Original Article

EFFICACY OF TASK SPECIFIC STEP-UP EXERCISES ON THE GAIT PARAMETERS OF CHRONIC HEMIPARETIC STROKE INDIVIDUALS

-Manju Vats.

Demonstrator Physiotherapy, Pt. DDU Institute for the Physically Handicapped, New Delhi, India.

ABSTRACT

Background: It has been contended that weight asymmetry and impaired balance function may be a consequence of a learned disuse of the paretic leg chronic hemiparetic stroke individuals. **Purpose of the study:** To determine whether the task- specific step up exercises would lead to greater improvements of spatio-temporal gait parameters of chronic hemiparetic stroke individuals. **Methods:** 30 individuals, who had a stroke for more than 6 months and able to ambulate independently, were included in the study. Participants were randomly assigned to the step up exercises group (n = 15) or control group (n =15). Participants were evaluated at baseline and after 4 weeks of intervention for gait measures like step length- affected/unaffected sides; stride length- affected/unaffected sides; natural velocity; maximum velocity and cadence. The experimental group performed forward, lateral and backward step up exercises, and the control group performed Conventional balance and gait training for30 min./session; five days/week. **Results:** Both groups improved significantly in all outcome measures .However, step up group demonstrated a significantly greater improvement in all gait measures compared with the control group (almost 2 fold of change was noticed in all gait measures of step up group as compared with control group). **Conclusions:** The results of this study convince us that a compelled weight-bearing protocol through the step up training program is one such approach designed to facilitate enhanced movement in the involved lower limb reducing the impact of learned disuse. **Brief Summary and Potential Implications:** The step up exercises are accessible to patients and can be performed in the home, especially when patients are not able to come for regular outpatient therapy.

KEY WORDS: Step-Up Exercises; Chronic Hemiparetic Individuals; Task Specific Exercises; Gait Parameters.

Address for correspondence: Ms. Manju Vats (PT), Demonstrator Physiotherapy, Pt. DDU Institute for the Physically Handicapped, New Delhi, India. **Phone No:** +919891182228
Email: manju.vats@rediffmail.com

Access this Article online

Quick Response code	International Journal of Physiotherapy and Research ISSN 2321- 1822 www.ijmhr.org/ijpr.html	
	Received: 15 August 2013	Accepted: 06 September 2013
	Peer Review: 15 August 2013	Published: 11 October 2013

BACKGROUND

Stroke or CVA (Cerebro-Vascular Accident) is the commonest cause of neurological disability and post-stroke individuals are the largest consumer of rehabilitation services. 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. For example, initially, following a stroke a person with hemiparesis may be unable or reluctant to bear much weight through the paretic limb when significant paresis exists, Later, continued weight-bearing asymmetry may continue and foster a further disuse despite the probability that improved motor function in the lower limb has occurred.[1]

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[2], differences in step length, primarily decreased step length of the unimpaired limb versus the impaired limb[3], stride lengths are significantly reduced in hemiparetic patients as compare to normal.[4]

Practice should focus on redirecting the patient into a centered position by moving toward the affected side, both in sitting and standing positions. Limits of stability (LOS) should be explored.[5] Because LOS changes with different tasks; a variety of functional activities should be practiced in different environmental settings. These abnormalities arise as a result of impairments in flexibility, strength, coordination, and balance and all of these are compromised in post stroke hemiparetic patients.

It is an established fact that Step-up exercise is a means of weight bearing exercises to increase lower limb muscle neuromuscular co-ordination.[6] In this study gait specific practice is a key feature. Vicki Stemmons Mercer et al[7] examined the limb- loading and weight – transfer abilities in stroke patients and concluded that step test, performed with the non paretic leg as the stepping leg, is a valid measure of paretic – limb loading during recovery. It has been demonstrated in series of experimental studies that compelled weight bearing of affected lower extremity is an effective strategy to improve the balance and locomotion.[1] Hence, raising a foot on a step appears to be an appropriate strategy for weight shift training of stroke patients. Since weight shifting to both the paretic and nonparetic limb of stroke patients is impaired, treatment strategies should include training in weight shifting to both lower extremities.[8]

Step up exercises are the activities which have been included in previous studies along with number of other task oriented exercises to improve the performance of walking in post stroke hemiparetic patients. As the forward displacement of the leading limb during ambulation is dependent upon weight transfer to the trailing limb, which is usually compromised in chronic hemiparetic stroke patients due the effects of disuse learning; placing the foot on a high step may be an appropriate strategy to improve gait parameters. This study was intended to carry out selective task of step up exercises for stroke patients and to clinically compare the measures of outcome of gait parameters with the control gait training.

