Errors in the knee joint forces and moments during gait depending on the foot and knee prosthetic components from stabilisation during gain stance

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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. [1-3] 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 [1-17]. 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.

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