RELATIONSHIP OF GRIP STRENGTH AND RANGE OF MOTION

IN BASEBALL PLAYERS

Megan Born

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Honors and Investigative Studies Committee by

Faculty Thesis Advisor

Thesis Committee Member

Thesis Committee Member

Thesis Committee Member

Date

Date

Date

Date

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Relationship of Grip Strength and Range of Motion in Baseball Players

OBJECTIVE: The purpose of this study is to compare grip strength and range of motion (ROM) against each other, and to player's position and hand dominance (HD) to determine whether catchers have increased grip strength on the non-dominant side and ROM of the wrist and elbow will be affected by increased grip strength. **DESIGN/SETTING:** Cross-sectional study; took place at practice and game facilities of participants. **PARTICIPANTS:** 94 male, baseball players (mean \pm SD, age = 22.24 \pm 2.84 years, height = 72.70 \pm 2.58 inches, weight = 196.19 \pm 20.15 pounds); 81 non-catchers and 13 catchers; 77 right-handed and 17 left-handed participants. **MEASUREMENTS:** Baseline® Hydraulic Hand Dynamometer (Fabrication Enterprises Incorporated, White Plains, NY) used in a relaxed, sitting position with three measurement of wrist flexion/extension in a sitting position with forearm on the table and a standing position for elbow flexion/extension with arms next to body. **RESULTS:** Dominant side (DS) grip strength significantly higher for non-catchers between sides (t(80) = 3.84, p = 0.00); player's position significantly influences the ROM on the non-dominant side (NDS) (*Lambda*(4,89) = 2.67, p = 0.04); HD affects ROM (*Lambda*(8,178) = 0.54, p = 0.00).

Keywords: Baseball, hand dominance, grip strength

INTRODUCTION

The baseball player's shoulder has been analyzed with respect to range of motion (ROM)^{1,2-5} and strength⁶⁻⁹. Biomechanical characteristics^{2,5,6,8-13} of the baseball throwing motion such as ground reaction forces⁸, angular velocities¹⁰, and distraction forces¹ have been observed, as well as how these mechanics and forces relate to upper extremity (UE) injuries.⁶ Injuries in baseball athletes do not only involve the shoulder, but are also common at the elbow joint and affect the athlete's performance.¹⁴ Common injuries at the elbow include ulnar collateral ligament (UCL) pathologies, ulnar nerve neuritis, pathology to the flexor-pronator muscle mass, medial epicondylitis or apophysitis, posterior impingement, and stress fractures.¹⁴ The bony anatomy of the joint provides stability from full extension to 20 of flexion and then after 120 of flexion.¹⁴ From 30 to 120 of flexion, static restraints such as ligaments (i.e. the Medial UCL) and dynamic restraints (i.e. the flexor and pronator muscle groups) provide stability to the joint.¹⁴ The muscles that provide this stability at the elbow also allow for full range of motion (ROM) at the wrist and fingers as well and control grip strength.¹⁴ Grip strength values have been normalized by previous research¹⁵⁻¹⁸ but has not been specified to baseball players. Grip strength and ROM have been studied as two separate entities, but conclusive evidence is lacking comparing the two which could help explain throwing velocity (TV) and mechanics of the baseball motion.

Azen and Boone³ and Erdogan et al⁴ attempted to set normative ROM values for the UE and lower extremity (LE) in males in the general population. Ergodan et al⁴ found a decrease in the amount of motion available on the dominant side (DS) compared to the non-dominant side (NDS) in both active and passive ROM for the shoulder, elbow, and wrist. Azen and Boone³ found in males with the age range of 20-29 the amount of shoulder extension and elbow flexion were increased compared to other age groups. No significant differences were found in ROM of the wrist; the average ROM available for elbow flexion (EF) was 142.9°, elbow extension (EE) of 0.9°, wrist flexion (WF) of 76.4°, and wrist extension (WE) of 74.9°.³ Brown et al⁷ found that all baseball players have a decreased amount of EE available on the dominant or throwing side.

Clerke and Clerke¹⁹ have focused on the differences in forearm strength between DS and NDS of individuals. The researchers found that there is no set definition of an individual's HD, so a comparison of results provided difficulty.¹⁹ Researchers¹⁹ reviewed literature and used the different definitions of HD to determine the DS is normally 10% stronger when compared bilaterally, and differences in strength could amount to 40% between sides. Clerke and Clerke¹⁹ reviewed studies that used the general public; there are still possibilities of comparisons of grip strength and ROM.

The purpose of this study is to compare the grip strength and ROM of collegiate and professional baseball players. The purpose is also to determine if the athlete's position or DS will produce a difference in any of the for-mentioned variables. I hypothesize that non-catchers (pitchers, infielders, and outfielders) will have an increase in grip strength on their DS; catchers will have an increase in grip strength on their NDS.

I hypothesize that ROM in the wrist and elbow will be affected in different ways as the grip strength of the individual increases. If grip strength increases, I hypothesize that active WF will increase and active WE will decrease. At the elbow, I hypothesize that an increase in grip strength will yield an increase in active EF.

