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

Janie L Astephen Wilson¹, Cheryl L Hubley-Kozey¹,², Michael J Dunbar¹,³
¹School of Biomedical Engineering, Dalhousie University, Halifax, Canada, Janie.Wilson@Dal.Ca
²School of Physiotherapy, Dalhousie University, Halifax, Canada
³Department of Surgery, Dalhousie University, Halifax, Canada

INTRODUCTION
Total knee arthroplasty (TKA) surgery has been shown to improve functional outcomes. For instance, magnitudes of knee joint loading and movement during gait move toward asymptomatic; however 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 periarticular 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). 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 and kinetics and neuromuscular control of knee muscles before and after TKA.

METHODS
Sixty-four (36 female, 28 male) individuals with end-stage knee OA underwent three-dimensional gait (Optotrak™ motion capture, AMTI force platforms) and simultaneous electromyography (EMG) (Bortec) testing within a week prior to TKA surgery and one year following surgery.

Two different knee systems were used: the NexGen Posterior Stabilized Complete Knee System (Zimmer, Warsaw, Ind) 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 flexion angle and moments and muscle groups (Deluzio and Astephen, 2007). Three-factor ANOVA was used to test for differences in these patterns between sexes, visits 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). 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) 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).

A visit by sex interaction in the overall magnitude of the gastrocnemius activity was also found (PC2, p = 0.01). Females peaked later in stance than males (e.g. Figure 2a). Females also had higher overall magnitudes of quadriceps activity in stance (PC1, p = 0.013) and more continued activation of the quadriceps muscles during stance than males (PC3, p = 0.05). This continued activation of the quadriceps became more pronounced in females post-TKA and less so for males (p = 0.05) (Figure 3b).

DISCUSSION AND CONCLUSIONS
These results suggest that knee joint loading pattern changes after TKA are sex-specific, with male patterns in general moving closer to more asymptomatic patterns than females (Figure 1). 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 (Figure 2). 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