Balance Deficits in Elderly Population

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Abstract: Impaired balance is common in old population with the resultant high risk of falls. It may increase the rate of mortality and morbidity, as well as decreased functional abilities. The current study aimed at investigating the changes of balance in elderly population. Thirty male participants were included and were assigned into two equal groups; young group aged 20 to 26 years and elderly group aged 60 to 69 years. Stability index (SI) and dynamic limit of stability from standing position were evaluated by Biodex stability system. Balance also was assessed clinically by the functional reaching test (FRT). The results showed significant increase in stability index including overall, antroposerior (A/P) and mediolateral (M/L) stability indexes, decrease in the directional control, increase in the time elapsed for completing the test and finally decreased FRT scores in the older group compared to that of the younger one. There was also significant positive correlation between directional control and FRT scores (p<0.05). It can be concluded that there are age-related changes of balance resulting in poor performance in standing position and decreased functional reaching in elderly people.

Key words: Aging • Balance • Biodex Stability System • Functional Reaching Test • Risk of Falls

INTRODUCTION

Aging is accompanied with decreased ability to respond to balance disturbing circumstances resulting in more frequency of falls [1]. The ability to maintain stability, while standing, is an essential characteristic of person motion. Difficulties in controlling balance increase the risk of falling and relevant harmful complications especially with aging where there is impaired neuromusculoskeletal system contributing to imbalance and leads to falls [2].

Impaired postural balance in older population is largely attributed to dysfunction of the cerebellum and vestibular system, visual impairments, decreased muscle power, fitness and agility [3].

Shumway-Cook and Woollacott [4] reported that postural control requires harmony between musculoskeletal and nervous systems. The musculoskeletal elements comprise joint range of movement, flexibility of the spine, muscular properties and biomechanical relationships among linked parts of the body. Whereas, the nervous elements, essential to
postural control, encompass motor processes that include synergies of neuromuscular reaction, sensory proceedings including the visual, vestibular and somatosensory systems.

Balance is an essential predictor of falls in old people. Normal balance is important to perform different daily functions. Many procedures were designed to quantitatively examine balance in older subjects [5].

The Biodex stability system is a recent device used to assess and train balance ability. The system is developed to excite mechanoreceptors of the joints and to enhance muscle contraction important for stability [6]. The level of platform tilting during evaluation is determined by the person’s ability for balance. One of the parameters, which could be calculated, is the stability index (SI). The SI quantifies the person’s ability to control the tilting angle of the platform. It represents the variation of platform dislocation in degrees from level position in every movement throughout the assessment. Low SI indicates many moments and a reduced time spent away from the level position and interpreted as a better balance score [7].

**MATERIALS AND METHODS**

**Participants:** Thirty male volunteers were selected from Makah city, KSA. Volunteers were assigned into two equal groups: Young (control) group; aged 20 to 26 years and elderly (study) group aged 60 to 69 years. Both groups were examined in the physical therapy department, faculty of applied medical sciences, Umm Al-Qura University, KSA.

**Inclusion Criteria:** The subject ages ranged from 20 to 30 years and from 60 to 70 years for the control and study groups respectively. All subjects were medically stable and they had grade good regarding cognition according to mini mental state examination. Exclusion criteria: Any disorder that may affect balance or cognition as neurological; musculoskeletal; and/or vestibular diseases, drug intake as minor; major tranquilizers or antihistaminic, or marked visual or auditory impairment.

**Procedures:** An informed consent was obtained from all volunteers about agreement of study participation after explanation from the research team for the study objective and procedures. Weight and height of the participants were measured and recorded. Biodex stability system (Biodex Corporation, shirly, NY) was used for testing both stability index and dynamic limit of stability (DLOS). High scores of overall stability index (OSI), antero/posterior stability index (APSI) and medio/lateral stability index (MLSI) indicate poor postural stability. The device platform stability ranges from 1–8, with one representing the greatest instability. The system is interfaced with computer software and connected with printer to print the test results.

**Stability Index:** The test was done to examine the person's ability to control the tilting angle of the platform as it indicates the amount of platform motion. Increased SI is indicator of a many motions and therefore less stability [7]. The subject was instructed to center himself on the platform before starting the test. In this position, the COG of the body is centralized over a point of the vertical ground reaction force. The participant was then informed to achieve a centered position on the released platform by shifting position of foot to keep cursor centered on the screen grid. He kept this position while the investigator identified the subject's feet positions on the platform grid through recording the heel coordinates and feet angles. Heel coordinates were measured from the center of the back of the heel while the feet angles were determined by finding a parallel line on the platform coincided to the central line of the foot. All these values were recorded on the balance system computer software to be used in each test to ensure the consistency of the tests that should be performed in the same centered position. The participant was then instructed to maintain a level platform for a period of 20s for each test and rest by sitting for one min. The mean of three trials for AP, ML indexes and OSI was calculated and were recorded in both groups.

