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Original Research Article

Relationship between Dynamic Trunk Balance and the Mini-Balance Evaluation Systems Test in Elderly Women

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Abstract

Aim: The purpose of the present study was to examine the relationship between dynamic trunk balance and BES Test scores in elderly women.

Methodology: 50 women volunteers aged 60 years or more from ANMMCH, Gaya, Bihar who could walk unaided were enrolled. The evaluation items were the BES Test total score, the scores of each of the six elements of the BES Test, dynamic sitting balance, static postural balance, and muscle strength (back muscle, iliopsoas muscle, and quadriceps). The BES Test total score and the scores for each of the six elements of the BES Test were measured. 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.

Results: This study included 50 elder women of age more than 60 years. Mean age of all the volunteers was 69±8 years. Volunteers had a mean height of 146±9 cm and mean weight of 50±14 Kg with a mean body mass index ratio 22.9±5.2 Kg/m^2. The mean BES Test total score was 84.9±10.8 in this study. According to the results, mean total length of center of gravity trajectory was 1438.9±449.5 mm (Dynamic sitting balance). Mean trajectory for static postural balance was 83.8±43.1 cm. Muscle strength of back extensor, iliopsoas, and quadriceps muscle was 154.2±68.8, 122.0±27.1, and 147.2±30.4 respectively.

Conclusion: From this study, it can be said that the relationship between the evaluation of the single leg standing by BES Test and the total COG trajectory length during dynamic sitting balance was affirmative of previous reports. In elderly women, the trajectory length of the COG during dynamic sitting was negatively correlated with the BES Test total score.

Keywords: Dynamic Trunk Babalce, Trajectory, Center of Gravity.

Introduction

Balance Evaluation Systems Test (BES Test) is the quantitative assessment tool that aims to identify the disordered systems underlying the postural control responsible for poor functional balance. By identifying the disordered systems underlying balance control, therapists can direct specific types of intervention for different types of balance problems.

Dementia, cerebrovascular disease, senility, fractures, and falls are major contributors to elderly subjects becoming bedridden, a condition that leads to loss of independence. Further, about 70% of the fractures that result in elderly people becoming bedridden are femoral fractures, and about 90% of femoral fractures are caused by falls [1]. Therefore, it is important to evaluate and minimize the risk of falls in the elderly [1, 2]. Risk factors for falls include visual impairment, cognitive impairment, decreased balance function, muscle weakness, walking, dizziness, and medications [3]. Furthermore, particularly for elderly people, it is important to prevent the deterioration of balance function and muscle strength that occur with age [3, 4]. Trunk stability is important in balance function and is related to fall prevention [4]. Elderly people retain the ability to acquire trunk stability through trunk training [5]. Therefore, increasing the trunk balance function may be useful for preventing falls in the elderly.

Balance deficits are one of the most common problems treated by physical therapists. Therapists need to identify who has a balance problem and then decide the best approach to rehabilitation. Current standardized clinical balance assessment tools are directed at screening for balance problems and predicting fall risk, particularly in elderly people [6-9]. These tools identify which patients may benefit from balance retraining, but they do not help therapists decide how to treat the underlying balance problems. Besides not being aimed at guiding treatment, the current balance assessment tools were developed specifically for older adults with balance problems.

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.

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]. Several studies have examined the relationship between falls and the BESTest score. However, there is no report on the relationship between BESTest scores and trunk balance evaluated by dynamic sitting. The purpose of the present study was to examine the relationship between dynamic trunk balance and BESTest scores in elderly women.

Materials and Methods

Total 50 women volunteers aged 60 years or more from ANMMCH, Gaya, Bihar who could walk unaided were enrolled. The evaluation items were the BESTest total score, the scores of each of the six elements of the BESTest, 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 BESTest total score and the scores for each of the six elements of the BESTest were measured. The BESTest 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) The subject’s center of gravity (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 stabilometer. 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.

Results:

This study included 50 elder women of age more than 60 years. Mean age of all the volunteers was 69±8 years. Volunteers had a mean height of 146±9 cm and mean weight of 50±14 Kg with a mean body mass index ratio 22.9±5.2 Kg/m^2.

Table 1: Demographic details.

