SAGITTAL ASYMMETRY IN BILATERAL AMPUTEE GAIT KINETICS

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INTRODUCTION

Healthy gait is characterized by symmetry in the sagittal plane with both lower extremities repeating the same kinetic cycle between two successive heel strikes. Lower limb amputation certainly causes a severe deviation in gait mechanics away from normal conditions (Papaioannou, 2010), leading to the disruption of this balance. In this study the loads applied on the two prosthetic pylons of a bilateral transtibial amputee are measured during prolonged gait and are used to examine the symmetry of the patient's kinetics through the use of Statistical Multivariate Analysis.

METHOD

A 65 year old transtibial amputee (Body mass: 85 kg, Height: 182 cm, left stump length: 11 cm, right stump length: 13 cm) participated in this study approved by the Institutional Review Board. The patient was asked to perform at his self-selected speed the Amputee Strenuous Activity Protocol (Papaioannou, 2011), which covers the most important tasks a person encounters in everyday life, while, a couple of wireless load cells (CPI, 2013) were used to measure the forces and moments applied on each prosthetic pylon (Figure 1). The experiment was repeated for two different socket technologies, namely: Total Surface Bearing (TSB) and Elevated Vacuum (EV).

After the detection and separation of the walking steps (784 in total), all left side measurements were mirrored in the sagittal plane for the easier comparison of the two extremities. Following preprocessing a set of thirteen parameters was defined using the local extrema of the measured waveforms and based on previous bibliography (Racic, 2009). Principal Component Analysis (PCA) was used to calculate the true dimensionality of the dataset which was then transformed into a number of independent variables using Independent Component Analysis (ICA).

RESULTS

The results of PCA revealed that three components can explain 92% of the dataset's variability, underlining its low dimensionality. The results of the ICA are summarised in Figure 2 that demonstrates the first independent component as a reliable discriminator of the extremity side. This result, together with the fact that 63% of the dataset's variability can be explained by this component, underlines the great disturbance of the subjects walking symmetry. Finally Figure 3 reveals that the axial (F_AX) and the anteroposterior force (F_AP) play the most important role in the definition of the independent variables (90% of the factor amplitudes) with the mediolateral force (F_ML) and all the components of moment (M) marginally affecting the final results.

DISCUSSION-CONCLUSION

ICA is widely accepted as a reliable technique for the detection of a variety of locomotion pathologies. In this study we tried to investigate the gait pattern of a bilateral amputee and concluded that the sagittal asymmetry contributes to the dataset's variability far more than any other factor, including fatigue and socket technology. Furthermore we took the first step towards the interpretation of these results based on the Mixing Matrix of the independent components

CLINICAL APPLICATIONS

The method of gait characterization that is proposed in this study is based on gait symmetry, a universally accepted characteristic of healthy walking, and points towards an objective evaluation of low limb prosthesis.

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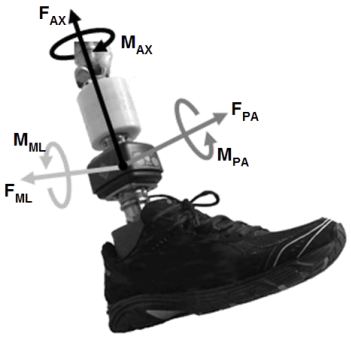

Figure 1. Diagram of the forces and moments measured by iPecs™

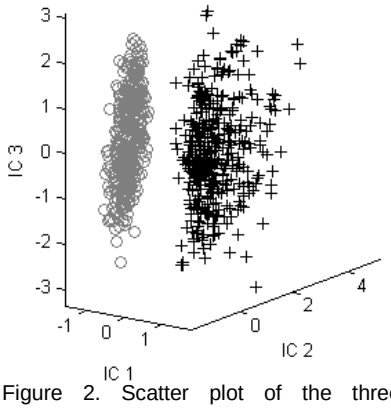

Figure 2. Scatter plot of the three independent components for both extremities (Left:o, Right: +).

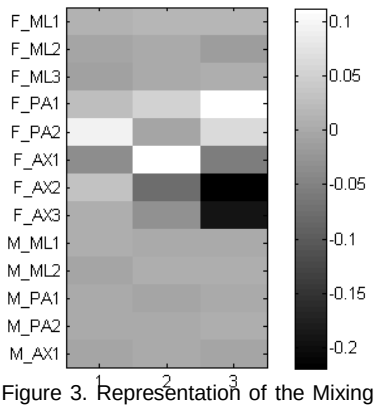

Figure 3. Representation of the Mixing Matrix of the independent components

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