Elastic Band as Perturbation on Balance Performance in Chronic Stroke Patients

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Abstract: ***Title**: Effect of 4 weeks training with Elastic band perturbation on balance performance in individuals with chronic Stroke. **Objective**: assess the effect of 4 weeks training with elastic band perturbation along with conventional balance exercises on balance performance versus only conventional balance exercises. **Outcome measures**: The outcome measures used were a) Clinical test-miniBEStest, b) Instrumental on Neurocom with long force plate- mCTSIB, unilateral stance, walk across and c) Patient perceived - Swedish fall efficacy scale. Assessment was done Pre training, post training at 4 weeks and follow up at 8th week after cessation of treatment. **Methodology**: It was an interventional prospective study carried out in tertiary care centre. 40 subjects (20 in experimental 20 in control) with stroke with onset more than 6 months, ambulating independently with or without assistive device, having cardiac fitness to perform exercises and having Mini mental score more than 24 were selected. **Results**: There is statistically significant greater improvement in balance performance in experimental group over control group. Mini-BEStest (p<0.0001), mCTSIB (p=0.0004), unilateral stance (p=0.0002), walk across (p<0.0001) and Swedish fall efficacy (p=0.0036) and this was retained at 8th week. **Conclusion**: Balance training in individuals with chronic Stroke for 4 weeks with elastic band as perturbation along with conventional balance exercises was effective in improving Balance performance than conventional balance exercises alone.*

Keywords: Elastic band, chronic Stroke, Balance training

1. Introduction

Stroke is defined by World Health Organization (WHO) as "rapidly developing clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours with no apparent cause other than that of vascular origin".[1] It is the most common cause of neurological disability in adult Indian population. It is found that the estimated adjusted prevalence rate of Stroke range from 84-262/100,000 in rural and 334-424/100,000 in urban areas.[2] Impaired motor function, sensory, perceptual deficits, impaired postural control & balance, emotional and cognitive limitations are the common impairments after stroke.[3] Of all possible sensorimotor consequences of Stroke, impaired postural control probably has the greatest impact on activities of daily life independence and gait.[4] About 83% of the affected individuals have balance disabilities.[5] Balance is achieved and maintained by a complex set of sensorimotor control systems that include sensory input from the somato-sensory, visual and vestibular systems and integration of that sensory input; and motor output to the eye and body muscles.[6]During quite stance, the somato-sensory system plays the major role in maintaining balance (70%), followed by the vestibular system (20%) and then the visual system (10%)[7]. An injury, disease, or an aging process can affect one or more of these components. Studies have demonstrated that human body has postural strategies that are general sensorimotor solutions for postural control and include ankle, hip and stepping strategies. Patients with Stroke use compensatory strategies to maintain same BOS, person with Stroke predominantly use the hip strategy and use the ankle strategy less. However, these strategies are often not efficient for stability, as indicated by high incidence of falls in patients with Stroke.[8] The ability to withstand external perturbations in an upright position is essential to the safety of standing and walking. In addition, internal perturbations. Caused by self-initiated movements must be counteracted as smoothly as possible to maintain balance during voluntary activities.[4] Individuals with stroke will avoid large passive body mass displacements and rely excessively on their non-paretic leg muscles to stabilize their posture. They will also limit the speed and amplitude of self-initiated movements causing internal perturbations of posture compared to healthy age-matched individuals. These phenomena have been referred to as 'stabilisation' strategies. [4,9]Patients with stroke only uses a small part of their base of support for voluntary weight displacements, which is probably compensated by the early use of change-in-support strategies or stepping responses, which appear to be relatively preserved.[4] Individual with stroke continued to have deficits in symmetrical stance and weight shifting abilities despite the improvements in motor selectivity of the paretic limb and in balance and walking skills. Both static and dynamic aspects of postural symmetry may remain impaired. It has been contended that weight asymmetry and impaired balance function may be a consequence of a learned disuse of the paretic leg.[4,10] In addition to decreased gait speed, asymmetrical gait patterns are commonly observed. Gait asymmetries are often characterized by decreased duration of single leg stance on the impaired limb, differences in step length, primarily decreased step length of the unimpaired limb versus the impaired limb, stride lengths are significantly reduced in hemi-paretic patients as compare to normal.[11]Thus, Ambulatory individuals with chronic Stroke are especially vulnerable to fall due to diminished balance function.[12]Balance training after stroke has become integral part of rehabilitation program and various techniques and advancement using conventional approach which includes Visual auditory biofeedback[13] [14] treadmill training,[15] [16] virtual stepping,[17,18] training on unstable surface by force platform perturbation [19] manual perturbation [20]etc. have been used to train balance and weight symmetry in chronic Stroke. The elastic resistance of the band has ability to act as a perturbation force; besides it has inherent advantages of easy to use, low cost, and highly versatile and can be administered for home exercises.[22]Training with elastic band as a perturbation force on normal side have shown significant improvement on balance performance in athletes with and without chronic ankle instability; [22] and in healthy elderly population, [23]Hence here we are conducting a study to assess and compare the effect of 4 weeks training with elastic band as perturbation along with Conventional balance exercises, versus Conventional balance exercises alone on balance performance in individuals with chronic Stroke.

