COMPARISON OF KINEMATICS AND ACCURACY OF OVERHAND AMERICAN FOOTBALL THROWING.

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This study examined elbow angle, wrist velocity and throwing accuracy during American Football throws. Six repetitions of three types of throws: Self-selected pass (SS), Lob pass (L), and a Bullet pass (B); were performed to hit a point scaled target from 10.97 m. Independent variables were frontal plane shoulder angle (more or less than 90°) and throw type; dependent variables were elbow angle in the sagittal plane, wrist velocity at ball release, and accuracy. There were no differences for shoulder angle for any variable; while throw types differed only for wrist speed (highest to lowest B, SS, and L). Significant interactions occurred for all variables. These findings suggest that recommendations for American football throwing technique are complicated by the combination of throw type and shoulder angle; and that with no restrictions subjects will throw with more accuracy.

KEY WORDS: Shoulder angle, Wrist speed, Elbow angle, Quarterback

INTRODUCTION: The overhand throw in American football has two very specific objectives; it must be quick to get the ball out of the quarterback's hand and it must be precise in getting to the desired location at the desired time. Hore, Watts, and Tweed (1996) investigated the errors associated with inaccurate throws in general. They noted that hand trajectory, position of ball at release and precise control of joint rotation are needed for an accurate throw. Furthermore, they noted that joint rotation was the cause of most inaccurate throws. They found the height the ball, where the ball struck the target, had no relationship to hand trajectory. Also with fast, arm-only, throws inaccuracy came from inappropriate timing of ball release (Hore et al., 1996). The understanding of the biomechanics for a football throwing motion has developed as the demands of these players have changed (Escamilla & Andrews 2009). Coaches recommend certain techniques that they feel will produce the best throwing performance (Austin, 2011; Kreuger, n.d.; Kerr 2013). Some of these recommendations include having the humerus parallel with the ground, putting your shoulder to your ear, stepping toward the target, and ending the throw with the thumb pointing down. However, there has been very little research conducted on the kinematics of football throwing under a variety of throwing conditions.
Baseball and Football throws are different as evidenced by the work done by Fleisig, et al. (1996). While prior research has examined the biomechanics of various stages of the overhand football throw (Kelly, Backus, Warren, & Williams, 2002), there appears to be a lack of literature on throwing performance. We know the muscle activity EMG of upper body muscle involved in throwing (Escamilla & Andrews 2009). With this current knowledge, does a shoulder angle matter for performance of a football throw? Will a cutoff of 90° for a shoulder angle hinder or increase performance of a subject throwing a football at a target. We hypothesize that a shoulder needs to have an angle above 90° to achieve improved throwing results.

METHODS: Five male subjects that were right hand dominant (24.4 ± 2.3 years, 1.85 ± 0.1 m, 98.4 ± 12.9 kg, football experience 7 ± 3.5 years) provided informed consent to participate in the current study, approved by the local Ethics Board. All subjects had received at least one year of coaching at least high school or above in American football, and had no history of recent injuries that would hinder normal throwing motion. A warm up consisted of a 5 min walk, 1 min of trunk twists, 30 s arm circles, above the head, arm stretch (30 s each arm), cross body shoulder stretch (30 s each arm), 2 minutes of throwing from one knee, and easy throws to keep the arm warm until data collection.
Following the warm up: the same tester placed reflective markers on the dorsal wrist, medial and lateral epicondyles of the elbow, head of the humerus of the throwing arm and anterior

superior iliac spine on the same side. Prior to each trial subjects received the following instructions: hold the ball in the ready position in the right hand and the tip of the ball just above the hip on the right side.

Each subject completed 18 throws, with the objective of scoring the maximum number of points for each throw at a target, which was 10.97 m away and had color-coded point areas. For six self-selected (SS) passes, subjects could throw in whatever way they felt would produce the most points. For six lob passes, the stipulation was to have the ball go over a rope that was suspended horizontally 3.05 meters above the ground. For six bullet passes, they were instructed to throw at 75-100% of maximum arm speed with a throw that travelled under the above-mentioned rope. These throws simulated throws that a quarterback would make throughout the normal progression of a game or practice.

