CHANGES IN UPPER EXTREMITY MUSCLE ACTIVATION IN THE PRESENCE OF STRESS

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This study examined the muscle activity of the flexor digitorum (FD), biceps brachii (BB), triceps brachii (TB), and pectoralis major (PM) during the American football throw with and without conditions of stress. Male subjects (n=5) with either football or baseball experience threw footballs at targets with distances of 12.91 m, 18.29 m, and 28.91 m. Throwing arm muscle activity was assessed via electromyography. Results showed that the flexor digitorum muscle had lower muscle activation for the stress condition at the long distance along with the pectoral muscle at the middle distance.

KEYWORDS: electromyography, EMG, American football, stress, throwing

INTRODUCTION Throwing movements can be classified as underarm, overarm, or side arm (Bartlett, 2000). The American football throw is classified as an overarm throw and is described by lateral rotation of the humerus, followed by medial rotation (Dillman et al., 1993). Four phases of motion have been identified in a previous study of professional American football quarterbacks. Kelly and colleagues (2002) designates these four phases as early cocking, late cocking, acceleration, and follow-through. In the current experiment, muscle activation was studied during the late cocking, and acceleration phases. The late cocking phase is characterized by external shoulder rotation while the acceleration phase continues the forward throwing motion until ball release (Kelly et al. 2002). Previous studies have examined how the changing of focus affects muscle activation. Vance et al. (2004) showed that while participants performed barbell curls, there was a higher degree of muscle activation when the subject was focused on their kinematic movements (internal focus) than when they were instructed to focus on the bar they were lifting (external focus). In a practical setting where performance was also measured, Lohse, Sherwood, and Healy (2010) used EMG along with video analysis to investigate concentration effects on dart throwing. This study agrees with Vance's findings that determined that with external focus, muscle activation is lessened and performance is increased. The purpose of the current study was to examine the effects of stressors on muscle activation during overarm American football throwing. It was hypothesized that when stress is place on the participants, their muscle activation will decrease and accuracy of their throws will increase, but EMG activation will not change significantly between a hit and miss result when throwing at the same target. These findings can be beneficial to instructors when teaching mechanics of throwing along with how to deal with psychological stressors during practice and competition to young athletes in any sport with overarm throws.

METHOD: Five male subjects (Mean ± SD: Age = 22.8 ± 4.1 y; weight = 84.5 ± 17.1 kg; height = 182.8 ± 6.5 cm; football experience: 7 ± 1.4 y; baseball experience: 5.6 ± 3.2 y) volunteered to participate in the study. Participants signed an informed consent form and competed a Physical Activity Readiness Questionnaire before participating in the study. Approval by the Institutional Review Board (HS14-602) was obtained prior to commencing the study.

Three targets were located at different distances from the line of scrimmage, the starting position for the passer. The first target was 18.3 m directly in front of the subject. The second target was located 9.1 m in front of the target and 9.1 m to the throwing side of the subject. The third target was set up 37.4 m in front of the subject and 9.1 m to the throwing side of the subject.

Participants first completed a dynamic warm up before each testing session. Once the warm up was complete, participants were given verbal instructions on what they were supposed to

do. Once participants understood these instructions, they completed 15 throws at the targets in a random order. The target to be thrown at was illuminated shortly after the passer started their drop back for each throw. For each testing session subjects first completed the 15 throws without any stress, then completed 15 more throws under stress. The stress procedure consisted of the same drop back, but with 3 tennis balls being thrown at the participant from different places. The goal for the participant in the stress trials was to avoid the balls being thrown at them, find which target was illuminated, and throw at that target. Each throw was recorded as a hit or miss, as well as which target was being thrown at.
Muscle activity was assessed via electromyography (EMG) of the *flexor digitorum* (FD), *biceps brachii* (BB), *triceps brachii* (TB), and *pectoralis major* (PM) on the throwing side of the participant. The electrode sites were prepared by abrading the epidermal skin layer, swabbing the sites with isopropyl alcohol to reduce impedance of the skin to < 5 kilo ohms. Disposable self-adhesive Ag/AgCl dual electrodes (Noraxon, Scottsdale, AZ, USA) were placed on the muscle bellies according to Cram et al (1997). EMG data were collected at 1000 Hz via BTS 300 FREEEMG (BTS Biomedical; Milan, Italy). Raw data were band pass filtered at 10-450 Hz, full wave rectified, and integrated with a 50 millisecond moving window.
Statistical analyses via SPSS version 22 consisted of 2X2 (control/stress X hit/miss) Repeated Measures ANOVAs for each muscle at each distance. Bonferroni's corrections were used for pairwise comparisons. Alpha was set *a priori* at p = 0.05.

