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Original Research Article

To Investigate the Correlation between Dynamic Trunk Balance and the Mini-Balance Evaluation Systems Test in Elderly Women

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Abstract

Aim: To investigate the correlation between dynamic trunk balance and the Mini-Balance Evaluation Systems Test in elderly women.

Material and Methods: This study was done in the department of PMR, NMCH, Patna, Bihar, India for one year. Thirty-one women volunteers aged 60 years or more with no obvious brain or nerve disorders or joint diseases and who could walk unaided were enrolled. The evaluation items were the BEST test total score, the scores of each of the six elements of the BEST test, dynamic sitting balance, static postural balance, and muscle strength (back muscle, iliopsoas muscle, and quadriceps). Written informed consent for the study and its publication was obtained from all subjects.

Results: The mean total BEST test score was 85.4 points (Tables 4), with a score of 93 points or less indicating some balance disorder. A negative correlation (r=–0.481, P=0.006) was observed in the total locus length of the COG for the dynamic sitting test and the BEST test total score . Among the six items of the BEST test, a significant negative correlation was found between the total locus length of the COG and biomechanical constraints (r=–0.492, P=0.005) and anticipatory postural adjustments (r=–0.532, P=0.002). There were no correlations between the dynamic sitting test total COG trajectory length, the stationary standing COG length, and muscle strength.

Conclusion: In elderly women, the trajectory length of the COG during dynamic sitting was negatively correlated with the BEST test total score. Future studies should investigate how the BEST test can be used to determine both the optimal treatment interventions to prevent falls and the efficacy of these interventions.

Keywords: dynamic trunk balance, elderly women, the Balance Evaluation Systems Test

Introduction

Maintaining balance is crucial for preventing falls and ensuring the independence of elderly women. Dynamic trunk balance, the ability to maintain stability and control of the trunk during movement, plays a significant role in overall balance and functional mobility. This aspect of balance is especially important in elderly women, who are at a higher risk for falls and associated injuries due to age-related changes in muscle strength, joint flexibility, and sensory function. [1-3] The Mini-Balance Evaluation Systems Test (Mini-BEST test) is a comprehensive tool used to assess different components of balance, including anticipatory postural adjustments, reactive postural control, sensory orientation, and dynamic gait. It provides valuable insights into an individual's balance capabilities and helps identify specific areas that may need improvement. The Mini-BEST test is particularly useful in elderly populations, as it can guide interventions aimed at enhancing balance and reducing fall risk. [4-8] Exploring the relationship between dynamic trunk balance and the Mini-BEST test can provide a deeper understanding of how specific aspects of trunk control contribute to overall balance performance in elderly women. By identifying correlations between dynamic trunk balance measures and Mini-BESTest scores, researchers and clinicians can develop targeted interventions to improve balance and reduce the likelihood of falls in this vulnerable population. [9] The Balance Evaluation Systems Test (BESTest) is a balance evaluation test developed in 2009 that has been translated for use worldwide. [10,11] This test measures problems associated with balance function based on six factors: (1) biomechanical constraints, (2) stability limits/verticality, (3) anticipatory postural adjustments, (4) postural responses, (5) sensory orientation, and (6) gait stability. The six factors consist of 27 item tests. The maximum BESTest score is 108 points, and scores of 93 points or less are considered to indicate a failure of balance. [10] The 27 items include the FRT and the Timed

Up & Go test (TUG), [12] which are common balance evaluation tests (Table 1). Compared with the BBS, an existing balance evaluation test, the BESTest has no ceiling effect, suggesting that it can detect minor balance problems that might not be indicated by other tests.

Table 1: Summary of the 27 items comprising BESTest under each of the six system categories

I. Biomechanical constraints	II. Stability limits/vertically	III. Anticipatory postural adjustments	IV. Postural responses	V. Sensory orientation	VI. Stability in gait
1. Base of support	6. Sitting verticality (left and right) and lateral lean (left and right)	9. Sit to stand	14. In-place response, forward	19. Sensory integration for balance (modified CTSIB) Stance on firm surface, EO Stance on firm surface, EC Stance on foam, EO Stance on foam, EC	21. Gait, level surface
2. CoM alignment	7. Functional reach forward	10. Rise to toes	15. In-place response, backward		22. Change in gait speed
3. Ankle strength	8. Functional reach lateral (left and right)	11. Stand on one leg (left and right)	16. Compensatory stepping correction, forward		23. Walk with head turns, horizontal
4. Hip/trunk lateral strength		12. Alternate stair touching	17. Compensatory stepping correction, backward		24. Walk with pivot turns
5.Sit on floor and stand up		13. Standing arm raise	18. Compensatory stepping correction, lateral (left and right)	20. Incline, EC	25. Step over obstacles
					26. Timed "Get Up & Go" Test
					27. Timed "Get Up & Go" Test with dual task

CoM=centre of mass, ROM=range of motion, CTSIB=Clinical Test of Sensory Integration for Balance, EO=eyes open, EC=eyes closed.