LITERATURE REVIEW

Baseball is comprised of four basic skills: fielding, catching, hitting, and throwing.¹⁰ The goal in throwing is to move the baseball from one point to another in the shortest amount of time and with the greatest linear or angular velocity possible.¹⁰ Many factors affect throwing velocity, including strength of the athlete, speed of ball release, power transfer from lower extremity, etc., but thus far no study has compared wrist and elbow ROM to grip strength for a greater understanding of the UE in the baseball athlete.^{8,10}

To have a complete understanding of these research questions, one must have a wellversed background in the anatomy, biomechanics, and previous research of this topic (see Appendix A – Figures 1 to 7 relating to the bony and muscular anatomy of the UE).

Biomechanics

The head of the humerus is a convex surface articulating with the concave glenoid fossa in the GH joint.^{20,21} The humeral head is rotated medially creating an angle of retroversion, which is also called humeral retroversion.^{20,21} Normal humeral retroversion is thirty degrees posterior to the midline of the body.^{20,21} This angle of retroversion is the alignment of the middle of the humeral head as compared to the humeral condyles.^{20,21} With a normal amount of humeral retroversion, the humerus will align with the scapula for a normal range of motion.^{20,21} Another angle to be taken into consideration in the UE is carrying angle or "valgus angle" of the elbow.^{20,21} This angle can be inspected in subjects and is formed by the humerus and ulna.^{20,21} The natural angle with an extended elbow is deemed normal cubitus valgus.^{20,21} Values for normal cubitus valgus are 10-15 degrees in women, while only 5-10 degrees in males.^{20,21} This angle is only found with extension of the elbow and will disappear with full flexion.^{20,21} Abnormalities of this angle are quantifiable, as excessive cubitus valgus is a measured angle greater than 20-25 degrees.^{20,21} An adaptation of carrying angle is made by many baseball pitchers, as the body is compensating for the valgus load applied to the elbow during the throwing motion.²⁰ At the elbow, the presence of cubital recurvatum needs to be assessed; the alignment of the humerus and forearm in full extension is considered abnormal if the angle created is beyond zero degrees.²⁰ (See Appendix B – Figure 8 for a visual representation of carrying angle).

According to Ryan and Starkey,²⁰ the throwing motion in baseball consists of five phases of motion: the wind-up, cocking, acceleration, deceleration, and follow-through. Researchers¹¹ state that the goal of the throwing motion is to transfer energy from the body into kinetic energy to move the ball. In the wind-up phase, the elbow will be positioned in some degree of flexion based on the athlete.²⁰ This is considered the pre-motion in which there is no muscular force produced by the UE, all force in this phase is generated by the LE.²⁰ (See Appendix B – Figure 9 for a visual depiction of the phases in the throwing motion).

The late cocking phase, shifts the humeral head posteriorly to maintain the stability of the shoulder and position of the rest of the joints in the UE.¹¹ The elbow is in approximately ninety degrees of flexion, and the greatest amount of force is placed on the medial elbow.^{12,20} In this phase of the throwing motion, the middle and anterior band of the inferior portion of the MUCL of the elbow are taut or elongated and twisted.²¹ In the acceleration phase, there is still stresses on the anterior GH joint capsule and the MCL of the elbow, but these are lessened with the change in position.²⁰ Whiteley¹² found that at release the greatest amount of elbow extension in the shortest amount of time will produce a greater amount of throwing velocity than a slower amount of time taken. In the deceleration phase, the elbow has 20-30 degrees of flexion moving into complete extension.²⁰ The final phase of the throwing motion is the follow-through where

the athlete is attempting to bring the body back to a normal position.²⁰ The elbow moves into full extension and the throwing motion is completed.²⁰

Previous Research

Andrews et al¹³ found that there is a significant amount of stress placed on the shoulder and elbow joints during the pitching motion that could cause significant and possible careerending injuries. The authors found that the valgus force place on the elbow could cause medial tension, compression of lateral structures, or injury to the posteromedial impingement of elbow.¹³ Due to the compressive forces on the shoulder complex during the pitching motion the labrum could be torn or impingement could be suffered by athletes.¹³ The increase in "elbow flexion torque" as stated by the authors was determined to possibly lead to an anterior labral tear during the pitching.¹³

Chirstophel et al²² the coupling movements that happen at the wrist as found that movements at the wrist are coupled together, and the attempt was made to disprove general goniometric measurements taken of isolated wrist movements. The coupled movements that were found included wrist flexion and ulnar deviation, compared to wrist extension and radial deviation.²² Any deviation in any direction was detected by surface markers to find the slightest motion of the wrist, forearm, and hand.²² The coordinates of the surface markers before movement were considered the subject's neutral position and a computerized motion analysis system was used to detect and record any motion.²² The amount of flexion or extension was linearly related to radial or ulnar deviation; as any motion underwent isolated testing, the coupled motion was found to occur.²² Any deviation was found to decrease the range of motion in the opposite direction of the deviation.²² The authors²² determined that wrist range of motion decreased if a deviation is motion was determined, so when measurements are taken the wrist should be placed and kept in a neutral position.

