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ORIGINAL ARTICLE

Effectiveness of partial body weight support treadmill training on gait & balance in patients with sub-acute stroke: an experimental study

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ABSTRACT
Stroke is a widespread health issue. Gait and balance abnormalitiesand other neuromuscular deficits are the most typical stroke symptoms. The ability to walk in the public will be limited for about 60% of patients with stroke; walking after a stroke is marked by changed gait parameters and a reduce in gait speed, which alters the quality and adaptability of walking patterns; for the best ambulation, the gait parameter, balance parameters and spatiotemporal parameters must be restored. Preventative measures like body weight and other neuromuscular impairments can be eliminated, which effectively helps in the restoration of the balance, gait and cadence. So this study was performed to evaluate the effect of partial body weight supported treadmill training (PBWSTT) by using The Performance-Oriented Mobility Assessment (POMA), The Functional Gait Assessment (FGA) and spatiotemporal parameter on balance, gait and cadence in sub-acute stroke subjects. An experimental research design with purposive sampling technique was employed. 36 patients with unilateral hemiparesis with sub acute stroke patient were randomized to CT group (n=18) and PBWSTT group (n=18) from SPB physiotherapy OPD and various hospitals attached to SPB physiotherapy college. Treatment duration was 3 sessions/week for 4weeks. Primary outcome measure are POMA and FGA and secondary outcome measure was spatiotemporal parameters were used for measuring balance, gait & cadence. The Data was analyzed by using Paired T-test and Independent T-test. The result of this study shows that, adding PBWSTT in sub-acute stroke rehabilitation is effective in improving of balance, gait and cadence, in additionit is safe.
Keywords: *Balance, Cadence, Gait, Partial Body Weight Supported Treadmill Training, Poma, Sub-Acute Stroke.*

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INTRODUCTION

Now, stroke is the leading cause of death and disability worldwide. Worldwide, in 2017, stroke was accounted for 132 million disability-adjusted life years. According to the Global Burden of Disease Study 2017, it is the third most common cause of mortality and also one of the top five causes of morbidity [1]. The rate of stroke will be more than double after the age of fifty five.[2] As age increases risk of stroke doubles over 55 years of age and also risk increases due to existence of hypertension, coronary artery disease or hyperlipidaemia. Risk factors of stroke can be of modifiable also or non-modifiable also [2]. Following a stroke, patients may experience neurological deficits include sudden unilateral weakness, impaired trunk control and posture, numbness, Cognitive dysfunction, dysphagia, speech and language disorders, altered consciousness, and visual loss changed emotional state, hemispheric behavioral variations, impaired perception, seizures, and problems with the bladder and bowels [3]. In India, it has become a common debilitating condition due to changes in people's dietary habits and lifestyles. An altered gait style results from residual muscle fatigue, aberrant movement synergy, and spasticity, which also raises the risk of falling, impairs equilibrium, and uses more energy when walking [4]. About 80% of stroke patients have hemiparetic weakness, and almost two-thirds of these patients have lower extremity functional disabilities, such as functional disability, balance impairment, andgait impairment.[5] Stroke is the primary cause of adult disease. More than half of those who undergo an acute stroke are unable to walk and may take additional recovery time to reach a functional level of ambulation [4]. The primary objectives of stroke rehabilitation are to minimize impairments and maximize function [5, 6]. As a result, restoring gait and posture is the primary focus in stroke rehabilitation, which requires a variety of interventions and often demands significant assistance from clinicians to assist individuals with supporting their body weight and controlling balance. After a stroke, gait disability significantly contributes to long-term disability; however, partial recovery of gait may be seen in survivors of stroke. Despite of gait training, out of 45 stroke survivors, only 22% were able to walk normally within acute stage of recovery, according to Wade et al. It is widely accepted that early walking training in rehabilitation is advantageous for stroke patients, but it is less certain what kind of treatment program would result in the optimal outcome [7]. Treadmill gait training with some Body Weight Support (BWS) is one of the method in training becomes very popular. Task specific repetitive approach is favorable concept of modern rehabilitation.[3] Moreover, higher intensities of walking practice has proven result for good outcomes after stroke. BWS provides assistance during walking as well as it increases the number of steps which facilitate walking [8]. Asymmetry of gait is common in more than 30 percentages of stroke patients. Asymmetry of steplength, long duration stance of nonparetic leg, swing phase asymmetry duration, double support time, single support time, and affected lower limb joint range of motion are the main manifestations of the problem [8]. Despite best efforts at rehabilitation, After six months of stroke, despite rehabilitation, walking problems will persist in up to 50 percentages of stroke, which contribute to the development of long-term secondary stroke problems such as tuberculosis, heart disease, trouble, and arthritis,, despite best recovery efforts [6]. The intricate process of balance involves taking in and integrating sensory information as well as planning and carrying out movements to attain an objective thatcalls for an upright posture. It has the ability to change the center of gravity (COG) based on the contribution of a particular emotional state. It is known from previous studies that partial body weight support treadmill training (PBWSTT) compared to traditional training, significantly more improves recovery Improvement in gait compared with the control group at baseline after stroke [9]. Task-oriented practicing like treadmill training "increases the morale, level of confidence, and active participation for the therapy". The concept of "Motor Learning" is used in treadmill training. Gait training on the treadmill requires feedback, which is a crucial component. Tactile and input are used to make the training programme attractive and demanding. Therefore, treadmill training offers patients a secure, efficient, and inspiring environment. The tendency has shifted toward shorter hospital stays and earlier discharge since improved medical facilities and early rehabilitation. To promote the functional rehabilitation of stroke patients, gait should be started as early as possible once the patient's medical condition becomes stable. In order to determine the feasibility and effectiveness of treadmill training, this study aim to check the effectiveness of PBWSTT on 'balance andgait in sub-acute stroke patients along with conventional therapy.

