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The Effects of a J-Band Warm-up on Muscle Activity of Colligate Baseball Players During Pitching

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ABSTRACT

Background: Baseball pitchers experience a high rate of injury to the elbow joint which may be prevented through proper warm-up techniques. However, few studies have investigated the effect of baseball specific warm-ups on muscle activity during pitching. This study aimed to compare the muscle activity differences that occurred during pitching with and without the utilization of a J-Band warm-up.
Methods: Fourteen male colligate baseball pitchers volunteered to complete two separate bull pen sessions; one following a standard warm-up and one following a J-Band warm-up. Muscle activity of the triceps brachii and serratus anterior was recorded and independent sample t-tests were run to compare peak and mean muscle activity differences between the two pitching sessions.
Results: Average muscle activity was higher in the triceps brachii during pithing following the completion of a J-Band warm-up (p = 0.047, d = 0.336). There were no other statistically significant differences in the triceps brachii or serratus anterior.
Conclusion: A J-band warm-up elicits higher average muscle activity in the triceps brachii in subsequent pitching. Given the stabilizing role of the triceps, this may lead to a reduction of pitching related injuries.

1. Introduction

Proper warm-ups in sport prevent injury and maximize athletic performance by transitioning the body from a resting to active state. While warm-up structure, duration, and intensity vary, most aim to prepare the body for exercise by stimulating neural pathways specific to the conditioning activity. Examining the efficacy of warm-up methods helps establish warm-up protocols most advantageous for a specific sport or activity to ensure optimal neuromuscular control for performance and prevention of injury. One method of evaluating the effects of a warm-up is the use of surface electromyography (EMG) to quantify the number of active motor units within a muscle and provide insight into the current neural state of a muscle (Farina, Merletti, & Enoka, 2014). Several types of warm-ups including general aerobic activities, static and dynamic stretching, and sport specific movements are all capable of increasing surface electromyography amplitudes and evoking enhanced performance in sport specific tasks (Gil, Neiva, Sousa, Marques, & Marinho, 2019; McGowan, Pyne, Thompson, & Rattray, 2015; Sotiropoulos et al., 2010).

Previous literature investigating the effects of various warm-up and stretching protocols on muscle activity have been largely inconsistent. One study found no significant differences in muscle activity of the vastus lateralis and rectus femoris when comparing acute static stretching to controls in active college males (Cramer et al., 2007). Conversely, other studies have found reductions in muscle activity after static stretching in the vastus lateralis and rectus femoris (Cramer et al., 2005; Rossi, Pereira, Simão, Brandalize, & Gomes, 2010), indicating that static stretching may potentially inhibit muscle activity and lead to decreased performance in subsequent tasks. Cramer et al. (2005) found that a static stretching protocol significantly reduced muscle activity during isokinetic leg extensions in both the stretched and unstretched contralateral limb. Similar results have been noted by both Haag, Wright, Gillette, & Greany (2010) and Williams, Harveson, Melton, Delobel, & Puentedura (2013) who saw no effects of static stretching or proprioceptive neuromuscular facilitation on pitching accuracy and velocity.

Dynamic stretching warm-ups have been shown to be effective at activating muscles involved in the subsequent tasks, generating greater jump heights and ability to lift higher external loads during resistance training exercises (Hough, Ross, & Howatson, 2009; Minas, Blazevich, Giakas, Seitz, & Kay; Sotiropoulos et al., 2010). Additionally, multiple studies have demonstrated that dynamic stretching activities produce significantly greater ($p < 0.05$) muscle activity than static stretching activities (Amiri-Khorasani, Abu Osman, & Yusof, 2010; Herda, Cramer, Ryan, McHugh, & Stout, 2008). Minas et al. (2016) found that chain loaded squats during a warm-up increased not only the participants free squat one-repetition maximum, but also eccentric EMG activity of the knee extensors. Similarly, a specific warm-up using explosive half squats has been shown to increase countermovement jump height as well

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as quadriceps EMG activity (Sotiropoulos et al., 2010). As a result of these studies, it is believed that sports specific warm-ups should include dynamic activities that involve the specific muscles that will be utilized during the sport.

