



Original Article

Effects of task velocity and center of mass acceleration during Y-Balance Test in elderly females with good and poor visual acuity

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Abstract. [Purpose] To explore the effects of good binocular visual acuity (BVA) compared to poor BVA, reach distance, task velocity, and center of mass (COM) acceleration were evaluated in elderly females performing the Y-Balance Test (YBT) using a cross-sectional design. [Subjects and Methods] A total of 13 participants had BVA of ≥ 0.4 log of the minimum angle of resolution (logMAR) (poor BVA group), and the other 13 had BVA of ≤ 0.3 logMAR (good BVA group). An accelerometer was attached over participants' L3 spinous process, and they then performed the YBT. [Results] The normalized reach distances in the three directions among the good BVA group were longer than those among the poor BVA group. The task velocity in the good BVA group was significantly higher, whereas COM acceleration in the A direction was significantly lower compared with the poor BVA group. [Conclusion] Visual status must be considered when older adult individuals undergo physical therapy and functional training to ensure that healthcare professionals can better assist older adult women.

Key words: Center of mass acceleration, Elderly females, Visual acuity

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INTRODUCTION

Balance is an essential factor for stable walking, independent activities of daily living, and many aspects of quality of life in the elderly. Balance may be classified as static, reflecting the attempt to maintain a base of support with minimal movement, or dynamic, which is the ability to maintain the projection of the body's center of mass (COM) within the limits of the base of support during transfer to a new base of support, as occurs during walking¹⁾. Successful balance control requires afferent sensory input, integration by the central nervous system, and implementation of effective motor responses by regulating the position of the lower extremities. Vision provides information regarding environmental conditions, and visual cues help determine the speed of locomotion. In addition, visual cues during movement affect alignment of the body and projection of COM with reference to a base of support, gravity, and the environment²⁾. Many studies have explored the role of vision in relation to balance in healthy subjects using numerous manipulation methods, such as open and closed eyes³⁾, wearing goggles⁴⁾, using a darkened room⁵⁾. However, these studies did not consider generally deteriorating visual acuity in individuals without specific visual impairments.

The Y-Balance Test (YBT) was developed as a clinical application of the star excursion balance test. It requires that the participant maintain a SLS while reaching as far as possible with the other leg. The YBT, as a dynamic single-limb balance test, has been used to identify individuals with chronic ankle instability who are at greater risk for lower extremity injuries in sports, and as a post-rehabilitation test⁶⁾. In addition, the advantages of the YBT has been reported as have high inter- (0.99–1.00) and intra-rater reliabilities (0.85–0.91)⁶⁾. However, few studies have explored functional dynamic balance in older people with poor binocular visual acuity (BVA) using the YBT kit. Thus, the purpose of this study was to examine the

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effects of reaching distance, task performance velocity, and COM acceleration during YBT in elderly female subjects with good or poor BVA in a cross-sectional design.

SUBJECTS AND METHODS

In total, 26 elderly females living in Gyeongsangnam-do, Republic of Korea, participated in this study. Visual acuity is measured by use of a YONG-HAN, JIN's vision test chart (JV Institute, Seoul, Korea). Each participant's BVA was evaluated with or without their own spectacles for classification into two groups: poor BVA (corrected BVA ≥ 0.4 logMAR) and good BVA (corrected BVA ≤ 0.3 logMAR)⁷. Poor BVA's average age (mean \pm standard deviation), height and weight were 76.62 ± 4.98 years, 149.72 ± 2.71 cm and 49.37 ± 6.35 kg, respectively and left side VA and right side VA of 0.52 ± 0.11 logMAR and 0.53 ± 0.13 logMAR respectively. Good BVA's average age, height and weight were 74.77 ± 6.30 years, 148.96 ± 5.09 cm and 48.50 ± 6.84 kg, respectively left side VA and right side VA of 0.22 ± 0.06 logMAR and 0.22 ± 0.10 logMAR respectively. All participants could walk independently without an assistive device, a score of more than 24 point on the Korean Version of the Mini-Mental State Exam. They had no past or present neurologic disorder, a musculoskeletal disease that might have interfered with daily activities, taking drugs that would have influenced the results of this study. Ethical approval was obtained from the Inje University Faculty of Health Science Human Ethics Committee, and all subjects signed an informed consent form prior to their participation.

A tri-axial accelerometer (Fit Life, Suwon, Korea) was used to measure task velocity and COM during the YBT. We measured raw data using the x , y , and z axes of acceleration. One accelerometer was fixed with double-sided adhesive tape over the L3 spinous process⁷. Data were collected at a sampling rate of 32 Hz. Task velocity was derived by dividing the distance of reach by the time required to complete the locomotor task. The COM acceleration was calculated using single-vector magnitude⁷. Each participant stood with one foot on the center footplate from the YBT Kit™ (Move2Perform, Evansville, IN, USA) at the starting line and her hands on her pelvis. Participants were asked to push the reach-indicator block with the free limb in the anterior (A), posterior medial (PM), and posterior lateral (PL) directions relative to the stance foot on the central footplate. The testing order was as follows: trials standing on the right foot reaching in the A direction, followed by trials standing on the left foot reaching in the anterior direction. This procedure was repeated for the PM and the PL reaching directions⁸. A trial was classified as invalid if the participant did not return to the starting position, placed the reach foot on the ground on either side of the line or tube, raised or moved the stance foot during the test, or kicked the plate with the reach foot to gain more distance. If an invalid trial occurred, the data were discarded, and the participant repeated the trial. The data were analyzed using SPSS software (ver. 18.0 for Windows, SPSS, Inc., Chicago, IL, USA). To express reach distance as a percentage of limb length, the normalized value was calculated as reach distance divided by limb length, and then multiplied by 100. The composite reach distance was the sum of the three reach directions divided by three times the limb length, multiplied by 100. We present dominant limb reaching values according to footedness⁷. The level of statistical significance was set at $p < 0.05$.

