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A comparative study between the effect of Functional Limb Overloading and Conventional therapy on gait parameters, balance and functional independence in Chronic Stroke patients

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Abstract

Introduction: Walking dysfunction post stroke arises from primary impairments like lower extremity weakness, decreased weight bearing on paretic leg, poor motor control and sensorimotor deficits and secondary musculoskeletal consequences of disuse and physical inactivities like tightness and soft tissue contracture. Post stroke, patients walk with slower velocity, shorter stride length and step length and increased double support phase. It is seen that despite of gait training, many of the patients do not achieve equal weight bearing and symmetrical walking. **Purpose of the study**: The study aimed at comparing the added effect between Functional Limb Overloading and Conventional therapy on Gait parameters, Balance and Functional Independence in Chronic stroke patients. **Method:** It was an experimental study-randomized controlled trial. 30 subjects with Chronic Stroke, satisfying the inclusion criteria were randomly divided into two groups. Group A received Conventional therapy while Group B received Functional Limb Overloading along with Conventional therapy. All the subjects were assessed for the outcome measures at baseline. Both the groups received treatment for 1 hour 3 times/ week for 4 weeks. Re-assessment of all the outcome measures post 4 week intervention was done. Outcome measures used were Dynamic Gait Index, Lower Extremity Functional Scale, Multidirectional Reach Test, Step length and Stride length. **Statistical Analysis:** Data was initially explored to find out normal distribution by using Winpepi software. Shapiro Wilk test was used for analysis. Test of significance was set at 0.05 ($p < 0.05$). The data analysis within and between group analysis was done using Wilcoxin Signed Rank test and Student t-test. **Results:** Comparison of Group A and Group B showed that Group B had significantly better improvement than Group A in all outcome measure except MDRT-Backward Reach. **Discussion:** The addition of a load on the paretic ankle in post-stroke participants leads to increases in mechanical demand which lead to increased power generation and absorption at the paretic hip and knee. Repetition of functional tasks caused improvement in performing activities of daily living and increased the confidence of stroke patients. Proprioceptive feedback is required to modify motor commands slowly in response to alterations in biomechanical properties of the limbs. Functional Limb Overloading induces proper weight bearing as well as proprioceptive inputs to the affected ankle and foot. **Conclusion:** The added effect of Functional Limb Overloading improves gait parameters, balance and activities of daily living in chronic stroke patients.

Keywords: Balance, Functional Limb Overloading, Functional Independence, Gait, Stroke.

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Background

In accordance with definition by World Health Organization, Stroke is defined as, ''rapidly developing clinical symptoms and/or signs of focal, and at times global, loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin''[(1)]. The prevalence rate of Stroke in India is 250-350/1,00,000[(2)]. Although 65-85% of stroke survivors learn to walk independently by 6 months, gait abnormalities persists through chronic stages of condition[(3)].

Middle Cerebral Artery territory is the most commonly affected territory in a cerebral infarction, due to the size of the territory and direct flow from internal carotid artery into the middle cerebral artery, providing the easiest path for thrombo-embolism[(4)]. Patients with hemiplegia have movement problem-impairment that leads to functional limitations and disability. Patients have difficulty in maintaining balance due to these impairments and have great difficulty in ambulation.

Poor balance post stroke is a factor for poor recovery of activities of daily living, mobility and risk of falls. Balance is detrimental for all the basic activities like getting up from bed, sitting, sit-to stand, toilet activities and walking. Owing to the fact that less weight is taken on the paretic leg, hemiplegics do not have even weight distribution. This is seen even in those hemiplegics who ambulate functionally in the community. Fall incidences have been found to be around 23-50% in chronic stroke patients[(8)(9)]. These balance impairments are due to delays in onset of motor activity, abnormal timing and sequencing of muscle activity and abnormal co-contraction which leads to disorganization of postural strategies causing falls.

Walking dysfunction post stroke arises from primary impairments like lower extremity weakness, decreased weight bearing on paretic leg, poor motor control and sensorimotor deficits and secondary musculoskeletal consequences of disuse and physical inactivities like tightness and soft tissue contracture. Post stroke, patients walk with slower velocity, shorter stride length and step length and increased double support phase[(13)]. Shorter step length and stride length leads to slowness in walking and asymmetry in gait. Thus, even though Stroke patients can walk independently, they do not return to social activities within the community, due to the deficits which hampers the walking at ease of stroke patients.

