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Kinematics and kinetics of two different overhead throws: passing and pitching

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Kinematics and Kinetics of Two Different Overhead Throws: Passing and Pitching

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ABSTRACT:
Study Design: Controlled Laboratory Study.

Objective: The purpose of this study was to examine kinematics and kinetics of the overhand throwing motion while throwing a football pass and a baseball fastball pitch.

Background: Though the football throw seems similar to the overhand baseball throw except for the weight of the balls [.42kg football versus .14 kg baseball] the weight has been shown to affect shoulder position and stress throughout the throwing motion [6,11]. In addition, a football quarterback is at risk of shoulder injury as is a baseball pitcher. It is often stated that football quarterbacks are at risk of shoulder injury secondary to both the throwing motion and direct contact. No matter the weight of the ball, there should still be proper kinematics and sequential activation of the kinetic chain. Previous studies have been conducted examining those individuals who played baseball pitcher versus those who were football quarterback [6]. However there has yet to be a study examining those individuals who are dual sport players, baseball pitcher and football quarterback. Therefore the purpose of this study was to examine throwing kinematics and sequential activation of the segments of the same individual while throwing both a football pass and a baseball fastball pitch. It was hypothesized that both throws would display sequentiality; however, the baseball throw would have greater segmental speeds and there would be significant differences between throwing kinematics.

Methods: Kinematic analysis was performed while 12 male athletes who play dual positions of quarterback and pitcher performed the two overhand throws: football

passing and baseball pitching. Data were collected and analyzed for the four major events (foot contact, maximum shoulder external rotation, ball release, and maximum shoulder internal rotation) during the overhand throwing motion.

Results: A multivariate analysis of variance revealed that there were significant differences between football and baseball throwing at foot contact in the degree of elbow flexion in the throwing arm and in the velocity of hip rotation among the two throws ($p \leq .05$). There was also a significant difference at maximum external rotation in the degree of elbow flexion in the throwing arm ($p \leq .05$).

Conclusions: This study examined overhand throwing mechanics during both a football pass and a baseball pitch. Results showed that differences existed between football and baseball throwing. Throwing mechanics of individuals who play both positions of quarterback and pitcher are similar to previous data describing the two throws. Although this study did not pinpoint specific benefits from playing both pitcher and quarterback, it appears that there are no consequences to the throwing motions of athletes who play both positions. Further study with perhaps a larger sample size could look to see if injury susceptibility was higher due to more throwing and training over the course of time.

Key Words: Baseball pitching, football passing, segmental speeds

Proper kinematics and kinetics of overhead throws are essential to achieving optimal performance with minimal risk of injury. Previous studies have examined the kinematics and kinetics of both throwing a baseball and a football, and one study in particular compared these throws noting key similarities and differences [6]. No studies, however, have examined the two throws from the same individual. Therefore, this study analyzed the kinematics and kinetics of a football pass and a baseball pitch of individuals who are dual position players of football quarterback and baseball pitcher.

By examining individuals who are dual sport athletes, I hoped to determine benefits or consequences or both that may occur due to the dual participation of quarterback and pitcher. These benefits may include stronger performance in one or both of the sports as well as greater injury resistance. Consequences of dual participation may result in improper mechanics, leading to diminished performance and greater prevalence for injury. Youth participation in the overhand sports of football and baseball throwing could be of a concern. Though there are few data available regarding youth injuries in football passing, there are numerous studies of youth pitching participation in baseball and their relation to injury. If improper mechanics are noticed in the participants' two different throws, and the deviations from the normal kinematics and kinetics of each of the two throws are significant, then participation in both sports as both a quarterback and a pitcher possibly could lead to greater injury susceptibility.

OVERHAND THROWING

The overhand throw is considered a dynamic movement that involves not only skill, but also the proper coordination of all body segments [1]. Papas, Zawacki, and Sullivan [16] went so far as to describe the skill of baseball pitching as the sequential activation of the skeletal musculature throughout the kinetic chain. This sequential activation begins with the contralateral foot and is transferred up the trunk, through the shoulder, to the wrist and hand for acceleration of the ball.