Baseball is one of the world's most popular sports, with over 3 million children playing annually in the United States and many of these children continuing their careers into high school and college (Melugin, Leafblad, Camp, & Conte, 2018). Elbow injuries are common in baseball, with ulnar collateral ligament injuries having a prevalence somewhere between 15-25% from all levels of baseball (Reiman et al., 2019). More specifically to college players, roughly 20.9% of injuries sustained are to pitchers and are largely attributed to shoulder and elbow pathology (Melugin, Leafblad, Camp, & Conte, 2018). To prevent these injuries, it has been suggested that sport specific movements be incorporated into pitching warm-ups that involve stretching and strengthening exercises through full ranges of motion at the shoulder joint and specifically target the muscles activated during pitching (Melugin, Leafblad, Camp, & Conte, 2018; Oyama, 2012). One such program that is specific to baseball is the J-Band protocol; an elastic band system which comes with pre-programmed exercises aimed to reduce injury risk and increase performance (Cole, 2020). To evaluate the effectiveness of this program, the purpose of this study was to compare muscle activity in the triceps and the serratus anterior during two separate pitching sessions: one after a standard dynamic warm-up vs. one after a dynamic warm-up including the J-band program. It was hypothesized that the inclusion of the J-Band protocol would produce greater muscle activity in the triceps and the serratus anterior during a subsequent pitching session.

2. Materials and Methods

2.1. Subjects

Participants consisted of n=14 National Collegiate Athletic Association (NCAA) Division II male pitchers (Height: 185.05 ± 5.62 cm; Weight: 85.73 ± 10.28; Age: 20.45 ± 1.02 years). All participants were notified of the benefits and risks of participation and completed an informed consent and a PAR-Q+ form prior to participation. Participants were required to attend two testing sessions in random, counterbalanced order and were asked to refrain from any pitching for two days before both the Dynamic Warm-Up Only and the Dynamic Warm-up Plus J-Band testing sessions.

2.2. Apparatus and Task

Muscle activity was measured for the triceps brachii and serratus anterior using surface EMG (iWorx Systems Inc. Dover, New Hampshire) during 5 fastballs at max intensity. Prior to placing EMG sensors, participant's skin was then prepared by exfoliation with redux paste and hair was removed, if necessary, to reduce signal impedance. The underside of the sensors was attached to the skin with double-sided adhesive tape and then the outside of the sensor was further secured with adhesive stretch tape. Maximal voluntary isometric contractions (MVICs) were recorded for normalization purposes and testing positions for MVICs are displayed in Table 1. Sensor placements were determined from the *Cram's Introduction to Surface Electromyography*, and are listed in Table 2 (Criswell, 2010).

The Dynamic Warm-up Only testing session began with each participant performing a light 5-minute jog, 20 forward arm circles, 20 backwards arm circles, and 2 sets of 25 meters high knees and butt kicks. They concluded with 25 light tosses at approximately 50% of maximal intensity as they would if they were preparing for a bullpen session.

The Dynamic Warm-up Plus J-Band consisted the same dynamic warm up from the Dynamic Warm-up Only session and then was followed by one set of 25 repetitions was performed of the following J-Band exercises**:** overhead forearm extensions, side extensions, diagonal extensional, forward flies, reverse flies, internal rotation, external rotation, elevated internal rotation, elevated external rotation, and forward motion throwing (Cole, 2020). This warm-up protocol was utilized because it is thought to specifically targets upper body musculature which is active during pitching, thus reflecting a sport or task specific warm-up which has been suggested to enhance sport specific performance (Samson, Button, Chaouachi, & Behm, et al., 2012).

Table 1.
MVIC Location and Measurement

Muscles	Measurement
Triceps	Sitting with the shoulder at approximately 90 degrees' abduction with the arm 90 degrees flexed and the palm of the hand pointing downwards. Extend the elbow while applying pressure to the forearm in the direction of flexion.
Serratus Anterior	Arm elevation to 90 degrees with resisted scapular protraction.

Table 2.
Muscle Sensor Location

Muscles	Location
Triceps	Electrodes were placed at 50% on the line between posterior crista of the acromion and the olecranon at 2 finger widths medial to the line.
Serratus Anterior	Participant flexed arm against resistance and contraction area was palpated anterior to the border of the latissimus dorsi at the level of the inferior tip of the scapula. Electrodes were placed below axillary area medial of the latissimus dorsi.

2.3. Procedures

The two testing sessions were separated by a minimum of 48 hours but were completed within seven days of one another. During the first attended session, anthropometric measures were taken while wearing a t-shirt and gym shorts. Height was assessed to the nearest 0.1cm using a stadiometer and body mass determined using a digital scale to the nearest 0.1 kg.

The participants then began either the dynamic warm-up only testing day or the dynamic warm-up plus J-Band testing day. Participant's skin was then prepared and surface EMG electrodes were attached to the skin using double sided adhesive tape. MVICs were recorded to be used for normalization of muscle activity in the serratus anterior and the triceps. The serratus anterior and triceps were tested because they are two of the most active muscle groups

during pitching; therefore, a warm-up protocol designed for pitching should elicit an increase in muscle activity for these muscles (Jobe, Tibone, Moynes, & Perry, 1984; Smidebush, 2018; Werner, Fleisig, Dillman, & Andrews, 1993). When sensor placement was complete, participants were allowed 3 warm-up pitches from the mound to adapt to the EMG electrodes. Following these participants threw 5 fastballs at max intensity from an NCAA approved pitching mound with the EMG connected to record muscle activity data and one minute of rest was provided between pitches.

