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Hip Abduction Strength and Its Relationship with Sequential Movement and Ball Velocity in Softball Players

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ABSTRACT

This study examined the relationship between hip abduction strength, segmental sequentiality of the upper extremity and ball velocity of throwing in softball positional players. Hip abduction strength, ball velocity, and related kinematics were collected on sixteen (167.7 ± 6.7 cm; 68.9 ± 10.4 kg; 19.2 ± 1.1 yrs) National Collegiate Athletic Association Division I softball players. The participant had to catch a simulated hit ball and perform her positional throw. A position player was on second base and only those throws that she was able to catch without stepping off the base were recorded. There was no significance in the relationship between hip, trunk, upper arm, or lower arm speed with hip strength or ball velocity though segmental sequentiality was exhibited for each participant.

INTRODUCTION

In any throwing sport, including softball, the quicker the ball can get from one player to another, the better. The velocity at which a player can throw a softball is a strong determinant in the success of the game. Softball is a team sport, and thus the team is only as strong as its weakest link. If this weak link can be identified and then quantified through analysis, then there is the possibility of strengthening it. In the throwing motion, the lower extremities generate power that is transferred to the upper extremities through the kinetic chain. The power generated in the lower extremities is transmitted through the core, shoulder, elbow, and on to the hand and ball as it is released.¹

This dynamic power is also generated from the core through the hips, therefore quantifying hip abductor strength is also of importance. It has been documented that strength produced in the lower extremity musculature is a critical contributor to baseball pitching velocity². Also, in reference to baseball pitchers, it has been shown that players who throw the fastest have the largest ground reaction forces, which suggests that a successful pitch depends on power that is generated through the lower extremity^{4,5}. In the overhand softball throw, as with the baseball overhand throwing motion, importance of energy generated through the lower extremity should hold true. It has been shown that in cases where individuals displayed sequentiality of their coordinated movements during the throwing motion, more ballistic energy was applied to the ball, which creates a higher ball velocity³. According to Oliver et al, kinematic alterations in the proximal segments may result in alterations in the distal segments³. Thus, assessment of proximal segmental strength such as hip abduction is of interest. It was the purpose of this research to examine hip abduction strength, sequentiality of the throwing motion, and their relationship to ball velocity in the softball throwing motion in an effort to determine if adaptations in either could change the success of the ball velocity in softball. This was done through

collection and analysis of kinematic data for simulated throws, hip abduction strength, and ball velocity of simulated throws.

METHODS

Sixteen collegiate softball players (167.7 ± 6.7 cm; 68.9 ± 10.4 kg; 19.2 ± 1.1 yrs) were recruited for this study. All the participants trained together as members of a National Collegiate Athletic Association Division I softball team. Data were collected during pre-season, in preparation for their competition season. The participants included catchers, infield, and outfield players.

All testing was done at the Health, Physical Education, and Recreation building at the University of Arkansas. All testing protocols followed the guidelines of the University's Institutional Review Board for using human participants. Prior to participation, the approved procedures, risks and benefits were explained to all participants and all participants gave their informed consent. For eligibility, participants had to be deemed injury free for the past six weeks and complete an injury history questionnaire. None of the participants were rejected from the study due to their answers on the questionnaire.

Participants were asked to not participate in resistance training or vigorous activity during the day before testing. Prior to throwing, participants had their voluntary maximum hip abduction strength tested. To test for hip abduction participants were in a side-lying position on a long table, on the non-tested side. The participants were strapped down at the waist and at the level of the lower thigh. A handheld dynamometer was affixed using the distal strap. A towel was placed below the dynamometer, and a thick blanket was placed between the knees for stabilization and comfort of the subject. Each participant was prompted to exert maximal force using the abduction movement from the hip for five seconds. There was a fifteen second rest

period between attempts, and the movement was repeated three more times. This testing protocol was performed bilaterally.

