EFFECTS OF STATIC STRETCHING ON MAXIMAL ISOKINETIC TORQUE

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The effects of 20 seconds of agonist (AGO), antagonist (ANT) or no (NO) pre-exercise stretch on concentric (CON) and eccentric (ECC) maximal isokinetic torque produced at the knee were examined. Twelve male semi-pro rugby players performed dominant isokinetic knee extension following the specified stretch protocol. One-way Repeated Measures ANOVA revealed AGO to be significantly less ($p < 0.05$) than the other protocols for both CON (270 28 Nm) and ECC (309 42 Nm) torque. There was no difference between the ANT or NO for either CON (303 35 Nm and 304 38 Nm, respectively) or ECC (341 40 Nm and 336 44 Nm). The results support the theory that pre-exercise agonist stretching may lead to performance decrements in maximal concentric torque production.

KEY WORDS: warm-up, quadriceps, concentric, eccentric.

INTRODUCTION: Most athletes undertake stretching as part of their warm-up prior to engaging in physical activity. However, although chronic stretching programs undoubtedly play a role in many athletes' training programs, their benefits are still under debate (High et al., 1989; Magnusson et al., 1998; Wilson et al., 1994). In addition, some research indicates that acute pre-exercise stretching could have a negative impact on skills where success is related to maximal force or torque output (Kokkonen et al., 1998; Fowles et al., 2000); while others have suggested that any decrement is specific to the type of exercise (Church et al., 2001; Young & Elliott, 2001).
Kokkonen and associates (1998) showed that passive, static stretching decreased concentric flexion and extension strength as assessed by Nautilus machines. The stretching program involved six repetitions of five stretches held for 15 seconds each (total time ~20 minutes). Fowles and colleagues (2000) found that the effect of maximal passive static stretching decreased isometric strength and neuromuscular aspects for up to one hour. It should be noted that this stretching included 13, 135 second bouts of increasing tension.
Young & Elliott (2001) found that drop jump performance decreased after three repetitions of a static stretch held for 15 seconds, but there was no difference between a control (no treatment) condition, three repetitions of proprioceptive neuromuscular facilitation, or three repetitions of a 5 second maximal voluntary contraction. Furthermore, they noticed no change in the performance of a squat jump test regardless of the type of warm-up used; suggesting the importance of a stretch shortening cycle (SSC) in the performance. Church and co-workers (2001) demonstrated that general warm up and static stretching with 10 exercises held for 20 seconds, focusing primarily on the quads and hamstrings, had no effect on vertical jump performance. It appears that the effects of stretching may be movement specific or related to a possible stretch shortening cycle (SSC). However, there is a paucity of information on this topic.
Therefore the purpose of the current study was to examine the effects of acute pre-exercise stretching on a stretch-shortening cycle during isokinetic knee extension. The effects of agonist (AGO), antagonist (ANT) and no (NO) pre-exercise stretch on eccentric (ECC) and concentric (CON) maximal isokinetic voluntary torque production were examined. The positioning of the eccentric contraction immediately preceding the concentric contraction was to allow an SSC-like effect to be examined. Furthermore, the duration of stretching 15 second static stretches, was selected to more closely mirror that used in a more typical daily stretching program.

METHODS: Twelve semi-pro, male, Rugby players (mean ± SD; age = 21.7±2.3 years, height = 1.87 ± 0.06 m; body mass = 93.7±13.0 kg) volunteered to serve as subjects for the current study. Approval for the use of human subjects was obtained from the Institutional Review

Boards prior to commencing the study. Informed consent was obtained from each subject. No strength training had been performed by the subjects in the 48 hours prior to data collection. Subjects were asked to report to the testing facility on the same day for four consecutive weeks. During the first session subjects underwent familiarization with the stretching protocol and the isokinetic dynamometer at the designated speeds. On each of the subsequent days they undertook a five minute warm-up of stationary cycling (60 Watts) followed by five warm-up repetitions of eccentric and concentric knee extension. After the warm-up repetitions, the subjects performed the designated stretching protocol for each condition.

The passive stretching protocols used in the current study were designed to focus on the agonist (AGO) and antagonist (ANT) aspects of the dominant leg's quadriceps muscle group. Three repetitions of a 20 second passive, static stretch were performed for both the quadriceps (AGO) and hamstrings (ANT) according to Alter (1996). In addition there was a three minute control (CON) condition with no stretching. In an effort to minimize the possibility of an order effect, the sequence of conditions was randomized.