During the J-Band Testing Session, procedures were identical to those in the Dynamic warm-up including the warm-up procedure, electrode placement, and normalization. After normalization was complete, participants completed the Dynamic Warm-up Plus J-Band. After the J-band warm-up was performed, the participant rested for 2 minutes to mitigate any effects of fatigue from the J-band protocol. After the rest period concluded, the participant performed their 3 warm-up pitches followed by their 5 pitches recorded for EMG analysis. The IRB protocol number for this study is 2020017.

2.4. Data Analysis

All EMG data was normalized to the maximal value MVIC data collected for each participant during training session to represent muscle activation as a % of peak muscle activity. A band-pass filter was applied to the EMG signal with cut off frequencies of 20 and 450 Hz and data signals were full-wave rectified and smoothed using a root-mean-square (RMS) procedure (Korak, Paquette, Fuller, Caputo, Coons, 2018; Mehls, Grubbs, Jin, & Coons, 2020). For EMG analysis, the peak and average amplitude for each pitch was entered in the final statistical analysis. All data analysis was conducted using iWorks LabScribe Version 4.01400 and Microsoft excel (2016).

All statistical analyses were performed using IBM SPSS Statistics 24 (Armonk, NY). Peak and average muscle activity was calculated for each of the 5 pitches thrown by each pitcher, resulting in a total of 70 pitches being entered into the analysis. Four independent sample t-tests were used to compare the differences in peak and mean muscle activity during pitching with and without the J- band warm-up in the triceps and serratus anterior. A significance level of $P \leq 0.05$ was set for all tests and effect sizes were calculated using Cohen's *d*.

3. Results

Normalized muscle activity data are presented in Table 3. The pitchers displayed a significantly higher amount of average muscle activity during the bullpen session following the J-Band session for the triceps compared to the dynamic only days ($t_{(70)} = 2.021$, $p = 0.047$, $d = 0.336$, 95% *CI* [-.790, 005]). However, there were no significant differences between the average muscle activity for the serratus anterior ($t_{(70)} = 1.742$, $p = 0.086$, $d = 0.304$, 95% *CI* [-.925, 13.67]). There were no significant differences between groups for muscle activity comparing peak values for triceps ($t_{(70)} = 1.404$, $p = 0.165$, $d = 0.238$, 95% *CI* [-1.30, .226]) or serratus anterior ($t_{(70)} = 1.781$, $p = 0.079$, $d = 0.298$, 95% *CI* [-.358, 6.33]).

Table 3.
Normalized Muscle Activity Data (M ± SD)

	Dynamic + J-Band Warm-up		Dynamic Warm-up Only	
	Triceps	Serratus Anterior	Triceps	Serratus Anterior
Muscle Activity	0.749 ± 1.66	0.987 ± 0.844	0.352 ± 0.202	3.97 ± 13.87
Peak Muscle Activity	1.42 ± 3.16	2.29 ± 2.17	0.882 ± 0.468	8.66 ± 30.17

4. Discussion and Conclusion

The current study examined the effects of a J-Band warm-up protocol on muscle activity during pitching in triceps and serratus anterior. Significantly greater average muscle activity was seen in the triceps during pitching after the use of the J-Band warm-up, demonstrating greater recruitment of motor units and potentially helping to reduce injury to the elbow through greater stabilization of the joint. To date several studies have investigated both muscle activity patterns during pitching (DiGiovine, Jobe, Pink, & Perry, 1992; Escamilla & Andrews, 2009; Gowan, Jobe, Tibone, Perry, & Moynes, 1987; Jobe, Tibone, Perry, & Moynes, 1983; Jobe, Tibone, Moynes, & Perry, 1984) and the effects of different warm-ups on pitching accuracy and velocity (Escamilla, Fleisig, Barrentine, Andrews, & Speer, 2000; Haag, Wright, Gillette, & Greany, 2010; Williams, Harveson, Melton, Delobel, & Puentedura, 2013). However, only one has examined changes in muscle activity during pitching as a result of a sports specific warm-up which found that utilizing a heavy baseball during pitching warm-ups reduced muscle activity of the triceps brachii during maximal effort pitching (Shin & Choi, 2018).

Pitching is a complex motion that requires the use of several joints and produces large forces, making the exact identification of proper form difficult, though several studies have examined the role of the triceps brachii in pitching. Existing older studies support that the triceps are most active during the acceleration phase of pitching, which is characterized by maximum abduction and external rotation at the shoulder as well as elbow extension. These studies proposed that the triceps brachii were actively adding velocity to the pitch during elbow extension and serving as a primary mover through the pitching motion (Jobe, Tibone, Moynes, & Perry, 1984; Werner, Fleisig, Dillman, & Andrews, 1993).

