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The Impact of Visual Impairments on Mobility Performance in Community-Dwelling Older Adults

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THE IMPACT OF VISUAL IMPAIRMENTS ON MOBILITY PERFORMANCE

IN COMMUNITY-DWELLING OLDER ADULTS

By

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A doctoral project submitted in partial fulfillment
of the requirements for the

Doctor of Physical Therapy

Department of Physical Therapy
School of Allied Health Sciences
Division of Health Sciences
The Graduate College

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We recommend the doctoral project prepared under our supervision by

Lauren Andrew, Talia Davis, and Christian Johnson

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ABSTRACT

Background and Purpose: Falls are a major concern for elderly adults and can have a significant impact on overall health and well-being. Declines in vision with aging may be related to the development of fear of falling (FOF) and impaired mobility. It is possible that impaired vision due to common eye diseases can increase the FOF avoidance behavior and affect mobility function in this population. The purpose of this study was to investigate the relation among visual impairment, mobility performance, and FOF avoidance behavior in older adults.

Methods: Inclusion criteria for eligible participants were: 50 years of age and older, able to walk 50 m without assistance, and able to understand simple instructions related to the assessments. A total of 455 participants from local community adult activity centers (males=152, females=303; age=73.1±7.7 years, range=51-97 years) participated. Physical mobility was assessed using an instrumented Timed Up-and-Go test. Visual acuity (VA) was tested using a standard Snellen chart. Avoidance behavior was assessed using the Fear of Falling Avoidance Behavior Questionnaire (FFABQ). Participants' general health and presence of eye diseases (age-related macular degeneration, cataracts, and glaucoma) was assessed using a survey of medical history. A two-way ANOVA was used to investigate effect of VA and avoidance behavior on TUG performance. An additional two-way ANOVA test was used to investigate the effect of self-reported eye disease and avoidance behavior on TUG performance.

Results and Discussion: There was a statistically significant difference between avoiders and non-avoiders' TUG score (avoiders=12.45±5.85 sec, non-avoiders 8.29±3.48, $p<0.001$). The VA has no significant effect on TUG time (no impairment= 8.69 ± 3.49 sec, mild impairment= 9.42 ± 5.05 sec, moderate impairment= 8.11 ± 2.08 sec, severe impairment= 9.45 ± 2.68 sec, $p=0.791$). There is no significant VA group by avoider group interaction ($p=0.66$). There was also a statistically significant difference in TUG scores between participants with and without eye disease (eye disease=9.37±5.08, no eye disease=8.29±2.80, $p=0.004$). There is no significant eye disease by avoider group interaction ($p=0.144$).

Conclusion: The results of this study indicated that the presence of one or more self-reported eye diseases and higher FOF avoidance behavior were both associated with decreased mobility. Contrary to the initial hypothesis of the present study, there was no relation between VA and mobility, nor VA and FOF avoidance behavior. It is important for clinicians to inquire about the presence of eye diseases and administer the FFABQ to older adults in order to identify risk factors related to decline in physical mobility. Presently, the continued use of the Snellen chart to assess for VA as a part of fall risk assessment may be inadequate. Future studies should focus on developing a more comprehensive clinical assessment of vision that expands beyond visual acuity for the geriatric population.

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INTRODUCTION

Despite advances in medicine and technology, the incidence of falls in older adults remains prevalent and is rising. As the life expectancy in the United States continues to increase, so does the incidence of falls.[1-3] Falls are the leading cause of death in adults 65 years and older who sustain an unintentional injury, which is defined as harm that could have been prevented.[4] Currently, 33% of community-dwelling elderly adults and 60% of nursing home residents experience at least one fall each year.[1] In persons greater than 75 years of age, 70% of accidental deaths are attributed to falls.[1] A study conducted by the Centers for Disease Control and Prevention (CDC) that quantified the incidence and related expense of falls in the United States found that the direct medical costs for non-fatal falls was 30.3 billion dollars in 2012.[5]

After a fall, it is common for the elderly to sustain serious injuries, require hospitalization and possible long term care, experience losses in their independence, and increases in morbidity.[1] Resultant psychological effects from falling can also be observed; some of the more common effects include fear of falling (FOF), avoidance behavior, isolation, decreased social interactions, and depression which can lead to further deterioration of function and mobility.[1,2] The presence of avoidance behaviors, anxiety, and participation restrictions, measured using the Fear of Falling Avoidance Behavior Questionnaire (FFABQ), have been shown to increase a person's vulnerability to future falls.[6] Given this information, the public health concern for falls is evident as is the continual need for updated and improved strategies to identify risk factors to the development of FOF.

