ABSTRACT TEMPLATE FOR ISG 2008

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1. INTRODUCTION

From the technical viewpoint, a successful fitting of an upper extremity amputee is generally conditioned by a good comfort and a subject-specific cosmetics of the prosthesis and by the person's ability in controlling the artificial limb. Considering above-elbow amputees fitted with myoelectrically controlled prosthesis with motorized elbow, wrist and hand, this last aspect requires the convergence of a number of factors. Firstly, the patient's ability in an appropriate modulation of muscle contraction for speed (and force) control of the motors of the device. Moreover, good control requires fast and precise switching between the different active joints or their coordinated activation [1]. Finally, it requires limited compensatory movements in the use of the prosthesis, e.g. for avoiding fatigue (i.e. degradation of EMG signals) or cumulative trauma disorders. As a guide for the therapy, tuning of the prosthesis and for monitoring patients overall posture, the adoption of tools for the assessment of control capacity appears essential [2]. In this context, quantitative motion analysis, biomechanical modelling and acquisition of the EMG signals used for prosthesis control can provide an insight into patient-prosthesis interaction. On one hand, in fact, quantitative motion analysis and biomechanical modelling allow the computation of the 3D joint kinematics of the residual sound/artificial limbs. On the other, the acquisition of the EMGs control siFrom the technical viewpoint, a successful fittingdelling and acquisition of the EMG signals used for prosthesis control can provide an insight into patient-prosthesis interaction. On one hand, in fact, quantitative motion analysis and biomechanical modelling allow the computation of the 3D joint kinematics of the residual sound/artificial limbs. On the other, the acquisition of the EMGs control signals allows to observe patients EMG modulation ability and their errors in switching between motors. The aim of this work is to give an example of control assessment though quantitative techniques, presenting the case study of a long-wearer trans-humeral amputee. Firstly, the movements at the neck, shoulder girdle and shoulder of the patient while executing elbow flexion-extension tasks with the prosthesis were measured in order to monitor possible compensatory movements. Secondly, the ability of the patient in controlling the prosthesis during specific assessment exercises was evaluated.

2. MATERIAL AND METHODS

2.1 Subject and prosthesis description

A Caucasian Italian male, initials M.G., aged 52, participated in this study. M.G. was first fitted in 1971, due to a traumatic amputation of the left upper arm (residual length: 35%). He was assessed in 2005 while wearing a prosthesis with myo-electrically controlled hand, wrist and elbow he had been using for 3 months (fig. 1a). M.G. controlled the prosthesis through contractions of the residual biceps and triceps. Contraction of the biceps resulted in elbow flexion, closing of the hand or pronation of the wrist, depending on the selected function, whilst activation of the triceps resulted in the opposite movements. A muscle contraction activated the selected motion only if it overcame the prosthesis ON threshold (0.54V); the motion was deactivated when the signals went below the OFF threshold (0.38V). A short co-contraction (CoCo) of both muscle groups enabled a switching between motors in the cyclic sequence hand-elbow-wrist. A CoCo was recognised only if both signals, after overshooting the correspondent ON threshold within 80ms from the first crossing, went below the OFF within 800ms. One, two or three short vibrations, informed the subject on a successful switch to elbow, wrist or hand. ted when the signals went below the OFF threshold (0.38V). A short co-contraction (CoCo) of both muscle groups enabled a switching between motors in the cyclic sequence hand-elbow-wrist. A CoCo was recognised only if both signals, after overshooting the correspondent ON threshold within 80ms from the first crossing, went

2.2 Quantitative assessment devices and biomechanical model

For the assessment of the prosthesis and patient, quantitative information regarding the control EMG signals and kinematics were obtained. For the acquisition and data storage of the former, we developed an hardware and a software in Visual Basic. The EMGs were those received by the prosthesis, since these were extracted in parallel from the wire connecting the electrodes to the prosthesis. The hardware converted the analogic signals into digital and sent the data to the software. For prosthesis and human motion acquisition a stereophotogrammetric system was used (Vicon 460, Oxford Metrics, UK), synchronized via-hardware with the EMG recorder. Being interested in elbow, wrist and

3. RESULTS

During the elbow flexion-extensions test, the shoulder girdle EL-DE and PR-RE remained very limited, ranging between 2.5° and 5°. Similarly the head lateral flexion always remained within 5°. Shoulder flexion-extension tended to follow the elbow movements, swinging of about 15°-20° mostly due to inertial effects during elbow extension. Considering the fine hand control exercise, the subject was always able to appropriately follow the recommendations. Over 4 repetitions of the sequence reported, the subject overshot the diameter of at most 1 cm. The analysis for ability in proportional control, highlighted the ability of the subject to consciously modulate the EMG signals, performing both linearly increasing and step-like EMG activations (fig. 2a).

4. DISCUSSION AND CONCLUSIONS

To follow the elbow movements, swinging of about 15°-20° mostly due to inertial effects during elbow extension. Considering the fine hand control exercise, the subject was always able to appropriately follow the recommendations. Over 4 repetitions of the sequence reported, the subject overshot the diameter of at most 1 cm. The analysis for ability in proportion

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5. REFERENCES

[1] Wu, G. et al., (2005), J. Biomech., 38, 981-992
[2] Kapandji, I. A. (1982), Churchill Livingstone

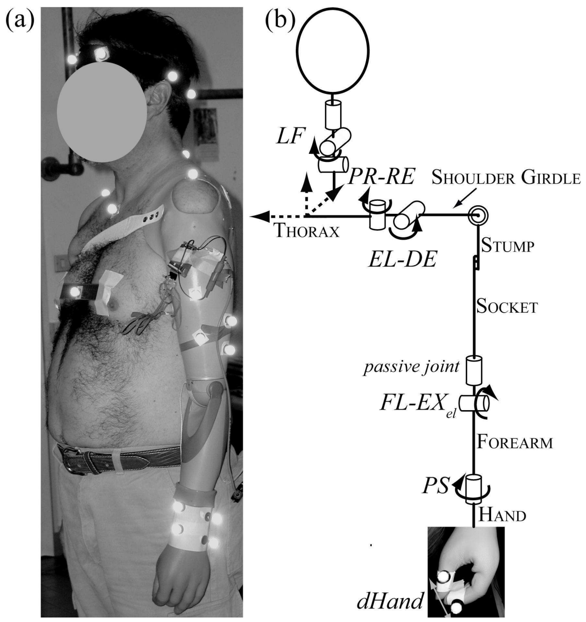

Fig. 1a,b Marker-set used and equivalent biomechanical model. Marker on T8 not visible in the figure.