Quantitative sEMG Description of Upper Extremity Muscle Activation during Baseball Pitching: Pre Fatigue & Fatigue

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INTRODUCTION

In attempt to reduce overuse injuries in baseball pitching, it is important to understand muscle activations during the pitching motion. Typically, injuries to the upper extremity that occur from baseball pitching are overuse in nature. It is not only important to understand muscle activation during the pitching motion, but it would be beneficial to understand the muscle activations during a fatigued state. Fatigue or overuse often leads to injury in pitchers. Therefore, it was the purpose of this study to examine upper extremity muscle activations during baseball pitching both pre fatigue and during a fatigued state.

METHODS

Eleven high school male baseball pitchers (mean age: 16.2 ± 2.1 years, height: 179.3 ± 6.6 cm, mass: 81.7 ± 17.2 kg) volunteered to participate. Throwing arm dominance was not a factor contributing to participant selection or exclusion. All data collection sessions were conducted indoors at the University's Health, Physical Education, and Recreation building and were designed to best simulate a competitive setting. All testing protocols were approved by the University's Review Board.

Surface electromyographic (sEMG) data were collected on the throwing arm biceps, triceps, and scapular stabilizers. To transmit surface electromyographic (sEMG) data to The MotionMonitor™ motion capture system (Innovative Sports Training Inc, Chicago IL), a Noraxon Myopac 1400L 9-channel amplifier was used. The signal was full wave rectified and smoothed based on the smoothing algorithms of root mean squared at windows of 100 ms. Throughout all testing, sEMG data were sampled at a rate 1000 Hz.

Kinematic data were collected in attempt to identify the different phases of the pitch. Prior to completing test trials, participants had a series of six electromagnetic sensors attached at the following locations: (1) the medial aspect of the torso at C7(Myers, 2005); (2) medial aspect of the pelvis at S1 (Meyers, 2005); (3) the distal/posterior aspect of the throwing humerus; (4) the distal/posterior aspect of the throwing forearm; (5) the distal/posterior aspect of the non-throwing humerus; and (6) the distal/posterior aspect of the non-throwing forearm.

After completing their warm-up and gaining familiarity with the pitching surface, each participant threw five maximal effort fastballs for strikes toward a catcher located the regulation distance from the pitching mound (18.44 m). After five strikes were thrown the participant then threw a 1kg ball into a rebounder until they reported fatigue. A scale of 0-3, with three being only able to throw five more pitches, was used to quantify fatigue. Once a fatigue of 3 was reported, they completed 10 more throws before returning to the mound to throw five maximum effort fastballs. Those data from the fastest pitch passing through the strike-zone for the pre fatigue and fatigue deliveries were selected for analysis.

RESULTS AND DISCUSSION

The pitching motion was divided into five different phases. Phase 1, stride phase, was described as the motion from the beginning of the pitch to stride leg foot contact. Phase 2, cocking, was from stride leg foot contact to maximum external rotation of the throwing shoulder. Phase 3, acceleration, was from maximum external rotation to ball release. Phase 4, deceleration, was from ball release to maximum internal rotation of the shoulder and Phase 5, follow through, was from maximum internal rotation throughout the follow through motion. Data are presented in Table 1.

Throughout the pre fatigue pitching motion, the triceps displayed the greatest muscle activation based on percent maximum voluntary isometric contraction (MVIC). Once fatigued, the triceps greatly decreased in their muscle activation and the deltoid and scapular stabilizers displayed greater activation. Scapular movement during the pitching motion allows for elevation of the acromion. During cocking and acceleration the scapula must rotate in order for the rotator cuff to clear the acromion. In attempt to gain maximum external rotation, the scapula must retract and then protract to achieve acceleration to ball release. Of the biceps, triceps, deltoid and scapula stabilizers, the scapula stabilizers provided the greatest activation from cocking, through acceleration, to ball release.
The scapula is the common point of attachment for the biceps, triceps and deltoid. Thus the scapula stabilizers essentially should have greater activation for efficient functioning of the biceps, triceps and deltoid when the humerus is in a position of 90° of abduction. If the scapula is not stable then alterations in all the musculature that attaches to the scapula will occur, thus altering the pitching mechanics.

The data revealed that during fatigue the deltoid and the scapular stabilizers had increased activation. The increased activation could be explained by the scapular stabilizers having to recruit more muscle fibers to perform the adequate stabilization because the surrounding muscles were fatiguing.

SUMMARY AND CONCLUSION

More studies need to be conducted in attempt to prove our results with higher level of evidence in describing muscle activity during dynamic muscle fatigue. However, from this study it is evident that great attention should be given to the strength and conditioning of the scapular stabilizers in baseball pitchers and the arch of motion that they are trained.

REFERENCE

1. Myers, JB, Laudner, KG, Pasquale, MR, et al. Scapular position and orientation in throwing athletes. *Am J Sports Med* 2005; **33**: 263-271.

Table 1: Mean Percent MVIC.

PreFatigue	Biceps	Triceps	Deltoid	S.Stabilizers	Fatigue	Biceps	Triceps	Deltoid	S.Stabilizers
Phase1	9.38	74.55	21.41	13.47	**Phase1**	9.87	14.14	51.07	41.3
Phase2	6.82	112.09	23.2	11.36	**Phase2**	7.39	14.01	48.58	26.11
Phase3	10.37	79.37	29.84	16.86	**Phase3**	10.16	12.99	47.6	29.05
Phase4	11.64	59.8	37.15	25.12	**Phase4**	12.81	15.33	48.49	33.17
Phase5	159.31	593.11	287.56	99.27	**Phase5**	183.46	453.3	159.52	103.62