Middle-East Journal of Scientific Research 13 (4): 477-482, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.13.4.72109

A Comparison of Superficial Heat, Deep Heat and Cold for Improving Plantar Flexors Extensibility

[1]Shabana Khan, [2]Sharick Shamsi and [3]Asmaa A.A. Alyaemni

[1]College of Applied Medical Sciences Department of Health Rehabilitation,
King Saud University, Riyadh, Kingdom of Saudi Arabia
[2]Raj Nursing and Paramedical College Gorakhpur, U.P. India
[3]Department of Health Rehabilitation, King Saud University Riyadh, Kingdom of Saudi Arabia

Abstract: The present study was done to compare the effects of heat and cold Applications during stretching on Improving plantar flexors extensibility. A total number of 40 volunteers of 18-30 years were participated in study. Subjects were randomly and equally assigned to moist heat pack with static stretching (group A), ice pack with static stretching (group B) static stretching (group C) and Continuous Ultrasound with Static Starching (group D). Subjects in each group were given stretching to plantar flexors with 1/3rd of body weight once a day for 5 days/week for three weeks. ROM was measured before and after treatment session on day of treatment and at the end of each week. Results revealed that means and S.D of ADFROM after 3 weeks were 19.70±2.21, 22.50±2.50,16.10±2.80 and 25.10±2.80 respectively for group A,B,C and D. ANOVA showed significant difference in pre and post intervention ADFROM in all four groups ($P < 0.05$).No statistically significant difference was found between group A and B, but when they were compared with group C and D, the difference was statistically significant ($P<0.05$).In conclusion, all groups showed increased plantar flexors extensibility resulting in increased ADFROM. Although Cryotherapy and thermotherapy have significantly improved ROM, however there was no difference between Moist heat and Ice Pack group. Deep heat group showed better Improvement compared to other groups. Ultrasound during stretching was safe and effective protocol for increasing tissue extensibility.

Key words: Cryotherapy · Thermotherapy · Flexibility · Static Stretching Ultrasound

INTRODUCTION

Flexibility training has its roots in 1900's due to increased orthopedic cases from World war I. Public attention was heightened with the 1950's publication by Kraus and Hirschland. Those who now proclaim flexibility training include coaches, personal trainers, fitness instructors, medical doctors, physical therapists, etc [1].

Planter Flexors play important role in gait cycle and postural control. Lack of their extensibility causes decrease in ankle dorsiflexion and contribute to Achilles tendinitis [2] together with shin splints, plantar fasciitis, muscle strain and joint sprain [3,4].

Increased tightness of gastrocnemius was found to be risk factor for Achilles tendinitis [5]. Mc Kay *et al*. [6] found that those athletes who did not stretch during warm-up were at significantly increased risk of injury compared with those who did stretch 6.

Physiotherapists use wide varieties of treatment to improve flexibility, decrease joint stiffness, prevent deformity and dysfunction.It includes – stretching, moist heat packs (MHP), Ice packs (IP), Ultrasound (US) therapy, CPM, active and passive exercises, etc [5, 7].

Static stretching (SS) is most commonly performed to increase muscle length [8, 9].

Corresponding Author: Shabana Khan C/O - Shakeel Ahmad ShamsiHumayunpur (North),
Near - Imambara, Raj Nursing and Paramedical College Gorakhpur, U.P India,
Gorakhpur, U.P-273001 India. Tel: +915512255782, Mob: +91-9918061106.

Therapeutic heat and cold are widely used in clinical application involving physiotherapy [10]. The principle methods by which superficial heat and cold modalities improve efficacy of stretching are by reducing muscle pain and muscle guarding [2].

Deep heating is thought to lessen nerve sensitivity, increase blood flow, increase tissue metabolism and decrease muscle spindle activity to stretch, cause muscle relaxation and increase tissue flexibility [11].

Superficial heat increases joint mobility by increasing connective tissue extensibility,reducing pain and tissue viscosity [4].

Similarly, cryotherapy enhances joint mobility by providing pain relief [12], inhibiting muscle spasm and reducing muscle tension [13].

Many researchers have attempted to determine how temperature influences ROM [2,4,10-12,14,15]. However, little scientific evidence exists regarding effectiveness of therapeutic application of cold and superficial heat combined with SS for limited ankle dorsiflexion range. But No Scientific evidence exists regarding effectiveness of cold and Deep heat with SS.

Purpose of this study was to investigate the efficacy of Cryostretch for increasing plantar flexors extensibility. This study compared the effect of local MHP, IP and US during SS on plantar flexors extensibility.