**Dynamic Limits of Stability:** It was used to test the subject’s ability to move from one target to another within the dimension of limits of stability which is eight degrees anterior, four degrees posterior and eight degrees on each side with as little deviation as possible. Prior to starting the test, the limits of stability (LOS) test screen displayed eight circles arranged around a central circle. The circles on the top portion of the screen represented the antero-medial and antero-lateral LOS. The circles to the left and right of the center represent medial and lateral limits of stability, whereas the circles at the bottom of the screen represent the posterior limits of stability.
The test started, with the footplate centered and the cursor over the flashing central circle, the subject must demonstrate adequate neuromuscular control to hold the cursor inside that central flashing circle until it stopped flashing. He was then instructed to shift the body weight while the feet were fixed on the footplate to move the cursor over the second randomly appearing flashing circle and also to hold the cursor inside that flashing circle until it stopped flashing. The participant was then asked to move the cursor back to the central flashing circle by shifting his body weight. Instructions were given to the subject to repeat the same process for each of the eight circles. The circles appeared in a random order until the subject has completed all eight circles. The elapsed time was calculated by the device. Once the subject had completed all eight circles, the clock stopped and the test trial ended. Then the foot platform automatically returned to the locked position.

At the end of each test trial, a print out report was obtained. This report included information about the total time elapsed to complete the test and direction control. Direction control is represented as a percentage of theoretical excursion value; 100% equals perfect control. A value outside that range represents subject had difficulty. The mean values of three trials of overall direction control and total time needed to complete the test; on the eighth stability level were calculated for each participant.

**Functional Reach Test:** The functional reach test was developed to evaluate the limits of stability in an anterior direction. The distance maximally reached anteriorly and horizontally by a person, while keeping a fixed base of support, was measured [8]. The test was done by placing tape measurement on the wall parallel to the floor, at the height of the subject's dominant acromion. Each volunteer was asked to stand with the feet apart at a comfortable distance; making a fist and flexing the shoulder forward. The subject was instructed to reach anteriorly as far as possible without taking a step or touching the wall. The distance between the start and end points was measured using the head of the metacarpal of the third finger as a reference point. Three trials were performed and an average was calculated.

**Statistical Analysis:** Descriptive statistical analysis had been made for all variables and data are presented as mean±SD. Independent samples t-test was used to compare between young and older groups. Level of significance was less than 0.05. Pearson test was used for correlation between FRT scores and biodex stability parameters measured.

**RESULTS**

**General Characteristics of the Participants:** There was no significant difference between the young and elderly groups regarding body weight and height (p>0.05) (Table 1).

**Overall, Antero/posterior and Medio/lateral Stability Indexes:** The results revealed significant difference in the mean values of the OSL, A/PSI and M/LSI between young and elderly groups (p= 0.002, 0.0001, 0.0001 respectively) (Table 2 and Fig. 1).

**Dynamic Limit of Stability:** The results also revealed that the mean value of the directional control was significantly different in the elderly group compared to that of the young one (p=0.0001) (Table 3 and Fig. 2). Moreover, there was a significant increase the mean values of the time elapsed to complete the test in the elderly group compared to that of the young one (p=0.0001) (Table 3 and Fig. 3).

**Functional Reach Test:** The mean values of the FRT 37.9±3.2 cm and 25.3±3.8 cm in the young and elderly groups respectively. Also, there was a significant difference in the mean values of the FRT between groups (p=0.0001) (Fig. 4).

**Correlation:** Significant positive correlation between FRT scores and directional control was revealed in the young and the elderly groups (r= 0.89 and 0.66 respectively) (Table 4 and Fig. 5 and 6).
Fig. 2: Directional control mean values in the young and elderly groups.

Fig. 3: Mean values of the time elapsed to complete the test in the young and elderly groups.

Fig. 4: Mean values of the FRT scores in the young and elderly groups.

Fig. 5: Correlation between the FRT scores and directional control in the young group.

Fig. 6: Correlation between the FRT scores and directional control in the elderly group.

Table 1: General characteristics of the participants and comparison of weight and height between the young and elderly groups.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Young</th>
<th>Mean ±SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.73 ± 2.46</td>
<td>64.07±2.96</td>
<td>40.54</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Body weight (Kgm)</td>
<td>74.73±6.12</td>
<td>72.07±7.27</td>
<td>-1.09</td>
<td>0.29</td>
</tr>
<tr>
<td>Height (m²)</td>
<td>1.69±0.71</td>
<td>1.70±0.85</td>
<td>0.07</td>
<td>0.952</td>
</tr>
</tbody>
</table>

*Significant, Kgm=kilogram, SD= standard deviation

Table 2: Comparison of stability indexes between the young and elderly groups.

