Biomechanical and Neuromuscular Changes after Total Knee Arthroplasty are Sex-Specific

+1Astephen Wilson, JL; 1Hubley-Kozey, CL; 1Dunbar, MJ
+1Dalhousie University, Halifax, NS, Canada
Janie.Astephen@Dal.Ca

INTRODUCTION:
Total knee arthroplasty (TKA) surgery has been shown to improve functional outcomes, such as increased walking velocity and knee range of motion (Yoshida et al., 2008). Magnitudes of knee joint loading and movement during gait move toward asymptomatic, but patterns of these measures over the gait cycle often remain irregular (Hatfield et al., 2011). Similar results have been found for the electromyography patterns of the periartricular knee muscles (Hubley-Kozey et al., 2010; Benedetti et al., 2003). There is evidence that females with moderate levels of knee osteoarthritis (OA) walk with different movement and loading patterns than their male counterparts (McKean et al., 2007). However, despite this as well as the recent emergence of gender-specific prostheses, there has been little research into the differences in the post-TKA response of the locomotor and neuromuscular systems between sexes. The objective of this study was to examine the sex-associated differences in the patterns of knee kinematics, knee kinetics and neuromuscular control of knee muscles before and after TKA surgery.

METHODS:
Sixty-four (36 female, 28 male) individuals with end-stage knee OA underwent three-dimensional gait (OptotrakTM motion capture, AMTI force platforms) and simultaneous electromyography (EMG) (Bortec) testing within a week prior to TKA surgery and one year following surgery. Informed consent was obtained according to the institutional review board. Two different knee systems were used: the NexGen Posterior Stabilized Complete Knee System (Zimmer, Warsaw, Ind) (cemented titanium and trabecular metal base plates) and the Medial Pivot Knee System. Participants walked at their self-selected speed, and 3D knee joint angles and net external moments were calculated over the gait cycle. EMG of 3 quadriceps (VL, VM, RF), 2 gastrocnemius (LG, MG) and 2 hamstrings (LH, MH) muscles was recorded simultaneously. Principal Component Analysis (PCA) was used to extract major patterns of the knee angles, moments and muscle groups (Deluzio and Astephen, 2007). Three-factor ANOVA was used to test for differences in these patterns between sexes, visits (pre and post) and muscle (p < 0.10).

RESULTS:
There were no significant age, BMI or gait speed differences between males and females, but males were significantly heavier than females (p = 0.02). Significant sex or sex interaction effects were found in the knee adduction and flexion moments, in the knee adduction and rotation angles, and in the activation of the quadriceps and gastrocnemius muscles during gait. A sex main effect was found in the knee adduction moment (PC2, p = 0.06) indicating that females had a more constant (similar early and mid to late stance values) knee adduction moment pattern during stance than males (Figure 1a). A sex by visit interaction in the knee flexion moment (p = 0.06) indicated that females shifted to a later peak extension moment in late stance and males to an earlier peak after TKA (Figure 1b).

DISCUSSION:
While patterns of knee joint loading during gait have been shown to move toward asymptomatic patterns post-TKA (Hatfield et al., 2011), these results suggest that pattern changes are sex-specific, with male patterns in general moving closer to more functional, asymptomatic patterns than females (Figures 1). TKA appears to affect males and females differently in terms of the patterns of the knee adduction and rotation angles during gait (Figure 2); however it is difficult to decipher which is more functional given the high variability in normal measures. Similarly, while it has been shown that EMG patterns also move toward asymptomatic patterns post-TKA (Hubley-Kozey et al., 2010), this study further indicates that females tend to lag their male counterparts in this regard and display more prolonged activity of the quadriceps and gastrocnemius muscles throughout stance.

SIGNIFICANCE:
This was the first study to indicate that the effect of TKA on knee joint kinematics, kinetics and neuromuscular activation patterns during gait is sex-specific. This has implications for sex-specific surgical decision-making, implant design and potentially post-TKA rehabilitation efforts.

REFERENCES:
Benedetti et al., Clinical Biomechanics 18(9), 2003.
Hubley-Kozey CL et al., Clinical Biomechanics 25(10), 2010.
McKean KA et al., Clinical Biomechanics 22(4), 2007.
Yoshida Y et al., Clinical Biomechanics 23(3), 2008.

Figure 1: a) mean knee adduction moment waveforms over the gait cycle; b) mean knee flexion moment waveforms (+ve: flexion).

Figure 2: a) mean knee adduction angle waveforms over the gait cycle (+ve: adduction); b) mean knee rotation angles (+ve: internal).

Figure 3: a) mean lateral gastrocnemius EMG waveforms over the gait cycle; b) mean vastus lateralis waveforms.

Poster No. 1943 • ORS 2012 Annual Meeting