INTRODUCTION

Elevated patellofemoral joint stress is thought to be a contributing factor with respect to the development of patellofemoral pain (PFP) (Heino 2002). As stress is defined as force per unit area, elevated stress could occur as a result of increased joint reaction force and/or a decrease in contact area. It has been suggested that individuals with patella alta (a condition associated with PFP) have altered knee extensor mechanics that predispose them to increased joint reaction forces (Singerman 1994 and Yamaguchi 1989). This premise however, was based on data obtained from cadaveric and mathematical models and therefore may not have been representative of a population of persons with patella alta. Currently, there are no in vivo data to support the premise that patella alta is associated with abnormal knee extensor mechanics and larger patellofemoral joint reaction forces. The purpose of this study was to compare the knee extensor mechanics and the influence of these mechanics on joint reaction force potential in persons with and without patella alta.

METHODS

Twenty seven subjects (25 female and 2 male) with a mean age of 27 ± 4 years, mean height 164 ± 5 cm, and mean weight 58 ± 8 Kg were enrolled in the study after informed consent was obtained. Subjects were screened for safety within the MR environment before being placed supine on the imaging table in a custom made loading device (Captain Plastic, Seattle, WA). This device (similar to a leg press) was loaded with 25% of body and simulated weightbearing knee extension. Sagittal plane images of the knee joint were obtained with a T1 weighted spin echo pulse sequence (TR 350 msec, TE 10 msec, NEX 1, Matrix 256 X 256, FOV 20 cm X 20 cm, slice thickness 10 mm) at 0, 20, 40, and 60 degrees.

Measurements of patellar ligament length (Lpl) and patellar length (Lp) were made on mid-sagittal images of the knee at 0 degrees of knee flexion. Subjects were then divided into patella alta (n=13) and normal patellar position (n=14) groups based on the Insall-Salvati criteria (Lpl/Lp ratio > 1.2 equals patella alta) (Insall 1971).

Measurement of the quadriceps effective lever arm (Meff) and calculation of the joint reaction force/quadriceps tendon force (Fq/Fq) ratio were computed using previously described methods (Yamaguchi 1989). Briefly, Meff takes into consideration the influence of the pulley and pivoting actions of the patella in determining extensor mechanism leverage capability. The Fq/Fq ratio indicates the magnitude of the joint reaction force per unit quadriceps force and is estimated based on the orientation of the quadriceps tendon and the patellar ligament. This variable represents the patellofemoral joint reaction force potential (Yamaguchi 1989).
A 2 X 4 (group X knee flexion angle) repeated measures analysis of variance was used to test for group main effects for $M_{\text{eff}}$, and the $F_r/F_q$ ratio with a significance level of 0.05.

RESULTS AND DISCUSSION

There was a significant group effect for $M_{\text{eff}}$ (Figure 1) but no differences in the $F_r/F_q$ ratio were found (Figure 2) across the range of knee flexion angles tested. When collapsed across all four knee flexion angles, the patella alta group had larger $M_{\text{eff}}$ than the control group (4.40 cm ± 0.09 cm vs. 4.00 cm ± 0.09 cm, respectively).

Figure 1. $M_{\text{eff}}$ at each knee angle. † denotes alta > control when averaged across all knee angles, $p \leq 0.05$.

The finding of a greater $M_{\text{eff}}$ suggests an increased mechanical advantage in the quadriceps and indicates that subjects with patella alta would be expected to use less quadriceps force to overcome the same knee flexion moment compared to subjects with normal patellar position. The lack of a difference in $F_r/F_q$ ratio indicates that persons with patella alta would be expected to have similar joint reaction forces per unit quadriceps force when compared to subjects with normal patella position.

SUMMARY

The observed differences in knee extensor mechanics suggest that individuals with patella alta have a more efficient knee extensor mechanism than subjects with normal patellar position. Given that these subjects would be expected to generate similar joint reaction forces per unit quadriceps force, subjects with patella alta may experience less joint reaction force to overcome the same knee flexion moment in the range of 0 to 60 degrees of knee flexion. These findings are contrary to previous in-vitro data suggesting that patella alta predisposes individuals to increased patellofemoral joint reaction forces.

REFERENCES


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