeks. Written informed consent was obtained from all participants prior to any data collection, and approval for this study was given from the Institutional Review Board of Appalachian State University.

Study Design

This study is a cross sectional, observation study, without intervention. Subjects came into the lab for only one visit. During that visit, written informed consent, health history questionnaire, Physical Activity Scale for the Elderly (PASE) questionnaire, two physical function tests, and one balance test were administered.

Physical Activity Questionnaire. The PASE questionnaire is a validated questionnaire and was used to determine to which activity group each subject would be assigned (Merom et al., 2014). Subjects were asked a series of questions about the activities they performed in the past 7 days. The questions ranged from walking outside to doing light, moderate, or strenuous sports and strength training. The questions also asked the duration of that activity in a given day. If the subject did participate in a specific activity, they were asked to write down the exact type of activity. Questions regarding different types of household activities were also given. We used the responses from this questionnaire to assign subjects into one of two groups: (1) a walking group (W) or (2) a cross training group (XT). Subjects who indicated walking as the only mode of exercise in which they participated were assigned to the walking group. Subjects who indicated more than one mode of exercise, regardless of type, were assigned to the cross-training group (XT).

Timed Up and Go Test. Performing the classical TUG test, as developed by Podsiadlo and Richardson (1991), requires rising out of a standardized chair (seat height 43 cm), walking 3 meters in a straight line to a tape on the floor or cone, turning around, returning to the chair, and sitting down again (Podsiadlo & Richardson, 1991). Each subject was given the verbal command "go" at which the timer was started. The test was complete and the time stopped when the subject's buttocks touched the seat. Each subject had one familiarization trial and two recorded trials. Subjects were given a minute rest between trials and the mean of the two trials was used for analysis.

Sitting-Rising test. The sitting-rising test (SRT) assesses muscular fitness by one's ability to sit on the ground from a standing position and then rise from the floor back to a standing position (de Brito et al., 2012). The scoring of this test is based on the support needed to get into the seated position on the floor and the support needed to rise from the floor. The SRT is administered with the subject standing in a 2x2 meter square on a firm surface. The subject is instructed: "Without worrying about the speed of movement, try to sit and then rise from the floor, using the minimum support that you believe is needed" (de Brito et al., 2012). Each subject starts with a score of 10 as they try to sit on the floor and rise again. One point is subtracted for each support that is used. Examples of support include hands on knees or floor, forearms on knees or floor, knees on the floor, and side of legs touching the floor. If the subject loses balance at any time throughout the test half a point will be subtracted from the total score. Subjects performed three trials, and the best score was recorded.

Balance. Postural sway was assessed using a force platform to measure balance which is commonly measured during quiet stance in an upright position. Postural sway measures how much the body sways in order to maintain balance in the given posture, and an increased area of sway is indicative of more effort being needed to maintain posture and of having poorer balance (Thapa et al., 1996). We used a portable force platform (Accusway, Advanced Mechanical Technology, Inc., Watertown, MA) with associated software (Balance Clinic, Advanced Mechanical Technology, Inc., Watertown, MA) to measure postural sway under two conditions: eyes open and eyes closed. Subjects performed each condition for durations of 30 seconds for two separate trials, in a randomized order (Lord, Clark, & Webster, 1991; Thapa et al., 1996). Subjects were asked to stand in a normal stance with arms by their sides and to look straight ahead at a piece of tape, at eye level, approximately two meters away from the force platform. Independent of the condition, subjects were asked to stand barefoot in what they believed to be a normal stance for them. Foot placement was marked with tape to ensure the same foot placement for subsequent trials. One-minute rest was given to each subject between each trial.

Analysis

We used independent samples t-tests to determine if differences existed in physical performance and balance outcomes between the W group and XT group. Further analysis examined the effect size for the physical and balance outcomes for each group. Analysis of data was performed using SPSS (IBM Corp. Armonk, NY, Version 22.0).

Chapter 4: Results

A total of 24 subjects completed the study. Table 1 describes subject demographics of the sample population. Male subjects were significantly heavier and taller ($p \leq 0.01$) than the female subjects.

