INTRODUCTION

Quantifying healthy shoulder motion enables comparisons to special (e.g. athletic, injured) populations and allows for the identification of mechanisms of diminished performance. Although previous work has documented shoulder motion using bone pins [1], the overall applicability is limited due to small sample sizes, and because the majority of shoulder kinematic studies utilize skin-mounted motion capture techniques for pragmatic reasons. Also, past investigations tend to focus solely on scapular plane abduction. This study generated an extensive collection of healthy 3-dimensional (3D) dynamic sternoclavicular (SC), acromioclavicular (AC), scapula-thoracic (ST), and glenohumeral (GH) kinematic profiles collected in multiple vertical movement planes utilizing skin-mounted shoulder motion capture.

METHODS

Healthy 3D right SC, AC, ST, and GH joint kinematics of 15 male and 14 female right-handed university-aged volunteers were recorded at 50 Hz by an 8 camera passive optoelectric motion analysis system (Vicon, Oxford, UK). Scapula orientation was recorded using an acromion marker cluster [2]. Segment definitions and joint rotation descriptions adhered to ISB standards [3]; however SC posterior rotation and AC posterior tilt were indeterminable with this setup.

Participants raised and lowered their fully extended right arm in six vertical movement planes: frontal plane, 30º anterior to frontal plane, scapular plane (40º anterior), 60º anterior, sagittal plane, and 30º medial to sagittal plane. Mean joint angles were calculated relative to TH elevation angle within each plane for each participant at 15º increments between 15º and 120º. These profiles were then averaged across all participants.

RESULTS

Sixty total (10 joint rotations x 6 movement planes) healthy shoulder kinematic profiles were generated for both motion phases. In general, as humeral elevation increased, ST upward rotation, ST posterior tilt, SC elevation, SC retraction, AC elevation and GH elevation all increased regardless of plane; however ST protraction/retraction, GH internal/external rotation, GH anterior/posterior plane of elevation, and AC protraction/retraction responses were less consistent as movement plane was modified. ST profiles for scapular plane elevation are provided as an example in Figure 1. This joint-plane combination is most often measured in upper extremity clinical research. Variability relative to range of motion (ROM) was high for most joints measured. For example, maximum relative ROM for ST protraction/retraction and posterior tilt were 319.15% and 126.78% respectively.

DISCUSSION & CONCLUSIONS

The healthy shoulder kinematic profiles produced through this study are the largest assembly of their kind. Most movement trends observed were similar in direction to previous studies using bone pins to directly measure kinematics [1] but had some occasional magnitude differences. The high variability in shoulder kinematics across individuals [1,2], combined with the smaller sample sizes of past investigations could contribute to these differences. Since most shoulder kinematic studies use skin-mounted motion tracking techniques similar to the AMC used in this study, the presented profiles have broad applicability for future upper extremity research that require a detailed understanding of healthy shoulder motion. Moreover, the results from this study encourage future shoulder kinematic investigations to move beyond singular scapular plane abduction.

REFERENCES


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