EFFECTS OF HEATING BY ULTRASOUND AND AEROBIC ACTIVITY ON FLEXIBILITY OF THE HUMAM TRICEPS SURAE – A COMPARATIVE STUDY

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The objective of this study was to compare the effects of increasing temperature by ultrasound and cycling on the triceps surae muscle *in vivo*. Seventy-nine students were randomly assigned to three groups (control, ultrasound, and bicycle). The subjects were tested for ankle flexibility and then heated based on their group. Then the subjects were again tested for ankle flexibility. Comparisons of the three groups showed a tendency of the groups that received intervention to reach a greater range of motion [mean difference of 7,4 (SD= 2,9) (P=0,000) for bicycle group and 5,8 (SD= 2,3) (p= 0,000) for ultra-sound group] than control group [mean difference of 4,7 (SD= 3,1) (P=0,000)]. The results of this study confirm previous results from *in vitro* studies and could be a useful reference for clinical application providing information about the effects of heating on flexibility.

Key words: Flexibility, heating, ultrasound, exercise.

INTRODUCTION

Flexibility has been an important factor both to physical therapy treatments and to sports practice. It is known that the flexibility exercises are likely to provide physical, postural and mental improvements (Lardner, 2001), however, there is no evidence supporting the idea that the flexibility could prevent injuries (Hill & Weklon, 2003). Chandler (1990) defined flexibility as “the ability of the joint to perform movement in a range of movement (ROM) without stress on the tendon-muscle unit”. Two important tissue properties should be defined in flexibility studies: elasticity and plasticity. Elasticity is defined as the tendency of a tissue to return to its original length after a passive stretch. Plasticity is defined as the tendency of a tissue to assume a greater length after a passive stretch (Wessling, Devane & Hylton, 1987). The magnitude of an elastic and plastic deformation can change considerably. It depends on the quantity of force applied, the duration of the force and the tissue’s temperature. Studies involving animals have shown that the increment of tissue temperature influences the connective tissue’s elasticity drastically affecting the ROM (Williford, 1986), however, the results of these studies refer to *in vitro* models only (Gersten, 1955). There are a few comparative studies regarding the effects of heat and stretching on the elasticity in humans but the methodologies and thermal agents are very different among these studies (Williford, 1986). Physiotherapists have been using several types of superficial heat (e.g. hot packs, paraffin), deep heat (e.g. short wave, microwaves, ultra-sound) or heating by physical activity (e.g. isometric contraction, isotonic contraction, aerobic activity) in clinical practice. This study used two methods of heating: continuous ultra-sound and aerobic exercises on the ergometric cycle. The aim of this study was to compare the effects of the heating on the flexibility of the human triceps surae *in vivo* under the influence of ultra-sound and physical activity on cycling exercises.

METHOD

Data Collection: Seventy nine physiotherapy students from the Catholic University of Minas Gerais – Brazil (women n=55, male n=24) with mean age of 20, 8±2, 8 years were randomly allocated to three groups (control, bicycle and ultrasound), the anonymity of allocation was achieved by using sealed opaque envelops without identification. Subjects with contra indications to physical exercises as described on the ACSM *Guidelines* (1995), including open wounds, pregnancy, fractures of tibia and/or fibula and muscle injuries on the calf region within less than one year were excluded. The goniometric measures were taken by the same assessor previously trained. These measurements were taken with the subject in prone position, with the knee extended. The assessor positioned the ankle in maximal passive dorsiflexion. The goniometer arm remained fixed parallel to the fibula and the mobile arm was placed parallel to the fifth metatarsus. A line was made over these anatomic references before the first measure to facilitate the measures. The assessor was unaware of subject's group membership by testing the subjects in a separated room from the intervention lab and the subjects were instructed to not reveal to the assessor which group he/she was grouped in. The triceps surae flexibility exercise was performed in 4 series of thirty seconds of active and static stretching, with 10 seconds of rest between the series (Williford, 1986). All the subjects used a 25 degree inclination slope to assist the flexibility task, all the procedures were performed in both sides, i.e. two measures were taken for each subject. ROM measurements were taken in the control group, then they were stretched, and measures were taken again; while in the bicycle group, the ROM measurements were taken, they were instructed to cycle between 15 to 20 Km/h on the ergometric cycle until they started to perspire (Hubley, Kozey & Stanish, 1984). The minimal time on the ergometric cycle was 15 minutes. The average of time on the ergometric cycle was 18.36 minutes. Subjects were then stretched and measures were taken again. In the ultrasound group, the ROM measurements were taken, than they received 7 minutes of continuous ultrasound (*Bioset-Brasil*) on the Achilles tendon. The dosage was of 1.5W/cm^2 with a 1 MHz frequency (Williford, 1986); a conduction gel was used in order to optimize the ultrasound treatment. A semi-static application was used, moving at most twice the effective radiation area of the transductor (transductor area = 2,5cm^2). The application was performed on both sides simultaneously, i.e. two ultra-sound machines were necessary. The subjects were than stretched and measures were taken again. The ultra-sounds were previously calibrated by a specialized company.

