BIOMECHANICAL ANALYSIS OF SIT-TO-STAND AFTER BILATERAL TOTAL KNEE REPLACEMENT

[1] H. Wang, [2]K. Simpson, [2]M. Ferrara, [3]S. Chamnongkich, [4]T. Kinsey, and [4]O. Mahoney
[1]Queens College, [2]University of Georgia, [3]Chiangmai University, [4]Athens Orthopedic Clinic;
email: hewang@forbin.qc.edu

INTRODUCTION

As the trend of longer life span continues, more and more people receive bilateral total knee replacements (TKR) in their lifetime. It is common that many patients have two different TKR systems implanted, one on each side. The functional performance of bilateral TKR patients with two different systems during daily activities is not well understood. Although it was reported that a single-radius TKR (SR) compared to a multi-radius TKR (MR) could facilitate unilateral TKR patients' sit-to-stand (STS) movement [1], it is not known if bilateral TKR patients with an SR and an MR on each side rely on their SR limbs to perform a STS movement.

The purpose of this study is to investigate the influence of an SR and an MR TKA on functional performance during a STS performed by bilateral TKR patients.

METHODS

Eight healthy participants (age = 71 ± 9 yr.) with an SR (Scorpio™ PS, Stryker Orthopaedics Inc.) and an MR (S-7000™ PS, Stryker Orthopaedics, Inc. and P.F.C.™ PS, Johnson & Johnson, Inc.) on each side took part in this study. Three high-speed video cameras (120Hz) were used to track participants' motion. An EMG system (1080 Hz) and a force platform (1080 Hz) were used to monitor leg muscles' activation and ground reaction force (GRF), respectively. Participants performed four STS trials for each leg.

An inverse dynamic method [2] was used to calculate joint reaction forces (JRF), moments, and powers of ankle, knee, and hip joints. Horizontal and vertical impulses were calculated for the forward-thrust phase and extension phase of the STS. Normalized root-mean squared (RMS) EMG was used to quantify the contractions of quadriceps and hamstrings. Paired Student t-tests were used to determine the kinematic, kinetic, and EMG differences between the SR and the MR limbs ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Compared to the MR limb, the SR limb exhibited greater: peak antero-posterior (AP) GRF; peak AP JRFs of the ankle and knee joints; and AP impulse during the forward-thrust phase (Table 1). However, the vastus lateralis (VL) RMS EMG of the SR limb (1.185 ± 0.508) was less than the MR limb (1.354 ± 0.031).

Due to the greater peak AP GRF, the SR limb had greater peak AP JRFs in the ankle and knee joints compared to the MR limb. Greater AP GRF accounted for the greater AP impulse during the forward-thrust phase. During this phase, the trunk segment rotates around the hip joint so that the upper body mass can be shifted from the seat to the feet. The increased AP impulse associated with the SR limb might help produce trunk rotation by producing extra rotational momentum.

As the moment arm length for the quadriceps force acting on the tibia via the patella tendon is longer for the SR design than the MR designs used in this study [3, 4], we anticipated that the MR limb would produce more quadriceps activation during the STS. However, we only found a weak support for this notion. The increased VL activation seen in the MR limb might be due to the TKR design differences but could also be related to knee stability.

Surprisingly, we did not detect the significant differences between the limbs for the lower extremity joint moments. Likely it was due to small sample size and high inter-individual variability.

CONCLUSIONS

Bilateral TKR patients with an SR and an MR on each side showed unique GRF differences and different VL muscle activation between the two limbs.

REFERENCES

1. Wang, et al. *Proceedings of 70th AAOS*, New Orleans, LA. 402, 2003.
2. Winter. *Biomechanics and motor control of human movement*. 75-102, 1990.
3. D'Lima, et al. *Clin. Orthop. Rel. Res*. (392), 213-220, 2001.
4. Mahoney, et al. *J. Arthroplasty*. 17(4), 416-421, 2002.

ACKNOWLEDGEMENTS

This study was funded by Stryker Orthopaedics, Inc. and CUNY Research Foundation.

	SR	MR	P value
Peak AP GRF (N)	60.5 ± 8.5	50.3 ± 10.0	0.007
Peak AP JRF of ankle (N)	60.5 ± 8.5	50.3 ± 10.0	0.007
Peak AP JRF of knee (N)	60.4 ± 9.8	50.9 ± 10.9	0.01
AP impulse of the forward-thrust phase (N*s)	13.9 ± 3.6	10.4 ± 3.5	0.006

Table 1. Peak AP ground reaction force, joint reaction forces of ankle and knee, and antero-posterior impulse between the SR and the MR limbs.