2. Materials & Methodology

This was a prospective interventional study. Study was approved by the institutional ethical committee. This was conducted during the period of January 2017 to January 2018 in the rural tertiary care hospital. A written informed consent was taken from the subjects .40 subjects meeting the inclusion criteria with chronic Stroke were included in the study. Inclusion criteria includes onset of stroke for more than 6 months, independent ambulators with or without assistive aid Cardiovascular fitness to perform exercises, Mini mental Score more than 24. Medically unstable patients who has not allowed to perform exercises. Patients who has undergone any lower extremity surgery in past 6 months, neural or muscular blocks in lower limb in the past 3 months and clinical manifestations of any other neuromuscular, visual or vestibular disorder were excluded from the study. Subjects were divided into 2 groups of 20 each. Both the groups received routine physical therapy of standing, stretching, and upper limb, lower limb trunk control exercises. Conventional balance exercises in standing consisting of weight shifts, one leg stand, tandem standing, side walking stepping, reach outs. In elastic band therapy, one end of the elastic band was applied to non-paretic ankle at the level of malleoli and the other end fixed to a stable support. The length of the band was kept so as the band was not in lax/stretched position and the subjects were instructed to stand at the marked starting position to ensure that the exercise is performed at same starting length. Step was taken by non-paretic leg up to or beyond another marking on the floor in the direction of movement The subjects were asked to perform a) Front pull - forward step at least up to the stride length of unaffected side or beyond. b) Back pull backward step at least up to back stride length of unaffected side or beyond. c) Cross over Lateral step (hip abduction) up to shoulder width or beyond. d) Reverse cross over Medial step (hip adduction) up to shoulder width of affected side or beyond. Each exercise was given for 8-10 repetition with 1-2 minutes break between the exercises. Group A has performed Elastic band exercises with Elastic band Theraband ®[30]along with Conventional balance exercises and whereas Group B has only performed Conventional balance exercises. All the subjects were assessed at beginning (pre) treatment, post treatment at 4th week and follow up at 8th week by clinical test and instrumental test. Clinical test was done by mini balance evaluation systems test (mini bestest) [26,27].it includes modified clinical test of sensory integration of balance (ctsib)-[25]unilateral stance, walk across. Instrumental tests was done with neurocom balance master (with long force plate platform).[28]swedish fall efficacy scale [29] (interclass correlation coefficient (icc) = 0.97)) was used to see individuals perceived changes. Analysis of data for this study was done using software Graphpad prism version 7. The results were considered significant at $p<0.05$ at 95% confidence interval. The data was tested for normal distribution by Shapiro-Wilk normality test.

3. Results

Amongst 40 subjects, 3 were lost to follow-up in group A whereas 4 lost in group B.

