5-2016

The Comparison of Dual-Tasking and Functional Fitness in Older Females

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An Honors Thesis Submitted in partial fulfillment of the requirements for Honors Studies in Kinesiology

By

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Spring 2016

Kinesiology
College of Education and Health Professions

Introduction

The aging population in the United States is growing faster than ever. Between 2010 and 2050, the number of Americans who are aged 65 and older is projected to increase from 40 million to over 88 million. The number of people over age 85 is expected to triple, from 6 million in 2010 to over 19 million by 2050 (Vincent & Velkoff, 2010). These changing demographics are presenting increasing challenges for healthcare providers and caregivers. One of these challenges is the high risk of falls among older adults. Over 33% of all adults aged 65 and older fall every year, contributing to a nearly $200 billion added burden on the healthcare system (Stevens, Corso, Finkelstein, & Miller, 2006). Among older adults, falls are the number one cause of injury-related death (Scheffer, Schuurmans, Dijk, Hooft, & Rooij, 2008).

Falling is such a serious issue that fear of falling can cause older adults to not participate in activities and become less social (Scheffer et al., 2008). Fear of falling is a psychological condition that describes anxiety that occurs during any activity that an individual might perceive as hazardous, and it is considered to be a significant health problem among older adults. A high fear of falling generally suggests a lower self-efficacy regarding physical tasks. If the fear of falling and decrease in self-efficacy are severe, these conditions can even result in a loss of independence. Studies report that up to 89% of older adults suffer from fear of falling. Fear of falling is prevalent among older adults that have experienced one or more falls, but older adults that have never experienced a fall can also suffer from fear of falling (Scheffer et al., 2008).

Falls are dangerous for all older adults, but women are at a particularly high risk of complications from a fall. Women are more likely to have a low bone mineral density after menopause, leading to an increased risk of fracture upon falling. In addition, women have a higher fall frequency when compared to their male counterparts. Females who are between ages 75 and 85 experience non fatal falls 1.5 times more than males, and women over age 85 experience almost twice as many falls as men (Stevens et al., 2006). Due to the older female population's high risk of injury from falls, it is important to understand why falls occur and what can be done to lessen the risks.

As people walk, there is a continuous cycle of becoming unstable as the center of gravity shifts forward during the swing phase and regaining stability at mid-stance (De Koster, n.d.). Since walking requires a good amount of balance control, any additional activity that divides the attention of older adults can be dangerous. Performance of dual-tasking activities is a risk factor for falls among older adults (Hall,Echt, Wolf, & Rodgers, 2011). Dual-tasking is defined as walking while simultaneously performing a cognitive task. Activities of daily living frequently involve dual-tasking; individuals often walk and talk simultaneously, such as having a phone conversation or visiting with a friend while walking outdoors. Dual-tasking is a measure of cognitive and physical function, and research has demonstrated that older adults have difficulty connecting these functions (Lindenberger, Marsiske, & Baltes, 2000).

An individual's level of functional fitness can also be a predictor of fall risk. Functional fitness is defined as "having the physiologic capacity to perform normal everyday activities safely and independently without undue fatigue" (Rikli & Jones, 1999). Older adults that are less functionally fit are at an increased risk for falling. Early identification of individuals with low functional fitness can help to reduce the risk of falls by taking preventative measures. Tests such as chair stands and the timed up-and-go are used to assess functional fitness, and poor performance during these tests has been linked to an increased occurrence of falls (Shumway-Cook, Brauer, & Woollacott, 2000).

There is a lack of research on older women with low functional fitness and dual-tasking conditions. This study investigated the effect of low functional fitness on walking speed under dual-tasking conditions. We hypothesized that women with lower levels of functional fitness would experience a greater decline in walking speed when under dual-task conditions, putting them at a greater risk for potential falls.