METHODS

Institute of Applied Medicines and Research, Duhai Ghaziabad (UP) India, ethical committee approved the protocol of the study. 30 post stroke hemiparetic individuals attending the outpatient physiotherapy department of Pandit Deen Dayal Upadhyaya Institute for the Physically Handicapped, New Delhi were selected for the study and all participants gave informed consent. All participants were randomly divided into Group A (Control Group) and Group B (Experimental Group). Randomization was done with the help of hat method to avail equal number of participants in both the study groups. Each group consisted of 15 participants. Inclusion criteria included both male and female chronic hemiparetic in the age group of 45-65 years with symptoms more than 6 months ,commencement of rehabilitation within 6 months of occurrence of first episode single stroke, able to walk 10 meters independently without an assistive device , above Stage 3 of Brunnstrom's stages in affected lower limb, oriented and ability to communicate independently, ability to step up 6" high step stool in forward, backward and lateral directions independently or either with manual guidance. Exclusion criteria included having Cognitive or perceptual disorders profound sensory impairments involving lower limbs, severe orthopedic or rheumatologic conditions interfering with gait, any associated medical problem or any high-risk cardiovascular disorders or any auditory and severe visual impairment.

The baseline data was measured using the ink foot-print record method before commencement of the therapy, by measuring the gait parameters on a 10 meter walkway with a plain sheet of paper on its surface. Inter-rater reliability of this outcome measure is high as well as the significant relationship of velocity, cadence, step length and SL: LEL to functional ambulation supports the validity of their use as an outcome measures.[9] Patients were instructed to step on an inkpad and were asked to walk on the paper roll. The footprints from the sole of the feet were produced on the paper as the patients walked from one end of the walkway to the other. The measurements of step length and stride length were taken beyond the 2 m, assuming that a uniform step would have been established by then. Two measurements of Step length, stride length, cadence, natural gait speed and maximal gait speed were made and average value was used for analysis.

Subjects in both groups participated in 30 min of their respective training program three times a week for four weeks.

Step up Exercise Protocol [8, 10 -15]

Included the three main activities:

1. forward Step up
2. lateral step up
3. backward step up

The exercise sessions were commenced in therapist's supervision and manual guidance. Each of above activity of step up exercise was repeated for 2 phases of exercises with a set of 10 repetitions in each phase. The rest period of 1 minute was given after the conclusion of first phase and the rest period of 5 min were given after the conclusion of the set before progressing to the next direction of step up activity. Exercises were given for duration of 4 weeks, 3 times a week. These Step-up exercises were practiced by using a step stool of constant step height of 15 cm i.e 6" (length18" and breadth 13") with the variable step length i.e. the distance between the feet and step stool. Progression of the step length was given weekly by 2", ranging between the 4"-10" within these 4 wks of training. The intervention began with the patient's toes 4" from the step for forward direction; v^{th} toe from the step for lateral direction and heels from the step for backward direction step up activity. It was observed that patients were comfortable with this weekly step length progression irrespective of duration of onset of stroke and spasticity grades.

In the first phase of the exercise, the patients were initially instructed to lead with the paretic lower extremity during ascent and the non-paretic extremity during descent followed by second phase in which patient will be instructed to lead with non-paretic lower extremity during ascent and the paretic lower extremity during descent. The order of the lead side was changed in the first and second phases of exercise after the 2 wks of therapy program.

