

# A Comparative Study of Eccentric Training Using Thera-Band and Static Stretching in Improving Triceps Surae Muscle Flexibility

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**Abstract.** Here we try To determine that if the flexibility of male students would improve after 3-weeks of eccentric exercise program. In addition the changes in the triceps surae flexibility that occurred after the eccentric program were compared with 3-weeks of program of static stretching and with a control group (no stretching). We used pre-test post test control group design. Subjects were assigned randomly to 1 of 3 groups: eccentric training, static stretching and control. A total sample of 60 healthy college male volunteers with mean age of 25.07 years participated in the study. Subjects were assigned randomly to 1 of 3 groups: (A) eccentric training, (B) static stretching and (c) control. Each group includes 20 subjects. Subjects in each group were treated for 30 seconds of intervention, 5 days in a week for six weeks. Results shows that both the experimental group, eccentric training(5.75) and static stretching(4.10) were shown statically significant improvement in triceps surae muscle flexibility, when compared with control group(0.15). where as follow up analysis indicated significant differences between eccentric training and static stretching group. This study shows that eccentric training and static stretching both are effective in increasing, but the eccentric training is more effective and statistically significant in increasing triceps surae muscle flexibility in males.

**Keywords:** Eccentric training, static stretching, flexibility, injury prevention, theraband.

## 1. Introduction

Flexibility has been defined as the ability of a muscle to lengthen and allow one joint (or more than one joint in a series.) to move through a range of motion<sup>2</sup>. Increased flexibility is one of the basic concerns addressed in the day to day practice of physical therapy. It is a goal for any patient recovery from a period of immobilization or injury involving the connective tissue. Optimal flexibility is also desirable for participants in most athletic activity and normal day to day function. A shortened muscle may create imbalance at joints and faulty postural alignment that may lead to injury and joint dysfunction.

Regarding the triceps surae Flexibility clinicians have reported that, even in healthy subjects, the loss of ankle dorsiflexion range of motion (ADFROM) may result in compensatory hindfoot pronation. Ankle dorsiflexion range of motion from tight calf muscle have been linked to injuries such as Achilles tendonitis, gastrocnemius strains, and plantar fasciitis.<sup>5</sup>

Extensibility is defined as the ability to stretch a muscle tendon unit to its fullest length<sup>1</sup>. Muscle contracture result in decreased extensibility joint motion. Physical therapists have used many different methods to maintain and increased joint motion and prevent deformity and dysfunction resulting from the muscle contracture. Research with clinical trials has long advocated the use of thermotherapy to increase flexibility in conjunction with a stretching program design to lengthen tissue. Lengthening the musculotendinous unit and supporting connective tissue increase the range of motion(ROM) through which a joint can move as well as the muscle ability to respond to stress placed upon it .<sup>8,14,15,16</sup>

Stretching is used as part of physical fitness and rehabilitation programme because it is thought to positively influence performance and injury prevention. Numerous studies<sup>1,3,5,15,19</sup> have been conducted to investigate the effectiveness of stretching. Shortness and contracture of plantar flexor muscle may cause limitation in range of motion (ROM) that restricts the normal range of muscle.

This potentially harmful condition may be managed with a stretching programme, which may be positively influence an individual's functional capacity of daily living and decrease of injuries. Several studies have reported an immediate increase in ankle dorsiflexion ROM following the application of calf stretching exercises.<sup>2,4,5</sup>

The literature reflects some interesting differences of opinion regarding flexibility training and consideration of static stretching as the gold standard. Some authors have questioned the importance of using static stretching to help reduce injuries and improve performance.

Murphy made a compelling argument against the use of static stretching. Although static stretching is often used as part of pre-activity preparation, Murphy argued that the nature of static stretching is passive and does nothing to warm muscle. Murphy suggested a better opinion for maintaining or increasing flexibility of a muscle is through active contraction using dynamic range of motion, there by adding fourth type of stretching.