It is known that with the proper throwing mechanics, individuals are able to achieve optimal performance with minimal risk of injury. When throwing overhead, there is a proximal to distal sequencing supplied by the kinetic chain. Alterations in this sequential motion could result in decreases in not only ball velocity, [16] but more importantly, increased injury potential [9,10].

Habitual motor patterns of the upper extremity are dependent upon lower extremity and torso muscle activation prior to any upper extremity muscle activation [19]. With any overhead throwing movement, there is a particular sequential timing of torso rotation, as well as scapular and humeral positing. With different types of overhead throwing, these variables could be altered in their timing but typically not in their sequentiality.

In general, the overhand throw can be divided into six phases (windup, stride, arm cocking, arm acceleration, ball release, and follow through) or four major events (foot contact, maximum shoulder external rotation, ball release, and maximum shoulder internal rotation). Two of the more popular sporting skills that incorporate overhead throwing are the baseball pitch and the football pass. The two skills are

very similar; however, each throw encompasses its own identity. Both skills, pitching and passing, incorporate each of the six phases. And though the two throws are similar, the weight of the ball is quite different. A football weighs 426g while a baseball weighs 142g. Due solely to the weight of the ball being propelled, throwing mechanics may be altered. Therefore, it was the purpose of this study to examine overhand throwing mechanics during both the football pass and the baseball pitch.

BACKGROUND

Youth participation in baseball and football has risen as the overall youth male participation in sports has reached 69.9% [15]. With the popularity of the two sports, it is not uncommon to have youth participating in both sports. Often if one is the baseball pitcher, he is also the football quarterback. The reason these youth are able to switch back and forth from pitcher to quarterback is that the overhand throwing mechanics are essentially the same, while the main difference is the weight of the ball.

Since a baseball is lightweight, strength training for baseball pitchers is commonly performed with a football (426g). Previous research has demonstrated that weighted ball training in pitchers has resulted in increased ball velocities. Similarly, quarterbacks have trained with lighter balls in attempt to increase arm velocity and gain a quicker release [3].

With youth participation within the two sports on the rise, there has been an increase in those youth participating in both pitching and passing. Youth participation in the overhand sports of football and baseball throwing could be of a concern.

Though there are few data available regarding youth injuries in football passing, there are numerous studies of youth pitching participation in baseball and their relation to injury. There has been such a concern of injury in youth pitchers that Little League Baseball began prohibiting a participant from playing catcher and pitcher in the same game in 2009. In addition, prospective injury studies have been conducted on youth participating in baseball that have revealed pitching more than 100 innings in a year significantly increases the risk of injury [5]. However, there has yet to be any type of data assessing youth football quarterbacks.

Much of the overhand throwing literature has been focused on the baseball pitch [2,4,8] with minimal focus on the football throw [17]. Though injury data have been documented on baseball pitching, the lack of injury documentation on football throwing does not mean that this overhand throw is not susceptible to youth injury. If improper mechanics occur in the participants' two different throws, and the deviations from the normal kinematics and kinetics of each of the two throws are significant, then participation in both sports as both a quarterback and a pitcher could lead to greater injury susceptibility.

RESEARCH DESIGN & METHODS

Twelve male athletes from the northwest Arkansas area with a mean age, mass, and height of 15.9 $\pm$ 4 yrs, 179.4 $\pm$ 19.7 cm, and 82.8 $\pm$ 23.7 kg respectively, volunteered to participate in the study. All participants were actively participating in both football and baseball. In addition, the participants all held the positions of quarterback and pitcher. Throwing arm dominance was not a factor contributing to participant

selection or exclusion for this study. All data collection sessions were conducted indoors at the University of Arkansas' Health, Physical Education, and Recreation building and were designed to best simulate a game situation for both pitching and passing. The University's Institutional Review Board approved all testing protocols used in the study, and prior to participation the approved procedures, risks, and benefits were explained to all participants. Informed consent was obtained from the participants, and the rights of the participants are protected according to the guidelines of the University's Institutional Review Board.

