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Effect of Rhythmic Auditory Stimulation and Task-Oriented Circuit Training on Improving Walking Ability in Subjects with Hemiparetic Stroke

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Abstract:-

BACKGROUND AND OBJECTIVES: Stroke is among the commonest causes of adult-onset disability. Six months after the stroke, only 50% of the patients achieve functional independence in ADLs and walk short distances. In research studies over the past ten years, exercise and rehabilitation strategies to improve walking ability have become more intensive and progressive, like rhythmic auditory stimulation, task-oriented circuit training, dual-task exercises, etc. Gains in the walking ability attained by the interventions as mentioned above within three months of stroke. Some evidence-based studies proved that RAS and TOCT effectively improve gait parameters like Stride length, Cadence, and Velocity in subjects with hemiparetic stroke. However, there is no comparative study of these two protocols. Hence, the purpose of this study is to compare the effects of RAS and TOCT on improving walking ability in subjects with hemiparetic stroke.

METHODS: Quasi experimental design. A total of 68 subjects, 64 of them met selection criteria for the study, and 4 of them dropped from the study. Therefore, 60 subjects divided into two groups, 30 members in group A (RAS), 30 members in group B (TOCT). Both groups performed intervention for 1 hour a day, five days a week for six weeks. The outcomes of the study were Stride length, Cadence, and Velocity. They were measured using the ink foot method with 10 meters walk test.

RESULTS: Paired T-test used to access the statistical significance between pre and post-test scores within the group, Independent T-test was used to access the statistical significance between pre and post-test scores between the groups, Statistical analysis of the data revealed that the RAS group has more difference when compared to TOCT group.

CONCLUSION: In this study, six weeks of treatment duration for RAS and TOCT showed significant effective changes in Stride length, Cadence, and Velocity. However, RAS has shown more effective when compared to TOCT in improving walking ability in subjects with hemiparetic stroke.

Keywords:- *Rhythmic Auditory Stimulation, Task-Oriented Circuit Training, Functional Ambulatory Category, Stride Length, Cadence, Velocity, Ink Foot Method, 10 Meters Walk Test.*

I. INTRODUCTION

World Health Organization (WHO) defined stroke as "rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than of vascular origin". By applying this definition, transient ischemic attack (TIA), which is defined to last less than 24 hours, and patients with stroke symptoms caused by subdural haemorrhage, tumours, poisoning, or trauma excluded [1].

According to the National Institute of Neurological Disorders and Stroke (NIH): Stroke occurs when the blood supply to part of the brain is suddenly interrupted or when a blood vessel in the brain bursts, spilling blood into the spaces surrounding brain cells. Brain cells die when they no

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longer receive oxygen and nutrients from the blood or sudden bleeding into or around the brain [2]. The pathological background for stroke may either be ischemic or haemorrhagic disturbances of the cerebral blood circulation.

Ischemic stroke occurs because of a loss of blood supply to part of the brain, initiating the ischemic cascade when a blood vessel supplying blood to your brain gets blocked by a blood clot. Brain tissue ceases to function if deprived of oxygen for more than 60 to 90 seconds. After approximately three hours, will suffer irreversible injury, possibly leading to the death of the tissue, i.e., infarction. Ischemic stroke again classified into Thrombotic and Embolic cerebral infarction [3].

Haemorrhagic stroke occurs from a weakened blood vessel that ruptures and bleeds into the surrounding brain causes a haemorrhagic stroke. The blood accumulates and compresses the surrounding brain tissue. A haemorrhagic stroke occurs when a weakened blood vessel ruptures. Two types of weakened blood vessels usually cause haemorrhagic stroke: aneurysms and arteriovenous malformations (AVMs) [4]

Subarachnoid haemorrhage occurs when blood released into the subarachnoid space, which surrounds the brain and spinal cord. The rupture of aneurysms occurs at the bifurcations of large arteries at the inferior surface of the brain. Symptoms of Subarachnoid haemorrhage include severe headache, nausea, vomiting, neck pain, nuchal rigidity, and photophobia [5].

According to the World Health Organization, 15 million people suffer stroke worldwide each year. Of these, 5 million die, and another 5 million are permanently disabled [6]. Stroke is one of the leading causes of death and disability in India. The estimated adjusted prevalence rate of stroke is 84-262/100,000 in rural areas and 334-424/100,000 in urban areas. The incidence rate is 119-145/100,000 based on the recent population-based studies. These values were higher than those of high-income countries [7].

