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# COMPARISON OF RHEOBASE AND CHRONAXIE IN TIBIALIS ANTERIOR MUSCLE BETWEEN PARETIC AND NON- PARETIC LIMB IN CHRONIC STROKE

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## ABSTRACT

***Objective:*** *Electrical activity and muscle properties always seem to be intimately interrelated. The disability of stroke leads to a relative inactivity, especially in the hemiparetic limb. The weakness and spasticity have an interesting influence on the muscle, causing both reduced motor unit recruitment and excessive co-contraction. Stroke affects the sensitivity of skeletal muscle contraction. The aim of the study is to compare the Rheobase and Chronaxie differences between paretic and non-paretic limb in chronic stroke.* ***Methods****: Fifty chronic stroke patients mean age of (64.70yrs) from vadallur were included in the study. Tibialis Anterior muscle's electrical property was observed between paretic and non- paretic limb.* ***Result:*** *The mean Rheobase and Chronaxie values of Tibialis Anterior muscle in paretic limb is 4.18±.18 (ms) and 3.48± .48(mA) respectively and the mean Rheobase and Chronaxie for non-paretic side is 3.08±.15 (ms) and 1.14 ± .11 (mA) respectively.* ***Conclusion:*** *This study concluded that there is a significant difference in Rheobase and Chronaxie between the paretic and non-paretic limb in chronic stroke patients. Thus, for an effective electrical stimulation, there is a need to provide an important basis for electric current and duration.*

## KEY WORDS

*Stroke, Electrical Properties, Tibialis Anterior, Electrical stimulation.*

## INTRODUCTION

Stroke is also known as "Acquired Brain Injury (ABI)", [1,2]. It can cause many significant health problems which have impact on the individual's physical and mental stability like altered sensory, motor, mental, perceptual and language functions. This in turn leads to reduced or limited Activities of Daily Living [6], which needs an unremitting and wide-range rehabilitation [7]. The common motor deficits are characterized by paralysis (hemiplegia) or weakness (hemiparesis) on one side of the body, opposite to the site of the lesion [5,6]. This leads to a permanent disability of the individual when it is not treated with appropriate measures.

The incidence and prevalence of stroke have been steadily raising in India, The Indian Council of Medical Research, reported that stroke contributes about 41% of deaths and 72% of Disability Adjusted Life Years.

In stroke, skeletal muscles are affected due to altered central neural activation and spasticity [8]. Skeletal muscle fibers have great adaptive potential. They have the ability to adjust their molecular, metabolic, and functional properties in response to altered functional demands, mechanical loading, or changes in neuromuscular activity [3, 4]. It is known that muscles which perform different tasks, in addition to having different muscle architecture, respond to different electrical input. The human brain is responsible for sending the body control signals. It is done through the Central Nervous System (CNS). The Central Nervous System and the brain use electrical signals that travel

through nerves to control the body. The electrical activity and muscle properties always seem to be intimately interrelated [3]. The weakness and spasticity have an interesting influence on the muscle, causing both reduced motor unit recruitment and excessive co-contraction.

The disability of stroke leads to a relative inactivity, especially in the hemiparetic limb. The physical inactivity results in reduced muscle mass and function, which parallels the decline that occurs with aging. The restricted movements of the muscle may lead to reduced muscle mass [cross sectional area] and function [2,9] hence, there is a rapid denervation of the muscle after stroke which leads to weakness or paralysis. This renders the muscles unable to produce voluntary forces needed to create joint movement that will allow functional performance of daily task [10].

Approximately 78% of adults with stroke regain their ability to walk [2] but show high energy expenditure [11,12] and atypical muscle activity during gait [13,14]. **Ryan et al (2011)** stated that the stroke survivors had 20% reduced muscle area and 25% higher intramuscular fat in quadriceps muscle in paretic side than non-paretic side, demonstrating substantial atrophy and muscle composition change [15]. A paucity of literature exists on skeletal muscle abnormalities and their clinical relevance after stroke. Skeletal muscle has not been systematically pursued as a potential target for exercise and/or rehabilitation after stroke. Stroke rehabilitation therapy aims to restore partially lost functions [16]. There are various therapeutic approaches practiced for the recovery of the lost functions.