It is also seen that despite of gait training, many of the patients do not achieve equal weight bearing and symmetrical walking[(14)(21)]. A study done by Ibrahim et al, proved that using a lateral foot wedge beneath the non-paretic foot and carrying a weighted bag with the paretic hand improve the loading function of the paretic limb and relieve the non-paretic limb from overloading.

A study showed that Functional Limb Overloading has a beneficial effect on Symmetrical Weight Bearing, Walking Speed, Perceived Mobility and community participation among Patients with Chronic Stroke[(26)]. Functional Limb Overloading is an approach where Task specific training is combined with Functional activities. Functional Limb Overloading is given to enhance loading of the paretic limb. In this method, the hemiplegic gets to train functionally about 90% of the waking times. This gives opportunity to the patients to practice loading and equal weight distribution in almost all the activities of daily living. Another study done, showed that Walking with a load led to an increase in gait speed and an increase in step length of the paretic leg[(27)].

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Several researchers have provided evidence that impaired lower extremity loading after stroke are associated with functional deficits [23].

Weight shifting and balance are considered fundamental for functional activities for Stroke patients. Limited walking ability that follows a stroke restricts the patient's independent mobility about the home and community, a significant social handicap. It is seen that although what physical activity occurred in therapy area, it accounted for only a small percentage of the day. Repetitive exercise and training in real life tasks following Stroke maybe a critical stimulus to the making of new or more effective functional connections within remaining brain tissue. Cramer and Bastings et al provided evidence for functional plasticity after Stroke with meaningful use of a limb involving Task-oriented repetitive exercises[25]. Relearning of an activity mainly depends on variability of practice, consistent use of feedback, close relationship between physical therapy and Activities of Daily Living and emphasis on active movement instead of passive guidance[4]. The aim of the study was to compare the added effect of Functional Limb Overloading and Conventional therapy on Gait parameters, Balance and Functional Independence in Chronic stroke patients. The objectives were to study and compare the effect of Conventional therapy alone and Functional Limb Overloading along with Conventional therapy on Gait parameters, Balance and Functional Independence in Chronic stroke patients. It was hypothesized that there will no significant difference (H0) or a significant difference(H1)between Functional Limb Overloading along with Conventional therapy and Conventional therapy alone on improving Gait Parameters, Balance and Functional Independence in Chronic stroke patients.

Methodology

Study design was Experimental: Randomized controlled trial – Open access. Sample size was calculated to be 30 as the average numbers of Stroke patients in Tertiary hospitals from February 2015 to February 2016 were 56, while patients meeting the inclusion criteria were 35. 30 patients between age group of 35-50 years both genders with history of Middle Cerebral Artery infarct of duration-more than 6 months up to 2 years and ability to walk up to 10 meters were included in the study. The exclusion criteria were any history of recurrent stroke, Subjects using any walking aids/assistive devices for lower limb, lower extremity fixed contractures and any cognitive deficits (Montreal cognitive assessment scale score>26). Ethical committee approval was obtained. Screening of subjects was done to select the subjects according to inclusion and exclusion criteria (n=31). Information about the study was given and written informed consent was taken. Subjects were randomly allocated to either Group A (n=16) or Group B (n=15) by Chit method. Group A received Conventional Therapy alone while Group B received Functional Limb Overloading along with Conventional therapy. Subjects were assessed for Stride Length, Step Length, Dynamic Gait Index, Multi-Directional Reach Test and Lower Extremity Functional Scale pre and post 4 weeks intervention. There was 1 dropout (relocated to other city) in Group A, so 1 subject was added.

Intervention

Group A(Conventional Therapy) includes 1) Active assisted Range of motion exercises for upper limb & lower limb, progressing to Active exercises (8-12 repetitions) and later progressing to Resistance exercises. 2) Weight bearing exercises on affected side. 3) Pelvic Bridging, progressing to unilateral pelvic bridging. 4) Sit-to-stand & Sit-down transfers. 5) Balance training- Sitting, lower extremity uncrossed to crossed, Standing- wide to narrow base of support,