MATERIAL AND METHODS

The experimental study was done on sub-acute stroke patients. First episodes of stroke between age group of 35-65, sub acute stroke patients (duration between 3 to 6 months) with Brunnstorm stage of recovery ≥ stage 3, MMSE- Mini mental state examination score ≥24 and weight < than 100 kg were selected for the study. Stroke patients with any neurological disorder, any vision impairment, severe dysarthria or aphasia, uncontrolled hypertension and diabetes, a history of recent lower limb deep vein thrombosis and history of cardiac diseases were excluded from study. Ethical-approval was taken prior commencement of the study from the institutional ethical committee. On basis of pilot study, the sample size was calculated. The sample size for the analysis was calculated in 'G Power 3.1.9.2' with an 'effect size of 0.8' and 'α = 80% power: 0.05'. The estimated sample size was 32; with a 10% probability of dropping out the estimated sample size was 36. Study was conducted from November, 2021 to June, 2022. They study was conducted in SPB Physiotherapy OPD and other various hospitals and clinics attached to SPB Physiotherapy College. The patients were recruited from study setting. The patients were evaluated according to established inclusion and exclusion criteria, with their demographic information recorded using an assessment form. Before the study began, the detailed procedure was thoroughly explained to the patients who had suffered a single stroke and have moderate to severe hemiparesis, are in healthy life, and were able to adhere to the instructions, and they provided a signed informed consent form. 65 stroke subjects were taken from which 36 met the inclusion criteria. All of them were allocated by using purposive sampling into two different groups (Group A- 18 subjects and Group B- 18 subjects).