MATERIALS AND METHODS

Subjects: 40 healthy students (M=20; F=20; Age-22.93 ± 2.42 years;Height-164.61 ± 8.45 cm;Weight-56.12 ± 6.98kg) completed study. The study design was approved by research committee of Jamia Hamdard and was conducted at Majeedia Hospital, Delhi. The inclusion criteria have inability to achieve 20 degrees of active dorsiflexion ROM [5]. We have excluded subjects having recent injury or H/O ankle injury, neuromuscular disorders (head injury, polio, stroke etc.), impaired sensation, musculoskeletal disorders involving trunk, spine and lower extremities, hyper mobility skin disease, open sores and any circulatory problem, subjects allergic to ice or hot packs, sports persons involved in any flexibility or strength training for calf muscle and subjects under medication (muscle relaxants)[2]. Subjects were informed about purpose and procedure of study and written consent was taken prior to participation. They were randomly assigned into group A (MHP+SS), group B (IP+SS), group C (SS alone) and group D (Continuous US+SS), each consisting of 10 subjects.

Design: Study utilized pre & post test control group design.

Equipments and Measuring Tools

Equipments: Moist heat pack, ice pack, Ultrasound Machine, Ultrasound gel, stop clock, permanent marker, straps, couch, pulley, metal cable and weights.

Measuring Tools: Transparent (plastic) Goniometer, weighing machine and measuring tape.

Procedure: 40 volunteers of 18-30 years participated in study. Subjects were randomly assigned to MHP with SS (group A), IP with SS (group B), SS alone (group C) and US with SS (group D), each consisting of 10 subjects. Subjects in each group were given 10 minutes to the right leg plantar flexors stretching with 1/3rd of body weight once a day for 5 days a week for three weeks. ROM was measured on day of treatment and end of each week. Subjects were instructed to report at same time every day for treatment [2]. A standard tape measurement was used to ensure that subjects were positioned prone on the testing couch with their lateral maleolus 9" beyond the tables' edge. All the subjects were instructed to wear shorts and secured to table with waist and knee straps. Their right leg (dominant) was used throughout the study [16].

The group C received 10-minute SS lying prone on table with 1/3rd of body weight.Group B received IP for 10 minutes during SS with 1/3rd of the body weight. Group A received superficial heat for 10 minutes prior to SS and 10 minutes during SS with 1/3rd of the body weight. Group D received 7 minutes Continuous US during SS with 1/3rd of body weight.

During every session, weight was adjusted in 2-kg increment until 1/3rd of the subjects' body weight [2].

For goniometric measurement, stationary arm was placed along the long axis of fibula by using marks on the fibular head and lateral maleolus. Moving arm of the Goniometer was placed parallel to the lateral border of the foot by using marks on base of the head of the fifth metatarsal. The zero position of dorsiflexion was defined as 90 degree angle between long axis of the fibula and lateral border of the foot. All the measurements were recorded immediately as the subjects achieved maximum ADROM [16].

Data Analysis: Data was analysed using statistical tests which were performed using SPSS 15.00 software package. A 2 factor (group and time) ANOVA with repeated measures on one factor time was performed.

RESULTS

In this study we have taken 40 subjects with a mean age of 22.93±2.42 years, average weight 56.12±6.98 kilograms and with mean height of 164.61±8.45 centimeters (Table1).

Dorsiflexion Range: Active dorsiflexion range of motion (ADFROM) was the dependent variable. Mean and SD of ADROM after 3 weeks were 19.70±2.21 for group A, 22.50±2.50 for group B,16.10±2.80 for group C and 25.10±2.80 for group D.

Within Group Analysis of ADFROM (Table 2, Table 3 and Figure 1): All four groups had significant difference in pretest and post test values as p values for groups A, B, C and D were p=0.000, p=0.000, p=0.000 and p=0.000 respectively. ANOVA shows that there was statistically significant improvement in ADFROM in all four groups ($p < 0.05$).

Between Group Analysis of Adfrom (Table 4.1, 4.2, Figure 2): Dorsiflexion ranges between four groups were compared at Pretest, PTW1, PTW2 and PTW3. No statistically significant difference was found between group A and group B (p=0.060) at the end of third week ($p>0.05$). When group A was compared with group C (p=0.011), group A with group D (p=0.010), group B with group C (0.000), group B with D (p=0.001) and group C with D (p=0.000) a statistically significant difference reported ($p<0.05$).

DISCUSSION

This study has documented the effects of heat and cold modalities in conjunction with SS for improvement of plantar flexor extensibility limited by soft tissue tightness in healthy subjects.