**Electrical Muscle Stimulation** (EMS), also known as **Neuromuscular Electrical Stimulation** (NMES) or **Electromyo stimulation**, its potential for rehabilitation recovery is immeasurable. In the early 1960s, Electrical Muscle Stimulation was often used in an attempt to prevent the muscular atrophy that occurs when skeletal muscle is denervated. It has been a main stay of physical therapy practice for many years as a method to rehabilitate muscles. Electrical Muscle Stimulation elicits muscle contraction using electrical impulses and became a popular treatment technique for patients who had sustained Central Nervous System impairment secondary to a stroke or spinal cord injury [17].

Electrical Muscle Stimulation is used in many forms to facilitate changes in action and performance, like **Neuromuscular Electrical Stimulation** (NMES), Functional Electrical Stimulation (FES). Electrical Muscle Stimulation can be used for improving muscle strength, reducing edema, decreasing atrophy, healing tissue and to reduce pain. It is used as a testing tool for evaluating the neural and/or muscular function in vivo.

Electrical stimulation is required for the maturation of skeletal muscle and as a way to nondestructively monitor muscle development [18]. It causes adaptation i.e. training the muscle fibers [19].However, the wrong stimulation parameters can result in electrochemical damage that impairs muscle development or regeneration. Due to wrong stimulation parameters, many stroke survivors adapt abnormal movement patterns [8,20,21].

If muscles have been damaged or become too weak due to immobility, Electrical stimulation can be used to build them along with the other rehabilitation methods [20]. The muscle can be contracted or flexed using Electrical muscle stimulation to break fibers. These fibers would rebuild over the period and the muscle would be stronger. Only few studies are available to examine the muscle abnormalities after the stroke and their relationship with fitness and functions [21,22,23].

In chronic stroke the paretic limb has spasticity of one group of muscles and weakness of other group of muscles, which causes imbalance in the lower limbs [24]. Stroke patients often demonstrate with gait impairments it may be either due to inadequate dorsiflexion causing “drop-foot,” or plantar flexor spasticity or stiffness causing decreased push off.

Dorsiflexors of the foot (mainly Tibilais anterior) aids in lifting the toes off the ground which is an important movement during walking and running to prevent tripping over one’s toes. The Tibialis Anterior also provides slight inversion of the foot by pulling the plantar surface of the foot towards the body midline. This motion is important in balancing the body weight on the foot during locomotion and standing on one leg. However, a recent study showed that stroke patients suffer from disproportionate muscle atrophy and other detrimental tissue composition changes on the paretic side [1,23].

The electrical properties such as Rheobase and Chronaxie are important factors in electrotherapy for rehabilitation. The appropriate adjustment of electric current increases the effectiveness of rehabilitation [23-26]. Rheobase is the lowest electrical intensity with

indefinite pulse duration which will stimulate muscle or nerve. Chronaxie is the minimum time required for the electric current (double the Rheobase) to stimulate the membrane. As stroke causes muscle weakness, there is reduced muscle activity and decreased balance in lower limb [1,16,27].

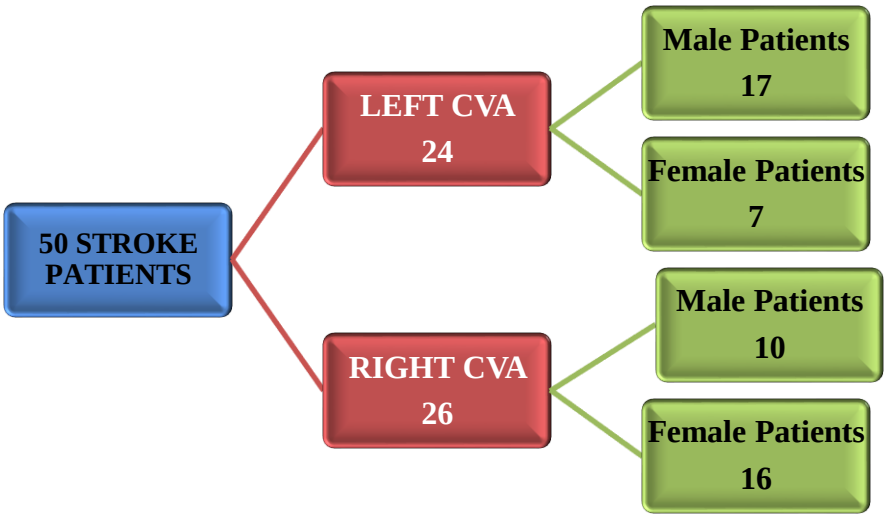
Stroke affects the sensitivity of skeletal muscle contraction. For an effective electrical stimulation, there is a need to provide an important basis for electric current and duration. Therefore, Chronaxie and Rheobase of the muscle should be compared. Thus, this study examines the muscle properties of ankle dorsiflexor (Tibialis Anterior muscle) of chronic stroke patients by using Rheobase and Chronaxie on paretic side and the non-paretic side to make the rehabilitation of stroke patients more effective.

