Viscoelastic Response of Skeletal Muscle to Four Days of Flexibility Training

Dain P. LaRoche, Lindsay Bilodeau, Justin Crowe, Shane Lynch.

Johnson State College, Johnson, VT.

INTRODUCTION: Flexibility training is commonplace in recreational and athletic settings and has been purported to increase the elasticity of muscles and reduce injury. In spite of this, there is little empirical evidence to support these claims. Futhermore, the majority of research to date has utilized range of motion (ROM) as the criterion measure and has not assessed the passive properties of skeletal muscle like stiffness and energy storage. Passive resistance to stretch is the amount of resistive force provided by the relaxed muscle as it is stretched from its resting to its maximum length. Studies that have examined muscle's passive properties have demonstrated that improvements in flexibility are not a result of reduced muscle stiffness, but are due to enhanced stretch tolerance (Magnusson, 1998).

PURPOSE: To determine if 4 consecutive days of stretching the human hamstring muscle group could alter the amount of passive resistance (PR) to stretch and increase the range of motion about the hip. The goal of this study was to ultimately assess the effect of the laboratory testing protocol on the tensile properties of muscle during passive stretching.

METHODS: Twenty five, recreationally active, aged 18-60yr., males who had not undergone routine flexibility training in the past 6 months, were participants in this study. On each of four consecutive days, using the left leg, they completed 4 maximal range of motion (ROM) stretches in a supine position involving passive stretching of the hamstrings at 0.087 radians per second (5deg/s). The stretches were completed on custom built equipment using an isokinetic dynamometer, equipped with a load cell and electrogoniometer, as the resistance unit. Passive torque from 0.35rad to 0.87rad (20-50deg) and from 0.87rad to 1.22rad (50-70deg) as well as peak ROM and peak resistive torque (PRT) were measured. Stiffness was calculated as the slope of the torque/angle curve and was expressed as Nm/rad. Data were sampled at 50Hz and stored on a personal computer using a data acquisition system. Comparisons between day 1 and days 2,3 and 4 were made using paired t-tests and alpha was adjusted with a Bonferroni procedure. The strength of the relationships between variables was tested using a Pearson product-moment correlation.

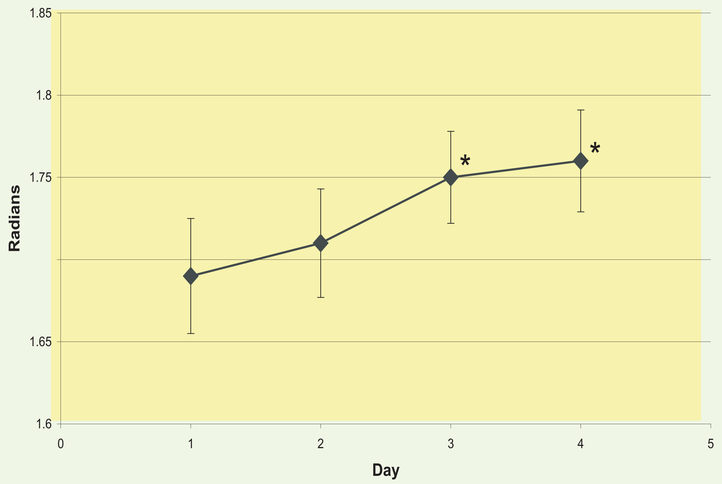

Figure 1. Range of Motion Over 4 Days of Stretching

* = different from Day1 (p<0.05)

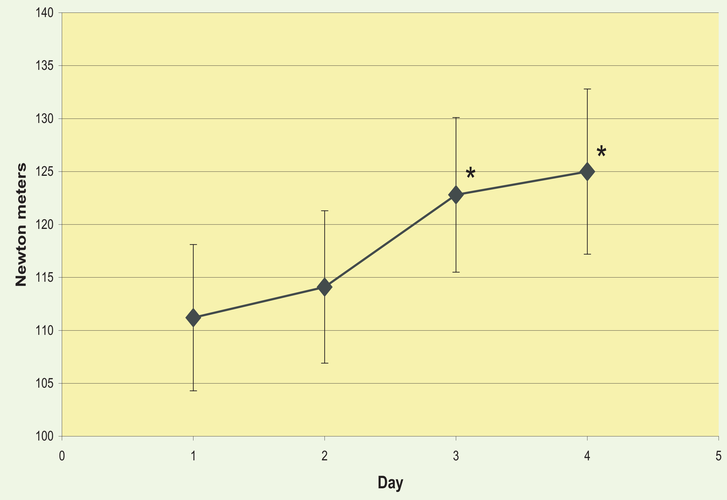

Figure 2. Peak Resistive Torque Over 4 Days of Stretching

Table 1. Changes in Passive Muscle Properties Across Days 1 - 4

	Day 1	Day 2	Day 3	Day 4
ROM (rad)	1.69 ± .17	1.71 ± .16	1.75 ± .14[a]	1.77 ± .15[a]
Peak Torque (Nm)	111.2 ± 34.6	114.1 ± 35.8	122.8 ± 36.5[a]	125.0 ± 39.2[a]
Stiffness ($Nm \bullet rad^{-1}$) 0.35-0.87 rad	19.6 ± 8.2	21.9 ± 9.9	20.9 ± 10.6	20.6 ± 9.0
Stiffness ($Nm \bullet rad^{-1}$) 0.87-1.22 rad	70.0 ± 22.7	70.2 ± 23.9	64.9 ± 15.1	67.4 ± 18.2

[a] different from Day 1, $p < .05$

RESULTS: There were no changes in stiffness across the 4 days in either the 0.35 to 0.87rad or 0.87 to 1.22rad ranges but stiffness was correlated to ROM ranging from r = -0.34 to -0.63 over the 4 days ($p<0.05$). ROM on day 1 (1.69±0.17rad) was not different from day 2 (1.71±0.16rad, $p=0.16$) but increased on days 3 (1.75±0.14rad, $p<0.01$) and 4 (1.77±0.15rad, $p<0.01$) (Figure 1). PRT on day 1 (111.2±34.6Nm) was not different from day 2 (114.1±35.8Nm, $p=0.41$) but increased on days 3 (122.8±36.5Nm, $p<0.001$) and 4 (125.0±39.2Nm, $p<0.01$) (Figure 2). ROM and PRT were correlated ranging from r = 0.66 to 0.81 over the 4 days ($p<0.001$).

DISCUSSION: ROM is often used as an indicator of muscle stiffness although the relationship between these two variables has not been well documented. The data in this study suggest that having low stiffness, in the low to middle portion of ROM, is associated with an increased peak ROM. This supports the common notion that those with the lowest muscle stiffness have the highest ROM. In contrast, the short term improvement in ROM seen with 4 days of stretching occured in the absense of reduced muscle stiffness. Magnusson (1998) demonstrated that the reduction in muscle stiffness seen after an acute bout of stretching disappears within one hour after stretching. Participants in the current study were capable of achieving greater ROM due to enhanced force tolerance (PRT) and not due to changes in the passive properties of the muscle. This conclusion was supported by the strength of the correlation between ROM and PRT. Although not seen in this short duration study, it is quite possible that participation in long term stretching programs as seen in dance, gymnastics and the martial arts, may elicit changes in the tensile properties of the muscle. Future research should be directed toward the effect of long duration flexibility training and aging on passive muscle properties and the relationship between passive muscle properties and injury risk.

REFERENCES:

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