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Original Research Article

Critical evaluation of effectiveness of step-up exercise program for improving gait in stroke patients in Udaipur region

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Abstract

Background: Stroke is the leading cause of long-term disability. Walking dysfunction affects more than 80% of stroke survivors. Despite rehabilitation efforts, 25% of all stroke survivors have residual gait impairments that necessitate full physical assistance before being discharged from the hospital. Step-up exercise is a type of weight-bearing exercise used to improve lower-limb neuromuscular coordination.
Objective: To analyze the effect of a modulated step up exercise program for gait rehabilitation in stroke patients.
Methodology: 30 post-stroke hemiplegic patients were selected for study. Further these 30 individuals randomly divided into two groups. Which were named as control group and experimental group with 15 patients in each group for conventional and step-up therapy. Duration of study was 4 months.
Result: While, comparing records of the two groups before the therapy, shows no diverge in the pre-test, considerably ($p>.05$), i.e., discovered to be statistically equivalent. In contrast, post therapy outcome shows significant change between the control and experiment group because p value for step length, natural velocity and cadence were <0.05.
Conclusion: The study's findings indicate that step-up exercises are more effective than traditional exercises in improving stroke patients' outcomes. Because the experimental group outperformed the control group in terms of step length, natural velocity, and cadence, the improvement in gait and balance is considerably greater.

Keywords: Step up exercise, post stroke therapy and gait dysfunction

Introduction

Any departure from the regular gait or walking pattern is referred to as a gait disturbance. There are several etiologies for these problems. A strong index of suspicion is needed because of their many clinical manifestations. Through lab tests, clinical presentation, and diagnostic testing, the etiology can be identified. This entity can also be classified into

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episodic and persistent disruptions. Patients who experience gait irregularities suffer greatly, especially in terms of quality of life, morbidity, and mortality [1].

Gait deviations can be caused by neurological conditions (e.g., sensory or motor impairments), orthopedic issues (e.g., osteoarthritis and skeletal deformities), and medical problems (e.g., heart attack, respiratory deficiency, peripheral arterial occlusive disease, and chubbiness) [2].

Gait variation in older people is typically caused by a combination of factors, including impaired proprioceptive function in polyneuropathy, deprived vision, frontal gait disorder associated with vascular encephalopathy, and hip or knee osteoarthritis.

In any case, if gait disarray develops suddenly, cerebrovascular, spinal, and neuromuscular causes, as well as adverse drug effects and psychiatric deviations should be considered.

Some familiar issues are also responsible for this dysfunction like:

- A degenerative disease (for example, arthritis)
- An inner ear disorders
- Stroke
- Foot problems
- A neurological disorder such as Parkinsonism.
- A simple example would be ill-fitting shoes.[2]

Stroke is the leading cause of long-term disability [3].Walking dysfunction affects more than 80% of stroke survivors [4]. Despite rehabilitation efforts, 25% of all stroke survivors have residual gait impairments that necessitate full physical assistance before being discharged from the hospital [5]. As a result, gait impairments make it difficult to perform daily activities and move around. When compared to healthy people, gait abnormality is distinguished by a prominent clinical presentation of gait asymmetry [6]. Stroke survivors have a shorter stance phase and a longer swing phase on the paretic side. Furthermore, the walking speed is reduced and the stride length is reduced [7]. Stroke survivors are at a high risk of falling due to these gait abnormalities and muscle weakness [8, 9]. Falls are most common in community-dwelling stroke survivors while walking [10]. As a result, improving walking safety and speed is the primary goal for stroke survivors in order to prevent falls and improve quality of life [6, 8].

Step-up exercise is a type of weight-bearing exercise used to improve lower-limb neuromuscular coordination. Raising one's foot on a step appears to be an appropriate strategy for stroke patients' weight shift training. Because stroke patients' weight shifting to both the paretic and non-paretic limbs is impaired, treatment strategies should include weight shifting training for both lower extremities.

Step-up exercises, along with a variety of other task-oriented exercises, have been included in previous studies to improve walking performance in post-stroke hemiparetic patients.

Step up exercise was a good choice for improving gait parameters. It was accomplished by placing one's foot on a high step. The purpose of this study was to perform selective task of step-up exercises for stroke patients and to compare clinically the measures of outcome of gait parameters with the control gait training [10].

