QUANTITATIVE ANALYSIS OF CORE MUSCULATURE DURING TWO TYPES OF BASEBALL PITCHES: FASTBALL AND CHANGE-UP

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Previous biomechanical studies have compared kinematic and kinetics of the fastball baseball pitch to the change-up, but there is yet to be a description of muscle activations between the two pitches. With the fastball being the most common baseball pitch and the change-up being the staple off-speed pitch, it is typical for a baseball pitcher to have these two pitches in his compilation of pitches. The change-up is thrown in attempt to mimic the fastball, however has a much lower velocity than the fastball. The intention of both pitches exhibiting the same delivery is an attempt to distract the batter. Therefore it was the purpose of this study to quantitatively analyze the core musculature attached to the pelvis during both the fastball and the change-up baseball pitches.

KEYWORDS: sEMG, overhand pitching, muscle activation

INTRODUCTION: Baseball pitching is considered the most dynamic throwing task in sports. Pitching biomechanics have been investigated extensively in attempt to identify optimal pitching mechanics in terms of pitching performance (Fleisig et al., 1999; Fleisig et al., 2006; Werner et al., 2001). Based on previous quantified upper body kinetics, it has been concluded that improved muscle strength is needed in attempt to achieve adequate upper body kinetics and consequently efficient pitching performances (Fleisig et al., 1999; Sabick et al., 2004; Werner et al., 2001). It is evident that efficient transfer of energy from the lower extremity to the upper extremity is paramount in proper pitching mechanics (Stodden et al., 2001). Recently differences in kinetic and kinematic properties have been recognized in different types of pitches (Escamilla et al, 1999; Fleisig et al., 2006). However, there is limited research regarding the muscle activations that drive these kinetic and kinematic properties. Therefore, it was the purpose of our study to examine the activations of muscles supporting the lumbo-pelvic hip complex during two commonly thrown baseball pitches, the fastball and change-up.

METHODS: Twelve male Division I collegiate baseball pitchers (20.1 ± 1.5 years, 188.9 ± 4.8 cm and 87.2 ± 7.5 kg) volunteered to participate. All participants had recently finished their collegiate fall baseball season, and were deemed free of injury. Throwing arm dominance was not a factor contributing to participant selection or exclusion for this study. All testing protocols were approved by the University's Review Board.

Participants reported for testing prior to engaging in resistance training or any vigorous activity that day. Location of bilateral gluteus maximus, gluteus medius, hip adductors and external obliques were identified through palpation. Adhesive 3M Red-Dot bipolar surface electrodes (3M, St. Paul, MN) were attached over the muscle bellies and positioned parallel to muscle fibers (Basmajian and Deluca, 1985). Once all electrodes had been secured, manual muscle tests (MMT) were conducted for each muscle using techniques described by Kendall et al. (1993) in attempt to identify maximum voluntary isometric contraction (MVIC) for each muscle. Each MMT was conducted to establish baseline readings for each participant's maximum muscle activity to which all surface electromyographic (sEMG) data could be compared.

Surface electromyographic data were transmitted to The MotionMonitor™ motion capture system (Innovative Sports Training Inc, Chicago IL) via a Noraxon Myopac 1400L 8-channel amplifier. All sEMG signals were full wave rectified. Signals were 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. In addition, all sEMG data were notch filtered at frequencies of 59.5 Hz and 60.5 Hz respectively (Blackburn & Pauda, 2009).

In addition to sEMG data, kinematic data were collected so as to event mark the phases of the pitching motion. Kinematic data were collected using The MotionMonitor™ motion capture system (Innovative Sports Training, Chicago IL). Prior to completing test trials, participants had ten electromagnetic sensors attached at the following locations: (1) the medial aspect of the torso at C7; (2) medial aspect of the pelvis at S1; (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; (6) the distal/posterior aspect of the non-throwing forearm; (7) distal/posterior aspect of stride lower leg; (8) distal/posterior aspect of the upper stride leg; (9) distal/posterior aspect of non stride lower leg; and (10) distal/posterior aspect of non stride upper leg (Myers et al., 2005).