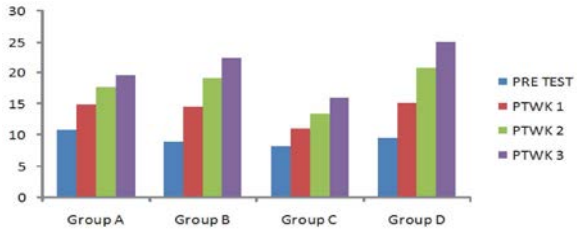

Fig. 1: Within group comparison of ADFROM (degrees). Mean and SD of pretest and post test week 1,2,3 values were used for comparison

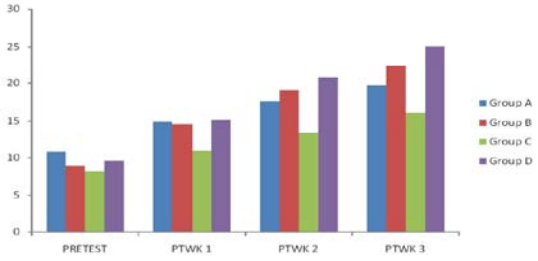

Fig. 2: Between group comparison of ADFROM (degrees). Mean and SD of pretest and post test week 1, 2, 3 values were used for comparison.

The main result of this study (SS+MHP, SS+IP, SS+US and SS alone) were effective in improving plantar flexors extensibility.

However, no significant difference in ADFROM has been found between groups A and B demonstrating that SS+IP was not so effective in improving ADFROM than SS+MHP. But significant difference ADFROM was found in b/w group A and D and B and D demonstrating that SS+US was more effective in improving ADFROM than SS+MHP and SS+IP.

The groups analysis showed that ADFROM has improved in all the four groups significantly (p=0.000, each group), meaning that all the three interventions were effective in improving plantar flexors extensibility.

Table 1: Mean and standard deviations of age, height & weight between group A, group B groupC and group D

	Group A Mean ± S.D N=10	Group B Mean ± S.D N=10	Group Mean ± S.D N=10	Group D Mean ± S.D N=10	ANOVA
Age (years)	23.30±2.26	23.10±2.64	22.50±2.27	22.85± 2.53	0.743
Height (cms)	164.90±8.49	164.10±7.65	164.30±9.73	165.15±7.95	0.977
Weight (kgs)	55.50±7.74	54.70±7.16	57.60±6.22	56.70±6.80	0.643

Table 2: Within group comparison of ADFROM (degrees). Mean and SD of pretest and post test week 1, 2, 3 values were used for comparison.

Groups	PRETEST Mean±S.D N=10	PTWK 1 Mean±S.D N=10	PTWK 2 Mean±S.D N=10	PTWK 3 Mean±S.D N=10	P Value P
Group A	10.80±3.45	14.90±2.46	17.60±2.54	19.70±2.21	0.000
Group B	8.90±3.69	14.60±3.06	19.10±2.37	22.50±2.54	0.000
Group C	8.20±3.35	11.0±2.98	13.40±2.95	16.10±2.80	0.000
Group D	9.60±2.45	15.17±2.37	20.75±2.53	25.10±2.80	0.000

Table 3: Post hoc analysis for within group c comparison of ADFROM (degrees).1= pretest; 2= post test week1; 3= post test week2; 4= post test week3.

Variables	Group A	Group B	Group C	Group D
1 vs. 2	0.000	0.000	0.000	0.000
1 vs. 3	0.000	0.000	0.000	0.000
1 vs. 4	0.000	0.000	0.000	0.000
2 vs. 3	0.002	0.001	0.003	0.000
2 vs. 4	0.000	0.000	0.000	0.000
3 vs. 4	0.000	0.000	0.000	0.000

Table 4.1: Between group comparison of ADFROM (degrees). Mean and SD of pretest and post test week 1, 2, 3 values were used for comparison

Variables	Group A Mean±S.D N=10	Group B Mean±S.D N=10	Group C Mean±S.D N=10	Group D Mean±S.D N=10	ANOVA P value
Pretest	10.80±3.45	8.90±3.69	8.20±3.35	9.60±2.45	0.247
PTWK 1	14.90±2.46	14.60±3.06	11.0±2.98	15.17±2.37	0.008
PTWK 2	17.60±2.54	19.10±2.37	13.40±2.95	20.75±2.53	0.000
PTWK3	19.70±2.21	22.50±2.54	16.10±2.80	25.10±2.80	0.000

Table 4.2: Post hoc analysis of b/w group comparison.