Prior to stepping, the patients were given the following specific instructions:

- stand with weight evenly distributed;
- step up at a comfortable speed;
- look at the step if necessary but don't bend at the waist to do so;
- don't push on your thighs for leverage; and
- return to evenly distributed weight bearing once upon the step

The step command prior to each repetition was 'ready, step on affected' or 'ready step on unaffected'. Upon completion of each step on, the patients were given a 'step down' command and instructed to return to the starting position (4"-10" range) from the step, depending which has been the starting distance between the toes and step stool. After completion of four weeks of therapy the patients were re-evaluated using the ink foot print method for any differences and the results were computed.

Continuous demographic variables (Age, Height, Weight and BMI) of two groups (Control and Experimental) were compared by independent t test while discrete (proportion of Sex) data was subjected with Fisher's exact test / chi-square test. The change score between the pre and post treatment gait parameters (Step length-affected/unaffected, Stride length- affected / unaffected, Natural velocity, Maximum velocity and Cadence) of two groups were compared by independent t- test. The pre post difference within the group was analyzed using paired t test. A two-tailed (α=2) probability (p) value $p<0.05$ was considered to be statistically significant.

For each treatment (groups) and gait parameter, a relative percent mean change [from 0 wk (pre test) to 4 wk (post test)] was also evaluated as

$$\% \text{ change} = \frac{\text{MEAN}_{4wk} - \text{MEAN}_{0wk}}{\text{MEAN}_{4wk}} \text{ X } 100$$

Further, change fold between the groups was also evaluated by the following formula.

$$\text{Change fold} = \frac{\text{Experimental \% Change}}{\text{Control \% Change}}$$

RESULTS

The basic characteristics of participants at baseline assessment are summarized in Table1. There were no baseline group differences (*P* ≥.05) in age, sex, height, weight, duration of stroke or side involvement(Table 1). There were no baseline group differences on any outcome measures (*P* ≥ .05; Table 2 and 3).

Table 1: Demographic characteristics summary (Mean ± SD, n=15) of two groups.

S.NO.	Characteristics	Groups		p value
		Control	Experimental	
1	Sex: M/F (no.)	(12/3)	(12/3)	1.3487
2	Age (yrs)	54.40 ± 7.25	53.00 ± 5.7	0.562
3	Height (cm)	164.08 ± 8.87	164.47 ± 7.63	0.899
4	Weight (kg)	65.07 ± 11.23	65.57 ± 11.84	0.906
5	Duration of stroke(months)	18.60±11.88	17.87±11.92	0.867
6	Involved side(rt/lt)	(10/5)	(7/8)	0.269

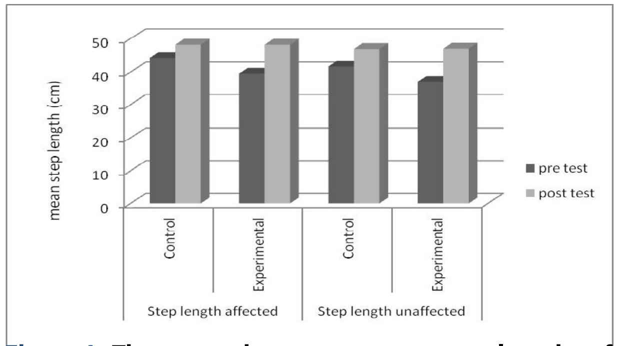

Figure 1: The pre and post treatment step lengths of two groups.

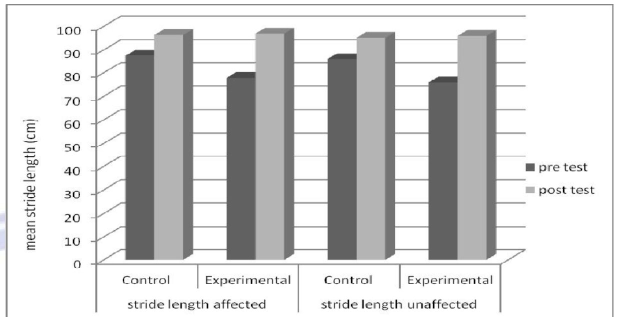

Figure 2: The pre and post treatment stride lengths of two groups.