Visual, vestibular, and proprioceptive inputs are the body's three main sensory systems that play a key role in postural control and mobility.[7] Visual impairment is commonly quantified by a person's visual acuity (VA) performance, which is a measure of the resolution of the eye, particularly its ability to focus and distinguish high contrast objects.[8] Changes in VA are often used to measure the severity and progression of certain eye diseases.[8] In regards to mobility, VA is important for avoiding small obstacles on the floor, reading signs in the environment, and recognizing landmarks.[9] VA has traditionally been used as the primary indicator of the degree of functional impairment caused by vision loss and is the most

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common tool to assess visual function.[8,9] The first chart to measure VA was designed in 1865 by Hermann Snellen, and though many modifications have been made to the original chart, the Snellen letter chart has remained prevalent.[9] There is currently no standardized VA chart, but the classic Snellen chart is one of the most widely used charts for VA testing.[8]

The prevalence of cataracts, age-related macular degeneration, and glaucoma increases with age.[10] When compared to patients with glaucoma, older adults with AMD have been found to exhibit greater decreases in VA.[11] A recent report estimated that 17% of individuals 65 years and older have complaints about their vision, even with corrective glasses and lenses.[12] People with visual impairments are more likely to be classified as having symptoms of depression, impaired mobility, decreased walking speeds, and difficulty in everyday tasks such as climbing stairs.[12,13] Visual impairment has been associated with dependency of performing activities of daily living (ADLs), reduced physical activity, social isolation, and mortality.[14]

Rubin et al. reported that those with visual impairments not only exhibit impaired mobility, they also express typical traits of avoidance behaviors regarding common social activities.[14] FOF is defined as "a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing".[15] A number of longitudinal studies have shown that the development of both a FOF [16] and mobility limitations[17] within five years after middle- to older-aged adults can be predicted by declines in VA in the presence of other medical conditions. Additionally, participants in the poorest category of VA exhibit a higher odds of developing a FOF, and those in the poorest categories for visual function had a higher odds of experiencing a fall.[16]

While previous studies have identified potential links between vision impairment, increased FOF, and ADL restrictions, it is currently unclear how vision affects physical mobility performance in community dwelling older adults. Therefore, the primary aim of this study was to investigate the relation among VA and mobility performance in this population. We hypothesized that impaired VA would have a significant impact on the mobility performance in older adults, and may compound with FOF avoidance behavior to exacerbate the effect. The second aim of the study was to analyze the impact of the presence

of eye diseases on mobility performance. Our hypothesis was that the presence of eye diseases in conjunction with FOF avoidance behavior would have a significant negative impact on mobility performance. The final aim of the study was to examine the correlations between mobility performance, VA, and FFABQ score. We hypothesized that decreased mobility would be correlated with impaired vision and increased FOF avoidance behavior.

Participants

Adults greater than 50 years of age who were able to walk 50m without assistance were included in this study. Participants were excluded if any of the following were present: unable to understand and follow simple instructions related to the assessments, concurrent injuries causing pain or inability to walk for more than 50 m, and presence of any conditions impairing ability to perform physical activities safely. Participants were recruited without coercion from adult activity centers in the U.S. State of Nevada (Las Vegas and Henderson areas). Participants were given an informed consent and explained the procedure and their rights as research participants in accordance with the Institutional Review Board for Biomedical Research of the UNLV Office of Research Integrity. Participant recruitment took place over a two year period for a total participant pool of 455. Since this is ongoing observational research, a priori power calculation of the sample was not conducted.

Procedures

The testing procedure included the Timed Up and Go (TUG) test, the Snellen test, FFABQ and a medical history questionnaire. The TUG test was administered using a force-instrumented stool (Figure 1). The instrumented TUG test including the standardized test procedure was validated in a prior study and was found to be of excellent reliability (ICC$_{3,3}$= 0.929-0.934).[18] Briefly, the stool was adjusted so that the participant's knee was at 90º of flexion with the ankles in neutral and feet flat on the floor. A cone was placed at 3m from the stool to indicate the walking distance. Each participant performed three trials of the TUG test and was allowed to rest as needed between trials (Figure 2).

