

Abstract presented at

ISB 2007 - Taiwan

INTER-JOINT COORDINATION PATTERNS OF ABLE-BODIED SUBJECTS FOR THE ANALYSIS OF COMPENSATORY STRATEGIES IN PATIENTS WITH SHOULDER IMPAIRMENTS

P. Garofalo^{1,2}, A.G. Cutti¹, A. Davalli¹, A. Cappello²

¹INAIL Prosthesis Centre, Vigorso di Budrio, Italy; email: agcutti@inail-starter.org

²DEIS, University of Bologna, Italy

INTRODUCTION

An altered scapulo-humeral rhythm can be generally observed in post-surgical patients treated for shoulder instability and rotator cuff tears. For these patients the target of rehabilitation is to increase the range of motion whilst removing the compensatory strategies. To quantitatively monitor the evolution of compensatory movements during the physical therapy, a motion analysis protocol was developed [1]. For each patient, the protocol requires the comparison of the affected-side coordination between shoulder-girdle and humerus kinematics with the coordination of the unaffected-side. For some patients, however, none of the sides can be considered unimpaired, precluding the intra-subject comparison. To overcome this limitation, the aim of this work was to extract inter-joint coordination patterns of able-bodied subjects for the tasks of the protocol, to be used as a reference.

METHODS

The upper-limb was modeled [1] as an open kinematic chain formed by three segments (thorax, shoulder-girdle and humerus) linked by two rotational joints with 5 degrees of freedom. The segments systems of references were defined following [2] and [1]. Through a static trial the girdle and humerus systems of reference were then reoriented in order to be parallel to that of the thorax when the subject stood in the anatomic posture. The two joints will be referred to hereinafter as shoulder-girdle joint (SGJ - between shoulder-girdle and thorax) and girdle-humeral joint (GHJ - between humerus and shoulder-girdle). By means of appropriate Euler sequences the following joint angles were computed: protraction-retraction (PR-RE) and elevation-depression (EL-DE) for the SGJ, flexion-extension (FL-EX), ab-adduction (AB-AD) and internal-external rotation (IN-EX) for the GHJ.

The kinematics of SGJ and GHJ was measured for 6 able-bodied subjects (21-29 years old) through an optoelectronic system (Vicon 460) [3], during the execution of the 4 activities of the protocol [1]: full shoulder flexion and hand-behind-head (in the sagittal plane), full shoulder abduction and hand-to-top-of-head (in the frontal plane). Subjects were instructed to consecutively repeat each task 5 times at a comfortable speed. Following [1], our aim was to compute for the subjects examined the mean coordination plots relating EL-DE and PR-RE with FL-EX for mostly sagittal tasks, and with AB-AD for mostly frontal tasks. For this purpose, joint angles kinematics vs time were firstly processed. Each repetition of the movement was divided in a forward and a backward phase, the former being enclosed between 0° and the maximum peak value of FL-EX or AB-AD depending on the task (MP), the latter being enclosed between MP and 0°. Given a task and a phase, the synchronization of all the curves of the subjects was obtained choosing the minimum value of MP shared among the subjects. Joint angles curves were then normalized with respect to phase duration. The point-to-point mean curve was

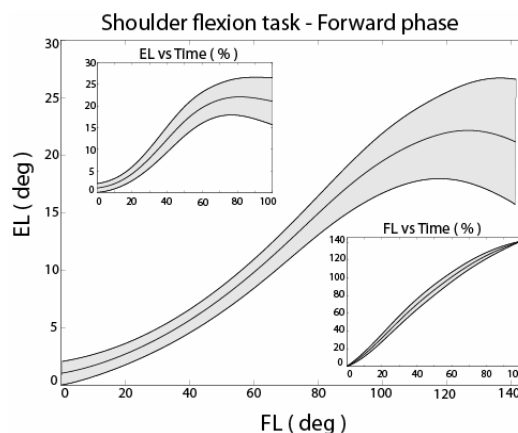


Figure 1: Example of mean inter-joint coordination plot, with variability bands.

then computed; lower and upper variability bands curves were calculated as ± 1 RMS difference between the mean curve and the subjects curves, as described in [4]. Mean coordination plots were finally computed by relating the mean plots 'joint angles vs time' obtained [4].

RESULTS AND DISCUSSION

As a representative example, the coordination plot of EL-DE vs FL-EX is reported in figure 1 for the forward phase of the shoulder flexion task, together with the associated kinematics for EL-DE and FL-EX vs time. A similar width for the variability bands was found for the other tasks. In particular, 16°–26° of EL-DE and -14°– -27° of PR-RE were found for the maximum FL-EX of 140° in sagittal tasks; for frontal tasks 20°–31° of EL-DE and -22°– -32° of PR-RE were found for the maximum AB-AD of 126°. Variability bands were generally narrower for GHJ kinematics than for that of SGJ. Results indicate therefore consistent patterns among the subjects, which can potentially allow a strict clustering of patients. The mean patterns found appear consistent with previous findings for the sternoclavicular and glenohumeral joints [5].

CONCLUSIONS

The method applied for the computation of the mean curve and variability bands proved to be robust and easy to implement. Preliminary results [1] indicate that the shoulder assessment protocol at the base of this study is simple and appropriate for routine clinical examinations. The results obtained extend the applicability of the protocol even when no intra-subject gold-standard exists.

REFERENCES

1. Cutti AG, et al. *Proc. ISG 2006*, Chicago, USA, 2006.
2. Wu G, et al. *J. Biomech.* **38**, 981-992, 2005.
3. Cutti AG, et al. *Gait. Posture.* **18**, 5, 2003.
4. Stergiou N., *Innovative analyses of human movements*, Human Kinetics, Part 1, ch. 2, 2004.
5. van der Helm FC, et al. *J. Biomech. Eng.*, **117**(1), 27-40, 1995.