

Bilateral Differences in Scapular 3D Posture and Kinematics: Implications for Scapula Dyskinesia Evaluation

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Summary

Clinicians assess scapular motion by comparing the symptomatic shoulder to the asymptomatic side, assuming symmetry in healthy individuals. This study examined 3D bilateral scapulothoracic differences during arm elevation and found consistently greater, though non-significant, motion on the dominant side. These findings should be considered in shoulder pathology assessments.

Introduction

The scapulothoracic (ST) joint is essential for glenohumeral (GH) function, providing a stable foundation for optimal shoulder mechanics [1,2]. Proper three-dimensional (3D) scapular motion maintains GH alignment and muscle function during daily activities [3]. To assess shoulder disorders, ST motion in pathological conditions is often compared to the contralateral normal shoulder. Altered scapular resting position and 3D motion have been observed in conditions such as frozen shoulder, impingement syndrome, and rotator cuff pathology. Identifying abnormal ST posture and kinematics is crucial for shoulder assessment and treatment evaluation and while asymmetry is often deemed pathological, ST symmetry in healthy individuals remains unclear. This study aims to examine bilateral scapulothoracic (ST) posture and kinematics in healthy individuals and identify normal variations based on arm dominance. Defining baseline 3D ST motion will enhance the accuracy of shoulder disorder diagnosis and improve the evaluation of treatment effectiveness.

Methods

Fifteen right-hand dominant males (25 \pm 2.3 years) with no shoulder pathology participated. Anthropometric data, activity levels, and scapular dyskinesia [4] were assessed. Participants

performed active arm elevation/lowering in sagittal, scapular, and coronal planes (5 trials/plane) while seated. Motion was tracked using 26 reflective markers with a 10-camera system (120 Hz). Bilateral scapular landmarks were digitized, and 3D movements processed via Euler sequences [5]. Bilateral scapular orientation was assessed at 45°, 90°, and 120° thoracohumeral elevation (TH_EL). Paired t-tests (SPSS V29, $\alpha = 0.05$) was used to evaluate bilateral differences.

Results

The bilateral angular scapulothoracic orientation at relaxed posture showed no significant differences, averaging 8.2° \pm 5.2° upward rotation (UR), 35.7° \pm 4.2° internal rotation (IR), and -12.4° \pm 4.7° anterior tilt (AT). The dominant scapula exhibited, not significant, slightly greater UR, IR, and anterior tilt across TH_EL angles (Table 1). Lesser 3D motion differences for the dominant side were noted in the scapular and coronal planes. UR and PT increased bilaterally across all planes with TH_EL, while IR increased in the sagittal and decreased in the coronal plane. Scapular ER and PT rose bilaterally from sagittal to coronal planes.

Discussion and Conclusions

Bilateral scapulothoracic kinematics showed slight dominance-related differences in healthy male adults. Mean differences with 95% confidence intervals can improve scapular dyskinesia assessment and disorder evaluation.

References

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Table 1: Mean (SD) values of 3D scapular kinematics of dominant and non-dominant arm at 3 different planes and elevation angles.

Thoracohumeral Elevation Angle	Sagittal Plane (Flexion)		Scapular Plane (Scaption)		Coronal Plane (Abduction)	
	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
Upward Rotation (UR) (+)						
TH_EL 45°	20.5 (6.5)	17.8 (7.1)	19.8 (4.0)	17.8 (5.9)	19.8 (3.7)	17.8 (5.1)
TH_EL 90°	33.4 (4.1)	30.6 (5.2)	31.6 (4.1)	31.4 (5.4)	41.1 (5.1)	38.4 (6.5)
TH_EL 120°	50.0 (5.3)	49.1 (6.8)	45.9 (6.0)	45.5 (8.2)	54.1 (5.8)	53.0 (8.9)
Posterior Tilt (PT) (+)						
TH_EL 45°	-7.1 (5.0)	-6.9 (5.4)	-5.0 (3.8)	-5.2 (4.3)	-7.4 (4.0)	-7.8 (4.1)
TH_EL 90°	-4.0 (5.6)	-2.3 (6.6)	1.6 (2.6)	2.5 (4.1)	3.7 (6.8)	4.6 (5.9)
TH_EL 120°	1.7 (6.0)	2.5 (2.5)	10.0 (8.5)	11.7 (8.4)	10.5 (7.7)	12.5 (6.6)
Internal Rotation (IR) (+)						
TH_EL 45°	38.3 (6.7)	36.0 (9.5)	33.1 (6.3)	30.9 (6.2)	19.4 (6.4)	17.5 (5.5)
TH_EL 90°	44.1 (6.1)	40.9 (6.7)	22.0 (8.1)	19.5 (7.6)	16.1 (10.0)	14.2 (9.6)
TH_EL 120°	44.8 (6.5)	41.4 (8.6)	19.3 (5.0)	13.3 (7.3)	11.2 (10.3)	9.2 (11.4)