Performance of Balance Impaired Elders on Three Balance Tests under Two Visual Conditions

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ABSTRACT

Purpose: This study compared differences in balance measures among elderly adults with different degrees of balance impairments under different visual conditions. **Methods:** This study was conducted on 89 adults (> 60 years) with balance impairments. Subjects were divided into 3 groups based on the initial Tinetti score: low risk of fall (LRF, n=29), moderate risk of fall (MRF, n=30) and high risk of fall (HRF, n=30). Three balance measures—Tinetti, Timed-up and Go (TUG), and Functional Reach—were tested with 2 different visual conditions: eyes open with normal vision (EONV) and eyes open with blurred vision (EOBV). All data were analyzed using repeated measures analysis of variance. **Results:** Subjects with EOBV had significantly decreased Tinetti ($P < .01$) and Functional Reach ($P < .01$) scores and increased TUG ($P < .01$) scores regardless of fall group. Subjects in the LRF group performed better in all 3 tests than those in MRF ($P < .01$) and HRF ($P < .01$) groups. Subjects in the MRF group performed better in all 3 tests than those in HRF ($P < .01$). There were significant interactions between vision and risk of falls in Tinetti ($P < .01$) and TUG ($P < .01$) scores. However, there was no significant interaction between vision and risk of falls in Functional Reach ($P > .05$) scores. **Conclusion:** Blurred vision significantly altered all 3 balance measure scores in all risk groups. However, blurred vision had a greater influence on Tinetti and TUG scores than Functional Reach scores in subjects with higher risk of falls.

Key Words: aging, balance, vision, fall

INTRODUCTION

Falls are a major problem among older adults. At least one-third to one-half of the population aged 65 and older fall each year[1-5] and these falls often result in serious injury. The majority of the falls by elderly persons appear to be multifactorial in etiology, including cognitive impairment, muscle weakness, postural hypotension, visual impairment, balance and gait abnormalities, foot problems, and medications.[6-9] Of all these, balance disorders appear to be the primary factor in falls.[10-13] There is general agreement that the ability of a person to maintain balance highly depends on the integration of the somatosensory, vestibular, and visual systems.[14] A deficit in any of these systems can lead to postural instability, balance disorder, and falls.

Postural control is the ability to control the body position in space. Postural sway is a corrective body movement resulting from the control of body position. Therefore, any increase in postural sway indicates poor postural control and poor balance.[15] Researchers have reported that postural sway increases with aging. Increased postural sway is associated with an increased risk of falls among community-dwelling elders.[16-18]

The role of vision in the maintenance of postural control and balance is crucial. Some investigators[19,20] have reported that postural sway is affected by viewing visual scenes that rotate or create a tunnel effect, with amplitude of sway being influenced by the frequency of the moving visual scene. Baloh et al[21] reported that changing visual input alone can increase postural sway. Similarly, Maki et al[22] noted that lateral sway with eyes closed was the single best measure from a battery of clinical and laboratory balance tests for predicting falls in 100 community-dwelling older persons. Vision plays an even greater role in postural control and balance when somatosensory and vestibular sensory input are reduced.[23]

While many of the previous studies focused on the effects of vision on postural sway and static balance, there is little research on the effect of vision on clinical balance measures. Therefore, the purpose of this study was to determine whether altered vision influenced 3 clinical balance measures [Tinetti, Timed-up and Go (TUG), and Functional Reach] in elderly adults with different degrees of balance impairments. The following hypotheses were tested: (1) the subjects in the low risk of fall (LRF) group will perform better in all balance tests than those in the moderate risk of fall (MRF) and high risk of fall (HRF) groups, (2) blurred vision will impair all balance measure scores.

METHODS

Subjects

This study was performed on 89 elderly adults (12 males, 77 females, mean age =79 ± 8 years, range = 60 to 97). Subjects in

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the LRF (n = 29) group were recruited from a retirement center. Subjects in the MRF (n = 30) and HRF (n = 30) groups were recruited from a long-term care facility in Jackson, Mississippi. Subjects were screened for medical problems that would prevent their participation. Inclusion criteria were: (1) ≥ 60 years of age, (2) ability to ambulate at least 6 meters with or without an assistive device (28 subjects used walkers, 6 subjects used canes, and 55 used no assistive devices). Exclusion criteria included: (1) inability to stand with both feet on floor; (2) demonstration of visual deficits not corrected with corrective lenses; (3) evidence of limited range of motion (range of motion was not within normal functional limit) at key joints including trunk and bilateral shoulders, elbows, wrists, hips, knees, and ankles; (4) presence of orthopedic problems with weight bearing status less than full weight bearing; or (5) failure to answer questions in a consistent manner. This study was approved by the Institutional Review Board (IRB) of the University of Mississippi Medical Center to ensure protection of human subjects. Prior to the data collection, each subject volunteered to participate in this study and signed an informed consent document that explained the tests and the risks involved.

