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Kinematic characteristics of the scapula and clavicle during military press exercise and shoulder flexion

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Background: The military press is an exercise frequently prescribed for scapular and shoulder rehabilitation. Although this exercise has previously been analyzed by electromyography, its kinematic features remain poorly understood. In this study, we aimed to clarify these features of the military press and suggest relevant clinical applications.

Methods: Sixteen healthy men participated in this study. The participants performed the military press while holding 2 kg weights, as well as shoulder flexion with and without 2 kg weights, and an electromagnetic motion capture system was used to analyze the kinematic features of the scapula, clavicle, and humerus during these exercises. The motions of the scapula and clavicle were analyzed at 10° increments of shoulder flexion from 30° to 120°.

Results: The military press involved less scapular internal rotation, greater upward rotation, and greater posterior tilt than shoulder flexion with or without weights, especially in the starting to middle range of shoulder flexion. Greater clavicular retraction and elevation were also seen during the military press.

Discussion: The movements of the scapula and clavicle during the military press differ significantly from those during shoulder flexion with and without weights. The kinematic features of the military press, which involved less scapular internal rotation, greater upward rotation, and greater posterior tilt than did shoulder flexion, may make it a useful re-education exercise (if pain allows) for patients with decreased scapular external rotation, upward rotation, and posterior tilting. The results of this study might provide a kinematic basis for the use of this widely performed shoulder exercise.

Level of evidence: Basic Science, Kinesiology Study.

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Keywords: Scapular motion; biomechanics; rehabilitation; military press; shoulder flexion; multi-joint movement

The military press is an exercise frequently used in scapular and shoulder rehabilitation.[2,3,7,10,21,26,29] It is a variation of an overhead press, which elevates the humerus overhead from an initial position with the elbow flexed and positioned anterior to the shoulder. Most of the previous studies on this exercise have involved electromyographic

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analysis. Townsend et al[29] analyzed the activities of the rotator cuff, deltoid, pectoralis major, and latissimus dorsi muscles of the shoulder during shoulder exercises, including the military press. They suggested that the supraspinatus, subscapularis, and anterior and middle deltoid muscles are highly active during the military press. Moseley et al[21] studied the activities of the scapular muscles during the military press and other rehabilitation exercises and suggested that the military press is a useful exercise for the upper trapezius, middle serratus anterior, and lower serratus anterior muscles.

On the other hand, the kinematic features of this exercise are not well understood. Crenshaw et al[4] indicated that the overhead pressing motion involved in the military press can decrease the amount of space in the subacromial area and thereby increase the stress on the subacromial space in throwing athletes who have pre-existing chronic changes in this space. However, it is also true that in clinical situations, there are many patients with shoulder complications (eg, impingement, labral injury, and frozen shoulder) who can elevate their arms (or weights) more easily during the military press than during shoulder flexion. Although many kinematic analyses have been performed on humeral elevation in various planes such as abduction,[16] scaption,[1,19,28] and flexion,[16] all of these analyses were performed with the arms fully extended. To our knowledge, there is no kinematic study of the military press, that is, humeral elevation accompanied by active elbow movement.

In this study, using an electromagnetic sensor, we aimed to investigate the 3-dimensional kinetic features of the military press in comparison with those of shoulder flexion, performed with and without weights, to clarify the clinically relevant characteristics of this exercise. We hypothesize that the military press has kinematic features such as greater scapular upward rotation, posterior tilt, and external rotation that could make it a better humeral elevation exercise than normal shoulder flexion with the elbow extended.

Materials and methods

Participants

Sixteen healthy men (age, 21.8 ± 1.1 years [mean ± SD]; height, 173.3 ± 5.3 cm; weight, 62.9 ± 7.3 kg) participated in this study. Subjects with a previous history of upper limb surgery, present neuromuscular disease or a history of neuromuscular disease, or any complaint in the upper limb in the past year were excluded from the study. The participants' dominant limbs were analyzed.

