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Comparison of Gyroscope Based Functional Electrical Stimulation Versus Ankle Foot Orthosis with Electrical Stimulation on Improving Muscle Performance and Gait in Post Stroke Subjects

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Abstract:-

➢ ***Background and Objective:***

Foot drop is a common complication of a stroke which can impede participation in rehabilitation and has been associated with poor outcomes. Gyroscope based functional electrical stimulation is one of the adjunct treatments of choice. The objective of this study was to compare the effect of Gyroscope based FES versus Ankle foot orthosis with Electrical stimulation for improving muscle performance and gait in post stroke subjects.

➢ ***Methods:***

Quasi experimental study design. 112 subjects with mean age of 58 years having a clinical diagnosis of stroke were allocated into two groups by using convenience sampling method. In Group A (n=56) were treated with Gyroscope based Functional Electrical Stimulation along with Standard rehabilitation program, whereas in Group B (n=56) subjects were treated by Ankle foot orthosis with Electrical Stimulation along with standard rehabilitation program. Participants were given intervention for five times a week for 6 weeks. The universal goniometer, pheezee and Tug were used to assess the intervention effectiveness.

➢ ***Results:***

Independent ‘‘t’’ test was used to compare the mean significance difference between continuous variables. Paired ‘‘t’’ test was used to assess the statistical significance difference between pre and post test scores. Statistical analysis of this data revealed that both groups showed significant improvement in parameters when compared within groups, where as in between groups comparison Gyroscope based functional electrical stimulation along with standard rehabilitation program showed better improvement compared to Ankle foot orthosis with Electrical stimulation along with standard rehabilitation program.

➢ ***Conclusion:***

In six weeks of intervention, both groups were shown statistically significant improvement in post-test values. However Gyroscope based functional electrical stimulation along with standard rehabilitation program was more effective when compared to Ankle foot orthosis with Electrical stimulation along with standard rehabilitation program. Hence treatment intervention may be incorporated in management of post stroke.

Keywords:- *Ankle Foot Orthosis, Electrical Stimulation, Gyroscope based Functional Electrical Stimulation, Post Stroke, Pheezee, Timed up and go Test and Universal Goniometer.*

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I. INTRODUCTION

Post stroke can significantly impact gait through reduced voluntary movement, decrease in strength and loss of balance. It results in inability to participate in activities such as walking and significantly affects functional performance and quality of life.[1] WHO have estimated 30.7 million people worldwide have survived stroke and reported stroke as third highest cause of disability in adults over 65 years of age.[2] The incidence of stroke ranged from 105 to 152/100,000 persons per year and the crude prevalence of stroke ranged from 44.29 to 559/100,000 persons in various parts of the country during the past decade.[3]

Foot drop is the most common gait abnormality consists of paralysis or significant weakness of ankle dorsiflexor muscles. An estimated 20 to 30 percent of stroke survivors experience foot drop. [4,5] It results in inability to actively, dorsiflex foot during swing phase and failure to achieve heel strike at initial contact that disturbs gait patterns after stroke such as slow walking, reduced foot clearance, high energy expenditure, increases the risk of falls and decreases the individual to function independently.[6]

Physical therapy interventions that are commonly used to treat foot drop includes electrical stimulation, joint mobilization, range of motion exercises, task specific repetitive functional training, muscle strengthening and ankle foot orthosis which have been found to enhance walking efficiency and speed.[7]

During stroke rehabilitation, Electrical stimulation (ES) is a commonly used adjuvant therapy. For motor stimulation in therapeutic rehabilitation, the most commonly used ES is the faradic current, which is a short-duration interrupted direct current with a pulse duration of 0.1-1 milliseconds and a frequency of 50-90 Hz.[8] By employing electrical impulses to stimulate muscles or nerves, electrical stimulation helps to promote voluntary movement. Through synchronous contraction in which every motor unit contracts at the same time it enhances long lasting cortical plasticity and motor recovery. [9]

Ankle foot orthosis (AFO) are commonly used to restore a normal safe walking pattern and to support who have abnormal gait patterns. AFOs come in a variety of forms and are utilized in a range of models, including articulated, non-articulated, rigid, and dynamic. The most often used thigh to hold the foot and ankle in the correct position. [10, 11] In addition it physically stop the foot from dragging during the gait cycle. Its basic process is the application of force required to produce an ankle plantar flexor moment, which permits weight bearing on the foot's distal portion. They were made to support the ankle's mediolateral stability in a variety of stances and to make walking easier during the swing phase of gait cycle. [12]

Functional electrical stimulation (FES) is a device which generates movement in body and delivers the electrical stimulation to activate the muscles during functional tasks. In the swing phase of the gait cycle, it dorsiflexes the ankle and everts the subtalar joint. [13] The orientation of gyroscope based FES moves freely in multiple directions and maintain its orientation. The propulsive force produced at the change from the stance phase to the swing phase of gait is lessened by FES because it reduces knee flexion and ankle plantar flexion at toe off.[14] By encouraging proprioceptive input, it enables more passive and active ankle movement for postural control. It helps to relearn the execution of impaired functions. [15]

Three fundamental components of functional electrical stimulation are first, the individual receiving therapy must attempt the movement and often achieved by asking them to complete a functional motor task. Second, the electrical stimulation facilitates the practiced task producing the motor response. Third, therapist guides the limb in motion to ensure the correctness and quality of movement. Repeated movement and the sensory feedback from the FES assisted movement produce changes that lead to restoration of voluntary movement function the motor response. [16]

There are numerous studies have been available on FES by using four channel FES, dual channel, FES and tilt sensors but there is limited literature available on Gyroscope based FES. The advanced system has been designed by integrating a wearable sensor set for stimulating the muscles and they use bio signals for controlling the stimulator. Moreover, there are various studies available on comparison of functional electrical stimulation and ankle foot orthosis in foot drop patients but lacks a comparison of functional electrical stimulation and electrical stimulation in post stroke. Thus the main idea of the study was to compare Gyroscope based functional electrical stimulation and Ankle foot orthosis with Electrical stimulation in post stroke.

II. MATERIALS AND METHODS

- *Study Design :*
  Quasi experimental study design

- *Ethical Clearance and Informed Consent:*
  This study protocol was approved by the Ethical committee of GSL Medical College & General Hospital; the investigator explained the purpose of the study and given the patient information sheet. The participants were requested to provide their consent to participate in the study. All the participants signed the informed consent and the rights of the included participants have been secured.

- *Study Population:*
  Post stroke subjects with foot drop

- *Study Setting :*
  The study was conducted at Department of physiotherapy, GSL General Hospital, Rajahmundry, Andhra Pradesh, India.

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➢ *Study Duration:*
The study was conducted during the period of one year

➢ *Intervention Duration:*
30 sessions, 5 days per week for 6 weeks, 30 minutes

➢ *Sampling Method:*
Convenience sampling

➢ *Sample Size:*
A total 120 subjects were screened in that 112 subjects were recruited to participate in the study. Recruited participants were explained the purpose of the study and relevance of the study. The participants were included in the study after obtaining informed consent.

- *Group A-*
Gyroscope based Functional Electrical Stimulation along with Standard Rehabilitation (56 subjects)

- *Group B-*
Ankle foot orthosis with Electrical Stimulation along with Standard Rehabilitation (56 subjects)

➢ *Materials used*

- Functional electrical stimulation
- Straps with sensor and electrodes
- Personal computer
- Ankle foot orthosis
- Electrical stimulator
- Universal Goniometer
- Pheezee

➢ *Criteria for Sample Selection*

- *Inclusion Criteria*

✓ Unilateral foot drop with hemiparesis
✓ Ability to walk with or without assistance for at least 10 meters
✓ At least 3 months after onset of stroke
✓ Mini Mental State Examination >24

- *Exclusion Criteria*

✓ Orthopedic injury to paretic and non-paretic limbs
✓ Motor disability due to a neurological diagnosis other than stroke
✓ Peripheral injury of peroneal nerve or sciatic nerve
✓ Subjects who have ankle dorsiflexion
✓ Allergies or bruises when electrodes placed

➢ *Study Tools and Outcome Measures*

- *Pheezee [17]:*
The muscle activity was used to measure through pheezee. It is a tool for assessing, monitoring and tracking recovery in rehabilitation. The surface EMG electrodes are placed on the particular muscle that is responsible for the motion of the joint and help us to show the electrical activity of muscle. Muscle such as Tibialis Anterior are measured before and after the muscle activity. The muscle activity acquired by the phone app and the data is transferred to the cloud-based server where it further processed and analyzed to understand prognosis in terms of consistency and control of the joint and muscle functions.