Approximately 30 s rest was instituted between throws to allow for collection of the ball and verification of successful data collection. The throws were always in the order of self-selected, lob and bullet pass and were thrown one after another.

Kinematic data were captured using six infrared 3D motion analysis cameras at 200 Hz (three Hawk cameras and three Raptor cameras) via Cortex software version 2.5 (Motion Analysis Corporation, Santa Rosa, CA). Marker coordinate data were tracked by Cortex software, using the cubic join function to join gaps in the marker coordinate data. A low pass, 12 Hz Butterworth filter was applied to the kinematic data. The following variables were examined relative to type of throw and whether frontal plane shoulder angle was greater or less than 90 degrees: 1) accuracy points; 2) elbow flexion-extension angle at the point of release; and 3) wrist velocity at the point of release.

Release point of the ball was defined as the point when the distance between the markers on the wrist and ball was greater than the average and two times the normal standard deviation of this distance as calculated from the initial stages of the throw. This technique is similar to that used for a deviation from baseline for electromyography (Di Fabio, 1987).

Statistical analyses were performed using SPSS 18.0 (SPSS Inc., Chicago, IL; USA). A two-way ANOVA (type of throw X shoulder angle) was used to compare differences across trials for the dependent variables of points, wrist speed, and elbow angle. Significance was set at $p < 0.05$. When significant main effects were present, Bonferoni corrected pair-wise comparisons were performed.

RESULTS: For all below figures SS = Self-Selected, Lob = Lob Pass, Bullet = Bullet Pass. There were no differences in the points accumulated with the different shoulder angles between the three throw types ($p > 0.05$) but there was a significant interaction within the variables (see Figure 1).

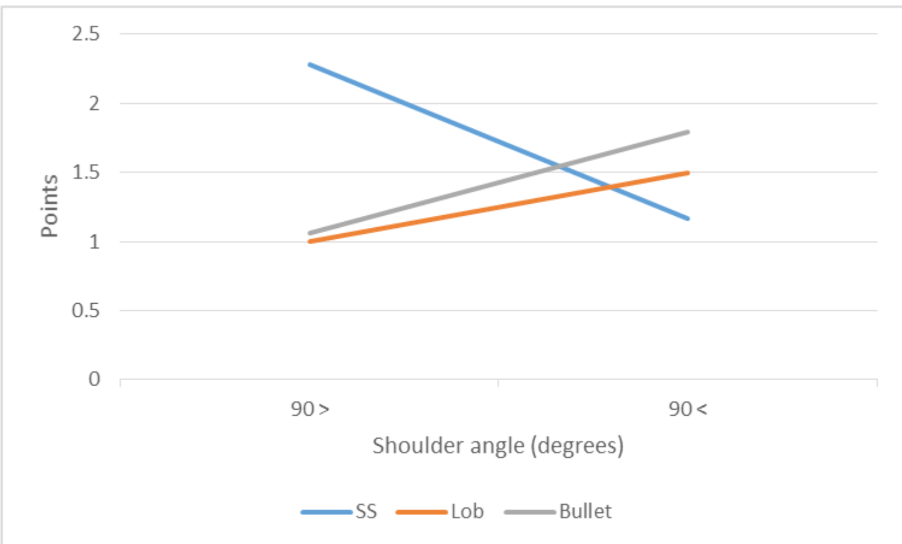

Figure 1. Comparison of Mean points scored for three throw types by shoulder angle (greater or less than 90º).

The elbow angle also had no differences between the three throw types or shoulder angles ($p > 0.05$), but there was again a significant interaction within the variables (see Figure 2). Wrist velocity had again no difference between shoulder angles ($p > 0.05$), but all three throw types were different ($p < 0.05$). In addition, there was not a significant interaction ($p > 0.05$) as illustrated in Figure 3.