Previous author<sup>1</sup> suggested that most of injuries occurs in the eccentric phase of activity. Although early groups have examined dynamic range of motion, none have investigated the use of an eccentric agonist contraction to improve flexibility; eccentric training a muscle through a full range of motion theoretically could reduce injury rates and improve the performance of subject and flexibility.

Russel et al<sup>2</sup> proved that in males ages 15-17 years old, hip flexion range of motion gains with eccentrically training were equal to those made by static stretching of hamstring muscle.

## 2. Methodology

It is a comparative study. The study has pre-test, post-test experimental control group design. Measurement was taken prior to and after respective treatment session. It was a single blinded study, the subjects being unaware of the groups they belong to.

There were 2 independent variables: eccentric training and static stretching. The dependent variable was active ankle dorsiflexion range of motion.

### 2.1. Subjects

A sample of 60 healthy college male volunteers with the mean age of 25.07 years participated in the study. All the subjects were students of Jamia Hamdard University. The study was conducted at Majeedia hospital, Jamia Hamdard, New Delhi. To participate, the subjects needed to have tight triceps surae (inability to achieve 20° of active dorsiflexion). Exclusion criteria included hypermobility, Subject under medication (muscle relaxants), Skin disease, wounds, neurological problem, any circulatory problem or metal implants in the leg.

All the subjects were informed the purpose and procedure of the study and an informed consent was taken from them prior to participation. Subjects were randomly assigned into Group A (eccentric training), Group B (static stretching) and Group C (control group) each group includes 20 subjects.

### 2.2. Instruments

A blue colored thera-band, a standard transparent full circle goniometer and a standard stop watch was used.

## 3. Procedure

The study was done over a 4 week period with each subject receiving 1 treatment a day for 5 consecutive days. Measurement was taken at pre- treatment on 1<sup>st</sup> day and post-treatment on 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> week. The ankle range of motion of all the subjects were measured after 7 days of the last treatment session as a follow up measurement.

The eccentric group performed full range of motion eccentric training for the triceps surae muscles. The subject lie supine with left leg fully extended. A 3-feet (0.91m) piece of blue theraband was wrapped around the fore foot of right leg and the subject held the ends of the thera band in each hand. The subject was instructed to keep the right knee flexed and ankle in neutral position. Then he was instructed to bring the ankle in dorsi flexion by pulling on the thera band attached to the forefoot with both arm, knee was taken towards extension. As the subject pulled the ankle in full dorsi flexion with the arms, he was instructed to simultaneously resist the ankle dorsi flexion and knee extension by eccentrically contracting the triceps surae

muscle during entire range of ankle dorsi flexion. The subject was then instructed to provide sufficient resistance with arms to overcome the eccentric activity of the triceps surae muscle, so that the entire range of ankle dorsi flexion took place approximately 5 seconds to complete.

Once achieved, this position was held for 5 seconds, and then extremity was made to gently relaxed. This procedure was repeated 6 times, with no rest in between, here by providing a total of 30 seconds of stretching at the end range.<sup>2</sup>



Figure 1. A Eccentric training initial position, B. Final position of full knee extension

The static group was asked to statically stretch the muscle for 30 seconds, 5 days per week for 3 week. Subject was instructed to place both forearms against the wall with their forehead resting on their hands. To stretch the calf, subjects stood barefoot about 2 to 3 feet from a solid wall, facing the wall with their right foot perpendicular to it, the opposite leg placed on the ground with the knee bend and the foot in front of the body. The intervention limb was placed straight out behind the body keeping the knee keeping the knee straight and heel flat on the ground. Once the subject was comfortable, he was instructed to lean forward at the hips until he feels a sensation of stretch in his calf muscle. Each stretch was hold for a duration of 30 seconds.<sup>5,7</sup>



Figure 2. Subject doing self stretching of triceps surae

No interventions were introduced to the controlled group and only measurement of active ankle dorsiflexion was taken.

