RESEARCH ARTICLE

COMPARATIVE EFFECT OF ULTRASOUND THERAPY VERSUS STATIC STRETCHING ON THE EXTENSIBILITY OF HAMSTRING MUSCLES

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ABSTRACT

Background: Many peoples suffer from tight hamstring muscles which predispose them to injury when they engage in vigorous physical activity. Ultrasound therapy have been used to enhance the effectiveness of muscle stretching, but evidence supporting their benefits is confusing.

Aims & Objective: The Objective of the current study is to compare the immediate effect of ultrasound (US) and static stretching exercise on the extensibility of hamstring muscles.

Materials and Methods: Forty normal Participants between the ages of 18 and 21 who demonstrated at least 15 degrees of unilateral hamstring tightness. They were randomly assigned to 1 of 4 groups: (1) ultrasound therapy; (2) 30 second static stretching; (3) ultrasound therapy and 30 second static stretching; and (4) control group which don't receive any treatment. The Main Outcome Measure was Hamstring extensibility measured by active knee extension test (AKE). Differences were compared within groups and between treatment groups using one way analysis of variance.

Results: There was a significant difference between pre and post-treatment in all treatment groups ($p<0.05$), but there was no significant difference regarding the control group ($p>0.05$). 30 second Static stretching exercise followed by 1 MHZ ultrasound therapy showed a significant increase in AKE when compared by sole treatment or control group ($p<0.05$).

Conclusion: The use of ultrasound therapy followed by 30 second static stretching enhance the flexibility of hamstring muscle. This results can aid in designing physical therapy protocols for similar conditions.

Key Words: Static Stretching; Ultrasound; Hamstring Muscle; Flexibility

Introduction

Movement of an individual smoothly depend on his flexibility which enhances both safety and optimal physical activity. Three muscles that are known collectively as the hamstring muscle cover the posterior thigh consisting of the semitendinosus, the semimembranosus, and the biceps femoris muscles that have a tendency to get shorten.[1]

Individuals of all ages and physical fitness levels have a high prevalence of hamstring muscle tightness which associated with almost one-third of lower extremity injuries. Lack of muscle extensibility (i.e., flexibility) has been identified as a contributing factor to many hamstring injuries.[2] Stretching have been facilitated by several treatment modalities including various forms of heat, massage, and vibration.[3] In the past, these modalities were generally believed to alter the muscle's viscoelastic properties, thus making it easier to lengthen. However, others now theorize that subsequent increases in muscle extensibility are more likely due to modified sensation. In other words, these modalities stimulate the nerves that inhibit the nociceptive (i.e., pain) response associated with muscle stretching. Many research reports on this topic are conflicting; however, an increasing evidence seems to support a sensory mechanism for enhancing muscle extensibility, rather than simply a biomechanical response.[4]

Therapeutic ultrasound can work as either a superficial or a deep heating modality depending on the frequency used. While 3 MHz ultrasound (US) provides superficial heating, 1 MHz. US heats tissues at depths of 3-5 cm and is considered to be a deep heating agent. US produces heat through high frequency acoustic vibrations. This type of energy transmission that it is minimally hindered by adipose tissue due to its high water content.[5] Adipose tissue can be a crucial obstacle for therapeutic heating agents because of its ability to insulate underlying tissues from external heating agents. Rose et al.[6] showed that US have the ability of reaching higher tissue temperatures at greater depth because of its ability to heat without affecting superficial structures.

Stretching techniques such as cyclic stretching[7], isometric exercise[8], proprioceptive neuromuscular facilitation protocol and static stretching[2,9] have been used to induce muscular flexibility. A proper stretching program is key to improving flexibility. Some research suggests that stretches can be held for 30 seconds, with at least 3–4 sets[10] Leads to an improvement in flexibility, it has been recommended that stretching be done 5 or more times per week.[11]

There is a lot of confusing research regarding the best physical therapy regime that is suitable for increasing hamstring flexibility, that why this research was done to compare the effectiveness of two treatment modalities that has been used in physical therapy to increase hamstring flexibility. Our study attempts to determine whether static stretching are more effective than ultrasound therapy and whether adding a ultrasound therapy to static stretching enhances the hamstring flexibility.

Materials and Methods

Participants

Forty male Participants with unilateral hamstrings tightness ranging in age from 18 to 21 years were purposively sampled at the University of Taif, KSA who demonstrated at least 15 degrees of unilateral hamstring tightness. Hamstring tightness was determined as knee extension deficit using the active knee extension test (AKET). They did not have any history of neurological abnormality, and previous injuries or disorders of the lower back or lower extremities.

