

## Training on Biodex balance system improves balance and mobility in the elderly

Furqan Ahmed Siddiqi<sup>1</sup>, Tahir Masood<sup>2</sup>

### Abstract

**Objectives:** To determine the effects of balance training with visual feedback using static and dynamic Biodex balance system for fall risk and mobility.

**Methods:** The two-arm pilot randomised controlled trial was conducted from July to October 2016 at Fauji Foundation Hospital Rawalpindi and comprised community-dwelling elderly individuals. Subjects having no major co-morbid conditions were recruited via non-probability purposive sampling. Subjects were randomly divided in two equal groups. The intervention group received 8-week training on Biodex balance system and the control group received no intervention. Data was collected using Biodex fall risk score, Berg balance scale and Timed Up and Go Test before and after the treatment. Data was analysed using SPSS 20.

**Results:** There were 18 subjects in two groups of 9(50%) each. Analysis within the groups showed significant improvement in the intervention group ( $p < 0.001$ ) while no significant improvement ( $p > 0.05$ ) was observed in the control group. Post-intervention the result remained unchanged while comparing the two groups ( $p < 0.05$ ).

**Conclusion:** Dynamic postural training using static and dynamic Biodex balance system had a positive effect on mobility and balance in the elderly.

**Keywords:** Biodex balance system, Balance training, Elderly, fall, Mobility, Postural control.  
(JPMA 68:1655; 2018)

### Introduction

Balance is the use of multiple systems of the body to keep the centre of gravity within the base of support.<sup>1</sup> Balance is maintained by integration of numerous systems, including visual, somatosensory and vestibular system. Aging results in impairment of any number of these systems<sup>2</sup> which can lead to problems in balancing. Impaired balance system of body results in increased risk of fall which is a major cause of mortality and morbidity in elderly population.<sup>3</sup> This leads to increased costs and need for rehabilitation services.<sup>4</sup> In 2014, over 11 million Pakistanis were aged 60 and above, and this figure is expected to rise to more than 17 million by 2025.<sup>5</sup> According to a study, globally 30-50% of population aged 65 years and above has problems

with their balance.<sup>1</sup> Worldwide, fall has been identified as the second leading cause of un-accidental or accidental injury. About 20-30% of falls cause moderate to severe trauma which results in decreased functional performance. Fall has been identified as a major cause of admission to hospital among the elderly in comparison to any other disease or injury. Falls result in significantly decreased mobility, disability, functional dependence and increased risk of premature death. Falls also result in long-term psychological effect, like the fear of recurrent falls and depression which, in turn, causes lower social participation and routine function.<sup>6</sup> Each year 1 out of 3 elderly persons suffer fall, of whom 6% suffer from fracture and 24% with other serious injuries. In Pakistan, the Survey of National Injury states the incidence rate of fall-related death is 8.85 out of 1000.<sup>7</sup> In the Mediterranean region, it was found to be 2.9 per 100,000.<sup>8</sup> However, balance training and exercise interventions tend to decrease the risk of falling and

<sup>1</sup>Foundation University Institute of Rehabilitation Sciences, Foundation University, Islamabad, <sup>2</sup>Riphah College of Rehabilitation Sciences, Riphah International University, Islamabad.