Group A underwent standard conventional treatment, while Group B received conventional treatment in along with partial body weight support treadmill training. Duration of conventional therapy [10] was 45 minutes and it includes Stretching of tight muscles (3 times for 30 seconds), range of motion exercise (upper limb and lower limb) (passive, activeassisted, and progressed to active range of motion exercises), strengthening exercise, co-ordination exercise, juggling, frenkel exercises, balloon tossing, pelvic bridging (with 10 to 15 seconds of hold), trunk rotation, over ground walking training, and gait training for 15 minutes Side walking, Forward and backward walking, and tandem walking (in parallel bar, starting with 8 to 10 repetitions and progressed to 15 – 20 repetitions), Balance training for 15 minutes (Bossu ball exercise training- both surface: eye open progress to eye close, Balance board exercise training, Weight shifting on affected side (reach outs), Sit to stand training (with clasped hands, initially give support), one leg standing training (with support and without support). Group B received same Conventional treatments and PBWSTT. PBWSTT was for 20 minutes duration. Blood pressure, oxygen saturation in blood and pulse were measured before starting training session, at every 5–7 minutes, and after completing training session by the researcher. Then therapist gave position of the patient on to the treadmill along with the body weight support harness. Previous research indicates that the harness and two points of Body Weight Support (BWS) provide essential postural stability along with weight assistance. Also in built locking wheels in the system facilitate BWS ambulation on a treadmill. It has an adult-sized frame along with an adjustable hand-rail. A harness was attached to the overhead frame via adjustable straps, which supports the participant around the lower abdomen and pelvis. Additionally, real time weight in kg was displayed in a bilateral symmetry scale mounted within the frame. The weight supported while standing at the beginning of each session was continuously monitored and recorded. According to previous literature, the treadmill ranged speed was "0.1 mph (0.04 m/s) to 10 mph (4.44 m/s)". The patient was secured into a harness and positioned on the treadmill for BWSTT. The patient's body weight was maintained in an upright position for enabling knee extension in mid stance and also enabling full hip extension in terminal stance. The therapist was in behind of the subject to encourage equal stance duration on each limb and full range hip extension,which was prevent knee hyperextension during mid-stance. The other individual has provided support for stepping and managing limb movement during both stance and swing phases by positioning themselves at the hemiparetic lower limb. Additionally, this person observed cadenceand stride parameters. The training technique concentrated on the 'upright trunk alignment', 'weight shifts', and 'weight bearing', which were key elements that were as standardized for each individual as possible. Each thirty-minute session included the following sequence: 5 minutes of warm-up exercises and stretching exercises of limbs, followed by 5 minutes to don the light harness. Next, participants walked without arm supports for 5 minutes, proceeding to 20 minutes of training interspersed with rest breaks of 3 to 5 minutes, depending on the perceived exertion, target heart rate, and patient fatigue. The session concluded with 5 minutes of cool-down exercises. Outcome measures were assessed at the beginning of the session and after a duration of 4 weeks using the Performance-Oriented Mobility Assessment (POMA) [11] and the Functional Gait Assessment (FGA). [12]

Data analysis

Statistical analysis was conducted using SPSS version 20.00. The study evaluated quantitative variables including age, gender, affected side, POMA, FGA, and cadence. For the normality testing of the data, the Shapiro-Wilk test was used. ($p>0.05$). Consequently, parametric tests were employed for data analysis. Baseline characteristics were analyzed to ensure homogeneity among the intervention groups. This test was also applied to all demographic variables and outcome measures, such as age, POMA, FGA, and cadence, prior to the intervention. Given that the sample size was less than 50, a paired t-test was implemented to evaluate pre- and post-intervention differences within each group, while between group analysis was done by an independent t-test. At 95% confidence interval the significance level for all statistical data was established at '$\alpha = 0.05$'.

RESULTS

Baseline characteristics of participants

A total 36 stroke patients were included in the study. They were assigned to treatment groups through purposive sampling. Mean age of participants in experimental and control group was 53.56 ± 3.898, and 55.88 ±6.428 respectively. (Table 1) There were 31.3% right side and 68.8% left side is affected in Group A, and 43.8%right side and 56.3%left side affected in Group-B, and there were 68.8% male and 31.3% female in Group A, while 50.0% male and 50.0% female in Group B. The baseline characteristics were comparable among the intervention groups ($p>0.05$). (See Table 2) The baseline traits showed no significant differences across the intervention groups '($p>0.05$)'.