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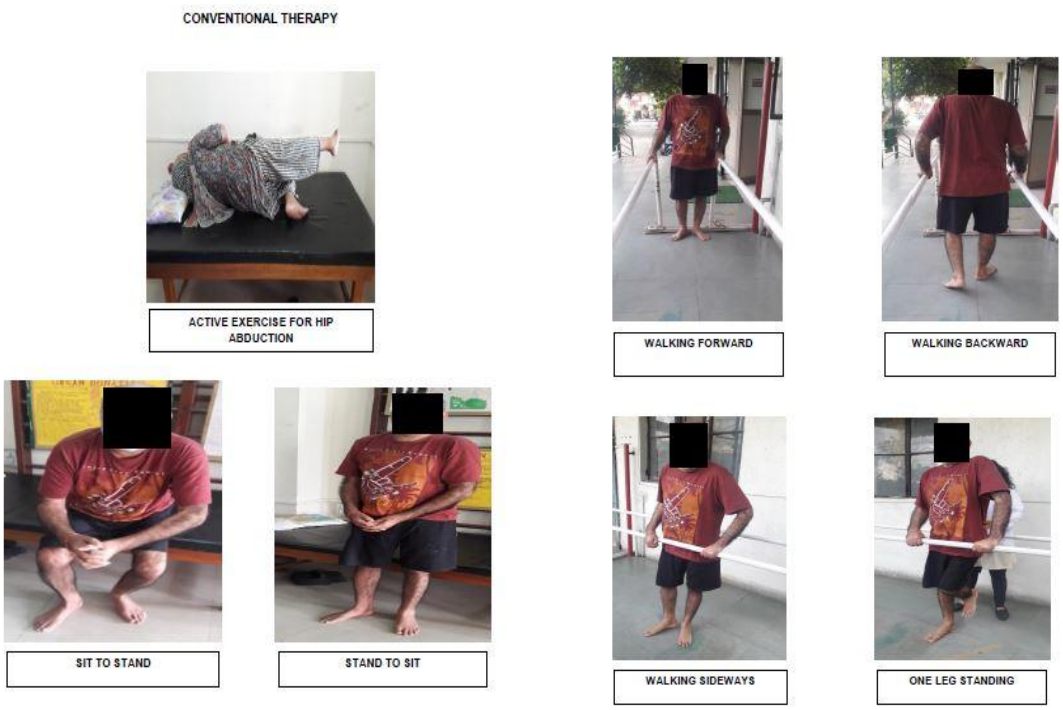
progressing to tandem position, Standing on affected lower extremity, Marching in place 6) Gait training- Facilitated by use of auditory cues & foot markers placed on floor & includes Task specific Locomotor skills- Walking forward, Walking backwards, Walking sideways, Braiding, Step up/step down and Lateral step up.



Group B (Functional Limb Overloading along with Conventional Therapy): Patients were asked to wear weight cuff equivalent to 5 percent of body weight for 90 percent of their awake times. The weight cuff was tied around the ankle of the affected side. Along with Conventional therapy, Group B performed Task specific locomotor skills with (5 percent of the body weight) weight cuff tied around the ankle of the affected side. These Task specific Locomotors skills includes- Walking forward, Walking backward, Walking sideways, Braiding, Step up/step down, Lateral step up, Stair climbing, Step-over-step. The task specific exercises were performed with 5% body weight equivalent weight cuff tied to the ankle of the affected limb of Stroke patients. Group B received treatment for 1 hour 3 times /week for 4 weeks.

