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A Perturbation Based Balance Intervention for an Octogenarian: A Case Study

Sampada S Jahagirdar

Amar Jyoti Institute of Physiotherapy, University of Delhi, India

Abstract: ***Introduction: Increased longevity has caused age related falls to become a major public health issue. Though much work has been done in devising interventions for prevention of falls in elderly, none of the interventions have been found to be effective for persons aged 80 years and above. Aims and Objectives: As it is known that balance reactions are critical for falls prevention and can be learnt by practice, this study attempts to develop a specialized balance intervention comprising of perturbations for an octagenarian. Methodology: An 86-year old man presenting with balance loss and lumbar canal stenosis was given a balance intervention comprising of self-initiated and externally generated perturbations for 5 days a week for 6 weeks. Balance was assessed on Unipedal Stance test (UPST), Functional Reach Test(FRT) and Timed Up and Go (TUG) test at the end of 4 weeks and then at the end of 6 weeks. Results: UPST showed increase in time for standing on one leg. FRT showed an improvement in the distance reached. The TUG test showed reduction in time taken. Conclusion: A one-to-one balance intervention including perturbation training is an effective way to improve balance in elderly above 80 years of age.***

Keywords: Balance, Falls, Elderly, Perturbations

1. Introduction

The population of India is pushed towards an ageing humanity. According to an NSSO survey, the elderly will account for more than 10% in the Indian population by 2021. It is observed that not only the percentage of people aged 60 or more is rapidly increasing; even the percentage of persons above age 80 is going up over the years.[1]This increase in longevity has not been accompanied by an increase in disease free life- expectancy. Research into ageing is required to improve the health and quality of life of older people.[2]

Falls associated with aging have become a major public health issue.[3]Approximately 30 % of people aged over 65 years fall every year.[4]Falls are complex clinical problem with numerous underlying factors. Postural stability is maintained by the integration of somatosensory, visual and vestibular inputs to the central nervous system, followed by outputs to the musculoskeletal system. Functions of all these systems deteriorate with age, resulting in loss of balance and falls.[5]Experiments involving electromyography (EMG) of ankle musculature of elderly people revealed the adoption of a co-contraction strategy with or without visual input. [6]Balance reactions such as rapid stepping or reaching movements that are critical for preventing falls are also impaired in healthy older adults. Thus, elderly have delayed onset and reduced magnitude of muscle activation required for compensatory postural adjustments for externally induced perturbations and anticipatory mechanisms of postural control prior to self-initiated perturbations.[7]

A comprehensive evaluation and targeted intervention can reduce falls by 30 to 40 per cent.[8]It is seen that even in the older adults capable of independent walking, there is a decline in balance performance that does not become evident until a slip or trip happens. Thus, preventing efforts are also required for improving balance of older adults who have not yet fallen.[9]

As the high risk factors for falls are loss of muscle strength and balance, falls prevention exercises for elderly consist of lower extremity resistance exercises and balance training.[10] A Cochrane review found that programs containing any two of the components of exercise programs for balance disorders i.e. strength, balance, flexibility or endurance, significantly improve balance.[8]Physical therapy or exercise reduce the risk of falls by risk ratio of 0.87. But, through a review of literature it was found that there are very few interventions that are effective in preventing falls.[11]It was also found that there is a need for a specialized, one-on-one falls prevention program for elderly persons in their 80s as existing interventions were not found to be effective for this high-risk group.[10]Also, previously, balance reactions were considered to be hardwired reflexes, but recent studies have shown that older adults are able to adapt in a reactive manner after participation in exercises involving disturbances to balance.[9]These disturbances can either be unexpected such as a movable stance support or external pushes and are recognized as external disturbances, or can be self-initiated and are called internal disturbances. Perturbation-based training has been found to be an effective intervention to improve balance of older adults. Self-initiated perturbations are created by altering arm position of the subject and can be easily used in a clinic.[12]

External perturbations are created by movable platforms or pulley systems.[7, 13]It is difficult to use such systems in clinical settings as they require a dedicated space and investment of money. Nudges and pushes to the patient standing in different stances has long been used clinically without much evidence. This method can be used as a practical and effective way to induce balance reactions. Also, the studies reviewed studied either internally initiated perturbations or externally initiated perturbations, but did not study their combined effect in improving balance measures in elderly.

