

Effects of Four Weeks of Stretching on Active Torque Development

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ABSTRACT

Flexibility training is common in recreational and athletic settings in an attempt to reduce the passive stiffness of muscles and reduce injury risk. One proposed mechanism by which stretching can reduce muscle stiffness is by decreasing alpha motor neuron activity and decreasing the output from, or sensitivity to, muscle and joint proprioceptors. However, the resultant reduced motor neuron and proprioceptor activity, as well as reduced stiffness, may have a negative impact on muscle force generation. **PURPOSE:** To determine if muscle force, power, and optimum length are affected by 4 weeks of static or ballistic stretching. **METHODS:** Twenty nine, recreationally active, aged 18-60yr., males who had not undergone routine flexibility training in the past 6 months were participants in this study. Prior to completing the stretching program and following habituation, measures of peak torque (PT), rate of torque development (RTD), work (W), and peak torque angle (PTA) were assessed in the hip extensors. All measures were completed on a isokinetic dynamometer at 1.05rad/s-1 (60deg/s-1) and involved hip extension from a flexed position. Then, participants completed 4 weeks of either static or ballistic flexibility training of the hip extensors for a total stretching duration of 3,600s. Following the 4 weeks of training and two days without stretching, assessment of active torque development was repeated. Comparisons between variables prior to and post-training were made using repeated measures analysis of variance. **RESULTS:** After training, PT increased by 5.3 ± 19.0% in the static group, 7.8 ± 12.7% in the ballistic group, and 6.1 ± 17.9% in the control group ($p = .94$). RTD increased by 4.8 ± 22.7% in the static group, 3.6 ± 28.0% in the ballistic group and by 9.7 ± 24.0% in the control group ($p = .85$). W increased by 3.9 ± 7.0% in the static group, 14.7 ± 27.4% in the ballistic group, and 5.5 ± 9.5% in the control group ($p = .35$). PTA changed little with a -1.6 ± 6.6% decrease in the static group, and increases of 0.86 ± 4.1% in the ballistic and 0.18 ± 8.7% in the control groups ($p = .80$). There were no statistical differences between groups for any measures. **DISCUSSION:** These data suggest that 4 weeks of stretching have little effect on parameters of active torque development. There were no changes in optimal muscle length (PTA) that would suggest that a lengthening of the muscle occurred with stretching. Furthermore, there were no significant or practical differences in these measures between either static or ballistic stretching modalities. These data indicate that engaging in a moderate duration stretching program does not adversely affect the generation of muscle force or power.

INTRODUCTION

Stretching is commonly performed before athletic events in an attempt to improve muscle flexibility, reduce the risk of skeletal muscle injury, as well as enhance performance with inconsistent evidence of its effectiveness. The effect of acute bouts of stretching on muscle stiffness, the development of muscle force, and power, has received recent attention in the literature. Stretching has been shown to decrease passive muscle stiffness, alpha motor neuron activity, and output from, or sensitivity to, muscle and joint proprioceptors. These changes would therefore allow a greater muscle length to be achieved, and would thus increase joint range of motion. These sound like advantageous changes, but the reduction in muscle stiffness, and voluntary as well as reflex induced muscle contraction has the potential to negatively affect muscle force output and physical performance. These results clearly have implications for those looking to maximize muscle force and power, and warrant studying the effects of longer-term stretching programs on muscle force development.

PURPOSE

The purpose of this study was to assess the effect of a chronic stretching program on the development of voluntary muscle force.

METHODS

Twenty-nine male subjects who were able-bodied, recreationally active, age 18-60 years, and had not participated in an organized strength training or flexibility program in the previous six months, were randomly assigned to the control (n=10), static (n=9), or ballistic stretching groups (n=10). A custom hip extensor torque apparatus was used to measure muscle torque and hip angle (Figure 1). The resistance arm was instrumented with a load cell to measure force and the axis of the Cybex isokinetic dynamometer was fit with an electrogoniometer to measure hip angle. Both force and hip angle data were imported into a BIOPAC MP30 data acquisition system, were sampled at 50 Hz, and smoothed every 10 samples using a mean averaging technique. Following a habituation protocol, participants performed maximal hip extension for the assessment of initial peak torque (PT), peak torque angle (PTA), rate of torque development (RTD), and work (W). For the next four weeks the two stretching groups met three times per week and performed ten sets of 30s of either static or ballistic stretching resulting in a total stretching duration of 3,600s. Following the four weeks of stretching, all measures of voluntary torque development were repeated.



