Asymmetries in Bilateral Scapulothoracic Motion Used to Assess Scapular Dyskinesis

1Jordan Bone DO'26 [1]Isaac Burton DO'26, [2]Jacob Seely DPT'25, [2]Vassilios Vardaxis PhD, & [2]Traci Bush DPT OTR
[1]College of Osteopathic Medicine, Des Moines University, Des Moines, IA & [2]Department of Physical Therapy, Des Moines University, Des Moines, IA

DES MOINES UNIVERSITY
MEDICINE & HEALTH SCIENCES

Introduction

- Scapular Dyskinesis (SD) refers to improper movement of the scapulothoracic (ST) joint, manifesting secondary to or causative of pathology.
- Bone pins are the gold standard method to measure scapular movement. However, invasiveness limits their clinical application.
- Motion capture (MOCAP) technology has shown that accurate 3D measurements of scapular motion using an Acromion Marker Cluster (AMC) is comparable to bone pins up to 120° of arm elevation[2] (limited to laboratory setting).
- MOCAP technology using inertia sensors, Inertial Measurement Units (IMU), has been shown to be a portable, less labor-intensive, suitable alternative for clinical use[3].
- Clinical observational assessment of asymmetrical SD is typically categorized based on upward/downward rotation, internal/external rotation, anterior/posterior tilt as well as scapular segmental prominence.
- Currently, there is limited information delineating specific parameters for typical scapular motion asymmetry compared with pathological asymmetry.

Specific Aims

Utilization of IMU technology will provide clinicians with a clinically feasible method for reliably and objectively determining dyskinesis.

Specific Aim 1: Determine the reliability and validity of IMU technology in assessing 3D scapular motion compared to AMC in healthy adults.

Validated standards of what is considered pathological vs. non-pathological asymmetry is critical when using IMU technology in clinical settings.

Specific Aim 2: Determine acceptable ranges for non-pathological baselines for 3D ST motion and asymmetry.

Methods

Proposed Study Population: 15 male, right-handed, healthy participants with no shoulder pathologies.

Overview of Tasks

- Participants perform six simple and complex tasks while seated with feet flat on the floor, knees together and maintaining proper trunk posture. Five trials of each task are performed, with five of the six tasks being weighted with dumbbells and time given to rest between each trial. Unless instructed otherwise, participants perform each task with their thumb pointed in the direction of motion. Each portion of the task (eccentric/concentric) takes approximately three seconds.

Simple Tasks

1. **Shoulder flexion** in the sagittal plane to maximum elevation
2. **Shoulder abduction** in the frontal plan to maximum elevation
3. **Shoulder scaption** in the scapular plane to maximum elevation

Complex Tasks

1. **Flexion-Horizontal Abduction-Adduction Task:** Starting with arms at sides and thumbs forward, the shoulder is flexed in the sagittal plane to 90°. Next, arms are horizontally abducted in the transverse plane to the level of the frontal plane. Finally, arms are adducted in the frontal plane, finishing in anatomical position. The task is then reversed to the initial starting position.
2. **Banded External Rotation Task:** Starting with elbows static at sides and elbows flexed to 90°, an elastic-band is secured around the participants wrists with Velcro straps. Participant then externally rotates arms to maximum while maintaining proper form and then returns to the starting position.
3. **Empty Can Test in Scapular Plane:** Start with arms internally rotated at sides so that thumbs are pointing posteriorly and in line with the scapular plane. Arms are then elevated in the scapular plane to maximum while maintaining IR and then lowered back to starting position.