An older study completed by Azen and Boone³ developed ROM standards for males, ages 1-54 years. ROM was taken for all participants in a supine position for the joints of the entire body; starting and ending positions were compliant with those in The American Academy of Orthopedic Surgeons.³ The participants were split into six groups for analysis, and significant differences were found in the age group of 20-29; these participants were found to have an increased amount of shoulder extension, EF, and ankle eversion on the left side.³ The study found that the oldest groups had a decreased range of motion for WF and EE.³ The researchers found the average amount of motion available in EF is 142.9 degrees and 0.9 degrees of EE; average measurements for the wrist were 76.4 degrees of flexion and 74.9 degrees of extension.³ From this research, there is a standard or normal number to compare results of further research towards.

Another study done by Erdogan et al⁴ attempted to determine the normal active and passive ROM in young adult males. A standard goniometer was used, and participants were supine for most measurements of the joints in the body.⁴ Two examiners completed measurements for all joints twice each to increase the reliability of results.⁴ Significant differences in active range of motion were found at the shoulder in abduction, adduction, internal and external rotation, horizontal flexion and extension; at the elbow in flexion, extension, and supination; at the wrist in extension and radial deviation.⁴ Passive ROM created an increase in the significant difference of motion, and the authors found the non-dominant side yielded a greater ROM when compared bilaterally.⁴ The normal active ROM on the dominant side for the shoulder were 165.7° of abduction, 95.5° of IR, and 65.9° of ER; compared to 168.2°, 98.3°, and

69.6° of motion respectively on the non-dominant side.⁴ Active ROM of the elbow found the difference of 142.4° of flexion on the non-dominant to 140.0 on the dominant, and 184.5° of extension on the non-dominant to 182.8° of the non-dominant.⁴ WE was measured as 69.0° on the non-dominant and 59.4° on the dominant, while WF was not reported.⁴ The changes in ROM were attributed to the degenerative wear and tear of daily activity on the UE that could damage ligaments utilized in daily activity.⁴ The degenerative damage to the dominant side could be predominant in baseball as athlete tend to focus and overuse one side of the body, especially in the UE.

Changes in ROM are not only attributed to injuries, but may be dependent on the position of the arm, elbow, and forearm.⁷ Brown et al⁷ conducted a study with 41 professional baseball players to determine UE ROM and strength of the shoulder. The researchers split the groups into pitchers and other position players, but also compared variables to the DS; they varied the position of the arm and then determined the ROM available.⁷ Pitchers were found to have an increase in shoulder ER with the arm in an abducted position, but a decrease in should extension on the DS when compared to the NDS.⁷ With the forearm pronated, pitchers were found to have a 5° increase in ER, but no significant difference with this position on IR.⁷ Position players had a comparable increase in ER with the arm abducted.⁷ Pitchers had a 6° decrease in EE in the DS compared to the NDS, while position players were found to have an 8° decrease in EE on the DS.⁷ The study found a greater torque strength in IR and ER for both groups on the DS, but pitchers were found to have an increase torque on the dominant and non-dominant side when compared to position players.⁷ This study focused on the differences between the dominant and non-dominant had and the effect on ROM.

Aoki et al²³ determined that handedness based on activities of daily living of a person is considered to be their DS. The purpose of the study by Aoki et al²³ was to determine if the DS that had been by Oldfield's Handedness Inventory (1971) was correct.²³ Each participant took the survey to determine HD and then went through static and dynamic grip strength assessments.²³ Static grip strength was considered maximal grip strength; while the force exertion test was considered the dynamic grip strength assessment.²³ The dynamic testing position was to be held for twenty-five seconds compared to maximal grip strength.²³ Each test was completed on both the DS and NDS, and both found the DS to be significantly stronger.²³ The authors compared grip strength between the two hands and found that dynamic testing found the DS to have stronger control and therefore can be identified as the superior hand.²³

Clerke and Clerke¹⁹ completed a review of literature to determine whether there is an effect of the grip strength ratio between DS and NDS. The hypothesis of this study was that grip strength of the NDS is the normative or comparative value for the DS.¹⁹ This literature review only took studies that had performed isometric grip strength testing using a Jamar® dynamometer (Lafayette Instrument Co., Lafayette, IN).¹⁹ The ratio used to determine grip strength between hands is calculated by dividing the measured value of force for one hand, by the force exerted by the other.¹⁹ The researchers found that HD must be established before testing for any study is completed; the research must choose how to define HD and this definition can be defined as preference to the subject, is more skilled, or is subjectively considered to be stronger.¹⁹ The review found that some researchers pay no attention to HD, as the belief is there is no significant difference.¹⁹ HD is difficult to define, so any differences that are found may have the debate of being valid.¹⁹ The research review that was done by the authors found in one study that the DS was considered 10% stronger when compared bilaterally;

but other studies found up to a 40% difference can occur between DS and NDS.¹⁹ The authors' concern is that the measure of HD may not be accurate as a participant might be apt to use their NDS for a measure of grip power, while the DS is used for precision grip skills.¹⁹ The conclusion drawn from this review is that an effect of HD on grip strength should be made on an individual basis.¹⁹