**Correspondence:** Furqan Ahmed Siddiqi. Email: furqan@fui.edu.pk

eventually the fall itself.<sup>4</sup> One of the most effective methods of reducing falls in the elderly population is prophylactic intervention on multiple risk factors of fall. These include outpatient balance training and fall-risk assessment.<sup>9</sup> Conventional balance training<sup>10</sup> programmes usually include functional training, mobility training, pilates, strengthening exercises, tai chi, yoga and flexibility training. Simple home-based exercises protocols<sup>11</sup> are also used for balance training but other than these, few computerised feedback postural control training systems<sup>12</sup> and sophisticated exercise machines<sup>13</sup> are also available for balance training. Force plate systems and mirrors which are parts of visual biofeedback (VBF) are often used for treatment of balance disorders, but are found to have no difference in educating compared to conventional management.<sup>14</sup> Moreover, conventional balance training programmes have been reported to have decreased adherence.<sup>15</sup> With advancements in technology, sophisticated systems capable of quantifying balance have emerged which provide reliable and valid data regarding balance. These systems can also be used for treatment purposes and also have various visual feedback systems for more educational benefits. One of these systems is Biodex balance system (BDEX), which allows testing and training in both static and dynamic (SD) formats, is used for balance and postural re-education, better proprioception, somatosensory and neuromuscular control. It uses an integrated system which involves patients in activities of re-education with relation to visual feedback to accommodate body accordingly.<sup>16</sup> Effectiveness of BDEX has been assessed in different neurological conditions like multiple sclerosis in improving balance.<sup>17</sup> Numerous studies evaluating the effects of balance training via BDEX on different balance parameters of diabetic neuropathy patients found positive results.<sup>18</sup> Furthermore this system was also found to improve balance in older adults, in a study investigating motor skills training as a function of attentional focus.<sup>19</sup> Being a developing country, Pakistan is still deficient in healthcare facilities. Research and suggestions of rehabilitation in elderly population addressing balance and fall-risk assessment via objective assessment tools is scarce. The current study was planned to determine

the effects of balance training with visual feedback using BDEX SD on fall-risk and mobility.