## MATERIALS AND METHODS

**Subjects:** 50 subjects were included in this study based on the following inclusion criteria: Chronic stroke patients, age from above 40years, both male and female subjects, Brunnstrom grading 4 and 5 in paretic lower limb, Mini mental status examination scale above 21 and exclusion criteria: Any open wounds in leg, Impaired sensory loss in leg, Any recent surgeries or metal implants in leg, Deep Vein Thrombosis, Any skin infections in lower limb, Any disability other than stroke , like spinal cord lesion, polyneuropathy, peripheral nerve lesion, Patient with pacemaker, Burns in lower limb. From Home for Aged (Vallalar Chennai Sangam) Vadallur. Materials used were the following: Electrical stimulator unit (Electrostim – DT; ES – TD - 641), straps, Saline water , cotton, Vaseline, Graph sheets , red and blue pencil and Mackintosh sheet. Measurement tools used was Strength Duration Curve (Rheobase and Chronaxie). To obtain the Rheobase and Chronaxie value of the Tibialis Anterior muscle, the muscle was stimulated using Electrical Muscle Stimulator using Galvanic current and the beginning of the contraction of the muscle was noted and plotted in the graph, then a Strength Duration Curve was plotted. It was done on paretic and non-paretic limb and its Rheobase and Chronaxie values were compared.

**PROCEDURE:**

Total of 50 subjects were selected by convenient sampling those who met the inclusion criteria, the procedure to be done was explained to the subjects in detail. Then a written informed consent was obtained from the subjects. The subjects were then instructed that in case any subject is not interested during the program or if he or she developed any pain or discomfort during the test then they can withdraw or can be excluded from the study. In this study none of the subject had any pain or discomfort so nobody was eliminated.




Checking of Electrical stimulator machine was done prior to the test, all precautionary steps were taken to avoid any burn or shock. All the subjects were given instructions that to be followed during the test. The subject has to inform the therapist immediately if they had any discomfort or difficulty while performing the test.

**Patient Position:** supine lying or long sitting with back support.

Skin resistance lowering in the area where the electrode to be placed was done to the patients

**Electrodes Placement:**

**Inactive Electrode:** Placed in the proximal 1/3rd of antero lateral aspect of leg to stimulate tibialis anterior muscle.

**Active Electrode:** On the muscle bulk (motor point) the tibialisanterior muscle was stimulated using pen electrode.

**Type of current used: Galvanic** current.

Duration was kept first in 300ms and the intensity was increased gradually till there is minimal visible or palpable contraction in the leg and the readings was noted. Then duration was reduced to 100ms, 30ms, till .01ms and the readings were noted. First on the non-paretic leg the readings were noted, then on the paretic leg measurements were noted. The noted readings was plotted on the graph sheet, a strength duration curve was plotted to know the rheobase and chronaxie value.

**DATA ANALYSIS:**

All statistical analyses were performed on an IBM compatible microcomputer using the Statistical Package for the Social Sciences (SPSS) (Windows version 17.0 Chicago IL, USA). The significance was set at α=0.05 level.

Descriptive statistics of mean, standard deviations, percentages and frequencies were used to describe the individual demographic data (Age, Sex, Height, Weight, BMI)

Student t- test was used to compare the rheobase and chronaxie value in tibialis anterior muscle between paretic and non-paretic limb in chronic stroke.

The results obtained from the analyzed data were tabulated and figured accordingly these are presented in the following pages.

## RESULTS AND DISSCUSSION:

Table – 1 presents the characteristics of the participants the mean age was 64.70± 14.30years, the mean height and weight were 1.50± .11 cm and 58.66± 12.06 kg respectively and the mean BMI 25.91 ± 3.97(kg/$m^2$) and the proportion of males to females was 52.0% and 48.0% respectively.

