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Title
Gait characteristics of 53 trans-tibial amputees

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Summary
We investigated the gait patterns of 53 trans-tibial (TT) amputees with respect to significant differences in comparison to non-amputees. In contrast to previous studies we found a more pronounced knee flexion during weight bearing and no overloading on the sound contra-lateral side.

Introduction
A TT amputation causes not only the loss of the ankle and foot with its various joints and muscles but also a deficiency of the proprioceptive system. The aim of the prosthetic fitting is to compensate these deficits and to enable the amputee an almost physiological gait. The influence of a TT amputation on gait characteristics with a prosthesis has been described previously but the results are inconsistent. A limitation of most investigations is the small sample size. For a representative overview of typical gait characteristic of TT amputees a larger group is desirable. Therefore, we analysed our database with 53 unilateral trans-tibial amputees and characterised their typical gait patterns.

Methods
Since 2002, gait analyses have been performed with amputees in our gait lab in Göttingen with a VICON system. In the center of the 12 m walkway, two Kistler force plates were positioned for measuring the bilateral ground reaction forces during one gait cycle. The data from these systems was collected in our database and was analysed retrospectively for this study.We identified one characteristic session with normal velocity on level ground for each unilateral TT amputee without any additional impairment. The prosthesis used for this measurement was required to be aligned with a commercially available foot according to the criteria defined by Blumentritt 1999.

Data from a control group with non-amputees was also obtained from our database.Group means were calculated based on the values of the control subjects and TT-amputees for the sound side and the prosthetic limb. Differences in biomechanical parameters between amputees and the control group were tested with the Mann-Whitney U-test.

Results

The amputees were on average 48 ± 15.7 years old, 1.77 ± 0.09 m tall and weighed 84 ± 17.8 kg. All subjects used passive prosthetic feet, eight were conventional, 42 energy storing and returning feet, and three not identified.

The trans-tibial amputees walked significantly slower than the control group (1.26 m/s vs. 1.43 m/s). Step length was significantly reduced for the prosthetic side (0.71 m) as well as the sound side (0.67 m) in comparison to the control group (0.76 m). Step length and stance phase duration asymmetry between both legs were significantly higher for the amputees.

The kinematic pattern of the sound limb in TT amputees appears to be more or less comparable with non amputees. Furthermore, the kinetic data of the sound side shows only four significant differences: 1. A lower dorsiflexion moment at terminal stance (1.61 Nm/kg vs. 1.77 Nm/kg), 2. A lower knee flexion moment in mid stance (0.47 Nm/kg vs. 0.64Nm/kg), 3. A lower second peak knee adduction moment (0.35 Nm/kg vs. 0.40 Nm/kg) and 4. A lower second peak vertical ground reaction forces (109 %BW vs 115 %BW) in comparison with the control group.

Most of the kinematic and kinetic parameters are also reduced for the prosthetic limb (Fig. 1).

Conclusion

The most obvious differences between TT amputees and the control group were seen at the prosthetic ankle. However, the results also indicate that the proximal residual joints are affected with respect to their kinetics and kinematics.

One of the most important kinematic parameters is the knee flexion during weight acceptance on the prosthetic side. The mean range of motion was reduced (11.4°); nevertheless, it was more pronounced than in other studies (7°, Breakey 1976; or 9.5°, Powers 1998). This knee flexion motion is influenced by the prosthetic alignment (Schmalz 2002). It was biomechanically optimised for the analysed patient group (Blumentritt 1999) whereas for the cited studies no

clear information about the prosthetic alignment is provided. Therefore this retrospective study demonstrated the importance of a good alignment.

Several studies reported increased knee moments and forces on the sound side of amputees during walking which may lead to osteoarthritis of the knee. However, our study showed no significant increase of the knee adduction moment, knee flexion moment and the vertical ground reaction forces on the sound side in comparison to able bodied subjects. Therefore, it seems reasonable to assume that with an optimized prosthesis the overloading of the sound side during walking is unlikely.