Data Analysis: Two separate analyses were performed, first we analyzed within-group differences to know if each procedure generated significant ROM and second we compared differences between groups (Student's t-test for independent variables). The emphasis was on an exploratory analysis rather than a confirmatory one (Huberty & Morris, 1989)

RESULTS

The results showed no significant differences between the pre and post flexibility exercises when the variables sex and dominance were considered. All groups (control, ultra-sound and bicycle) showed a significant increase in their ROM, i.e. the chosen exercise was enough to provide a gain of ROM, independent of the heating modality (table1).

Table 1 Within-group differences before and after each procedure.

Group	n (subjects)	n (ankles)	Mean Difference	SD	p
Bicycle	28	56	7.4	2.9	<0.001*
Ultra-sound	25	50	5.8	2.3	<0.001*
Control	26	52	4.7	3.1	<0.001*
All groups	79	158	6.0	3.0	<0.001*

In the comparison test among groups, it was seen that the bicycle group had the highest ROM improvement, followed by the ultra-sound group and then the control group, with significant differences between the groups (table 2).

Table 2 Differences between the groups

Groups Comparison	N (ankles)	Mean difference	SD	p
Bicycle X US	56 / 50	1.6	0.6	<0.001*
Bicycle X Control	56 / 52	2.7	0.2	<0.001*
US X Control	50 / 52	1.1	0.8	0.023*

DISCUSSION

The aim of this exploratory study was to compare the possible change of ROM of ankle dorsiflexion under the influence of ultra-sound and aerobic exercise. It was observed a significant dorsiflexion's improvement in all groups, with significant difference among the groups. The significant gain of ROM on the three groups can be explained by the choice of the stretching technique, which to increase the triceps surae muscle's flexibility confirming the results of the studies of Williford (1986) and Knight(2001). The ultrasound group reached values considerably higher of ROM compared to the control group. The dosage, the application technique, the adequate use of the conductor and the calibration of the ultra-sound followed the recommendations from the study of Draper(1995) which used invasive methods to determine muscle temperature with and without ultrasound application, determined the patterns adopted in our study. Despite of our study did not measured the tissue temperature, one explanation can be that the ultrasound application lead to an increase of temperature on the muscle structures causing a muscle relaxation and an increase of viscoelasticity of the inert structures of the triceps surae, which explain the additional gain of ROM compared with the control group. It is necessary a study that measure the muscle temperature to assure this increase. Studies using superficial heating and massage did not achieve the same outcomes (Möller, 1983; Taylor, Waring & Brashear, 1995). Knight (2001) in his study that also used ultrasound achieved comparable results to our study. The bicycle group achieved values significantly higher than the ultra-sound and control groups. Possibly it happened because the heat dissipation in this group is slower than the ultra-sound group, which received selective heating of the triceps surae only, which was not possible on the bicycle group. Studies that used exercises to analyze the heating effects on the flexibility achieved similar results to our study, however, they used different types of exercises, for example: triceps surae active contraction (Knight, 2001) and running (Williford, 1986). It is suggested that further studies the usage of other forms of heating, other techniques of flexibility and involve different muscle groups.

CONCLUSION

The results of this study confirm previous results from *in vitro* studies and can be a useful reference for clinical application providing information about the effects of heating on flexibility.

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