THREE-DIMENSIONAL COMPARISON OF STATIC AND DYNAMIC SCAPULAR MOTION TRACKING TECHNIQUES

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INTRODUCTION

The shoulder is a complex joint comprised of many moving parts [1]. Accurately measuring shoulder rhythm is difficult, but imperative due to the shoulders susceptibility to numerous chronic and acute injuries. To identify pathological movement and risk for injury, clinicians typically assess shoulder motion dynamically through observation of humeral raising and lowering phases. However, static measures of shoulder rhythm are the preferred method of analysis and are often reported in shoulder rhythm descriptions [2]. Whether these two methods of scapular tracking identify the same shoulder rhythm is unknown. Clinicians and upper limb researchers would benefit from knowing whether dynamic measures of shoulder rhythm are useful and comparable indicators of static scapular positioning. The purpose of this paper was to determine how closely dynamic measures of scapular tracking represent static measures in a healthy population.

METHODS

Data for the present study were taken from two studies previously conducted at the University of Waterloo DIESEL lab using the same group of participants. Five shoulder angles were assessed for 24 participants ((13 M, 11 F; age 23+/- 2.47 years; weight 70+/-15.22 kg; height 174.25+/-10.66 cm) – scapulothoracic protraction/retraction, medial/lateral rotation and tilt, and sternoclavicular protraction/retraction and elevation/depression. Participants were monitored using dynamic and static tracking techniques during humeral elevation in three planes (frontal, scapular and sagittal). The static protocol instructed participants to elevate their arm to 0°, 45°, 90°, 120°, and 180° in each of the three planes. The dynamic protocol instructed participants to raise and lower their arm in the same three planes through 120° of elevation to the timing of a metronome. Elevation angles in the dynamic conditions were measured and recorded at 5° increments from 10° to 120°. Eight Vicon MX20+ cameras (Vicon Motion Systems, Oxford, UK) recorded the three-dimensional positions of reflective skin markers overlying upper extremity anatomical landmarks. Data reduction was performed in custom MATLAB 7.9.0 R2009b software. To compare between static and dynamic results, regression equation lines of best fit were generated for all static conditions for each participant. These equations were used to predict static measures that corresponded with each of the recorded dynamic elevation angles. Mean differences were determined between each of the tracking techniques – lowering-static, raising-static, and lowering-raising. ANOVAs were used to identify the influences of plane, elevation angle, and tracking technique (static, dynamic raising, dynamic lowering) on the between-technique differences.

RESULTS AND DISCUSSION

Mean differences existed across all techniques. These mean differences existed for all shoulder angles ($p<0.001$), except for elevation plane in scapulothoracic protraction/retraction ($p=0.955$).

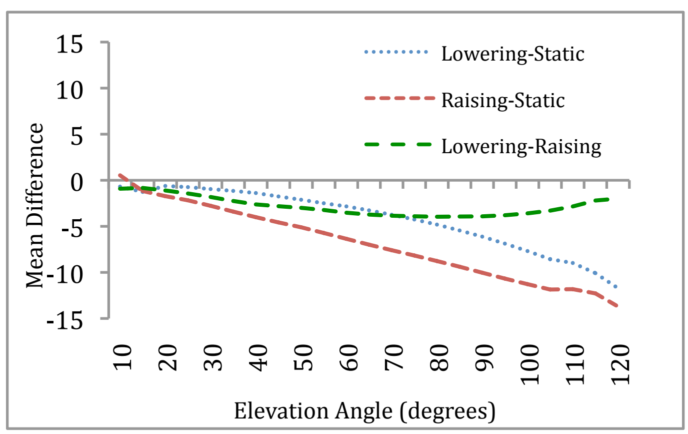

Figure 1: Mean differences between the three tracking techniques for the shoulder angle of Scapulothoracic Tilt.

Tracking techniques were influential ($p<0.001$), but the grouped mean differences fell below a relevant intra-individual variability benchmark of 5° [3], making them comparable to static measures. While mean differences remained small, the standard deviations were comparatively very large for all shoulder angles in the lowering-static and dynamic-static mean differences (Table 1). There was large variation in mean differences of the techniques across individuals.

Mean differences were most pronounced at higher humeral elevation angles, particularly in scapulothoracic tilt (Figure 1). It is hypothesized that the greater mean differences at higher elevation angles contributed to the large standard deviation noted in Table 1. Dynamic measures may under-estimate static measures, particularly at higher humeral elevations, such as above 90 degrees, as demonstrated by the negative mean differences in tracking methods (Figure 1 and Table 1). It has been demonstrated in previous research that dynamic scapular tracking techniques become increasing unreliable and harder to interpret at humeral elevation angles above 100° [4]. The lack of re-palpation in dynamic measures of shoulder angle could increase errors in this technique. This factor may be responsible for the differences found betweens static and dynamic measures at higher elevation angles. Both dynamic motion phases produced similar shoulder angles and thus had a small mean difference for all five shoulder angles (Table 1 Lowering-Raising), which was expected based on previous results.

Intra-individual differences were also large and may have contributed to the standard deviation in Table 1, but were mitigated by the group means. Previous work has demonstrated large intra-individual differences [5]. While perhaps not a concern for group analyses, intra-individual differences between static and dynamic measures have the potential to be quite large. This places further caution on the use and interpretation of dynamic measures in place of static measures, as the intra-individual differences are unpredictable and potentially large enough to skew data results and conclusions. However, both static and dynamic results are in agreement with previous research, demonstrating that both methods can represent a reliable representation of shoulder rhythm.

CONCLUSIONS

While population averages are similar, individual static and dynamic shoulder assessments may be different. Caution should be taken when dynamic shoulder assessments are performed on individuals, as the observed shoulder rhythm may not reflect that found in the more highly documented and thus preferred static shoulder rhythm assessment. Current dynamic approaches may require modification or repetition to identify pathological shoulder rhythm as robustly as the preferred static measures.

REFERENCES

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Table 1: Mean differences and standard deviation (SD) in degrees, between the three levels of technique. Comparisons are made between dynamic lowering and static (Lowering-Static), dynamic raising and static (Raising-Static) and both phases of dynamic motion (Lowering-Raising).

Shoulder Angle	**Lowering-Static (SD)**	**Raising-Static (SD)**	**Lowering-Raising (SD)**
ST Protraction/Retraction	-4.98 (17.59)	-3.71 (17.42)	1.35 (3.38)
ST Med/Lateral Rotation	-1.02 (14.47)	0.37 (15.17)	1.49 (8.23)
ST Posterior/Anterior Tilt	-9.14 (15.05)	-10.62 (15.37)	-1.48 (3.65)
SC Protraction/Retraction	0.86 (10.44)	3.67 (10.32)	2.83 (2.54)
SC Elevation/Depression	-4.02 (7.41)	-3.48 (7.51)	0.55 (2.30)