Need of study

Following a stroke, a person with hemiparesis may be unable or unwilling to bear significant weight through the paretic limb. Later on, despite the possibility of improved motor function in the lower limb, continued weight-bearing, asymmetry, and disuse may occur.

A task-specific step-up exercise programme is expected to improve gait parameters in stroke patients.

Objective

- To compare the impact of task specific step-up exercise program over conventional exercise program on step length of stroke patients.
- To compare the impact of task specific step-up exercise program over conventional exercise program on natural velocity of stroke patients.
- To compare the impact of task specific step-up exercise program over conventional exercise program on cadence of stroke patients.

Material and Methods

Sample size

30 post-stroke hemiplegic patients were selected for study. All patients were informed about the study. A duly filled consent form with sign collected from them for record purpose. Further these 30 individuals randomly divided into two groups. Which were named as control group and experimental group with 15 patients in each group. Duration of study was 4 months.

Inclusive criteria

Sample size included both male and female chronic hemi-paretic patients aged 45-65 years with symptoms lasting more than 6 months, beginning rehabilitation within 6 months of the emergence of the first episode of single stroke, being able to walk 10 meters singly without a mechanical aids, being above Stage 3 of Brunnstrom's stages in the affected lower limb, being oriented and communicating independently, and being able to step up a 6" high step stool in forward, backward, and later directions.

Exclusive criteria

Selection criteria excluded perceptual and cognitive disabilities, significant sensory impairments in the lower limbs, serious orthopedic or rheumatologic conditions trying to meddle with gait, any linked medical issue or any high-risk cardiovascular disorders, as well as any auditory and severe vision problems.

Clinical examination

Before and after therapy, each study group completed a standardized evaluation of balance, functional mobility, and sensorimotor dysfunction with a physical therapist (>10 years of experience) using standardized instructions.

Gait analysis

Before beginning a new programme, gait parameters were measured on a 10-meter walkway with a standard sheet of paper on its base using the ink foot-print record approach. Patients were instructed to walk and step on a paper roll and an ink pad. The soles of the patients' feet created tracks on the paper as they travelled from one end of the walkway to the other.

Procedure

Control group were assigned with conventional therapy and experimental group assigned with step up exercise. Data of gait analysis collected both time pre and post therapy for comparison purpose.

Step up exercise

These exercises promote better foot clearance and step length through increased hip flexor strength, quadriceps and glute strength through increased force generation and walking speed, and pelvic stability and standing balance through weight shifting. It contains three main actions Forward step, backward step and Lateral step.

Program for conventional exercise

The pre-test score of Gait Parameters was taken before giving the exercises to record Independent Variable. The patients were instructed to do weight bearing on both legs, weight transfer between both legs, single leg stance, and standing with both legs with their eyes closed. Each exercise was performed three times in the presence of a physiotherapist. All gait metrics were scored again after the intervention.

Data analysis and statistics

The shift in score between pre- and post-treatment gait variables (Step length, natural velocity, and Cadence) of two groups (Control and Experimental) and continuous demographic variables (Age, Height, Weight, and BMI) of two groups (Control and Experimental) was evaluated by comparing using an independent t-test. The mean difference+ SD were used to represent the whole data. The paired t-test was performed to analyze the groups pre- and post-differences.

Results

Demographic characteristics

Table No. 1 elucidates all general data like age, sex, duration of a stroke, height, weight and paretic side. P-Value of all recorded data is >0.05, it shows that it is statistically insignificant and has no intergroup difference.

Table 1: Demographic characteristics of participants

S. No.	Characteristics	Experimental group (n=15)	Control group (n=15)	p value
1	Gender: male/female (No.)	8/7	7/8	0.723
2	Age (yrs)	56.40±6.25	55.53±6.73	0.552
3	Height (cm)	163.52±5.43	165±6.92	0.889
4	Weight (kg)	64.5±4.15	65.12±5.43	0.743
5	Duration of stroke (months)	5.47±1.45	4.98±2.13	0.501
6	Paretic side (right/left)	9/6	10/5	0.462

*Values are expressed as mean ±Sd. Where, SD is standard deviation.
*P value >0.05.

Gait variables

Table No. 2 shows comparison between two groups and within the group data. Statistics shows no baseline difference between two groups.