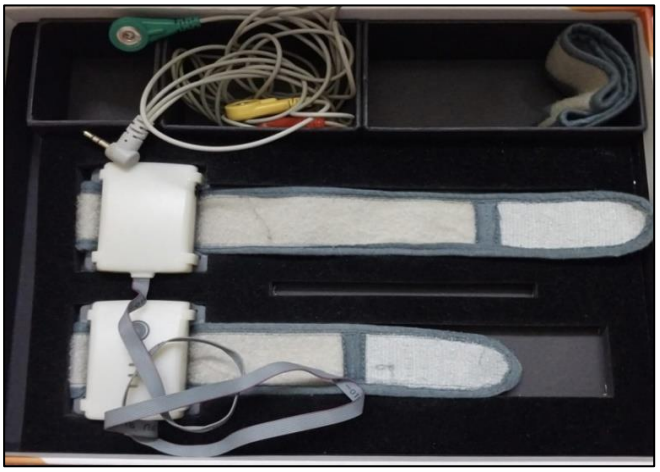

Fig 1 Pheezee Device

- *Universal Goniometer [18]:*
Range of motion (ROM) is measured through universal goniometer. Movements of ankle such as dorsiflexion are measured before and after treatment.

- *Timed up and go Test [19] (Tug):*
Timed up and go test is a simple, quick and widely used clinical performance based measure of lower extremity, function, mobility. It was used for quantifying gait, dynamic balance activities. Time to complete the task is measured with stopwatch. Shorter performance indicates better performance.

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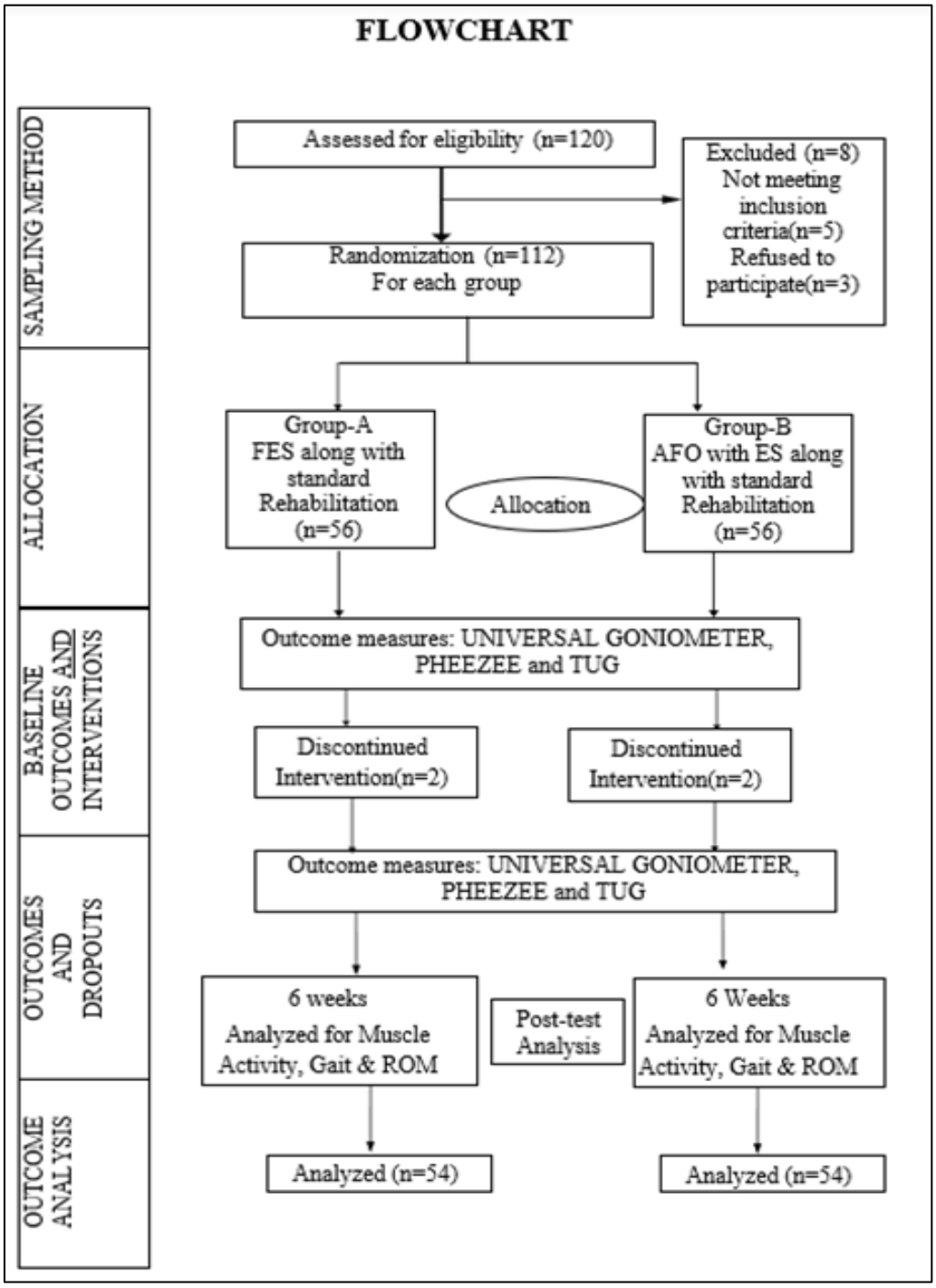

Fig 2 Flow Chart

➢ *Interventions*

The study consisted of 6 weeks of intervention which includes Gyroscope based functional electrical stimulation along with standard rehabilitation program (Group A) and Ankle foot orthosis with Electrical stimulation along with standard rehabilitation program (Group B). Before the commencement of treatment the study was explained individually to the subjects to minimize the learning effect during the course of the study. Baseline measures were taken before the treatment by using universal goniometer, tug and pheezee and post-test measures were taken after 6 weeks ofintervention by using universal goniometer, tug and pheezee.

➢ *Group A: Functional Electrical Stimulation* [16]

In this group A, 56 subjects were screened did baseline evaluation and during 6 weeks of treatment. Subjects received 30 sessions of functional electrical stimulation followed by standard rehabilitation program.

MStim Drop LGT-233 device was utilized to deliver functional electrical stimulation and it is a wearable device consists of wireless inertial sensors attached on the lower limb; the data is transmitted to personal computer and recorded for gait evaluation. The stimulator then sends electrical signals via two surface electrodes. These electrodes were placed over the common peroneal nerve as

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it passes over the head of fibula and motor point of Tibialis anterior slightly lateral to this elicit dorsiflexion and eversion of foot during the swing phase of walking by reducing foot slap produced during the load response phase. The stimulation current with a frequency of 60-80 Hz with a pulse width 0.3 millisecond pulses in the constant mode within the subject's tolerance level. [20]

FES has two training modes such as walking mode and training mode. Depending on the ambulation status the mode was applied. Non-Ambulatory patients were administered FES training mode in 30 min session. When patient started to stand, the mode was changed from Training mode to walking mode. Ambulatory patients were applied FES walking mode in 5-30 min session. It includes gait training in different directions of gait such as side, back and forward stepping.

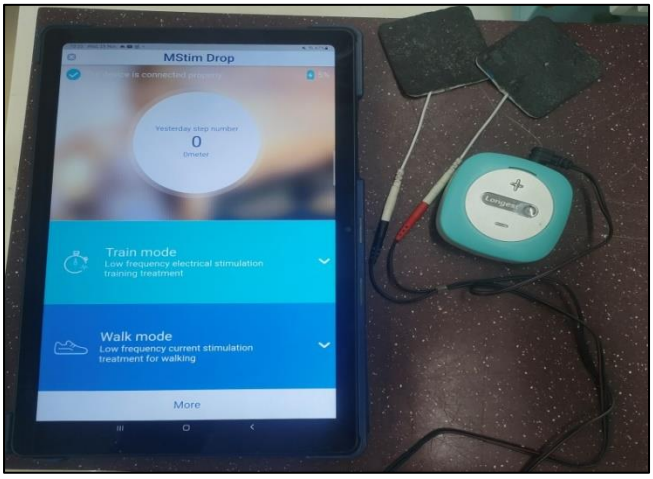

Fig 3 MStim Drop LGT-233 (Gyroscope based FES Device)


Fig 4 Application of Functional Electrical Stimulation while Walking


Fig 5 Functional Electrical Stimulation Delivered during Acceleration Phase


Fig 6 Functional Electrical Stimulation Delivered during Mid-Swing Phase

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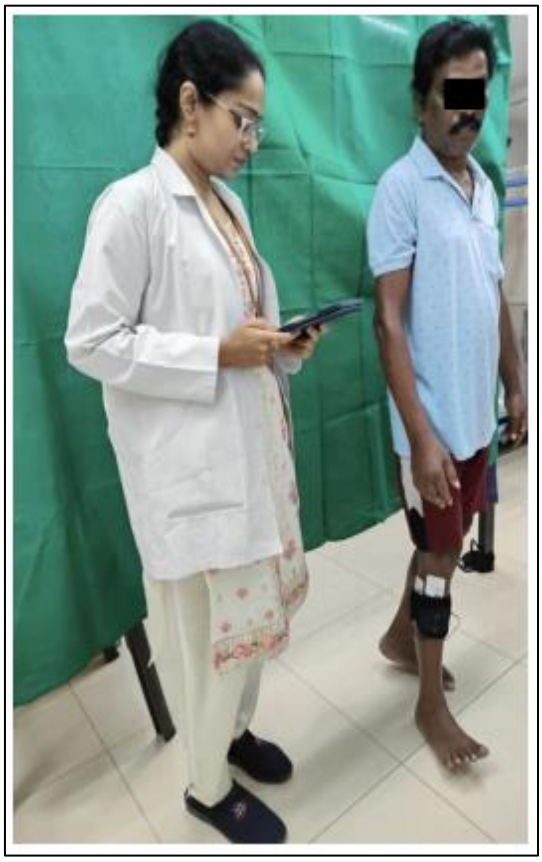

