INTRODUCTION

It has previously been demonstrated that the maximal voluntary contraction (MVC) torque for the quadriceps femoris (QF) muscle occurs within the mid-range (i.e., 45 – 90 deg flexion) of knee range of motion (Ng, et al, 1994; Suter and Herzog, 1997; Welsch et al, 1998). Decreases in voluntary torque generation at the extremes of the functional joint range of motion (0 – 90 deg flexion) may be attributed to mechanical and/or muscle activation factors. The purpose of this study was to examine the effects of knee joint angle on QF activation and knee extensor torque.

METHODS

Fifteen healthy male and 15 healthy female volunteers participated (mean age = 24.2 ± 4.2 years, mean height = 171.8 ± 8.0 cm, mean weight = 69.8 ± 2.5 kg). Subjects performed an active warm-up involving 5 min of sub-maximal cycling, followed by 3-4 sub-maximal and maximal effort isometric QF contractions. For the isometric contractions, subjects sat in an upright position and were stabilized with thigh, pelvic and torso straps on the Biodex System II isokinetic dynamometer. Subjects then performed a series of isometric maximal voluntary contractions (MVC) with their knee in the following positions: 0, 10, 30, 50, 70, and 90 deg flexion. Each subject performed 3 MVCs (5 sec each) at each angle, in a random order, with 2 min rest in between each contraction.

Peak torque (PT) was recorded and averaged for the 3 MVCs at each knee angle. Muscle activation was assessed via surface EMG for the vastus medialis (VM), vastus lateralis (VL), and rectus femoris (RF) muscles. Pre-amplified bi-polar circular electrodes (Ag/AgCl) were placed on pre-determined areas of each muscle with a fixed inter-electrode distance (center to center) of 2 cm. The reference electrode was placed over the medial shaft of the tibia. EMG activity was collected at 1000 Hertz (CMRR=87 dB at 60 Hertz, input impedance >25 Mohms at dc) with a gain range of 1K to 5K. The raw EMG signal was bandpass filtered (20-500 Hertz), full-wave rectified and integrated over the middle 3 sec of each contraction. A 2-way ANOVA (knee angle by gender) with repeated measures was performed on isometric PT. A 1-way ANOVA with repeated measures (knee angle factor) was performed for isometric EMG activity for each muscle, separately.

RESULTS AND DISCUSSION

The results demonstrated a significant angle (F5,140 = 270.85, p<0.05), gender (F1,28 = 29.35, p<0.05), and angle by gender interaction (F5,140 = 19.81, p<0.05) for QF PT. It was observed that peak isometric QF
torque was attained at a 70 degree angle, and that males experienced a significantly greater increase in torque from angles 30 to 70, than females (Figure 1).

These findings appear to be similar to those of Ng et al (1994) and Welsch et al (1998) who found that isometric quadriceps PT was highest at 60 degrees flexion. Although this specific knee angle was not investigated in the present study, Welsch et al (1998) also demonstrated minimal differences in isometric torque between 60 and 78 degrees flexion. The present findings, however, are in contrast to those of Suter and Herzog (1997) who observed peak isometric QF torque to occur at 90 degrees flexion, as opposed to 60 degrees.

The results showed a statistically significant increase in VM EMG from knee angles 0 to 50 degrees (F5,145 = 13.87, p<0.05), and no significant differences between angles 50 to 90. There were no significant differences in VL EMG between the different knee angles. Rectus femoris EMG activity was found to significantly increase from knee angles 0 to 10 (F5,145 = 4.78, p<0.05), while angles 10 to 90 were not significantly different.

This pattern of activation of the VL muscle is similar to the findings of Suter and Herzog (1997) in which the same muscle demonstrated no significant EMG differences across knee angles 15, 30, 45 and 60 degrees. However, the EMG signal was found to be significantly highest at a knee angle of 90 degrees (Suter and Herzog, 1997).

**SUMMARY**

The major finding of the present study demonstrates that peak QF isometric torque occurred at 70 degrees flexion in both males and females. It was also observed that the EMG signal of the VM muscle only, followed a similar trend as the PT values. Vastus lateralis and RF muscle EMG appeared to be less sensitive to changes in knee joint angle.

**REFERENCES**