Kinematic data were collected using The MotionMonitor™ motion capture system [Innovative Sports Training, Chicago, IL] in order to visualize, digitize, and record the movements of the participants. Participants had a series of 10 electromagnetic sensors [Flock of Birds Ascension Technologies Inc., Burlington, VT] attached at the following locations: [1] medial aspect of c7; [2] medial aspect of pelvis at S1; [3] distal/posterior aspect of throwing humerus; [4] distal/posterior aspect of throwing forearm; [5-6] bilateral distal/posterior aspect of upper leg; [7-8] bilateral distal/posterior aspect of lower leg; and [9-10] bilateral proximal dorsum of foot. Sensors were affixed to the skin using double-sided tape and then wrapped using flexible hypoallergenic athletic tape to ensure proper placement. Sensors were placed over areas with the least muscle mass in attempt to minimize sensor movement. Following sensor assignment placement, a 11th sensor was attached to a wooden stylus and used to digitize the palpated positions of the body landmarks.^{7,8} Participants were instructed to stand in anatomical neutral while selected body landmarks were accurately digitized. The coordinate systems used were in accordance with the International Shoulder Group of the International Society of Biomechanics Recommendations.⁹ Data describing the position and orientation of electromagnetic sensors were collected at 100 Hz. Raw data were independently filtered along each global axis using a 4th order Butterworth filter with a cutoff frequency of 13.4 Hz. in hopes to filter out data that could potentially distort the results¹⁰. Two points described the longitudinal axis of the segment and the third point defined the plane of the segment. A second axis was defined perpendicular to the plane and the third axis was defined as perpendicular to the first and second axes. Neutral stance was the y-axis in the vertical direction, horizontal and to the right of y was the x-axis, and posterior was the

z-axis. Euler angle decompositions were used to determine humeral orientations and positions in order to have a visual representation of the movement in the world axis.⁸

Following electromagnetic sensor set-up, participants were given an unlimited time to warm-up. Once the participants deemed themselves warm, they were instructed on the throwing protocol. The participants had to catch a simulated hit ball and perform their positional throw. If the participant were an infielder she caught and threw to second base. If the participant was an outfielder she was to crow hop and throw to second, simulating a game setting where a runner was trying to steal second. A crow hop is a common crossover stepping maneuver to increase throwing velocity in outfield players.¹² A position player was on second base and only those throws that she was able to catch without stepping off the base were recorded.

Data were analyzed in the current study using the statistical package of PASW 18.0 for Windows [SPSS, Chicago, IL]. Mean and standard deviation for all kinematic, hip strength, and ball velocity parameters were calculated for the fastest throw from the catcher to second base by each participant. Pearson product moment correlation coefficients were then calculated to identify the possible relationships between all variables.

RESULTS

This is the first study to investigate hip abduction strength and its relationship with throwing kinematics in softball position players. Means and standard deviations of segmental velocities, ball velocity, and hip abduction strength are presented in Tables 1-5. Pearson correlation revealed no significant relationships ($p < 0.05$) between these factors. Upon completion of analysis, there was no significance in the relationship between hip, trunk, upper arm, or lower arm speed with hip strength or ball velocity ($r = .16$; $r^2 = .02$ and $p = .53$), so it was decided to look more at the relationship across positions with regards to their differences in results.

DISCUSSION

The purpose of this study was to examine the relationship between hip abduction strength, sequentiality of upper extremity segments and ball velocity in the softball overhead throwing motion. It was hypothesized that hip abduction and segmental velocities would predict ball velocity. The literature has described the upper extremity in softball and baseball pitching with minimal data discussing the lower extremity in these throwing motions^{3, 8, 13}. This study quantitatively analyzed segmental speeds in attempt to find a relationship between segmental sequentiality and ball velocity. Though there were no significant relationships, the current study did reveal a definite proximal to distal segmental sequentiality among all participants. These data of segmental velocities are in agreement with Atwater and Oliver who have described body segments accelerate 'in turn'^{14, 8}. As our data reveal, the distal segments gained acceleration from the preceding proximal segments.

The current study was unable to reveal a relationship between hip abduction strength and ball or segmental velocities. Hip abduction strength was analyzed because of the function of the gluteus medius during the throwing motion. While on single leg support the contralateral gluteus medius has to counterbalance the loss of limb support and stabilize the pelvis. It has been reported that the activation of the gluteal muscle group and its ability to stabilize the pelvic allows for efficient energy transfer from the proximal segments to the more distal segments of the upper extremity and on to the ball¹¹.

Thus as the literature supports the current data in the evidence of sequentiality as well as the relationship between the gluteal muscle group and throwing velocity, our data did not reveal that relationship^{8, 13, 11}. It is postulated that though the participants did exhibit segmental sequentiality, they may have effective functionality of their gluteus medius. The gluteus medius

is a primary abductor of the hip. And it would be beneficial if the current study could have quantified gluteus medius muscle activation during the throwing motion for a more defined rationale for the relationship between abductor strength and gluteal muscle activation.