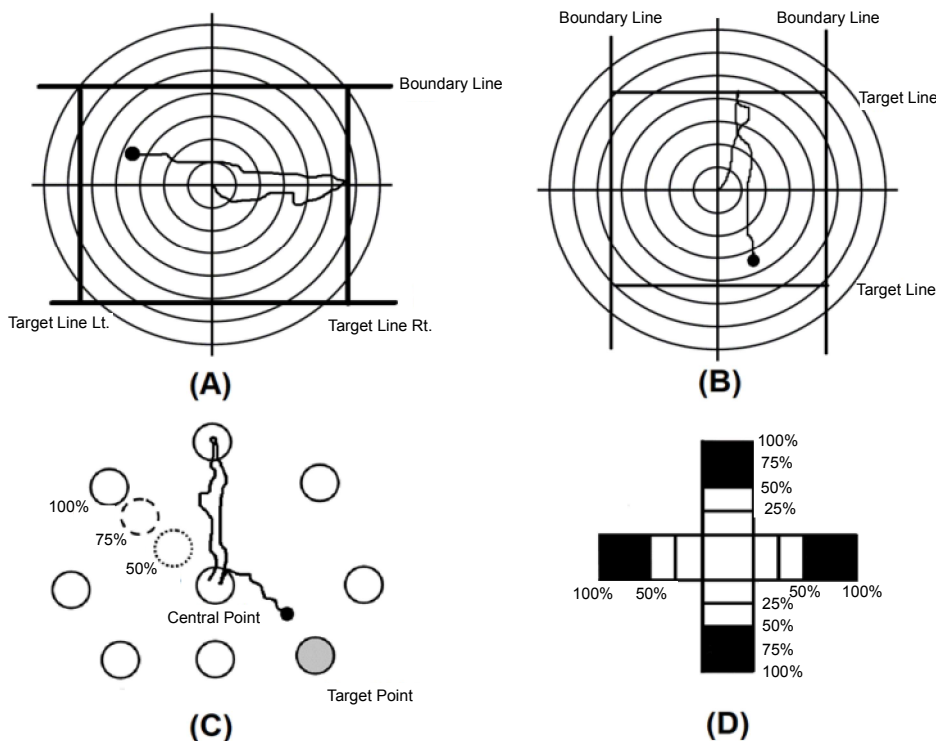
## Subjects and Methods

The two-arm pilot randomised controlled trial was conducted from July to October 2016 at the Department of Physical Medicine and Rehabilitation at Fauji Foundation Hospital Rawalpindi and comprised community-dwelling elderly individuals. Approval for the study was obtained from the institutional ethics review committee of Foundation University, Islamabad. The subjects were selected via non-probability purposive sampling. Those selected were healthy individuals of both genders, aged 50-80 years and with an ability to stand for 10 seconds with eyes open. Those having musculoskeletal conditions, like fractures, severe arthritis, etc., vestibular problems, subjects with neurological conditions like epilepsy, Parkinson's disease, Alzheimer's disease, impaired cognition, systemic diseases or major co-morbidities, intake of any medication that affects balance, osteoporosis, and history of fall in recent years were excluded.

The subjects were equally distributed into BDEX group and CTRL group that had controls. The allocation was done using simple randomisation via coin toss method after obtaining written informed consent. As participants were healthy individuals, the CTRL group received no exercise intervention.

BDEX Group participants performed exercise for 30-45 minutes per day, 3 times a week for 8 weeks. The exercises were performed under the supervision of a trained physical therapist. They received 5 minutes of warm-up exercises before balance training intervention, followed by 20-30 minutes of exercise regime followed by 5 minutes of cool-down exercises. Balance intervention in BDEX group was provided using BDEX SD system (Model 950-440, Biodex, Inc., Shirley, NY, USA) which is a dynamic balance testing and training system commercially available. BDEX SD has a moveable circular balance platform resembling a wobble board that provides a surface tilt of 20° in 360° direction. The tilt is provided with spring resistance from a fixed to a mobile surface ranging from level 1 to 12; where 12 is least mobile while level 1 is highly mobile. The subjects were required to control this platform via feet to control the dot displayed in front of the participant on a screen. BDEX balance training included SD balance training components starting from static training and progressing to dynamic components over the period of 8 weeks to

**Figure-1:** A) Weight Shift training mediolateral direction. B) Weight Shift Training Anteroposterior Direction. C) Limits of Stability Training with different levels. D) Percentage Weight Bearing Training.



increase the balance challenge. This challenge was also increased individually in each BDEX training method which included weight shift training, requiring participants to shift weight in mediolateral (Figure-1A) and anterior-posterior (Figure 1B) direction within limited mobility area displayed on screen, limits of stability training (Figure 1C) require individuals to shift weight in 360 degree space to reach the end of sway window and percentage weight-bearing training (Figure-1D) require individuals to equally bear weight in all direction.

Data was collected at baseline and after 8 weeks of intervention using Berg balance scale (BBS), Timed up and go (TUG) test and Biodex fall-risk scores (BFRS). BFRS was assessed using BDEX SD. BFRS provides an objective measure of balance and is considered highly reliable.<sup>20</sup> The subjects were assessed using BFRS for 20-second trial duration on level 8 mobility on BDEX SD. The subjects were asked to stand on circular platform and try to keep the marker in the centre of the bull's eye screen of BFRS. During this period, the platform was freely movable in

medial-lateral and anterior-posterior direction. Higher scores of BFRS signified increased fall risk, impaired balance and vice versa. Assessor was unaware of group allocations and participants were instructed not to discuss study protocol with the assessor.

Data was analysed using SPSS 20. Demographics such as age, weight, height, body mass index (BMI) were reported in the form of mean and standard deviation, whereas gender distribution was reported in form of percentages and frequencies. Shapiro-Wilk Test of normality was used at baseline to evaluate distribution. Non-significant result ( $p > 0.05$ ) justified use of parametric tests. Analysis between groups was done using independent samples t-test whereas analysis within the groups was done using paired

samples t-test. Level of significance was set at  $p < 0.05$ .