Table 2: Mean (SD) of spatial outcome measures.

Outcome measures	Groups	Periods		P value^a	Change		
		Pre test	Post test		Mean	%	Foldd
Step length affected	Control	44.23 ± 8.97	48.16 ± 9.61	0.001	3.93±3.48	8.16	2.2
	Experimental	39.53± 14.21	48.16± 14.27	< 0.001	8.62±4.43	17.91	
	p value^b	0.288	**0.003**				
Step length unaffected	Control	41.68± 12.21	46.92± 11.32	< 0.001	5.23±3.82	11.16	1.9
	Experimental	36.98±14.20	47.00±12.17	< 0.001	10.02±4.6	21.31	
	p value^b	0.339	**0.005**				
stride length affected	Control	87.44±19.35	96.27±19.10	0.001	8.83±7.65	9.17	2.1
	Experimental	77.85±26.02	96.87±24.47	< 0.001	19.02±6.30	19.63	
	p value^b	0.262	**< 0.001**				
stride length unaffected	Control	85.98±19.46	95.11±19.13	<0.001	9.12±6.34	9.59	2.1
	Experimental	75.97±26.52	95.90±25.74	<0.001	19.93±7.16	20.78	
	p value^b	0.248	**<0.001**				

*P value^a indicates the pre post difference within the group whereas p value^b indicates comparison between the groups at pre test as well as post test levels. A two-tailed (α=2) probability (p) value p<0.05 was considered to be statistically significant.

Table 3: Mean (SD) of temporal outcome measures.

Outcome measures	Groups	Periods		P value^a	Change		
		Pre test	Post test		Mean	%	Fold
Natural velocity	Control	0.66±0.15	0.75±0.17	<0.001	0.09±0.05	11.93	2.2
	Experimental	0.52±0.23	0.72±0.26	<0.001	0.19±0.06	26.94	
	p value^b	0.068	**<0.001**				
Maximum velocity	Control	0.984±0.28	1.04±0.294	<0.001	0.061±0.03	5.38	3.1
	Experimental	0.831±0.35	1.00±0.370	<0.001	0.16±0.08	16.9	
	p value^b	0.202	**<0.001**				
Cadence	Control	88.63±9.99	94.46±12.79	0.01	5.82±7.62	6.17	2.1
	Experimental	78.95±17.12	90.88±15.04	<0.001	11.93±7.15	13.12	
	p value^b	0.069	**0.032**				

*P value^a indicates the pre post difference within the group whereas p value^b indicates comparison between the groups at pre test as well as post test levels. A two-tailed (α=2) probability (p) value p<0.05 was considered to be statistically significant.

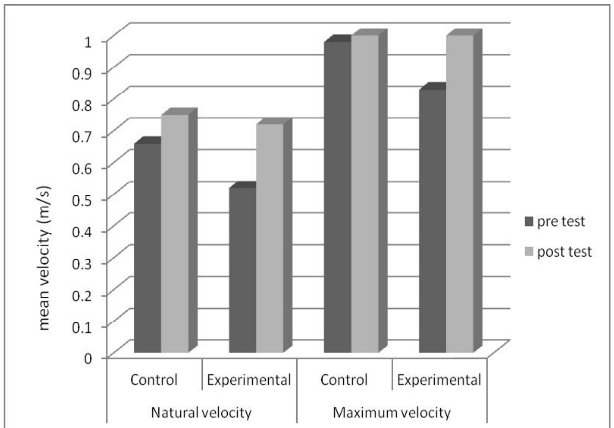

Figure 3: The pre and post treatment natural and maximum velocities of two groups.

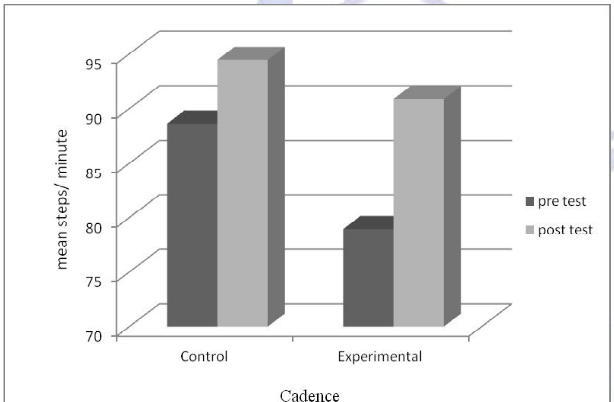

Figure 4: The pre and post treatment cadence of two groups.