Table 2: Comparison of gait variables between two groups, pre and post therapy

S. No.	Outcome measures	Groups	Time			
			Pre therapy		Post therapy	
			Mean	SD	Mean	SD
1.	Step length	Control	43.32	9.11	47.15	8.12
		Experiment	38.52	14.12	47.14	14.25
		p value	0.273		0.002	
2.	Natural velocity	Control	0.65	0.20	0.76	0.12
		Experiment	0.50	0.19	0.70	0.22
		p value	0.071		<0.001	
3.	Cadence	Control	87.65	8.20	93.76	13.01
		Experiment	77.50	16.99	89.71	14.24
		p value	0.0681		0.029	

*Values are expressed as mean ±Sd. Where, SD is standard deviation.
*p value shows difference between two group's pre and post therapy.
* $p<0.05$ deemed as statistically significant value.

While, comparing records of the two groups before the therapy, shows no diverge in the pre-test, considerably (>.05), i.e., discovered to be statistically equivalent. In contrast, post therapy outcome shows significant change between the control and experiment group.

Step length

In control group mean value of step length was 43.32 and in experiment group 38.52. While after therapy step length increased in both groups. It was 47.15 for control group and 47.14 for experiment group. On comparison experiment group shows significant change with p value 0.002.

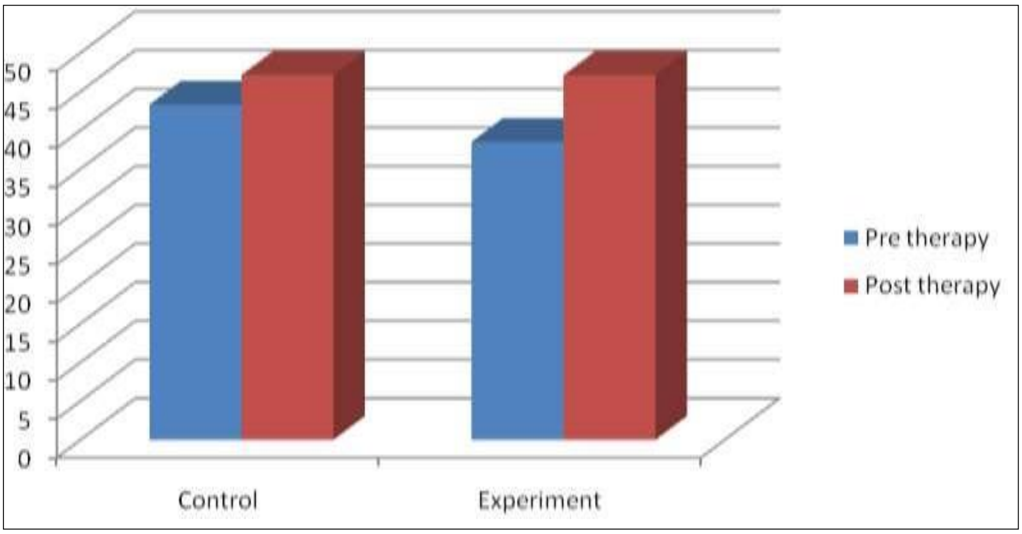

Fig 1: Step length (mean value) comparison of two group pre and post therapy.

Natural velocity

Before therapy mean of natural velocity for control group was 0.65 and 0.50 for experiment group. P value was 0.071 for both groups so baseline difference is zero. But post exercise it shows significant difference in two group $p<0.001$.