### Results

There were 18 subjects in two groups of 9(50%) each. The overall mean age was  $62.89 \pm 7.91$  years. Mean height and weight was  $1.59 \pm 0.09$  meters and  $74.48 \pm 10.68$  kg respectively, whereas mean BMI was  $29.48 \pm 3.86$  kg/m<sup>2</sup>. There were 7(38.9 %) males and 11(61.1%) females (Table-1). No significant difference was observed between the groups after 8 weeks of intervention ( $p = 0.07$ ) (Table-2). Analysis within the groups showed significant

**Table-1:** Demographics distribution between BDEX Group and CTRL Group.

Variable	CTRL Group	BDEX Group
Age (Years)	$62.89 \pm 9.31$	$62.89 \pm 6.81$
Weight (kg)	$77.57 \pm 13.84$	$71.39 \pm 5.39$
Height (m)	$1.59 \pm 0.12$	$1.60 \pm 0.07$
BMI(Kg/m <sup>2</sup> )	$30.80 \pm 4.54$	$28.67 \pm 2.67$
<b>Gender Distribution</b>		
Males	33.3% (n=3)	44.4% (n=4)
Females	66.7% (n=6)	55.6% (n=5)

BDEX- Biodex Balance Training Group  
CTRL- Control Group

**Table-2:** Between Group analysis after 8-week assessment for BBS, BFRS & TUG.

Variable	BDEX Group	CTRL Group	P Value
BBS	45.22 ± 1.30	41.89 ± 4.73	0.07
BFRS	3.18 ± 0.64	4.19 ± 1.44	0.08
TUG	11.07 ± 0.85	16.48 ± 3.36	<0.001

BDEX- Biodex Balance Training Group  
CTRL- Control Group  
TUG-Timed Up and Go Test

BFRS-Biodex fall risk score  
BBS-Berg balance scale

**Table-3:** Within Group analysis for BBS, BFRS & TUG.

Variable	Group	Baseline Assessment	8 Week Assessment	P Value
BBS	BDEX Group	40.89 ± 1.76	45.22 ± 1.30	<0.001
	CTRL Group	42.78 ± 5.87	41.89 ± 4.73	0.67
BFRS	BDEX Group	5.29 ± 0.75	3.18 ± 0.64	<0.001
	CTRL Group	4.03 ± 1.39	4.19 ± 1.44	0.82
TUG	BDEX Group	15.45 ± 1.50	11.07 ± 0.85	<0.001
	CTRL Group	16.12 ± 3.37	16.48 ± 3.36	0.42

BDEX- Biodex Balance Training Group  
CTRL- Control Group  
TUG-Timed Up and Go Test

BFRS-Biodex fall risk score  
BBS-Berg balance scale

improvement ( $p=0.52$ ) after 8 weeks was observed in the CTRL Group (Table-3).

Similar to BBS, no significant difference ( $p=0.08$ ) was seen in BFRS between the groups post-intervention. Analysis within the groups showed significant improvement in BDEX group ( $p<0.001$ ) whereas the CTRL group showed no significant improvement ( $p=0.82$ ) after 8 weeks. In contrast to BBS and BFRS, TUG showed significant difference between the groups ( $p<0.001$ ). Analysis within groups showed significant improvement in BDEX group ( $p<0.001$ ) whereas the CTRL group showed no significant improvement ( $p=0.42$ ) after 8 weeks (Table-3).

## Discussion

There is a recognised need for objective measurement indices for balance/risk of fall, yet limited evidence on such measures is available. Moreover, no commercially available device has emerged as gold standard of balance assessment.<sup>21</sup> The BDEX has a wide range of clinical applications for balance training and evaluation. It has proved its worth as a consistent and objective apparatus.<sup>22</sup> Many previous studies have reported about this system to improve body balance and avert falls among the elderly through neuromuscular training.<sup>23</sup> This study is first of its kind in Pakistan to assess and train the elderly population using modern balance training and assessment system obtaining quantitative and objective balance measures.

