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Examining Upper Extremity Injuries In Male Baseball Players Between The Ages Of 14 To 22 Years Old

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The number of upper extremity injuries is increasing in advanced baseball (14 to 22 years old) at an alarming rate. The length of seasons, multiple leagues and the velocity of throwing in overhead sports are the most common causes of elbow and shoulder injuries. In addition, biomechanical variables also influence the risk of injury. Any alteration in range of motion (ROM) directly impacts the biomechanics of overhead activities, such as pitching or throwing a baseball. Any decrease in shoulder or elbow ROM has a negative influence on the kinetic chain during overhead activities, significantly increasing the likelihood of an upper extremity injury. Many upper extremity injuries sustained in young advanced baseball players go undiagnosed, misdiagnosed or are not reported by the athlete at all. Therefore, there is a need to better understand the injury patterns within advanced youth baseball, particular in those athletes who have a history of prior injury.

The current study used a descriptive survey to examine and assess the prevalence of shoulder and elbow injuries in advanced baseball players over the course of one season, and investigates the relationship between prior injury to the development of elbow pain and injury. The results of this study provided new information about a group of athletes that has not been extensively studied to date. The data collected was evaluated to identify further areas of research and to design educational materials and programs to decrease upper extremity injuries in advanced baseball players.

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Chapter 1

Introduction

Statement of the Problem:

Many youth and adolescents participate in sports, and the number participating in overhead activities has grown over the past few years.[1, 2, 3, 4] There are millions of participants who partake and compete in overhead activities such as baseball in America.[4] Overhead activities such as baseball have a low injury rate, but the rate of injury is increasing.[1, 3, 4] Approximately 45% of all injuries sustained during baseball practice or competition are to the upper extremity.[5] Pitchers sustain 56%-75% of the injuries that occur, and of that percentage, 67% are upper extremity injuries.[1, 3, 4, 6, 7, 8, 9, 10] Nationally there are approximately 131,555 injuries sustained in high school baseball, which correlates to approximately 1.26 injuries per 1000 athlete exposures.[7] Injuries to the shoulder and elbow are three times more likely to occur during competition (injury rate of 1.89 per 1000 athlete exposures) compared to practice (injury rate of 0.85 per 1000 athlete exposures).[6, 7, 8, 9]

The shoulder and elbow are the most common sites for injury in baseball.[1, 2, 3, 4, 7, 9 11, 12] Over 75% of all injuries sustained in high school baseball are to the shoulder and elbow while 45% of injuries in collegiate and professional baseball are to the upper extremity.[6, 7, 9, 11, 12] Ligament and muscle sprains (incomplete tears) were the most common diagnosed injury in baseball. Incomplete ligament tears accounted for 21% of reported injuries, and muscles strains accounted for 20%.[7] Of these upper extremity injuries, 65% resulted in time lost from participation of less than 7 days, and 9.7% of these injuries resulted in a medical disqualification for the rest of the season. Finally, 9.4% of these injuries required surgery.[6, 7]

Many shoulder and elbow injuries that occur in baseball are considered overuse injuries, which account for 82% of injuries in youth baseball players.[1, 3, 11] Approximately 67% of high school baseball players sustained some sort of overuse injury to their shoulder or elbow that required an average of seven days missed of games and practice.[12] Pitchers are particularly at risk for these overuse injuries to the upper extremity. Pitchers in youth and high school baseball players have twice the risk of shoulder or elbow injury compared to position players.[13] Many risk factors influence shoulder and elbow injuries which contribute to over half of the injuries sustained to little league pitchers.[1, 3, 4, 11, 12]