An unlimited time was allotted for the participants to perform their own specified pre-competition warm-up routine. After completing their warm-up and gaining familiarity with the pitching mound, data collection began. Each participant threw a series of five maximal effort fastballs and 5 changeups for strikes toward a catcher located the regulation distance from the pitching mound (18.44 m). Those data from the fastest fastball pitch passing through the strike-zone and those data from the slowest change-up pitch passing through the strike-zone were selected for analysis. Pitch velocity was determined by JUGS radar gun (OpticsPlanet, Inc., Northbrook, IL) positioned at the base of the pitching surface and directed towards home plate.

Raw data regarding sensor orientation and position were transformed to locally based coordinate systems for each of the respective body segments. Euler angle decomposition sequences were used to describe both the position and orientation of the torso relative to the global coordinate system (Wu et al., 2002; Wu et al., 2005). The use of these rotational sequences allowed the data to be described in a manner that most closely represented the clinical definitions for the movements reported (Myers et al., 2005).

Data were analyzed in the current study using the statistical analysis package SPSS 15.0 for Windows. Descriptive statistics means and standard deviations, for all sEMG were calculated for both the fastball and changeup.

RESULTS: The pitching motion was divided into five phases (stride, cocking, acceleration, deceleration, and follow through). Stride phase was described as the motion from the beginning of the pitch to stride leg foot contact (FC). The cocking phase was from stride leg FC to maximum external rotation (MER) of the throwing shoulder. Acceleration was from MER to ball release (BR). Deceleration was from BR to maximum internal rotation (MIR) of the shoulder and follow through was from MIR throughout the follow through motion. Means of %MVIC for each muscle for both pitching styles are presented in Figures 1 and 2.

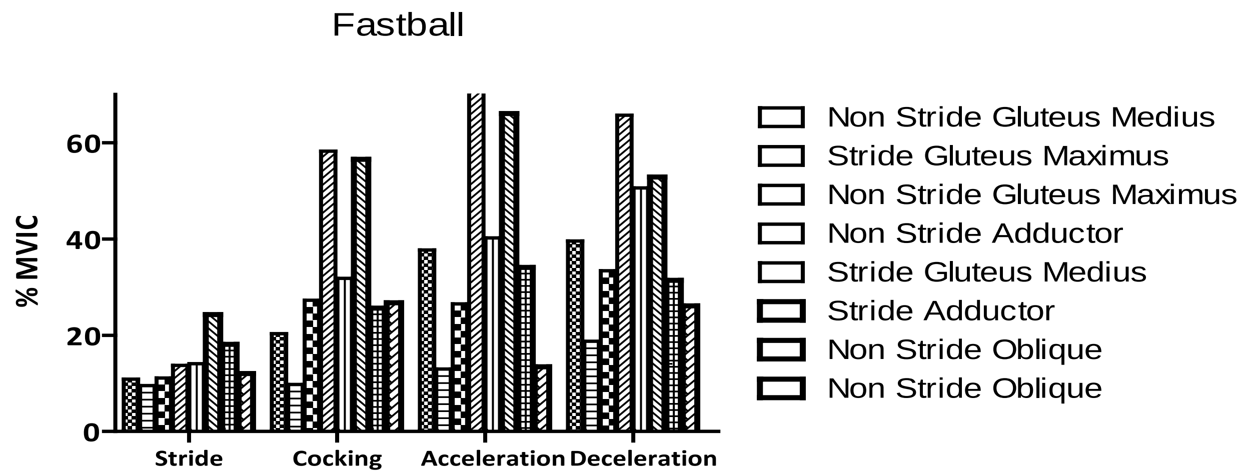

Figure 1. Muscle activations as %MVIC throughout cocking through the follow through phase while throwing the fastball.