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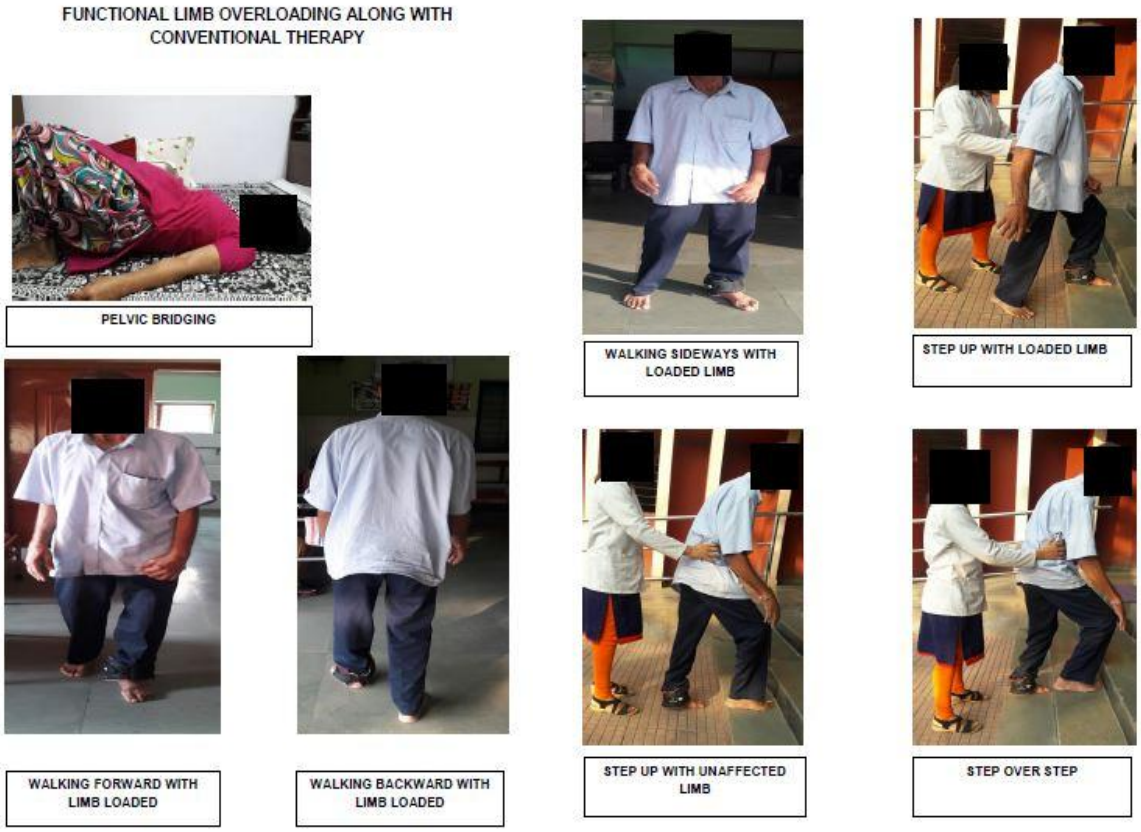

Results

Data was initially explored to find out normal distribution by using Winpepi software. Shapiro Wilk test was used for analysis. Statistical descriptive analysis was done by using Primer biostatistics software. Test of significance was set at 0.05 ($p < 0.05$). The data analysis within and between group analysis was done using Wilcoxin Signed Rank test and Student's t-test.

Table 1 and Graph 1 shows the mean age and gender distribution. Results showed that Group A (Conventional therapy) showed significant difference in DGI scores, LEFS scores and MDRT-FR,MDRT-BR,MDRT-RR and MDRT-LR post intervention .But, it did not show any significant difference in Paretic step length, Non Paretic step length, Paretic stride length and Non Paretic stride length. (Table 2 and Graph 2)

While Group B showed significant difference in DGI scores, LEFS scores, MDRT-FR, MDRT-BR, MDRT- RR-and MDRT-LR, Paretic step length, Non Paretic step length, Paretic stride length and Non Paretic stride length.(Table 3 and Graph 3).

Comparison of Group A and Group B showed Significant difference in DGI scores, LEFS scores , MDRT-FR, MDRT-RR and MDRT-LR, Paretic step length, Non Paretic step length, Paretic stride length and Non Paretic stride length except Backward Reach (Table 4 and Graph 4)

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Table 1: Showing age and gender in both Group A and Group B

		Group A	Group B	Total
Age	**Mean + SD**	44.27+ 4.8	43.87+ 4.0	-
Gender	**Males**	09	10	19
	Females	06	05	11
	Total	15	15	**30**

Graph 1: Showing gender distribution in the study

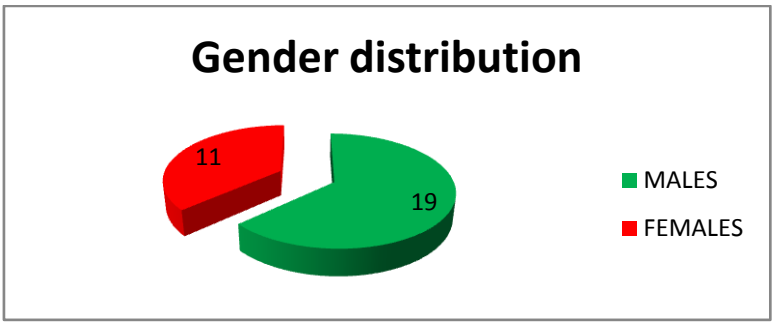

Table 2: Showing pre post intervention comparison of Group A (Conventional Therapy) of all outcome measures.