The second part of the testing procedure was to test the participant's VA using the Snellen eye exam chart. Participants stood 20 ft. from a well-illuminated flat wall on which the eye exam chart was secured and were instructed to read the lowest visible line (Figure 3).[19] Participants were instructed to cover one eye with their hand while the uncovered eye was tested, and then repeat the process with the other eye. If a participant made more than one error while reading the selected line, they were instructed to read the line above. This was repeated until the lowest visible line was accurately reported by the

participant.[20] Participants were allowed to wear corrective eye lenses for both the TUG test and the VA test if they typically wore them for community ambulation.

The health and wellness surveys included a brief medical history and the FFABQ. The medical history survey included demographic data (age, gender, height, weight, and ethnicity), medical conditions, and medications. The participants were asked to report if they have a diagnosis of the following common eye diseases: cataracts, glaucoma, and macular degeneration. Participants were only considered to have the eye disease if they had not received surgery to correct it. History of falls and number of prescription medications were also recorded. Finally, participants completed the FFABQ to assess avoidance behavior of common daily activities. Table 2 presents the content and validity of the outcome measures used in this study.

Data Analysis

TUG times were calculated as from when 90% of the participant's weight was removed from the stool to when 90% of the weight was replaced on the stool.[18] VA of the eye with better vision was selected for overall VA because Rubin *et al.* reported that monocular VA of the better eye can be considered as equivalent to binocular VA.[21] Participants were categorized into four VA groups (no impairment=<20/30, mild impairment=20/30-20/60, moderate impairment=20/60-20/160, severe impairment=20/160-20/400) based on the findings of Clarke *et al.* and the ICD-10 classification system.[22,23] In order to analyze VA scores in a correlation analysis, the Snellen scores were converted into LOGmar notation and then a negative of its logarithm was used.[24]

Statistical analysis

The outcome variables included FFABQ scores, presence of eye diseases, TUG performance, and VA based on Snellen vision score and category. Group comparisons were performed using two-way ANOVA to investigate the main effects of VA category (4 levels; no impairment, mild impairment, moderate impairment, severe impairment) and avoidance behavior (2 levels; FFABQ<20=non-avoiders, FFABQ≥20=avoiders[25]) on TUG performance. A second analysis was performed using two-way ANOVA tests to investigate the effect of self-reported eye disease (2 levels; yes vs. no) and avoidance behavior (2

levels) on TUG performance. If the main effect or interaction effect was significant, post-hoc tests with Bonferroni correction were performed to compare the TUG performance among the subgroups. Pearson correlation analyses were performed to examine the correlations between the TUG performance, VA score, and FFABQ score. All statistical analysis was done using IBM SPSS Statistics Version 22 for Windows. The α level for all statistical analyses were set at 0.05.

There were 455 participants (152 males and 303 females, mean age = 73.1) included in the analysis of the FFABQ and self-reported eye diseases (Table 1). 271 of these participants were from a previous cohort who did not measure VA. The VA data analysis included the remaining 184 participants (67 males and 117 females, mean age = 72.4). Of the 455 study participants, 218 reported eye disease and 235 reported that they do not have eye disease. Based on the results of the FFABQ, 57 participants were categorized as avoiders and 396 were non-avoiders. Of the participants with VA data, 83 had "no impairment", 88 had "mild impairment", 6 had "moderate impairment" and 5 had "severe impairment".

There was a statistically significant main effect between avoiders and non-avoiders' TUG performance (avoiders=11.62 ± 4.1 sec, non-avoiders=8.69 ± 4.18 sec, p=0.029). The main effect of the VA categories on TUG performance was not significant (no impairment= 8.69 ± 3.49 sec, mild impairment= 9.42 ± 5.05 sec, moderate impairment= 8.11 ± 2.08 sec, severe impairment= 9.45 ± 2.68 sec, p=0.791) (Figure 4). There was no significant VA category by avoider group interaction (p=0.66).

