EFFECT OF CRYOCOMPRESSION AND TISSUE FLOSSING ON HAND SPASTICITY AND FUNCTION - A RANDOMIZED CLINICAL TRIAL

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ABSTRACT:

PURPOSE: The purpose of the study was to evaluate and compare the effect of Cryo Compression and Tissue Flossing on hand spasticity and its function.

METHODS: Twenty eight adults with hand impairment were recruited in the study and randomly allocated to two groups. Group A received Cryocompression therapy while Group B was given Tissue Flossing for 10 sessions in 2 weeks. The outcome measures used in the study were Modified Ashworth Scale for spasticity assessment and Wolf Motor Function Test for hand function evaluation. All the outcome measures were assessed at the beginning and at the end of the intervention.

RESULTS: There was no significant difference seen in demographic characteristics between the two groups. Both the groups showed improvements in the MAS and WMFT scores from pre to post intervention, but no significant difference was seen in the MAS scores between the two groups. However Tissue Flossing group illustrated significant improvement in the WMFT scores post intervention when compared to the Cryocompression group. (p<0.05)

CONCLUSION: This study supports the use of Cryocompression and Tissue Flossing, as a useful treatment technique to manage spasticity. However Tissue Flossing offers an added benefit of greater enhancement in the hand functions in patients with upper limb dysfunctions.

Keywords: Hand spasticity, hand function, cryo compression, tissue flossing, theraband x trainer.

I. INTRODUCTION

Neuromuscular dysfunctions can cause various disabilities that have a distressing effect on patients lives, of which spasticity is a common and debilitating feature.¹ It is associated with persistent or intermittent involuntary activation of muscles, hyper excitability of stretch reflex which is velocity dependent, motor weakness, loss of dexterity, and reduced movement control.² Spasticity occurs at a inconsistent rate and has been reported to affect 40% of people with Spinal Cord Injury, 50% of those with Traumatic Brain Injury, 35% with Stroke and 37% - 78% with Multiple Sclerosis.³ It is majorly seen affecting the upper extremity than the lower which impairs the individuals motor performance.³,⁴ It can also lead to upper limb dysfunction, with up to 40% not retrieving purposeful use of the upper limb in daily activities.³ A study demonstrated that 80% of the stroke cases experienced hemiparesis of which 70% had residual upper extremity impairment which lead to dependency in performing activities of daily living.⁶ Thus there is immense need to treat and manage muscle spasticity in order to enhance the functions of the hand as it would considerably influence the upper limb function.

Cryotherapy is a desirable technique which has been used time and again, to reduce spasticity as it is easy to apply and has negligible side effects.⁷ Cold application reduces the conduction velocity of the nerves to cease the spasm.⁸
and also decreases the firing of action potential. Previous investigations depicted that cold application was effective in improving hand function by reducing the spasticity when it is given in combination with conventional therapy.

Compression of the involved segment is another technique that has been proven effective in reducing the muscle tone and improving joint alignment. This produces a circumferential pressure that decreases the alpha motor neuron activity and reduces the spinal motor neuron overexcitability. Compression reduces the tone and increases the range of motion due to constant stimulation of the C fibres that activate the autonomic nervous system response, which influences decrease in spasticity. Compression therapy provides icing along with compression, which is colder as the skin contact improves and the tissue density increases by the continued static compression. Thus the muscle arrives at its lowest temperature faster and it maintains its cool even after the intervention ends.

Blood flow restriction exercise has been reported as one of the rehabilitation intervention that can enhance the size of the skeletal muscle and increase its strength. This method requires applying external circumferential pressure to occlude the blood flow and thus trapping the metabolites in the working muscle, which after repeated exposure produce muscle adaptations similar to high load exercises. Floss bands are increasingly being used to apply compression while the individual performs the movement within the full or available range. The pressure exerted by the floss band secures arterial inflow of blood but decreases or impedes venous outflow distal to the site. On removal of the compression the desired changes are brought about by the muscle tissue re perfusion.

As there are no previous published reports that depict which intervention is most suitable to reduce hypertonia, this study aims to evaluate and compare the effect of Cryocompression and Tissue Flossing on hand spasticity and function in patients with upper extremity impairment.