The result of this study were promising and showed that over period of 8 weeks, there was significant improvement in balance and mobility of subjects in BDEX Group compared to CTRL Group, showing noticeable reduction in fall-risk. Although there was statistically no significant difference between groups in BBS and BFRS, analysis within groups in BBS and BFRS showed that there was marked difference between baseline and post-intervention values in BDEX group, showing striking reduction in fall-risk as shown by improvement in BBS and BFRS compared to the CTRL group; hence proving improvement of balance was more in BDEX group compared to CTRL group. Similarly, significant improvement occurred in mobility of BDEX group compared to CTRL group as shown by decreasing TUG scores.

The findings of the current study are similar to another research on balance improvement using Biodex system which demonstrated a considerable improvement in Biodex fall-risk index after discharge from rehabilitation ( $p<0.001$ ). In contrast, a study had some limitations as no control group was recruited and fewer trainers were available for BDEX use.<sup>24</sup>

In another study on balance improvement in diabetic patients using BDEX, TUG test ( $p = 0.01$ ), fall risk index (FRI) ( $p=0.002$ ) and BBS ( $p=0.04$ ) showed considerable improvement in the treatment group after training, but had no distinct changes in the CTRL Group.<sup>15</sup> These findings are in line with the findings of the current study where significant improvement over time was observed in BBS, TUG and BFRS of BDEX Group.

The findings of the current study support the result of another study in which balance training using the BDEX SD was done by the BDEX Group. The TUG test, Romberg test, BBS, FRI and postural stability tests were assessed in both groups at baseline and after 12 weeks. There was significant improvement in the outcome measures of TUG, FRI, and overall stability index (OSI) in the treatment group after 24 sessions.<sup>17</sup>

A randomised control trial on institutionalised older people for balance training involved 12-week protocol comprised of balance/re-balance training (two sessions per week) with BDEX. There was greater reduction in fall risk in intervention group at 12 weeks compared to the control group.<sup>23</sup> These results are also supported by our study which showed significant improvement in mobility, static and dynamic balance and reducing fall risk as indicated

by BBS, TUG, Biodex fall risk scores.

The current study was a pilot study conducted in a single centre. The sample was limited and not pre-calculated. Thus, the results of the study cannot be generalised to general population. Further multi-centre studies need to be carried out with larger sample sizes to make the results more generalisable.

## Conclusion

Dynamic postural balance training using BDEX SD had a positive effect on mobility and balance in healthy older individuals and can be used as a training tool to reduce fall risk and improve balance and mobility.

**Acknowledgments:** We are grateful to Dr. Muhammad Ehab Azim P.T. and Dr. Sana Khalid P.T. for their help in proof-reading the draft. Thanks are also due to Foundation University, Islamabad, for providing necessary equipment and work space.

