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## **Errors in the knee joint forces and moments during gait depending on the foot and knee prosthetic components**

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### **Background**

Previously studies showed that inverse dynamics based on motion analysis and force-plate is inaccurate compared to direct measurements for individuals with transfemoral amputation (TFA). Indeed, direct measurements can appropriately take into account the absorption at the prosthetic foot and the resistance at the prosthetic knee.<sup>[1-3]</sup> However, these studies involved only a passive prosthetic knee.

### **Aim**

The objective of the present study was to investigate if different types of prosthetic feet and knees can exhibit different levels of error in the knee joint forces and moments.

### **Method**

Three trials of walking at self-selected speed were analysed for 9 TFAs (7 males and 2 females, 47±9 years old, 1.76±0.1 m 79±17 kg) with a motion analysis system (Qualisys, Goteborg, Sweden), force plates (Kitsler, Winterthur, Switzerland) and a multi-axial transducer (JR3, Woodland, USA) mounted above the prosthetic knee<sup>[1-17]</sup>. TFAs were all fitted with an osseointegrated implant

system. The prostheses included different type of foot (N=5) and knee (N=3) components.

The root mean square errors (RMSE) between direct measurements and the knee joint forces and moments estimated by inverse dynamics were computed for stance and swing phases of gait and expressed as a percentage of the measured amplitudes. A one-way Kruskal-Wallis ANOVA was performed (Statgraphics, Levallois-Perret, France) to analyse the effects of the prosthetic components on the RMSEs. Cross-effects and post-hoc tests were not analysed in this study.

### **Results**

A significant effect (\*) was found for the type of prosthetic foot on anterior-posterior force during swing (p=0.016), lateral-medial force during stance (p=0.009), adduction-abduction moment during stance (p=0.038), internal-external rotation moment during stance (p=0.014) and during swing (p=0.006), and flexion-extension moment during stance (p = 0.035).

A significant effect (#) was found for the type of prosthetic knee on anterior-posterior force during swing ( $p=0.018$ ) and adduction-abduction moment during stance ( $p=0.035$ ).

**Table 1. Overview of the errors**

RMSE (mean +/- standard deviation) in %		Stance	Swing
Force	Anterior-Posterior	13 +/- 6	47 +/- 9 **
	Proximal-Distal	6 +/- 4	44 +/- 22
	Lateral-Medial	21 +/- 17 *	56 +/- 23
Moment	Adduction-Abduction	22 +/- 16 **	36 +/- 15 *
	Internal-External Rotation	40 +/- 27 *	42 +/- 16
	Flexion-Extension	14 +/- 7 *	49 +/- 12

### Discussion & Conclusion

The RMSEs were larger during swing than during stance. It is because the errors on accelerations (as derived from motion analysis) become substantial with respect to the external loads. Thus, inverse dynamics during swing should be analysed with caution because the mean RMSEs are close to 50%.

Conversely, there were fewer effects of the prosthetic components on RMSE during swing than during stance and, accordingly, fewer effects due to knees than feet. Thus, inverse dynamics during stance should be used with caution for comparison of different prosthetic components.