Literature Review

Functional Fitness

Walking is a vital aspect of functional fitness. Approximately 70% of older adults walk as a form of leisure time physical activity. For many of these individuals, walking is the only type of exercise in which they participate. Older women, in particular, participate in significantly less physical activity than older men (Lee, 2005). American women also outlive men by an average of 5 years (Arias, 2014). Because of the decrease in exercise and higher life expectancy, it is possible that women experience low functional fitness at a higher rate than men. If this is the case, does a lower level of functional fitness cause more difficulty completing dual-task activities, subsequently increasing fall risk for older adult women?

To assess functional fitness, the 8-foot up and go is often used, as it is a measure of agility and dynamic balance. This test was designed as a part of the Senior Fitness Test, a battery of six assessments used to determine overall functional fitness for older adults (Rikli & Jones, 1999). The 8-foot up and go can be used to classify older females as either functionally fit or functionally dependent. This test has also been validated as a predictor of fall risk. Older adults who took 8.5 seconds or longer to complete the test were much more likely to be a faller than individuals who completed the test in a shorter amount of time (Rose, Jones, & Lucchese, 2002). The Timed Up and Go assessment is similar to the 8-foot up and go, but it requires subjects to walk 3 meters rather than 8 feet. This test has also been demonstrated to be a successful predictor of fall risk. The traditional Timed Up and Go test has been examined alongside a dual-task version of the Timed Up and Go using two groups classified as fallers and non-fallers. Functional mobility was assessed using a 3-minute walk test, and a combination of self-report, the Berg Balance Test, and the Activities-Specific Balance Confidence scale assessed fall risk. Subjects were asked to divide their attention by counting backwards by threes while completing the Timed Up and Go as quickly as possible. The dual-task protocol increased the time it took to complete the Timed Up and Go for both groups. Time was increased by 25% for fallers and 16% for non-fallers. This evidence supports the assertion that individuals with a lower level of functional fitness experience a sharper decline in walking speed when under dual-tasking conditions than individuals with higher functional fitness capabilities (Shumway-Cook et al., 2000).

Dual-Tasking

Walking is a process that, though it may seem automatic, requires attention. This is supported by the decline in various gait parameters when a subject is concurrently completing a task that requires cognitive attention. The concept of dual-tasking is well studied, particularly in an older adult population. A lower ability to complete dual-task activities successfully has been linked to a higher risk and incidence of falls, and individuals with a history of falls experience a greater change in gait parameters including walking speed and cadence under dual-tasking conditions when compared to individuals who do not have a history of falls (Hall et al., 2011). Under single-task walking conditions, the difference in the gait parameters such as walking speed, stride length, and step cadence of fallers and non-fallers is not significant (Toulotte, Thevenon, Watelain, & Fabre, 2006). Because of this relationship, the analysis of gait parameters under dual-tasking conditions provides valuable information about an individual's risk for future falls.

Many older adults can be observed halting walking when they are simultaneously talking. Even something that seems like a simple task has been shown to be an indicator of fall risk. With as many as 83% of people who stopped walking when they were having a conversation experienced a fall within the next 6 months. In the other group, 76% of people who did not stop walking when having a conversation did not experience a fall within the next 6 months (Lundin-Olsin, Nyberg, & Gustafson, 1997). Walking while talking is a real-world example of dual-tasking during daily activities, and the relationship between walking while talking and future falls can serve as a powerful predictor of future functional decline.

