Rakesh Kumar  
Assistant Professor, Meridian College of physiotherapy, Varanasi

**ABSTRACT**

The present study has been conducted to compare the effects of two frequencies of Ultrasound for increasing the extensibility of plantar flexors.

**Method:** 50 subjects with tight plantar were randomly assigned to two groups Group A and Group B. 25 subjects were allotted in each group. Group A was given 1 MHz frequency ultrasound before static stretching. Group B was given 3 MHz frequency ultrasound before static stretching. Dorsiexion range was measured (with knee flexion and extension) at day 1 and after 6 weeks of treatment.

**Result:** Mean diff (0-6) weeks for Dorsiexion Active R.O.M. with Knee Flexion and Extension was 7.88±2.00 & 8.24±2.20 respectively for group A and 5.28±1.42 & 5.72±1.67 respectively for group B.

Mean diff (0-6) weeks for Dorsiexion Passive R.O.M. with Knee Flexion and Extension was 8.04±1.74 & 8.36±1.93 respectively for group A and 5.28±1.88 & 5.08±1.80 respectively for group B.

**Conclusion:** Among the two frequencies use of 1 MHz ultrasound before stretching may be more effective for increasing ankle dorsiflexion R.O.M.

**KEYWORDS:** Extensibility, Plantar Flexors, Dorsiexion, Goniometry, Ultrasound.

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**Introduction**

Shortening of a muscle can be as a result of prolonged immobilization, restricted mobility, connective tissue or neuromuscular disease, tissue pathology due to trauma, congenital and acquired deformities.

Stretching is a general term used to describe any therapeutic maneuver designed to lengthen (elongate) pathologically shortened soft tissue structures and thereby to increase range of motion.

Warming up soft tissues prior to stretching increases the extensibility of the shortened tissues. Increased extensibility increases the length gain for the same force of stretch while also reducing the risk of tissue damage.

Ultrasound is one of the widely used deep heating modalities. Therapeutic ultrasound has been used extensively to treat a variety of conditions because of its documented thermal effects. It has already been shown to increase tissue temperature at a depth up to 5 cm with only minimal increase in skin temperature.

Previous studies done on human body indicate that continuous ultrasound of sufficient intensity and duration to increase the tissue temperature may increase soft tissue extensibility. Yet it is not clear which of the two frequencies that is 1 MHz and 3 MHz is better for increasing the extensibility of plantar flexors. This study has been conducted to compare the effects of two frequencies of Ultrasound for increasing the extensibility of plantar flexors.

**Methodology.**

The present study is a prospective study conducted on fifty patients of department of Physiotherapy, Janta Seva Hospital Varanasi.

**Inclusion Criteria**
- Patients of Both Gender, Age between 20 and 30 years, Ankle Dorsiexion Range less than 15°, Not involved in any regular exercise program.

**Exclusion Criteria**
- Patient Having impaired sensation, Pathology or Recent Surgery in Knee or Ankle, Thrombophlebitis, Patient on Radiotherapy for last six months, Malignant Tumor, Metal Implant, Patient taking muscle relaxant, Skin Disease and Pregnant Women.

**Equipment Used** were Ultrasound Apparatus having both 1 MHz and 3 MHz frequency modes, Towel for Self Stretching, Measuring Tape, Couch, Pillow, Standard Full Circle Goniometer and Stop Watch.

In the study there were two groups: Group A and Group. Fifty Patients were selected from those who matching the prerequisites. With the help of Systematic Random sampling technique 25 patients were divided into two groups (Group A and Group B). Subjects in both were treated three times a week for six weeks.

**Outcome Measures**

Dorsiexion range with knee flexion and extension
The Patient was positioned in prone position with foot hanging out of couch, and the subtler joint was maintained in the neutral position. Dorsiexion range was measured with a standard goniometer as the angle formed by the lateral midline of the leg on a line from the head of fibula to the tip of the lateral malleolus and the lateral midline of the foot in line with the border of the rear foot/calcaneus.