Spatio-temporal Gait Parameters

- On comparing the step and stride lengths on affected / unaffected sides, natural and maximum velocities and cadence between the groups at pre test did not differ significantly (≥.05) i.e. found to be statistically the same.
- Whereas at post test all the outcome measures between the groups, the mean change differed significantly between the two groups.
- Similarly, comparing all the measures within the groups, both the groups showed significant increase in mean change at post test as compared to pre test.
- It was observed that all the outcome measures (i.e step length at affected side; at unaffected side; stride length at affected side; at unaffected side; natural velocity; maximum velocity and cadence) in both the groups increased (improved) after the treatment and the increase was evident higher in Experimental group (17.91%; 21.31%; 19.63%; 20.78%; 26.94%; 16.9%; 13.12%)) than Control group (8.16%; 11.16%; 9.17%; 9.59%; 11.93%; 5.38%; 6.17%) respectively.
- The results of the study suggested that the patients who received step up exercises, improved their step length- affected, step length- unaffected, stride length- affected, stride length- unaffected, natural velocity, maximum velocity and cadence 2.2, 1.9, 2.1, 2.1, 2.2, 3.1 and 2.1 times respectively than those who received the Control intervention.
- The pre and post treatment spatial and temporal characteristics of two groups are summarized in table 2 and table 3 respectively and also shown graphically in figures 1-4.

DISCUSSION

The participants in both the therapy groups improved in all gait parameters and it may be largely due to the learning and practice effects associated with the interventions in both the groups. However, the step up exercise intervention additionally reinforced balance, strength and loading of the affected as well as unaffected limb, which could explain the findings of the experimental group.[8, 10, 13, 16, 17] Further, the improvement of control group may be explained by Ernst E A review in which Conventional physiotherapy for gait training is generally recognized as beneficial in patients with stroke.[18]

Hyuk Cheol. Kwon et al[10] studied the Characteristics of Lower Extremity Weight Bearing in Independently Ambulatory Hemiparetic Patients, it was proved that while the patients stand on the flat ground, basically the weight bearing removes to the sound lower extremity, the weight bearing other than that on the stool is loaded more, and the higher the stool i.e 6'' (15cm) stepped by a foot is, the more weight bearing of any lower extremity on the ground happens. It was further supported by the Richard W Bohannon and Patricia A Larkin[16] and Laufer et al.[8] Moreover, lateral step up exercises were found to improve the loading response by influencing the shifting of COG through the enforced recruitment of gluteus medius activity of the supporting leg and adductor longus of stepping leg.[13]

Relation between step length asymmetry and gait velocity and propulsive forces during hemiparetic walking was established by Chitralakshmi K[19] and it was found that to have symmetrical and significant increase in step lengths and gait velocity one needs to generate greater propulsive forces with both the legs. In accordance with this we can assume that both the therapies were able to generate greater propulsive forces than before the intervention but there may greater generation of forces with step up intervention. This may be attributed to the improvement in paretic as well as non paretic extremity strength with step up intervention. The same may be applied for significant improvement of bilateral stride lengths between the groups as stride length is the combination of both sides of step length in a gait cycle. This is also supported by Monger et al[20] who examined the effects of Sit-to-stands & step-ups (both limbs) exercises in ambulatory stroke patients. At 3 weeks, significant improvements were demonstrated in Motor Assessment Scale sit-to-stand scores, walking speed, and timing of peak vertical ground reaction force.