Dual-tasking abilities can vary based on the cognitive cost of the task and the cognitive capabilities of an individual. Findings have demonstrated that there is a reasonably strong linear relationship between dual-tasking abilities and cognitive abilities. Individuals who are more cognitively capable and who do not have any form of cognitive impairment are more successful when attempting dual-task activities. If an individual is asked to do an easier or simpler cognitive task, this linear relationship fades and becomes less correlated (Venema, Bartels, & Siu, 2013). Based on this model, a moderately challenging cognitive task could be expected to provide a moderate linear correlation. Hall et al. (2011) tested four different cognitive assignments of varying difficulty as one of two simultaneous tasks. These tasks included saying the alphabet, saying the alphabet with alternating letters, counting backwards by threes from a predetermined number, and saying as many words as possible that begin with a particular letter. All four of these tasks caused subjects to have a slower walking speed. The task of saying every other letter of the alphabet caused the sharpest decrease in gait speed (30%), while normal recitation of the alphabet caused the smallest gait speed change (4%). Normal alphabet recitation is rhythmic and somewhat automatic, while alternate alphabet recitation is unfamiliar and requires greater concentration. When subjects were asked to count backwards by threes from a predetermined number, they experienced a moderate decline in gait speed (18%). Counting backwards by threes engages working memory and attention over a sustained period. This is a suitable assessment of dual-tasking ability because it provides a cognitive task without overloading an individual with an extremely complex assignment (Hall et al., 2011). Counting backwards by other numbers other than three has been assessed using particularly active and high functioning older adults. These individuals walked while participating in an attention-demanding task—counting backwards by 7s from 100 and by 13s from 100. Both activities decreased walking speed, with the former resulting in a 5% change and the latter resulting in a 12% change (van Iersel, Ribbers, Munneke, Borm, & Olde Rikkert, 2007). Overall, backwards counting is considered to be a standard method of analyzing dual-tasking capacity.

Generally, walking performance is the focal point of dual-tasking studies. However, counting performance has also been analyzed in relation to fall risk. During a test of counting backwards, older adults who had a stronger performance while walking rather than sitting (a positive cognitive performance) demonstrated a slower walking speed and a higher incidence of falls in the 12 months following the study (Beuachet, Dubost, Allali, Gonthier, Hermann, & Kressig, 2007). Based on this information, both the counting and walking performance during dual-task tests can be used as a predictor of falls in older adults.

Another variable in dual-tasking studies is the level of prioritization of one task over another. Even if subjects are encouraged to devote equal attention to both the cognitive and the motor task, they often focus more one task than another without realizing. Using both younger and older adults, Yogev-Seligmann, Rotem-Galili, Mirelman, Dickstein, Giladi, & Hausdorff (2010) attempted to define the link between performance and prioritization. Subjects were asked to walk for one minute at regular pace and then complete this walk while saying as many words as possible beginning with a particular letter. Then, they were advised to do this dual-task walk two more times—once prioritizing the motor task and once prioritizing the cognitive task. Gait speed was significantly reduced when comparing the single-task and dual-task trials in both older and younger adults. However, the older adults did not exhibit a significant change in gait speed between the three dual-task conditions. This suggests that the effects of cognitive versus motor task prioritization are minimal and that individual differences in task prioritization do not have a significant impact on the gait speed of older adults (Yogev-Seligmann et al., 2010).

Cognition

Maintaining the necessary balance to be able to walk without issue requires a large amount of cognitive control. There is a strong tie between cognitive and physical functioning in older adult populations, and aging has a significant negative effect on the cognitive processes that are involved in balance and gait. When compared with younger counterparts, older adults exhibit a sharper decrease in walking speed and a decline in accurate memorization when executing simultaneous cognitive and motor tasks (Lindenberger et al., 2000). The concept of Dual-Task Costs (DTCs) explains this relationship. If dual-task conditions exceed the capabilities of an individual, their execution of one or both of the activities suffers. It has been documented that older adults have higher DTCs for cognitive activities than their younger counterparts. Additionally, the difficulty of a cognitive task was increased to determine its effect in a dual-tasking relationship. They found that raising the difficulty level of cognitive task significantly reduced balance and stability in older adults (Doumas, Rapp, & Krampe, 2009). It has been found that cognitive declines often occur before or simultaneously with physical declines as individuals age (Atkinson et al., 2010). This decrease in functional ability with age combined with a task that taxes memory or other cognitive processes can cause a significant change in balance and the ability to safely ambulate.

The level of effort with which an individual walks can also play a role in dual-tasking. Deshpande, Metter, Bandinelli, Guralnik, & Ferrucci (2009) alleged that it took more cognitive attention to walk at maximal speed rather than habitual speed. It was also suggested that maximal gait speed could be used as a stronger predictor of cognitive decline than habitual gait speed. However, there was no link found between dual-task walking speed and cognitive decline in the subsequent three years (Deshpande et al., 2009). By measuring dual-task ability with habitual and maximal walking speed, this relationship can be better examined.