The gait of Hemiparetic stroke patients characterized by specific spatiotemporal patterns, including decreased cadence, prolonged swing duration on the paretic side, prolonged stance on the non-paretic side, and stride length asymmetry. Low cadence typically found in subjects with stroke. This is because cadence is inversely proportional to the duration of the gait cycle, as the gait cycles phases are abnormally long, thereby contributing to the low cadence and consequent low velocity [9]. Quantitative gait analysis may be useful in monitoring gait performance and functional recovery following stroke. Gait at natural speed of patients control was recorded using the clinical foot print method. This method is easy to apply and inexpensive and suitable for Hemiparetic patients [10].

Various rehabilitation approaches used in post-stroke treatment for improving gait are Body weight supported Treadmill training, Rhythmic Auditory Stimulation, Task-specific training, Dual-task training, Bobath approach, Motor relearning programme, etc.,

Rhythmic-auditory stimulation (RAS) defined as a therapeutic application of pulsed rhythmic or musical stimulation to improve gait or gait-related aspects of the movement mainly works on auditory–motor synchronization in the reticulospinal tract. It has demonstrated that stroke patients can synchronize their gait pattern to auditory stimulation using music. RAS guides the patients to hit the ground with their feet as they walk and simultaneously hear an external auditory cue, synchronizing the time of contact between the foot and ground with the sound, which leads to immediate improvements in stride time, and stride length symmetry as well as weight-bearing time on the paretic side. Recently, RAS has clinically applied as a therapeutic intervention to improve the upper and lower extremity functions in patients with various neurological diseases [11].

Task -oriented Circuit training consists of exercises performed in successive stations with a predetermined number either of repetitions or for a set duration with varying amounts of rest between each exercise [12].

II. MATERIALS AND METHODS

RESEARCH DESIGN: Quasi experimental design.
STUDY POPULATION: Subjects with difficulty in walking ability after stroke.
STUDY SETTING: Subjects were recruited from the Department of physiotherapy, Neurology department, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, India.
STUDY DURATION: The study was conducted during the period between July 2020 to June 2021.
INTERVENTION DURATION: 6 weeks
TREATMENT DURATION: 1 hour a day, 5 days a week for 6 weeks.

SAMPLING DESIGN: Convenient sampling.
STUDY SAMPLE: A total number of 68 patients, both men and women suffering from gait abnormality due to Hemiparetic stroke and who are willing to participate in the study, were included. In addition, as per the study, 64 subjects met the criteria, and after obtaining the consent forms, the 64subjects were allocated into two groups by convenient sampling, and 4 subjects were dropped out from the study 2 from each group.

Two groups: GROUP-A: 30 patients, GROUP-B: 30 patients.
GROUP-A: Rhythmic Auditory Stimulation + Conventional Physiotherapy.
GROUP-B: Task-Oriented Circuit Training + Conventional Physiotherapy.
OUTCOME MEASURES:
Gait Parameters: Gait parameters measured are Stride length, Cadence, and Velocity.
10METERS WALK TEST

ISSN No:-2456-2165

INCLUSION CRITERIA:
First episode single stroke
40 to 60 years of age
Stroke duration less than 3 months
Subjects who can walk more than 10 metres with or without support of lower limb orthosis
Ability to distinguish auditory stimuli

EXCLUSION CRITERIA:
Amputation of lower limb
Orthostatic hypotension
Uncontrolled medical problems, which can affect vital signs
Hearing problems even with hearing aids
Cognitive impairment
Global Aphasia
Cardiac Arrhythmias

MATERIALS USED IN THE STUDY:
Ink
Bluetooth speaker
14mtr paper roll
Scale
Measuring Tape
Marker
Treadmill
Cycle Ergometer
Stopwatch

PROCEDURE

68 subjects were included in the study with 8 dropouts, 4 not meeting the criteria and 2 from rhythmic auditory stimulation, and 2 from task-oriented circuit training. A Total number of 60 subjects with hemiparesis taken by convenient sampling. All the subjects has explained about their condition and mode of assessment, and written informed consent obtained from them. They were allocated into Group-A and Group-B.

GROUP A (RHYTHMIC AUDITORY STIMULATION):

The group subject's gait parameters measured before intervention. In RAS intervention, the initial pace of the subjects measured by playing the rhythmic cues familiar to the subjects ranging from 40 to 100 beats per minute. The identified pace of RAS has chosen to match each individual's original and increased cadence. The RAS training consisted of following steps.