The procedure was adequately explained to the Participants before obtaining their informed consents. All the procedures in this study complied with the Ethical Principles for Medical Research Involving Human Participants i.e. the Helsinki declarations as amended. The consenting Participants agreed that they would not engage in any other lower limb exercises aside the one designed for this study for the six –week period. They were then randomly assigned, using simple random technique, into one of the four groups.

- Group 1: Consisted of 10 Participants and received ultrasound therapy.
- Group 2: Consisted of 10 Participants and received static stretching exercise.
- Group 3: consisted of 10 Participants and received static stretching exercise in addition to ultrasound therapy.
- Group 4: Consisted of 10 Participants and don't receive any treatment and served as control group.

Evaluation Procedure

Baseline Measurement: The baseline knee extension deficiency was measured using a double-arm goniometre with 0.97 reliability value.[12] The Participant performed the active knee extension test procedure as described by Spernoga et al.[13] Each Participant wore a pair of shorts, to avoid any restriction to movement in the lower limb. The greater trochanter, the fibula head and the lateral malleolus of the Participant were marked with a felt-tipped pen, and served as anatomical landmarks for the goniometric assessment.

Each Participant was positioned supine on the plinth and the hip of the lower limb being assessed was flexed to 90o. The distal part of the anterior surface of the thigh was placed in contact with the cross-line of a specially constructed wooden frame. With his ankle in relaxed position, and ensuring that his thigh maintained contact with the cross line on the wooden frame, the Participant was instructed to actively extend the knee to the point where he started feeling a stretch. The knee extension deficiency was measured using the goniometer. Zero degree was considered to be full extension of the knee.

The duration of this study was 6 weeks and the study involved every other day. After 18 sessions of treatment and training, all Participants were retested using the same procedures and personnel described for the pretest.

Treatment Procedure

A. *Stretching Protocol:* After determining the baseline value, the Participants were taken through the stretching exercise training for the duration specific for the group to which he belonged. The stretching exercise was carried out as follows: Starting Position: Participant assumed the full supine -lying position on a plinth with his two feet pointing upwards. The contra-lateral lower limb was securely strapped to the plinth using 2 slings positioned across the thigh and over the anterior superior iliac spine to stabilize the pelvis. The lower limb being stretched was passively moved into the extreme of extension, up to the limit where the Participant felt a gentle stretch at the posterior aspect of the thigh. This placed the hamstring muscles at their greatest possible length. The stretch was sustained for 30 seconds. The procedure was carried out on alternate days for 6 consecutive weeks in the intervention groups only.

B. *Ultrasound Protocol:* The ultrasound therapy device used was a Sonopuls 434 Enraf-Nonius, with 3 W/cm 2 peak power and 1 and 3 MHz frequency. In two ultrasound therapy groups, continuous therapeutic ultrasound was administered 3 times/ week for 6 weeks. The ultrasound treatment was administred with a power of 2 W/cm2 , a frequency of 1 MHz, continuously, 5 min daily on the medial and lateral hamstrings (2 min for each tendons) and between two tendons (1 min) after ultrasound therapy stretching was applied immediately in the third group.

Statistical Analysis

Data were analyzed using SPSS10. A one-way analysis of variance was used to determine differences between groups. A Tukey Honestly Significant Difference post hoc analysis was performed to interpret the findings. A paired t-test was used for comparison between pretest and posttest measurements. An alpha level of $p<0.05$ was the level of significance.

Results

Forty Participants completed the study, however two were excluded because they did not attend one day of the intervention and was substituted by another two patients. The characteristics of the sample at baseline are presented in Table 1. The groups were similar in age, weight, height, as well as ROM before procedures began (Initial ROM) according to the ANOVA test ($p>0.05$).

Table-1: Participant characteristics prior to intervention for each group

Groups	ST	US	ST-US	C	P value	Significance
Age (year)	18.18 ± 0.80	17.88 ± 0.71	18.59 ± 0.85	18.59 ± 1.15	>0.05	NS
Weight (kg)	56.48 ± 1.24	57.02 ± 1.08	55.92 ± 0.76	56.63 ± 0.96	>0.05	NS
Height (cm)	165.34 ± 1.40	166.23 ± 1.10	166.83 ± 1.47	165.25 ± 1.78	>0.05	NS
ROM (degrees)	148.44 ± 2.38	147.16 ± 1.28	148.65 ± 2.05	149.28 ± 1.28	>0.05	NS

Each data were expressed as Mean ± SD. ROM: range of motion; ST: Static stretching group; US: ultrasound group; ST-US: static stretching + ultrasound therapy group; and C: control group