RESULTS

In the good BVA group, the normalized reach distances (A, PM, and PL) and composite reach were significantly longer ($p < 0.05$), task velocity in the three directions was significantly higher ($p < 0.05$), and COM acceleration in the A direction was significantly decreased ($p < 0.05$) compared to those values in the poor BVA group (Table 1).

DISCUSSION

In this study, we explored differences in reach distance, task velocity, and COM acceleration during YBT in elderly females with good and poor BVA. We found that normalized reach distances in the A, PM, and PL directions as well as the composite reach distance and velocity during YBT were significantly higher in the good BVA compared to the poor BVA group, whereas COM acceleration during YBT in the A direction was significantly decreased in the good BVA compared with the poor BVA group. Reach distance in YBT reflects the degree of dynamic balance control, and longer reach distances are indicative of greater dynamic postural control⁸. Our results indicate that BVA affected dynamic single-limb balance in reach distance, velocity, and COM acceleration in the A direction on the YBT. Furthermore, elderly subjects with poor BVA showed more cautious trunk movement strategies when visual awareness was decreased, such as during PM and PL reaching. In a previous study, Shin and An⁸ found that the normalized reach distance in three directions and the composite reach distance were significantly longer in the good BVA group during YBT compared with those for the poor BVA group. Under stable conditions such as normal two-limb standing support, healthy individuals depend on the somatosensory system. However, when faced with a challenging condition such as an unstable surface or single leg standing, they increase the sensory weighting allocated to vestibular and visual information and decrease their reliance on surface somatosensory inputs for postural control⁵. Thus, as the conditions become more challenging, such as during the YBT, balance control strategies rely more heavily on vision. Based on our results, the difference in the A direction reach distance and velocity are due to differences in visual acuity during YBT.

Table 1. Comparison of gait velocity and COM between PBVA and GBVA group

Variable	Directions	Poor BVA group	Good BVA group	Effect size
Normalized reach distance (%)	A	54.79 (5.80) *	61.75 (7.06)	-1.121
	PM	83.52 (9.27) *	95.47 (8.11)	-1.428
	PL	80.69 (5.49) *	90.69 (9.91)	-1.298
	C	73.00 (6.06) *	82.64 (7.72)	-1.445
Velocity (cm/sec)	A	11.06 (3.37) *	14.63 (3.82)	-1.032
	PM	20.75 (7.09) *	28.30 (7.70)	-1.062
	PL	18.42 (4.64) *	24.87 (7.88)	-1.038
COM (cm/s ²)	A	232.71 (104.94) *	134.70 (45.95)	1.259
	PM	203.93 (88.53)	154.74 (41.03)	0.742
	PL	230.06 (100.64)	176.43 (54.85)	0.689

Data are mean (standard deviation).

BVA: binocular visual acuity; COM: center of mass; A: anterior; PM: posteriomedial; PL: posteriolateral, C: composite. Effect size: (Cohen's d).

*p<0.05.

In this study, COM acceleration in the A direction was lower in the good BVA group. Our results indicated that COM frequently changed in individuals with poor BVA compared to those of good BVA. According to Wang et al.⁹⁾, a decrease in the functional area of the stability boundary in vision deficiency could predict increased rotation of segments around the COM. Considering these previous findings⁹⁾ and our results, COM affects dynamic balance control during YBT in A direction reaching, even in individuals with mildly poor BVA.

In this study, in the PM and PL directions, visual awareness decreased compared with the A direction, and participants with good BVA had longer reach lengths and faster reach velocities than did those with poor BVA. Additionally, COM acceleration increased in the PM and PL directions compared with the A direction in the good BVA group, whereas COM acceleration changed minimally in the PM and PL reach directions compared with the A direction in elderly subjects with poor BVA. The A reach was performed in the sagittal plane, whereas PM and PL were performed in diagonal planes; the PM and PL reach may require complex trunk control in the integrated plane (i.e., the diagonal planes). Furthermore, movement in the PL direction required crossing over the midline of the trunk and more rotation of the trunk than did that in the A direction. This indicates that movements in the PM and PL directions are more challenging for older adult women than are movement in the A direction. Trunk movements generally offer a stable platform for lower limb movements and vision and head control. During the YBT, they constitute an important balance-correcting strategy to keep the COM over the base of support. Counterbalanced trunk movements minimize shifting of the COM and prevent deterioration of balance caused by limb reach¹⁰⁾. Based on a previous study¹⁰⁾ and our findings, we suggest that elderly subjects with poor BVA employ more cautious trunk movement strategies when visual feedback is diminished and under more challenging balance conditions, such as when performing PM and PL reaching. Thus, cautious trunk movement strategies in elderly subjects with poor BVA result in both decreased reach distance and decreased performance velocity in the PM and PL directions. It is for this reason that there was no difference in COM acceleration in the PM and PL direction between groups. When the participant's reaching limb moved in the PM or PL direction, the base of support widened, and COM location lowered compared with the starting position. Although we did not statistically analyze task velocity within groups, our results showed that task velocity was faster in the PM and PL than in the A direction. Thus, we consider that widened base of support and lowered COM location affect task velocities. There were several limitations to this study. First, we measured COM acceleration using a single vector magnitude method. Thus, we did not address the frontal, sagittal, and coronary plane COM trajectories or compensation. Second, we measured only BVA. Although we did not measure the visual field, it does influence postural control. Third, we assessed only females, so caution should be used when generalizing these results. Further studies should explore hip, knee, and ankle strategies during the YBT in elderly subjects with good and poor BVA.

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Conflict of interest

None.

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