The initial step consisted of a 5meters warm-up bare foot walk, a 3 minutes-rest, followed by a 10-meter walk with preferred walking speed according to subjects endurance level without rhythm cue. The second step of gait training consisted of the 2 minutes-rest, 1-minute toe tapping to the RAS, followed by 10 meter-walk with the rhythm cue provided in the tempo of the participant's cadence. The third and fourth steps of gait training executed in a similar way, except the cadence was provided with an increase of 5% and 10% respectively for each step with RAS [43].After the four steps the subject is advised to sit and discontinue RAS.

RAS sessions executed for 5 times a week for 6 weeks.

GROUP B (TASK-ORIENTED CIRCUIT TRAINING):

The group subject's gait parameters measured before intervention. The Task-oriented circuit training consists of five exercises divided into five circuits. The exercise circuit aimed to strengthen the muscles in the affected leg for practice of locomotor related tasks. The exercises included in the circuit are treadmill walking, squatting, straight leg raise (SLR), stair walking, and cycling.

Circuit 1 – consists of Treadmill walking for 3 minutes with a speed of 0.9 km/h , Circuit 2 – consists of 1 set of squatting exercises with 15 repetitions per minute , Circuit 3 – consists of 1 set of Straight Leg Raise exercise with10 repetitions per minute, Circuit 4 – consists of Stair walking exercise for 3 minutes, Circuit 5 – consists of Cycling for 3 minutes.

Each circuit was performed twice per session and intensity targeted between 10 (light) and 15 (hard or heavy) of Borg's scale of rating of perceived exertion (RPE). Each circuit should start at a light intensity at the beginning and hard intensity towards the end of the session. The speed of the treadmill starts with 0.9 km/h and later progress to 3. Km/h, the speed of cycling and resistance should increase gradually, number of repetitions of squatting, straight leg raise and duration of stair walking adjusted according to the training intensity [44].

Task oriented circuit training was given three times per week for six weeks.

CONVENTIONAL PHYSIOTHERAPY:

Conventional physiotherapy program consists of stretching, strengthening exercises, balance exercises, coordination exercises; range of motion exercises, and over ground practice given for both Groups.

The subject's gait parameters were reassured after 6 weeks of treatment for both groups and served as a reference for determining the effectiveness of treatment.

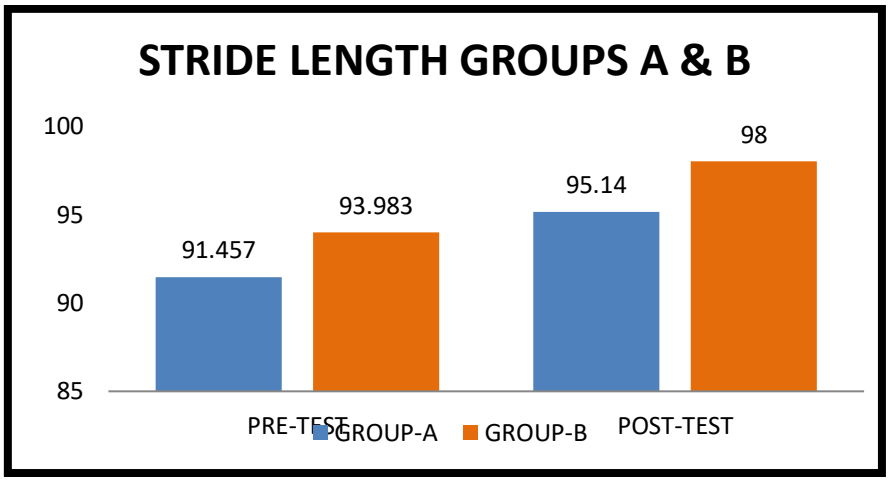
ISSN No:-2456-2165

III. DATA ANALYSIS & RESULTS

TABLE – 1: ANALYSIS OF PRE-TEST AND POST-TEST MEAN VALUE OF STRIDE LENGTH BETWEEN GROUP-A AND GROUP-B.

GROUPS	Stride length	N	Mean	SD	SEM	P value
GROUP-A	PRE-TEST	30	91.457	6.6081	1.2065	0.070
GROUP-B	PRE-TEST	30	93.983	6.4686	1.181	
GROUP-A	POST-TEST	30	95.14	7.0455	1.2863	0.043
GROUP-B	POST-TEST	30	98	6.3473	1.1589	

