STIFFNESS MEASUREMENT OF THE GLENOHUMERAL JOINT

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INTRODUCTION

Stroke is the leading cause of activity limitation among older adults in the United States. More than 700,000 strokes occur each year [1], with a prevalence of approximately 4 million (AHA, 1997). A common complication of stroke is hemiplegic shoulder pain with reported prevalence ranging between 34% and 84% [3][2].

Shoulder pain following stroke has been associated with subluxation in the gleno-humeral (GH) joint, but this is disputed and the aetiology is poorly understood. It is hypothesised that dynamic stability is a better predictor of pain than subluxation, which is a simple measure of joint instability.

The objectives of this research are to identify the mechanical and neuromuscular changes in the hemiplegic shoulder following stroke and their relationship to the development of pain, and to investigate possible mechanisms underlying that pain. Mechanical characteristics of the gleno-humeral joint will be determined using a system identification technique, modelling the shoulder as a second-order system.

METHODS

Displacement perturbations in the range 0-6Hz, 0-2cm, were applied to the arm during a constant force task, using a mechanical manipulator, while measuring end-point forces using a force transducer. The subject was firmly attached to the manipulator by means of a cast from the mid humerus level to the wrist, with the elbow in $90°$.

System Identification techniques were used to quantify dynamic stiffness of the shoulder, with humeral end-point motion as input and end-point force as output for the system.

$$\begin{bmatrix} F_x(f) \\ F_y(f) \end{bmatrix} = \begin{bmatrix} H_{xx}(f) & H_{xy}(f) \\ H_{yx}(f) & H_{yy}(f) \end{bmatrix} \begin{bmatrix} X_x(f) \\ Y_y(f) \end{bmatrix} \quad (1)$$

RESULTS AND DISCUSSION

Figure 1 shows stiffness curves for the three principal directions (leading diagonal) as well as the interaction between directions (off-diagonal). The curves for K_{xx} (top left) and K_{zz} (bottom right) have the typical tick-mark shape of a second-order system, but the curve for K_{yy} (centre) is all over the shop.

Partial and multiple coherence values for the identifications were found to be very good in the principal directions.

CONCLUSIONS

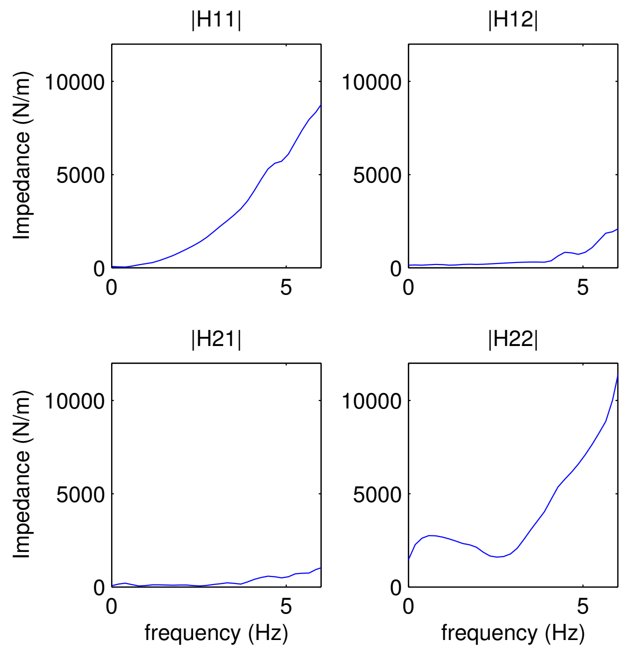

Figure 1: Dynamic stiffness of the shoulder during a 10N vertical (up) push task.

References

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