References

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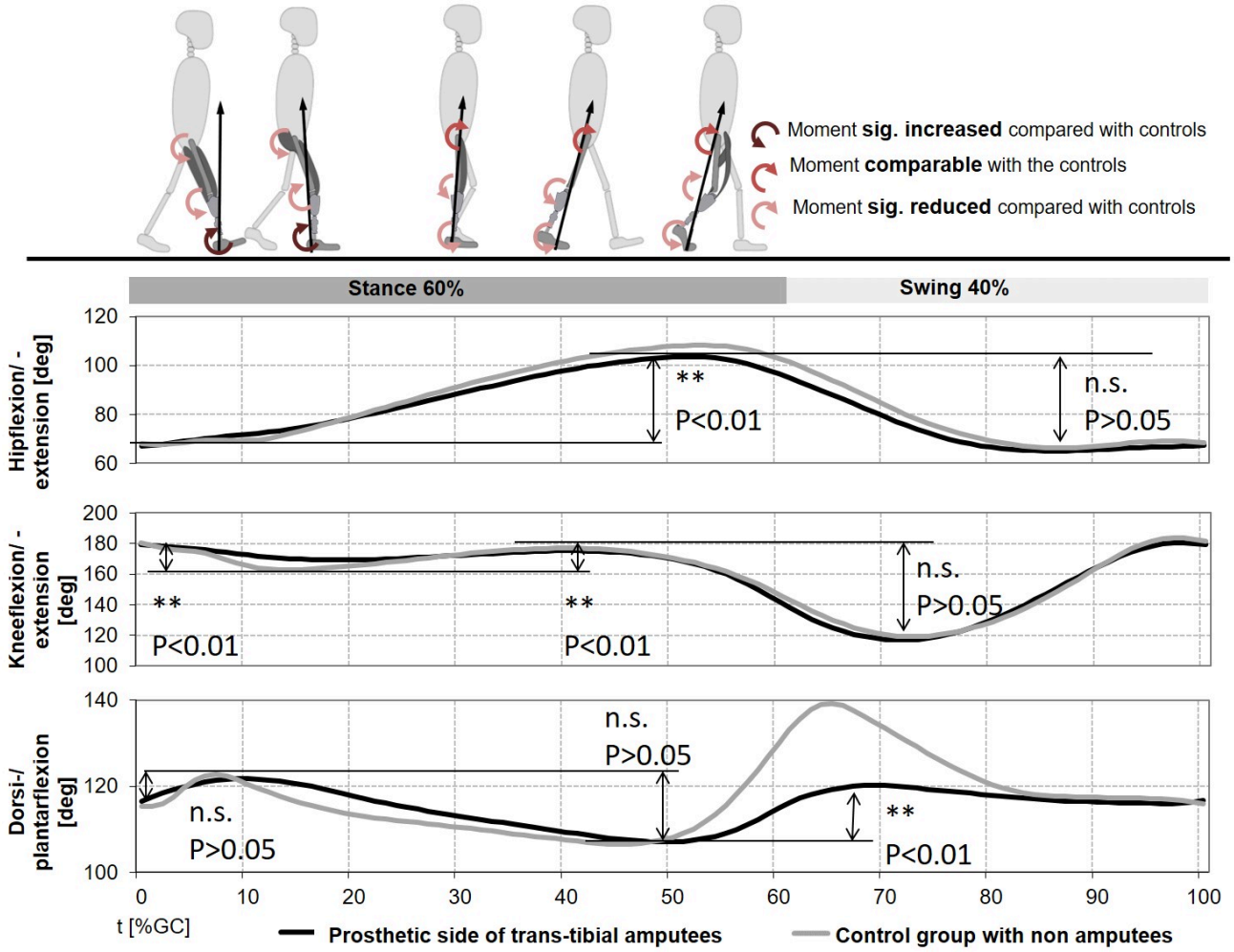

Fig. 1 Biomechanical gait patterns averaged for 53 trans-tibial amputees in comparison to a control group with non amputees (n=52). The differences of the sagittal joint moments are shown above. The averaged pattern of joint motion are shown below. Significant differences between the amputees and control subjects are marked.