The second ANOVA analysis showed that there was a statistically significant difference between avoiders and non-avoiders' TUG performance (avoiders=12.45 ± 5.85 sec, non-avoiders 8.29 ± 3.48, p<0.001) (Figure 5). There was also a statistically significant difference in TUG performance between participants with and without eye disease (eye disease=9.37 ± 5.08, no eye disease=8.29 ± 2.80, p=0.004) (Figure 6). There is no significant eye disease by avoider group interaction (p=0.144).

The Pearson Correlation analysis showed that there was a statistically significant moderate correlation between FFABQ scores and TUG performance (r=0.438, p<0.001). We did not observe an association between TUG performance and VA scores or between FFABQ scores and VA scores (Table 4).

DISCUSSION

The purpose of this study was to analyze the impact of visual impairments on mobility and FOF avoidance behavior in older adults. Participants with the presence of self-reported eye diseases were found to have significantly poorer mobility performance than those without self-reported eye disease. We also found that higher FOF-avoidance behavior was related to decreased mobility. However, VA was not found to have any statistically significant effect on either mobility performance or FFABQ score. Our findings showed that there was not a significant interaction between the presence of visual impairments and FOF avoidance behavior on mobility performance.

The relation between decreased mobility and FOF avoidance behavior has been reported by previous studies. According to Rossat *et al.*, community dwelling older adults exhibiting poor TUG performance were found to have a significantly increased number of falls, which can lead to continual avoidance behaviors.[26] Additionally, Patil *et al.* demonstrated that women who are highly concerned about falling were significantly more likely to have poor quality of life and lower functional ability.[27] Additionally, it was observed that decreased physical performance, measured with the Short Physical Performance Battery, 400m walk and stair climb tests, lead to increased FOF.[28] Our results agreed with these previous findings that FOF avoidance behavior is a significant predictor of mobility deficits.

Contrary to our initial hypothesis, there was neither a correlation between VA scores and FOF-avoidance behavior score nor a relation between categorical VA and mobility. Similar to our findings, Deshpande *et al.* showed that VA is not related to activity restriction.[29] In their study, they utilized the Snellen chart to measure VA and the Survey of Activities and Fear of Falling in the Elderly (SAFE) questionnaire to measure activity restriction.[29] Similarly, Donoghue *et al.* did not observe a relation between VA and activity limitation.[15] VA was measured using the Early Treatment Diabetic Retinopathy Study (ETDRS) chart and activity limitation was determined subjectively via a "yes" or "no" question. Different from the findings of the present study, Donoghue *et al.* observed that those with the lowest VA, combined with a FOF-related activity restriction, exhibited decreases in mobility (TUG).[15] This finding demonstrates a possible moderating effect of VA on FOF-related activity restriction and mobility. Also

contrary to the results of the present study, Swenor *et al.* found that participants with visual impairment had slower ambulation speed than non-visually impaired counterparts at baseline, 2 years, 4 years, 6 years, and 8 years. However, the change in walking speed over time was similar for participants with visual impairments and those without visual impairment. Visual impairment was defined as best-corrected visual acuity worse than 20/40 on the ETDRS chart or having less than 20° of visual field. Mobility was measured with the following 3 mobility tests: walking upstairs, walking down stairs, and walking 4m.[13] It is possible that the Snellen chart, although commonly used in clinical practice including fall risk screening[30], is not ideal for examining visual acuity. For example, the ETDRS chart has an equal number of characters per row, an equal logarithmic decrement between successive rows, and uses character types which are of relatively uniform legibility.[31] For these reasons, the ETDRS chart is often considered superior to the Snellen chart, however studies have shown that the time taken to complete the ETDRS is longer than the Snellen chart.[32] This specific chart was utilized due to its common and feasible use in a clinical setting by physical therapists, and is recommended use by the Centers for Disease Control (CDC) as a screening item in the STEADI Falls Prevention toolkit.[30] Further studies are needed to determine which vision test is more appropriate for examining visual acuity and other vision performance in the older adult population.

