Between-day reliability of shoulder anatomical landmark calibration by using a new anatomical palpator method

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INTRODUCTION

Evaluation of the shoulder kinematics remains a challenge to document a functional disorder and its evolution. To ensure subject follow-up, the kinematic analysis must be repeatable and reproducible. Previously, a new technique of anatomical landmark (AL) palpation using a newly-developed finger gauntlet including a technical frame (TF) was developed to study the 3D shoulder joint kinematics. The precision and accuracy of this method of shoulder AL calibration have been evaluated [2].

The purpose of this paper was first to estimate the test-retest reproducibility of palpation performed by the same examiner who digitized eleven ALs on humerus and scapula three times on each subject the same session day and repeat the session one week later at the same day and hour. The second aim was to evaluate the propagation of palpation error on four analytical movements and three activities of daily living.

METHODS

Experimental design. Between-day reliability was established from data collected on eleven volunteers (Age: 25 y-o; BMI:23 kg/m²) without any shoulder complain. A optoelectronic stereophotogrammetric system (8 cameras Vicon 612,UK) was used for data acquisition. The volunteer was seated. Eleven ALs were palpated by the examiner index finger pulp calibrated beforehand using the above-mentioned method [2]. For the within-day palpation reproducibility, the same examiner repeated three times this palpation of five ALs on humerus and six ALs on scapula. After the three digitizing repetitions, the palpated volunteer performed flexion, extension, ab-adduction and rotation movements and more functional tasks like hand-to-head or hand-to-back to estimate the propagation of palpation error. During each task, the volunteer realized three motion cycles to estimate the variability of subject. One week later, the same within-day protocol was repeated to estimate between-day reliability.

Data processing and statistics. Joint angles were computed by using conventional ISB axis definitions. Euler sequences followed the ISB proposal for scapula (YX'Z"). For humerus, the choice of Euler sequence was linked to the principal plane of the task [3]. Curve reproducibility was estimated by coefficient of multiple correlation (CMC) and standard deviation computed from the variance of within- and between-CMC formulas [4].

RESULTS

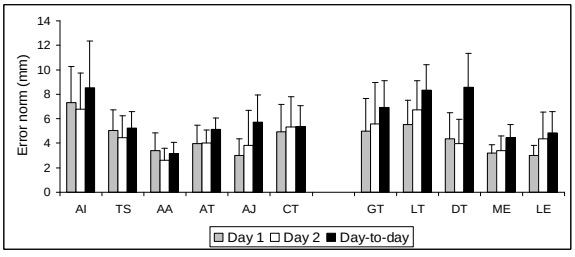

Figure 1: RMSE error norm. **Left side** (scapula): IA: Inferior angle; RS: Root of spine; AA: Acromial angle; AT: Acromial tip; AJ:Acromioclavicular joint; CT: Coracoid tip. **Right side (humerus)**: GT & LT:Greater & Lesser tubercle; DT: Deltoid tuberosity; ME & LE: Medial & lateral epicondyle.[5]

Palpation error. For both within-day and between-day, RMSE distance between the respective mean AL position and the current AL position expressed in their anatomical frame was processed. (Figure 1). Mean RMSE within-day was respectively 4.6 (S.D. 1.5) mm and 4.5 (S.D. 1.2) mm for scapula and humerus. Mean RMSE between-day was respectively 5.5 (S.D. 1.7) mm and 6.6 (S.D 1.9) mm for scapula and humerus.

Error Propagation. CMC values higher than 0.9 were observed for the variability due to the three repetitions of palpation with RMSE angle lower than 2° for scapulo- and humerothoracic joint angle components. CMC values higher than 0.8 were found for the intrinsic variability due to subject with SD ranged from 3 to 8° for scapulo- and humerothoracic joint angle components. CMC values higher 0.8 was also observed for the variability due to day with SD ranged from 4 to 11° for scapulo- and humerothoracic joint angle components.

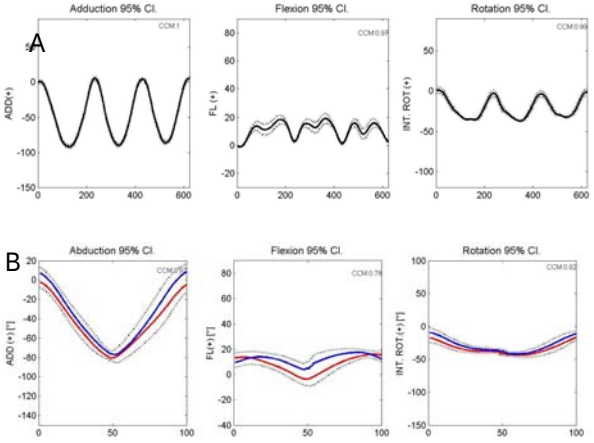

Figure 2: Error propagation of a typical subject during an shoulder abduction A: Variability due to palpation for humero-thoracic joint angle components. B Between days reliability

DISCUSSION and CONCLUSIONS

The between-day reproducibility of the new method (6 mm RMSE) was good. Effect of ALs palpation on joint kinematics was small, probably due to the use of a rigorous method with recommendations, guidelines and expertise. Also interesting was the more important variability of subject depending on the RoM & number of dof used by the shoulder. Variability in time was very acceptable (CCM 0.9). From these results, evaluation of upperarm and scapular kinematics is possible with confidence, and may help the pre- and post-surgery diagnostic and follow-up of patients and during rehabilitation.

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