Procedure

Subjects were divided into 3 groups according to their initial Tinetti score: (1) LRF (total Tinetti score: 25-27/28), (2) MRF (total Tinetti score: 19-24/28), and (3) HRF (total Tinetti score < 19/28).[24-26] Each subject performed 3 different clinical balance tests: Tinetti, TUG, and Functional Reach under 2 different visual conditions: eyes open with normal vision (EONV) and eyes open with blurred vision (EOBV). Normal vision defined that participants did not have a medical history of vision deficits that could not be corrected by corrective lenses. Blurred vision was created by asking participants to wear vision distortion glasses which were also coated with a thin layer of 100% petroleum jelly. Subjects performed a single trial of the Tinetti and TUG after being given the appropriate instructions. They performed 2 trials of the Functional Reach tests after being given the appropriate instructions. The final Functional Reach score was the average from the 2 trials. The order of the tests was randomized. Each subject was allowed a 2 minute resting period between each test.

Tinetti test comprised a series of tests that measured subjects' gait and balance. Subjects were scored 0 to 2 on the individual items, with 0 representing the most impairment and 2 representing independence. The individual items were combined into 3 measures: (1) an overall gait score (12 points), (2) an overall balance score (16 points), and (3) a gait and balance score (28 points). Subjects who scored 25 to 27 were classified as low risk of falls (LRF). Those who scored 19 to 24 points were classified as moderate risk of falls (MRF) and 18 or below were classified as high risk of falls (HRF).[24-26]

The TUG test consisted of the subject rising from an armchair and walking 3 meters and returning to the chair to sit while a researcher recorded the time.[27] Instructions given to the participants were: "sit in this chair with your back against the chair and your arms resting on the chair arms; when I say 'go,' scoot to the edge of the seat, and place your feet flat on the floor close to the front edge of the chair; use armrests of the chair to push up into standing and walk at your normal speed to the line on the floor; then turn around, return to the chair, and sit down carefully." Timing began on the word 'go' and ended when the subjects returned to the start position with their back against the chair.

For the Functional Reach test, a 48-inch ruler was attached to a wall at the level of the subject's acromion. Subjects were asked to extend their arm to 90° and reach forward as far as possible without losing their balance or taking a step.[28]

To ensure safety, one researcher guarded the subject during the test period for all tests, while another researcher recorded the results. All balance measures were tested by 2 experienced physical therapy faculty and 3 senior physical therapy students. Prior to testing, all examiners had a practice session together to ensure all examiners were using the same technique and instructions. All data were collected in either the retirement center (for LRF group) or the long-term care facility (for MRF and HRF groups).

Data Analysis

Performance on each balance test was summarized using the mean, standard deviation, and confidence intervals. Repeated measures analysis of variance (ANOVA) procedures were performed to determine if there were significant differences in each of the balance measures between the 3 risk groups under the 2 visual conditions. Post-hoc Student-Neuman-Keuls were used to test differences between risk groups. $P < .05$ was accepted as a statistically significant difference.

RESULTS

The balance measures from the Tinetti, TUG, and Functional Reach tests are presented by fall risk group and visual condition in Table 1. Results of ANOVA procedures are summarized in Table 2. The Tinetti scores in LRF group were significantly higher than those in MRF ($P < .01$) and HRF ($P < .01$) groups. Visual condition and risk group had significant main effects on all 3 balance measures and an interactive effect on the Tinetti and TUG scores. Post-hoc tests showed that Tinetti scores in MRF group were significantly higher than those in HRF group ($P < .01$). Figure 1A shows the differences of Tinetti scores between risk group and visual condition. The TUG scores in LRF group were significantly lower than those in MRF ($P < .01$) and HRF ($P < .01$) groups. TUG scores in MRF group were also lower than those in HRF group ($P < .01$). Figure 1B shows the differences of TUG scores between risk group and visual condition. The subjects in LRF had significant higher Functional Reach scores than subjects in MRF ($P < .01$) and HRF ($P < .01$). In addition, the subjects in MRF group had significantly higher Functional

Reach scores than those in HRF group ($P < .01$). Figure 1C shows the differences of Functional Reach scores between risk group and visual conditions.

DISCUSSION

Findings of this study indicated significant interactions between vision and risk groups in Tinetti ($P < .01$) and TUG ($P < .01$) tests. As indicated by Figure 1A, subjects in the MRF and HRF groups had a greater decrease in Tinetti scores than those in the LRF when their vision changed from EONV to EOBV. A similar response was observed in the TUG test. As shown in Figure 1B, subjects in MRF and HRF groups had a greater increase in TUG scores than those in LRF when blurred vision was added.