Table 1: Demographic features of sample population

Group (sample size)	Gender M	Gender F	Age(yrs.) Mean (SD)	Onset(months) Mean (SD)	Side R	Side L
Experimental(17)	13	4	46.5(10.5)	17.9(14.9)	10	7
Control (16)	14	2	50.2(8.33)	17.5(12.0)	7	9

Table 2: Comparison of Mini-BESTest scores of Experimental and Control group

Mini-BESTest score	Experimental	Control	p value	significance
Anticipatory	2.4(1.3)	0.6(0.6)	<0.0001	ES
Reactive postural control	3(1.6)	0.8(0.5)	<0.0001	ES
Sensory orientation	1(0.8)	0.9(0.8)	0.695	NS
Dynamic gait	2.5(1.3)	0.9(0.8)	0.0001	HS
Total	8.9(4.6)	3.4(2.4)	<0.0001	ES

Table 3: Comparison of mCTSIB, unilateral stance, walks across and Swedish fall efficacy scale amongst experimental and control

	TEST	Median (95% CI)		P value	Significance
		Experimental	Control		
1	mCTSIB (COG sway deg/sec)	0.3(0.1-0.4)	0(-0.07-0.07)	0.0004	HS
2	unilateral stance (COG sway 0/ sec)				
	Ipsilateral	1.1(0.8-1.4)	0.4(0.2-0.7)	0.0002	HS
	Contralateral	0.6(0.3-0.9)		0.1768	NS
3	walk across (% step asymmetry)	11(8.2-16.4)	3(2.1-4.1)	<0.0001	ES
4	Swedish falls efficacy scale %	13.7(10.4-17.4)	6.6(4.7-9.9)	0.0036	HS

4. Discussion

This study was conducted to determine the effect of 4 weeks of training with elastic band as perturbation on balance performance in individuals with chronic stroke.