Slow walking after stroke may be a behavioral adaptation to poor endurance, poor balance and decreased stability. Significant improvement in cadence and gait velocity in experimental group than the control therapy group is attributed to more appropriate timing of lower limb muscles, improved balance and coordination as a result of improved ability to use the affected leg for support, increased load taken through the affected foot and greater stimulation of coordinated muscle activity. Yang YR *et al*[21] examined the effectiveness of additional backward walking on gait outcomes including walking speed, cadence, gait cycle and symmetry in stroke patients and observed significant improvement in selected gait parameters. The results of this study also support improvement in cadence and gait velocity.

Kirker *et al*[22, 23] have shown that hip abductor activity post stroke is primarily disrupted while initiating movement (e.g. taking a first step) and when responding to external perturbations. These abilities are important for independent walking at home and in the community. Interventions which improve hip abductor activity during these movements may be more effective in promoting recovery. These conclusions are supported by Kim and Eng[24] in the study to investigate the relationship between walking speed in stroke survivors and kinematic and kinetic gait profile. This study also concluded that interventions which increase frontal plane hip powers by strengthening the hemiplegic hip abductors would increase gait speed. In accordance with this, Step up exercises was found to be beneficial in accomplishing the task of challenging the lateral stability and maximum recruitment of hip abductors. This is supported by the investigative studies of Sims and Brucer et al[12] and Vicki Stemmons Mercer et al.[14]

Onley et al[25], Richard W.Bohannon[26] and De Quervain[27] studies revealed that weakness of paretic hip flexors and extensor, knee flexors, ankle planter flexors and dorsiflexors are strong predictor of altered velocity and abnormal pattern of motion whereas the strength of the hip abductor and knee extensor muscle groups were only significantly correlated with cadence. Appropriate timing of lower limb muscles might be due to increase in the strength of these lower limb muscles as it has been supported by a kinesiological study by Man- Ying et al[28] on forward and lateral stepping activities. While lateral step up places greater demand on the knee extensors and ankle planter flexors in older adults, forward step- up places greater demand on the hip extensors. This was further examined by Yukari mori et al[17] study in which effects of a 12 week home based bench step exercise program on aerobic capacity, lower extremity power and static balance in elderly subjects were seen and it was concluded that there was a significant improvement of all the three.

Step - up exercise group improved significantly both in stride length and cadence, which would have resulted in the increase of walking speed, which is usually the aim to improve the functional significance as suggested by Wade et al.[29] There have been two strategies suggested to raise walking speed; increasing the stride, or step length, and increasing the cadence. Typically, an individual combines both strategies until the longest comfortable step length is reached. From that point on, a further increase in speed is solely related to increased cadence[30]. Significant improvement in maximum velocity in experimental group compared with control group may be attributed to the significant increase in cadence, step length and stride length of this group.

Schmid et al[31] and Perry et al[32] determined that household ambulation is equivalent to severe gait impairments and a walking speed of <0.4m/s. moderate gait impairments are equivalent to between 0.4 and 0.8 m/s and represent limited community ambulation. Full community ambulation indicates mild impairment and a walking speed of > 0.8m/s. In this study gait speed increased significantly in both therapy groups and remained to limited community ambulation (<0.8m/s) but this was evidently improved (2.2 times) in experimental group than the control group. This lack of full community ambulation achievement may be attributed to short duration of the study.

As it was suggested by Taub and Wolf [33], the learned disuse of the affected limb could be a cause of lack of progress in recovery in some individuals with stroke. This fact taken together with a common view that persons with chronic stroke reach a plateau in their motor recovery in a year after brain damage and exhibit very little improvement in gait performance for the rest of their lives.[34] They emphasized the importance of finding new treatment approaches for such people.

CONCLUSION

There are certain limitations associated with this study, even if certain gait deviations associated with hemiparesis were improved. The training may not be relevant to the more severely impaired individuals with hemiplegia with the Brunnstrom stage lesser than 3 and had limited sample size and did not assess the functional outcome of subjects following gait training intervention. The results of this study convince us that a compelled weight-bearing protocol through the step up training program is one such approach designed to facilitate enhanced movement in the involved lower limb reducing the impact of learned disuse.

Funding Source

This research did not require any funding from an outside source.