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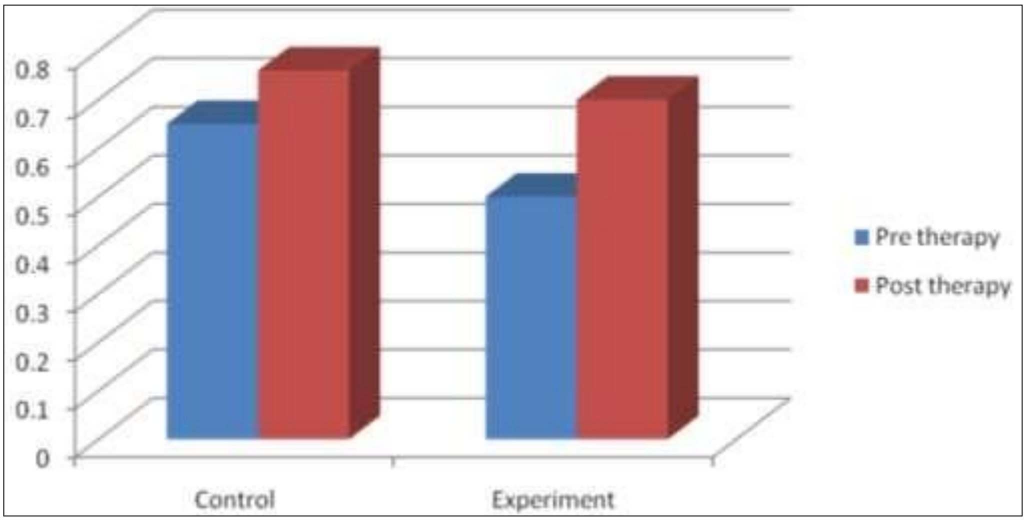

Fig 2: Natural velocity (mean value) comparison of two group pre and post therapy

Cadence

In control group, the mean value was 87.65 and 93.76 pre and post therapy. Respectively, in experiment group it was 77.50±16.99 and 89.71±14.24. Both groups present a considerable increase in cadence after therapy. On comparison experiment group shows significant change with p value 0.029.

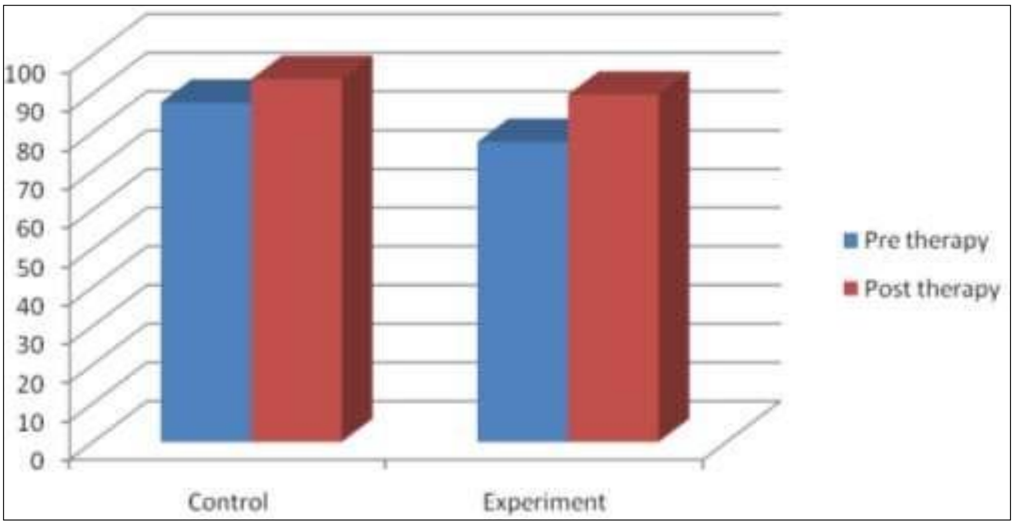

Fig 3: Cadence (mean value) comparison of two group pre and post therapy

Discussion

The purpose of this study was to determine whether step-up training can improve the walking capacity of patients with chronic stroke and, if so, which technique is more effective in improving stroke patient's walking ability. We discovered that step-up training enhanced the walking abilities of chronic stroke patients, with step-up training increasing walking velocity with mean value 0.70 and step length by 47.14. These findings imply that step-up training mimics the benefits of stair walking and functional training.

Participants in both therapy groups benefited in all gait metrics, which may be attributed to the learning and practice effects of the interventions in both groups. The step-up exercise regimen, on the other hand, strengthened balance, strength, and loading of the afflicted leg,

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which could explain the experimental group's findings [11, 12, 13, 14, 15]. Ernst E may also describe the improvement of the control group in a review in which conventional physiotherapy for gait training is widely acknowledged to be useful in stroke patients [16].