Post hoc analysis					
A Vs B	A Vs C	A Vs D	B Vs C	B Vs D	C Vs D
0.709	0.327	0.501	1.000	0.615	1.000
1.000	0.207	1.000	1.000	1.000	0.041
1.000	0.015	1.000	0.026	0.014	0.006
0.643	0.004	0.232	0.000	0.003	0.000
0.060	0.011	0.010	0.000	0.001	0.000

The findings of this study are consistent with the findings of many researchers [2, 4, 8,15].

Thermotherapy has been used to increase tissue extensibility in many clinical trials and researches [6, 10, 17-18].

Kenneth *et al*. [16] stated that a combination of static stretch and ultrasound treatment increased the extensibility of triceps surae muscles more than only static stretch treatment.

According to Robertson *et al*. [19] Deep heat produce significantly greater gain than superficial heat in dorsiflexion ROM.

It has been suggested that heating an area before and during a stretch then cooling the area in the stretched or loaded position will optimize the permanent plastic deformation of the connective tissue structure. Static stretching involves maintaining a constant amount of tension on a muscle for a given period of time in order to create a progressive deformation of the tissues and increase their length [11].

The findings of this study are consistent with the findings of Robert *et a l*. [13] and Lentell *et al*. [14].

Cryotherapy has been found to affect the viscoelastic properties of muscle tendon unit [20] and muscle's myostatic reflex [7].

These two mechanisms allow muscle to relax and be stretched more fully during stretching. According to William Prentice [20] cryotherapy increases the muscles viscosity and hence slows down the muscles ability to contract and spasm. Also cooling of stretched muscle has been found to cause depression of stretch reflex [7, 12, 21].

The postulated mechanisms for this effect are that the cryotherapy causes direct sensory stimulation of primary and secondary muscle spindle afferent fibers and thus indirect reflex inhibition which decreases γ-activity and lowers muscle's threshold to interfere in muscle excitability [17].

Bell *et al*. [7] found that SS combined with cryotherapy showed reduced T- reflex. According to Knight [21] the ice treatment if combined with SS, subjects may find it easier to endure the mild discomfort commonly felt at the terminal position of stretch allowing the muscle to be stretched more fully.

The results of this study supported YH Lin [10] who stated that application of cold combined with SS achieved a significant increment of ROM in clinical settings.

The findings of this study are in accordance with Minton [17] who reported that both cryotherapy and thermotherapy significantly improved immediate ROM; however, there was no difference between two treatment conditions.

Our results are in contrary to Gary *et al.* [22]. Differences in protocol, subjects, treatments and data analysis may be partly responsible.

Present study also included equal number of males and females to demonstrate difference in flexibility between them. However, there was no significant

difference in terms of flexibility in males and females in this study. These results are in contrast with Youdas *et al*. [23]who reported that there is statistically significant effect of gender on HML (hamstring muscle length) with women having more HML than their male counterparts.

CONCLUSION

All the groups showed increase in extensibility of plantar flexors, resulting in increase in ADROM. Both the cryotherapy and thermotherapy significantly improved ROM of plantar flexors. Deep heat group showed better Improvement when compared to other groups. Continuous Ultrasound during stretching is a safe and effective protocol for increasing tissue extensibility.

These results suggest that an athlete may select either cryotherapy or thermotherapy modalities for the purpose of optimizing the effects of stretching. However the choice should depend on condition of the joint and surrounding tissues as well as individual preference for ice or heat. This study will allow clinicians the choice of cost effective treatment alternative.

Interest of Conflict:

- Limited and small sample size.
- Lack of measuring thickness of subcutaneous fat around the calf muscle which could have produced difference in intramuscular temperature.
- These results cannot be applied to older or injured subjects without further research.
- Lasting effects of increased flexibility was also not measured.
- Room temperature was not regulated.

ACKNOWLEDGEMENT

This research project was supported by a grant from the "Research center of the center for female scientific and medical colleges", Deanship of scientific research, King Saud University.