<table>
<thead>
<tr>
<th>Stability Index</th>
<th>Young Mean ±SD</th>
<th>Elderly Mean ±SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.75±0.35</td>
<td>1.17±0.35</td>
<td>3.258</td>
<td>0.002*</td>
</tr>
<tr>
<td>A/P</td>
<td>0.81±0.3</td>
<td>1.48±0.37</td>
<td>5.512</td>
<td>0.0001*</td>
</tr>
<tr>
<td>M/L</td>
<td>1.13±0.47</td>
<td>1.77±0.48</td>
<td>3.724</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

*Significant, SD= standard deviation

Table 3: Comparison of dynamic limit of stability between young and elderly groups.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Young</th>
<th>Mean ±SD</th>
<th>Elderly</th>
<th>mean ±SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directional control</td>
<td>35.3±6.8</td>
<td>20.87±5.2</td>
<td>6.504</td>
<td>0.0001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time elapsed (sec)</td>
<td>44.87±11.9</td>
<td>84.6±22.8</td>
<td>5.975</td>
<td>0.0001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant

Table 4: Correlation between the FRT scores and the directional control in both groups.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Young</th>
<th>0.89</th>
<th>0.0001*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elderly</td>
<td>0.66</td>
<td>0.007*</td>
</tr>
</tbody>
</table>

*Significant
DISCUSSION

The current study was conducted to investigate balance problems in elderly people. Regarding the stability indexes, the results showed significant difference between elderly and young groups in all test parameters that could be explained by increased effort to keep balance in elderly. This comes in agreement with the findings drawn by Hojjati and Sheikhpour [9] who found impaired functional balance, manifested by decreased scores of Berg balance scale, in females aged 60 years and older. In the same line, Laughton [10] suggested that raised postural leaning in short time periods in elderly was partially due to increased lower extremity muscle contraction while standing and these contractions were linked to postural sway.

In addition, Benjuya et al. [11] reported different variations related to age in the postural control in elderly who exhibited profound ankle muscular co-activation, in comparison with younger individuals. Also, this agrees with Fitzpatrick et al. [12] who reported that ageing is related to reduced maintenance of postural balance during standing and when responding to sudden balance disturbances. Other explanation for increasing stability indexes in elderly group, which indicates balance impairment, is the sensory changes in visual, proprioceptive and vestibular inputs. This comes in agreement with Lord and Ward [13] who postulated that with age, the decreased standing balance is associated with specific sensory and motor deficits such as weakness of lower limb muscles, peripheral hypoesthesia, visual impairments and decreased reaction time.

Also, this explanation is supported by Fitzpatrick and McCloske [14] who suggested that the interaction of vision, vestibular system and proprioceptive input has been indicated by altering each of them and recording the resultant change in postural sway. In normal young individuals, the changes were minimal, as a result of compensation by other inputs and it is suggested that peripheral sensation is the most essential information source. In elderly and individuals who have sensory impairments, the increase in sway was greater, denoting lack of balance control.

In addition, the results of the present study revealed significant increase in A/P stability index. This is consistent with Okada et al. [15] who found that when balance disturbance is externally employed, elderly adults exhibit what is called “hip-like” strategy, that necessitates contraction of hip muscles. This is due to reduced ability of muscles around the ankle to produce enough torque and a delayed onset latency of these muscles in response to a forward or backward body sway.

The results of the current research revealed significant increase in M/L stability index. In the same line, Sturnieks et al. [16] reported that age-related difference in the lateral direction is clear; proposing that balance the control in the lateral direction is specifically a major problem in elderly.

Regarding the dynamic limit of stability test, the significant decrease in directional control in elderly group is consistent with the findings of Hatzitaki et al. [1] who suggested that the increased postural disturbances employed by the different activities could prevent older individuals from shifting their center of gravity near to stability boundaries. Moreover, Hageman et al. [17] reported that sway during standing at the edge of the stability limit is observed more in elderly compared to young one.

The time elapsed to complete the dynamic limit of stability test was significantly increased in elderly. This finding is agreed with Lajoie et al. [18] who reported that normal old individuals exhibit significant slower reaction times in a narrow base support during standing position compared to the young individuals.

Finally, the findings of the present work revealed significant decrease in the scores of functional reach test in the elderly group. This comes in agreement with King et al. [19] who examined women's capability, aged 20 to 91 years, to reach as far anteriorly and posteriorly as possible during upright position, to determine the functional base of support. They found that the base of support was significantly reduced over 60 years-old, with a decrease of 16% per decade thereafter. Subsequent studies have shown significant age-related decline in functional reach scores [17, 20].

The association found in the present research between directional control and FRT scores supports the clinical validity of the FRT. Its increased application in the elderly people may serve as valuable screening test for balance impairments and a sensitive assessment tool of variations in balance skills. Behrman et al. [21] demonstrated that a cut off reach score of 10 inches differentiates subjects at high risk for falling suggesting that the FRT scores may better anticipate the risk of postural instability that occurs during daily functions.
CONCLUSION

There are age-related changes of balance resulting in poor performance in standing position and decreased functional reaching in elderly people.

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REFERENCES