INVESTIGATION OF WRIST AND HAND FUNCTION FOR THE IMPROVEMENT OF UPPER LIMB PROSTHETIC DEVICE DESIGN

Cunha-Matos C.[1] , Andres F.J.[2] , Day S.J.[1] , Buis A.[1]

[1]Department of Biomedical Engineering - University Of Strathclyde, Glasgow, United Kingdom, [2]Department of Mechanical Engineering and Construction - Universitat Jaume I, Castellon, Spain

BACKGROUND

The development of upper limb prostheses faces many different challenges. Specifically, improvements in device design are urgently required, together with increased personalisation of devices according to patients' needs and overall device ease of use and affordability. This investigation is part of a project entitled Anthropomorphic Design for Advanced Manufacturing (ADAM) which aims to develop a new Design System for personalisation of upper limb prosthetics using additive manufacturing technology. Here, a novel procedure for acquiring data on the movement features of the sound and prosthetic upper limb will be presented, as input for those design requirements.

AIM

The aim of this study was to develop a procedure to consistently investigate the relationship between prosthetic and sound upper limb function over specific tasks, in order to improve upper limb prosthesis design.

METHOD

For the first phase of this study, able-bodied volunteers performed a clinically validated hand function test – the Southampton Hand Assessment Procedure (SHAP) – whilst kinematic data was recorded for all the tasks using a Vicon camera system, as well as electromyography and inertial data. Specific data acquisition and analysis procedures were developed, namely for the full kinematic analysis of the arm and hand. In a second phase, transradial amputees using various types of prostheses underwent the same procedure. Additionally, 3D-printed concept demonstrators were also tested.

RESULTS

Following data collection, data was analysed and structured to build a benchmark of a range of behaviours and conditions which form the base of a novel Design System. Data obtained for the able-bodied subjects provided a baseline for normal hand function as the ideal prosthesis design. Specifically, SHAP scores and kinematic data were assessed in parallel and used to quantify the differences between sound limbs and prosthetic devices when performing the same tasks under the same conditions. Subsequently, data obtained with the concept demonstrator developed as part of this project was compared with the benchmarked data and points for improvement were identified.

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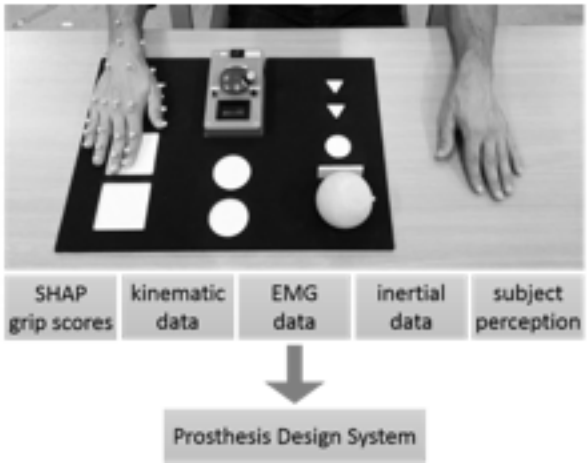

Figure 1. Photograph of the experimental setup and schematic of the types of data obtained with the developed procedure, which are inputs for a novel prosthesis design system

DISCUSSION & CONCLUSION

In this work, kinematic, EMG, inertial and hand function data were obtained for able-bodied subjects. Additionally, kinematic and hand function data were obtained for transradial amputees wearing different types of prostheses. Using a clinically validated procedure allowed for a wide range of hand functions to be assessed. The obtained information set provides valuable input to any prosthesis design system and can be used to gauge the performance of existing and new devices. Additionally, the procedure can be adapted for use with different levels of amputation.

Overall, the developed procedure is a novel combination of techniques which can be used to create structured databases, constituting the base for new personalised prosthesis design systems, with great potential especially for additive manufacturing applications.

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