Although this research was quite ambitious and the expected results were not achieved, it is believed that continued research could prove the importance of the sequentiality of upper extremity segments and kinetic chain throughout the throwing motion for both softball, baseball, or any throwing sport. It has been indicated in previous research that lower body kinematics and momentum from lower body muscles are strong contributors to pitching speed^{2,6}, but this project did not denote that.

One limitation of this study is the number of participants. The study had a goal of higher participation, but the feasibility and logistics were not fully considered during the planning stages. Although there were a low number of participants, there were no outliers evident. Also, the low number of participants did not take into account for those that did not perform maximum effort on either their throws or hip strength measurements. After analysis of results, standard deviations across the board were extremely high. This indicates that across the spectrum of results there was a lot of variance. Because of the high standard deviations, it is difficult to draw conclusions about the relationships between data. In addition this study examined the positional players, which is novel in this realm of research. Data analysis did not correct for the differences in throwing distances, which were visibly different. In addition, it is logical to assume that these players' maximum efforts in the throws are going to vary due to differences in positional duties and distances. Just like hip abduction strength testing, the participants threw at voluntary maximum effort.

CLINICAL IMPLICATIONS

The clinical significance of this study is that further research needs to be done on the biomechanical relationships involved in softball throwing. Although a relationship between hip abduction strength, sequential movement and ball velocity was not demonstrated in this study, it represents only a beginning in this area of research. Future studies with similar approaches have the potential to yield constructive feedback for softball players looking to have the most efficient and powerful body mechanics possible.

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Table Legend.

Table 1. Kinematics & Kinetics: Foot Contact.

Table 2. Kinematics & Kinetics: Maximum Shoulder External Rotation.

Table 3. Kinematics & Kinetics: Ball Release.

Table 4. Kinematics & Kinetics: Maximum Shoulder Internal Rotation.

Table 5. Ball Velocity & Hip Abduction Strength.

Table 1

Kinematics & Kinetics: Foot Contact

Variable	Infielders (n=8)	Catchers (n=4)	Outfielders (n=6)
Hip Speed [°/sec]	153 ± 93	135 ± 95	115 ± 6
Trunk Speed [°/sec]	121 ± 63	139 ± 56	213 ± 33
Upper Arm Speed [°/sec]	416 ± 120	162 ± 66	341 ± 6
Lower Arm Speed [°/sec]	697 ± 240	289 ± 131	679 ± 177

Table 2

Kinematics & Kinetics: Maximum Shoulder External Rotation

Variable	Infielders (n=8)	Catchers (n=4)	Outfielders (n=6)
Hip Speed [°/sec]	481 ± 72	356 ± 114	421 ± 17
Trunk Speed [°/sec]	796 ± 112	809 ± 84	826 ± 220
Upper Arm Speed [°/sec]	1084 ± 277	925 ± 170	1227 ± 163
Lower Arm Speed [°/sec]	1347 ± 125	1382 ± 351	1547 ± 113

Table 3

Kinematics & Kinetics: Ball Release

Variable	Infielders (n=8)	Catchers (n=4)	Outfielders (n=6)
Hip Speed [°/sec]	58 ± 72	188 ± 190	87 ± 84
Trunk Speed [°/sec]	39 ± 90	368 ± 65	382 ± 171
Upper Arm Speed [°/sec]	572 ± 416	1850 ± 425	1452 ± 353
Lower Arm Speed [°/sec]	2384 ± 388	2726 ± 132	2900 ± 195

Table 4

Kinematics & Kinetics: Maximum Shoulder Internal Rotation

Variable	Infielders (n=8)	Catchers (n=4)	Outfielders (n=6)
Hip Speed [°/sec]	142 ± 64	103 ± 29	235 ± 100
Trunk Speed [°/sec]	210 ± 100	222 ± 159	335 ± 60
Upper Arm Speed [°/sec]	1374 ± 358	1159 ± 293	1086 ± 38
Lower Arm Speed [°/sec]	1206 ± 391	1012 ± 338	924 ± 25

Table 5**Ball Velocity & Hip Abduction Strength**

Variable	Infielders	Catchers	Outfielders
Ball Velocity (mi/hr)	48.0 \pm 5.7	47.4 \pm 2.0	47.8 \pm 5.7
Hip Strength (kg)	19.1 + 10.8 (R) 14.8 + 8.4 (L)	11.2 + 8.3 (R) 14.1 + 8.2 (L)	11.5 + 2.5 (R) 12.0 + 6.5 (L)