Dual-tasking has been thoroughly studied in individuals with cognitive impairments. Executive functioning involves complex thinking and encompasses processes including problem solving, planning, and changing tasks (Elliot, 2003). Successful executive functioning is vital to accomplishing many dual-task activities. Deterioration of executive functioning controls including working memory and divided attention is common for older adults who have mild or major cognitive impairments (Makizako, Doi, Shimada, Yoshida, & Suzuki, 2013). Vascular dementia is a variation of cognitive impairment that primarily attacks executive functioning and attention. It would seem that individuals with this diagnosis would have an even more pronounced difficulty with dual-tasking (Inasaridze, Foley, Logie, & Della Salla, 2009). Because individuals with diagnosed cognitive or severe motor impairments would likely create a greater dual-task decline in walking speed than healthy adults, they will be excluded from this study.

Fear of Falling and Self-Efficacy

Fear of falling can have a substantial negative impact on gait speed. Reelick, van Iersel, Kessels, & Olde Rikkert (2009) assessed this relationship under dual-tasking conditions. It was concluded that for individuals with and without a fear of falling, the gait speed change in a dual-task trial was not significantly different. However, this study did not classify participants based on varying functional fitness levels. It has yet to be determined if there is a relationship between dual-task ability, functional fitness level, and fear of falling. (Reelick et al., 2009).

There are many surveys available to assess fear of falling. These tests range from falls efficacy questionnaires to activity based forms, and they have been shown to give broad results. In a review of 33 studies using various fear of falling assessments, it was apparent that females generally report a fear of falling at a higher frequency than men. It was also found that as few as 3% or as much as 85% of older adults experience fear of falling. This large range suggests that there is no flawless or uniform measure for fear of falling. One of the more consistent tools used is the FES-I (Falls Efficacy Scale-International) (Scheffer et al., 2008). This test is a self-reported questionnaire designed to examine an older adult's fear of falling during normal activities in the home and more difficult activities of daily living (ADLs) and social situations. The study that developed the FES-I demonstrated its strengths. The International version of FES retained many of the original situations in a simpler and easier to understand form. The inclusion of more challenging outdoor and social activities accounts for even more situations that older adults might be likely to encounter. It is a reasonable indicator of fall risk and fear of falling because older adults who had previously fallen or suffered from dizziness or chronic illness displayed a significantly higher total FES-I score than those who were less at risk for falls. It has been reviewed and validated in many countries (Yardley, Beyer, Hauer, Kempen, Piot-Ziegler, & Todd, 2005).

Methodology

The subjects were women aged 65 and older. The total sample size consisted of 26 subjects (*n* = 26). The control group consisted of 13 women (*n* =

13) with an above-average level of functional fitness (8-foot up age group percentile of 60 or above). The experimental group consisted of 13 women (*n* = 13) with a moderate to lower-than-average level of functional fitness (8-foot up and go age group percentile of less than 60). Exclusion criteria included: diagnosis of cognitive impairment such as Alzheimer's Disease and diagnosis of severe neurological disease such as Parkinson's Disease.

Procedures

Before any physical assessments, all subjects completed a written informed consent form approved by the Institutional Review Board at the University of Arkansas, a health history questionnaire assessing general health, previous falls, orthopedic disorders, and neurologic disorders, and a FES-I (Falls Efficacy Scale International) questionnaire to assess fear of falling. The FES-I is a self-reported questionnaire that required subjects to assess their confidence in performing activities and rate themselves on a scale of 1 to 4, with one being most confident and four being least confident. Height and weight were measured and recorded for each subject.

Functional fitness was assessed using the standard protocols for the 8-foot up and go set forth in the Senior Fitness Test, or SFT (Rikli & Jones, 1999). The 8-foot up-and-go assessment timed the subject as they stand up from a chair, walk 8 feet forward, round a cone, walk back to the chair, and sit down as quickly as possible. The 8-foot up and go test is a measure of agility and dynamic balance, so it was the primary focus for classification by functional fitness level. Individuals that scored higher than the 60th percentile for their age group were placed in the high functioning category, and individuals who scored in the 60th percentile or lower were placed in the moderate functioning category.