Dorsiexion range with knee flexion and extension
Ankle joint dorsiflexion was measured with the knee in extension and again in Knee 90 degree flexion. The average of two trials with 5 second pause between the trials was recorded.

Active and Passive R.O.M. both were taken in knee extension and knee at 90 degree flexion53.

**Ultrasound Application**

Patient Position- patient was positioned prone on couch with his/her foot hanging out of the couch.

Site of application- Ultrasound application was divided into two sessions. In the first session it was applied to the upper half (20 cm2 area) of the muscle belly of calf muscles followed by stretching. In the second session it was applied to the lower belly of the calf followed by the same stretching protocol.

**Method of Application-** Direct contact. Medium – Aquasonic sterile Gel. Speed – 4 cm/sec

**Group A**
- Freq- 1MHz, Mode- Continuous, Intensity-1.5watt/cm2, E.R.A.-10cm2, Duration-10 min

**Group B**
Graph 1
The mean and standard deviation of active R.O.M. of dorsiflexion when knee is flexed at pre and post 6 weeks treatment (Graph 1). For group A values are 11.36 ± 1.87 and 19.40 ± 0.58 respectively. For group B values are 11.60 ± 1.60 and 16.88 ± 1.01 respectively. Mean deviation for group A and B are 8.04 ± 1.74 and 5.28 ± 1.88 respectively.

Comparison of mean values and S.D. of passive R.O.M. of dorsiflexion when Knee is flexed between Group A and Group B

Graph 2
The mean and standard deviation of active R.O.M. of dorsiflexion when knee is flexed at pre and post 6 weeks treatment (Graph 2). For group A values are 10.92 ± 1.98 and 19.28 ± 0.61 respectively. For group B values are 10.88 ± 1.73 and 15.96 ± 0.88 respectively. Mean deviation for group A and B are 8.36 ± 1.93 and 5.08 ± 1.80 respectively.

Comparison of mean values and S.D. of passive R.O.M. of dorsiflexion when Knee is extended between Group A and Group B

Table 1: Comparison of mean value for dorsiflexion at pretreatment and post treatment within group A and group B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Knee Position</th>
<th>Group A</th>
<th>Group B</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.R.O.M.</td>
<td>Flexion</td>
<td>-19.63</td>
<td>-18.47</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>18.69</td>
<td>17.13</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>P.R.O.M.</td>
<td>Flexion</td>
<td>-23.05</td>
<td>-14.04</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>21.61</td>
<td>14.11</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Table 2: Comparison of mean value of dorsiflexion at pre-treatment with knee flexion and extension between Group A and Group B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Knee Position</th>
<th>Group A Vs Group B</th>
<th>t value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.R.O.M.</td>
<td>Flexion</td>
<td>-0.521</td>
<td>0.601</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>0.926</td>
<td>0.391</td>
<td></td>
</tr>
<tr>
<td>P.R.O.M.</td>
<td>Flexion</td>
<td>0.488</td>
<td>P &gt; 0.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>0.076</td>
<td>P &gt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Comparison of mean value at Post interval with knee flexion and extension between Group A and Group B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre interval</th>
<th>Group A Vs Group B</th>
<th>t value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.R.O.M.</td>
<td>Flexion</td>
<td>10.852</td>
<td>P &lt; 0.05</td>
<td></td>
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<tr>
<td></td>
<td>Extension</td>
<td>10.735</td>
<td>P &lt; 0.05</td>
<td></td>
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<tr>
<td>P.R.O.M.</td>
<td>Flexion</td>
<td>10.806</td>
<td>P &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>15.514</td>
<td>P &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Comparison of Mean diff. (0-6) weeks with knee flexion and extension between Group A and Group B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean diff. (Pre – Post)</th>
<th>Group A Vs Group B</th>
<th>t value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.R.O.M.</td>
<td>Flexion</td>
<td>5.277</td>
<td>P &lt; 0.05</td>
<td></td>
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<tr>
<td></td>
<td>Extension</td>
<td>4.556</td>
<td>P &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>P.R.O.M.</td>
<td>Flexion</td>
<td>5.391</td>
<td>P &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>6.214</td>
<td>P &lt; 0.05</td>
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</table>