Participants reported for testing prior to engaging in resistance training or any vigorous activity that day. Kinematic and kinetic data were collected using The MotionMonitor^{TM} motion capture system (Innovative Sports Training, Chicago, IL). Participants had a series of 10 electromagnetic sensors (Flock of Birds Ascension Technologies Inc, Burlington, VT) 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 leg shank; (8) distal/posterior aspect of the stride leg femur; (9) distal/posterior aspect of non-stride leg shank; and (10) distal/posterior aspect of non-stride leg femur [12].

Participants were then allotted an unlimited time to perform their own specified pre-competition warm-up routine. During this time, participants were asked to spend at least five minutes of their warm-up throwing from the indoor

pitching/throwing surface to be used during the test trials. After completing their warm-up and gaining familiarity with the pitching/throwing surface, each participant was instructed to either throw a series of maximal effort fastballs for strikes toward a catcher located the regulation distance from the throwing surface (18.4 m). Or they were instructed to pass the football to a receiver located at the same distance. Throwing distance was the same for both the baseball pitch and football pass to attempt control for velocity and mechanical variation. The order of pitching and passing was randomized. The pitching/throwing surface was positioned so that the participant's stride foot would land on top of a 40 x 60 cm Bertec force plate (Bertec Corp, Columbus, OH). For the study, those data from the fastest pitch through the strike zone or fastest pass completed to the receiver was selected for detailed analysis [7,13,14,18]. A JUGS radar gun (OpticsPlanet, Inc., Northbrook, IL) was used to determine ball velocity.

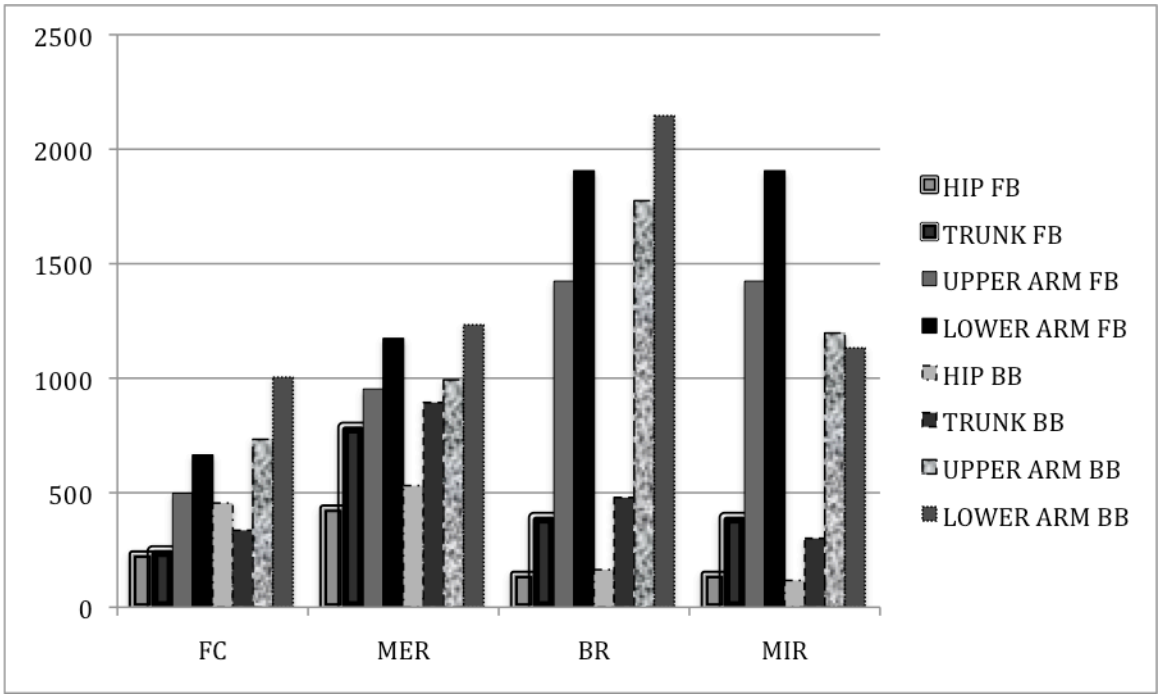
Of the kinematic data recorded, data analyzed were focused on eight factors: shoulder plane of elevation, shoulder elevation, shoulder rotation, elbow flexion, hip rotational speed, trunk rotational speed, upper arm rotational speed, and lower arm Data were analyzed using an analysis of variance (ANOVA) with a level of significance set at $p \leq .05$.