Fig 7 Functional Electrical Stimulation Delivered during Deceleration Phase

Fig 9 Application of Functional Electrical Stimulation during Backward Stepping

Fig 8 Application of Functional Electrical Stimulation during Forward Stepping

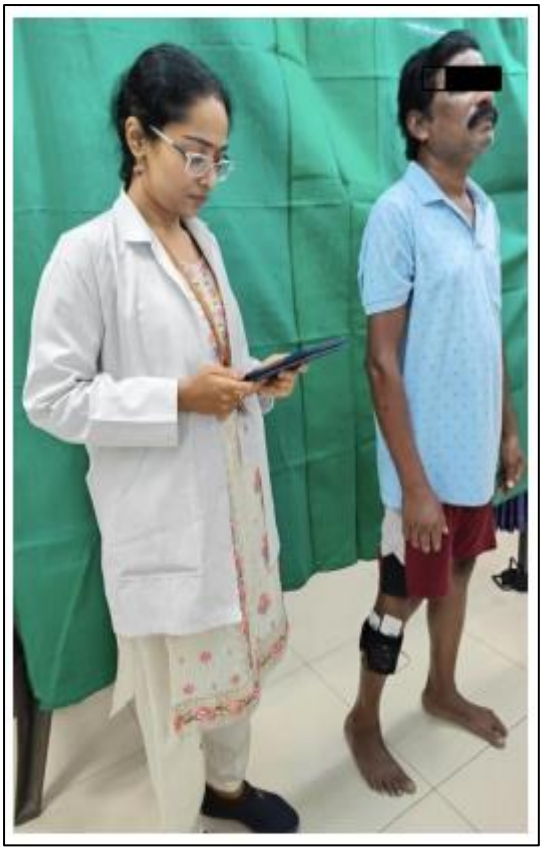

Fig 10 Application of Functional Electrical Stimulation during Side Stepping

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➢ *Group B: Ankle Foot Orthosis with Electrical Stimulation*

In this Group B, 56 subjects were screened and did baseline evaluation, during 6 weeks of treatment the subjects received total 30 sessions, 5 sessions per week for 30 minutes per day. The Group B received AFO with ES along standard rehabilitation program. Thermoplastic solid ankle foot orthosis is the most commonly used and places the foot in a dorsiflexed or neutral position throughout the gait cycle. AFOs were personally fitted to each subject according to plaster model of the leg prepared by skilled orthotist. When the subjects achieved the ability to safely and consistently walk with no physical assistance during the sessions then AFO is encouraged to the subject during the day and not just during the sessions. It allowed for ongoing practice and provided for home usage until the end of the study. [20]

Fig 11 Thermoplastic Solid Ankle AFO Encouraged while Walking

The Electrostim-Dt was utilized to deliver electrical stimulation therapy. Subjects received ES in supine position for 10 minutes. The anode was placed over the common peroneal nerve and cathode over the point of tibialis anterior. ES was delivered with frequency 100Hz (pulse duration 0.1ms, pulse interval 0.9ms) in surge mode (surge duration 4s and rest between surge 6s) and applied for 10 minutes. The intensity of current was adjusted to produce muscle contraction within participant's tolerance level. They were not asked to voluntarily contract the muscle during application of currents as it may enhance flexor synergy and spastic co-contraction. The participants were asked to inform the therapist if they feel any discomfort during treatment. [29]

Fig 12 Application of Electrical Stimulation to Tibialis Anterior Muscle

➢ *Standard Rehabilitation Program*

Both groups received Standard rehabilitation program along with the intervention. The standard rehabilitation program includes lower leg specific exercises. [31]. It includes lower leg specific exercises such as

- Weight bearing exercise on the affected leg
- Stepping up exercise with the affected leg
- Heel lifts from dorsiflexed position
- Standing from a chair

Fig 13 Subject is Performing Weight bearing Exercise with the Affected Leg under Supervision of the Therapist

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Fig 14 Subject is Performing Stepping up Exercise with the Affected Leg under Supervision of Therapist

Fig 15 Heel Lifts from Dorsiflexed Position

Fig 16 Standing from a Chair under the Supervision of Therapist

III. STATISTICAL ANALYSIS

All statistical analysis was done by using SPSS version 21.0 and Microsoft Excel 2007. Descriptive statistical data was presented in the form of mean +/- standard deviation and mean differences, percentages were calculated and presented.

- *Within the Groups:*

Paired student "t" test was performed to assess the statistical difference within the group for muscle activity, ankle dorsiflexion ROM and gait form pre-test and post-test values in post stroke.

- *Between the Groups:*

Independent student "t" test was performed to assess the statistical difference in mean value between the groups for Pheezee for muscle activity, Universal Goniometer for ankle dorsiflexion ROM and Timed up and go test for gait.

- *For all Statistical Analysis $p \leq 0.05$ was Considered as Statistically Significant.*

IV. RESULTS

The aim of the study was to compare Gyroscope based functional electrical stimulation along with standard rehabilitation program versus Ankle foot orthosis with Electrical stimulation along with standard rehabilitation program for improving muscle performance, gait and range of motion in post stroke subjects. The consort flow chart of the study showed the study organization in terms of subjects screening, random allocation and analysis following the intervention.

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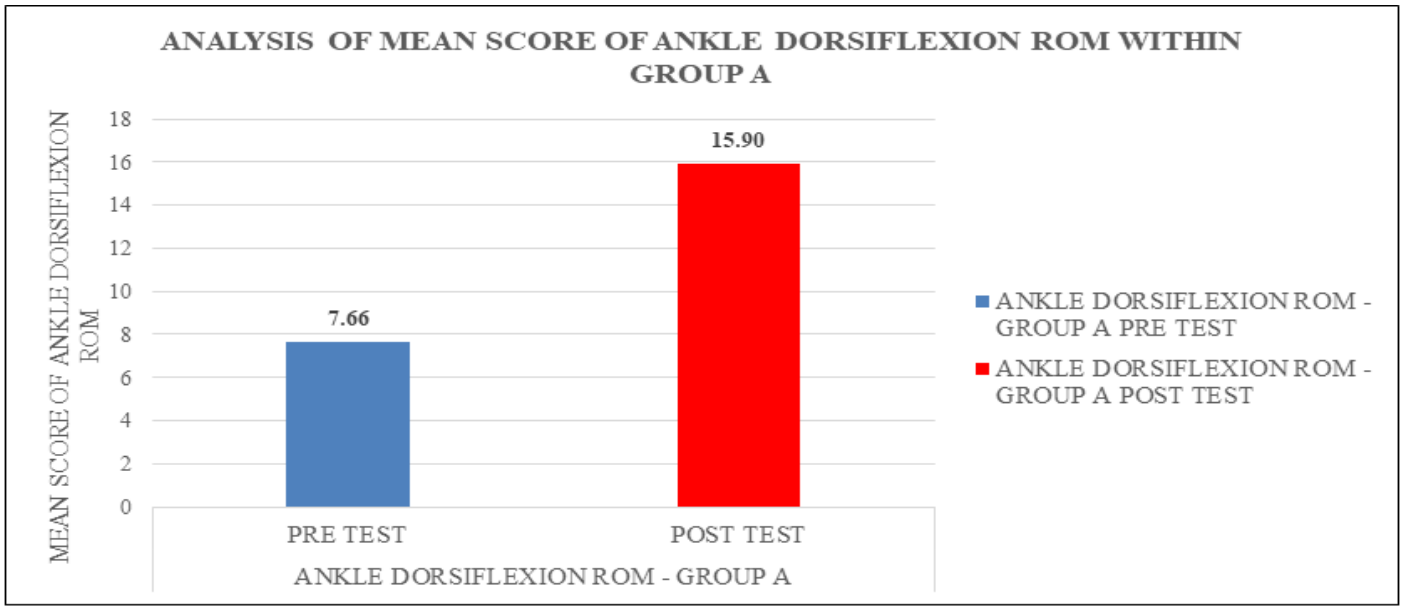
A total of 120 subjects were screened for eligibility, 112 subjects were included in the study trial they underwent baseline assessment and the subjects who met the inclusion criteria were randomized into two groups.

In this study 54 subjects completed training in group A and 54 subjects completed training in group B. With dropouts of 2 in respective groups. The results showed that there is a statistical significance in two groups.