Though VA is commonly used as the primary measure of visual function, visual impairments may also encompass deficits in visual field (VF), depth perception (DP), and/or contrast sensitivity (CS). Deficits in any of these have been associated with decreases in mobility levels of community-dwelling adults.[15] Testing VF is an essential component of a neurologic examination, as loss of the field of vision is often the first sign of a neurologic lesion to the anterior or posterior visual pathways.[33] Properly functioning DP requires the correspondence of two retinal images, and comparison across the visual field in relation to depth. The most common cause for DP deficit is amblyopia, in which one eye fails to provide adequate visual input.[34] CS is the relative difference in light emitted from a target compared to its background. CS is impaired in many conditions and may be reduced even when VA is normal.[35] CS may be impaired in ophthalmic conditions including but not limited to cataracts[36], AMD[37], and glaucoma[38]. In

the present study, presence of one or more self-reported eye disease (AMD, cataracts, glaucoma) was predictive of decreased mobility. The changes in CS seen in these specific visual impairments may explain why impaired mobility was observed in patients with self-reported eye diseases but not in those with decreased VA. In other words, a test for CS might better differentiate levels of visual impairments than VA. The Snellen chart is primarily an assessment tool for VA and therefore may not provide adequate information regarding the other important properties of visual function.

The main strengths of the present study were use of a validated and widely used quantitative measure of physical mobility and use of a validated fear of falling avoidance behavior questionnaire. Both of these measures have been shown to predict fall risk in the older adult population. Previous studies have speculated that TUG may play a more important role when assessing the relation between vision and mobility.[12,13,15] This is due to the requirement of transfers, turning, walking, and balance which requires use of one's vision to a higher degree when compared to straight line walking.[15] Considering future research, it would be beneficial to continue use of these items to assess FOF avoidance behaviors and functional mobility.

The main limitation of the study was the exclusive use of the Snellen chart to test VA. Additionally, singularly assessing VA may not be the best indicator of functional vision since everyday living requires scenarios of low contrast conditions, sources of glare, and suboptimal lighting.[9] Therefore, the development of an updated vision test is necessary. To provide a more comprehensive visual assessment, tests for CS, DP, and VF should be included as all have been shown to have a deleterious effect on mobility.[12,13]Additional limitations of the study include a lack of a diverse participant population in terms of ethnicity, socioeconomic status, due to the sole inclusion of community-dwelling older adults. Inclusion of homebound individuals may reveal different results due to the differences in epidemiology of homebound older adults. A recent article in the Journal of the American Medical Association found that completely homebound individuals were more likely to be older, female, of nonwhite race, have less education and income, and have more chronic conditions.[39] The relation of vision, FOF avoidance behaviors and mobility should include these more at-risk populations. Another limitation of the study is

the collection of the self-reported eye diseases. It is possible that an individual may have any of these conditions unknowingly. A participant may respond that they did not have any of these conditions while the condition may have been present in one or both eyes.

Future Studies:

As a majority of activity level outcome measures used in physical therapy are often conducted in ideal environments with optimal lighting and level walking surfaces, vision is not generally challenged to the extent that visual impairments would have an impact on mobility. It would be beneficial to develop a valid mobility assessment that integrates a visual element. Similar to the TUG manual and TUG cognitive outcome measure to assess dual task performance, performance of the TUG test in a dimly lit room where the subjects have to identify and turn around a target may provide valuable information regarding the impact of vision on mobility. This would allow for therapist's to assess a patient's safety and fall risk when completing tasks such as walking to the restroom at night, or walking outside in the evening.

CONCLUSION

The results of this study indicated that mobility can be negatively impacted by the presence of eye diseases and FOF-avoidance behavior. Therefore, clinicians should inquire about self-reported eye diseases and administer the FFABQ to older adult patients, in order to detect potential risk factors for decreased mobility and fall risk. Presently, use of the Snellen chart to assess for VA and fall risk in physical therapy settings cannot be recommended as there was no observed relation between VA and mobility. Additional methods of testing VA and other visual domains may reveal a relation between impaired vision and decreased mobility; however the present study cannot conclude the presence of such a relation. Though decreases in VA have no significant effect on mobility or FOF-avoidance behavior in community-dwelling older adults over the age of 50, the same cannot be concluded for non-community dwelling older adults. Further research is warranted to determine the primary factors relating to impaired mobility in older adults.