RESULTS: Repeated Measures ANOVA for each muscle at the various distances showed that muscle activity was greater for the control condition of the *flexor digitorum* muscle at the long distance and the *pectoralis major* muscle at the middle distance ($p < 0.05$) (see Figures 1 & 2).

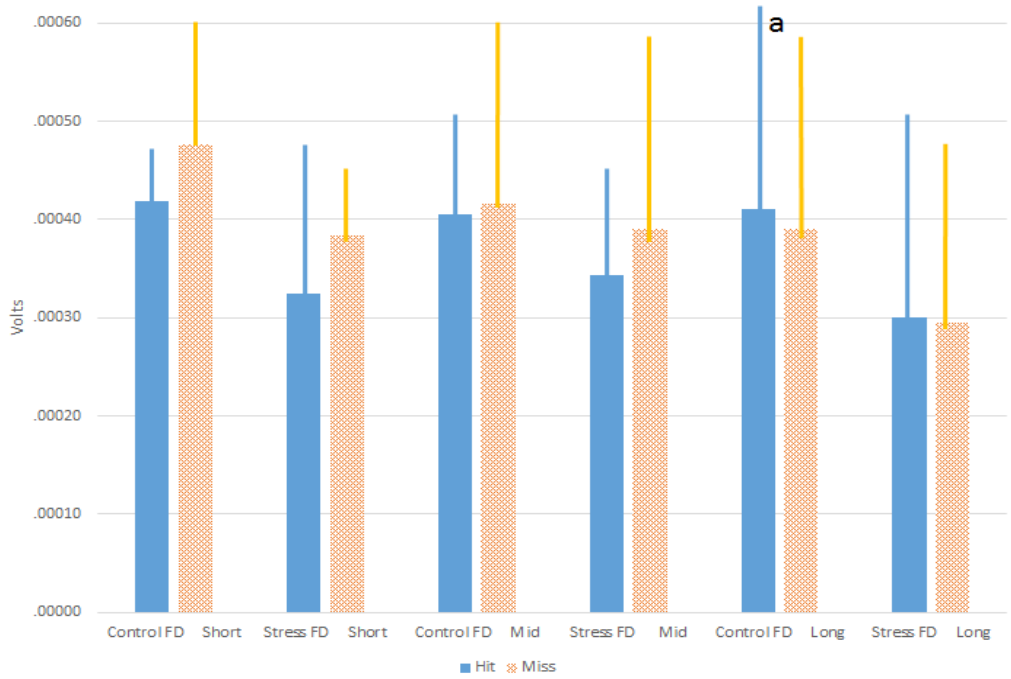

Figure 1. Muscle activation (Volts) for *Flexor Digitorum* (FD) under stress/control conditions for hit/miss at three distances. [a] indicates significant difference ($p < 0.05$) for control/stress at the long distance.

As illustrated in Figures 3 and 4 for *biceps brachii* and *triceps brachii,* there were no differences in stressor conditions for these muscles ($p > 0.15$). Furthermore, there were no differences in whether the target was successfully hit or not and no target X stress interactions for any of the muscles studied ($p > 0.15$).