Table 1. Subject Demographics

	N	Age (yr)	Height (cm)	Weight (kg)
Female	16	66.2 ± 4.8	162.8 ± 7.0	69 ± 9.6
Male	8	67.1 ± 5.5	176.3 ± 7.7**	81.3 ± 10.7**
Total	24	66.5 ± 4.9	167.3 ± 9.6	73.1 ± 11.4

** Males vs. Females (p≤0.01)

When subjects were separated by exercise group, there were 10 subjects (Male=4, Female=6) in the walking group and 14 subjects (Male=4, Female=10) in the XT group. Table 2 shows the descriptive statistics for each activity group. No significant differences existed for age, height, or weight for the walking and XT groups ($p \geq 0.05$

Table 2. Descriptive statistics for each type of activity

Activity Type	N	Age (yr)	Height (cm)	Weight (kg)
Walking	10 (M=4, W=10)	66.7 ± 5.0	166.3 ± 8.2	77.3 ± 12.6
XT	14 (M=4, F=10)	66.4 ± 5.0	168.0 ± 10.8	70.1 ± 10.0

From the three assessment tests performed, we only found a significant difference ($p \leq 0.01$) for the SRT. The XT group (M = 7.5 SD = 1.7) scored significantly higher on the test compared to the walking group (M = 5.4 SD = 1.8). No significant difference was found for the TUG test ($p \geq 0.05$), area of 95% ellipse during eyes open condition ($p \geq 0.05$), or area of ellipse during eyes closed condition ($p \geq 0.05$) between activity groups. See Table 3 for statistics.

Table 3. Scores for all three assessment tests for W and XT groups

				Area of 95% ellipse (sq in)			
Activity Type	N	TUG (s)	SRT (# of support)	Best score EO	Best Score EC	Mean score EO	Mean score EC
Walking	10	8.8 ± 1.0	5.4 ± 1.8	.271 ± .163	.352 ± .304	.329 ± .159	.407 ± .323
XT	14	8.4 ± 1.7	7.5 ± 1.7**	.268 ± .240	.270 ± .189	.326 ± .238	.371 ± .244

** ($p \leq 0.01$) XT vs. W

Chapter 5: Discussion

The purpose of this study was to examine if outcome scores from the TUG, postural sway test, and SRT are different between two groups of exercisers: regular walkers (W) and regular cross-trainers (XT). We found that the SRT was the only test that was significantly different, in terms of outcome scores, between the W and XT groups ($p \leq 0.05$). Significant differences were not observed for the TUG test or the postural sway between the walking and XT groups.

Sitting-Rising Test

To the best of our knowledge, this is the first study to compare a non-traditional fall risk assessment test to traditional fall risk assessment tests. The SRT was originally designed to measure mortality risk. Our results support part of our hypothesis, in that differences between exercise groups would be observed in the SRT. Our findings indicate that the SRT may be more sensitive to differences in muscular strength, balance, and flexibility between groups of healthy, active community dwelling adults, compared to the TUG and postural sway tests. However, without conducting a longitudinal study and measuring falls during a follow up period, it is impossible to say whether the SRT can predict future falls in this population. Moreover, the SRT might be able to detect the subtle changes in muscular strength, balance, and flexibility, associated with natural aging. Ability to recognize the subtle changes in muscular strength, balance, and flexibility may prove beneficial by implementing exercise interventions earlier and potentially to prevent future falls. The only other study comparing the SRT to another assessment compared SRT scores to flexibility scores. Completed by the authors of the original SRT study, Brito, de Araujo, and de Araujo (2013), found a moderately positive correlation between flexibility test scores and SRT scores (r = .296). These results bring to light the flexibility component that can be measured during the SRT test, without having a separate test for flexibility.