II. METHODOLOGY

The study was a Parallel group, Randomized Clinical Trial which performed with the approval of the Institutional Ethical Committee. The study was in accordance with the ethical guidelines of Helsinki Declaration for human experimentation. The objectives and requirements of the study were explained to all the participants and their informed consent was obtained.

Twenty eight patients with hand impairment were recruited in the study from Tertiary care hospitals and clinics in Belagavi. The participants in the study were within the age group of 40-70 years, who had upper extremity spasticity with Brunnstrom recovery stage of 4 or 5 and Chedoke McMaster Hand Assessment score of ≥3. Only subjects who did not show a hyperreactive response to Cold Pressor test were included in the study. Patients on antispastic medications or those who have a history of Peripheral Vascular Diseases, Cardiovascular Diseases, Uncontrolled Hypertension, reduced and altered sensations, Peripheral Neuropathy, Cold Urticaria, Latex allergy, Ulcers and skin lesions on the hand were excluded from the study.

III. OUTCOME MEASURES

Muscle spasticity was assessed using the Modified Ashworth Scale. Wrist, finger and thumb flexor spasticity was assessed and rated on a scale from 0-4. The reliability of the scale was found to be between 0.61-0.87.

Wolf Motor Function Test was used to evaluate the subjects motor ability. The abbreviated version was used, that includes 6 tasks (hand to table, hand to box, reach and retrieve, lift can, lift pencil and fold towel) along with two added grip strengthening and flip card tests. The time required to perform the tasks is recorded and the scoring is done according to the Functional Ability Scale which grades the quality of the movement performed. The validity of the scale for performance time is 0.91 and 0.91 for functional ability, while the reliability was noted to be 0.91 and 0.89 respectively.

IV. INTERVENTION

The subjects were randomly assigned to either the Cryocompression group or the Tissue Flossing group by using sealed opaque envelopes. Before the commencement, pre assessment values of Modified Ashworth Scale and Wolf Motor Function Test was performed and documented. Both the groups performed 30 minutes of conventional
therapy exercises comprising of passive stretching, active range of motion exercises, weight bearing exercises and exercises with the theraband X-trainer.

**Group A**: The Aircast Cryocompression unit was used to deliver the Cryocompression Therapy, where in the subjects were made to sit comfortably on a chair and the Cryo cuff was placed on the patients hand and forearm. The device was switched on and applied for 20 minutes during which compression was provided for 45 seconds followed by relaxation for 15 seconds.

**Group B**: The subjects received Blood Flow Restriction via Tissue Flossing. The floss band was applied distal to proximal with approximately 50% tension on the band. The band was wrapped for 2 minutes during which the subject had to perform wrist and finger movements in all planes, wrist flexion-extension, radial-ulna deviation, hand opening-closing and finger abduction-adduction. After two minutes the floss band was removed.

The intervention was performed for 5 sessions per week for 2 weeks, following which post treatment assessment of outcome measures were carried out.

V. **STATISTICAL ANALYSIS**

Statistical evaluation of the data was implemented using SPSS Version 23. For the continuous data numerous mathematical calculations such as mean, standard deviation were employed and for categorical data, percentages were performed. The Kolmogorov-Smirnov test was used to assess the normality of Modified Ashworth Scale and Wolf Motor Function Test Scores. The homogeneity of the data was verified using the Chi Square Test for gender distribution and Independent t Test for the Age, Brunnstrom stage and Chedoke McMaster Scores. Dependent t Test was administered for within group comparison of Wolf Motor Function test time score and grip strength, while Independent t Test was utilized to execute between group analysis of the same. For WMFT Functional Ability Scale and Modified Ashworth Scale Scores, Wilcoxon Signed Rank test was performed for within group analysis and Mann-Whitney U test for between group comparison of the data. Level of significance was considered at 5% and p-values < 0.05 was contemplated powerful.