After categorizing subjects based on their functional fitness levels, walking speed was measured with a wireless timer system (Brower Timing Systems, Draper, UT). Subjects walked a 10 m distance with 3 m extra at each end to control for acceleration and deceleration. First, the subjects walked the length of the runway at their normal, habitual walking speed, as if they were walking somewhere in their home. The two similar were be recorded and averaged. Then, the subjects were asked to again walk at their habitual speed and also complete a cognitive task. For the purpose of this study, the cognitive task was counting backwards by threes from a predetermined three-digit number (e.g., 125, 132). This was repeated, and these trials were recorded and averaged. The number of correct and incorrect subtractions made while walking were also recorded. Next, the subjects were asked to walk the length of the runway as quickly as they could. This was repeated, and the two trials were recorded and averaged. Finally, subjects were asked to walk as quickly as possible again, this time while counting backward by threes. Number of correct and incorrect subtractions made while walking were also recorded.

Data Analysis Procedures

The independent variable was the individual's level of functional fitness—moderate or high. The dependent variables were the dual-task walking time and the dual-task cost for each individual, calculated by subtracting the single task walking time from dual-task walking time. Overall, this study compared the single-task walking and dual-task walking difference between the two groups. A one-way ANOVA was used to determine differences between dual-task decrement of the habitual and maximal walking speed trials between the functional fitness groups. All values were reported as means plus or minus the standard deviation. Statistical significance was set at α = .05 for all analyses.

Results

Upon conclusion of testing, data were gathered for 26 individuals, with 13 women in the moderate functioning group and 13 women in the high functioning group. The age, weight, and height means were similar for both groups, suggesting that these measures did not have an effect on walking speed during any of the trials. Fear of falling was also analyzed using the self-reported Falls Efficacy Scale-International. FES-I has a scale of 16 to 64, with 16 being least fearful of falling and 64 being most fearful. The FES-I score of the moderate functioning group was 21.9 ± 6.4, while the FES-I score of the high functioning group was 22.2 ± 6.6. These values were not significantly different from one another, suggesting that fear of falling was not a contributing factor during the trials.

Table 1

Subject demographics for moderate, high, and combined subjects

Measure	Moderate (*n* = 13)	High (*n* = 13)	Total (*n* = 26)
Age (y)	79.4 ± 6.2	79.8 ± 4.5	79.6 ± 5.5
Weight (kg)	65.1 ± 10.4	64.2 ± 7.4	64.4 ± 8.8
Height (cm)	160.9 ± 5.7	161.0 ± 5.2	161.0 ± 5.3

FES-I score	21.9 ± 6.4	22.2 ± 6.6	22.1 ± 6.5

The 8-foot up and go time was the method of moderate versus high functional fitness classification. Individuals in the moderate group recorded a mean 8-foot up and go time of 8.3 ± 2.4 s, while individuals in the high group produced a mean time of 5.7 ± 0.9 s. The 8-foot up and go time difference between the two groups was 2.6 ± 1.5 seconds. The difference between the dual-task walking times of the moderate and high groups under habitual conditions was 0.3 ± 1.2 seconds. The difference in the maximal walking time of the moderate and high groups was 1.1 ± 0.1 seconds. For habitual walking time, there was not a significant Dual Task Cost difference between the moderate and high groups (p = .79). However, a significant difference was found between the groups' maximal walking times (p = .04).

Table 2

Walking time measurements for moderate, high, and combined subjects.