After each stretching condition the subject performed three repetitions of maximal knee extension. A Con-trex isokinetic dynamometer (CVH AG Dübendorf, Switzerland), was calibrated before each subject and used to determine maximal eccentric and concentric torque of the quadriceps muscle of the dominant leg. The speeds for the eccentric and concentric phases were set at 90 ·s-1 and 60 ·s-1, respectively. During the test the subject was stabilized at the thigh, pelvis and trunk with Velcro straps. Torque was determined to be the maximal value attained during the three repetitions of knee extension. Statistical treatment of the data was performed using a One-way Repeated Measures ANOVA for concentric and eccentric torque. Alpha level was set at $p=0.05$ and Bonferroni post-hoc contrasts used to determine where differences were located when a significant main effect was noted.

RESULTS: One-way Repeated Measures ANOVA revealed AGO to be significantly less ($p < 0.05$) than the other protocols for both CON (270 28 Nm) torque production (see Table 1). The ECC (309 42 Nm) torque production only differed from the NO condition ($p < 0.05$). There was no difference between the torques of ANT or NO for either CON (303 35 Nm and 304 38 Nm, respectively) or for the ECC condition (341 40 Nm and 336 44 Nm). The magnitude of the performance decrements for the AGO condition were 11% and 9% for CON and ECC, respectively.

Table 1 Maximal isokinetic quadriceps torque (Mean SD) following static stretching (n=12).

	Control	*Agonist*	*Antagonist*
Concentric (Nm)	303±35	270±28[a]	304±38
Eccentric (Nm)	341±40	309±42[b]	336±44

a Significantly different ($p<0.05$) from Control and Antagonist.
b Significantly different ($p<0.05$) from Control.

DISCUSSION: The current results support the evidence suggesting that pre-exercise agonist stretching may in fact lead to a performance decrement in maximal torque production; especially if the SSC is part of the activity (Young & Elliott, 2001). A decrease in musculotendinous stiffness has been shown to influence the amount force that can be generated by the muscle during a concentric contraction; with the effect more evident in activities that require an SSC (Wilson et al., 1994; Young & Elliott, 2001).

Flexibility training has been shown to decrease musculotendinous stiffness (Wilson et al., 1992), which could then result in the decreased force production. Although an intriguing line of reasoning, the authors are unaware of any studies that have investigated this theory. Furthermore the findings of Wilson et al. (1994) indicated that the level of musculotendinous stiffness was not related to eccentric force production, thus additional factors must be at work.

In contrast, McHugh et al. (1998) found that stiffer, less flexible muscles had increased storage and return of elastic energy, which may be related to movements involving an SSC; however they did not employ stretching as an independent variable in their study.

Kokkonen et al. (2000) suggested that a depression of muscle activation might be an alternative reason for the decrease in concentric force production seen after static stretching. However, the effect of stretching the antagonistic muscle can not be determined from findings of Kokkonen et al. (2000), as their subjects performed stretches of both the agonist and antagonist muscles and the decreased strength was found for both flexion and extension movements.

The current study focused on a single muscle and found static stretching of the antagonist had no effect on quadriceps' performance of concentric or eccentric isokinetic contractions, but that stretching the muscle of interest decreased torque for both concentric and eccentric contractions. An increase in Golgi Tendon Organ (GTO) activity following passive stretching has been implicated by Fowles et al. (2000) as a factor in reducing strength of the stretched muscle.

However, the lack of a statistically significant change after antagonist stretching somewhat complicates the explanation of decreased neural activity in the antagonist muscle.

It remains to be seen how long the act of stretching effects eccentric maximal force production. Fowles et al. (2000) report that the effect of stretching on force production lasts for approximately one hour during the concentric phase of exercise. However the authors of the current paper are unaware of any research reporting the time course during eccentric exercise.

CONCLUSION: The results of the current study suggest that stretching the active muscle shortly before maximal strength activities would be counterproductive. This is true for both concentric and eccentric movements and based on earlier studies may be most important in activities incorporating a stretch shortening cycle. Thus, in weightlifting and events involving moderately quick (0.5-1.5s), eccentric-concentric actions, it may be advisable not to stretch prior to exercise if the performance outcome is based on maximal force production.

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