GRAPH -1: PRE-TEST AND POST-TEST MEAN VALUES OF STRIDE LENGTH BETWEEN GROUP-A AND GROUP-B

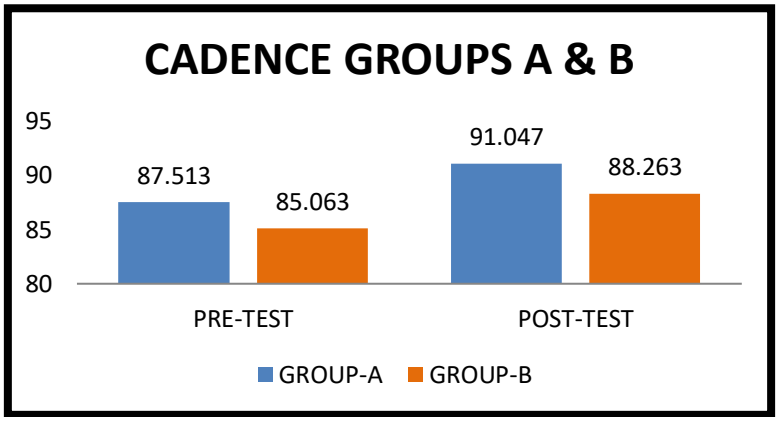


RESULTS: The above Table and Graph shows improvement in stride length in both groups A and B. Significant improvement is seen in group A.

TABLE– 2: ANALYSIS OF PRE-TEST AND POST-TEST MEAN VALUE OFCADENCE BETWEEN GROUP-A AND GROUP-B

GROUPS	Cadence	N	Mean	SD	SEM	P value
GROUP-A	PRE-TEST	30	87.513	5.5134	1.0066	0.042
GROUP-B	PRE-TEST	30	85.063	5.2431	0.9573	
GROUP-A	POST-TEST	30	91.047	4.1496	0.7576	0.000
GROUP-B	POST-TEST	30	88.263	4.9113	0.8967	

GRAPH-2: PRE-TEST AND POST-TEST MEAN VALUE OF CADENCE BETWEEN GROUP-A AND GROUP-B.



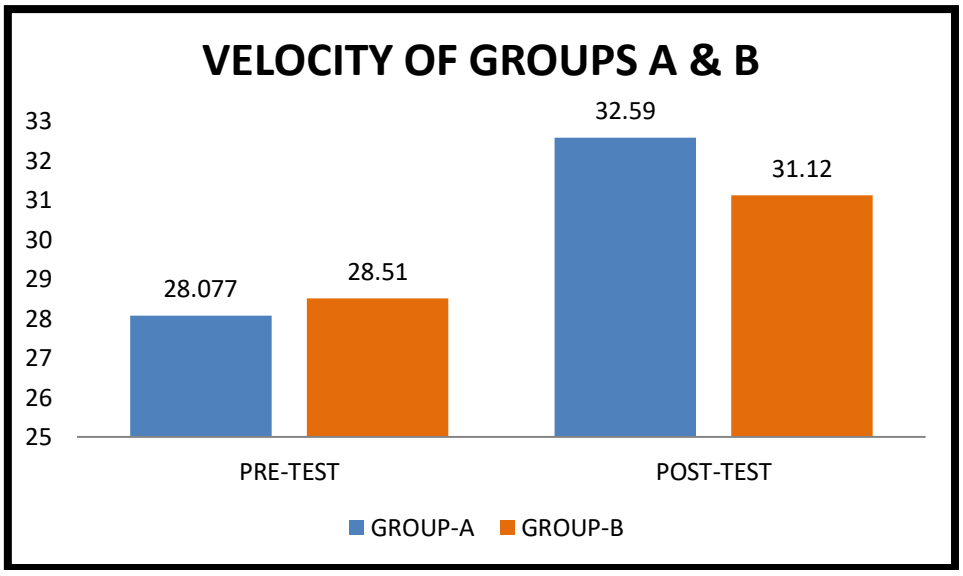
RESULTS: The above Table and Graph shows improvement in cadence in both groups A and B. Significant improvement is seen in group A.

ISSN No:-2456-2165

TABLE – 3: ANALYSIS OF PRE-TEST AND POST-TEST MEAN VALUE OF VELOCITY BETWEEN GROUP-A AND GROUP – B

GROUPS	10meter walk test	N	Mean	SD	SEM	P value
GROUP-A	PRE-TEST	30	28.077	3.3949	0.6198	0.304
GROUP-B	PRE-TEST	30	28.51	3.1021	0.5664	
GROUP-A	POST-TEST	30	32.59	0.501	0.0915	0.000
GROUP-B	POST-TEST	30	31.12	0.4408	0.0805	

GRAPH-3: PRE-TEST AND POST-TEST MEAN VALUE OF VELOCITY BETWEEN GROUP-A AND GROUP-B.