Declaration of Conflicting Interests

No commercial party having a direct financial in the results of the research supporting this article has or will confer a benefit upon the author or upon any organization with which the author is associated.

Acknowledgements

Author thanking to all the participants and extend heartiest gratitude to Dr. Dharmendra Kumar MS (Ortho.), DNB (PMR), Director Pt.DDUIPH and Mrs. Manda Chauhan MPT,HOD(PT) Pt.DDUIPH; New Delhi.

REFERENCES

1. Alexander S. Aruin, Tim Hanke, Gouri Chaudhuri, Richard Harvey, Noel Rao. Compelled weight bearing in persons with hemiparesis following stroke: The effect of a lift insert and goal-directed balance exercise. Journal of Rehabilitation Research and Development Vol. 37 (1), January/February 2000 Pages 65-72.
2. Chen G, Patten C, Kothari D, Zajac F. Gait Differences Between Individuals With Post Stroke Hemiparesis And Non Disabled Controls At Matched Speeds. Gait Posture, 2005; 22:51-56.
3. Hsu A, Tang P, Jan M. Analysis of impairments influencing gait velocity and asymmetry of hemiplegic patients after mild to moderate stroke. Arch phys Med Rehabil. 2003; 8: 1185-1193.
4. Y Zverev, A Adeloye, J Chisi. Quantitative analysis of gait pattern in hemiparitic patients. East African Medical Journal vol.79 No 8 August 2002.
5. Susan B.O'Sullivan Physical Rehabilitation: Assessment and treatment .Fifth edition page 501.
6. Eng J: Strength training in individuals with stroke. Physiother Can 56:189, 2004.
7. Vicki Stemmons Mercer, Janet Kues Freburger, Shu-o Hsiu Chang, Jama L Purser. Measurement of paretic -lower-extremity loading and weight transfer after stroke. Physical Therapy vol.89 (7), July 2009.
8. Laufer Y, Dickstein R, Resnik S, Marcovitz E. Weight-bearing shifts of hemiparetic and healthy adults upon stepping on stairs of various heights. Clin Rehabil. 2000; 14: 125-129.
9. Maureen k holden, kathleen mgill, marier magliozzi, john nathan and linda piehl- baker; clinical gait assessment in the neurological impaired: reliability and meaningfulness. Phys Ther Vol. 64, No. 1, January 1984, Pp. 35-40.