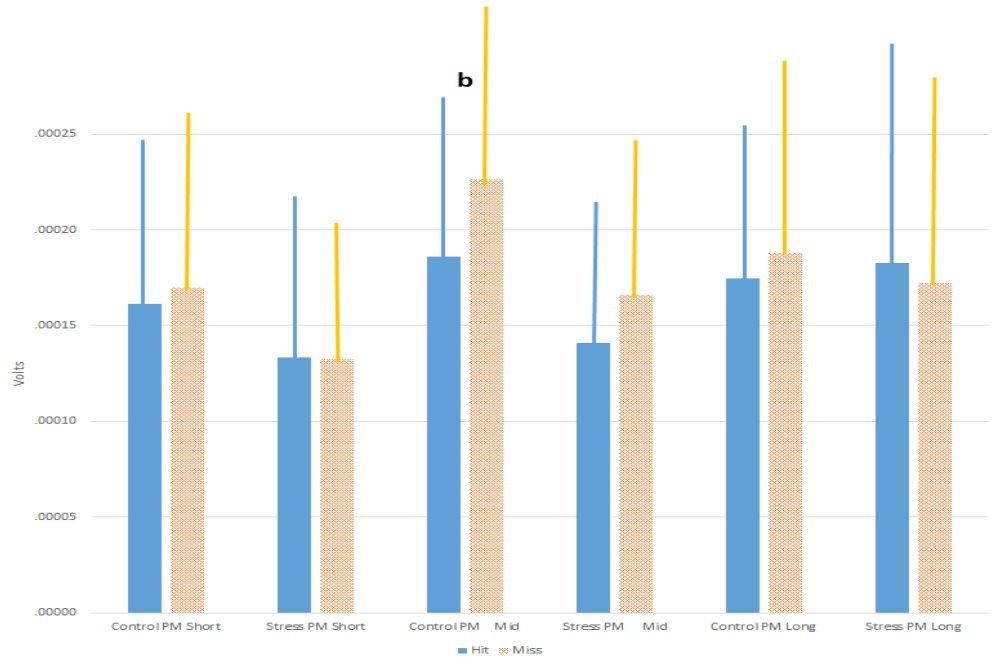

Figure 2. Muscle activation (Volts) for *Pectoralis Major* (PM) under stress/control conditions for hit/miss at three distances. [b] indicates significant difference ($p < 0.05$) for control/stress at the middle distance.

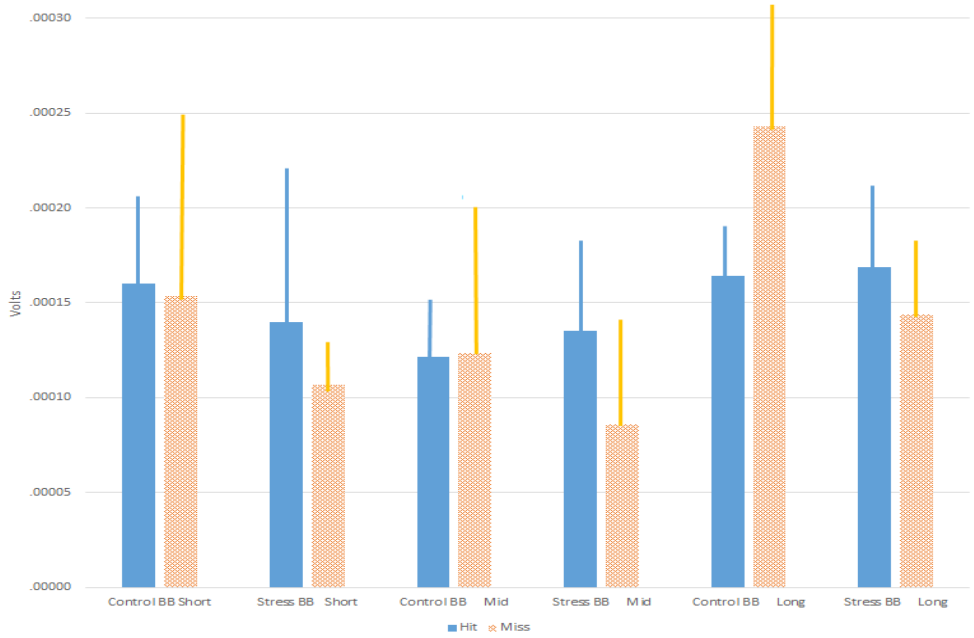

Figure 3. Muscle activation (Volts) for *Biceps Brachii* (BB) under stress/control conditions for hit/miss at three distances. No conditions differed ($p > 0.05$).