When Hyuk Cheol. Kwon *et al.* [12] investigated the Characteristics of Lower Extremity Weight Bearing in Independently Ambulatory Hemiparetic Patients, it was discovered that while the patients stand on the level ground, the weight bearing is removed to the sound lower extremity, and 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, the more weight bearing of any lower extremity. It was also backed up by Richard W Bohannon and Patricia A Larkin [14], as well as Laufer *et al.* [11]. Furthermore, lateral step-up exercises were discovered to improve loading response by altering COG shifting via the forced recruitment of gluteus Medius activity in the supporting leg and adductor longus of the stepping leg [13].

Chitralakshmi K [17] formed a relationship between step length asymmetry, gait velocity, and propulsive forces during hemiparetic walking and discovered that in order to have symmetrical and significant increases in step lengths and gait velocity, one must generate greater propulsive forces with both legs. According to this, we may assume that both therapies were able to produce greater propulsive forces than before the intervention, but that the generation of forces may be bigger with step-up intervention. This could be due to improvements in both paretic and non-paretic extremities strength following step-up treatments. The very same principle can be employed to significantly enhance bilateral stride lengths between groups, as stride length is the sum of both sides of step length in a gait cycle.

Monger *et al.* [18] investigated the effects of Sit-to-stands and step-ups (both limbs) exercise in ambulatory stroke patients. Substantial advances in Motor Assessment Scale sit-to-stand scores, walking speed, and peak vertical ground reaction force timing were seen after three weeks.

Slow walking after a stroke may be a behavioral adaptation to impaired stamina, balance, and stability. Significant improvements in cadence and gait velocity in the experimental group compared to the control therapy group are attributed to better 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 increased stimulation of coordinated muscle activity. Yang YR *et al.* [19] investigated the impact of additional backward walking on gait outcomes such as walking speed, cadence, gait cycle, and symmetry in stroke patients and found considerable improvement in selected gait metrics. This study's findings also suggest improvements in cadence and gait velocity.

Kirker *et al.* [20, 21] discovered that hip abductor activity is particularly impaired after stroke when commencing mobility (e.g., taking a first step) and responding to external perturbations. These skills are necessary for independent walking both at home and in the community.

Interventions that increase hip abductor activity during these motions may be more successful in facilitating recovery. Kim and Eng [22] support these findings in their study on the link between walking speed in stroke survivors and kinematic and kinetic gait profiles. This study also concluded that therapies that boost frontal plane hip capabilities by strengthening the hemiplegic hip abductors will increase gait speed. Step up exercises were found to be useful in fulfilling the aim of demanding lateral stability and maximum recruitment of hip abductors. This is corroborated by the research of Sims and Brucer *et al.* [23] and Vicki Stemmons Mercer *et al.* [24].

According to studies by Onley *et al.* [25], Richard W. Bohannon [26], and De Quervain [27], weakness of paretic hip flexors and extensors, knee flexors, ankle plantar flexors, and dorsiflexors is a strong predictor of altered velocity and abnormal pattern of motion, whereas strength of the hip abductor and knee extensor muscle groups was only significantly correlated with cadence. Appropriate timing of lower limb muscles may be related to an increase in their strength, as shown by a kinesiological investigation on forward and lateral stepping exercises by Man-Ying *et al.* [28]. In older individuals, lateral step-ups put more strain on the knee extensors and ankle plantar flexors, whereas forward step-ups put more strain on the hip extensors. Yukari mori *et al.* [15] studied the effects of a 12-weeks home-based bench step training programme on aerobic capacity, lower extremity power, and static balance in older participants and reported that there was a significant improvement in all three.

The step-up exercise group improved significantly in stride length and cadence, which would have led in an improvement in walking speed, which is normally the goal to improve functional relevance, as Wade *et al.* stated [29]. To increase walking speed, two ways have been proposed: expanding the stride, or step length, and raising the cadence. Individuals typically blend both tactics until the longest comfortable step length is obtained. After that, any further gain in speed is purely due to increased cadence [30]. The considerable increase in cadence, step length, and stride length in the experimental group compared to the control group may be attributed to this group's significant rise in maximum velocity.

Conclusion

The study's findings indicate that step-up exercises are more effective than traditional exercises in improving stroke patients' outcomes.

- Both groups achieve a satisfactory improvement in gait.
- The experimental group outperformed the control group in terms of outcome measures.
- Because the experimental group outperformed the control group in terms of step length, stride length, natural velocity, maximum velocity and cadence, the improvement in gait and balance is considerably greater.

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