

SCAPULAR MOTION: ACCURACY AND RELIABILITY OF ANATOMICAL MARKER AND ACROMION MARKER CLUSTER METHODS

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INTRODUCTION

To assess scapular motion using reflective skin markers, two main methods can be used. The International Society of Biomechanics recommends to place three markers on three anatomical landmarks of the scapula (3AL) [1]. This method suffers from soft tissue artefact error [2]. To reduce it, Van Andel et al., proposes the use of an acromion marker cluster (AMC). It approximates real motion but provides also error measurement [3]. To our knowledge, the evaluation of the recommended method, 3AL, and the new method, AMC, have not yet been realized during the same motion. The aim of this study was to evaluate accuracy and reliability of both methods during shoulder flexion. Palpation was carried out to obtain real scapular motion, considering this method as a gold standard for static measurement of scapula kinematics [4].

METHODS

Ten healthy subjects participated in this study. Scapular rotations were collected using an optoelectronic tracking system (Vicon, Oxford Metrics Ltd, Oxford, UK). In neutral flexion/extension of the shoulder, anatomical markers were placed on AA (Angulus Acromialis), TS (Trigonum Spinae), AI (Angulus Inferius), C7 (7th cervical vertebra), IJ (Incisura Jugularis), T8 (8th thoracic vertebra) and PX (Processus Xyphoideus) in accordance with ISB recommendations. A rigid cluster of three markers were added on the flat surface of the acromion (Figure 1). The subjects were sat down on a chair and their right arms were guided using a wooden board. Static positions of the scapula were recorded with their arm elevated at 0°, 40°, 80°, 120°, 160° (landmarks on the board) in the sagittal plane. Then, AA, TS and AI markers were removed and a metal rod with 3 reflective markers was used to digitize anatomical landmarks palpated in the same arm positions. To apply AMC method, the 3 palpated landmarks in initial position of the arm was expressed in the AMC frame. The recording of the AMC motion provided the calculated position of the scapula. For 3AL, the position was directly given by the 3 skin markers. For each method, angle and subject, we realized 3 measurements. To standardize the humeral elevation angles among subjects, data were smoothed by fitting spline functions through the raw data of the three consecutive trials. The obtained spline functions were subsequently sampled at 20, 40, 60, 80, 100 degrees of humeral elevation. The kinematic data for scapular orientations were described using three scapular rotations based on the Euler rotation sequences of internal-external rotation (Y), upward-downward rotation (X) and anterior-posterior tilt (Z).

Repeated measurement analysis of variance and root mean square errors (RMSE) were performed to compare methods

to palpation. Inter-trial reliability was assessed for both methods with Intraclass Correlation Coefficient (ICC 2,1).

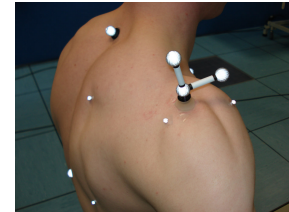


Figure 1: Experimental set up (3AL and AMC).

RESULTS AND DISCUSSION

3AL method was significantly different than palpation for X ($p < 0.01$) and Z ($p < 0.05$) rotations whereas AMC method did not significantly differ from palpation. In comparison to palpation, the two methods presented differences which were less than 10° (Figure 2). X rotation was over-estimated with 3AL (RMSE=6.65°) whereas AMC under-estimated it (RMSE=4.44°). Z rotation was under-estimated with 3AL (RMSE=6.06°) and was well estimated with AMC (RMSE=1.45°). Both methods over-estimated Y rotations but AMC (RMSE= 6.15°) more than 3AL (RMSE=4.94°). For both methods, the error increases with the shoulder flexion. Inter-trial reliability was good for both methods (3AL=0.95, AMC=0.90).

Overall, AMC method, compensating a part of the soft tissue artefact, is more accurate than 3AL method to measure scapula motion. Reliability was similar. However, AMC provides error, particularly for Y rotation measurement, that needs to be considered for clinical application.

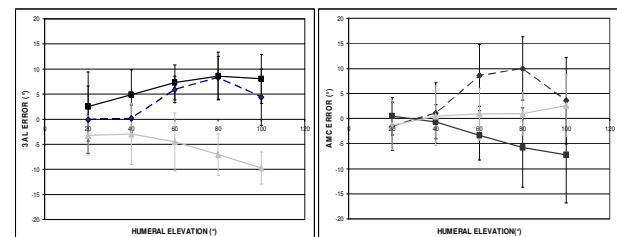


Figure 2: Error measurements for both methods (left: 3AL, right: AMC) in comparison to palpation recordings (base line). The 3 rotations are presented (Y: dotted, X: black, Z: grey) according to humeral elevation.

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