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Table 1. Demographic Data

	Male	Female	Total
Number	152	303	455
Age (Year)	73.2 ± 7.9 (51-95)	72.9 ± 7.63 (51-97)	73.1 ± 7.7 (51-97)
Height (m)	1.76 ± 0.07 (1.55-1.96)	1.6 ± 0.2 (1.35-1.8)	1.6 ± 0.2 (1.35-1.96)
Weight (kg)	89.8 ± 16.5 (58-139)	71.6 ± 36 (37.5-130)	76.4 ± 18.4 (37.5-139)
BMI (kg/m^2)	28.59 ± 6.3 (19.7-40.39)	26.2 ± 17.4 (15.8-47.7)	27 ± 6.1 (15.8-47.7)

Table 2. Outcome Measures

| Scale	Construct	Reliability	Validity
Timed up and Go (TUG)	TUG is a test of mobility that requires the participant to stand up, walk 3 meters, turn, and then return to the seated position. Time taken to complete the test is strongly correlated to level of functional mobility.[40]	TUG has excellent inter-rater reliability (ICC=0.99).[40]	The TUG was found to be a sensitive (sensitivity=80%) test for predicting fallers and specific (specificity=93.3%) measure for predicting non-fallers.[40]
Snellen Visual Acuity	Chart used in which participant reads lowest line of letters possible to assess for visual acuity	Test - Retest ICC = 0.94[41]	Significance of difference of a slope of 1.0: t=3.93, p<0.001 (df=113)[42]
Fear of Falling Avoidance Behavior Questionnaire (FFABQ)	Questionnaire given to assess avoidance behavior due to a FOF.	Test - Retest ICC = 0.812[6]	Individuals classified as fallers reported a greater amount of avoidance behavior than non fallers[6]

Table 3. Pearson Correlation

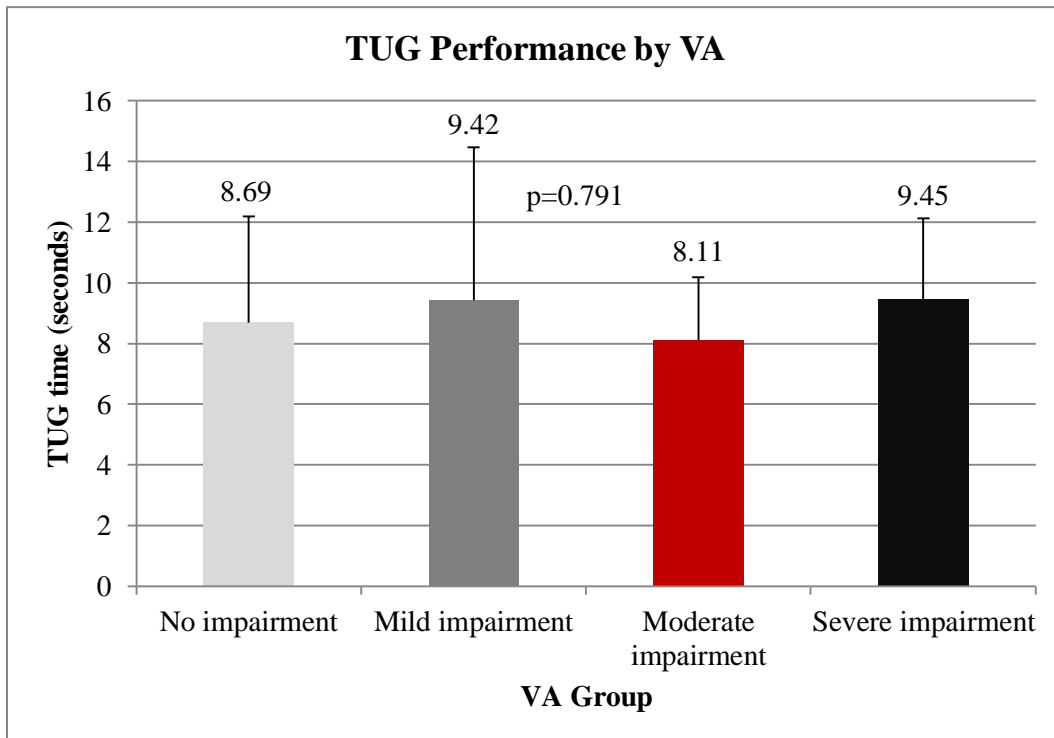|		TUG 3m	VA	FFABQ
TUG 3m	Pearson Correlation	1	.065	.438
	Sig. (2-tailed)		.392	.000
	N	455	178	453
VA	Pearson Correlation	.065	1	-.032
	Sig. (2-tailed)	.392		.671
	N	178	178	176
FFABQ	Pearson Correlation	.438	-.032	1
	Sig. (2-tailed)	.000	.671	
	N	453	176	453