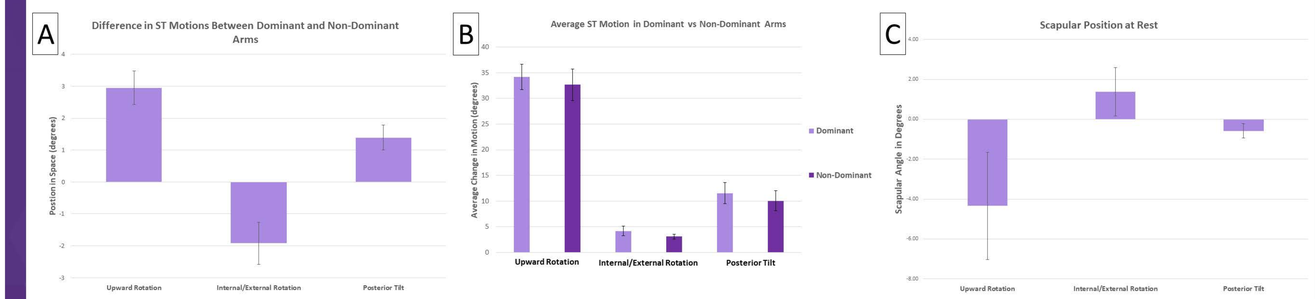
- The scapula 3D motion capture will be done relative to the torso (Scapulothoracic motion: Up / Down-ward rotation; Anterior/Posterior tilt; and Internal / External Rotation). (**Fig. 1**)The MOCAP – AMC and IMU technology will be synchronized and captured for all tasks (above).

Literature Findings

Fig. A: Scapulothoracic motion differences between dominant and non-dominant upward rotation, Internal/external rotation, and posterior tilt. (Negative and positive values signify increased motion in dominant or non-dominant arm respectively.) [8, 9, 10, 11, 12]

Fig. B: Total motion change of dominant and non-dominant ST motions from resting position to 120° of humeral elevation.[8, 9, 10, 11, 12]

Fig. C: Differences in scapular position between dominant and non-dominant shoulders at resting position. [9, 10, 11, 12, 13, 14]



Marker/Sensor Placement

MOCAP – AMC Marker Placement (Bilateral)
- Wrist (2)
- Forearm (Cluster 3)
- Elbow (2)
- Upper Arm (Cluster 3)
- Scapula Acromion (Cluster 3)
- Anterior Torso (4)
- Posterior Torso (5)

IMU – Placement (Right / Dominant side)
- Forearm
- Upper Arm
- Scapula Acromion
- Sternum Manubrium

Digitizer
- Four (4) Markers
- One IMU

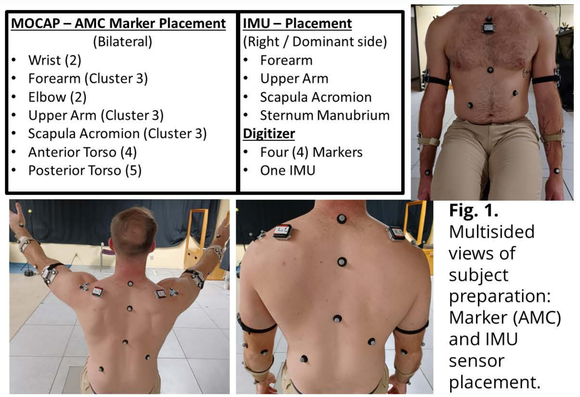


Fig. 1. Multisided views of subject preparation: Marker (AMC) and IMU sensor placement.

Conclusion

Data has been collected from 9 out of 15 subjects and will be compared to literature findings to validate the IMU accuracy for the clinical setting and to determine acceptable ranges for non-pathological baselines for 3D ST motion and asymmetry.