On the other hand, there was no interaction between vision and the risk group in Functional Reach test ($P > .05$). As shown in Figure 1C, Functional Reach scores from all 3 groups were parallel, indicating all 3 risk groups had a similar response to the changes in vision. The exact reason for the different effect of blurred vision on the 3 clinical balance measures is not known. A potential explanation may be that the different visual effect on the clinical balance measures might be associated with the specific components of each test itself. Both the Tinetti and TUG tests were involved with gait and other multiple components.[24-27,29] Whereas, the Functional Reach test involved an anterior and posterior displacement of center of gravity and had no gait component.[10,28] Therefore, the Tinetti and TUG tests are more dynamic than the Functional Reach test. The results of the present study suggested that blurred vision has greater influence on dynamic balance measures (Tinetti and TUG) than static balance measure (Functional Reach).

Tinetti, TUG, and Functional Reach test are commonly used for the measurements of balance impairment in physical therapy clinics.[24-28] Based on the study of Abbruzzese,[26] the Tinetti test was used to classify different degrees of balance impairments. The TUG and Functional Reach tests were chosen as the assessment tools in this study because both tests are widely used, require minimal time to complete, require no sophisticated equipment, are easy to administer, and yield measurements that have known reliability and validity.[10,27-29] The results of the present study indicate that all 3 balance tests are useful tools for discriminating balance between fall risk groups and visual conditions because all subjects in the LRF group performed better in all 3 tests than MRF ($P < .01$) and HRF ($P < .01$) groups under both visual conditions. More specifically, the subjects in the LRF group performed significantly better in all 3 tests under both visual conditions (EONV and EOBV) than subjects in both of MRF and HRF groups ($P < .01$). These results are consistent with previous studies in the literature.[6,10,26,28-30]

The hypothesis that blurred vision would impair all balance

Table 1. Mean Scores, Standard Deviations (SD), and 95% CI of Balance Measures among Different Risk Groups

Outcome Measures	LRF (n=29)		MRF (n=30)		HRF (n=30)	
	Mean ± SD	95%CI	Mean ± SD†	95%CI	Mean ± SD† ‡	95%CI
Tinetti with EONV	27.0 ± 1.1	26.6,27.4	21.6±1.8	20.9,22.1	14.2±2.8	13.2,15.3
Tinetti with EOBV	26.3 ± 1.2*	25.8,26.7	14.2±4.3*	12.6,15.8	10.2±3.5*	8.9,11.5
TUG with EONV (seconds)	12.0 ± 3.4	11.2,14.1	28.3±15.4	22.4,34.2	54.5±39.1	40.1,69.3
TUG with EOBV (seconds)	14.1 ± 4.1*	12.3,15.4	34.1±18.4*	27.1,41.1	60.1±48.6*	51.5,88.2
Functional reach with EONV (in)	9.4 ± 2.1	8.6,10.2	5.2±2.1	4.4,6.0	3.2±1.4	2.6,3.7
Functional reach with EOBV (in)	9.1 ± 2.8*	8.1,10.2	4.8±2.0*	4.0,5.5	2.5±1.3*	2.0,2.9

Note: TUG: Timed-up and Go; EONV: eyes open normal vision; EOBV: eyes open blurred vision; LRF: low risk of fall; MRF: moderate risk of fall; HRF: high risk of fall; CI: confidence interval; * $P < .001$ as compared to EONV; † All values are significantly different from LRF group at $P < .001$; ‡ All values are significantly different from MRF group at $P < .001$;

Table 2. Summary of Analysis of Variance Results of 3 Balance Measures

Balance Measures	Source	df	F-value	*P*-value
Tinetti	Visual Condition	1	162.33	<0.001
	Risk Group	2	295.81	<0.001
	Vision x Risk	2	35.19	<0.001
Timed Up and Go	Visual Condition	1	51.7	<0.001
	Risk Group	2	24.48	<0.001
	Vision x Risk	2	15.54	<0.001
Functional Reach	Visual Condition	1	14.56	<0.001
	Risk Group	2	87.63	<0.001
	Vision x Risk	2	1.14	0.33