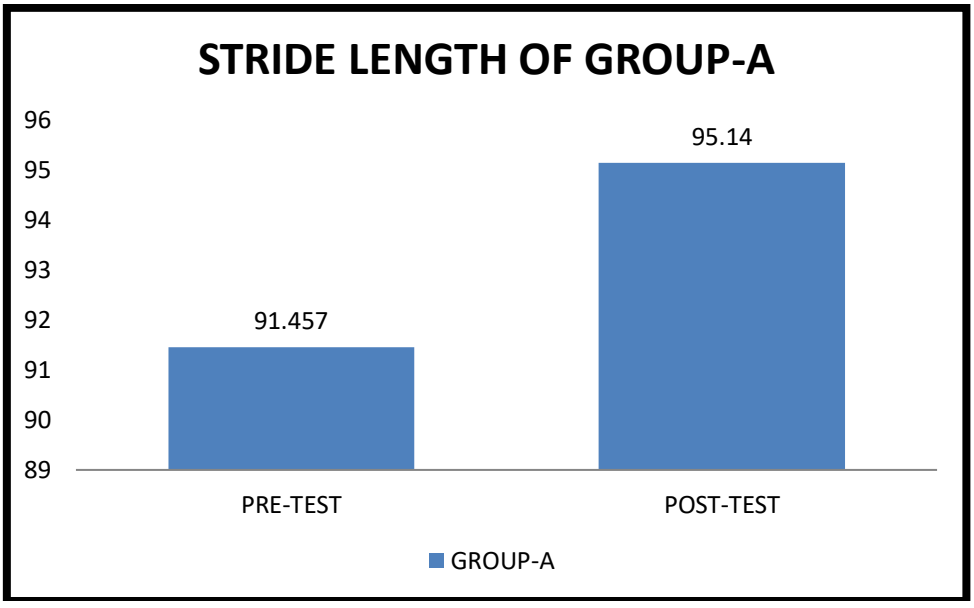


RESULTS: The above Table and Graph shows improvement in velocity in both groups A and B. Significant improvement is seen in group A.

TABLE – 4: ANALYSIS OF PRETEST AND POST TEST MEAN VALUE OF STRIDE LENGTH IN GROUP-A

		N	Mean	SD	SEM	p-value
STRIDE LENGTH	PRE-TEST	30	91.457	1.2065	30	0.000
	POST-TEST	30	95.14	1.1745	30	

GRAPH-4: PRE-TEST AND POST-TEST MEAN VALUE OF STRIDE LENGTH IN GROUP-A



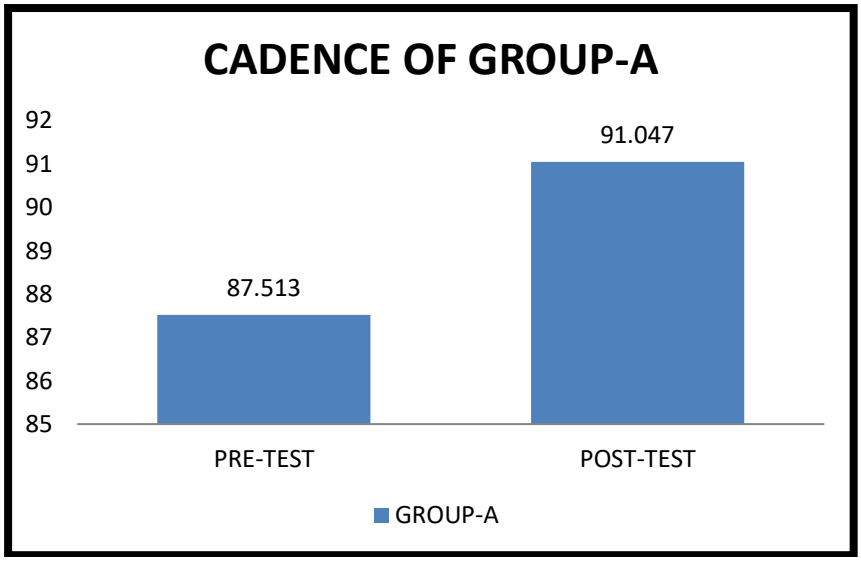
ISSN No:-2456-2165

RESULTS: The above Table and Graph shows improvement of stride length in Group-A. There is a significant improvement within the group.