Outcome measure	Pre (Mean + SD)	Post (Mean+ SD)	t /w value	Degree of Freedom	p value	Significance
As the Shapiro-Wilk value for normally distributed data is p >0.05, t-test is used						
Dynamic Gait Index	16.27 + 3.20	19.87 + 2.36	3.512	28	0.002	HS
Paretic Step Length	41.60 + 12.44	46.29+12.69	1.023	28	0.315	NS
Non Paretic Step Length	38.6 + 11.13	42.67+11.37	0.990	28	0.331	NS
Paretic Stride Length	80.33+22.51	85.80+22.41	0.666	28	0.511	NS
Non Paretic Stride Length	75.0 + 20.8	81.13 + 21.0	0.804	28	0.428	NS
MDRT-Right Lateral Reach	4.40 + 2.261	6.93 + 1.751	3.430	28	0.002	HS
MDRT-Left Lateral Reach	5.27 + 1.39	7.00 + 1.41	3.389	28	0.002	HS
The Shapiro-Wilk value for normally distributed data is p >0.05 .As the p<0.05,Wilcoxin Signed Rank Test is used						

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Lower Extremity Functional Scale	43.47+12.61	52.47+12.24	3.405	-	0.001	HS
MDRT-Forward Reach	7.33 + 2.41	9.47 + 2.20	3.450	-	<0.0001	HS
MDRT-Backward Reach	4.53 + 1.92	7.00 + 1.60	3.456	-	<0.0001	HS

Graph 2: Showing pre post intervention comparison of Group A (Conventional therapy)

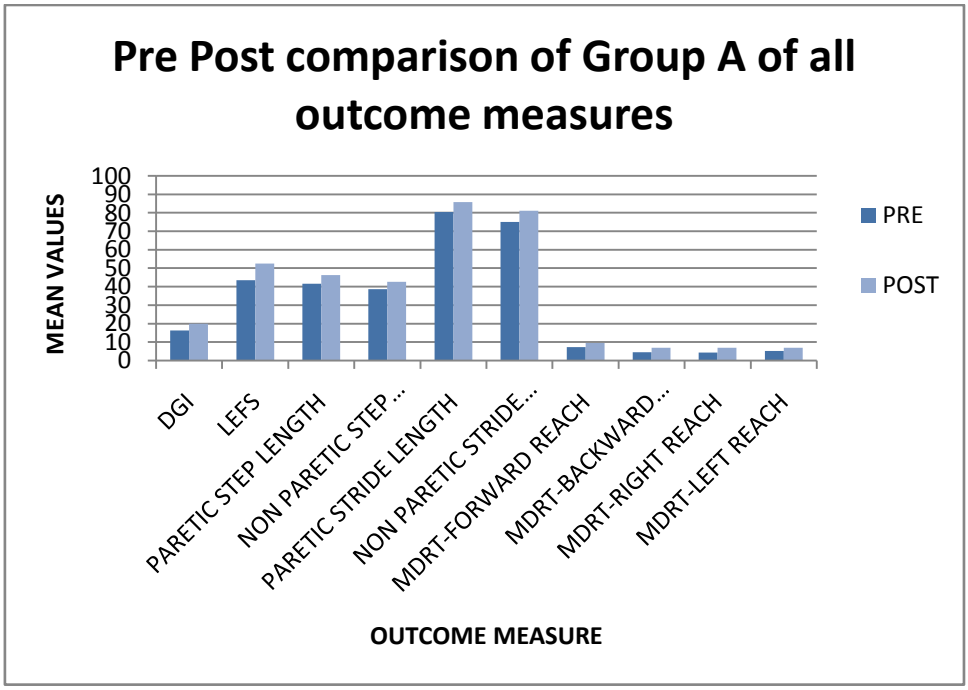

Table 3: Showing pre post intervention comparison of Group B (Functional Limb Overloading along with Conventional Therapy) of all outcome measures.