The results show outcome was significant for the groups. Thus, we can conclude that there are meaningful differences between pre- and post-assessments for POMA, FGA, and cadence in both groups (see Table 3). Also, between groups comparison shows there are significant variations between the groups, and also indicate improvements across all three parameters. (Table 4)

DISCUSSION

A stroke is a debilitating condition that requires immediate medical intervention and rehabilitation [13]. Early rehabilitation is reported to be more beneficial.[3] Early implementation of gait training and balance training will aid the patient in achieving a considerable functional improvement for both standing and ambulation [13]. Here, treadmill training commenced as part of a standard rehabilitation program. It shows that greater gait independence and improvement in balance following a stroke is connected with earlier gait and balance recovery, and that the most successful treatments may be task-specific ones that are used early and frequently. The present study aimed to determine the impact of PBWSTT on balance and gait in individuals with sub-acute stroke, in conjunction with traditional therapy. In this study subjects were assessed for balance and gait by using POMA, Functional Gait Assessment (FGA) and Spatiotemporal Parameter i.e., cadence. In this research, the average age of participants in group A was 55.88 years, while in group B, the average age was 53.56 years. Another study revealed that the mean age of most stroke patients was 54.5 years. In current study the male participants are more involve then female participants. The statistical analysis confirmed our hypothesis wherein on additional effect of PBWSTT in experimental versus control group. The findings show the experimental group has notable enhancements in balance and gait following intervention with respect to another group. Additionally, the study highlighted a significant disparity in balance and gait improvements among patients with sub-acute strokes. Results indicated that the experimental group showed a marked improvement in POMA performance compared to the control group. Furthermore, mean score of POMA also shows considerable difference in pre and post-test. Study result is supported by other research findings. Similar improvements on the 'Fugl-Meyer' and 'Berg balance' scales were observed in both the groups in earlier research, comparing BWSTT with other standard ground gait training in recovery of stroke during early stages [8, 14]. The current study's findings are in accordance with previously published research that show sub-acute stroke patients' balance can be improved with early intervention. BWSTT is less effective for improving balance, which is also in agreement with 'Nilsson et al. [14] and Franceschini et al [8]. According to the findings, two gait training methods have similar clinical outcomes and might be employed as part of the continuing treatment protocols [15]. Abhishek Srivastava et al., discussed that, BWSTT shows progress in gait, but it does not offer a notable benefit compared to traditional gait training methods for individuals with chronic stroke during 4-week intervention. Shirley Roth Shema et al., [16] discussed that, A valuable and effectual resource that can be employed for physiotherapy outpatient department is treadmill training enhanced by virtual reality. It appears that this training enhances gait, mobility, and postural control during 5 weeks of programme, in which they were use Time up and go test, it's time to complete were decreased by 10.3%, the distance covered by walking during the 2- minute walk test is increased by 9.5%, and performance on the four square step test is improved by 13% [17]. The study revealed that there was a notable change in the gait parameters (cadence) for both groups. After 4 weeks of training, both groups lower extremity motor function and balance were reported to have improved. However, gait assessment showed that compared to the CT group throughout this time, the PBWSTT group's abnormal gait pattern and cadence had improved more. These findings suggest that treadmill training with early post-stroke body weight support may help to increase walking speed and correct abnormal gait patterns at the stance phase [15]. According to Yu-Rang Mao et al., an enhancement in the temporal-spatial parameters, such as increased 'cadence', 'stride length', and 'step length' are attainable. The study's results indicate that patients recovering from sub acute strokes can enhance their gait velocity within three weeks of starting Body Weight Support Treadmill Training (BWSTT), stemming from improvements in stride length, step length, and cadence.[15] Locomotion is rhythmic motor activity produced by "Central Pattern Generators (CPG)" in spinal neural networks. CPGs are neural networks that generate the walking rhythm and modify the motor neuron burst pattern in the leg muscles [18]. Body weight supported treadmill training works through "CPG theory of gait control and recovery". According to the hypothesis, a group of neurons, known as CPGs, are principally positioned at the spine level and are primarily responsible for controlling gait. Leg movement, weight shifting, and postural alignment can all excite these neurons, either naturally or with assistance. When body weight and other neuromuscular limitations are removed during suspension during waking on a treadmill, the gait's characteristics and speed are effectively restored. To effectively restore gait speed in stroke therapy, utilizing a body weight support treadmill is beneficial [19, 20]. For the start and adaptive control of goal-directed locomotion, supraspinal regions activate, modify, and inhibit these spinal networks. CPGs have the ability to create independent of sensory response, self-sustaining behavioral patterns. Sensory feedback plays a vital role in the overall motor control system, being crucial for adapting central pattern generator (CPG)-generated programs to facilitate continuous adjustments to the environment [21,22]. Body Weight Supported Treadmill Training should be designed based on "motor learning" principles and should incorporate speed, reduced lower extremity loads, and limb movements that optimize sensory inputs interpretable by the 'spinal' and 'supraspinal' locomotor networks as typical walking cues. This approach aims to enhance experience dependent plasticity in the CNS. Consequently, this study indicates that the improvements in gait, balance, and cadence achieved through body weight supported treadmill training may be maintained and adapted to full weight-bearing walking following the training process. However, lower - limb muscular strength was not measured, so it is difficult to interpret the biomechanical results in the study. Future studies could investigate muscle strength by utilizing isokinetic and EMG equipment, especially focusing on the hip flexor, knee extensor, and ankle plantar flexor, to gain insights into the underlying mechanisms. Also, this was done on patients with sub-acute stroke so, further study can be done on different population such as acute or chronic stroke and may include observational gait analysis using video recording or quantifiable gait analysis.