Instrumentation

Three-dimensional kinematic data for the scapula, clavicle, and humerus were recorded with a 6-*df* electromagnetic motion tracker system (Liberty; Polhemus, Colchester, VT, USA). The Liberty motion tracker system consists of a transmitter and sensors. Its System Electronics Unit generates and senses the magnetic fields and computes the position and orientation of each

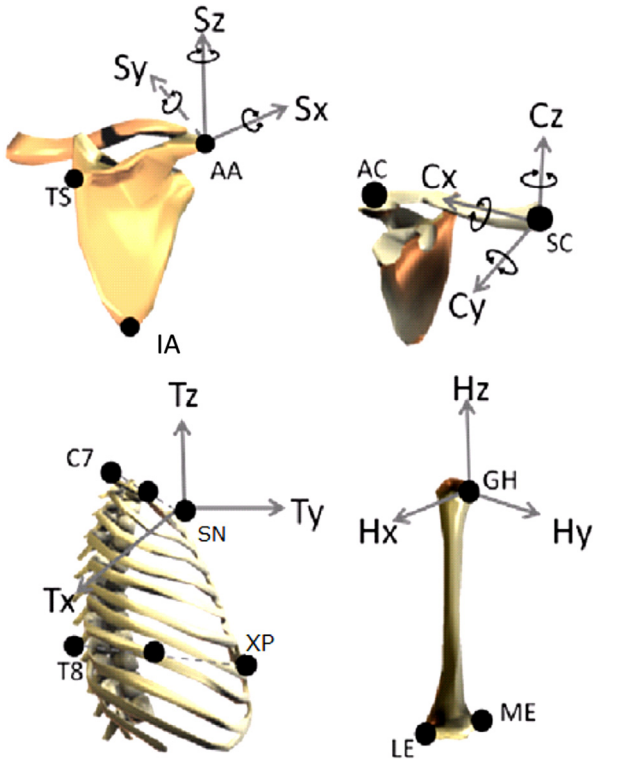

Figure 1 Locations of anatomic landmarks used for digitization and establishment of coordinate axes.

sensor. Previous studies have shown the accuracy of this device for the measurement of upper limb motion. For angles of shoulder flexion less than 120°, the error of measurement of the scapula and clavicle (relative to measurements made using bone pins) is less than 5°.[12,13,16,18] Therefore, only the data corresponding to shoulder flexion angles up to 120° were analyzed in this study.

The transmitter was fixed on a rigid wooden board, and the global coordinate system was established. The sensors were fixed to the skin overlying the flat surface of the superior acromion process, the sternum, and the humerus (via a molded thermoplastic cuff at the midpoint of the humerus). Next, the bony landmarks of the scapula, clavicle, and humerus were palpated and then digitized with the Liberty sensor stylus to establish the anatomically based local coordinate systems (LCSs). These measurements were performed with the subjects standing still with their arms hanging beside their bodies. Each LCS was defined according to the International Society of Biomechanics standardization proposal for the upper extremity[32] (Fig. 1). The acromial angle (AA), trigonum spinae (TS), and inferior angle (IA) were used to define the LCS of the scapula. The scapular x-axis (Sx-axis) was directed from the TS to the AA. The scapular y-axis (Sy-axis) was perpendicular to the plane defined by the TS, AA, and IA, and the scapular z-axis (Sz-axis) was defined as the cross product of the Sx-axis and Sy-axis.

The xiphoid process (XP), suprasternal notch (SN), spinous process of the seventh cervical vertebra (C7), and spinous process of the eighth thoracic vertebra (T8) were used to define the LCS of the thorax. The thoracic vertical axis (Tz-axis) was directed from the midpoint of the T8 and XP to the midpoint of the SN and C7; the transverse axis (Tx-axis) was perpendicular to the plane defined by the SN, C7, T8, and XP; and the sagittal axis (Ty-axis)

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