It was found that the subjects in experimental group and control group both showed a statistically significant improvement in all parameters ($p<0.05$) at 4 weeks' post training. Both the groups also showed statistically no significant difference ($p>0.05$) in improvement post training between 4 weeks and follow up at 8th week after cessation of balance training at 4th week, thus indicating that improvement in balance was retained even after cessation of treatment. Comparison of the change recorded on all the parameters between the two groups indicated experimental group showed statistically significant greater improvement over control group. In clinical outcome measure- The total scores of Mini-BES Test in experimental group was statistically extremely significant ($p<0.0001$) over control group as also in the individual components of the test viz; anticipatory balance ($P<0.0001$), Reactive postural control ($p<0.0001$) and dynamic gait ($p=0.0001$) showed significant improvement,(Table 2) where as the sensory orientation component showed no significant difference($p=0.695$).The anticipatory postural mechanism of the body activates some muscles in anticipation i.e.; even before the movement is performed, according to the type of the task and movement planned/required to stabilize the body[21]. When the subject had to pull against the elastic resistance offered by the band with the non-paretic leg, i.e. an anticipated increase of the internal perturbation, it demanded greater anticipatory mechanisms and thus improving the component of anticipatory balance to prepare to transfer weight on and support the whole-body weight on the hemipareticleg. The exercises with elastic band performed by stepping in all four directions imposed a postural control challenge that muscles of the ankle, knee and hip joints of the hemiparetic leg must effectively resist while keeping the COG within BOS. [21] The stretch of the elastic band offered an external perturbation in opposite direction of the movement. Forward pull (step) gives backward perturbation and similarly back pull a forward perturbation, cross pull a medial and reverse cross over a lateral perturbation. To maintain balance against this external perturbation imposed by elastic band the weight bearing hemiparetic leg must actively counter it and resist the forces by activating the muscles of ankle strategy[21] and/or hip strategy. The CNS constantly adjusts keep COM within BOS. It is suggested that CNS utilizes ‘throw and catch’ pattern to generate torques on opposite side of the joint to maintain equilibrium.[24] It is possible that perturbation caused by the elastic band imposed an accentuated neural training effect like throw and catch pattern[22] thus improving the body’s ability to react to the external perturbation, and improvement in this component of the scale. Improvement in the anticipatory balance and reactive postural control reflected in their ability to perform better in the dynamic functions of gait in different situation of the test. viz: change in speed, walking with horizontal head turns, walking with pivot turns, obstacle crossing, timed up and go. Sensory Orientation component tests the static balance. It consisted of standing on firm surface, standing on foam and standing on incline surface. The maximum that can be scored in this component is 6. Ceiling effect was observed in this component of the tests as many subjects scored full 6 in both the groups. This could probably be the reason for non-significant difference between Experimental group and control group. On instrumental assessment –mCTSIB and unilateral stance assessed the static balance of the body and recorded the mean COG sway velocity. The subjects in experimental group showed statistically significant improvement on mCTSIB($p=0.0004$) and ipsilateral unilateral stance ($P=0.0002$).(Table 3) This greater improvement in the static balance could not be detected in the clinical test of sensory orientation component in the Mini-BEStest. It is possible that the perturbation caused by elastic band imposes an accentuated neural training effect like throw and catch pattern, improving the ability of muscles around ankle to effectively maintain balance. It has been seen that the body sway in quite standing is like the motion of an inverted pendulum pivoted at the ankle. The COP and COG oscillations for quite standing fit the equation of the inverted pendulum. It has been found that ankle mechanisms dominate in the sagittal plane with an almost synchronous sway of body parts. The ankle torque used for balancing the pendulum can be apportioned into intrinsic mechanical and neutrally controlled elements[24] .The subjects in experimental group(walk across) showed significant greater improvement in percent step length symmetry than control group ($p<0.0001$).(Table 3) Stroke patients walk with step asymmetry with the step length of non-hemi-paretic leg shorter than the hemi-paretic due to inability to adequately transfer weight and maintain balance on affected side while the non-hemi-paretic leg is the swing phase[10,11].By stepping in the required directions against the resistance offered by the band to the non-hemi-paretic leg, forced the subject to transfer weight and maintain weight on hemi-paretic side for a longer time than required while stepping without a band. This improved the stance time on hemi-paretic side. The improved step length symmetry indicates the improvements in subject’s ability to transfer weight and maintain balance on hemi-paretic side. Balance training in chronic stroke improves balance performance is supported by many authors. Evidence shows improvement in balance on different outcome measures clinically and instrumentally. The goal of any rehabilitation is functional improvement and patient’s ability to perform in his surroundings/community. In the self-reported Swedish falls efficacy scale Patients showed significant improvement in confidence level in both the groups, but subjects in experimental group showed greater statistically significant improvement than control group. This indicates that improvement observed in static and dynamic balance got transferred in subject’s daily activities as well. The improvement in balance performance persisted at 8th week after cessation of balance training in both the groups. This indicates that balance or postural control training has imposed a neural stimulus causing the central nervous system to “retune” input and output processing of somato-sensory information necessary to control balance.[22] and has probably imposed change in neural circuitry hence in line with the plasticity of the nervous system thus explaining the retention of training effect after 8 weeks. Perturbation studies have shown that movement strategies for achieving balance are not the result of stereotyped reflexes, but emerge as the CNS learns to apply generalized rules for maintaining equilibrium in a variety of tasks and contexts. It is found that motor skill emerges from the interaction of multiple systems that are organized to meet functional task goals and that are constrained by environmental context. Balance viewed as a motor skill suggests that, like any skill, balance can improve with practice. That is, postural motor coordination can be learned. Therapeutic intervention is directed at changing impairments and improving functional performance, including the capacity to adapt performance to changing task and environmental demand[24]. It is stated that sensorimotor perturbation training results in shortened latency of postural muscles as well as down training of the H-reflex and the Achilles tendon reflex in elderly population.[31]

5. Conclusion

Balance training in individuals with chronic Stroke for 4 weeks with elastic band as perturbation along with conventional balance exercises was effective in improving Balance performance than conventional balance exercises alone.

6. Limitation

Objective strength assessment of unaffected side was not considered for both Pre and post training change. Change in colour of band required was not documented. Objective assessment of the perturbation force was not done. Electromyograpic assessment of muscles of ankle and hip strategy was not done. Effect of length of elastic band and % elongation for different perturbation force was not assessed.

Conflict of Interest: None

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