Results

The means and standard deviations of the shoulder and elbow kinematic and kinetic data were analyzed for each phase of foot contact (Table 1), maximum external rotation (Table 2), ball release (Table 3), and maximum internal rotation (Table 4). Segmental sequentiality of hip, trunk, upper arm, and lower arm were also analyzed

(Figure 1). These data are also displayed for each phase of foot contact (Figure 2), maximum external rotation (Figure 3), ball release (Figure 4), and maximum internal rotation (Figure 5). A multivariate analysis of variance revealed that there were significant differences between football and baseball throwing at foot contact in the degree of elbow flexion in the throwing arm and in the velocity of hip rotation among the two throws ($p \leq .05$). There was also a significant difference at maximum external rotation in the degree of elbow flexion in the throwing arm ($p \leq .05$). Examining the segmental sequentiality, it is evident that sequential activation takes place as the hip and trunk speeds for both football and baseball peak earlier in the throw at maximum external rotation while the upper and lower arm speeds for both football and baseball peak at ball release. When comparing the speeds of each segment between football and baseball, at every phase baseball speeds are higher than the football. The only point where this trend does not occur is the upper and lower arm speeds at maximum internal rotation. Additional data analyses are included in Appendix A.

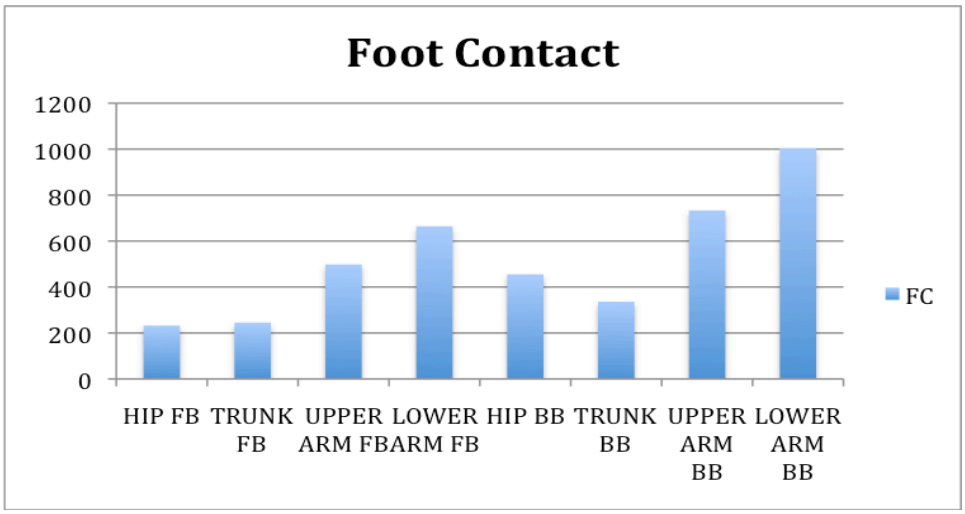
Figure 1: Segmental Sequentiality of Hip, Trunk, Upper Arm, and Lower Arm



Legend:

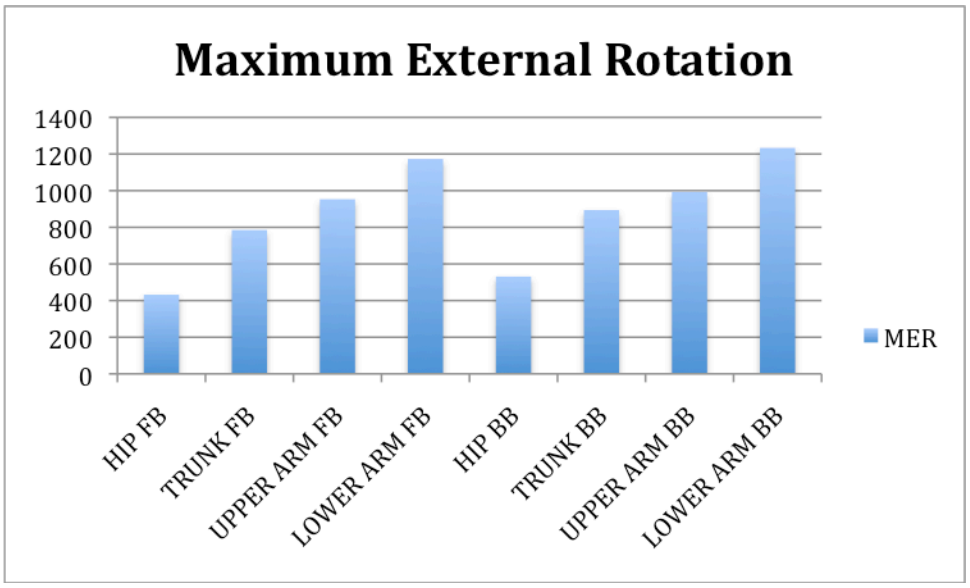
Y-axis:	deg/sec
X-axis:	FC=Foot Contact
	MER= Maximum External Rotation
	BR= Ball Release
	MIR= Maximum Internal Rotation

Figure 2: Segmental Sequentiality of Hip, Trunk, Upper Arm, and Lower Arm at Foot Contact



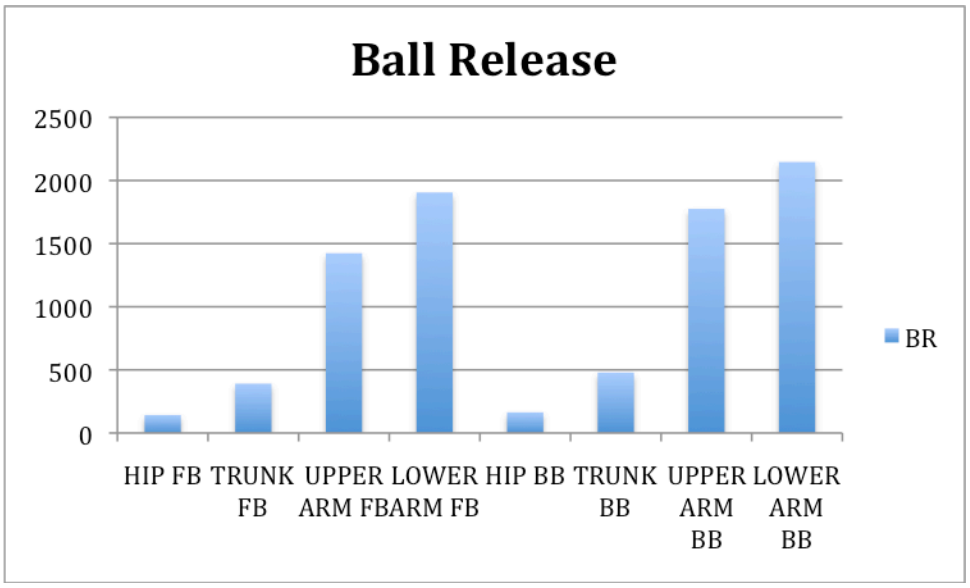
Legend: Y-axis: deg/sec

Figure 3: Segmental Sequentiality of Hip, Trunk, Upper Arm, and Lower Arm at Maximum External Rotation