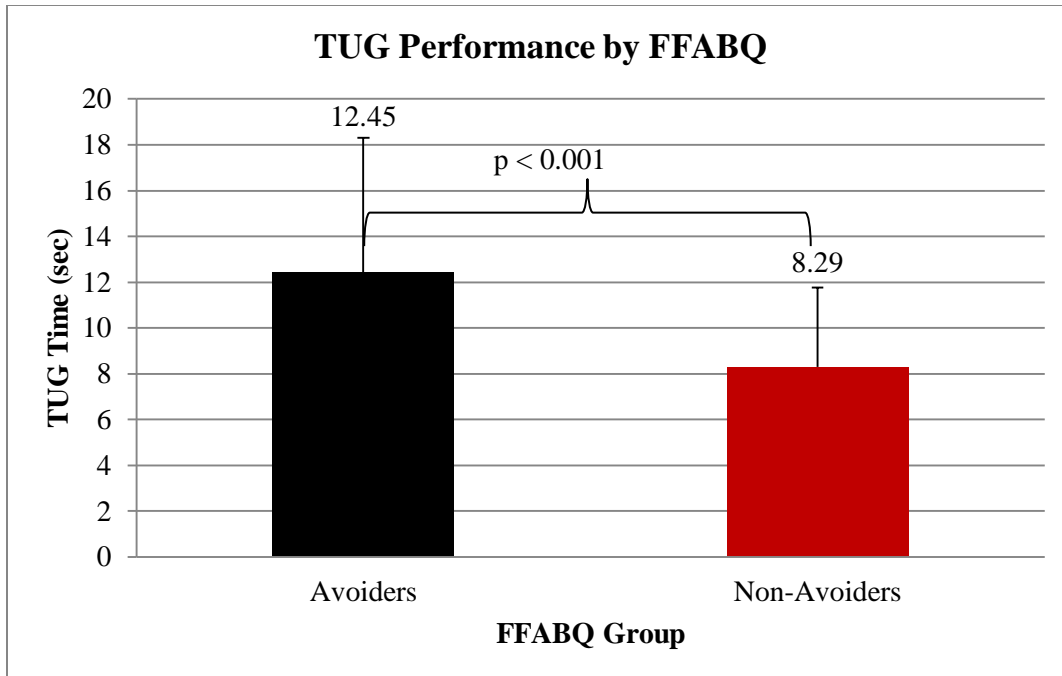**Figure 1.** Force Plate Instrumented Stool
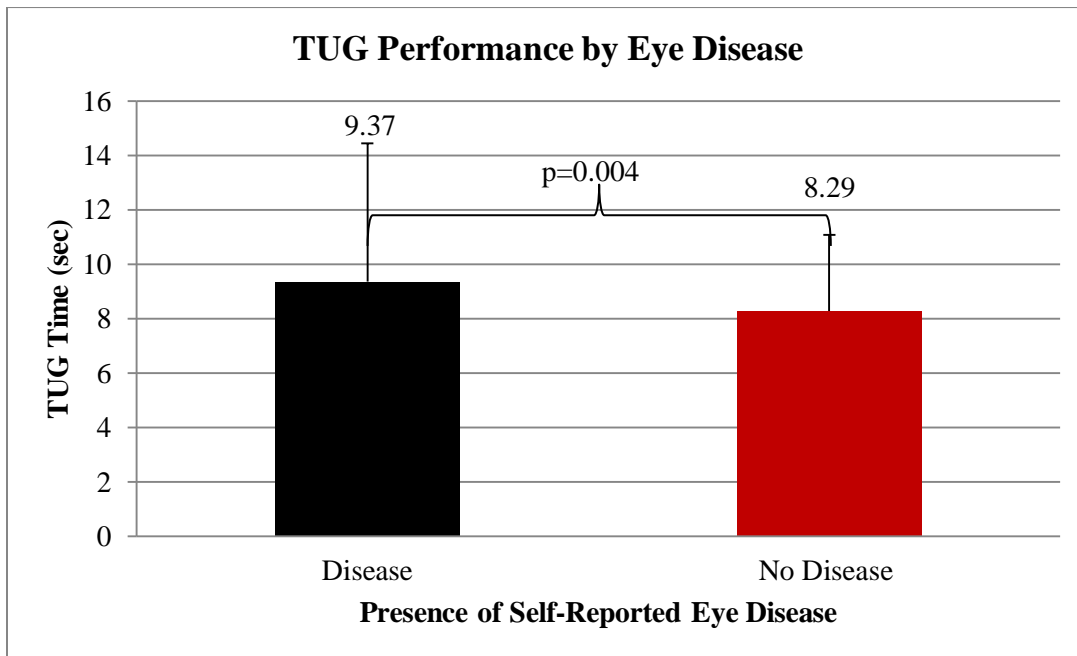

