Electromyography Analysis of Scapular Muscles During Baseball Pitching

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INTRODUCTION:

Scapular muscles play an important role in achieving the appropriate motion and position of the shoulder during baseball pitching. The failure of these muscles to perform this role causes the shoulder to function inefficiently, and this limits the physiological and biomechanical performance of the player.

In the past, shoulder muscle activity during baseball pitching has been examined extensively by many researchers[1]. Among them, many researchers reported the importance of scapular motion and activity. However, little study has been carried out on the electromyography(EMG) activity of scapular muscles, and the role of these muscles during pitching is yet to be fully elucidated.

The rhomboid muscle, which connects the scapula with the thoratic spine , is considered to stabilize scapular position and motion. It consists of two parts—rhomboid major and rhomboid minor—both of which were thought to perform the same function. Therefore, the two muscles have not been studied separately.

The purpose of our investigation was to dynamically measure the normalized EMG activity of scapular muscles during baseball pitching.

METHODS:

9 male volunteers with no history of shoulder pain or pathology participated voluntarily in this study. Their physiological parameters (mean ± standard deviation) were as follows: age = 20.5 ± 1.2 years, height = 170.0 ± 7.5 cm, weight = 68.3 ± 4.4 kg, and number of years played = 8.5 ± 2.1. The subjects had to undergo a brief clinical examination (medical history, manual shoulder muscle testing, and range-of-motion measurements). The approval for this study was obtained from the Institutional Review Board of Waseda University, and each subject was required to sign a consent form prior to his participation in the study. All the experiments were carried out under appropriate safety conditions and in the presence of an orthopedic surgeon.

After stretching and warming up, the subjects were asked to throw 10 overhand fastball pitches. The time interval between the pitches was set to 90 s. The pitching phase was recorded using a 210-Hz high-speed digital camera (FX-20, CASIO, Tokyo, Japan). The pitching motion was divided into six phases according to Fleisig et al.[2] and the following five phases were monitored: early cocking (EC), late cocking (LC), acceleration (ACC), deceleration (DCC), and follow through (FT). The data obtained for each phase was averaged for all the pitches.

The EMG signals of eight muscles were measured. Fine-wire electrodes were used for the rhomboid major (RMJ) and rhomboid minor (RMN), supraspinatus (SSP), and infraspinatus (ISP) muscles; standard active surface electrodes were used for the upper/middle/lower trapezius (UT/MT/LT) and serratus anterior (SA) muscles. To ensure that the recorded activity was indeed that of the rhomboid muscles, we used an ultrasound (Voluson I, GE Yokogawa Medical Systems, Tokyo, Japan) and EMG electronic stimulator (SEM-42D1, Nihon Kohden, Japan) and monitored the insertion site and the point where the needle tip was located after insertion.

After attaching all the electrodes, a manual muscle test (MMT) was performed. The MMT for the rhomboid muscles involved scapular adduction at the shoulder, internal rotation, and 90° elbow flexion.

The recorded EMG signals were processed using signal processing programs in conjunction with LabVIEW 2009 (National Instruments Corp., TX, USA). The signals were then filtered, and an average rectified value (ARV) was calculated according to previously described procedures. The sampling frequency was 2000 Hz, and signal processing was carried out offline. Next, the EMG signals were digitally low-pass filtered (4th order, 5 Hz). After filtering, a notch filter (low pass, 5 Hz) was used to smooth the signals and calculate the ARV.

One second of greatest activity of the maximal voluntary contraction (MVC) of each muscle was selected to normalize the EMG activity. The EMG activity of each muscle in each phase, expressed as a percentage of MVC, was used in the EMG analysis. The normalized ARV (nARV), which was obtained by changing the shoulder angle, was determined by averaging the results of each trial to define the experimental value.

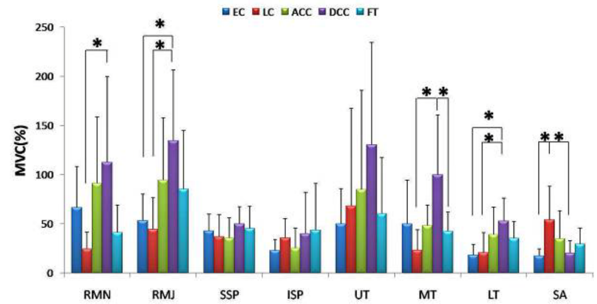

Fig.1 EMG activity of scapular muscles during baseball pitching. Five pitching phases were observed: EC=early cocking, LC=late cocking, ACC=acceleration, DCC=deceleration, and FT=follow through. Eight scapular muscles were testsed: RMN=rhomboid minor, RMJ=rhomboid major, SSP=supraspinatus, ISP=infrasupinatus, UT=upper trapezius, MT=middle trapezius, LT=lower trapezius, and SA=serratus anterior. All data are expressed as mean ± SD.

All statistical analyses were performed using PASW statistics ver.18 (SPSS, IL, USA). One-way ANOVA were used to statistically determine the significant differences in each parameter in each pitching phase ($P < 0.05$).

RESULTS

The EMG activity of the eight scapular muscles showed some significant differences during baseball pitching (Fig.1).

RMN showed high EMG activity in the DCC phase (114.24 ± 87.22), and it was significantly different from that in the LC phase (24.13 ± 17.10) ($P < 0.05$). In the case of RMJ, the EMG activity in the DCC phase was the highest (134.41 ± 71.90) and it was significantly different from that in the EC phase (52.80 ± 27.32) and the LC phase (44.42 ± 31.99) ($P < 0.05$). The EMG activity of SA in the LC phase showed a significant difference from that in the EC and DCC phases. The EMG activity of SSP, ISP, and UT showed no statistical relationship among all the pitching phases.

DISCUSSION:

We monitored the EMG activity of scapular muscles during baseball pitching. In the past, Jobe et al.[1] and Gowan et al.[3] have studied the EMG activity of scapular muscles. However, the rhomboid minor and major muscles have not been studied separately in detail.

RMN and RMJ showed the highest activity during the DCC phase and the second highest activity in the ACC phase Further, the activity patterns for these two muscles were different. On the other hand, SA showed the highest activity during the LC phase. In this phase, the dominant side of the trunk rotated forward as the horizontal protraction of the scapula was initiated, providing a forward propulsive platform for the humerus. The ACC phase started with maximal shoulder rotation, and the DCC phase finished with maximal shoulder internal rotation. In these short-term dynamic phases, the scapula switched from protraction to retraction while the humerus was forward flexed horizontally. Thus, it is considered that RMN, RMN, and SA produced traction force during these phases and controlled the scapulothoracic joint for providing a stable glenoid against which the humerus could rotate.

Such an understanding of the EMG activity of the scapular muscles during pitching will be helpful in the development of rehabilitation programs that address the pathology accurately and specifically.

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