Outcome measure	Pre (Mean + SD)	Post (Mean+ SD)	t value/w value	Degree of Freedom	p value	Significance
As the Shapiro-Wilk value for normally distributed data is p >0.05, t-test is used						
Dynamic Gait Index	15.20 + 2.24	20.87 + 1.60	7.971	28	<0.0001	HS
Lower Extremity Functional	40.53 +13.92	52.60 +10.24	2.704	28	0.012	S

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Scale						
Paretic Step Length	46.93 + 8.22	53.27 + 8.08	2.128	28	0.042	S
MDRT-Backward Reach	4.20 + 1.70	7.40 + 1.59	5.319	28	<0.0001	HS
MDRT-Right Reach	3.47 + 1.96	7.47 + 1.64	6.061	28	<0.0001	HS
MDRT-Left Reach	5.27 + 1.39	7.00 + 1.41	3.389	28	0.002	HS
The Shapiro-Wilk value for normally distributed data is p >0.05 .As the p<0.05,Wilcoxin Signed Rank Test is used						
Non Paretic Step Length	42.33 + 7.35	49.00 + 6.99	3.412	-	<0.0001	HS
Paretic Stride Length	82.47 +20.86	96.82 +19.91	3.404	-	<0.0001	HS
Non Paretic Stride Length	75.47 +21.09	89.27 +19.47	3.400	-	<0.0001	HS
MDRT-Forward Reach	6.87 + 2.17	10.00 + 1.69	3.450	-	<0.0001	HS

NS- Not Significant, S- Significant, HS-Highly Significant

Graph 3: Showing pre post intervention comparison of group B (Functional limb overloading along with Conventional therapy)

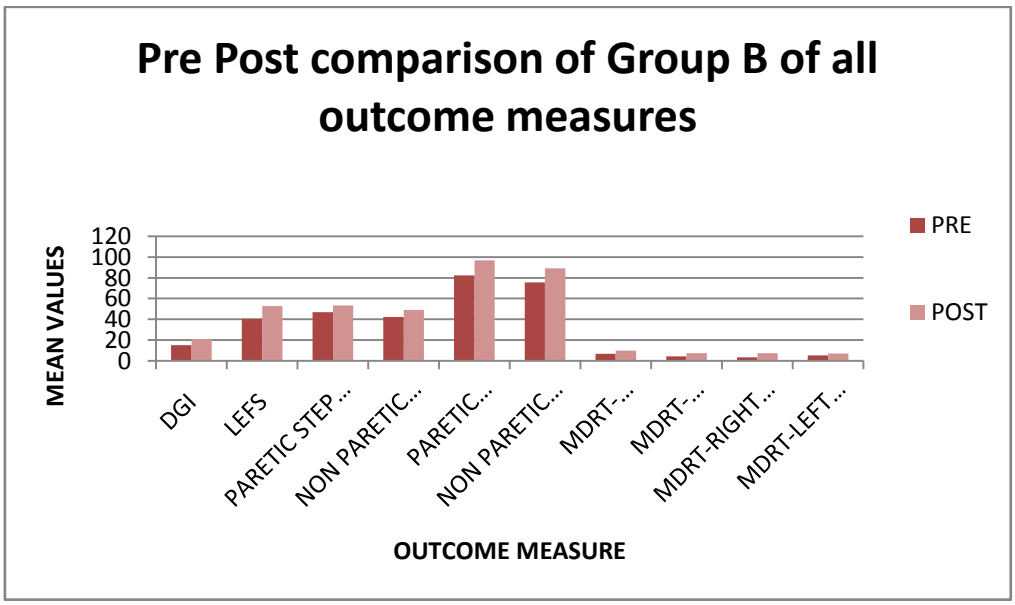

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Table 4: Showing post mean difference comparison of Group A (Conventional Therapy) and Group B (Functional Limb Overloading along with Conventional Therapy) of all outcome measures.

Outcome measure	Pre (Mean + SD)	Post (Mean +SD)	t value	Degree of Freedom	p value	Significance
Dynamic Gait Index	3.60 +1.298	5.60 +1.595	3.767	28	<0.0001	HS
Lower Extremity Functional Scale	8.87 +2.264	11.00 +3.23	2.095	28	0.045	S
Paretic Step Length	4.693+2.13	6.267 +1.83	2.171	28	0.039	S
Non Paretic Step Length	4.07 + 1.44	6.67 + 1.59	4.700	28	<0.0001	HS
Paretic Stride Length	5.47 + 1.68	14.53 +3.56	8.910	28	<0.0001	HS
Non Paretic Stride Length	5.93 + 2.74	13.80 +3.65	6.679	28	<0.0001	HS
MDRT-Forward Reach	2.13 + 0.74	3.13 + 0.92	3.284	28	0.003	HS
MDRT-Backward Reach	2.47 + 1.25	3.20 + 1.15	1.677	28	0.105	NS
MDRT-Right Lateral Reach	2.53 + 0.92	3.80 + 1.37	2.972	28	0.006	S
MDRT-Left Lateral Reach	1.73 + 0.70	3.47 + 1.64	3.758	28	<0.0001	HS