DISCUSSION: Results of the current study partially agreed with previous research done by Vance and colleagues (2004), and Lohse, Sherwood, and Healy (2010) who found that muscle activation decreases when the primary focus for the subject is external. In those studies subjects were instructed to focus either inside or outside the body. During the stressor condition of the current study, subjects were asked to perform two tasks at once, avoiding being hit by thrown balls while finding a target to throw at. Therefore, not only was an external focus present, subjects were actually performing different tasks. Nevertheless, in the current study only two muscles at one target distance each had muscle activity differ between stress and non-stress conditions. This might be attributable to the low number of subjects. More subjects would likely improve the statistical outcome.

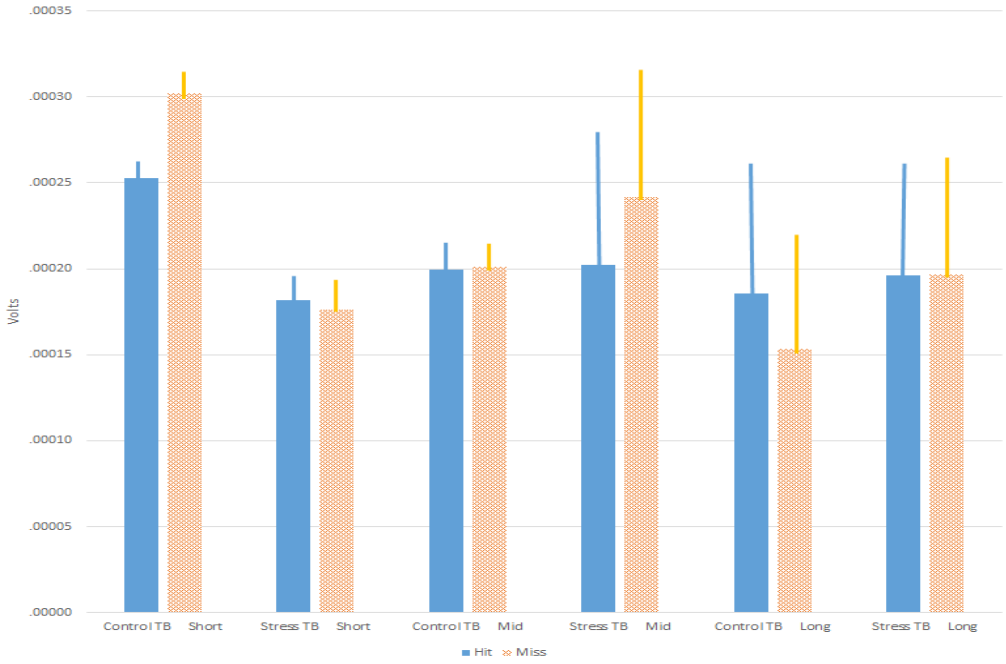

Figure 4. Muscle activation (Volts) for *Triceps Brachii* (TB) under stress/control conditions for hit/miss at three distances. No conditions differed ($p > 0.05$).

In addition, there was no difference in muscle activity between successful and unsuccessful attempts to hit the target. As hypothesized, muscle activity compared between hits and misses on the same target did not change significantly. This is most likely because whether the target was hit or missed, the thrower is attempting to throw the ball the same distance and therefore generates the same muscle activity.

CONCLUSION: With limited data, the flexor digitorum at the long distance, and pectoral muscle at the middle distance were the only muscles to exhibit changes in muscle activity between stress and non-stress conditions. In addition, there was no significant difference in EMG activity when comparing hit and missed targets at the same distance in any of the muscles examined. Due to the small number of subjects involved in the current study, additional research is recommended.

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