For the all group, ROM was measured with the goniometer.<sup>18</sup> For goniometric measurements, fibular head, lateral maleolus, the base of 5th metatarsal and the 5th metatarsal head were marked with a permanent marker. Stationary arm of the Goniometer was placed along the long axis of fibula by using the marks on the fibular head and the lateral maleolus. Moving arm of the Goniometer was placed parallel to the lateral border of the foot by using the marks on the base and head of the 5th metatarsal.

The axis of the Goniometer then fell on the lateral border of foot. The zero position of dorsiflexion was defined as the 90-degree angle between the long axis of the fibula and the lateral border of the foot. All the measurements were recorded as the subjects achieved maximum active dorsiflexion. To establish reliability of ROM measurements across sessions, we took pre and post treatment ROM thrice and used their mean for analysis.<sup>1, 5, 6</sup>



Figure 3. Measuring triceps surae flexibility

### 3.1. Data Analysis

Means and SDs for all groups and all measurements were calculated. We used one-way ANOVA with repeated measure to analyze the data. Appropriate post hoc tests were performed to interpret the findings. An alpha level of  $P < 0.05$  was the level of significance.

## 4. RESULTS

A total of 60 subjects participated in the study. Each group included 20 subjects. Mean age of the subjects were  $25.45 \pm 1.61$  for group A,  $25.25 \pm 1.37$  for group B and  $24.50 \pm 1.93$  for group C. Mean and S.D for pre-test and post test measurements were calculated for each group. A multivariate test was also applied to compare the dependent variable in all three groups. Post hoc analysis for ANOVA was performed using Bonferroni (all-pairwise) multiple comparison in order to interpret the significant effect on dependent variable. The data was analysed for both within group and between groups. Significance for all the statistical tests was accepted at the 0.05 level of probability.

Dorsiflexion range of motion between three group were compared at Pre-test (ROM 0), ROM 14, ROM 21 and ROM 28. All pretest mean values for ADFROM for group A, B, C were  $12.47 \pm 2.45$ ,  $12.41 \pm 3.38$  and  $13.47 \pm 2.52$  respectively ( $P = 0.415$ ). At day 14 mean values for ADFROM for group A, B, C were  $15.51 \pm 3.10$ ,  $15.21 \pm 3.37$  and  $13.65 \pm 2.36$  respectively ( $P = 0.112$ ). At day 21 mean values for ADFROM for group A, B, C were  $18.21 \pm 3.61$ ,  $16.51 \pm 3.45$  and  $13.62 \pm 2.38$  respectively ( $P = 0.00$ ). At day 28 mean values for ADFROM for group A, B, C were  $17.62 \pm 3.64$ ,  $15.07 \pm 3.25$  and  $13.73 \pm 2.45$  respectively ( $P = 0.00$ ).

Finally, a one-way ANOVA was calculated to assess the posttest scores of the 3 groups, revealing a significant difference ( $F = 10.67$ ,  $P < 0.05$ ). post hoc analyses indicated that the mean score of the static group ( $16.51 \pm 3.45$ ) was significantly different from the control group ( $13.62 \pm 2.38$ ). Also, the eccentric group ( $18.21 \pm 3.61$ ) was significantly different from the control group, but the eccentric and static groups did not differ from each other.

The follow up measurement (1 week later) was compared to the last measurement taken i.e. after the ROM of 21<sup>st</sup> day treatment session. It was found that ROM lost in group A was  $-0.59^\circ$  ( $p = 0.00$ ), group B had lost  $-1.43^\circ$  ( $p = 0.02$ ) and group C had gain  $0.11^\circ$  ( $p = 0.00$ ). However when the 28<sup>th</sup> day measurement was compared with 1st day pretreatment ROM, it was highly significant in both the 2-groups ( $p = 0.00$ ).