Table-2: Within group comparison of three treatment groups and control group

Groups	ST		US		US-ST		C	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	148.44	153.22	147.16	153.63	148.65	159.52	149.28	149.59
SD	2.38	1.00	1.28	0.65	2.05	1.87	1.28	1.28
P- value	p<0.05		p<0.05		p<0.05		p>0.05	
Significance	S		S		S		NS	

ST: Static stretching group; US: ultrasound group; ST-US; static stretching + ultrasound therapy group; C= control group, SD; standard deviation; pre; pre-treatment measurement; post; post-treatment measurement

Table-3: Post-treatment comparison of three treatment groups and control group

ROM (degrees)	Groups			
	ST	US	US-ST	C
Pre	148.44 ± 2.38	147.16 ± 1.28	148.65 ± 2.05	149.28 ± 1.28
Post	153.22 ± 1.00*¥	153.63 ± 0.65*¥	159.52 ± 1.87*	149.59 ± 1.28

The values of ROM was expressed as mean ± standard deviation. * Significantly different from control; ¥ significantly different from US-ST group. ST: Static stretching group; US; ultrasound group; ST-US; static stretching + ultrasound therapy group; C= control group

Paired t- test performed to show the difference between pretreatment and post treatment values of ROM was revealed in table 2. This table shows that there was a significant increase in ROM for all treatment groups ($p<0.05$), on the other hand there was no significant difference between pre and post treatment ROM regarding the control group ($p>0.05$). One-way analysis of variance was used to determine the post-treatment differences between groups as shown in table 3 revealed that all treatment groups have shown a significant increase in ROM ($p<0.05$) when compared with control group. On the other hand, there was no significant difference between static stretching group (ST group) and ultrasound group (US group) ($p>0.05$), but there was a significant difference between static stretching and ultrasound group (ST – US group) when compared with either sole treatment or control group ($p<0.05$).

Discussion

Muscle flexibility can be defined as the ability to move a joint or series of joints with comfort and ease in an unrestricted and painless range of motion (ROM).[14] Flexible muscles are considered important factors in the reduction of the potential for injury, as well as in muscle rehabilitation and the development of better athletic performance[15,16] This clinical trial was designed to demonstrate a comparison between static stretching and US in the treatment of asymptomatic population to increase flexibility.

As shown in the current study static stretching was effective in increasing hamstring flexibility which coincide with other study[17] which stated that passive static stretching is the best option for the improvement of both active and passive range of motion. Two mechanisms are essentially considered responsible for ROM increase after muscle stretching: in the first one, an alteration in the sensitivity of pain receptors increases stretching tolerance and, consequently, the effectiveness of the techniques[18]; and in the second one, changes in tissue viscoelasticity, such as the decrease in the passive tension of the muscle tendon unit immediately after stretching, are the primary reasons for the flexibility gain[19]. It is suggested that these effects occur due to a hysteresis effect, seen as an indication of tissue viscosity, with a reduction in the dissipation of tissue energy after stretching. In addition, changes in the muscle tendon stiffness may occur with the adaptation of the series and parallel elastic components, and with the rearrangement of the collagen fibers.[20]

US can be used to target the collagen-rich tendinous units of the hamstring muscles because of its ability to penetrate deeper tissues. Several researchers have demonstrated the beneficial effects of heat on collagenous tissue.[21,22] It has been shown that increasing the temperature of collagen to 40 degrees Celsius will increase the elasticity of the tissue.[23] This increased elasticity allows for an even distribution of force and reduces the stress on localized areas of the tissue.

A factor that often inhibits significant gains in tissue temperature is the body's natural homeostatic mechanism.[24] As the tissue temperature increases, vasodilation occurs, bringing cooler blood into the tissue to help normalize the temperature. It has also been shown that because tendon tissue is less vascularized than muscle tissue, tendons will retain heat for longer periods of time.[25] This lack of vascularity prevents the body from cooling these tissues as efficiently as others because it cannot bring in as much cool blood. Chan et al.[25] demonstrated that tendon reaches greater temperatures and heats more quickly than muscle. It was also shown that the tendon was able to maintain vigorous heating for longer periods than muscle. That why ultrasound unfortunately gain more advantage than static stretching alone.

The result of our study have stated that the addition of ultrasound prior to static stretching have succeeded in improving hamstring more than using sole treatment. However our result goes hand in hand with an animal study done by Warren et al.[21] who found that the application of heat with a low load produced a faster elongation of the tendon than the load without heat. He also found that the tendons treated with heat were able to support greater loads and sustained less tissue damage than those that were not.

Conclusion

The addition of ultrasound therapy prior to static stretching techniques have effective means of increasing extensibility of the hamstring muscle group.

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