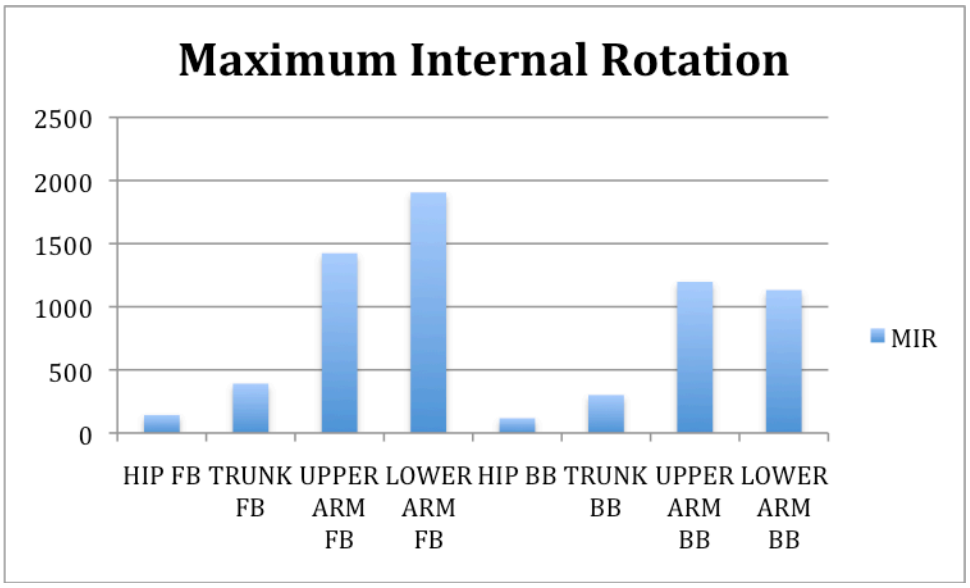
Legend: Y-axis: deg/sec

Figure 4: Segmental Sequentiality of Hip, Trunk, Upper Arm, and Lower Arm at Ball Release



Legend: Y-axis: deg/sec

Figure 5: Segmental Sequentiality of Hip, Trunk, Upper Arm, and Lower Arm at Maximum Internal Rotation



Legend: Y-axis: deg/sec

Table 1: Shoulder and Elbow Kinematic and Kinetic Data at Foot Contact

Foot Contact	Football		Baseball	
	Mean	SD	Mean	SD
Shoulder Plane of Elevation (°)	36.9	31.2	37.7	33.4
Shoulder Elevation (°)	77.7	39.0	75.5	44.8
Shoulder Rotation (°)	122.7	45.6	102.1	64.1
Elbow Flexion (°)	86.2	25.4	60.3	32.9
Shoulder Moment (N)	2.3	4.5	5.3	10.5
Elbow Moment (N)	1.6	3.2	1.5	2.9

Table 2: Shoulder and Elbow Kinematic and Kinetic Data at Maximum External Rotation

Maximum External Rotation	Football		Baseball	
	Mean	SD	Mean	SD
Shoulder Plane of Elevation (°)	42.8	33.7	39.2	41.3
Shoulder Elevation (°)	81.2	32.3	66.1	37.1
Shoulder Rotation (°)	106.7	36.5	97.9	44.4
Elbow Flexion (°)	90.3	16.1	62.3	31.2
Shoulder Moment (N)	10.8	22.5	7.2	14.2
Elbow Moment (N)	1.6	3.2	6.0	13.0

Table 3: Shoulder and Elbow Kinematic and Kinetic Data at Ball Release

Ball Release	Football		Baseball	
	Mean	SD	Mean	SD
Shoulder Plane of Elevation (°)	43.0	32.2	32.6	31.8
Shoulder Elevation (°)	85.2	30.9	68.8	37.3
Shoulder Rotation (°)	103.7	34.0	92.0	43.6
Elbow Flexion (°)	53.3	19.7	39.3	21.8
Shoulder Moment (N)	18.1	40.9	16.1	32.6
Elbow Moment (N)	1.6	3.2	7.5	14.5