VI. **RESULTS**

A total of 28 participants with upper limb spasticity and impaired hand function completed the study. The mean age of participants in the Cryocompression Group was 57.29 ± 8.94 years and 52.93 ± 8.81 years in the Tissue Flossing Group. There were equal number of males and females in each group and there was no significant difference seen in the Brunnstrom stage and Chedoke McMaster scores between the two groups, which means the groups were comparable (Table 1).

The results of the present study revealed that both groups showed decrement in the Modified Ashworth Scale scores post treatment and there was no significant difference in between the groups for the wrist flexors, finger flexors and thumb flexors scores with p values of 0.198, 0.963, 1.000 respectively. However the Cryocompression group demonstrated higher percentage of improvement in comparison to the Tissue Flossing group in all the three components. (Table 2).

Although both groups also showed improvements in the Total WMFT time and Functional Ability Scale scores, the Tissue Flossing group illustrated significantly greater improvements compared to the Cryocompression group with p value of 0.0038 and 0.0001 respectively. There was significant improvement seen in all the components of Time and FAS scores from pre to post treatment analysis, however significant difference between the two groups was only noticed in four components (lift can, lift pencil, fold towel and flip cards) at the end of intervention with p value < 0.05 (Table 3 and Table 4).

The change in grip strength was significant in both the groups post intervention, yet between group comparisons depicted greater significant improvement in the Tissue Flossing group with a p value of 0.0002 when compared to the Cryocompression group.

VII. **DISCUSSION**

The effect of Cryocompression and Tissue Flossing in patients with hand spasticity and impaired function was investigated in the current study. The participants were given the intervention for 10 days for a duration of 2 weeks. The results of the study depicted that there was decrement in the spasticity in terms of Modified Ashworth Scale
and improvement seen in the Wolf Motor Function Test time and Functional Ability Scale scores. Grip strength also showed significant improvement post intervention.

Cryocompression is a technique that provides Cold therapy under pressure. Cryotherapy is proven to decrease spasticity by inducing a localized cooling effect on various components of the sensorimotor segments like skin receptors, afferent alpha and gamma motoneurons, myoneural junctions, intrafusal and extrafusal muscle fibres. There are several underlying mechanisms that elucidate how cold therapy may help decrease hypertonia. One of which is explained in a study conducted by Miglietta et al., where they observed significant drop in the muscle temperature abolishing spasticity and clonus due to stimulation of sympathetic fibres. Activation of these fibres causes vasoconstriction which leads to reduction in spindle sensitivity, thereby decreasing spasticity. Similarly Eldred et al. study suggested that the sensory terminal is the location of thermal effect, which results in alteration of the membrane stability by lessening the temperature. Thus Cold application is reported to manage hypertonia, reduce clonus, excitability of tendon reflexes, while increasing the joint range of motion and enhancing the antagonistic group muscle power. These findings could be the mechanisms corresponding to the improvements in spasticity seen in the current study resulting in decrement in the Modified Ashworth Scale scores which in turn may lead to enhancement of functions.

Deep pressure is a proprioceptive technique that causes motor neuron inhibition in the nervous system. Pressure that is applied circumferentially provides a deep, prolonged contact encompassing the whole body segment with an invariable pressure. This stimulates peripherally the muscle and cutaneous receptors of the agonist and antagonist musculature, causing decrease in the alpha motor neuron excitability with a longer lasting inhibition of H-reflex. A study carried out by Twist et al. reported that there was reduction in the spasticity following 1 hour of wrapping bandages and wearing gloves over the spastic upper extremity in patients with Cerebrovascular Accident. The mechanism leading to the reduction in tone was presumed to be the constant stimulation of C fibres that alters the Autonomic Nervous System response by inhibiting the sympathetic outflow to the brain. Another possible rationale for the improved tone following compression was given by Tally et al. suggesting that continuous pressure application may cause a Tonic Pressure Reflex, which generates at first a strong contraction of the spastic muscles followed by relaxation of the same.