➢ *Analysis of Mean Score of Ankle Dorsiflexion Rom Within Group A*

Table 1 Analysis of Mean Score of Ankle Dorsiflexion Rom within Group A

GROUP A		MEAN	SD	P VALUE	INFERENCE
ANKLE DORSIFLEXION ROM	PRE TEST	7.66	1.34	0.001	Highly Significant
	POST TEST	15.90	1.70		

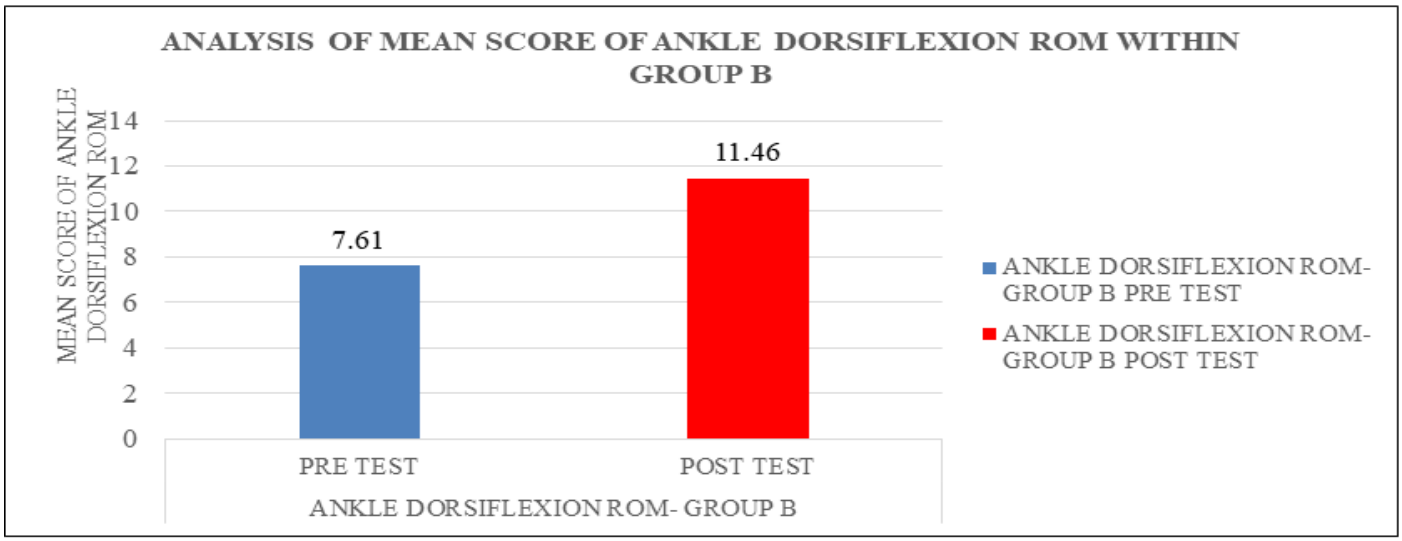


Graph 1 Analysis of Mean Score of Ankle Dorsiflexion Rom within Group A

➢ *Analysis of Mean Score of Ankle Dorsiflexion Rom within Group B*

Table 2 Analysis of Mean Score of Ankle Dorsiflexion Rom within Group B

GROUP B		MEAN	SD	P VALUE	INFERENCE
ANKLE DORSIFLEXION ROM	PRE TEST	7.61	1.36	0.001	Highly Significant
	POST TEST	11.46	1.67		



Graph 2 Analysis of Mean Score of Ankle Dorsiflexion Rom within Group B

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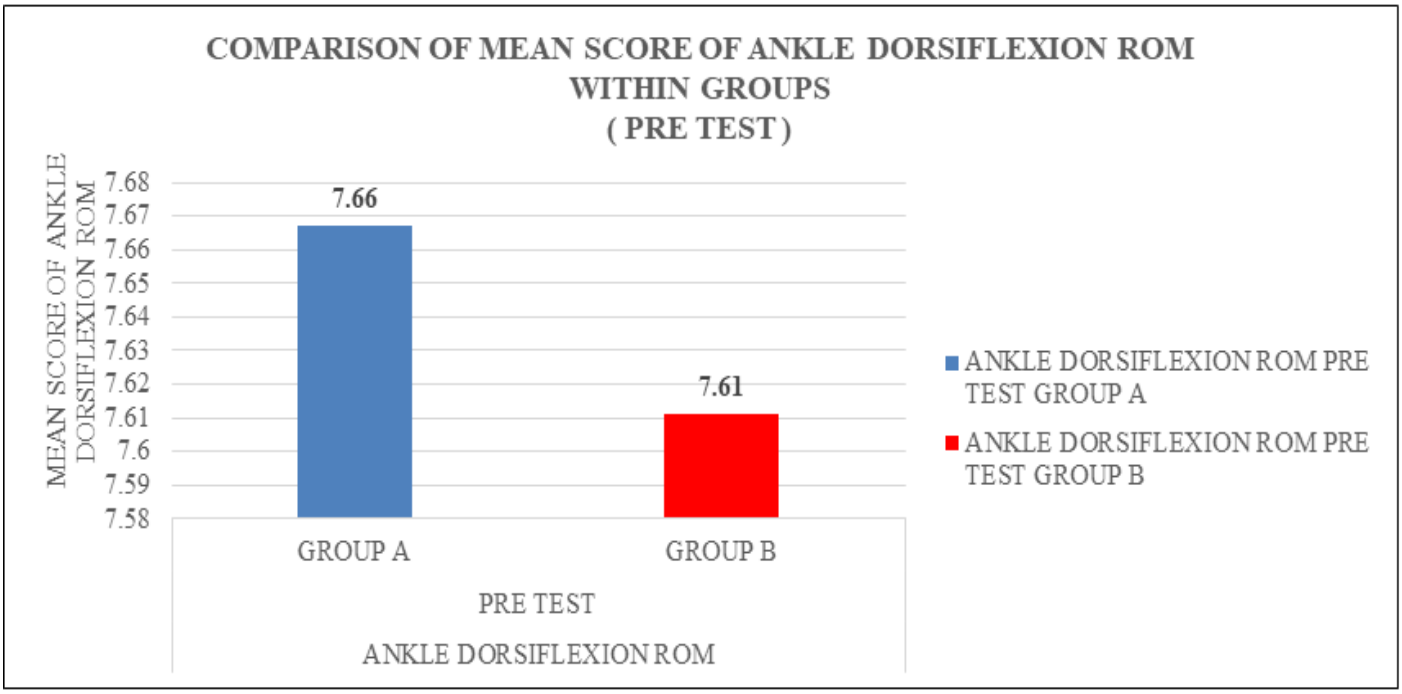
➢ *Comparison of Mean Score of Ankle Dorsiflexion Rom in between the Groups (Pre Test)*

Table 3 Comparison of Mean Score of Ankle Dorsiflexion Rom in between the Groups (Pre Test)

GROUPS		MEAN	SD	P VALUE	INFERENCE
ANKLE DORSIFLEXION ROM PRE TEST	GROUP A	7.66	1.34	0.832	Insignificant
	GROUP B	7.61	1.36		

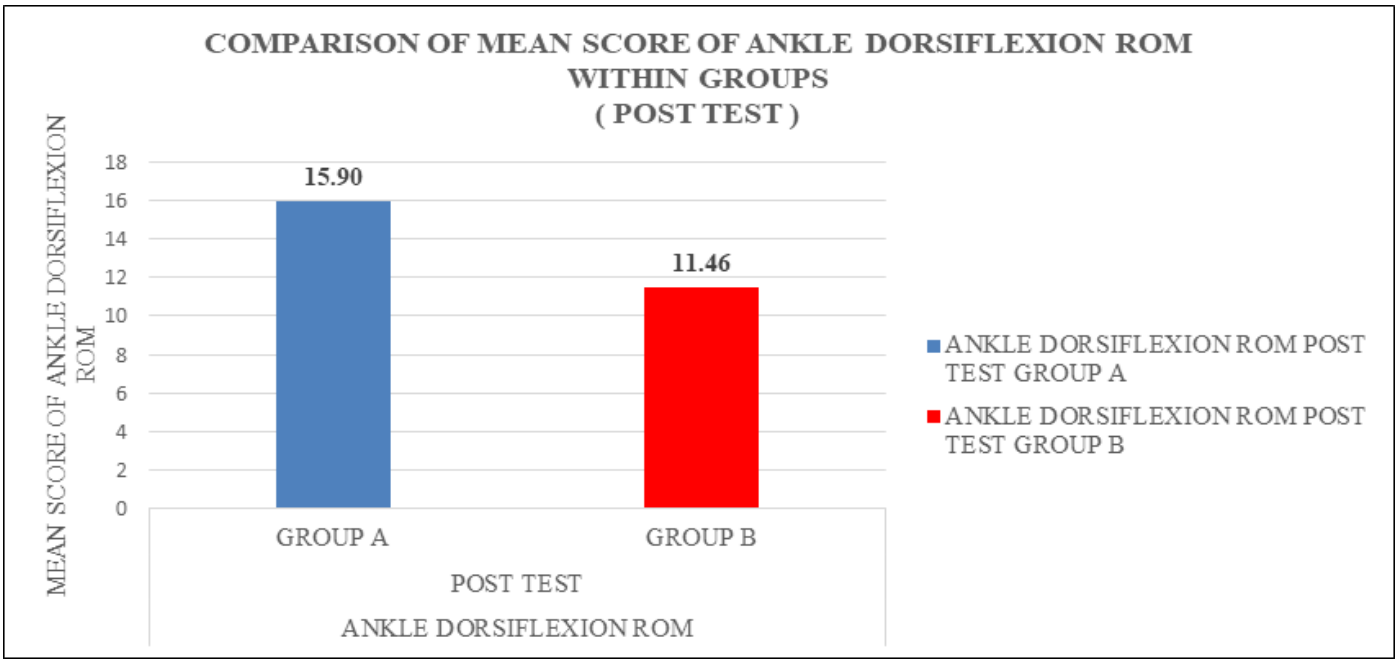


Graph 3 Comparison of Mean Score of Ankle Dorsiflexion Rom in between the Groups (Pre Test)

