Validation of kinematic and kinetic prosthetic knee joint parameters during walking of persons with a transfemoral amputation

E. Pröbsting[1], **M. Ernst[1]**, V. Schopper[1,2], T. Schmalz[1], H. Böhm[3,4], M. Bellmann[1,4]
[1]Research Biomechanics, CR&S, Ottobock SE & Co. KGaA, Göttingen, Germany, [2]German Sport University Cologne, Germany, [3]Orthopaedical Childrens Hospital, Aschau in Chiemgau, Biomechanical Lab, Germany, [4]HAWK University of applied sciences and arts Göttingen, Germany.
Email: michael.ernst@ottobock.com

Summary

Accurate and valid gait analysis parameters of prosthetic knee joints are essential to evaluate the functionality and safety of these components. In the present study, the sagittal knee angle and knee moment were determined using standard gait models and a newly developed gait model. During the measurements, sensor data of the prosthetic knee joint were recorded simultaneously. These data were used to validate the results of the models. The results show, that motion analysis of persons with a transfemoral amputation leads to more accurate results when the specific model is used.

Introduction

Gait analysis parameters are often used to evaluate the functionality and safety of prosthetic knee joints. A methodological problem for determining these measures has been that standard gait models for calculating kinetic and kinematic parameters were developed for analyzing movement in able-bodied people. In the present study, essential gait parameters characterizing functionality of prosthetic knee joints, such as the sagittal knee angle and moment, were determined using different gait models and validated by comparing them with internal sensor data of the prosthetic knee joint.

Methods

Measurements took place in two gait laboratories. In total, level walking of 19 persons with a transfemoral amputation (PTFA) at their usual speed (1.23±0.17m/s) was biomechanically analyzed. All participants used microprocessor-controlled knee joints (Genium or X3, Ottobock). Optoelectronic cameras (VICON, GB) and force plates (KISTLER AG, CH or AMTI, US) were used for gait analysis. Prosthetic knee moment and angle were calculated with three different models: Plug-in Gait (PIG) [1,2], adapted Cleveland (CC) [3], and a new model (TF) specifically developed for the analysis of PTFA.

During the gait analysis, sensor data of the prosthetic knee joint (BL, knee angle and moment) were simultaneously recorded.

Results Discussion

The mean curves of knee angle and knee moment of all participants, normalized to the gait cycle, showed only small differences, which are also visible in the small RMSE values between the models and BL: sag. knee moment: TF: 0.05±0.02 Nm/kg, CC: 0.06±0.02 Nm/kg, PIG: 0.12±0.04 Nm/kg; sagittal knee angle: TF:1.6±0.5 deg, CC: 3.2±1.4 deg, PIG: 3.2±1.1 deg. Here, both values for the TF-model are the lowest (figure 1).

When comparing the range-of-motion of specific parts of the gait cycle as well as peak moment values, statistically significant ($p<0.05$) differences between the models have been found. The only model without significant differences to BL is TF .

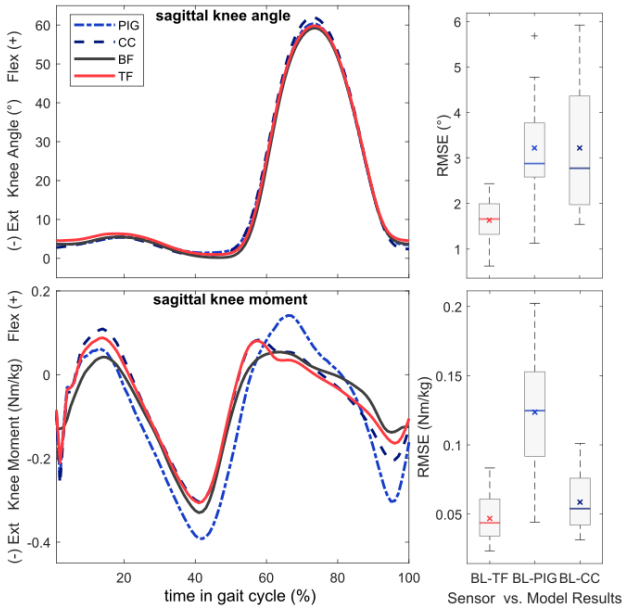

Figure 1: Mean sagittal knee moment and mean sagittal knee angle of the prosthetic side for the different models and corresponding RMSE of sensor and model data.

Discussion and Conclusions

Relevant parameters of the prosthetic knee joint can be determined using gait analysis, but not all models have the level of accuracy required for evaluating prosthetic knee joints.

The new model, specifically developed for the analysis of PTFA, showed the most reliable data.

References

[1] MP Kadaba et al. (1990). *J Orthop Res.*, **8(3)**: 383-92.
[2] *Plug-in Gait Reference Guide*, www.vicon.com
[3] DH Sutherland (2002). *G&P*, **16**:159-179.