Blood Flow Restriction training has shown evidence not only in normalising tone but also increasing the strength of the muscle by training at lower intensities and eliciting physiological responses parallel to those attained when exercising at higher intensities. Several mechanisms correspond to the effectiveness of Blood Flow Restriction on tone and strength of muscles, including augmented muscle protein synthesis, enhanced glycogen usage and increments in neural drive. In a study conducted by Gorey et al., they reported that FES training of wrist extensors when combined with Blood Flow Restriction was effective in increasing the cross-sectional area of the muscles in subjects with Spinal Cord Injury. With BFR the increase in area was 17% higher than without BFR, as hypoxic environment is expected to hasten protein synthesis of the exercising muscles leading to muscle hypertrophy. Similarly Larkin et al. observed in his study that BFR combined with knee extension exercise enhanced the Vascular Endothelial Growth Factor along with additional angiogenic factors, resulting in improvements in the tissue perfusion and density of capillaries which contributes to improved muscle endurance. Increments in the length and strength of muscles are attributed to the favored recruitment of Type II fibres, which is explained in the study by Moritani et al. Stavres et al in his study stated that simple blood flow occlusion with a cuff in Spinal Cord Injury patients reduced spasticity as a result of hypoxemia, which influences metabolite accumulation. These metabolites are expected to activate the anabolic factors and influence the peripheral adaptations. This in turn leads to increase in length of the muscle contributing to improved functional activities off the affected limb.

In the current study, decrement in the Modified Ashworth Scale scores is seen in both the groups post intervention. Although statistically significant difference is not seen in between the two groups, CryoCompression group has higher percentage of change post treatment in all the 3 components (wrist flexors, finger flexors and thumb flexors) when compared to the Tissue Flossing Group. This might be attributed to the combined application of Cold therapy and Compression that resulted in spasticity reduction.

Similarly, the present study illustrated that there was significant improvements noted in the hand function in terms of Wolf Motor Function Test Time and FAS scores. In item analysis of Wolf Motor Function Test Time and FAS scores, certain components like hand to table, table to box and reach and retrieve did not show significant improvement in both the groups owing to lack of involvement of the proximal arm segments in the treatment. However this was compensated with significant change in the other components, resulting in overall significant
change of the Total Time and FAS scores within both the groups. A previous study supported the findings of the current study, where they observed substantial improvement in hand function post wrist extensor stimulation and mirror therapy, while the upper extremity performance did not differ significantly. There is evidence that proximal movement depend on bihemispheric characterizations while the distal components rely on unilateral presentations which activate the lateralised motor presentations of the distal component.26

On the other hand between group analysis of the components demonstrated that the Tissue Flossing group showed better improvements in the Time score and Functional Ability Scale items such as Lift Can, Lift Pencil, Fold Towel, Flip Cards as well as the Total Time and FAS scores when compared to the Cryocompression group. These findings may be a result of tone reduction in addition to the improved muscular strength that is offered by Tissue Flossing exercises to enhance function, in contrast to Cryocompression which works remotely on tone reduction. Tissue Flossing creates an ischemic preconditioning environment in the skeletal muscles which leads to improved muscle force and contractility that provides an added benefit to the improvement in hand function.27

Hand grip is an valuable tool to predict high levels of independence during purposeful activities and is associated with function of the upper extremity. Credeur et al. stated in his study that hand gripping exercises along with venous occlusion by a pneumatic cuff, significantly improves the grip strength by 50% as a result of rise in the growth factor, hormonal changes and greater recruitment of large motor units.28 A study carried out by Furlan et al. stated that regaining function following upper limb impairment with rigorous strength training involving all forms of wrist and finger actions of the affected side, may reduce the harmful effects of depression in the perilesional regions of the brain due to disuse and help improve function of the hand.29 In the present study, both the groups depicted significant increments in the grip strength post intervention, however the Tissue Flossing group showed greater improvements when compared to the Cryocompression group suggesting that Flossing which causes Blood Flow Restriction may induce muscle hypertrophy. Muscle hypertrophy causes increased cross sectional area of the wrist and finger musculature, that may contribute to the increase in muscle strength adding to the improvement in hand function.28

Both the groups illustrated improvement in spasticity at the end 10 sessions, with higher decrement noted in the Cryocompression group which was not statistically significant. However the Tissue Flossing group revealed statistically significant enhancement in the hand function in terms of Wolf Motor Function Test in addition to the reduction in spasticity, making it a more favorable treatment option.