The present study aimed at looking at the effect of a one-to-onebalance treatment intervention involving perturbationsin improving balance of an octogenarian.

2. Case Description

Patient history and System review: This case study includes an 86-year-old man who presented with a sense of unsteadiness during standing and walking. He also complained of pain in right hip and right calf on standing beyond five minutes and walking for about half an hour. He also complained about an on and off pain and feeling of stiffness in right shoulder forthe last 15 years (since 71 years of age) after he had fallen on hand and had fractured his wrist.He had mild hypertension which was well controlled with medication. The subject had always been physically active and used to play Tennis regularly till few years back. The patient had two falls in the past, one in an aircraft four years ago after he accidentally had a push from a fellow passenger. The second fall was in the bathroom of his house. The patient was living independently and was capable of all activities of daily living.

On observation, the subject was found to have slight kyphotic posture with tendency to lean more towards right side, which was correctible on command. The patient walked cautiously with minimal arm swing, trunk and pelvic rotation. The stride length during gait also appeared to be small.

2.1 Examination

Palpation was normal. Examination for higher mental functions, cranial nerves and sensations was found to be normal. The range of motion of all the joints was within normal limits. There was no tightness anywhere except for bilateral Hamstrings and Gastro soleus at end range of abduction and external rotation at right shoulder. The subject had normal muscle strength except plantar flexors and dorsiflexors which had 'good' (Grade 4) and hip abductors had Grade 3+ strength. Straight leg test was found to be positive on right side at 40 degrees. Slump test was also positive bilaterally. Deep tendon reflexes for Biceps, Quadriceps, Hamstrings and Tendo-achillis were normal.Coordination of upper and lower limbs on either side was found to be normal. The patient showed normal static and dynamic sitting balance. The standing balance was found to be poorer.

DXA Bone Densitometry reported osteopenia indicating moderate fracture risk. An MRI of lumbosacral spine showed transitional vertebra at lumbosacral junction with lumbarisation of S1 vertebra, mild narrowing of spinal canal at L5-S1 level, narrowing of bilateral neural foramina at L4-L5 and L5-S1 levels. Depression of superior and inferior endplates of L5 vertebra as well as mild spondylotic changes were seen with facet joint arthropathy and subluxation at L5-S1 level. Colour Doppler study of both lower limbs suggested atherosclerotic changes with increased intima media thickness.

2.2 Diagnosis and Prognosis

The clinical findings combined with results of the investigations point towards balance loss due to ageing along with lumbar canal stenosis. As the patient had always been physically active and had involved himself in sports in the past, he seemed to have good prognosis as compared to his peers who had majorly sedentary lifestyle in their youth or had limited physical activity level during old age.

Goals for Treatment and Plan of Care

The goals for treatment were to reduce pain in legs that appeared on standing and walking, to improve strength of bilateral plantar flexors, dorsi-flexors and hip abductors and to improve static and dynamic standing balance.

After thorough assessment, the patient was explained about his condition and was educated about the loss of balance during ageing. Precautions regarding safe environment and reduction of fatigue were explained to him in detail. The patient was also told to have a glass of water before getting up from bed for urination at night in order to prevent postural hypotension leading to a fall. After this an exercise protocol comprising of stretching, strengthening and balance exercises including perturbations was administered for 5 days a week for 6 weeks

2.3 Method

Design: Single subject case study
Subject: 86 year old male
Materials:Stopwatch, Measuring tape, Sticking tape, Standard chair, Chalk, 8 inch Stepping stool, Green Thera band(Hygenic Corporation, Akron, OH, USA)