Table 1: Baseline Characteristics

VARIABLE	GROUP A	GROUP B
AGE(YEARS)	**Mean ± SD**	**Mean ± SD**
	55.88 ± 6.428	53.56 ± 3.898
AFFECTED SIDE	**RIGHT:**31.3%	**RIGHT:** 43.8%
	LEFT:68.8%	**LEFT:**56.3%
GENDER	**MALE:** 68.8%	**MALE:** 50.0%
	FEMALE: 31.3%	**FEMALE:** 50.0%

Table 2: Pre-treatment group comparison

OUTCOME MEASURE	GROUP A	GROUP B	
	PRE- INTERVENTION (Mean ± SD)	PRE- INTERVENTION (Mean ± SD)	P-VALUE
MMSE	28.19 ± 1.328	27.81±0.981	0.37
POMA	19.69 ± 1.740	19.13± 1.500	0.33
FGA	21.00± 1.141	20.38± 1.088	0.17
CADENCE	68.06 ± 4.568	68.63± 2.419	0.66

Table 3: Intra group comparison of POMA, FGA and Cadence by using pairsample t-test

OUTCOME MEASURE	GROUP A		P-VALUE
	PRE INTERVENTION (Mean ± SD)	POST INTERVENTION (Mean ± SD)	
POMA	19.69 ± 1.740	24.44±1.209	0.008
FGA	21.00± 1.414	26.19±0.911	0.004
CADENCE	68.06 ± 4.568	75.06± 4.509	0.00
OUTCOME MEASURE	**GROUP B**		**P-VALUE**
POMA	19.13± 1.500	26.06± 0.680	0.048
FGA	20.38 ±1.088	26.88 ± 1.025	0.018
CADENCE	68.63± 2.419	79.31± 3.135	0.015

Table 4: Between group comparison of difference of outcome measures usingindependent t-test

OUTCOME MEASURE	GROUP A	GROUP B	P-VALUE
	PRE-POST DIFFERENCE (Mean ±SD)	PRE-POST DIFFERENCE (Mean ±SD)	
POMA	24.44±1.209	26.06±0.680	0.000
FGA	26.19±0.911	26.88±1.025	0.054
CADENCE	75.06±4.509	79.31±3.135	0.004