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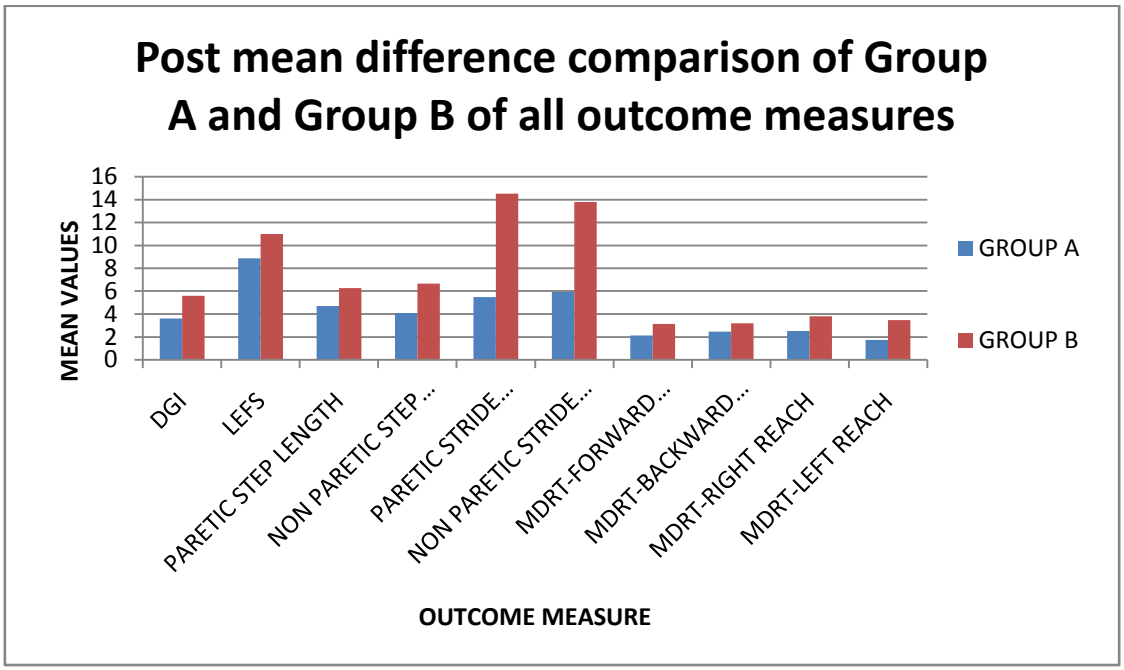
Graph 4: Showing post mean difference comparison of Group A (Conventional Therapy) and Group B (Functional Limb Overloading along with Conventional Therapy)



Discussion

Stroke causes various impairments such as muscle weakness, poor balance, spasticity, reduced ambulation and dependency in activities of daily living[47][48]. Conventional therapy included task-specific activities like walking forward, walking backward, walking sideways, stepping which helps in improving the gait of stroke patients. Conventional therapy focuses on improving the mechanics and quality of walking by using verbal commands and visual cues like walking in front of the mirror, foot marks in gait training. A study done on stroke population showed that task-specific training program gained and maintained improvements in walking and functional abilities[49]. A Study done by Hollands et al showed that visual cue training helps in improving the walking and turning post stroke[20]. Task-specific training activities like walking forward, walking backwards, walking sideways, braiding , stepping focuses on practice of skilled motor performance facilitates neural reorganization[10].

Stroke results in significant impairments in balance as they typically show delayed, varied or absent balance responses due to inappropriate timing, amplitude and latency of muscle activity. Conventional therapy includes weight bearing exercises on affected limb, balance training which helps in enhancing the dynamic balance of stroke patients. Comparative study on the effect of weight-bearing and Non-weight-bearing positions showed that weight bearing positions improved knee proprioception in patients with chronic stroke, as Weight Bearing positions offered more proprioception and sensorimotor feedback than Non Weight Bearing positions[45].