2.4 Procedure

After the subject was clinically assessed and informed consent was obtained, a pre-intervention baseline measurement on outcome measures was documented. Intervention comprised of hot fomentation, stretching, strengthening, and balance exercises. The intervention was done for six weeks 5 days a week, at the end of which, post intervention measurement on balance parameters was done twice, first at the end of four weeks and then at the end of six weeks.Timed Unipedal Stance test was done to test for static balance.[14] Active static balance was tested by Functional Reach test[15,16] and dynamic balance was measured using Timed Up and Go tests.[17, 18]

2.5 Intervention

The following interventions were usually done in the same sequence. Adequate rest period was given in between the interventions to avoid any form of discomfort and pain.

1) Mild hot fomentation for 15 minutes using a hot pack on Bilateral Hamstring and Gastro soleus
2) Stretching of right and left Hamstrings and Gastro soleus muscles in supine lying- hold time of 30 seconds, repeated three times.
3) Neural Stretch for Sciatic Nerve- hold time of 6-10 seconds, repeated three times

4) Knee to chest exercise- unilateral on both sides followed by both together, done in this order three times
5) Unilateral Straight leg raise in supine- 15 repetitions on both sides with hold time as tolerated.
6) Static Gluteal sets- 15 contractions with hold time of 5 seconds or as tolerated
7) Resisted hip abduction, plantar flexion and dorsiflexion in supine lying using Green Thera band (Hygenic Corporation, Akron, OH, USA) -15 repetitions with 5 seconds hold time each.
8) Self-initiated perturbation was created using changing arm positions during quiet standing with normal base of support. The subject was supposed to take a red coloured cylindrical peg from the therapist's hand presented at arm length distance and place it back in the therapist's hand. The peg was randomly given and taken back at different heights and directions.
9) External perturbation was given by the therapist to the subject in the form of nudges and pushes while he was standing quietly first with normal stance i.e. normal base of support (BOS), then the BOS was reduced by placing the feet together and then in semi tandem. The nudges and pushes were given side to side at shoulders and in antero-posterior direction at sternal and mid-scapular levels. The force for the nudges and pushes were varied throughout, adequate guarding was provided to prevent fall.
10) Sit to stand from standard chair- 10 time at comfortable pace
11) Stepping on low stool (8 inches in height) from front and sideways- 5 times each
12) Walking across a standard floor ladder- 4 rounds
13) Retro-walking- with verbal feedback from the therapist- 6 rounds of 9 meter distance
14) Gait re-education with emphasis on heel strike at Initial Contact and reciprocal arm swing.

3. Result

There was an improvement on all the three balance parameters.Unipedal Stance Test for right leg showed increase in time for which the subject was able to stand on one leg from 3 seconds to 4 seconds and then to 6.3seconds. Similarly, Unipedal Stance Test for left leg showed increase in time from 2 seconds to 3.9 to 6.4 seconds. The Functional Reach Test showed a steady improvement in the distance reached, from 11inches to 12 inches and then to 12.75 inches. The Timed Up and Go Test showed gradual reduction in time taken to complete the task. The subject initially took 12 seconds to complete it while subsequently, the time taken was reduced to 8 seconds and then to 7.1 seconds.

The Straight leg test done at the end of four weeks was positive at 70 degrees on right side and 80 degrees on left side.

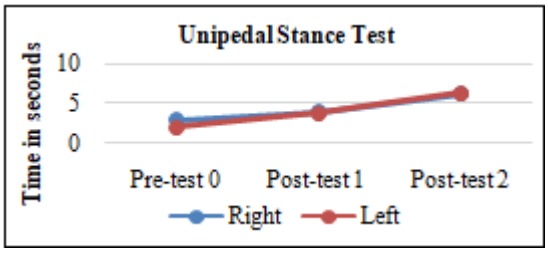

Figure 5: Graphical presentation- Pre-post intervention Unipedal Stance Measures

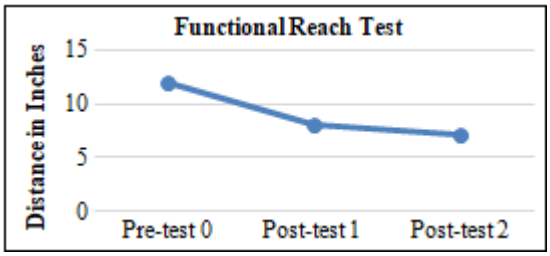

Figure 6: Graphical presentation- Pre-post intervention Functional Reach Measures