➢ *Comparison of Mean Score of Ankle Dorsiflexion Rom in between the Groups (Post Test)*

Table 4 Comparison of Mean Score of Ankle Dorsiflexion Rom in between the Groups (Post Test)

GROUPS		MEAN	SD	P VALUE	INFERENCE
ANKLE DORSIFLEXIONROM POST TEST	GROUP A	15.90	1.70	0.001	Highly Significant
	GROUP B	11.46	1.67		



Graph 4 Comparison of Mean Score of Ankle Dorsiflexion Rom in between the Groups (Post Test)

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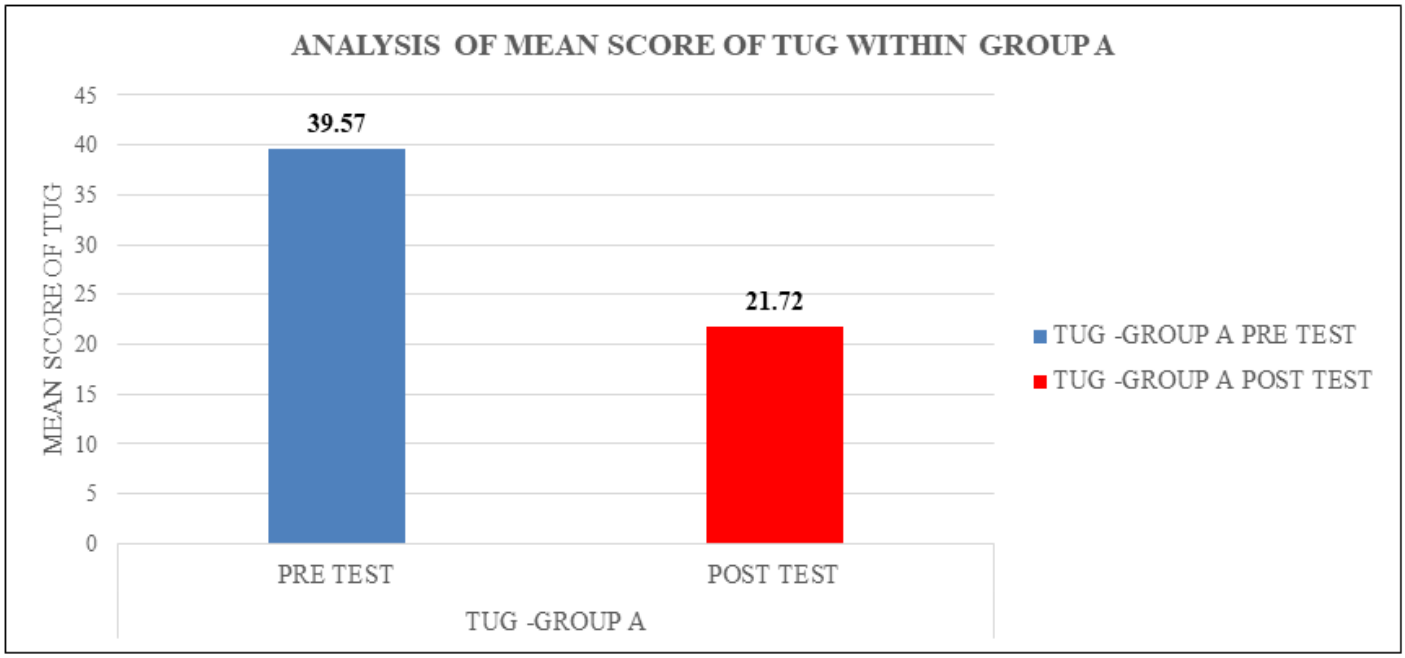
➢ *Analysis of Mean Score of TUG within the Group A*

Table 5 Analysis of Mean Score of TUG within the Group A

GROUP A		MEAN	SD	P VALUE	INFERENCE
TUG	PRE TEST	39.57	6.90	0.001	Highly Significant
	POSTTEST	21.72	6.61		

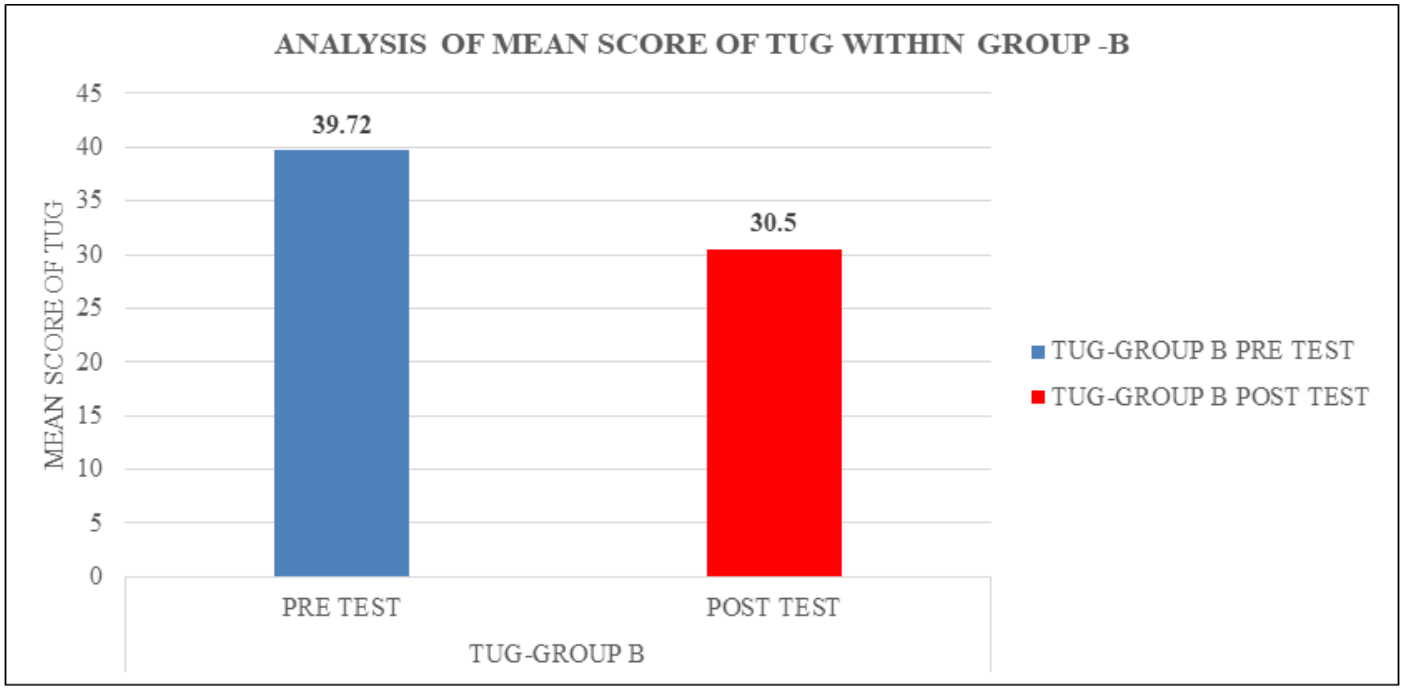


Graph 5 Analysis of Mean Score of TUG within the Group A

➢ *Analysis of Mean Score of TUG within the Group B*

Table 6 Analysis of Mean Score of TUG within the Group B

GROUP B		MEAN	SD	P VALUE	INFERENCE
TUG	PRE TEST	39.72	6.74	0.001	Highly Significant
	POSTTEST	30.50	6.34		