When trunk balance disorders occur, especially in the elderly, the dorsum of the spine is strengthened, the spine leans forward, and the COG fluctuates when standing, increasing the possibility of falls. [13,14] Methods for assessing trunk balance include the standing COG swing test using force plates, the FRT, and the TUG. However, these tests methods assess problems with the lower limbs and do not reflect balance of the trunk alone. In addition, for elderly people, these tests are associated with a risk for falling due to dizziness or other issues; therefore, the evaluation itself may be dangerous and difficult to complete.

We developed a balance-measuring device using a dynamic sitting position to safely measure balance function. [15] Because this device applies a disturbance load while subjects are seated, dynamic trunk balance alone can be measured. Moreover, elderly people are safe during this test because they remain in a seated position.

To the best of our knowledge, several studies have examined the relationship between falls and the BEST test score. For example, Marques et al. investigated the relationship between BEST test and falls in older people living in the community. [16] The BEST test has excellent interrater reliability with a mixed population of individuals with neurological disorders and balance limitations, and it has excellent test–retest reliability for individuals with Parkinson's disease.[17,18] In addition, there are reports that the relation between fall risk and BEST test score of healthy elderly people depends on age, and the fall risk detection is reliable. [19,20] However, there is no report on the relationship between BEST test scores and trunk balance evaluated by dynamic sitting. The purpose of the present study was to examine the relationship between dynamic trunk balance and BEST test scores in elderly women.

Material and Methods

This study was done in the department of PMR, NMCH, Patna, Bihar, India for one year. Thirty-one women volunteers aged 60 years or more with no obvious brain or nerve disorders or joint diseases and who could walk unaided were enrolled. The evaluation items were the BESTest total score, the scores of each of the six elements of the BEST test dynamic sitting balance, static postural balance, and muscle strength (back muscle, iliopsoas muscle, and quadriceps). The protocol was approved by the Ethics Committee of our institute. Written informed consent for the study and its publication was obtained from all subjects.

The BEST test total score and the scores for each of the six elements of the BEST test were measured. The BEST test consists of 27 tests, and the measurements took 40–50 min; as a result, the BESTest was performed only once. Dynamic sitting balance was measured with a dynamic sitting balance measuring device that we developed and described previously.[15] This device tilts to a maximum of 3° to either side by means of a direct current motor (BHM62MT-G2; Oriental Motor, Tokyo, Japan). The subject's COG can be measured using three triaxial force sensors arranged under the seat. Participants sit on the device with their arms folded across the anterior chest, eyes open, and their feet off the floor. Dynamic trunk sway during external stimuli was measured as the length of the COG trajectory for 30 s; in this way, the ability to respond to external stimuli was assessed. The external stimulus was applied to the subjects by the device automatically tilting the seat left and right. The total length of the COG trajectory and the rectangular area containing the COG were considered indicators of dynamic postural balance. The test was performed twice, and the mean of the two scores was used. Static postural balance was measured with a stabilimeter . The COG deviation was recorded using a microcomputer with the participant standing unaided in the upright position with the eyes open for 30 s and then with the eyes closed for 30 s. The total movement of the COG during measurement was calculated as the total length.

To assess muscle strength, the strengths of the iliopsoas and quadriceps muscles were measured twice on each side with a hand-held dynamometer, and the mean values of the left and right sides were used. Back muscle strength was measured twice as the isometric muscle strength using a strain gauge with subjects in the prone position, and the maximum value was used.

Statistical Analysis

Data were analysed using SPSS version 19.0 for Windows (SPSS, Chicago, IL, USA). A P-value of <0.05 was considered statistically significant.

Results

Table 2 shows the background data of the subjects. The mean age was 73 years (range, 64–87 years).