Table 4: Shoulder and Elbow Kinematic and Kinetic Data at Maximum Internal Rotation

Maximum Internal Rotation	Football		Baseball	
	Mean	SD	Mean	SD
Shoulder Plane of Elevation (°)	50.1	43.6	50.2	35.0
Shoulder Elevation (°)	87.6	28.2	69.8	31.1
Shoulder Rotation (°)	112.8	56.0	104.3	65.1
Elbow Flexion (°)	38.1	8.7	28.8	18.0
Shoulder Moment (N)	23.9	55.2	28.2	63.1
Elbow Moment (N)	1.6	3.2	7.9	22.7

Discussion

Proper kinematics and kinetics of overhead throws are essential to achieving optimal performance with minimal risk of injury. A previous study conducted by Fleisig and associates examined the kinematics and kinetics of both of these throws noting key similarities and differences [6]. However, the current study examined the two throws by analyzing the kinematic and kinetic data from individuals who are dual position players of football quarterback and baseball pitcher. Comparing Fleisig's data with the data from this study, it was determined that the overall results were very similar. Both studies found there to be significant differences for baseball and football throwing at foot contact for elbow flexion and hip speed. While Fleisig et al. focused their study on professional athletes only, this study examined a wider pool including junior high athletes as well. It is noteworthy that despite a wider range of age and experience, the results from this study still followed similar trends in kinematic and kinetic data to the Fleisig et al. study.

When examining the segmental sequentiality of each throw, it is important to look for the sequential activation of the skeletal musculature throughout the kinetic chain. This sequential activation begins with the contralateral foot and is transferred up the trunk, through the shoulder, to the wrist and hand for acceleration of the ball. Examining the results, it is evident that this sequential activation takes place as the hip and trunk speeds for both football and baseball peak earlier in the throw at maximum external rotation while the upper and lower arm speeds for both football and baseball peak at ball release. When comparing the speeds of each segment between football and baseball, at every phase baseball speeds are higher than the

football. This trend can be explained by the difference in the weight of the baseball and the football. The only point where this trend does not occur is the upper and lower arm speeds at maximum internal rotation. This exception is likely due to the weight of the ball no longer having an effect on the arm speed since it has already been released.

For future studies, it would be beneficial to increase the sample size and compare data between more defined groups. The varying age and experience levels of the athletes in this study make it difficult to determine specific benefits to playing both positions. If a future study could compare the throws of athletes across three main groups (junior high, high school, and college), then it would be possible to see how athletes' throws develop as they continue to train in both sports for a number of years.

Conclusion

This study examined overhand throwing mechanics during both the football pass and the baseball pitch. Results revealed that there were significant differences between football and baseball throwing at foot contact in the degree of elbow flexion in the throwing arm and in the velocity of hip rotation among the two throws and at maximum external rotation in the degree of elbow flexion in the throwing arm. It was concluded that the throwing mechanics of individuals who play dual sports and are in dual positions of quarterback and pitcher are similar to previous data describing the two throws. Although this study did not pinpoint specific benefits from playing both pitcher and quarterback, it appears that there are no consequences to the throwing

motions of athletes who play both positions. Further study with perhaps a larger sample size could look to see if injury susceptibility was higher due to more throwing and training over the course of time. The issue of football and baseball throwing mechanics deserves further study as their unique similarity lends to potential benefits in the future of athletic competition.

Appendix A

	F	Sig
Shoulder Plane of Elevation	0.204	0.652
Shoulder Elevation	3.174	0.078
Shoulder Rotation	1.482	0.227
Elbow Flexion	10.115	0.002*
Shoulder Moment	0.003	0.956
Elbow Moment	0.049	0.825
Hip Speed	4.192	0.044*
Trunk Speed	1.954	0.166
Upper Arm Speed	1.729	0.192
Lower Arm Speed	1.288	0.259

(*) P-value $\leq$.05

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