Crosby et al²⁴ were the first to study grip strength of participants on all five levels of the Jamar dynamometer, as well as a pinch gauge. There were 214 participants in this study, and each participant used the Jamar® dynamometer (Lafayette Instrument Co., Lafayette, IN) to assess power grip with an increase in grip levels with every trial; a pinch gauge was used to assess precision grips.²⁴ The DS and NDS were tested at all levels as well as tested with the pinch gauge.²⁴ Hand positioning was not regulated with testing and the position of the hand was natural to the individual to make the participant comfortable while testing.²⁴ Power grip scores were recorded to the nearest five pounds, while pinch gauge measurements were recorded to the nearest one pound.²⁴ The grip level with the best result was repeated and this measurement was recorded as the maximum or optimal grip strength.²⁴ Researchers in this study found that there was a 50% increase for maximum grip strength as the grip level increased.²⁴ The authors concluded that there was an average difference in grip strength of 6% between the DS and NDS.²⁴ Women and left-handed subjects were found to have a weaker grip strength compared to males or right-handed counterparts.²⁴ Gender was found to play the most important factor in the difference of maximum grip strength.²⁴ The authors also found a stronger correlation of grip strength to recreational hobbies than to occupation.²⁴

The researchers in the study by Crosby et al²⁴ attempted to determine a normative value for the generalized population, and there are other researchers such as Bohannon et al²⁵ that have

attempted this feat also. The study by Bohannon et al²⁵ was a world-wide study that recognized the reliability of grip strength as measurement of post-injury status; although, the researchers in this study were attempting to show a correlation between grip strength and other health problems. The first round of testing was completed in 2000-2003 and then in 2004-2006; the height, weight, and Body Mass Index (BMI) of the person was taken to determine the health of the person.²⁵ The researchers split participants into groups by age, and found a weak positive correlation between grip strength and age, as well as BMI and grip strength.²⁵ The authors concluded that an increased BMI will relate to an increase in grip strength, but this was difficult as there were countries with no person with a BMI over 25, which is considered mal-nourished in more advanced societies.²⁵ The authors did report normative or average values for all age groups, and for the group of 20-29 years the findings were an average measurement of 47 kilograms in the right hand and 45 kilograms in the left.²⁵ The authors not only provide a normative value for grip strength, but an insight as to how BMI will affect the grip strength of an individual.²⁵ This will provide more information in the evaluation of grip strength measurements in baseball players, as their body composition is different than the general population and may need to be taken into consideration.

The position of the subject's hand in this study during testing was not regulated; however, in other studies such as Fong and Ng²⁶ various hand positions were regulated, rendered, and repeated to determine the position of maximal strength. The researchers found 30 male participants, ages 20-69, who were tested in six different positions.²⁶ The positions included varying degrees of wrist extension and ulnar deviations.²⁶ These two motions were chosen to test because of the wrist extensors acting as synergists during gripping, and the coupled motion providing the maximal amount of grip strength.²⁶ The researchers found the maximum amount of grip strength to be in 15 or 30 degrees of extension with no radial or ulnar deviation, and the results were repeated on a second day of testing.²⁶ The results of this study help determine a position of the greatest amount of force generated for a maximal grip strength.

Maximum grip strength produced by the participant has been found by Bassi et al²⁷ to not have statistical significance when compared to the average grip strength for an individual. The researchers placed 100 volunteers in a position with the shoulder adducted and flexed to 90 degrees, the wrist extended to 30 degrees, and a comfortable position on the dynamometer which the participant was asked to choose.²⁷ The participants were asked to hold the maximal grip strength three times for six seconds, and the researchers found the in nearly 75% of participants the maximum grip strength was achieved with the first trial.²⁷ The DS was found to have an increased grip strength in 60% of participants, but the authors found no difference between the maximum and average measurements.²⁷ The authors also made note that the position of most comfort with the dynamometer may prove to raise question as to whether the measured maximum is a true measurement; while the positioning of the rest of the body seems standard for testing of grip strength in subjects.

In an article found in the Instruction Manual for the Baseline® Hydraulic Hand Dynamometer that will be used for data collection, Dr. Virgil Mathiowetz²⁸ concludes that the data found by the Baseline and Jamar Dynamometers are comparable. The recommended position be the author is that the participant is seated, the shoulder adducted and flexed to 90 degrees.²⁸ The shoulder should not be in any rotation and the forearm should be in a neutral position, with the wrist in up to 30 degrees of flexion and up to 15 degrees of ulnar deviation.²⁸ The results found that the average grip strength measurements for males ages 20-24 were 121.0 pounds for the right and 104.5 for the left hand.²⁸ For ages 25-29, the average results were found to be 120.8 in the right hand, and 110.5 in the left.²⁸ The author also found the percentage of difference between the DS and NDS by the equation:

% = (dominant score-non dominant score)/dominant score.²⁸ The results indicated a 14 % difference between hands in participants ages 20-24, and a 9% difference in participants ages 25-29.²⁸ The results of this study provide a more specific age group for the age range of participants in this study.