Graph 6 Analysis of Mean Score of TUG within the Group B

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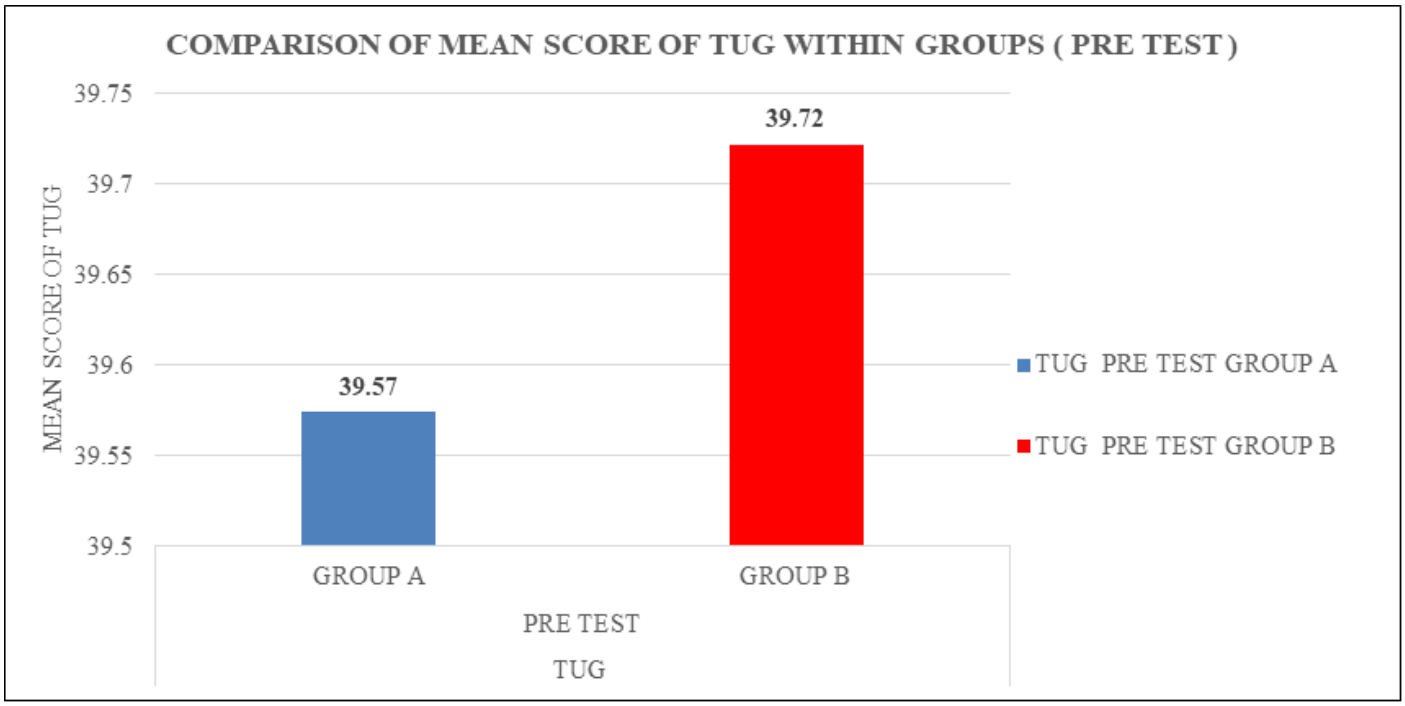
➢ *Comparison of Mean Score of TUG in between the Groups (Pre Test)*

Table 7 Comparison of Mean Score of TUG in between the Groups (Pre Test)

GROUPS		MEAN	SD	P VALUE	INFERENCE
TUG PRE TEST	GROUPA	39.57	6.90	0.91	Insignificant
	GROUP B	39.72	6.74		

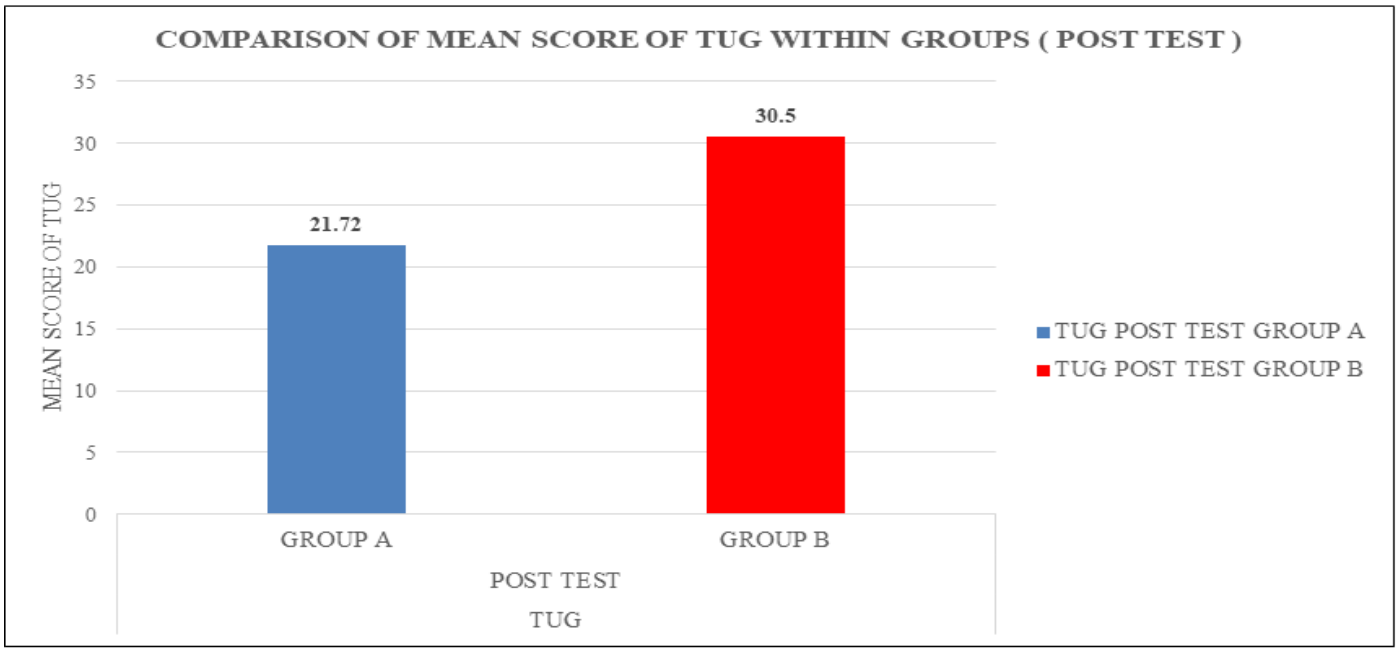


Graph 7 Comparison of Mean Score of TUG in between the Groups (Pre Test)

➢ *Comparison of Mean Score of TUG in between the Groups (Post Test)*

Table 8 Comparison of Mean Score of TUG in between the Groups (Post Test)

GROUPS		MEAN	SD	P VALUE	INFERENCE
TUG POSTTEST	GROUP A	21.72	6.61	0.001	Highly significant
	GROUP B	30.50	6.34		



Graph 8 Comparison of Mean Score of TUG in between the Groups (Post Test)

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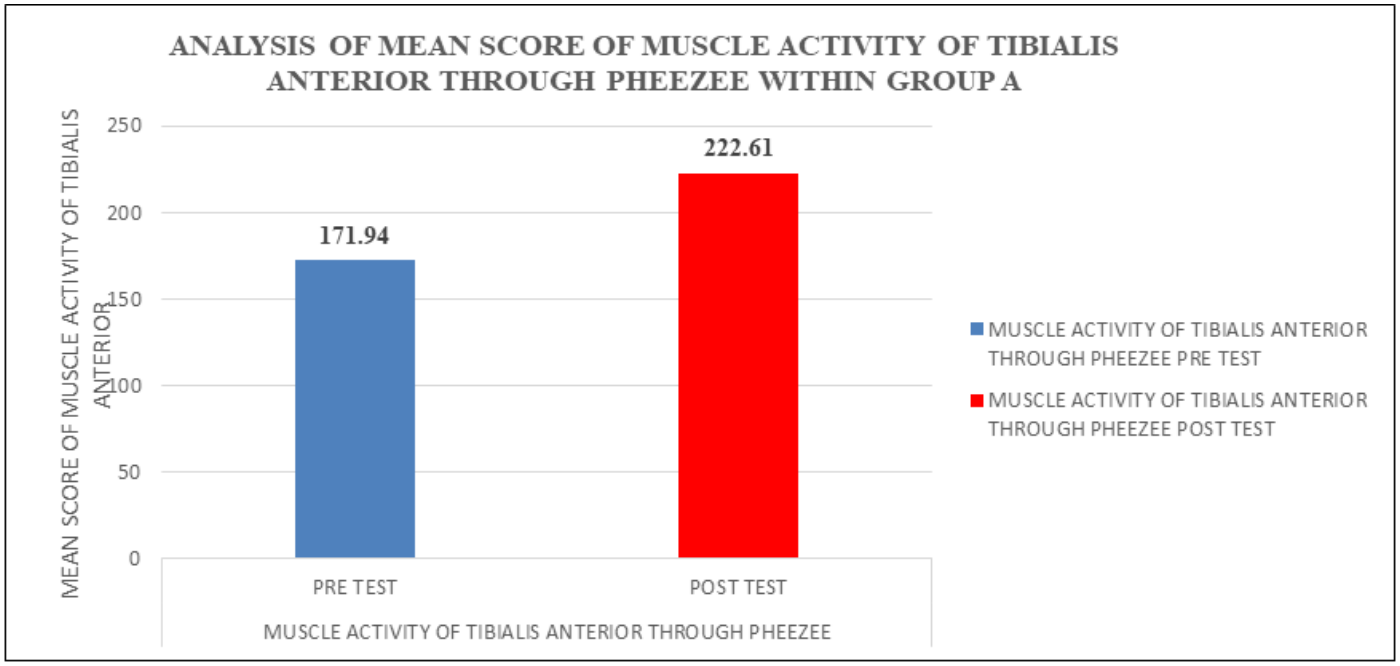
➢ *Analysis of Mean Score of Muscle Actvity of Tibialis Anterior Through Pheezee within the Group A*