This study had some limitations. First, generalization of the study results cannot be done due to the small sample size, Second, no follow up was done to check the long term effects of the treatment, Third, the study utilized a subjective tool instead of objective, to quantify spasticity.

VIII. CONCLUSION

This study provides support for the use of Cryocompression and Tissue Flossing, as a suitable form of treatment strategy to manage spasticity. However Tissue Flossing offers an added benefit of greater improvement in the hand functions in patients with neurological impairment causing upper limb dysfunctions. Further studies with larger sample size, longer duration and follow up are needed to evaluate the effect of the treatment on hand spasticity and function.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial or profit and sectors.

CONFLICT OF INTEREST:

None

Ethical Approval was obtained from Research and Ethics Committee, KAHER Institute of Physiotherapy and the approval number is 716.

Acknowledgement

The authors thank all the participants of the study for their co-operation
REFERENCES

FIGURE 1: CONSORT CHART

TABLES

Table 1. Demographic and clinical characteristics of participants:

<table>
<thead>
<tr>
<th>Gender n (%)</th>
<th>Group A</th>
<th>Group B</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>8 (57.14)</td>
<td>10 (71.43)</td>
<td>$\chi^2=0.6220$</td>
<td>0.4300</td>
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<tr>
<td>Female</td>
<td>6 (42.86)</td>
<td>4 (28.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>57.29±8.94</td>
<td>52.93±8.81</td>
<td>t=1.2990</td>
<td>0.2054</td>
</tr>
<tr>
<td>Brunnstrom Stage</td>
<td>4.07±0.27</td>
<td>4.14±0.36</td>
<td>t=-0.5927</td>
<td>0.5585</td>
</tr>
<tr>
<td>Chedoke McMaster Assessment Score</td>
<td>4.21±0.58</td>
<td>4.43±0.51</td>
<td>t=-1.0360</td>
<td>0.3097</td>
</tr>
</tbody>
</table>

*Significant at 5% level, p<0.05

Table 2. Within and Between group comparison of Modified Ashworth Scores in the Cryocompression group and Tissue Flossing group:

<table>
<thead>
<tr>
<th>Variable MAS Score</th>
<th>Cryocompression Group</th>
<th>Tissue Flossing Group</th>
<th>z-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist flexors</td>
<td>Pre-int 1.86±0.23</td>
<td>Post-int 1.18±0.42</td>
<td></td>
<td>0.0009 *</td>
</tr>
<tr>
<td>Finger flexors</td>
<td>Pre-int 1.68±0.32</td>
<td>Post-int 1.07±0.51</td>
<td></td>
<td>0.0009 *</td>
</tr>
<tr>
<td>Thumb flexors</td>
<td>Pre-int 1.57±0.39</td>
<td>Post-int 0.86±0.60</td>
<td></td>
<td>0.0001 *</td>
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</table>

*Significant at 5% level, p<0.05, MAS : Modified Ashworth Scale
Table 3. Within and Between group comparison of Wolf Motor Function Test (Time scores) in the Cryocompression group and Tissue Flossing group:

<table>
<thead>
<tr>
<th>Variable WMFT (Time Score)</th>
<th>Cryocompression Group</th>
<th>Tissue Flossing Group</th>
<th>p value</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-int</td>
<td>Post-int</td>
<td>Pre-int</td>
<td>Post-int</td>
<td></td>
</tr>
<tr>
<td>Hand to Table</td>
<td>3.85 ± 1.03</td>
<td>2.79 ± 0.98</td>
<td>0.000</td>
<td>1*</td>
<td>0.2979</td>
</tr>
<tr>
<td>Table to Box</td>
<td>4.34 ± 1.08</td>
<td>3.39 ± 1.07</td>
<td>0.000</td>
<td>1*</td>
<td>-2.593</td>
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<tr>
<td>Reach and Retrieve</td>
<td>4.98 ± 0.86</td>
<td>3.92 ± 1.04</td>
<td>0.000</td>
<td>1*</td>
<td>-0.470</td>
</tr>
<tr>
<td>Lift Can</td>
<td>6.77 ± 1.55</td>
<td>5.39 ± 1.38</td>
<td>0.000</td>
<td>1*</td>
<td>-3.869</td>
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<tr>
<td>Lift Pencil</td>
<td>7.91 ± 0.95</td>
<td>6.56 ± 0.93</td>
<td>0.000</td>
<td>1*</td>
<td>-5.870</td>
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<tr>
<td>Fold towel</td>
<td>13.21 ± 4.19</td>
<td>10.87 ± 3.6</td>
<td>0.000</td>
<td>1*</td>
<td>-7.545</td>
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<tr>
<td>Flip Cards</td>
<td>15.26 ± 3.96</td>
<td>12.94 ± 3.73</td>
<td>0.000</td>
<td>1*</td>
<td>-8.851</td>
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<tr>
<td>WMFT Time Score</td>
<td>56.32 ± 9.85</td>
<td>45.85 ± 9.30</td>
<td>0.000</td>
<td>1*</td>
<td>-11.841</td>
</tr>
</tbody>
</table>

*Significant at 5% level, p<0.05, WMFT : Wolf Motor Function Test

Table 4. Within and Between group comparison of Wolf Motor Function Test (Functional Ability Scale) scores in the Cryocompression group and Tissue Flossing group:

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<tr>
<th>Variable WMFT (FAS)</th>
<th>Cryocompression Group</th>
<th>Tissue Flossing Group</th>
<th>p value</th>
<th>z value</th>
<th>p value</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pre-int</td>
<td>Post-int</td>
<td>Pre-int</td>
<td>Post-int</td>
<td></td>
</tr>
<tr>
<td>Hand to Table</td>
<td>3.57 ± 0.51</td>
<td>4.64 ± 0.50</td>
<td>0.0009</td>
<td>1*</td>
<td>0.000</td>
</tr>
<tr>
<td>Table to Box</td>
<td>3.43 ± 0.51</td>
<td>4.50 ± 0.52</td>
<td>0.0009</td>
<td>1*</td>
<td>0.000</td>
</tr>
<tr>
<td>Reach and Retrieve</td>
<td>3.29 ± 0.47</td>
<td>4.36 ± 0.50</td>
<td>0.0009</td>
<td>1*</td>
<td>0.0022</td>
</tr>
<tr>
<td>Lift Can</td>
<td>3.07 ± 0.47</td>
<td>4.07 ± 0.47</td>
<td>0.0009</td>
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<td>0.0009</td>
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<tr>
<td>Lift Pencil</td>
<td>2.64 ± 0.63</td>
<td>3.43 ± 0.76</td>
<td>0.0033</td>
<td>1*</td>
<td>0.0009</td>
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<th>Grip Strength</th>
<th>Cryocompression Group</th>
<th>Tissue Flossing Group</th>
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</thead>
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<tr>
<td>Fold towel</td>
<td>2.29 ± 0.47</td>
<td>3.14 ± 0.53</td>
<td>0.0014*</td>
<td>2.36 ± 0.50</td>
</tr>
<tr>
<td>Flip Cards</td>
<td>2.36 ± 0.50</td>
<td>3.00 ± 0.78</td>
<td>0.0076*</td>
<td>2.14 ± 0.36</td>
</tr>
<tr>
<td>WMFT FAS</td>
<td>20.64 ± 2.53</td>
<td>27.1 ± 2.85</td>
<td>0.0001*</td>
<td>21.29 ± 1.49</td>
</tr>
</tbody>
</table>

*Significant at 5% level, p<0.05, WMFT : Wolf Motor Function Test , FAS : Functional Ability Scale

Table 5. Within and Between group comparison of Grip strength in the Cryocompression group and Tissue Flossing group :

**Authors Statement**

Manuscript Title: Effect of Cryocompression and Tissue Flossing on Hand spasticity and Function - A Randomized Clinical Trial

We assure you that the following information regarding author’s contribution to the work reported in the manuscript is true

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Acknowledgement: None

This Statement is signed by all Authors

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