**Table – 1 Descriptive statistics of demographic data (Age, Sex, Height, Weight, BMI)**

| Characteristics | Mean | Standard. Deviation |
|---|---|---|
| Age(Yrs) | 64.70 | 14.30 |
| Height (M) | 1.50 | .11 |
| Weight (Kgs) | 58.66 | 12.06 |
| Body Mass Index (kgs/$M^2$) | 25.91 | 3.97 |

| Characteristics | Frequency | Percentage % |
|---|---|---|
| **Gender** | **24** | **48.0** |
| **Female** | | |
| **Male** | **26** | **52.0** |

The above table presents the description of the participant's demographic data Descriptive statistics of mean, standard deviation and frequencies were used to summarize individual variables.

Table - 2 reveals that the Rheobase and Chronaxie values of Tibialis Anterior muscle in paretic and non-paretic limb in chronic stroke. The mean Rheobase and Chronaxie for paretic side is 4.18±.18 (ms) and 3.48± .48(mA) respectively and the mean Rheobase and Chronaxie for non-paretic side is 3.08±.15 (ms) and 1.14 ± .11 (mA) respectively. There was significant difference in Rheobase and chronaxie values between Paretic and Non - Paretic Limb respectively in chronic stroke patients.( P< 0.05) It shows that Non-Paretic limb has lower Mean value than Paretic limb.

**Table – 2: Comparison of Rheobase And Chronaxie In Tibialis Antrior Muscle Between Paretic and Non- Paretic Limb In Chronic Stroke.**

| PARETIC SIDE | | NON-PARETIC SIDE | |
|---|---|---|---|
| **Rheobase (msec)** | **Chronaxie mA** | **Rheobase (msec)** | **Chronaxie mA** |
| 4.18±.18 | 3.48± .48 | 3.08±.15 | 1.14± .11 |

The above table revealed that the Rheobase and Chronaxie values of Tibialis Anterior muscle in paretic and non-Paretic limb in chronic stroke. The mean Rheobase and Chronaxie for paretic side is 4.18±.18 and 3.48± .48 respectively and the mean Rheobase and Chronaxie for non-paretic side is 3.08±.15 and 1.14 ± .11 respectively.

## DISCUSSION:

Stroke involves muscle weakness, spasms, disturbed muscle timing and reduced ability to selectively activate muscles. This study was conducted to determine the Tibialis Anterior muscle's electrical properties i.e.Rheobase and Chronaxie between paretic and non-paretic limb in Chronic Stroke patients. Findings of this study showed a significant difference in electrical properties between Paretic limb and Non-Paretic limb in chronic stroke patients. Stroke affects the sensitivity of skeletal muscle contraction. An effective electrical stimulation with appropriate intensity and duration is essential to provide an important basis for treatment protocol for stroke patients. The electrical activity and muscle properties always seem to be intimately interrelated [3]. The weakness and spasticity have an interesting influence on the muscle, causing both reduced motor unit recruitment and excessive co-contraction. The appropriate adjustment of electric current increases the effectiveness of Rehabilitation [23-26]. A paucity of literature exists on skeletal muscle abnormalities after stroke and their clinical relevance. In a pilot study conducted by Won-Deok Lee et al (2013) stated that there is a difference in Rheobase and Chronaxie between paretic and non – paretic limb in quadriceps muscle [28]. Alastair Khodabukus et al (2012) stated that electrochemical damage occurs in muscle at a voltage field greater than six-times rheobase and therefore optimal muscle stimulation should be performed using lower electric fields (two- to four-times rheobase) [20]. In this study approximately 75% of the Chronic Stroke patients were in the rural area. Their functional activity level after stroke was less compared to the individuals lived in the urban areas. They merely had any knowledge about physiotherapy, so they did not perform any therapeutic exercises for the paretic limb. Among the various factors affecting the electrical properties of the skeletal muscles, like age, type and duration of the lesion, additional factor could be lack of knowledge about physiotherapy for he reduced motor recruitment for paretic limb. Thus, the future studies can be done to compare the electrical properties of the skeletal muscle for pre-& post exercises in stroke patients.

Electrical stimulation is required for the maturation of skeletal muscle and as a way to non-destructively monitor muscle development [18]. It can be used to build them along with other Rehabilitation methods [20]. The Rheobase and Chronaxie values in Non- Paretic limb was less when compared to Paretic limb in chronic stroke patients. Thus, this study shows that the chronic stroke patients have significant changes in the sensitivity of the skeletal muscle between Paretic and Non –Paretic limb. So, the treatment protocol for the stroke patients should be framed according to the Rheobase value of the patient.