### Reference

1. Dumas, R., L. Cheze, and L. Frossard, Loading applied on prosthetic knee of transfemoral amputee: comparison of inverse dynamics and direct measurements. *Gait Posture*, 2009. 30(4): p. 560-2.
2. Dumas, R., L. Cheze, and L. Frossard, Load during prosthetic gait: Is direct measurement better than inverse dynamics? *Gait & Posture*, 2009. 30(Supplement 2): p. S86-S87.
3. Frossard, L., L. Cheze, and R. Dumas, Dynamic input to determine hip joint moments, power and work on the prosthetic limb of transfemoral amputees: ground reaction vs knee reaction. *Prosthet Orthot Int*, 2011. 35(2): p. 140-9.
4. Vertriest, S., P. Coorevits, K. Hagberg, R. Branemark, E. Haggstrom, G. Vanderstraeten, and L. Frossard, Static load bearing exercises of individuals with transfemoral amputation fitted with an osseointegrated implant: reliability of kinetic data. *IEEE Trans Neural Syst Rehabil Eng*, 2015. 23(3): p. 423-30.
5. Frossard, L., J. Beck, M. Dillon, M. Chappell, and J.H. Evans, Development and preliminary testing of a device for the direct measurement of forces and moments in the prosthetic limb of transfemoral amputees during activities of daily living. *Journal of Prosthetics and Orthotics*, 2003. 15(4): p. 135-142.
6. Lee, W.C., L.A. Frossard, K. Hagberg, E. Haggstrom, D.L. Gow, S. Gray, and R. Branemark, Magnitude and variability of loading on the osseointegrated implant of transfemoral amputees during walking. *Med Eng Phys*, 2008. 30(7): p. 825-833.
7. Frossard, L., R. Tranberg, E. Haggstrom, M. Percy, and R. Branemark, Fall of a transfemoral amputee fitted with osseointegrated fixation: loading impact on residuum. *Gait & Posture*, 2009. 30(Supplement 2): p. S151-S152.
8. Frossard, L., E. Haggstrom, K. Hagberg, and P. Branemark, Load applied on a bone-anchored transfemoral prosthesis:

- characterisation of prosthetic components – A case study *Journal of Rehabilitation Research & Development*, 2013. 50(5): p. 619–634.
9. Frossard, L., N. Stevenson, J. Sullivan, M. Uden, and M. Percy, Categorization of Activities of Daily Living of Lower Limb Amputees During Short-Term Use of a Portable Kinetic Recording System: A Preliminary Study. *JPO Journal of Prosthetics and Orthotics*, 2011. 23(1): p. 2-11.
10. Frossard, L.A., Load on osseointegrated fixation of a transfemoral amputee during a fall: Determination of the time and duration of descent. *Prosthet Orthot Int*, 2010. 34(4): p. 472-87.
11. Frossard, L., N. Stevenson, J. Smeathers, D. Lee Gow, S. Gray, J. Sullivan, C. Daniel, E. Häggström, K. Hagberg, and R. Brånemark, Daily activities of a transfemoral amputee fitted with osseointegrated fixation: continuous recording of the loading for an evidence-based practice. *Kinesitherapie Revue*, 2006. 6(56-57): p. 53-62.
12. Frossard, L.A., R. Tranberg, E. Haggstrom, M. Percy, and R. Branemark, Load on osseointegrated fixation of a transfemoral amputee during a fall: loading, descent, impact and recovery analysis. *Prosthet Orthot Int*, 2010. 34(1): p. 85-97.
13. Frossard, L., D.L. Gow, K. Hagberg, N. Cairns, B. Contoyannis, S. Gray, R. Branemark, and M. Percy, Apparatus for monitoring load bearing rehabilitation exercises of a transfemoral amputee fitted with an osseointegrated fixation: a proof-of-concept study. *Gait Posture*, 2010. 31(2): p. 223-8.
14. Frossard, L., K. Hagberg, E. Häggström, D.L. Gow, R. Brånemark, and M. Percy, Functional Outcome of Transfemoral Amputees Fitted With an Osseointegrated Fixation: Temporal Gait Characteristics. *JPO Journal of Prosthetics and Orthotics*, 2010. 22(1): p. 11-20.
15. Frossard, L., K. Hagberg, E. Haggstrom, and R. Branemark, Load-relief of walking aids on osseointegrated fixation: instrument for evidence-based practice. *IEEE Trans Neural Syst Rehabil Eng*, 2009. 17(1): p. 9-14.
16. Lee, W., L. Frossard, K. Hagberg, E. Haggstrom, and R. Brånemark, Kinetics analysis of transfemoral amputees fitted with osseointegrated fixation performing common activities of daily living. *Clinical Biomechanics*, 2007. 22(6): p. 665-673.
17. Frossard, L., N. Stevenson, J. Smeathers, E. Haggstrom, K. Hagberg, J. Sullivan, D. Ewins, D.L. Gow, S. Gray, and R. Branemark, Monitoring of the load regime applied on the osseointegrated fixation of a trans-femoral amputee: a tool for evidence-based practice. *Prosthet Orthot Int*, 2008. 32(1): p. 68-78.