Measure	Moderate (n = 13)	High (n = 13)	Total (n = 26)	p-value
8-ft up and go (s)	8.3 ± 2.4	5.7 ± 0.9	7.0 ± 2.2	.001
DT usual (s)	10.2 ± 1.8	9.9 ± 3.0	10.0 ± 2.4	.785
DT max (s)	7.9 ± 1.5	6.8 ± 1.4	7.3 ± 1.5	.044

Dual-Task Costs were calculated as dual-task walking time minus single-task walking time and analyzed using another one-way ANOVA. The moderate group displayed a lower DTC under usual conditions, with a difference of 1.3 ± 1.5 seconds. The moderate group also had a lower DTC under maximal conditions, with a difference of 0.3 ± 0.3 seconds. Neither usual speed DTC (p = .11) nor maximal speed DTC (p = .38) were statistically significant. However, there was a large effect size (0.72) for DTC under usual conditions. The effect size for DTC under maximal conditions was smaller (0.36).

Table 3

Dual-Task Costs for moderate, high, and combined subjects.

Measure	Moderate (n = 13)	High (n = 13)	Total (n = 26)	p-value
DTC usual (s)	0.9 ± 1.0	2.2 ± 2.5	1.56 ± 2.0	.11
DTC max (s)	0.8 ± 0.8	1.1 ± 1.1	1.0 ± 1.0	.38

Discussion

Individuals who are less functionally fit are at a higher risk of falling, and individuals who have a greater decrease in walking speed under dual-task conditions are at a higher risk of falling (Shumway-Cook et al., 2000 & Hall et al., 2011.). Logically, it would be assumed that individuals who are less functionally fit and have a large decrease in dual-task walking speed would be at a particularly high risk for falls. According to this study, there was no significant link between functional fitness and dual-task decrements. Contrary to our hypothesis, the moderate functional fitness group had a lower average Dual-Task Cost for both the habitual and maximal trials. However, there was a significant difference in maximal dual-task walking speed, with the high functioning group performing much better than the moderate functioning group. Therefore, it appears that maximal dual-task walking time is more closely linked to functional fitness level than habitual dual-task walking time. Since there was no significant difference found for the habitual speed Dual-Task time between the groups, it can be assumed that dual-task walking at a habitual speed is not a consistent contributor to fall risk.

The assertion that dual-tasking at maximal walking speed is a more important factor to consider than dual-tasking at habitual walking speed is consistent with findings from previous studies. It takes more cognitive attention to walk at maximal speed than it does to walk at usual speed, so by examining walking speed, it appears that those who are more functionally fit are able to divide attention between counting backwards and walking more successfully (Deshpandi et al., 2009). More generally, the results of this study align with other studies that suggest maximal walking speed is more related to functional fitness than is habitual walking speed (Gray, Paulson, & Powers, 2015).

The demographic information for these individuals was largely similar. There was little difference in the mean ages of the groups, and all of the participants were volunteers from a retirement community. Based on the information gathered through the FES-I questionnaires, fear of falling can be ruled out as a confounding variable between the two groups. Neither group had a particularly high fear of falling, and there were no outliers in this data set.

This study was not without limitations. The sample size of the study was small, with 13 in each group. Additionally, there were 2 outliers in the high group for DTC under usual conditions. Another large limitation was the functional fitness level of the individuals. Most participants were on the higher side of functional fitness, and there were very few that would truly be classified as low—only 6 of the 26 subjects fell in the 30th percentile or below for the 8-foot up and go. Because of the limited size and varying functional fitness levels, groups had to be assessed by dividing the sample in half, with those with the 13 fastest 8-foot up and go times being placed in the high group, and individuals with the 13 slowest times being placed in the moderate group. Everyone in the high group exhibited above average levels of functional fitness, with 8-foot up and go times ranking in the 60th percentile or higher for their age group. The limited subject pool and division of participants down the middle resulted in the moderate group being more functionally diverse, with individuals falling anywhere from the 55th to the 1st percentiles for their age group. This suggests that the results might not be entirely applicable to individuals who are truly moderately functionally fit, as a few individuals in this group exhibited very low functional abilities (4 out of 13 in the 20th percentile or below.)

Based on the information from this study, neither habitual nor maximal Dual-Task Costs have strong ties to functional fitness level. However, maximal dual-task walking speed was significantly linked to functional fitness level, and it is a factor that should be considered when assessing fall risk for older females.

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