Effect of transtibial below-knee prosthesis on biomechanical parameters in the lower limb during gait

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INTRODUCTION

Many studies have assessed prosthesis alignment from the kinematic and temporal distance point of view [1-3]. The present project intended to compare human gait between a non-disabled group of subjects and a unilateral transitiabial amputee group of patients to investigate the symmetry of the gait cycle. Eleven able-bodied people and thirteen unilateral below knee amputee patients with endoskeletal prosthesis (Figure 1) were recruited for this project.

Figure 1. Prosthesis

AIMS AND OBJECTIVES

The aim of the study was to evaluate the clinical results in terms of motion measurement which are related to static and dynamic changes from unilateral transtibial amputees who have used an endoskeletal transtibial prosthesis for at least one year. The project measured the effect of alignment change from static to dynamic states as related to the individual gait symmetrical pattern in terms of kinematics and kinetics (Figure 2).

Figure 2. Clinical gait analysis lab

METHODS AND MATERIALS

- Anthropometric measurements (Figure 3)
- Marker placement
- Electromyography (EMG) positioning
- Vicon® Software (Figures 2,4)
- Force platforms
- Statistical analysis (SPSS software)
- Comparison between able bodied and patient groups

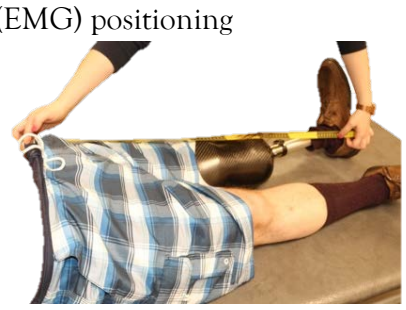

Figure 3. Anthropometric measure

Figure 4. Walking trial, lateral view

RESULTS

1) EMG DATA

The Tibialis Anterior and Lateral Gastrocnemius showed higher peaks and their contraction lasted longer during the gait cycle in the patients' sound limb when compared with the able-bodied participants' limb ($p<0.05$).

2) KINEMATIC DATA

The hips had a range of motion of 40° for both patients' and participants' limbs in the sagittal (X) and transversal (Z) planes. The prosthesis rotated internally during the swing phase (Figure 5).

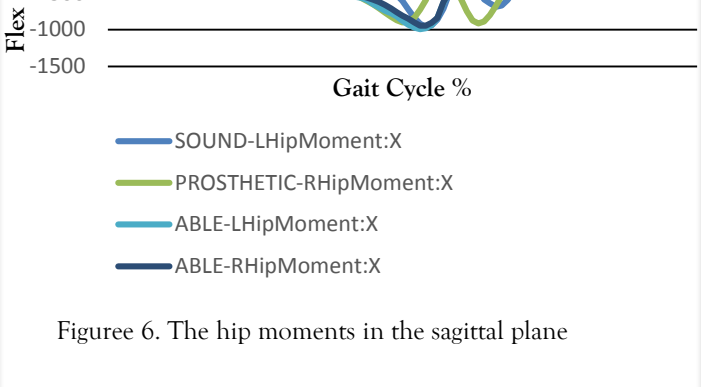

Figure 5. The hip angles in the transversal plane

3) KINETIC DATA

The moment of the prosthetic limb in the sagittal plane (X) at the hip was much smaller than the sound and able-bodied limbs at the beginning of the stance phase (Figure 6).

Figuree 6. The hip moments in the sagittal plane

The absorption of energy at the ankle was greater in the prosthetic side than the sound and able-bodied limbs (Figure 7). The hip power generation was very low in the prosthetic limb.

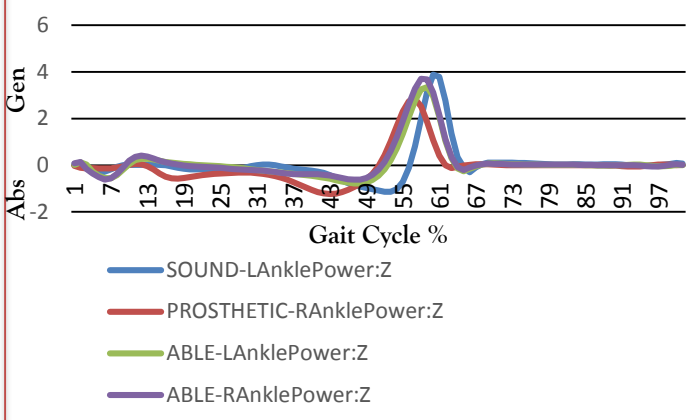

Figure 7. The ankle powers

DISCUSSION

PATIENTS' LIMBS

✓ Abnormal activity of the lower muscles Tibialis Anterior and Lateral Gastrocnemius

- Consequence of lack of flexibility and proprioception ability of the prosthetic foot [3]; the sound limb assumes a compensatory behaviour and it is reflected at a major extent in the distal joints and muscles [2].

✓ Internal rotation of the hip on the prosthetic side

- To push the foot forward and lengthen the step due to the absence of the ankle and also of the sensory information from that joint [2].

✓ Greater extension moment at the hip on the prosthetic side and bigger flexion moment at hip on the sound side

- The position of the GRF behind the hip caused an extension moment at the hip on the prosthetic side with a flexion moment in the swing phase [1].

✓ Absorption of energy on the prosthetic foot

- Attributed to the elastic material which the prosthesis is made from [1].

CONCLUSIONS

The current study demonstrates that symmetrical differences exist between the intact and prosthetic limbs of the same individual, and also diversities are shown between the patient and the able-bodied person.

These results suggest that the asymmetrical pattern of the patients' gait is not related to the normal asymmetry between the legs of a subject, but instead it concerns the discrepancies between the unaffected and affected limbs.

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