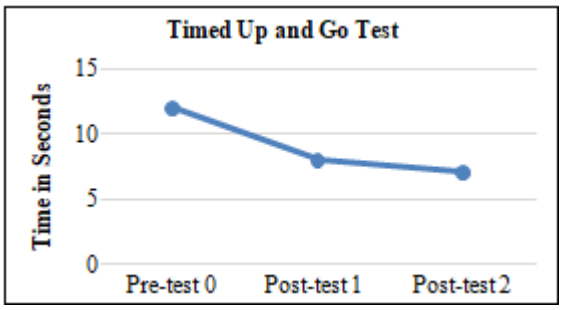

Figure 7: Graphical presentation- Pre-post intervention Timed Up and Go Measures

4. Discussion

The purpose of this case study was to examine the effectiveness of exercise intervention using perturbations, self-initiated and external, for improving the balance in elderly. The treatment used in this case focussed on improving static and dynamic balance. This case study demonstrates an example of physiotherapy being an effective method of improving balance of elderly.

The result of the customised one-on-one interventionshowed improvements in both static and dynamic balance just after 4 weeks. The improvement further enhanced after six weeks. At the end of three weeks, the patient reported slight reduction in pain frequency and intensity during walking and standing with improvement observed in SLR Test. The subject also felt less unsteady at the end of the sixth week.

Warming the muscle reduces the viscosity and makes the tissue compliant and easy to stretch.[19]Strengthening exercises for leg muscleswhich are important for postural stability using elastic resistance was found to be practical as they have only a small risk of injury, provide consistenttension, have less initial inertia as compared to weight cuff and are easily portable and inexpensive.Stretch/relax neural mobilization cycles of Sciatic nerve stretch diminished intra-neural swelling by

dispersing tissue fluid, resulting in increased range in straight leg raising.[20]

To counteract the disturbances brought about by arm raises during reaching activity and nudges and pushes on progressively reducing base of support,the body reorganizes the spatial segment positions.[12]Such anticipatory postural strategies with training can be a potential focus of balance rehabilitation.[7]

Task-specific training improves walking.[21]There is modulation of cutaneous reflexes in leg muscles during backward walking by a reversal of central motor program for locomotion. This mechanism augments static balance in retro-walking.[22]

Similar improvements were observed in a previous study in which balance exercises and elastic-resistance exercises improved leg muscle strength and proprioception.[10]

The perturbations along with other balance exercises, elastic-resistance exercises and stretching techniques used in the present study do not require specialized equipment and can be adjusted to personal physical capability. Thus, these techniques areeasily accessible and can be used by physiotherapists in any clinical setting.

5. Limitation and Future Research

The major limitation of this study is that it cannot be generalized. The present study follows A-B design for case studies, which does not allow control on the study.In order to ensure cause and effect relationship between the intervention and outcome of the study control should have been established on the study by a 'no intervention period' following the post-treatment measurement. As it was ethically not possible to withdraw the intervention in such short period, two post-treatment measurement, first at the end of four weeks and second at the end of six weeks were performed. The continuity of improvement on all test measures ensures the effectiveness of the treatment to some extent. Also, generalization of the findingsof this study would require a controlled trial of the treatment protocol on more number of similar subjects.

6. Conclusion

A one-to-one balance intervention including perturbation training is an effective way to improve balance in elderly above 80 years of age.The results of this case study suggests a practical and cost-effective way of imparting a physiotherapeutic intervention comprising of perturbations for improving balance of elderly.

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