10. Hyuk Cheol. Kwon Dong Hoon Jeong, Jin Yong Kong, Oh Yun Kwon. A Study of the Characteristics of Lower Extremity Weight Bearing in Independently Ambulatory Hemiparetic Patients. Journal of Asia-Pacific Special Education March 2001, Vol. 1, No. 1, pp. 139- 159.
11. M C Maybury, J Waterfield. An investigation into the relation between step height and ground reaction forces in step exercise: a pilot study. Br J Sports Med 1997;31:109-11doi:10.1136/bjsm.31.2.109.
12. Sims KJ, Brauer SG: A raid upward step challenges medio- lateral postural stability. Gait Posture, 2000, 12:217-224.
13. Hiroshige Tateuchi,Toshihiko Yoneda, Takahiro Tanaka, Hitoshi Kumada, Masahiro Kadota, Hiroshi Ohno, Kazunari Tanaka, Jun Yamaguchi . Postural control of Initiation of Lateral step and Step up motion in Young adults; J.Phys.Ther.Sci.18:49-55; 2006.
14. Vicki Stemmons Mercer, Michael T. Gross, Subhashini Sharma,Erin Weeks; Comparison of Gluteus Medius Electromyographic Activity During Forward and Lateral Step-up Exercises in Older Adults; Phys. Ther.vol.89(11)2009.
15. J A Smutnick & R W Bohannon. Hip and knee flexion of lead and trail limbs during ascent of a step of different heights by normal adults. Physiotherapy Canada 2009 vol.95, No.4.
16. Richard W Bohannon and Patricia A Larkin. Lower Extremity Weight Bearing Under Various Standing Conditions in Independently Ambulatory Patients with Hemiparesis. Phys Ther Vol. 65, No. 9, September 1985, pp. 1323-1325.
17. Yukari mori, Makoto Ayabe, Takuya Yahiro, Takuro Tobina, Akira Kiyonaga, Munehiro Shindo, Tatsuo Yamada, Hiroaki Tanaka. The Effects of Home –based Bench step exercise on Aerobic Capacity, Lower Extremity Power and Static Balance in Older Adults. International journal of sports and health science Vol.4, 570-576, 2006.
18. Ernst E A. Review of stroke rehabilitation and physiotherapy - Stroke 1990.
19. Chitralakshmi K Balasubramanian, Mark G. Bowden, Richard R. Neptune, Steven A. Kautz. Relationship between step length asymmetry and walking performance in subjects with chronic hemiparesis. Arch Phys Med Reabil Vol 88, Jan 2007.
20. Monger C, Carr JH, Fowler V. Evaluation of a home-based exercise and training programme to improve sit-to-stand in patients with chronic stroke. Clin Rehabil 2002; 16: 361–367.
21. Yea-Ru Yang, Jyh-Geng Yen, Ray-Yau Wang, Lu-Lu-Yen and Fu-Kong Lieu. Gait outcomes after additional backward walking training in patients with stroke: a randomized controlled trial Clin Rehabil 2005 19: 264
22. Kirker SG, Simpson DS, Jenner JR, Wing AM. Stepping before standing: Hip muscle function in stepping and standing balance after stroke. J Neurol Neurosurg Psychiatry. 2000; 68: 458-464.
23. Kirker SG, Jenner JR, Simpson DS, Wing AM. Changing patterns of postural hip muscle activity during recovery from stroke. Clin Rehabil. 2000; 14: 618-626.
24. Kim CM, Eng JJ. Symmetry in vertical ground reaction force is accompanied by symmetry in temporal but not distance variables of gait in persons with stroke. Gait Posture 2003; 18: 23-28.
25. Olney SJ, Griffin MP, Monga TN, McBride ID. Work and power in gait of stroke patients. Arch Phys Med Rehab 1991; 72: 309-314.
26. Richard W.Bohannon: Strength Of Lower Limb Related to Gait Velocity and Cadence in Stroke Patients .Physiotherapy Canada, 1986, Vol. 38, No.4.
27. De Quervain (1996) Gait Pattern in the Early Recovery Period after Stroke.The Journal of Bone and Joint Surgery 78:1506-14 (1996).
28. Man-Ying Wanga, Sean Flanagana, Joo-Eun Songa, Gail A. Greendaleb, George J. Salema Lower-extremity biomechanics during forward and lateral stepping activities in older adults Clin biomech. Volume 18, Issue 3, Pages 214-221 (March 2003).
29. Wade DT, wood va, heller a, maggs j, langton hewer r. Walking after stroke. Measurement and recovery over the first 3 months. Scand J Rehabil Med. 1987; 19 (1):25-30.
30. Donald A Neumann, kinesiology of the musculoskeletal system; foundations for physical rehabilitation; page: 528-529.
31. Arlene Schmid, Pamela W. Duncan, Stephanie Studenski, Sue Min Lai, Lorie Richards, Subashan Perera and Samuel S. Wu. Improvements in Speed-Based Gait Classifications Are Meaningful. Stroke 2007; 38; 2096-2100.
32. Perry J, Garrett M, Gronley JK, Mulroy SJ. Classification of walking handicap in the stroke population. Stroke 1995; 26: 982-89.
33. Taub, E. Wolf, S. L. Constraint Induced Movement Techniques To Facilitate Upper Extremity Use in Stroke Patients. Topics In Stroke Rehabilitation 1997, Vol 3; Number 4, pages 38-61.
34. Clive E Skilbeck, Derick T Wade, R Langton Hewer, Victorine A Wood. Recovery after stroke. J Neurol Neurosurg Psychiatry 1983; 46: 5-8.

How to cite this article:

Manju Vats. Efficacy of task specific step-up exercises on the gait parameters of chronic hemiparetic stroke individuals. Int J Physiother Res 2013;04:130-37.