From the previous research found on related topics, I have been able to explore various methods and procedures to determine what will work best in my study. I have also been able to see different forms of recruitment and subject pools that have demonstrated different results in related studies. With the background of anatomy and biomechanics, I will learn from previous research and set standards for my study.

METHODS

Participants

Ninety-four participants took part in this study (age = 22.24 ± 2.84 years, height = 72.70 ± 2.58 inches, weight = 196.19 ± 20.15 lbs). Participants were excluded from testing if they were being held from participation for any reason. Whether that reason be that they were experiencing any shoulder, elbow, forearm, wrist, or finger pain that restricted their participation in competition or they were being withheld from participation because of surgical or non-surgical injuries or conditions. The age range of the group is 18 to 29 years, height range is 66 to 77 inches, weight range is 125 to 235 lbs, years at current level range is 0 to 12 years, and total experience range is 6 to 24 years. There were 13 catchers and 81 non-catching position players

(pitchers, infielders, outfielders) that participated in this study. Of the participants, 77 were right hand dominant and 17 were left hand dominant with dominance was considered to be the throwing arm.

Collegiate participants were members of NCAA Division I, II, and III varsity baseball teams. Professional participants were members of an Independent Professional baseball league. Participants were recruited from varsity collegiate and professional teams through a team meeting.

For this cross-sectional study, the researcher traveled to the facilities of participating teams. This study was approved by the Human Subjects Committee (HSC) at Marietta College (MC) prior to testing. Each participant read and signed a Statement of Informed Consent approved by HSC at MC. Data collection took place from May 2011 to October 2011.

Procedures

Each participant went through testing in the following order: grip strength then active ROM. Testing was completed in the same order for each participant. First, grip strength was measured in the seated position, and the participant was able to familiarize themselves with the Baseline® Hydraulic Hand Dynamometer (Fabrication Enterprises Incorporated, White Plains, NY) that was used for grip strength assessment. The participant was seated with a flat surface next to their testing side.

The arm position for each position in this study was the shoulder abducted approximately 10 degrees, the elbow flexed to approximately 90 degrees, and the forearm firmly secured on the table. The elbow was placed into 90 degrees of flexion because Fan and Ng²⁹ found that the maximum grip strength measurements were produced in this position compared to other various elbow positions. The participant was asked to place the wrist in a starting position of

approximately 30 degrees of wrist extension, as O'Driscoll et al³⁰ found that a position of 25 degrees of wrist extension or greater will provide the position needed for maximum grip strength. The instrument was adjusted so that the palm of the hand was on the back of the dynamometer, the middle phalanges rest on the front, and the thumb against the side. The participant was asked to remain seated with their back straight and feet flat on the ground.

Throughout testing, the position of the participant's hand was kept the same with each individual. Hughes et al³¹ made adjustments specific to each athlete so that the proximal part of the dynamometer rested in the palm of the hand being tested. The researchers also concluded that with the dynamometer in proper position the middle phalanx of the third digit should lay flat on the distal portion of the dynamometer.³¹ During data collection, the attempt was made to keep the DIP and PIP joints of each digit flexed to 90 degrees, the palm resting on the back of the instrument, and the thumb or first digit resting on the side. Each trial was held for three seconds.

The hand position was maintained throughout, but with contraction of the forearm the participant was able to bring the wrist into some degree of flexion (see Appendix C – Figure 10 and 11 for visual representations of starting and ending positions with grip strength testing). Three measurements were taken in the dominant hand first, then three in the non-dominant hand. There was a required twenty second rest period between testing of the dominant and non-dominant hands. The peak measurement by the dynamometer during the three second hold determined the maximum grip strength for that trial; three measurements were completed on each side and used for analysis. When the participant completed all six trials for grip strength, the participant remained seated for ROM testing.

The second portion of testing was active ROM, and the participant's arm remained in the same position with the shoulder abducted approximately 10 degrees, the elbow flexed

approximately 90 degrees, and the forearm firmly place on the table. The wrist of the participant was freely moveable and the fingers placed in a comfortable position, whether slight flexion or neutral position. With the measurement of WF the forearm was pronated, and then changed to a supinated position with the measurement of WE. The researcher demonstrated the motion to perform and asked to be conscious of deviations that could occur with movement. A standard goniometer was used in all ROM testing. For wrist measurements, the fulcrum was placed at the ulnar styloid process, the movement arm with the head of the fifth metacarpal, and the stationary arm with the shaft of the ulna. For the measurements of elbow motion, the fulcrum was placed on the lateral joint line of the elbow. The movement arm was parallel to the shaft of the radius, and the stationary arm was aligned with the lateral, long axis of the humerus. For the elbow, the participant was asked to stand and measurements of extension were taken first. For elbow extension (EE), the participant was instructed to straighten the elbow as far as possible while keeping the elbow pressed into the side of the body; this position did not allow the participant to skew measurements with deviations of the arm or shoulder. For EF, the participant was asked to maintain elbows at their side and bend the joint so the wrist was brought to the shoulder. The elbows were again kept against the side to prevent deviation. All ROM measurements were taken bilaterally (see Appendix C – Figures 12 to 15 for visual representation of ROM testing positions).