TABLE – 5: ANALYSIS OF PRE-TEST AND POST TEST MEAN VALUE OF CADENCE IN GROUP-A

		Mean	N	SD	SEM	p-value
CADENCE	PRETEST	87.513	30	5.5134	1.0066	0.000
	POST TEST	91.047	30	5.4354	0.9924	

GRAPH-5: PRE-TEST AND POST-TEST MEAN VALUE OF CADENCE IN GROUP-A

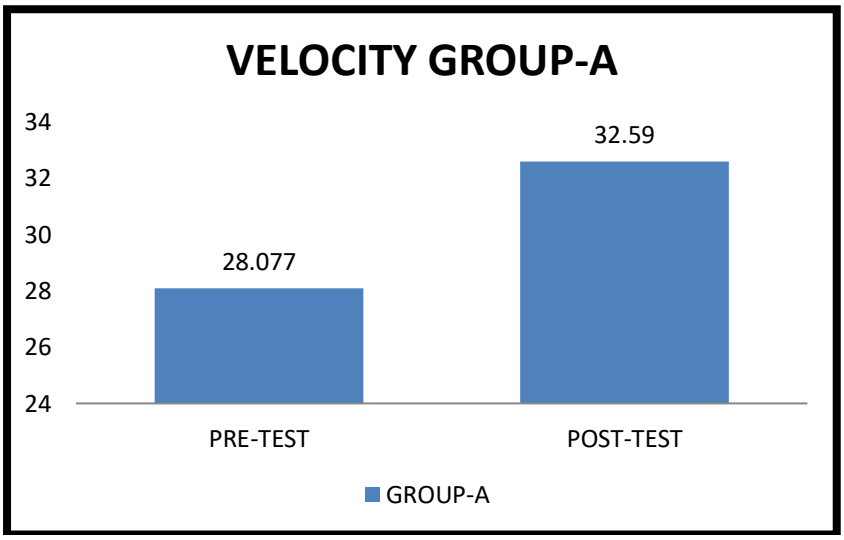


RESULTS: The above Table and Graph shows improvement of cadence in Group-A. There is a significant improvement within the group.

TABLE – 6: ANALYSIS OF PRE & POST TEST MEAN VALUE OF VELOCITY IN GROUP- A

		Mean	N	SD	SEM	p-value
VELOCITY	PRE TEST	28.077	30	3.3949	0.6198	0.000
	POST TEST	32.59	30	3.4478	0.6295	

GRAPH-6: PRE-TEST AND POST-TEST MEAN VALUE OF VELOCITY IN GROUP-A



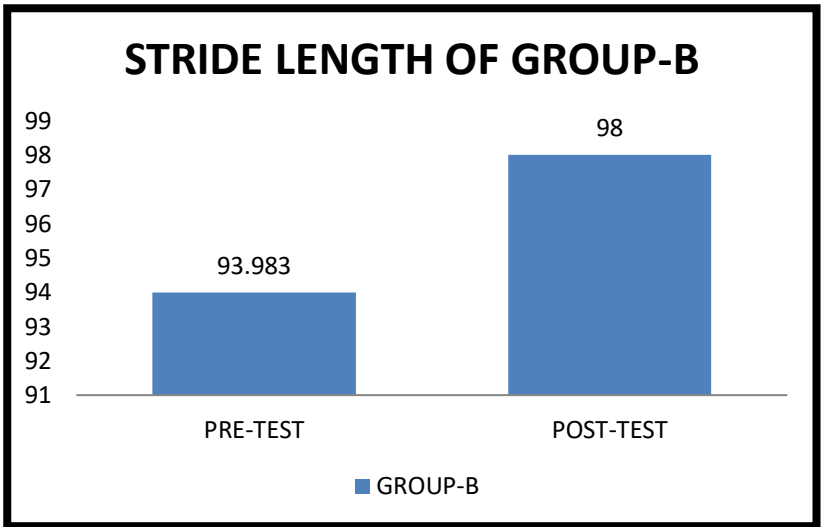
RESULTS: The above Table and Graph shows improvement of velocity in Group-A. There is a significant improvement within the group.