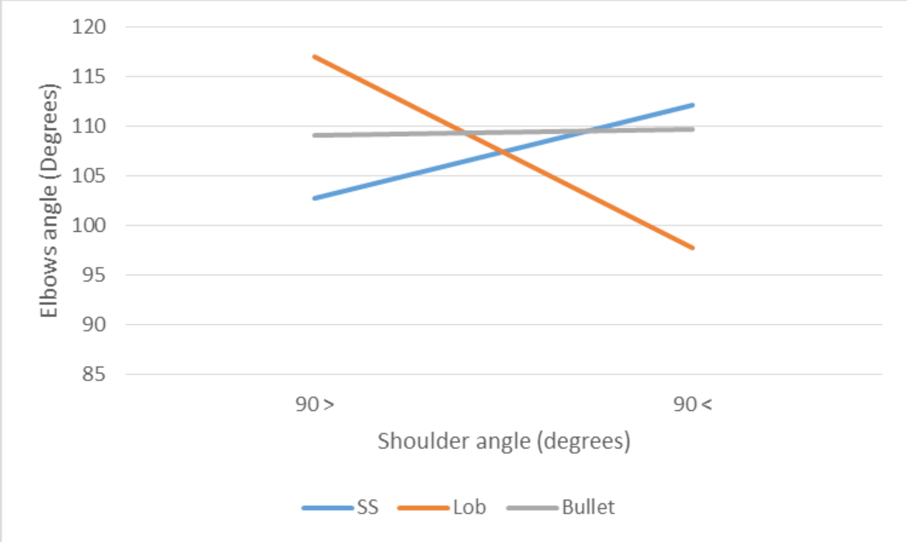

Figure 2 Mean elbow angle comparison of throw type by shoulder angle (greater or less than 90º).

Figure 3 Mean wrist speed comparisons of throw type by shoulder angle (greater or less than 90º).

DISCUSSION: For the SS throw, when the shoulder was angled less than 90° the scores were the highest. These findings disagree with recent research by Kerr (2013) It is possible that without specific constraints of throwing a particular pass (SS) that the subjects felt the most comfortable throwing with the below 90 shoulder angle. For the lob and bullet throw, more points were scored when the shoulder was more than 90°, which was in agreement with Kerr (2013). This suggests that greater shoulder angle will result in better accuracy for this type of throw. When not constrained by the type of throw and shoulder position, modifications to improve accuracy may be possible.

Similar to points scored there were no differences across throw type or shoulder angle for elbow angle, but there was a significant interaction of the main effects ($p < 0.05$). In this case, the lob pass and SS displayed opposite tendencies; shoulder angle greater than 90° resulted in lesser elbow angle for the Lob and greater for the SS while the bullet pass did not change (see Figure 2). Previous literature has not addressed these situations; and because elbow angle changes were different from those of points scored (Figures 1 and 2), it is unknown how elbow angle effects accuracy.

Wrist speed differed for all three-throw types, but there was no difference between shoulder angles (see Figure 3). The difference between throw types was not unexpected, as the lob required the athlete to throw the ball with an arc while the bullet pass led to a more “straight line” throw with the SS being in between the other two. Similar to the elbow angle, changes in wrist speed did not match up with points scored for the various throw types (Figures 1 and 3). A limitation of the current study was that while the subjects all had experience in throwing a football, none was self-described quarterbacks, the individuals who throw most frequently in American Football. Further research is recommended with experienced quarterbacks who may display different techniques for the types of throws used in the current study. Another future study would be to separate the different throws by individual types to see what the changes take place according to different heights over or under the obstacles that the subjects will have to maneuver. As in example, for the lob pass, the subjects should throw over different height requirements; and the bullet pass should have a maximum height that the ball can travel vertically.

CONCLUSION: The major findings of the current study were that the interaction of variations in shoulder angle (greater or less than 90º of shoulder abduction) and throwing type resulted in changes in wrist speed, elbow flexion and accuracy of throwing as determined by points scored. In addition, there was a difference in wrist speed with different types of throws (see Figure 3). These findings suggest that recommendations for American football throwing technique are complicated by the combination of throw type and shoulder angle.

This study set out to find out if the shoulder above 90º would be the most accurate. When looking at athletes with limited quarterbacking experience throwing a football, we see that for the bullet and lob pass the greater then 90º shoulder angle does produce more points. Although when the subjects have no restrictions, they may feel more comfortable, throwing the football with less than 90º shoulder angle abduction in the frontal plane as these subjects accumulated the highest point average, which means they performed best.

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