References

1. Roche SJ, Funk L, Sciascia A, Kibler WB. "Scapular dyskinesis: the surgeon's perspective. Shoulder Elbow." 2015 Oct;7(4):289-97. doi: 10.1177/1758573215595949.
2. Grewal, T., et. Al. "Comparing Non-Invasive Scapular Tracking Methods Across Elevation Angles, Planes of Elevation, and Humeral Axial Rotations." Journal of Electromyography and Kinesiology. 2017; 37: 101-107., doi: 10.1016/j.jelekin.2017.10.001.
3. Ertzgaard, P., et al. "A New Way of Assessing Arm Function In Activity Using Kinematic Exposure Variation Analysis and Portable Inertial Sensors—A Validity Study." Manual Therapy Journal. 2016; 21:241-249. Doi: 10.1016/j.math.2015.09.004.
4. McClure P, Tate AR, Kareha S, Irwin D, Zlupko E. A clinical method for identifying scapular dyskinesis, part 1: reliability. J Athl Train. 2009;44(2):160-164. doi:10.4085/1062-6050-44.2.160
5. Uhl TL, Kibler WB, Gecewich B, Tripp BL. Evaluation of clinical assessment methods for scapular dyskinesis. Arthroscopy. 2009;25(11):1240-1248. doi:10.1016/j.arthro.2009.06.007
6. Wright AA, Wassinger CA, Frank M, Michener LA, Hegedus EJ. Diagnostic accuracy of scapular physical examination tests for shoulder disorders: a systematic review. Br J Sports Med. 2013.
7. Jayasinghe, Gihan Shantha MBBS, BSc (Hons), MRCS. Scapula Dyskinesis: A Review of Current Concepts and Evaluation of Assessment Tools. Current Sports Medicine Reports: October 2018 - Volume 17 - Issue 10 - p 338-346 doi: 10.1249/JSR.0000000000000526
8. Turgut, E., Duzgun, I., & Baltaci, G. (2016). Scapular asymmetry in participants with and without shoulder impingement syndrome; a three-dimensional motion analysis. *Clinical Biomechanics, 39*, 1–8. https://doi.org/10.1016/j.clinbiomech.2016.09.001
9. Lee SK, Yang DS, Kim HY, Choy WS. A comparison of 3D scapular kinematics between dominant and nondominant shoulders during multiplanar arm motion. Indian J Orthop. 2013 Mar;47(2):135-42. doi: 10.4103/0019-5413.108882. PMID: 23682174; PMCID: PMC3654462.
10. Schwartz, C., Croisier, J. L., Rigaux, É., Denoël, V., Brüls, O., & Forthomme, B. (2014). Dominance effect on scapula 3-dimensional posture and kinematics in healthy male and female populations. Journal of shoulder and elbow surgery, 23(6), 873–881. https://doi.org/10.1016/j.jse.2013.08.020
11. Matsuki, K., Matsuki, K. O., Mu, S., Yamaguchi, S., Ochiai, N., Sasho, T., Sugaya, H., Toyone, T., Wada, Y., Takahashi, K., & Banks, S. A. (2011). In vivo 3-dimensional analysis of scapular kinematics: comparison of dominant and nondominant shoulders. Journal of Shoulder and Elbow Surgery, 20(4), 659–665. https://doi.org/10.1016/j.jse.2010.09.012
12. Yoshizaki, K., Hamada, J., Tamai, K., Sahara, R., Fujiwara, T., & Fujimoto, T. (2009). Analysis of the scapulohumeral rhythm and electromyography of the shoulder muscles during elevation and lowering: comparison of dominant and nondominant shoulders. Journal of shoulder and elbow surgery, 18(5), 756–763. https://doi.org/10.1016/j.jse.2009.02.021
13. Morais, N., & Pascoal, A. (2013). Scapular positioning assessment: Is side-to-side comparison clinically acceptable? Manual Therapy, 18(1), 46–53. https://doi.org/10.1016/j.math.2012.07.001
14. Hosseinimehr SH, Anbarian M, Norasteh AA, Fardmal J, Khosravi MT. The comparison of scapular upward rotation and scapulohumeral rhythm between dominant and non-dominant shoulder in male overhead athletes and non-athletes. Man Ther. 2015 Dec;20(6):758-62. doi: 10.1016/j.math.2015.02.010. Epub 2015 Mar 5. PMID: 25795109.

Acknowledgements

Connor Frawley DO'25, Yochana Kancherla DO'25, Hollis Neal DO'25, Rianna Reimers DO'25, Adam Schweitzer DO'25, Rebecca Taylor DO'25