ISSN No:-2456-2165

TABLE – 7: ANALYSIS OF PRETESTAND POST TEST MEAN VALUE OF STRIDE LENGTH IN GROUP-B

		Mean	N	SD	SEM	p-value
STRIDE LENGTH	PRE-TEST	93.983	30	6.4686	1.181	0.000
	POST TEST	98	30	6.275	1.1457	

GRAPH-7: PRE-TEST AND POST-TEST MEAN VALUE OF STRIDE LENGTH IN GROUP-B

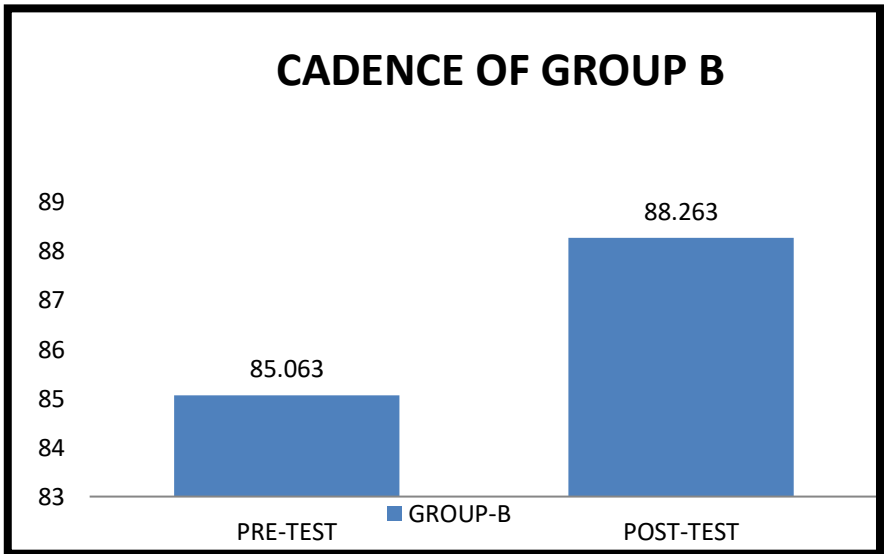


RESULTS: The above Table and Graph shows improvement of stride length in Group-B. There is a significant improvement within the group.

TABLE – 8: ANALYSIS OF PRE TEST AND POST TEST MEAN VALUE OF CADENCE IN GROUP-B

		Mean	N	SD	SEM	p-value
CADENCE	PRE TEST	85.063	30	5.2431	0.9573	0.000
	POST TEST	88.263	30	5.2651	0.9613	

GRAPH-8: PRE-TEST AND POST-TEST MEAN VALUE OF CADENCE IN GROUP-B



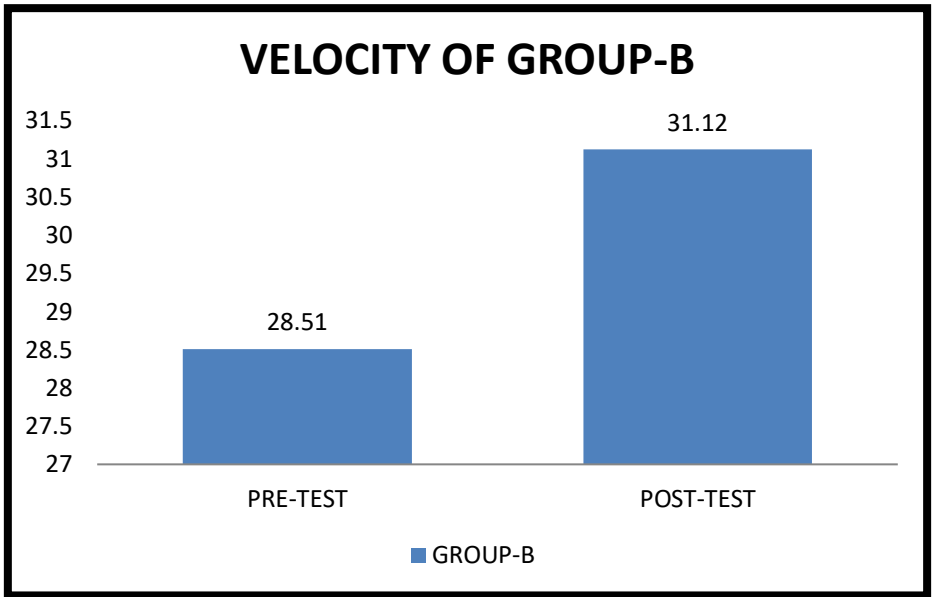
RESULTS: The above Table and Graph shows improvement of cadence in Group-B. There is a significant improvement within the group.

TABLE – 9: ANALYSIS OF PRE-TEST AND POST TEST MEAN VALUE OF VELOCITY IN GROUP-B

		Mean	N	SD	SEM	p-value
VELOCITY	PRE TEST	28.51	30	3.1021	0.5664	0.000
	POST TEST	31.12	30	3.0872	0.5636	

ISSN No:-2456-2165

GRAPH-9: PRE-TEST AND POST-TEST MEAN VALUE OF VELOCITY IN GROUP-B



RESULTS: The above Table and Graph shows improvement of velocity in Group-B. There is a significant improvement within the group.