Figure 1: Hamstring Torque Apparatus

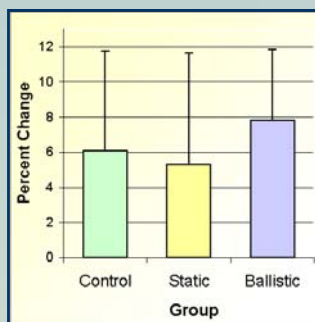


Figure 2: Peak Torque

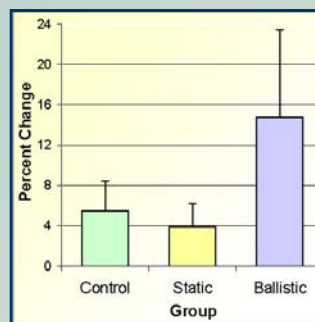


Figure 3: Work

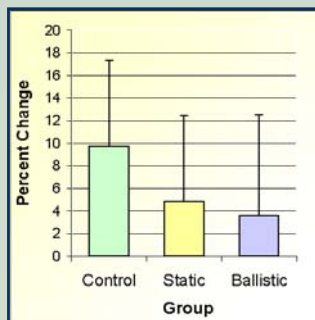


Figure 4: Rate of Torque Development

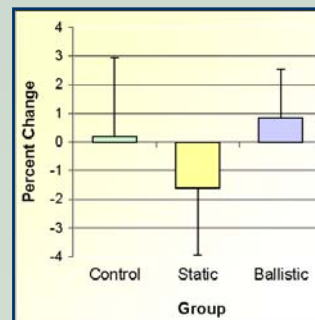


Figure 5: Peak Torque Angle

Table 1: Subject Characteristics

	Total M ± SD N=29	Control M ± SD n=10	Static M ± SD n=9	Ballistic M ± SD n=10	p
Age (years)	31.6 ± 15.2	35.1 ± 17.4	31.0 ± 16.4	28.2 ± 11.9	0.62
Mass (kg)	81.1 ± 15.0	80.1 ± 10.1	77.0 ± 9.2	86.3 ± 22.5	0.42
Height (m)	1.76 ± 0.06	1.76 ± .07	1.78 ± .18	1.77 ± .08	0.86
Minutes of stretching week ⁻¹	17.5 ± 23.7	17.7 ± 26.5	16.3 ± 15.7	18.5 ± 29.4	0.96
Initial Range of Motion (rad)	1.71 ± .19	1.77 ±.22	1.69 ± .16	1.66 ± .17	0.36
Initial Peak Torque (Nm)	117.0 ± 36.6	131.1 ± 41.9	113.1 ± 30.3	105.3 ± 34.3	0.26
Initial Stiffness (Nm·rad ⁻¹)	94.7 ± 27.6	84.4 ± 30.0	97.2 ± 23.1	101.6 ± 29.5	0.46
Initial Work (Nm·s)	423.4 ± 74.9	401.9 ± 2.8	440.4 ± 54.0	428.5 ± 97.1	0.52

RESULTS

There were no statistical differences between groups in age, mass, height, minutes of stretching per week, initial range of motion, initial peak torque, initial stiffness, or initial work at the beginning of the study (Table 1). Figures 2-5 present the mean percent changes in PT, RTD, PTA, and W by group. After training, PT increased by 5.3 ± 19.0% in the static group, 7.8 ± 12.7% in the ballistic group, and 6.1 ± 17.9% in the control group ($p = .94$) (Figure 2). W increased by 3.9 ± 7.0% in the static group, 14.7 ± 27.4% in the ballistic group, and 5.5 ± 9.5% in the control group ($p = .35$) (Figure 3). RTD increased by 4.8 ± 22.7% in the static group, 3.6 ± 28.0% in the ballistic group and by 9.7 ± 24.0% in the control group ($p = .85$) (Figure 4). PTA changed little with a -1.6 ± 6.6% decrease in the static group, and increases of 0.86 ± 4.1% in the ballistic and 0.18 ± 8.7% in the control groups ($p = .80$) (Figure 5). There were no statistical differences between groups for any measures.

DISCUSSION

The lack of change in PTA seen using this protocol suggest that there were no lasting changes in muscle length as a result of the four weeks of stretching. This study indicates that in addition to having no negative effect on PT or the amount of W done, chronic stretching has no significant effect on the RTD. The fact that the three groups demonstrated a comparable response, supports the idea that chronic stretching has little effect on the parameters of active force development, and that the decrease in muscle force and power following acute bouts of stretching is transient. It was hypothesized that the dynamic nature of ballistic stretching may mitigate the reduction in muscle activation seen following static stretching and preserve muscle force production. The current study showed no differences in measures of force production following a program of static or ballistic stretching, but the effect of stretching modality on muscle force production warrants further investigation. These results may alleviate some of the concerns of athletes, coaches, and clinicians who are looking for maximal muscle power during training and competition yet desire to maintain overall joint range of motion.

CONCLUSIONS

- Four weeks of stretching have little effect on peak torque and work capacity
- Peak torque angle changed little, suggesting that a lengthening of the muscle with stretching did not occur
- No differences in measures of voluntary muscle force between static or ballistic stretching
- A moderate duration stretching program does not adversely affect the generation of muscle force or power

ACKNOWLEDGEMENT

This paper was made possible by the Vermont Genetics Network through Grant Number P20 RR16462 from the INBRE Program of the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of NCRR or NIH.