Comparison of scapula soft tissue artefact compensation methods during manual wheelchair locomotion

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1. Introduction

Two third of manual wheelchair (MWC) users report suffering or having suffered from shoulder pain or injury [1]. To favour the understanding of these disorders, it is crucial to quantify the shoulder kinematics and kinetics during MWC locomotion [2]. However, soft tissue artefacts (STA) are particularly present at the scapula, making it difficult to accurately track the bone motion [3], motivating researchers to propose compensation methods based on acromion or scapula spine marker clusters and a calibration pose [4]. Apart from invasive or irradiative methods, the reference method to localize the scapula bone is based on external palpation generally through the use of a scapula palpator (SP) [5]. In this study, we propose to compare the scapula kinematics reconstructed from a cluster with STA compensation based on one or two calibration static poses during the push phase with the reference method using a SP.

2. Research question

Which calibration method best compensates STA at the scapula when analysing locomotion in MWC from motion capture data?

3. Methods

The two calibration methods proposed in this study are:

- Rigid: rigid transformation of the cluster reference frame to the SP reference frame in one pose corresponding to the middle of the propulsion phase
- Linear: Linear transformation of the cluster frame to the SP frame between the start and end of propulsion. Transformation is computed using spherical linear interpolation [6] with regards to the position of the cluster frame.

During the experiments, 5 MWC users equipped with spinal cluster were seated in a static ergometer and were asked to reproduce MWC locomotion in slow motion. An experimenter followed the movement of the right scapula with a SP. Subjects performed between 2 to 6 trials of 5 propulsion cycles (10–30 cycles per subject). Calibration poses were extracted from each cycle and served to reconstruct SP markers from cluster. The comparison between calibration methods was done through the marker reconstruction root mean square error (RMSE) between measured and reconstructed SP [7].

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4. Results

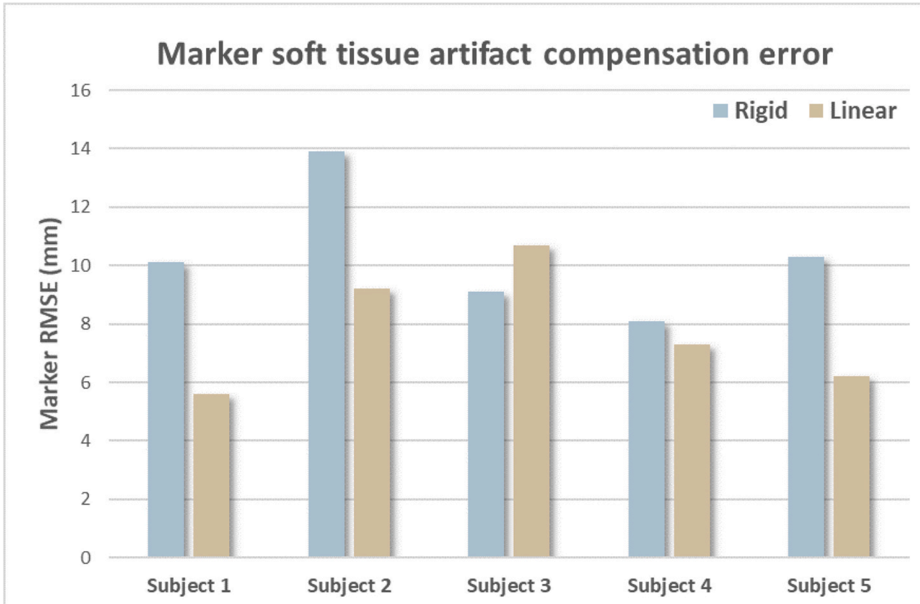

Fig. RMSE between experimental and reconstructed scapula landmarks for each subject.

Results show a reduction of the RMSE for 4 subjects using the 2 poses calibration method compared to the single pose method. Using this method, the RMSE ranged between 0.56 cm and 1.07 cm for the whole cohort.

5. Discussion

This study shows encouraging results with the two poses calibration method with RMSE that were lower than the error of the reference itself, as reported by De Groot et al. (i.e. 1.1 cm with a SP) [8]. If it can be hypothesized that more calibration poses would improve further the scapula reconstructed kinematics, the two poses could provide an acceptable trade-off between result accuracy and time dedicated to model calibration.

References

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