Timed Up and Go Test

The Timed Up and Go Test (TUG) test is one of the most commonly used tests in the tool kit of fall risk screens. It is used to examine multiple factors associated with mobility, including balance, gait speed, and functional ability (Beauchet et al., 2011). However, the TUG test is often criticized for its lack of predictive value of future falls across elderly individuals with varying degrees of mobility. We did not find a significant difference in time to complete the test between the W group (Mean = 8.8 (s), SD = 1) and XT group (Mean = 8.4 (s), SD = 1.7). Our findings are in line with a more recent study (Singh, Pillai, Tan, Tai, & Shahar, 2015) that found the TUG was not a predictor of fall risk in community-dwelling adults when comparing it to the physiological profile assessment tool. The physiological profile assessment tool measures vision, vestibular function, peripheral sensation, vibration sense, proprioception sense, muscular force production, postural sway tests, and reaction time tests to differentiate between fallers and non fallers (Lord, Menz, & Tiedemann, 2003). This shows that an assessment test, like that of the physiological profile assessment tool, that examines the relationship of the many factors associated with prevention of falls does not result in the same predicative outcome as the TUG. Such a complex assessment like the physiological profile assessment works well in research settings but might be too difficult to perform in community settings or clinical office settings. Thus, a simpler, yet equally sensitive test, such as the SRT, might be a better choice for community settings. A study by Shumway-Cook, Brauer, and Woollacott (2000) found the TUG test to be valid for community-dwelling adults and set the cutoff time at 13.5 seconds for individuals with a high risk for future falls. However, a systematic review and meta-analysis (Barry et al., 2014) agreed that the TUG test is limited in predicting future falls in community dwelling adults and should not be used, except in concert with other fall risk assessment tests to predict future falls.

Balance

To assess balance among subjects, we analyzed the center of pressure, which represents the changes in forces applied to the force platform in order to maintain a quiet upright stance (Thapa et al., 1996). We analyzed postural sway two ways using the 95% area ellipse to give us the area covered by the center of pressure (COP) excursions. The first way was looking at the best score from each experimental condition, eyes open and eyes closed. The second way was taking the mean of the two trials for each of the conditions to get the mean 95% area ellipse for each condition. The two analyses resulted in no significant differences between exercising groups. Our findings are similar to another study that examined postural sway in women participating in three different types of exercise groups (de Oliveira et al., 2014). No differences were observed in postural sway between a mini trampoline group, aquatics gymnastics group, and a floor gymnastics group after 12 weeks of training. All groups showed positive changes in postural sway following training, but no differences were observed among groups. Another study by Judge, Lindsey, Underwood, and Winsemius (1993) found that six months of combined training (walking, lower body strength training, and postural control exercises) did not result in improvement of double leg static balance compared to flexibility training alone. However, single leg stance COP improved by 17% for the combined training compared to no change in the flexibility group (Judge et al., 1993). The first study by de Oliveira et al. (2014) showed that even though all exercise groups improved in their performance in postural balance, no difference was observed between the groups. These findings support similar findings that lead us, as health professionals, to think that any exercise will be beneficial to the individual. Washburn, McAuley, Katula, Mihalko, and Boileau (1999) found this when using the PASE questionnaire, used to measure physical activity, that it is correlated with general health measures such as obesity, blood pressure, and oxygen consumption. They found that the higher the score on

PASE, indicating more physical activity, was strongly correlated with better health measurements. The study by Judge et al. (1993) only found differences in postural balance between combined training groups and a flexibility group when making the postural position more difficult. Again, these findings tell us that physical activity can improve our scores in common assessment tests, but these assessment tests may not be sensitive enough, like the more complex assessment tests, to be used in a community setting to predict future falls. As found in this study, the SRT might be more sensitive to differences in physical fitness across otherwise healthy, older, community dwelling adults.

Limitations

One of our major limitations is that we did not directly measure muscular strength, flexibility, or any other physical measures throughout this study. This makes it difficult to say if the SRT is actually revealing discrepancies in those measures or in something else. In addition, the amount of physical activity for each exercise group was not controlled. The PASE questionnaire was used to assign subjects into either a walking group or XT group, but the amount of time each subject spent doing an activity was not recorded. The PASE questionnaire is used to record leisure and household activities for the past seven days. Furthermore, a control group was not used and therefore, we cannot compare differences between two physically active groups and a sedentary group.

Chapter 6: Conclusion

Differences in outcome scores of the TUG test and postural sway under eyes open condition and eyes closed condition were not observed between groups participating in different types of physical activity, walking (W) and cross training (XT). We did find a significant difference in the SRT between the two groups. To our knowledge the SRT has never been used to investigate risk for future falls. We noticed that the SRT might be able to detect differences in functional movement in healthy, active, older adults where other tests might have fallen short. Future studies will need to further investigate these findings. Comparing strength and power measurements to SRT scores might provide insight into the underlying mechanisms responsible for differences in SRT performance outcomes. Lastly, longitudinal studies would be beneficial to elucidate whether the SRT can predict future falls in an elderly population.

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Vita

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