Statistical Analysis

Data was analyzed using SPSS PASW 18.0 (SPSS Inc., Chicago, IL). Two paired samples *t*-test were used to compare the dominant and non-dominant grip strength of catchers and then other positions. A MANOVA was completed to compare the dominant ROM to dominant grip strength, non-dominant ROM and non-dominant grip strength, ROM of the

dominant and non-dominant hand to hand dominance of the participant; another MANOVA was completed to compare the ROM of the dominant and non-dominant hand to the position of the participant. A regression analysis was completed for each of the following relationships: dominant ROM and dominant grip strength, and non-dominant ROM and non-dominant grip strength.

RESULTS

Grip Strength

A paired-samples *t* test was calculated to compare the dominant grip strength and nondominant grip strength of non-catchers. A significant difference was found from dominant to non-dominant grip strength (t(80) = 3.84, p = 0.00). Dominant grip strength (60.00Kg ± 8.26) was significantly higher than non-dominant grip strength (57.84Kg ± 7.55) for non-catchers (see Appendix D – Figure 16 for graphical representation of this relationship).

A paired-samples *t* test was calculated to compare the dominant grip strength (55.31Kg \pm 7.39) and non-dominant grip strength (54.96Kg \pm 8.73) of catchers. No significant difference from dominant to non-dominant grip strength was found (*t*(12) = 0.49, *p* = 0.64). Dominant grip strength posed no significant difference to non-dominant grip strength for catchers.

A multiple linear regression was calculated predicting participants' dominant grip strength based on dominant ROM. The regression equation was not significant (F(4,89) = 0.81, p > 0.05).

A multiple linear regression was calculated predicting participants' non-dominant grip strength based on non-dominant ROM. The regression equation was not significant (F(4,89) = 2.08, p > 0.05). For the dominant and non-dominant hand, ROM measurements cannot be used to predict grip strength for the respective side.

Range of motion

A MANOVA was calculated and found an no overall significant effect of hand dominance on dominant ROM (*Lambda*(4,89) = 1.69, p > 0.05); however, a significant influence was found for hand dominance on dominant WE (F(1,92) = 5.62, p = 0.02).

A MANOVA was calculated finding a significant effect of position on non-dominant ROM (Lambda(4,89) = 2.67, p = 0.04).

A MANOVA was calculated finding a significant effect of HD on differences in ROM between the right and left sides (*Lambda*(8,178) = 0.54, p = 0.00).

A one-way MANOVA found no significant effect of position on dominant ROM (*Lambda* (4, 89) = 0.34, p > 0.05).

A MANOVA found no significant effect of dominant ROM on dominant grip strength (Lambda(4,89) = 1.69, p > 0.05).

A MANOVA found no significant effect of non-dominant ROM on non-dominant grip strength (Lambda(4,89) = 0.84, p > 0.05).

DISCUSSION

The goal of this study was to examine the relationship between grip strength, ROM, and TV. Previous research^{19,23-25} found a significantly higher grip strength measurements on the dominant side compared to the non-dominant in young males or the general population. Aoki et al²³ concluded that the dominant hand a stronger sense of control deeming this side the superior hand, while studies by Clerke and Clerke¹⁹ and Crosby et al²⁴ found grip strength measurements

of 10 and 50% for the dominant side compared to the non-dominant. In contrast, Reikerås³² concluded that grip strength is similar bilaterally and when injured, the uninjured hand can be used as a reference point for normal strength of the individual. This study found a significant increase in grip strength for the dominant side of non-catching position players, but no significant difference was found in catchers. These results suggest that catchers have even strength between dominant and non-dominant hands, while non-catchers have a significantly higher strength in the dominant hand. This suggests that catching specific movement, repetitive catching or squeezing glove during practices or games, on the non-dominant side create equality in strength compared to other positions. The constant use of the non-dominant side to grip could possibly explain the similarity in bilateral grip strength found in catchers. This study specifically examined baseball players and found an increase in grip strength measurements of this population compared to the normative values for the general population as stated in previous research.^{19,23-25}

Studies by Christophel et al²² and Davidson et al³³ suggest that deviations in motion or increases in strength on the dominant side could play a role in the amount of motion measured at a joint. Christophel et al²² found that movements at the wrist are coupled, so any deviation in the ulnar or radial direction will decrease the motion available. Davidson et al³³ found that the relative strength of the forearm could limit the motion available at the wrist joint. While this study found no significant relationship between grip strength and wrist ROM, there was a significant relationship founded between WE and WF on both the dominant and non-dominant sides. Brown et al⁷ concluded a decrease in elbow extension of the dominant side compared to the non-dominant, which varied by position. This study supports the conclusion by Brown et al⁷ that as elbow extension was decreased on the dominant side, but was not a significant finding.