However, a later study conducted by DiGiovine, Jobe, Pink, & Perry (1992) saw triceps activity highest during the acceleration phase of the pitch and these authors believe the triceps were not primarily responsible for increasing ball velocity. They contend that the lower body and trunk work to generate large amounts of torque which ultimately are responsible for the angular velocity at the elbow. Therefore, while triceps extension does occur and angular velocity at the elbow increases during the acceleration phase of the pitch, they believe that this increase in triceps muscle activity functions to maintain the elbow joint's position and stability (DiGiovine, Jobe, Pink, & Perry, 1992). This view has been

supported by a review article that notes several studies have shown that the majority of angular torque at the elbow during pitching is generated through the lower body, not from the extension of the elbow (Escamilla & Andrews, 2009). While the present study did not examine muscle activity during each phase of the pitch, the results support the notion that the triceps function as stabilizing musculature during pitching as average muscle activity increased after the use of a J-band warm-up.

Stabilization at the elbow is vital to injury prevention. Although "perfect" pitching form has not been established, there are certain pitching mechanics that may place increased valgus stress at the elbow (Hibberd, Brown, & Hoffer, 2015). Excessive valgus torque can increase stress to the ulnar collateral ligament (UCL) and lead to injury (Hibberd, Brown & Hoffer, 2015; Melugin, Leafblad, Camp, & Conte, 2018). Existing literature suggest that the triceps act as dynamic stabilizer during pitching to assist the UCL in prevention of excessive elbow valgus (Feltner & Dapena, 1986; Fleisig & Escamilla, 1996; Werner, Fleisig, Dillman, & Andrews, 1993). The results of this study support that completing a J-band warm-up increased triceps muscle activity, thus including a j-band warm-up for collegiate pitchers to increase activation of the triceps may further stabilize the elbow and may assist in the prevention of UCL tears. However, the triceps also has been shown to act as a decelerator during pitching, and this study demonstrates that this may be occurring through a primarily isometric contraction. It is feasible that this is less efficient movement and may lead to increased fatigue and injury. Future research should investigate the effects of increased average muscle activity during movement and its potential effects on fatigue and injury risk.

Effective warm-up protocols prepare the body for the increased physiological demand of exercise and sport performance as well as prevent injury, but there currently remains limited data regarding the effect of sports specific warm-ups in collegiate baseball (Gil, Neiva, Sousa, Marques, & Marinho, 2019; Melugin, Leafblad, Camp, & Conte, 2018). When utilizing a warm-up protocol consisting of banded exercises and hip thrusts to target the gluteal muscle groups, researchers found no difference between the warm-up and control group in gluteus maximus or rectus femoris activation when performing countermovement jumps and short sprints (Pinfold & Cochrane, 2018). These findings are somewhat contradictory to the present study which saw an increase in average muscle activity of the triceps following the use of a band-style activation warm-up. The mixed results that have occurred with studies examining activation warm-ups are likely linked to the highly complex nature of the movements examined as well as the specificity of the warm-ups employed. Taking the present study as an example, the J-Band protocol contains several exercises which specifically target the triceps brachii, while none specifically target the serratus anterior. This likely explains why enhanced muscle activation was seen in the triceps following a J-band warm-up, but not in the serratus anterior.

This study was not without limitations, first being the sample size. While statistical significance was achieved for some variables, it is possible that a larger sample population would have yielded more robust results. A second limitation was that the researchers did not control the amount of time it took to place the EMG electrodes or the total warm-up time which could have had deleterious effects on the muscle activity seen during the subsequent pitching session. Additionally, this study only examined the muscle activity of the triceps brachii and serratus anterior. There currently is a limited body of literature regarding the effects of varied warm-ups on muscle activity during pitching which should be expanded. Furthermore, it would appear that the effects of different warm-up protocols vary based on a number of factors, and future studies should work to examine the effects of specific warm-ups on complex movement patterns that occur in sport.

The elbow joint is one of the most commonly injured in baseball pitchers at all levels. Preventing injury to this joint is paramount to pitching success and can be difficult because of the complex nature of the pitching motion. The triceps brachii appears to function as a stabilizing muscle to the elbow joint during pitching. This study supports the use of a J-Band warm-up as a means to enhance triceps muscle activity during baseball pitching in Division II colligate baseball pitchers to stabilize the elbow and potentially reduce injury by providing greater stabilization and efficient force transfer around the elbow joint.

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Conflicts of interest

The Authors declare that there is no conflict of interest.

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