IV. DISCUSSION

Stroke is among the commonest causes of adult-onset disability. Six months after the stroke, only 50% of the patients achieve functional independence in ADLs and can walk short distances. However, recovery of walking ability is incomplete. So, the goals of physiotherapy interventions should be aimed at improving the walking ability for long distances, which is crucial for community ambulation.

In research studies over the past 10 years, exercise and rehabilitation strategies to improve walking ability have become more intensive and progressive, like rhythmic auditory stimulation, task-oriented circuit training, dual-task exercises, etc. The above-mentioned interventions attained Gains in walking ability within 3 months of stroke.

Although they are many studies on both the techniques individually which showed improvements in gait parameters, this is the first study to compare the Rhythmic Auditory Stimulation and Task-Oriented Circuit Training. A total of 68 subjects were included in the study, with 4 not meeting the inclusion criteria and 4 dropouts 2 from the Rhythmic Auditory Stimulation and 2 from the Task-Oriented Circuit Training. The gait parameters measured in the study were stride length, cadence, and velocity and were assessed with the Ink foot method using a 10-meter walkway.

There was statistically significant improvement in stride length (p=0.000), cadence (p=0.000), and velocity (p=0.000) in pre and post-test values within the Rhythmic Auditory Stimulation group (RAS). The underlying Neurological mechanism behind Rhythmic Auditory Stimulation may be that exposure to external rhythmic cues leads to internal unconscious perceptual shaping at the subcortical level that causes excitability of spinal motor neurons mediated by auditory-motor circuitry at the reticulospinal pathway. Which in turn synchronizes and regulates the phase and period of movement pattern such as gait43. Thus, changes in stride length, cadence, and velocity were noted in group A with Rhythmic Auditory Stimulation.

In a previous study that was done by Thaut. et al. 2009, stated that a significant increase in gait velocity was noted in post-stroke patients after 5 weeks of Rhythmic Auditory Stimulation, in which Gait velocity and walking speed increased by 36.5%.

In another study done by Dragon et al., Rhythmic Auditory Stimulation training showed a positive effect on gait training in cerebral palsy children in which children responded positively in their gait to tempo cues imbedded in the musical rhythm.

Task-oriented circuit training is one of the effective and evidence-based training for improving walking ability and balance. The results of the study showed a statistically significant improvement in stride length (p=0.000), cadence (p=0.000), and velocity (p=0.000) in pre and post-test values within the Task-Oriented Circuit Training group. The explanation for this phenomenon is that task-oriented circuit training, which consists of higher-level motor tasks and aerobic exercises that will lead to improvements in muscle strength and endurance of lower limb muscles, improved cardio-respiratory functions, speed, Neuromuscular control, and coordination, which in turn increases walking ability [44].

In a controlled pilot study conducted by Dean et al .(2000) revealed that Task-Oriented Circuit Training improved gait speed, walking distance in patients with chronic stroke.

Van de port et al. (2012) suggested that Task-Oriented Circuit Training is a safe and effective method for improving community ambulation after stroke.

Therefore, based on the analysis of the present study, both Rhythmic Auditory Stimulation and Task-Oriented Circuit Training, along with conventional physiotherapy, helps in improving walking ability and community ambulation among hemiparetic patients. But Rhythmic Auditory Stimulation showed some superior results when compared with Task-Oriented Circuit Training. As there is a significant difference between the two groups in stride length (p=0.043), cadence (p=0.000), and velocity (p=0.000) and my study accepted an alternate hypothesis.

My study findings suggest that adding Rhythmic Auditory Stimulation along with conventional physiotherapy will significantly improve the walking ability in hemiparetic stroke patients.

LIMITATIONS
Long term effects were not analyzed
Small study sample
No blinding of evaluators of outcome was done
The sampling method used was convenient sampling, which would have resulted in sampling error.

RECOMMENDATIONS FOR FURTHER RESEARCH
There is a need to compare the effects on gender difference.
Inclusion of any other valid and reliable advanced gait assessment methods, as ambulation requires multiple domains.
The mechanism of effect of Rhythmic Auditory Stimulation requires more study for further reference.

V. CONCLUSION

This study concludes that both Rhythmic Auditory Stimulation and Task-Oriented Circuit Training can be used as effective treatment methods for improving gait parameters among hemiparetic patients. However, Rhythmic Auditory Stimulation is superior to Task-Oriented Circuit Training on improving walking ability in hemiparetic stroke.

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