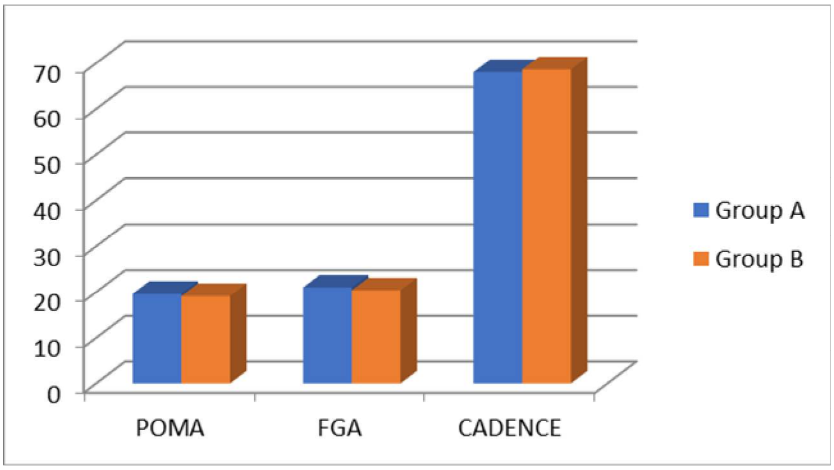

Figure1: Pre-intervention comparison of means

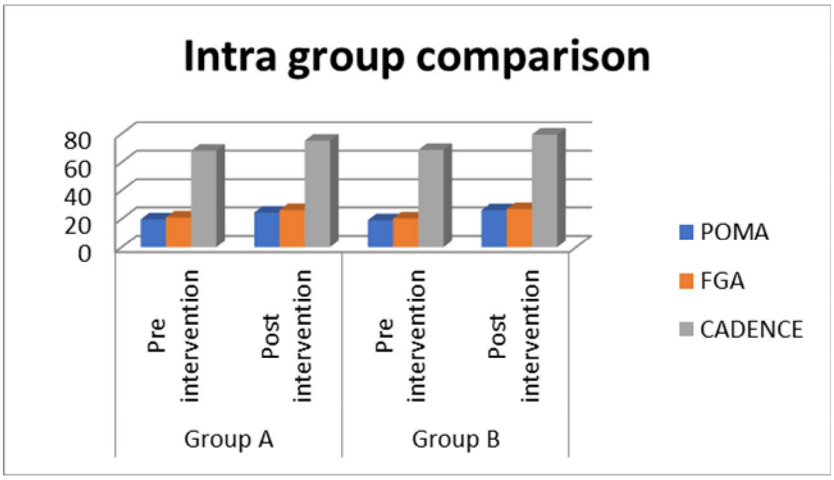

Figure 2: Pre-intervention comparison of means

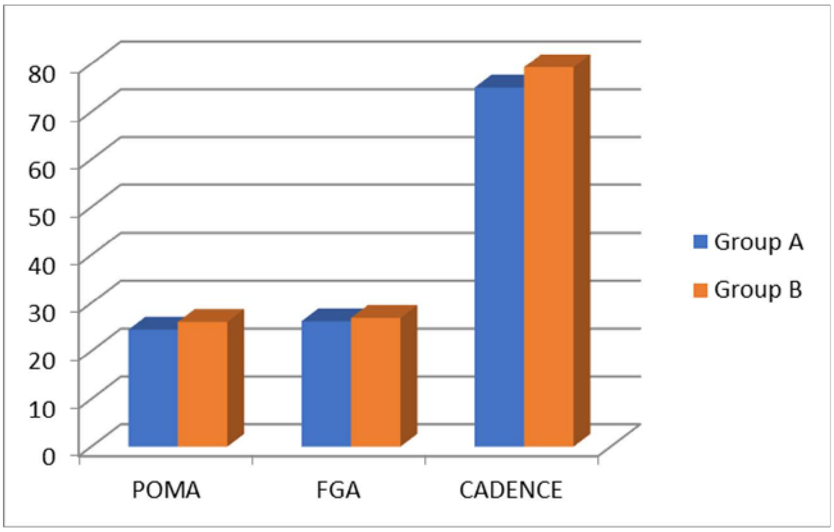

Figure 3: Between group comparison of POMA, FGA and Cadence

CONCLUSION

Hence, we concluded according to the findings of this study, partial body weightsupport treadmill training (PBWSTT) is a convenient and secure technique for performing balance and gait and balance training in sub-acute stroke rehabilitation and for providing assistance to sub-acute stroke patients in recovering their gait, balance, and cadence. For a physiotherapist, improvement in patient's independency is an importantaim of rehabilitation of stroke patients. Interventions combining PBWSTT will enhance postural control, balance, gait and cadence and in turn would definitely lead to better results for such patients. Therefore, it would be beneficial for patient as well as for thephysiotherapists to include such effective and novel intervention strategy in regular protocol to improve delivery of rehabilitative care.

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