Variables	
Age (In years)	69±8
Height (cm)	146±9
Weight (Kg)	50±14
Body mass index (Kg/m^2)	22.9±5.2

Table 2: Results for the 27 items of BESTest

1 Biomechanical constraints		2 Stability limits/ verticality		3 Anticipatory postural adjustments		4 Postural responses		5 Sensory orientation		6 Gait stability	
1	2.7±0.6	6	Sitting verticality Left: 2.6±0.8 Right: 2.5±0.8 Lateral lean Left: 2.9±0.6 Right: 2.8±0.6	9	2.9±0.4	14	2.1±0.9	19	Stance on firm surface eyes open 2.9±0.2 eyes closed 2.9±0.4 Stance on foam eyes open 2.8±0.3 eyes closed 2.7±0.5	21	2.3±0.7
2	2.8±0.9			10	2.8±0.9	15	1.4±0.8			22	2.8±0.5
3	2.4±0.8			11	Left: 1.9±0.9 Right: 1.8±0.8	16	2.0±0.8			23	2.1±0.7

4	1.1±1.2	7	2.3±0.7	12	2.4±0.8	17	1.9±0.8	20	3.0±0.6	24	2.6±0.6
5	2.5±0.9	8	Left: 1.8±0.5 Right: 1.8±0.5	13	2.7±0.7	18	Left: 2.0±0.9 Right: 2.1±0.8			25	2.7±0.8
										26	2.5±0.6
										27	2.0±0.7

The mean score of all the six categories of BESTest score is given in the table 3. The mean BESTest total score was 84.9±10.8 in this study. According to the results, mean total length of center of gravity trajectory was 1438.9±449.5 mm (Dynamic sitting balance). Mean trajectory for static postural balance was 83.8±43.1 cm. Muscle strength of back extensor, iliopsoas, and quadriceps muscle was 154.2±68.8, 122.0±27.1, and 147.2±30.4 respectively. P-value for Biomechanical constraints component, Anticipatory postural adjustments component and BESTest total score was found statistically significant (<0.05).

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

Variables	Mean score
Biomechanical constraints	11.1±2.6
Stability limits/verticality	16.1±2.5
Anticipatory postural adjustments	15.2±3.6
Postural responses	11.9±3.8
Sensory orientation	13.9±0.7
Gait stability	16.8±2.9
BESTest total score	84.9±10.8

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

Variables	
Dynamic sitting balance (Total length of COG trajectory in mm)	1438.9±449.5
Static postural balance with eyes open (Total length of COG trajectory in cm)	83.8±43.1
Back extensor strength (N)	154.2±68.8
Iliopsoas muscle strength (N)	122.0±27.1
Quadriceps muscle strength (N)	147.2±30.4

Discussion

Most existing clinical balance tests are directed at predicting fall risk or whether a balance problem exists, rather than what type of balance problem exists [6-8]. Although these tests have proven valid in predicting the likelihood of future falls, with sensitivity and specificity values of 80% to 90%, the test results do not help therapists' direct treatment [15-17]. Lord et al [6] developed a different type of test, directed at identifying physiological impairments that could affect balance, such as impaired proprioception, visual function, or reaction time delays. Although the test is helpful for understanding the physiological reasons for balance problems, it is not apparent how to translate many of the impairments into specific balance exercise programs. Identification of impairments may help to identify the pathology, such as peripheral neuropathy or vestibular loss that may be responsible for the balance problem. However, therapeutic exercise is not best designed based on pathology, because the functional ability of each patient is multifactorial and depends not only on the patient's pathology but also on the patient's compensation, experience, and motivation, prior and concurrent pathologies, age, and so on.

Although the categories of systems in the BESTest were selected from current, scientific understanding of neurophysiological systems underlying postural control, the systems are quite interdependent. For example, constraints on the base of foot support (item 1) will necessarily affect the forward limits of postural stability in standing (item 7), and difficulty using vestibular information to stand on foam with eyes closed (item 19D) may make it difficult to perform head turns during gait (item 23). Furthermore, the tasks selected to reveal function of each of the 6 postural systems may not be ideal; some tasks are likely too easy to be discriminatory. For example, the standing arm raise to look for anticipatory postural adjustments (item 13) and stance with eyes open to examine postural sway (item 19) may only be sensitive in a laboratory, where surface reactive forces or body kinematics can be measured to detect physiologically significant, but not clinically apparent, changes in postural control.

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 [18, 19], BESTest total scores in elderly women were similarly low [18].

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. 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. It is known that spinal alignment imbalances in older adults cause a decrease in balance function and are associated with falls [19-23]. Moreover, the possibility that a decrease in BESTest static alignment affects trunk balance during dynamic sitting has been suggested [24].

Conclusion

From 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. In elderly women, the trajectory length of the COG during dynamic sitting was negatively correlated with the BESTest total score. [25]

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