## CONCLUSION:

The present study concluded that there is a significant difference in Rheobase and Chronaxie between the paretic and non-paretic limb in chronic stroke patients. Thus, for an effective electrical stimulation, there is a need to provide an important basis for electric current and duration. Therefore, when performing physical therapy, the electrical properties of the muscle of each stroke patients need to be carefully considered for effective rehabilitation along with the other management.

## LIMITATIONS:

Small sample size, Sarcopenia of aging is a multifactorial process that affects the skeletal muscle, Aging can also reduce the motor unit firing threshold, Number of

motor units recruited during stimulation could be exactly found by Electromyography recording.

**RECOMMENDATIONS:**

Large sample size can be included , Acute & sub-acute stoke patients can also be included in further studies, Influence of patient's activity level can be determined, The electrical properties of other muscles can be included, Need to expand our knowledge on brain plasticity and the use of different electrical stimulation strategies to modulate the neural system and To foresee an increase in therapies combining different training principles, for example, the combination of Neuromuscular Electrical Stimulation and robotics or neuromodulating.

**Fig -1 Electrical stimulator with active pen electrode, inactive pad electrode, strap, gel.**

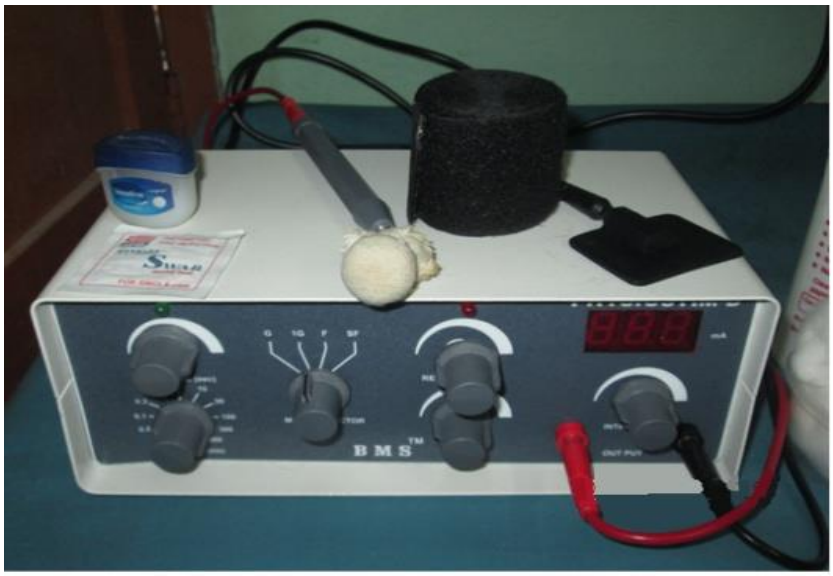
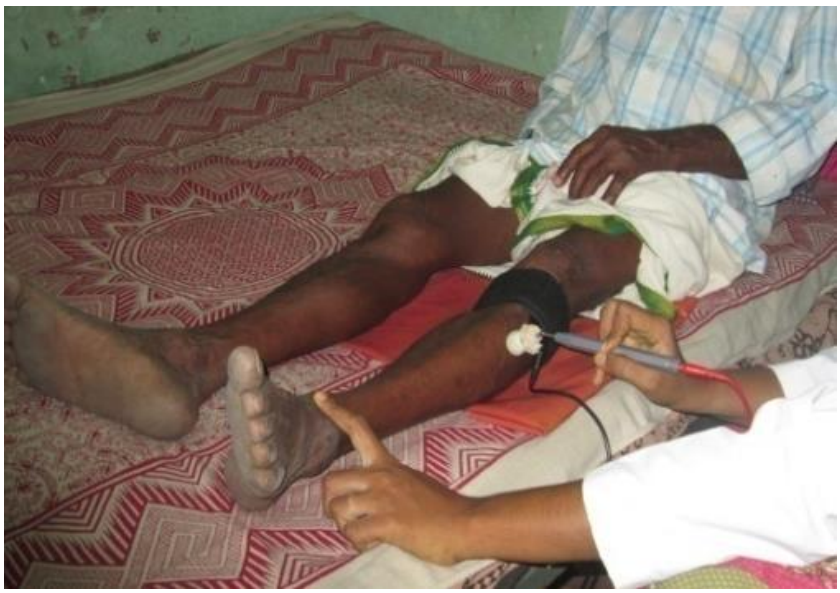
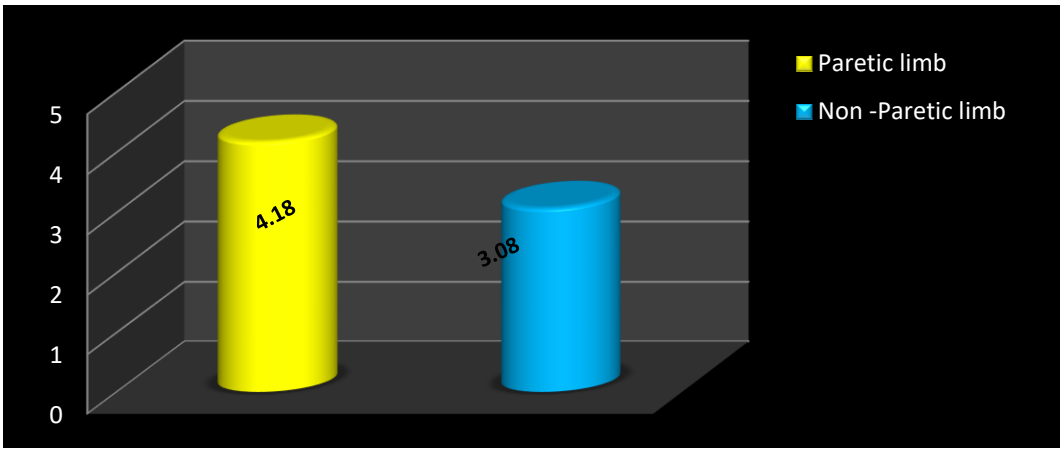