**Disclaimer:** This article is part of a Ph.D. Rehabilitation Sciences dissertation.

**Conflict of Interest:** None.

**Source of Funding:** None

## References

- Mancini M, Horak FB. The relevance of clinical balance assessment tools to differentiate balance deficits. *Eur J Phys Rehabil Med.* 2010;46:239.
- Geoba Sa. The World: Life Expectancy. [Online] [Cited 2015 March 12]. Available from: URL: <http://geoba.se/population.php?pe=world&type=015&page=2>.
- Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. *Maturitas.*2013; 75:51-61.
- Schoene D, Valenzuela T, Lord SR, de Bruin ED. The effect of interactive cognitive-motor training in reducing fall risk in older people: a systematic review. *BMC Geriatr.*2014; 14:107.
- Finance Mo. Population, Labour Force and Employment. *pakistan economic survey 2014-15.* 2014; pp 202.
- Chang VC, Do MT. Risk factors for falls among seniors: implications of gender. *Am J Epidemiol.*2015; 181:521-31.
- Bachani AM, Ghaffar A, Hyder AA. Burden of fall injuries in Pakistan-analysis of the National Injury Survey of Pakistan/Charge des traumatismes par chute au Pakistan-analyse de l'enquête nationale sur les traumatismes. *East Mediterr Health J.* 2011; 17:375.
- Mathers CD, Ma Fat D, Inoue M, Rao C, Lopez AD. Counting the dead and what they died from: an assessment of the global status of cause of death data. *Bull World Health Organ.*2005; 83:171-7c.
- Tinetti ME, Kumar C. The patient who falls:"It's always a trade-off". *Jama.* 2010; 303:258-66.
- Hauer K, Rost B, Rüttschle K, Opitz H, Specht N, Bärtsch P, et al. Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with a history of injurious falls. *J Am Geriatr Soc.*2001; 49:10-20.
- Barnett A, Smith B, Lord SR, Williams M, Baumand A. Community based group exercise improves balance and reduces falls in at risk older people: a randomised controlled trial. *Age Ageing.*2003; 32:407-14.
- Hagedorn D, Holm E. Effects of traditional physical training and visual computer feedback training in frail elderly patients. A randomised intervention study. *Eur J Phys Rehabil Med.* 2010; 46:159-68.
- Wolf SL, Barnhart HX, Ellison GL, Coogler CE. The effect of Tai Chi Quan and computerised balance training on postural stability in older subjects. Atlanta FICSIT Group. *Frailty and Injuries: Cooperative Studies on Intervention Techniques.* *Phys Ther.* 1997; 77:371-81.
- Geiger RA, Allen JB, O Keefe J, Hicks RR. Balance and mobility following stroke: effects of physical therapy interventions with and without biofeedback/forceplate training. *Phys Ther.*2001; 81:995-1005.
- Harris DM, Rantalainen T, Muthalib M, Johnson L, Teo WP. Exergaming as a Viable Therapeutic Tool to Improve Static and Dynamic Balance among Older Adults and People with Idiopathic Parkinson's Disease: A Systematic Review and Meta-Analysis. *Front Aging Neurosci.* 2015;7:167.
- Cadore EL, Rodríguez-Mañas L, Sinclair A, Izquierdo M. Effects of different exercise interventions on risk of falls, gait ability, and balance in physically frail older adults: a systematic review. *Rejuvenation Res.* 2013; 16:105-14.
- Eftekharsadat B, Babaei Ghazani A, Mohammadzadeh M, Talebi M, Eslamian F, Azari E. Effect of virtual reality-based balance training in multiple sclerosis. *Neurol. Res.* 2015; 37:539-44.
- Eftekhar Sadat B, Azizi R, Aliasgharzadeh A, Toopchizadeh V, Ghojzadeh M. Effect of balance training with Biodex Stability System on balance in diabetic neuropathy. *Ther Adv Endocrinol Metab.* 2015; 6:233-40.
- De Bruin ED, Swanenburg J, Betschon E, Murer K. A randomised controlled trial investigating motor skill training as a function of attentional focus in old age. *BMC Geriatr.* 2009; 9:15.
- Cachupe WJC, Shifflett B, Kahanov L, Wughalter EH. Reliability of Biodex Balance System Measures. *Meas Phys Educ Exerc Sci.* 2001 2001; 5:97-108.
- Pickerill ML, Harter RA. Validity and reliability of limits-of-stability testing: a comparison of 2 postural stability evaluation devices. *J Athl Train.* 2011; 46:600.
- Arnold BL, Schmitz RJ. Examination of balance measures produced by the Biodex Stability System. *J Athl Train.* 1998; 33:323.
- Gusi N, Adsuar JC, Corzo H, del Pozo Cruz B, Olivares PR, Parraca JA. Balance training reduces fear of falling and improves dynamic balance and isometric strength in institutionalised older people: a randomised trial. *J Physiother.* 2012; 58:97-104.
- Prometti P, Olivares A, Gaia G, Bonometti G, Comini L, Scalvini S. Biodex fall risk assessment in the elderly with ataxia: a new age-dependent derived index in rehabilitation: an observational study. *Medicine (Baltimore).* 2016; 95:e2977.