These variables were not compared in this study, but provide evidence that there is a relationship of the joints in the UE to provide sport specific motions such as throwing or pitching.

Limitations

The athletes participating in this study were NCAA division I, II, and III, and independent professional, male baseball players; therefore, this study may only be generalized to those specific populations. The athletes in this study also ranged in age from 18 to 29 yrs, so generalization cannot be made to other playing levels. A limitation of this study is if participants did not perform at a maximal level of ability. Relationships were observed and no causation was proved or suggested through research.

Future Research

Future research should compare ROM values of the shoulder to the rest of joints in the UE to see if there are any relationships that may help explain prominence of elbow and shoulder injuries in baseball athletes. Other research could also expand to the inclusion of pronation, supination, ulnar and radial deviation, and determine relationships between grip strength and a full ROM of the elbow and wrist. Future research may be able to use different equipment than in this study to measure grip strength and compare them to the other variables studied to determine relationships. Strength differences could be compared in a longitudinal study from adolescent, to college, to young professional/rookie, to experienced professional/veteran; as this could provide insight to the degenerative changes in the UE possibly due to overuse or muscular changes. Future research could also determine any differences or relationships in the variables of this study after injury to the elbow or wrist to aid in the determination of rehabilitation programs.

CONCLUSION

The purpose of this study was to determine if a baseball player's position and/or hand dominance would contribute to differences in grip strength, ROM, and TV; as well as determining how grip strength, ROM, and TV related to the others. Normative values for grip strength and ROM of the dominant and non-dominant sides were found, and a statistical difference was found in the comparison of dominant and non-dominant grip strength of non-catchers. Analysis founded dominant WE to have a significant effect on dominant grip strength, and athlete's position had a significant effect on non-dominant ROM. A correlation was found between dominant EF and TV. The results that were found significant may be due to a present relationship or small group sizes when broken by position or handedness. The results of this study could interest further research in the topic, and help reshape some theories surrounding the game of baseball.

WORKS CITED

- 1. Cook TD, Gill TJ, Hawkins RJ, Murray TA, & Werner SL. Relationships between throwing mechanics and shoulder distraction in professional baseball pitchers. *Am J Sports Med.* 2001; 29(3): 354-358.
- 2. Andrews JR, Fleisig GS, McLean SP, & Stodden DF. Relationship of biomechanical factors to baseball pitching velocity: within pitcher variation. *J Applied Biomechanis*. 2005; 21(1):44-56.
- 3. Azen SA, & Boone DC. Normal range of motion of joints in male subjects. *J Bone Joint Surg Br.* 1979; 61 (5): 756-759.
- 4. Erdogan O, Gokturk E, Gunal I, Rose N, & Seber S. Normal range of motion of the joints of the upper extremity in male subjects, with special reference to side. *J Bone Joint Surg Am.* 1996; 78 (9): 1401-1404.
- 5. Andrews JR, Barrentine SW, Escamilla RF, Fleisig GS, & Zheng N. Kinematic and kinetic comparison of baseball pitching from a mound and throwing from flat ground. 1996; Annual Meeting of the American Society of Biomechanics.
- 6. Loebenberg ML, Park SS, Rokito AS, & Zuckerman JD. The shoulder in baseball pitching: Biomechanics and related injuries-part 1. *Hospital for Joint Diseases*. 2002-2003; 61 (1&2): 68-79.
- 7. Brown LP, Harrah A, Hirshman HP, Niehues SL, & Yavorsky P. Upper extremity range of motion and isokinetic strength of the internal and external shoulder rotators in major league baseball players. *Am J Sports Med.* 1998; 16 (6): 577-585.
- 8. Chao EY, Choi T, MacWilliams BA, McFarland EG, & Perezous MK. Characteristic ground-reaction forces in baseball pitching. *Am J Sports Med.* 1998; 26(1): 66-71.
- 9. Elsner RC, Farewell V, Lang J, Predegana LR, Roberts D. The relationship of upper extremity strength to throwing speed. *Am J Sports Med.* 1982; 10(6): 352-354.
- 10. Hay JG. The Biomechanics of Sports Techniques, 4th ed. Upper Saddle River, NJ: Prentice Hall, Inc.; 1993.
- 11. Andrews JR, Fleisig G, Meister K, & Wilk KE. Biomechanics of the overhead throwing motion. *Sports Med & Arthro Rev.* 2000; 8(2).
- 12. Whiteley R. Baseball throwing mechanics as they relate to pathology and performance a review. *J Sport Sci & Med.* 2007; 7: 1-20.
- 13. Andrews JR, Dillman CJ, Escamilla RF, & Fleisig GS. Kinetics of baseball pitching with

implications about injury mechanisms. Am J Sports Med. 1995;23(2):233-239.