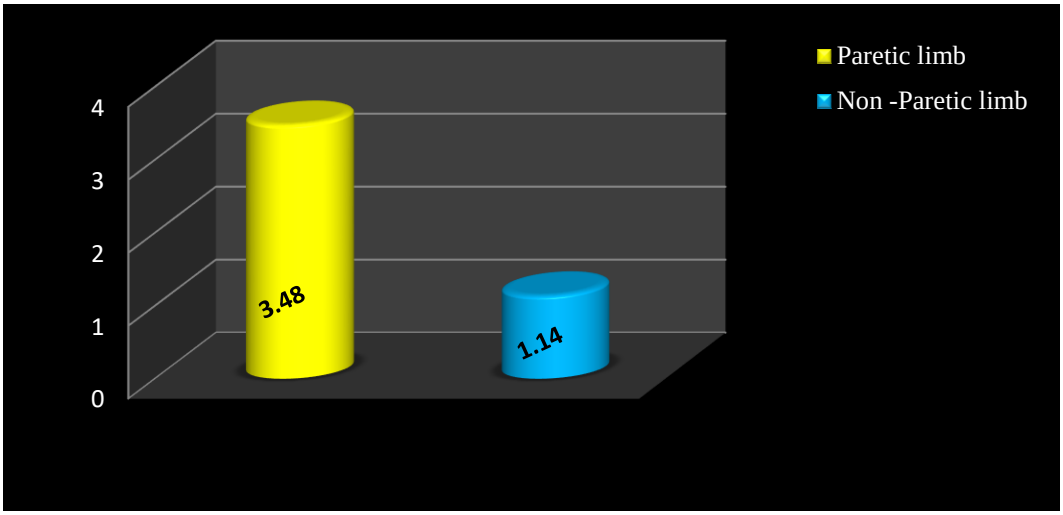

**Fig 2: Stimulation of Tibialis Anterior muscle on left paretic limb, inactive electrode on head of the fibula and active electrode on motor point**



**GRAPH – 1: COMPARISON OF RHEOBASE IN TIBIALIS ANTRIOR MUSCLE BETWEEN PARETIC LIMB AND NON-PARETIC LIMB IN CHRONIC STROKE.**




**GRAPH – 2: COMPARISON OF CHRONAXIE IN TIBIALIS ANTRIOR MUSCLE BETWEEN PARETIC LIMB AND NON-PARETIC LIMB IN CHRONIC STROKE PATIENTS.**




**ABBREIVATIONS:**

| | | |
|---|---|---|
| ABI | : | Acquired Brain Injury |
| CNS | : | Central Nervous System |
| EMS | : | Electrical Muscle Stimulation |
| NMES | : | Neuromuscular Electrical Stimulation |
| FES | : | Functional Electrical Stimulation |

**AUTHOR'S CONTRINUTION**

Ms. Logeshwari Selvaraj – Conceptualize the idea, designed the study, Data Collection Data Analysis & Manuscript Preparation

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