FLO is a high intensity training program as the patients have to wear the weight cuff for 90% of awake times. This training targets various impairments, such as muscle activation and coordination, balance, endurance, walking rhythm and functional strength of the lower limbs. A

study done on Effects of walking with loads on gait parameters of persons with hemiparesis after stroke showed that Post-stroke participants are able to increase hip and knee power bursts to meet the increased mechanical demand of added loads attached to the paretic ankle, while preserving the basic pattern of walking[27]. Another study done on incomplete spinal cord injury (SCI) showed that loading the legs during the swing phase of walking enhances flexor muscle activity due to additional proprioceptive input[46]. Adding load to the ankle imposes resistance during swing phase, which results in greater activation of flexor muscles of lower limb. This response can be considered as a strategy of neuromotor adaptation mediated by feedback mechanisms that occur due to changes in proprioceptive input during gait with load. Additional observation in this study was that patients in Functional Limb Overloading group reported that they found more it easier to do sit-to-stand activities when the limb was loaded. The reason could be as it gave better stability due to increased weight- bearing on the affected limb

The addition of a load on the paretic ankle in post-stroke participants leads to increases in mechanical demand which lead to increased power generation and absorption at the paretic hip and knee[50][35]. These changes were associated with a longer paretic step length and stride length. A study done by Weiss et al (2017) showed that High Intensity Strength Training Improves Strength and Functional Performance after Stroke[51]. Similar study showed that High Intensity Resistance Training Improves Muscle Strength, Self-Reported Function, and Disability in Long-Term Stroke Survivors[52]. A case study done on combined task-specific training and strengthening which included limb-loaded cycling and body-weight supported treadmill walking showed positive effects on locomotor recovery post-stroke[53].

Functional Limb Overloading causes repetition of functional tasks with strengthening of lower limbs. Any type of movement if repeated over a significant period of time, then plastic adaptation of neuromuscular system ensures that it becomes a part of library of motor behavior for reproduction in all relevant situations[54]. Thousands of repetitions of an action may be necessary to develop an optimal way for performing the action.

Loading of the affected limb gave a constant proprioceptive feedback to the patients. Proprioception has been defined as one's ability to integrate the sensory signals from various mechanoreceptors to thereby determine body position and movements in space and is important in balance control[55].Afferent feedback plays a crucial role in adapting and modulating the operation of the Central Pattern Generator in the real environment. Through dynamic interactions, sensory inputs can participate in the correct positioning of the feet in uneven terrain or in response to obstacles[56]. A study on chronic stroke patients showed that Ankle Proprioceptive Control Program improves Balance and Gait Ability[57][58][44] Functional Limb overloading is a high intensity task specific training involving all the Activities of Daily Living. Conventional therapy neglects the repetitive element of task performance that forms an essential part of motor rehabilitation. The ability to integrate somatosensory information from the lower extremities for balance is compromised after stroke. Balance is affected due to malfunction of proprioceptive sense and proper weight bearing[57]. A Study showed that the loading of one of the limbs helps induce general reorganization involving all bodily segments to maintain balance while providing rhythm constancy, adding mass to ankle caused increase in arm movement and muscle activity[59][60]. Cutaneous and joint somatosensory information from the feet and ankles play an important role in assuring the form of postural movements.

A study done by Agarwal et al on comparison of effect of sensorimotor integration with conventional therapy proved that added effect of sensorimotor integration helped improve balance and gait of stroke patients[38].Proprioceptive feedback can be regulated by generation of

motor commands by correcting errors using negative feedback loop, providing signals used in planning of movement by providing information about limb position to set parameters of feedforward commands[61][62][63]. A combination of motor and sensory training helps in better improvement of balance, gait parameters and functional independence which is in agreement with previous studies. It is seen that sensorimotor training helps the patients in regaining normal or near normal dynamics of postural control. New neural programs are developed, refined by repetition and transferred to the more fundamental regions of the brain, from where they are executed with less effort and relayed much faster[55].

Conclusion

The study concludes that the added effect of Functional Limb Overloading is beneficial in improving gait parameters, balance and functional independence as compared to only conventional therapy in Chronic Stroke patients

Limitations and suggestions

No long term follow up of the patients were taken

Abbreviations

DGI-Dynamic Gait Index, LEFS- Lower Extremity Functional Scale, MDRT- Multi-directional Reach Test, FR- Forward Reach, BR-Backward Reach, RR- Right Reach, LR- Left Reach, FLO- Functional Limb Overloading, MOCA- Montreal Cognitive Assessment

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