Table 1. within group comparison of ADFROM

ROM	G1(n=20) Mean $\pm$ SD	G2(n=20) Mean $\pm$ SD	G3(n=20) Mean $\pm$ SD
ROM 0	12.47 $\pm$ 2.45	12.41 $\pm$ 3.38	13.47 $\pm$ 2.52
ROM14	15.51 $\pm$ 3.10	15.21 $\pm$ 3.37	13.65 $\pm$ 2.36
ROM21	18.21 $\pm$ 3.61	16.51 $\pm$ 3.45	13.62 $\pm$ 2.38
ROM28	17.62 $\pm$ 3.64	15.07 $\pm$ 3.25	13.73 $\pm$ 2.45

Table 2. Pre-test,Post test and gain in ADFROM

	Group		
	Eccentric training	Static stretching	Control
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Pre test	12.47 $\pm$ 2.45	12.41 $\pm$ 3.38	13.47 $\pm$ 2.52
Post test	18.21 $\pm$ 3.38	16.51 $\pm$ 3.45	13.62 $\pm$ 2.38
Gain	5.75 $\pm$ 2.12	4.10 $\pm$ 1.23	0.15 $\pm$ 0.58
Follow up	17.62 $\pm$ 3.64	15.07 $\pm$ 3.25	13.73 $\pm$ 2.45

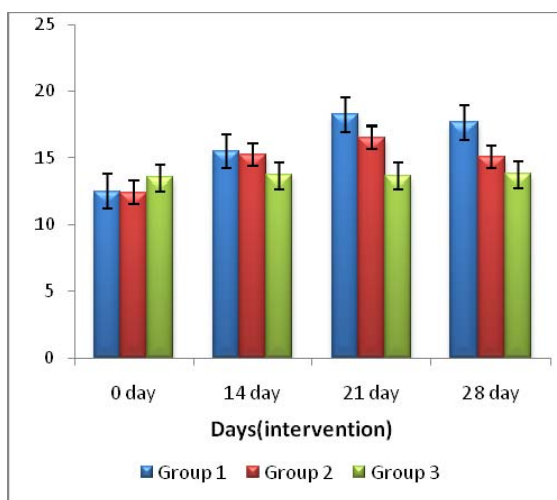


Figure 4: weekly changes in ADFROM in 3 Groups

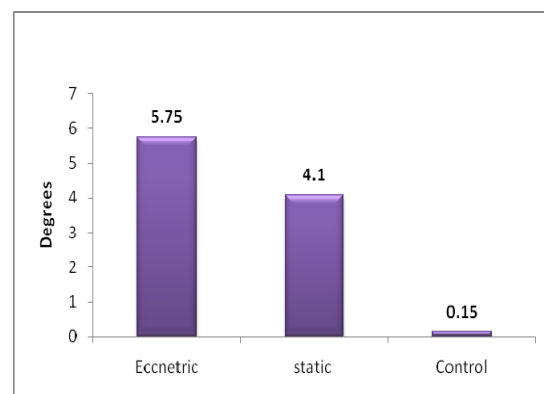


Figure 5 : Mean change (difference between pre and post) in ADFROM

## 5. Discussion

We reject the null hypothesis that no difference would be seen in triceps surae flexibility after 3 weeks of eccentric training compared with the static stretching. The group that performed static stretching and eccentric training in triceps surae shows significantly greater gains in flexibility than the control group. Given the significant difference in triceps surae flexibility between the experimental groups, eccentric training appears to be more effective in increasing triceps surae muscle flexibility. In within group analysis both the experimental groups are shown to be effective and improving significantly then control group.

The result supports the theory that eccentric training through a full range of motion increases muscle flexibility. The gains obtained in static stretching group are quite similar to the 3 previous longitudinal studies on the effect of duration of static stretching.<sup>3, 15,17</sup>

Bandy et al<sup>20</sup> examine the effects of statically stretching the hamstring for a variety of duration, including 30 seconds. The gains in knee-extension range of motion after 6 weeks of statically

stretching hamstring muscle for 30 seconds were very similar to the gains by the static stretching group in our study.