Table 9 Analysis of Mean Score of Muscle Actvity of Tibialis Anterior Through Pheezee within the Group A

GROUP A		MEAN	SD	P VALUE	INFERENCE
PHEEZEE	PRE TEST	171.94	23.38	0.001	Highly Significant
	POSTTEST	222.61	25.94		

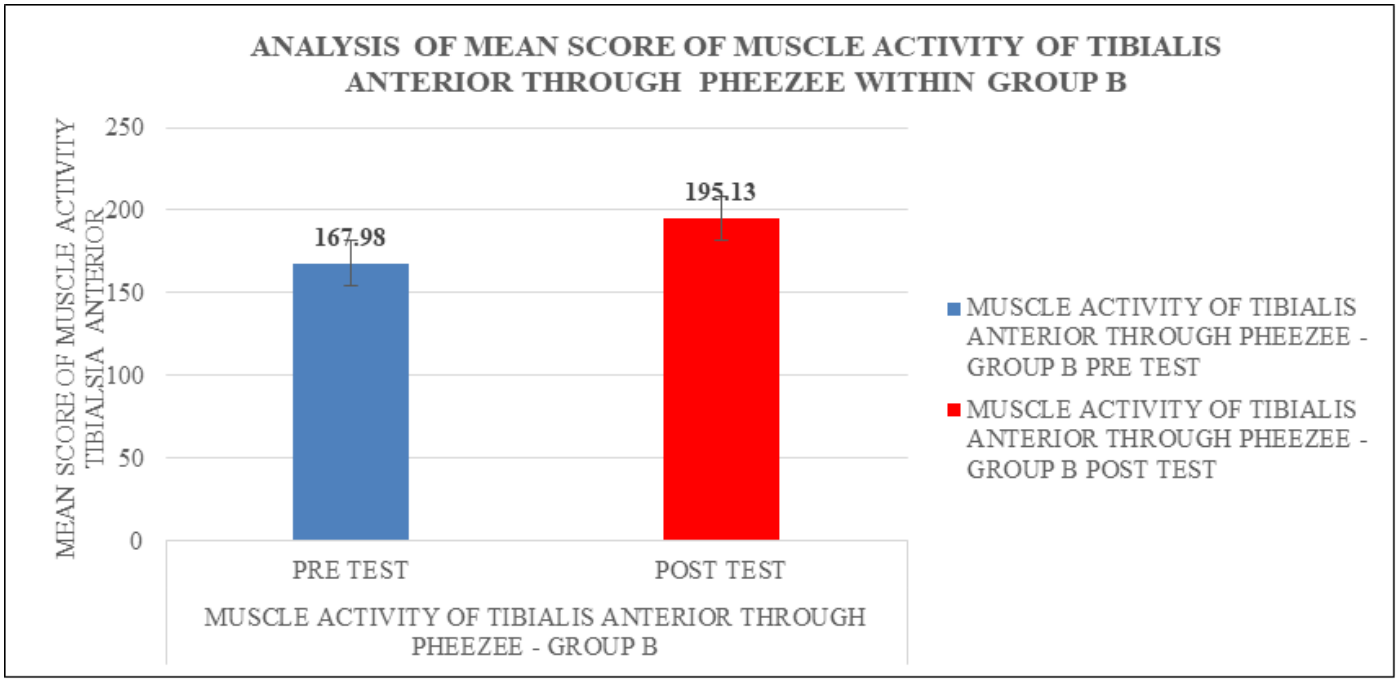


Graph 9 Analysis of Mean Score of Muscle Actvity of Tibialis Anterior Through Pheezee within the Group A

➢ *Analysis of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee within the Group B*

Table 10 Analysis of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee within the Group B

GROUP B		MEAN	SD	P VALUE	INFERENCE
PHEEZEE	PRE TEST	167.98	25.16	0.001	Highly Significant
	POSTTEST	195.13	25.64		



Graph 10 Analysis of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee within the Group B

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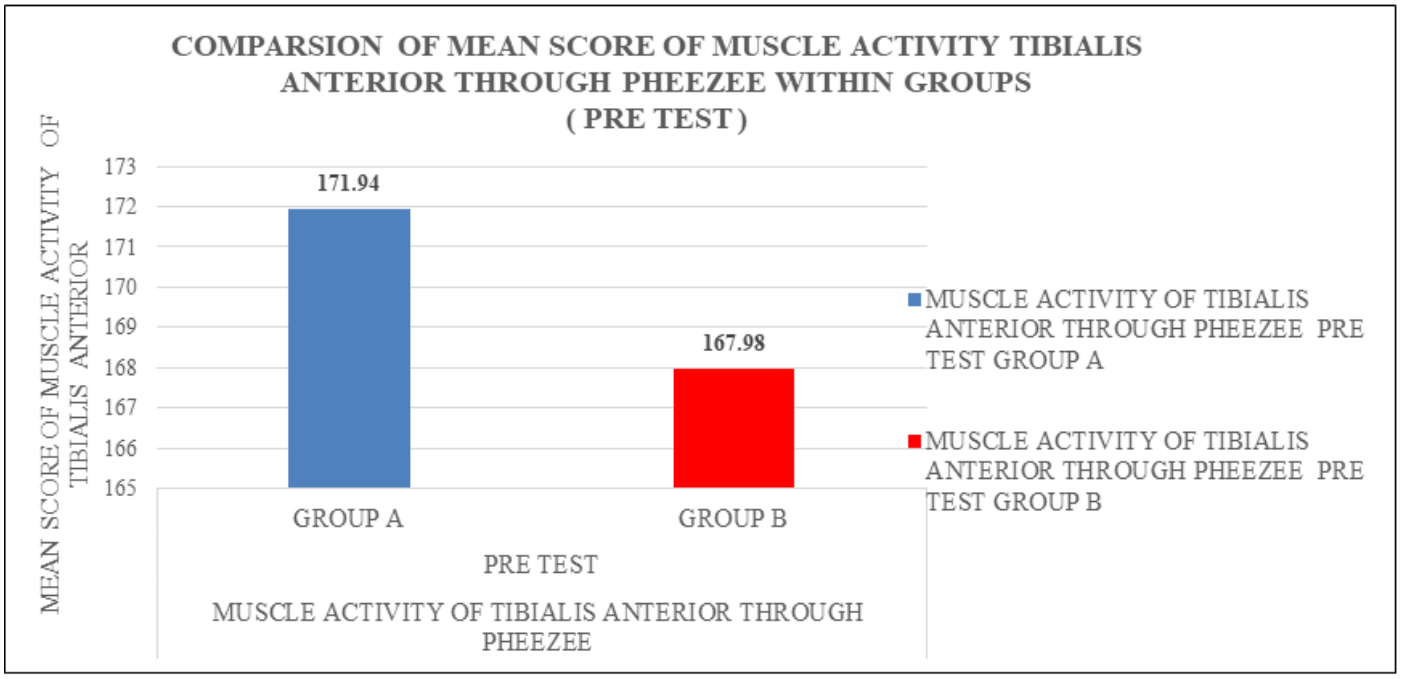
➢ *Comparison of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee in between the Groups (Pre Test)*

Table 11 Comparison of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee in between the Groups (Pre Test)