Discussion.
The present study suggests that 1 MHz ultrasound improves the extensibility of tight Plantar flexors more than that of 3 MHz ultrasound (p<0.05)

The mean difference between pre and post treatment for Group A and B were as follows:

1) Active R.O.M. with Knee Flexion 7.88 ± 2.00 and 5.28 ± 1.42 respectively.
2) Active R.O.M. with Knee Extension 8.24 ± 2.20 and 5.72 ± 1.67 respectively.
3) Passive R.O.M. with Knee Flexion 8.04 ± 1.74 and 5.28 ± 1.88 respectively.
4) Passive R.O.M. with Knee Extension 8.36 ± 1.93 and 5.08 ± 1.80 respectively.

Mechanism responsible for the result
Ultrasound waves applied to the body tissue collides with the molecules present in the tissue. This causes molecular agitation. As a result here is heat production in the tissues. Warming up soft tissue prior to stretching will increase the extensibility of the shortened tissue. Warm muscles relax and lengthen more easily, making stretching more comfortable for the patient. As the temperature of the muscle increases, the amount of force required to elongate noncontractile and contractile tissues and the time the stretch force must be applied decreases. As the intramuscular temperature increases, connective tissue yields more easily to passive stretch and the sensitivity of the GTO increases. Heating also minimizes the chance of micro trauma to the soft tissue during stretching.

Soleus Stretching
Soleus was also stretched in the same way only difference was one pillow was kept below the knee to isolate soleus stretching.

- Each Stretch was maintained for twenty second duration followed by ten second rest
- Gastrocnemius and Soleus were stretched alternately.
- The Sequence was repeated four times.
Heat increases the activity of the cutaneous thermo receptors which can have an immediate inhibitory gating effect on the transmission of the sensation of pain at the spinal cord level. Heating effect of 1 MHz ultrasound therapy is deep penetrating as compared to 3 MHz ultrasound. So, when ultrasound was applied to the plantar flexor muscles more fibers were exposed with 1 MHz ultrasound as compared to 3 MHz. Along with that thermal decay of 1 MHz ultrasound is slower than 3 MHz ultrasound. Therefore in patients treated with 1 MHz ultrasound (Group A) more number of fibers were heated as compared to the patients treated with 3 MHz ultrasound (Group B). The stretching window was also open for longer period for patients in group. This is the reason for increased extensibility in 1 MHz ultrasound group as compared to 3 MHz ultrasound.

According to the statistical analysis there is a significant improvement in the extensibility of plantar flexors in both the groups. Group A is statistically more significant as compared to Group B. The finding is supported by following researchers:

Claudia A K et al (2001) concluded that out of active exercise, moist heat and ultrasound (1 MHz) for 7 minutes ultrasound is the best modality for increasing extensibility of plantar flexor. Tashiro T S et al (2004) concluded that there was significant difference between the control group and the groups given ultrasound of 1 MHz over the muscle.

But there was no significant difference between the group given ultrasound over mid-belly of hamstring and the group given over the area subject felt greatest perceived tightness. Rose S et al (1996) concluded that thermal decay of 1 MHz ultrasound was slower than 3 MHz and deeper tissue cooled at a slower rate than superficial tissue following 1 MHz ultrasound.

Conclusion
The result indicates that there is a significant gain achieved in range of motion of ankle dorsiflexion indicating improvement in plantar flexors length by both 1 MHz and 3 MHZ Ultrasound therapy before stretching. 1 MHz ultrasound was statistically more significant than 3 MHz ultrasound for improving the extensibility of plantar flexors.

References