In a study done by Knight et al, comparison of the effects of 3 treatments on ankle dorsiflexion range of motion was seen. Our study has similar effects of static stretching as that of stretching group in his study.<sup>4</sup> In another study done by Youndas et al<sup>5</sup>, the effects of a 6-week program of stretching of the calf muscle tendon unit (MTU) on active ankle dorsiflexion range of motion (ADFROM) was examined, where he found that there was no effect of treatment, but in our study contrary to that significant difference in stretching group as compared to control group was seen.

Noberga et al<sup>21, 2</sup> says that resistance training alone did not increase flexibility, but resistance training did not interface with increase in joint range of motion during flexibility training. These results support the concept that specific training should be employed in order to increase either muscle strength or flexibility, where as eccentric training increases strength of the muscle and in our study we had proved that it also increases flexibility.

The mechanism for the increased flexibility with eccentric muscle activity through the full range of motion is unclear. One explanation may be found in examining the possible neurologic mechanism that occurs with stretching. Static stretching may be effective in increasing the length of the muscle due to the prolonged stretching, which may allow the muscle spindle to adapt over time and cease firing.<sup>17</sup> The result of this adaptation/relaxation of the muscle spindle increases length in the muscle. Given that eccentric exercise through the full range of motion is a continual movement lasting only 5 seconds, the muscle spindle does not appear to have time to adapt, and this explanation does not appear to be appropriate for explaining the change in flexibility due to the eccentric activity. Although eccentric training of the triceps surae muscle achieves the same flexibility gains as static stretching, the eccentric training offers more functional option for flexibility training. Individuals training muscle eccentrically may reduce the chance of injury by training the muscle in a more functional type of activity.<sup>2, 22</sup>

In our study we found that after the six days of rest, lasting effect in both the experimental group decreases, which support the previous studies. We also found that there was less decrease in eccentric group than that of stretching group. In a study by Zito et al,<sup>24</sup> who investigated that lasting effect of 15 seconds of passive stretch on ankle dorsiflexion range of motion, and found that after taking measurement over 24 hours no significant length gain was seen. This is similar to our study.

In another study Knight et al<sup>4</sup> found that after the six days of rest there is a increase in the ROM, which is contrary to our results. In our study there was a decrease in the ROM

T. G Potier et al<sup>13</sup> investigated whether eccentric strengthening changed the muscle architecture of human biceps femoris and consequently, knee range of motion and they found increase in FL (fascicle length) in the biceps femoris and this could lead to increase in ROM of knee.

Batista et al,<sup>23</sup> evaluated the effects of an active eccentric stretching program for the knee flexor muscles on range of motion and torque. They concluded that this program was effective for increasing the flexibility.

Russel et al<sup>2</sup> had studied on hamstring muscle flexibility by using both eccentric training and static stretching for six weeks program and after six weeks they concluded that the gains achieved in range of motion of knee extension with eccentric training were equal to those made by statically stretching of hamstring muscle, and in our study on triceps surae we concluded the gains achieved in range of motion of dorsiflexion with eccentric training for 3 weeks were significant as compared to those made by static stretching.

Therefore, other research is now needed to determine if gains are made in strength, injury reduction, and performance improvement through an eccentric-training exercises program similar to the program used in the present study.

The first limitation of our study was only male patient have taken. Study could be elaborated on the female patients also.

The second limitation was age group taken was limited. Further studies can be done with different age group.

The last limitation was measurement with goniometer needs more perfection, with inclinometer or more

recent devices.

We suggest that, this project could also be adapted to test the extensibility of other joint muscle groups such as the hamstrings or quadriceps femoris muscle.

## 6. Conclusion

Two of the three groups in this study showed increase in the flexibility of the right triceps surae, resulting in increase ADFROM. Both the static stretching and eccentric training significantly improved range of motion as compared to control group; however there is significant difference in these two groups in the last measurement.

This result suggests that there is further scope for the use of eccentric training for flexibility training in individual muscle group in a more functional type of activity.

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