Figure 2. TUG Test at 3m
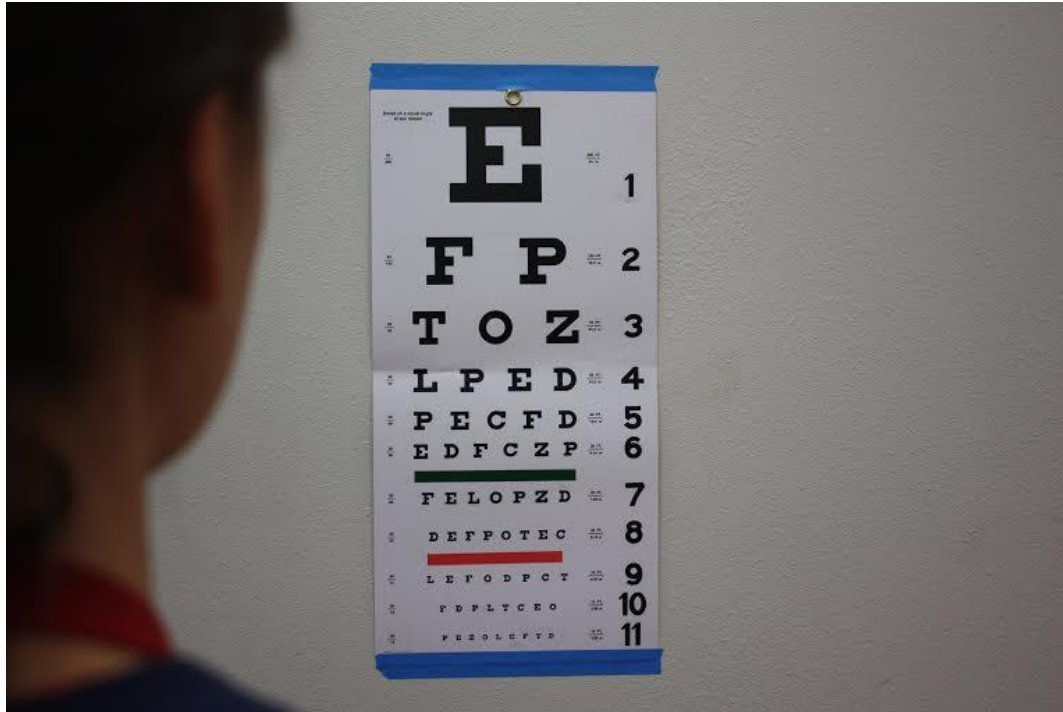
Figure 3. Snellen Chart

Figure 4. TUG Performance by Visual Acuity

Figure 5. TUG Performance by FFABQ

Figure 6. TUG Performance by Eye Disease

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- Renown Rehabilitation. Reno, NV. Acute Rehabilitation. Oct – Dec 2016.
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- The Cleveland Clinic Lou Ruvo Center for Brain Health. Las Vegas, NV. Outpatient Neurological Rehabilitation. July – Sept 2016.
- Rehoboth McKinley Christian Health Care Services. Gallup, NM. Outpatient Care. July – Aug 2015.

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- Comprehensive Physical Therapy. Henderson, NV. Outpatient Care. July – Aug 2015

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- Graduate Assistantship Research Experience. Fall 2015 – Spring 2016
  - Data Analysis – Lee S, Billington E, Devries S, Scoggin K. Effects of internal vs. external attentional focus instructions on running form re-education
  - Data Analysis – Lee S, Poggemiller M, Tracy I, Gray C. Effects of internal vs. external attentional focus instructions on running form re-education