- 14. Andrews JR, Dugas JR, Cain EL, & Wolf RS. Elbow injuries in throwing athletes: A current concepts review. *Am J Sports Med.* 2003;31(4):621-635.
- 15. Crosby CA, Wehbe MA, Mawr B. Hand strength: normative values. *J of Hand Sur-AM*. 1994; 19(4): 665-670.
- 16. Bohannon RW, Gill TK, Hill CL, Massy-Westropp NM, & Taylor AW. Hand grip strength: Age and gender stratified normative data in a population-based study. *BMC Research Notes*. 2011; 4: 127-131.
- 17. Bassi S, Deshmukh SC, Haidar SG, & Kumar D. Average versus maximum grip strength: which is more consistent? *J Hand Surg-Brit Eur*. 2004; 29 (B1): 82-84.
- Mathiowetz V. Norms for adult grip strength. Instruction Manual: Baseline
 By Hydraulic Hand Dynamometer. 1993.
- 19. Clerke A, & Clerke J. A literature review of the effect of handedness on isometric grip strength differences of the left and right hands. *J of OT*. 2001; 55(2): 206-211.
- 20. Brown S, Ryan J, & Starkey C. Evaluation of Orthopedic and Athletic Injuries, 3rd ed. Philadelphia, PA: F.A. Davis Company; 2010.
- Neumann DA. Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation, 2nd ed. St. Louis, MO: Mosby, Inc.; 2010.
- 22. Christophel TH, Fisk JA, Kuxhaus L, & Li ZM. Coupling between wrist flexionextension and radial-ulnar deviation. *Clinical Biomechanics*. 2005; 20(2): 177-83.
- Aoki H, Demura S, & Noguchi T. Superiority of the dominant and nondominant hands in static strength and controlled force exertion. *Perceptual & Motor Skills*. 2009; 109(2): 339-46.
- 24. Crosby CA, Wehbe MA, Mawr B. Hand strength: normative values. *J of Hand Sur-AM*. 1994; 19(4): 665-670.
- 25. Bohannon RW, Gill TK, Hill CL, Massy-Westropp NM, & Taylor AW. Hand grip strength: Age and gender stratified normative data in a population-based study. *BMC Research Notes*. 2011; 4: 127-131.
- 26. Fong PWK, & Ng GYF. Effect of wrist positioning on the repeatability and strength of power grip. *Am J Occup Ther*. 2001; 55 (2): 212-216.
- 27. Bassi S, Deshmukh SC, Haidar SG, & Kumar D. Average versus maximum grip strength: which is more consistent? *J Hand Surg-Brit Eur*. 2004; 29 (B1): 82-84.

- 28. Mathiowetz V. Norms for adult grip strength. Instruction Manual: Baseline® Hydraulic Hand Dynamometer. 1993.
- 29. Fan ACC and Ng GYF. Does elbow position affect strength and reproducibility of power grip measurements? *Physiotherapy*. 2001; 87(2): 68-72.
- O'Driscoll SW, Horii E, Ness R, Cahalan TD, Richards RR, An KN. The relationship between wrist position, grasp size, and grip strength. *J Hand Surg-AM*. 1992; 17(1): 169-77.
- Hughes SS, Lyons BC, Mayo JJ. Effect of grip strength & grip strengthening exercises on instantaneous bat velocity of collegiate baseball players. J Strength & Cond Res. 2004; 18(2): 298-301.
- 32. Reikerås O. Bilateral differences of normal hand strength. *Orthopaedic and Trauma Surgery*. 1983; 101(3): 223-224.
- Davidson PA, Jobe FW, Perry J, Pink M. Functional anatomy of the flexor pronator muscle group in relation to the medial collateral ligament of the elbow. *Am J Sports Med.* 1995; 23(2): 245-250.

Appendix A

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Figure 1: Distal portion of the humerus articulates with the proximal radius and ulna of the forearm

Figure 2: Bony anatomy of the forearm; articulates with humerus at the elbow joint; articulates with the carpal bones at the wrist



Figure 3: Carpal bones of the hand; proximal, middle, distal phalanges



Figure 4: Flexor-pronator muscle group of the forearm affecting the elbow and wrist



Figure 5: Extensor muscle group of the forearm affecting the elbow and wrist



Figure 6: Musculature of the palmar aspect of the hand affecting the wrist and fingers



Figure 7: Musculature of the dorsal aspect of the hand affecting the wrist and fingers

Appendix B





Figure 8: Carrying angle at the elbow



Figure 9: Phases of the throwing motion

Appendix C



Figure 10: Starting grip strength position in slight extension.



Figure 11: Ending grip strength position in slight flexion.



Figure 12: Position for testing WF.



Figure 13: Position for testing WE.



Figure 14: Position for testing EE.



Figure 15: Position for testing EF.



Figure 16: Dominant and non-dominant grip strength, non-catchers