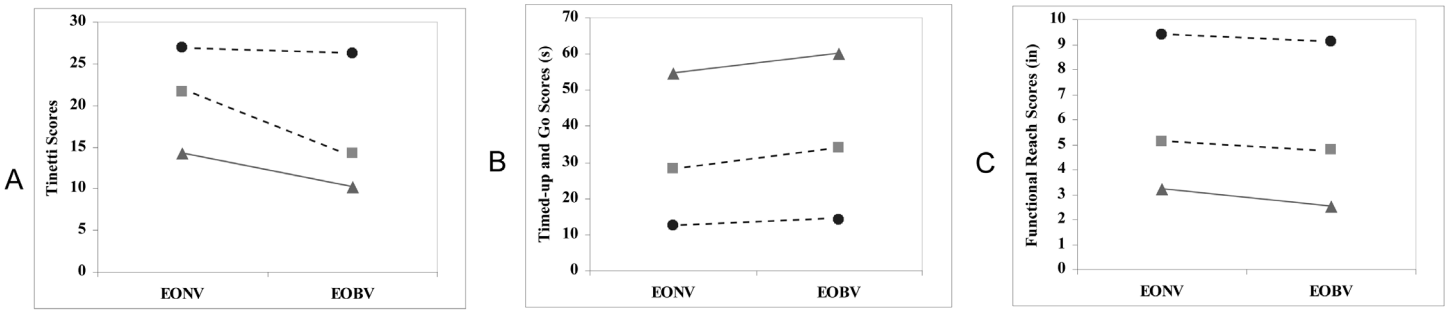

Figure 1. Performance on 3 balance tests by subjects in 3 fall risk categories [low fall risk (● - - - ●), moderate fall risk (■-----■), high fall risk (▲_____▲)] under 2 visual conditions (EONV = eyes open normal vision, EOBV = eyes open blurred vision).

measure scores was supported by study results. Subjects with blurred vision demonstrated significantly ($P < .01$) decreased Tinetti scores, increased TUG scores, and decreased Functional Reach scores in all risk groups. Previous studies have shown that the ability of subjects to maintain a good balance is complex, involving somatosensory, vestibular, and visual systems.[8,31] The changes in any of these systems will change the outcome of balance measures. Lord et al[32] reported that increased sway in elderly persons is associated with a loss of sensory input from the lower limbs, and that visual and vestibular systems appear to be secondary in the maintenance of posture under normal conditions. However, subjects with poor vision and strength demonstrated greatly increased sway when the subjects were standing on the foam (reduced surface support). Redfern and Furmen[15] reported that moving visual environments can cause postural changes, disequilibrium, and motion sickness in healthy adults. In patients with balance disorders, these affects can be even greater. In addition, Potvin and associates[33] claimed that the balance task with eyes closed has greater age dependency than the same task with eyes open and age dependency in balance is augmented by elimination of visual cues. Present study results are consistent with the previous concept that vision plays an important role in balance.[14,19,31,32] However, the visual conditions used in previous studies included only eyes closed. This is the first study comparing balance measures in balance impaired elderly adults under EOBV with those under EONV. In addition, in many of the previous studies, much effort was focused on the effect of vision on postural sway and static balance. This study focused on the contribution of the visual system on dynamic balance measures.

There were a number of limitations associated with this study. A learning curve may occur between the repeated measurements under 2 different visual conditions although authors do not believe the learning curve will affect the interpretation of the results because subjects performed balance tests with a normal vision followed by blurred vision. Intra-rater and inter-rater reliability of the testers were not assessed. Multiple measurements and multiple testers involved in this study could have created a larger variability in different test scores in different groups. The number of trials given to subjects to perform different balance tests was not consistent. The subjects had only 1 trial for Tinetti and TUG. This occurred because some of the subjects in HRF group could not tolerate 2 trials of all balance tests. However, 2 trials were given to subjects to perform Functional Reach. This occurred because a greater variation between the repeated trials in Functional Reach tests was observed in the pretrial test. Finally, balance impairment was totally determined by initial Tinetti scores. The actual number of falls related to the balance scores and balance impairments was not assessed.

Many clinical balance tests are available to determine the presence of balance impairments in elderly adults. However, research is lacking concerning how to select a proper test for a patient with balance impairment plus visual impairment. Blurred vision had greater influence on dynamic balance measures with a gait component (Tinetti and TUG) than static balance measure without a gait component (Functional Reach). Therefore, the findings of the present study may support the concept that dynamic balance measures with a gait component may be superior to static balance measures without a gait component for elderly adults with different degrees of balance impairment during visual impairment. Based on the fact that vision plays an important role in determining the balance score, we recommend that clinicians consider the correction of visual problem as an essential part of treating elderly adults with balance and visual impairments.

CONCLUSION

Blurred vision significantly altered all 3 balance measures in older adults with different degrees of balance impairments, suggesting that the visual system plays an important role in balance assessment. Blurred vision had a greater influence on Tinetti and TUG than Functional Reach tests, suggesting that dynamic balance measures with a gait component are better balance indicators than static balance measure without a gait component in elderly adults with both blurred vision and balance impairment.

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