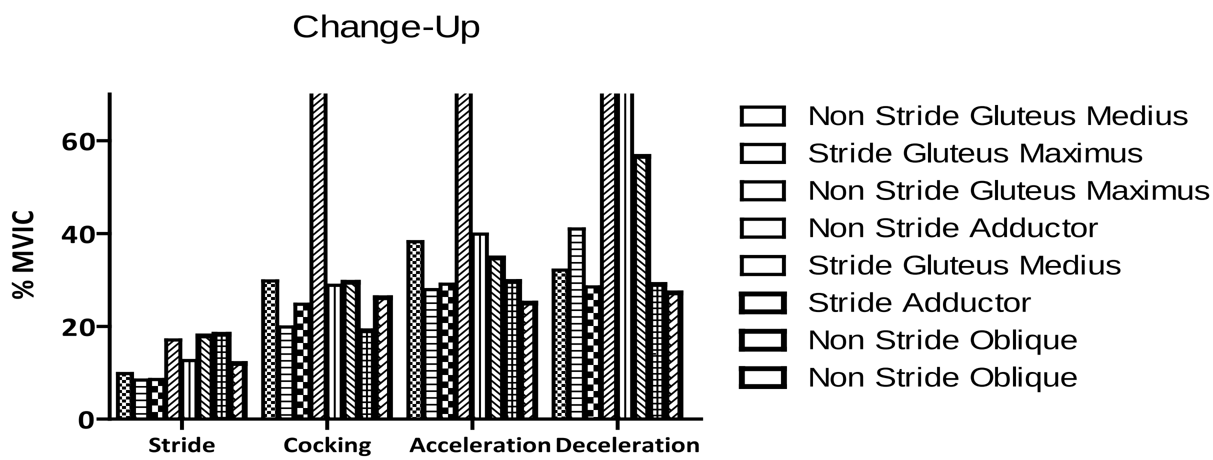

Figure 2. Muscle activations as %MVIC throughout cocking through the follow through phase while throwing the change-up.

DISCUSSION: This is the first study to investigate sEMG of the muscles supporting the lumbo-pelvic hip complex during the fastball and change-up in collegiate baseball pitchers. During the stride the hip adductors and obliques displayed a trend with the greatest activation regardless of pitch type. The fastball exhibited greater activation of the stride adductor and oblique than the non stride side during the stride phase. The activation of the gluteals, adductors and obliques during the stride is explained by their role in core stabilization while on single leg support as the pitcher is striding out into FC. As exhibited by the Trendelenberg effect, when on single leg support, the gluteus medius of the single support leg allows for pelvic stabilization to counterbalance the opposing non supported leg (Kendall et al, 1993). The cocking phase displayed the trend of greater activation of all muscles examined for both pitches as compared to the stride phase. The acceleration phase continued the trend of increases in muscle activation with the adductor muscle group generating the most activation. During the fastball pitch stride and non stride adductors were similar with the non stride side displaying greater activation. The change-up did not show adductor consistency with the stride and non stride legs having a greater difference in activation. In addition the non stride obliques demonstrated similar activations for the two pitches while the stride side oblique had decreased activation during the change-up. During deceleration the fastball and change-up deliveries demonstrated a similar trend as displayed in the acceleration phase. Follow through revealed greater muscle activation in the fastball as compared to the change-up.

CONCLUSIONS: The current study quantified and described muscle activation of the musculature controlling the lumbopelvic-hip complex while delivering two different styles of pitches. This is one of the few studies to examine the adductors and obliques during the pitching motions. We have presented only generalizations of muscle activations during both the fastball and change-up baseball pitches. It is speculated, from the data presented, that not only are the gluteals important in pelvic and torso stability (Oliver & Keeley, 2010) but also the adductors and obliques are most active in their role of pelvis and torso rotational control. Thus in attempt to target this musculature, focus should be placed training the core and torso through functional core and torso strength training protocols (Szymanski & Fredrick, 1999; Akuthota & Nadler, 2004). Additional studies are warranted in attempt to validate our results with a higher level of evidence of muscle activation and movement kinematics during the baseball pitching motion.

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