GROUPS		MEAN	SD	P VALUE	INFERENCE
PHEEZEE PRE TEST	GROUP A	171.94	23.38	0.001	Insignificant
	GROUP B	167.981	25.16		

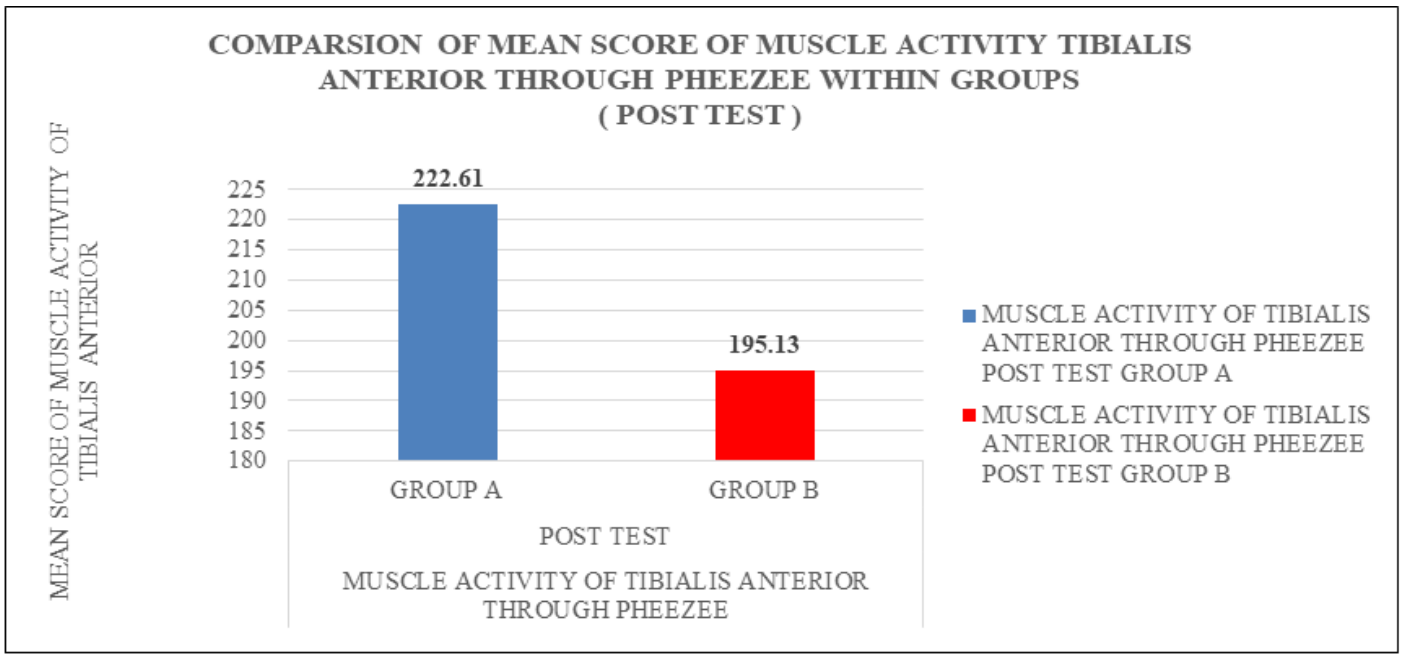


Graph 11 Comparison of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee in between the Groups (Pre Test)

➢ *Comparison of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee in between the Groups (Post Test)*

Table 12 Comparison of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee in between the Groups (Post Test)

GROUPS		MEAN	SD	P VALUE	INFERENCE
PHEEZEE POST TEST	GROUP A	222.61	25.38	0.001	Highly significant
	GROUP B	195.13	25.64		



Graph 12 Comparison of Mean Score of Muscle Activity of Tibialis Anterior Through Pheezee in between the Groups (Post Test)

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V. DISCUSSION

The aim of the study was to compare the Gyroscope based functional electrical stimulation and Ankle foot orthosis with Electrical stimulation in post stroke subjects. The following outcome measures were universal goniometer, pheezee and TUG to assess the muscle performance and gait. The results showed significant improvement in outcome measures such as universal goniometer, pheezee and Tug. The two interventions were similarly effective in improving foot drop.

Several studies have reported positive effects on functional electrical stimulation, but there are limited studies on comparing Gyroscope based Fes in foot drop. Subjects were assessed to improve muscle performance, gait and range of motion at baseline and the end of intervention using pheezee, Tug and universal goniometer. There were two dropouts in Group A and in Group B.

This study supports the early study of Namma karniel PT, Msc, Eitan raveh et al conducted a study on Functional electrical stimulation compared with Ankle foot orthosis in sub acute post stroke patients with foot drop. The study was conducted for 12 weeks to compare the gait patterns in patients with foot drop. Subjects who received 12 weeks of FES had significant increase in their subjective perception improvement in gait after 4 weeks, but AFO showed improvement only after 12 weeks. This may be because of immediate increase in the perception of improved gait ability and their motivation is a significant factor. [20]

In Group A (Functional Electrical Stimulation along with standard rehabilitation program) there is statistically more significant improvement in Universal goniometer, Pheezee and Tug ($P < 0.001$). There was an earlier study by Sukanta k.Sabut et al states that combination of Fes therapy along with conventional rehabilitation program was more effective in improving gait characteristics, effort of walking, improves in active/passive ankle joint ROM, dorsiflexor strength, reduction of plantar flexor spasticity and improving lower extremity functions than conventional rehabilitation. Our findings in this study were consistent with the above studies. [21]

Michael kafri, yocheved Laufer et al states that when functional electrical stimulation is coupled with sensory stimulation causes voluntary contraction and force of contraction increases cortical excitability, which aids in the reorganization of the motor map of the corresponding muscles. In addition to producing motor stimulation, it also excites superficial and propriceptive sensory fibers.[22] Zhimei Tan, Huihma liu et al explained repetitive functional activity and task specific training combined with goal directed walking may help with motor relearning when using FES. The impaired brain receives sensory input and visual feedback on motor information through repetitive sensory stimulation, which may improve functional recovery. [23]

Sarah prenton, Kristen L states that strength duration curve shows that the stimulating impulses of the same duration require larger current strength for functional movements in chronic subjects, indicating that early and intensive rehabilitation could significantly improve sub-acute rather than chronic patients due to larger difference in excitability.[24] Giulia Schifino, veronica cimolin et al mentioned that FES improves continuous integrative control to maintain balance during activity in order to improve instability in single leg standing. Additionally, walking training may improve mediolateral symmetry through foot contact on the ground and shifts the body weight to medial side and this leads to significant improvement in strength. [25]

In Group B (Ankle foot orthosis with Electrical stimulation along standard rehabilitation program) there is statistical significant improvement in universal goniometer, Tug and pheezee. The paralyzed lower extremities may have contributed more to weight bearing or dynamic balance regulation, which could improve the gait function. Improvements in the angles of the knee at toe-off and the ankle at initial contact may be signs of better gait Reduction in gastrocnemius activity takes place when wearing AFO may be the cause of the improvement in knee flexion angle. By promoting ankle dorsiflexion, limiting plantarflexion and inversion AFO enhances gait function and corrects gait patterns. [26]

According to Corien D.M.Nikamp collegues mentioned that the subjects provided with AFO early after stroke has highest number of falls compared to the subjects had not been provided AFO. The highest number of falls during standing and transfers because they had no independent walking ability and balance. [27] Rajesh kumar mohanty et al states that the dorsi-plantarflexion angle of the ankle's range of motion and the asymmetry between the paretic and contralateral limbs with regard to the ankle at first contact can both be decreased with solid and dynamic ankle foot orthosis. Because of the proprioceptive input from the external device, the AFO typically causes an increase in the contraction of a few muscles on the paretic side during mid-stance, such as the gastrocnemius and tibialis anterior. [28]

Electrical stimulation is thought to have a therapeutic impact on CNS neuroplasticty through an increase in afferent input is proposed mechanism of action. Functional and unused preexisting neural connections are either triggered or their suppression is halted. According to Freeha sharif, samina ghulam et al proposed that therapeutic electrical stimulation helps to improve voluntary motor control by strengthening muscles, reducing spasticity and increasing range of motion.[29] G.Shankar ganesh, Ranjitha kumara et al states that Fast twitch (Type 2) muscle fibers are phasic in nature and respond to electrical stimulation. The frequency of currents causes tetanic muscular contraction because the tension created during one twitch cannot be released before the occurrence of next, which causes subsequent twitches to accumulate and result in an increase in muscle strength. [30, 31]

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The Study findings indicating that after 6 weeks of intervention Gyroscope based functional electrical stimulation along with standard rehabilitation was statistically more significant in Pheezee, Tug and universal goniometer than Ankle foot orthosis with electrical stimulation along standard rehabilitation on muscle performance, gait and range of motion. This study concludes that Gyroscope based functional electrical stimulation is a useful adjunct in post stroke subjects.

VI. LIMITATIONS

- Due to small sample size in this study results couldn't be generalized to large group of population
- No blinding of evaluators of outcomes was done
- There is no follow up in this study to evaluate the sustained effectiveness of the intervention over time

VII. RECOMMENDATIONS FOR FUTURE RESEARCH

- Future Research could benefit from employing a more rigorous randomization technique and considering a large sample size to enhance the robustness of the results
- Efforts to minimize potential bias through blinding or objective outcome measures couldenhance the validity of the results
- The study may benefit from long term follow-up assessments to evaluate the effectiveness of intervention over time.

VIII. CONCLUSION

The present study concludes both Gyroscope based functional electrical stimulation along with standard rehabilitation and Ankle foot orthosis with Electrical stimulation along with standard rehabilitation showed significant improvement in muscle performance, gait and range of motion in post stroke subjects. However Gyroscope based functional electrical stimulation along with standard rehabilitation was more effective when compared to Ankle foot orthosis with Electrical stimulation along with standard rehabilitation. Hence treatment intervention may be incorporated in post stroke subjects.

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