Table 2: Baseline characteristics of the participants

No. of subjects (n)	31
Age (years)	73±6
Height (cm)	150±6
Weight (kg)	52±8
Body mass index (kg/m^2)	23.3±3.9

Table 3 shows the results of each of the 27 items of the BESTest. The mean total BESTest score was 85.4 points (Tables 4), with a score of 93 points or less indicating some balance disorder.[10]Table 5 shows the total COG trajectory length of the 30-s dynamic sitting test; the stationary standing COG sway test; and muscle strengths of the back, the iliopsoas, and the quadriceps.

Table 3: Average BESTest total score and the scores for the six categories

BESTest total score (108)	85.4±10.2
Biomechanical constraints (15)	11.4±2.3
Stability limits/verticality (21)	16.4±2.1
Anticipatory postural adjustments (18)	14.8±2
Postural responses (18)	11.4±3.2
Sensory orientation (15)	14.3±0.8
Gait stability (21)	17.0±3.1

Table 4: Average total length of COG trajectories (dynamic sitting balance and static postural balance) and muscle strengths

Dynamic sitting balance Total length of COG trajectory (mm)	1447.5±454.5
Static postural balance with eyes open Total length of COG trajectory (cm)	84.1±43.6
Back extensor strength (N)	153.7±69.0
Iliopsoas muscle strength (N)	121.7±27.5
Quadriceps muscle strength (N)	147.5±30.0

A negative correlation (r=–0.481, P=0.006) was observed in the total locus length of the COG for the dynamic sitting test and the BESTest total score. Among the six items of the BESTest, a significant negative correlation was found between the total locus length of the COG and biomechanical constraints (r=–0.492, P=0.005) and anticipatory postural adjustments (r=–0.532, P=0.002). There were no correlations between the dynamic sitting test total COG trajectory length, the stationary standing COG length, and muscle strength (Table 5).

Table 5: Correlation with dynamic sitting balance total trajectory length of COG

Item	Correlation coefficient (r)	P value
BESTest total score	–0.481	0.00617 *
Biomechanical constraints	–0.492	0.00492 *
Stability limits/verticality	–0.326	0.0731
Anticipatory postural adjustments	–0.532	0.00208 *
Postural responses	–0.326	0.0737
Sensory orientation	–0.0501	0.789
Gait stability	–0.349	0.0543
Static postural balance with eyes open	0.248	0.177
Back extensor strength	–0.304	0.0961
Iliopsoas muscle strength	–0.18	0.332
Quadriceps muscle strength	–0.222	0.23

Discussion

We hypothesized that dynamic trunk balance in older women is related to the BESTest results. In support of this hypothesis, a significant negative correlation was found between the total dynamic sitting test COG trajectory length and the BESTest total score. Although balance function is said to decrease with age, [17,21] BESTest total scores in elderly women were similarly low. [17] Furthermore, in the current study, there was a negative correlation between the dynamic sitting test COG total trajectory length and the BESTest total score, suggesting that the decline in dynamic trunk balance ability may be associated with a low BESTest score.

In addition, biomechanical constraint, one of the six elements in which a negative correlation was recognized, is composed of five items: base of support, center of mass alignment, ankle strength and range of motion, hip/trunk lateral strength, and standing up from the sitting position. The base of support and the center of mass alignment assess malalignment between the sagittal and coronal planes of the spinal column. It is known that spinal alignment imbalances in older adults cause a decrease in balance function and are associated with falls. [22,23,24,25] Moreover, the possibility that a decrease in BESTest static alignment affects trunk balance during dynamic sitting has been suggested. [18]

Anticipatory postural adjustments were also negatively correlated with the dynamic sitting test total COG length. The five items that make up the BESTest anticipatory postural adjustments category are sitting to stand, rising to toes, standing on one leg, alternate stair touching, and standing arm raise. In this study, except for standing on one leg, maximum scores were almost always recorded, suggesting a relationship with standing on one leg. Trunk function is related to stability when standing on one leg, and it is believed that the activity of the trunk muscle on the standing leg side increases to stabilize the pelvis against the increase in the load when standing on one leg. [26] Although there was no relationship between static postural balance with eyes open (COG swing of both legs standing) and the BESTest score in this study, it can be said that the relationship between the evaluation of the single leg standing by BESTest and the total COG trajectory length during dynamic sitting balance was affirmative of previous reports.

Conclusion

In elderly women, the trajectory length of the COG during dynamic sitting was negatively correlated with the BESTest total score. Future studies should investigate how the BESTest can be used to determine both the optimal treatment interventions to prevent falls and the efficacy of these interventions.

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