REFERENCES

1. Kravitz, L. and V. Heyward, 2003. Flexibility Training: Fitness Management. 1995, 11(2): 32-33, 36-38.
2. Steven, E., Peres, David O. Draper, Kenneth L. Knight and Mark D. Ricard, 2002. Pulsed Shortwave Diathermy And Prolonged Long Duration Stretching Increase Dorsiflexion Range Of Motion More Than Identical Stretching Without Diathermy. J. Ath. Train. 37(1): 43-50.
3. Kisner, C. and L.A. Colby, 1996. Therapeutic Exercise Foundation And Techniques. 3rd Edition, F A Davis: Philadelphia. 24-25, 221, 157, 482-483.
4. Claudia, A. Knight, Carrie R. Rutledge, Michael E. Cox, Martha Acosta and Susan J. Hall, 2001. Effect Of Superficial Heat, Deep Heat And Active Exercise Warm-Up On The Extensibility Of The Plantar Flexors. Phys. Ther., 81(6): 1206-1214.
5. Murphy, D.F., D.A. Connolly and B.D. Beynnon, 2003. Risk Factors For Lower Extremity Injury: A Review Of The Literature. Br J. Sports Med., 37: 13-29.
6. Mc Kay, G.D., P.A. Goldie and W.R. Payne and B.W. Oakes, 2001. Ankle Injuries In Basketball: Injury Rate and Risk Factors. Br J. Sports. Med., 35: 103-108.
7. Kathleen, R. Bell and Justus F. Lehmann, 1987. Effect Of Cooling On H- and T- Reflexes In Normal Subjects. Arch. Phys. Med. Rehabil., 68: 490-493.
8. Michael, K. Sullivan, Joseph J. Dejulia and Teddy W. Worrell, 1992. Effect Of Pevic Position And Stretching Method On Hamstring Muscle Flexibility. Med. Sci. Sports. Exerc., 24(12): 1383-1389.
9. Craig, A. Smith, 1994. The Warm-Up Procedure: To Stretch Or Not To Stretch. A Brief Review. J. Orthop Sports Phys. Ther., 19(1): 12-17.
10. Lin, Y.H., 2003. Effect Of Thermal Therapy In Improving The Passive Range Of Knee Motion: Comparison Of Cold And Superficial Heat Applications. Clin Rehabil., 17: 618-623.
11. Rather Aijaz, Y., Puja Chaudhary and Nishat Quddus, 2009. Ultrasound and Prolonged duration stretching increase triceps surae muscle extensibility more than identical stretchinh alone. IJPOT, 1: 3.
12. Bugaj, R., 1975. The Cooling, Analgesic And Rawarming Effects Of Ice Massage On Localized Skin. Phys. Ther., 55(1): 11-19.
13. Robert Price, Justus F. Lehmann, Sherlyn Boswell-Bessette, Anne Buleign and Bashara J. Delateur, 1993. Influence Of Cryotherapy On Spasticity At The Human Ankle. Arch. Phys. Med. Rehab. 74: 300-304.

14. Gary Lentell, Thomas Hetherington, Jeff Eagan and Mark Morgan, 1992. The Use Of Thermal Agents To Influence The Effectiveness Of A Low-Load Prolonged Stretch. J. Orthop Sports. Phys. Ther., 16(5): 200-207.
15. David, O Draper, Jennifer L. Castro, Brent F. Shane Schulthies and Dennis Eggett, 2004. Shortwave Diathermy And Prolonged Stretching Increase Hamstring Flexibility More Than Prolonged Stretching Alone. J. Ortho. Sports. Phys. Ther., 34: 13-20.
16. Kenneth, C. Wessling, Dawn A. Devane and Cynthia R. Hylton, 1987. Effects Of Static Stretch Versus Static Stretch And Ultrasound Combined On Triceps Surae Muscle Extensibility In Healthy Women. Phys. Ther., 5: 674-679.
17. Minton, J., 1993. A Comparison Of Thermotherapy And Cryotherapy In Enhancing Spine Extended Leg, Hip Flexion. J. Ath. Train. 28(2): 172-176.
18. Brent, F. Taylor, Christopher A. Waring and Teresa A. Brashear 1995. The Effects Of Therapeutic Application Of Heat Or Cold Followed By Static Stretch On Hamstring Muscle Length. J. Orthop Sports Phys. Ther., 21(5): 283-286.
19. Robertson, V., A. Ward and P. Jung, 2005. The effect of heat on tissue extensibility: a comparison of deep and superficial heating, Arch Phys. Med. Rehb., 86: 819-825.
20. Prentice,W.E., 1990. Therapeutic Modalities in sports medicine. St. Louis. Mo. Times mirror/ mosby.:90-92.
21. Kenneth L. Knight, 1995. Cryotherapy In Sports Injuries Management. 1st Edition. Human Kinetics, USA. 127-147, 171.
22. Gary, R. Brodowicz, Robert Welsh and James Wallis, 1996. Comparison Of Stretching With Ice, Stretching With Heat, Or Stretching Alone On Hamstring Flexibility. J. Ath. Train. 31(4): 324-327.
23. James, W. Youdas, David A. Krause, John H. Hollman, William S. Harmsen and Edward Laskowsi, 2005. The Influence Of Gender And Age On Hamstring Muscle Length In Healthy Adults. J Orthop Sports Phys. Ther., 35: 246-252.