There are a variety of potential risk factors for shoulder and elbow injuries in baseball players.[1, 3, 4, 11, 12, 13] Two significant risk factors, consistently identified in the research, include the number of pitches thrown and the number of innings pitched.[1, 3, 4, 11, 12, 13] Since many youth and advanced baseball leagues have different pitch counts or number of innings a youth pitcher can pitch, poor overall pitch monitoring is a major concern for athletes and coaches.[1, 2, 11, 14, 15] Lack of rest periods between games or innings pitched also appear to increase the risk of shoulder or elbow injuries.[1, 3, 4, 11, 12] Improper management of pitch counts and the number of innings pitched along with the lack of rest cycles may lead to overuse injuries to the shoulder or elbow among baseball players.[1, 3, 4, 11, 12] Additional risk factors for shoulder or elbow injury include increased length of seasons, participating in multiple leagues, and the single sport focus at an early age.[2, 14, 15, 16] Researchers hypothesize that increased pitch counts and increased throwing velocity are the most common causes of elbow and shoulder injuries in youth and adolescent overhead athletes.[2, 14, 15, 16, 17] Thus, increased exposure to overhead activity, in particular pitching, appears to greatly influence the risk of injury in baseball players.

Another risk factor related to shoulder and elbow injuries among youth and high school baseball players are biomechanical and physical factors. Baseball involves a high repetition of overhead throwing that causes tremendous biomechanical stresses, forces and torques on the upper extremity.[2] These forces and torques may increase the risk of injury by causing developmental adaptations, such as humeral retrotorsion and glenohumeral internal rotation deficit (GIRD), in the shoulder and elbow joint in young overhead athletes.[3] GIRD is a loss of internal rotation (IR) range of motion (ROM) of the dominant (throwing) shoulder compared to the non-throwing shoulder.[10, 18, 19] GIRD has a been found to have a direct correlation with an increased risk of medial/ulnar collateral ligament (UCL) tears of the elbow by increasing valgus stress causing instability which approaches the physiological strength of the UCL.[10] Researchers also hypothesize that injury to the elbow and shoulder joint is caused by overuse coupled by the body's inadequate ability to properly manage and stabilize the joints during overhead motions.[14] Overhead throwing requires increased rotator cuff muscle activity to resist the high shoulder distractive forces during arm cocking and deceleration phases.[18] Rotator cuff muscles become fatigued from repeated overuse, and when combined with lack of rest, fatigue increases the risk of shoulder injuries.[18, 19] Thus, multiple biomechanical factors may interact with increased exposure and decreased rest to increase the risk of injury to baseball players, particularly pitchers.

One important factor in the development of a shoulder or elbow injury may be a prior history of injury. One research study determined that softball players who have sustained a previous injury to their shoulder or elbow are at greater risk of playing with pain, which may indicate injury.[4, 13] There is also a strong correlation between playing despite arm pain or fatigue during pitching, and suffering a subsequent injury in baseball players.[4, 13] A recent study also

found that reporting a prior throwing injury was strongly associated with suffering a subsequent elbow injury in baseball players.[11] Thus, it appears that prior injury, or playing despite possible signs of injury, does impact the risk of injury in baseball players and other overhead athletes.

Baseball players often report pain or fatigue while throwing without receiving care or being evaluated for a potential injury.[3, 4, 11, 13] This lack of medical care could be contributed to social environments, underreporting, which is a common phenomenon in sport culture, or lack of direct access to appropriate medical professionals.[1-10, 11-13] Over 30% of baseball pitchers experienced some type of elbow or shoulder pain while playing baseball.[4] Many baseball players fail to report pain to coaches or medical providers when they initially recognize shoulder or elbow pain.[10, 17, 20] Many youth and high school baseball players who experience elbow pain or discomfort continue to play despite these symptoms, which may increase the risk of suffering a more serious injury.[10, 17, 21] Over a two year study, 47% of youth baseball pitchers reported shoulder or elbow pain. These players reported that their pain limited their pitching capability, velocity and overall performance throughout the season.[4] One method that can be used to monitor pain and arm fatigue is the use of patient rated outcomes (PRO's). PRO's have been used to evaluate pain, symptoms, arm function and fatigue in many types of overhead athletes.[22] Theses PRO's are used prior to season, during the season and after the conclusion of a season to track, monitor and identify pain, function, fatigue, or any potential injuries to the shoulder or elbow.[22] There is a growing demand to control the rise of shoulder and elbow injuries among adolescent, youth and high school age baseball players, thus properly monitoring players' self-reported symptoms of pain and fatigue may be critical in preventing injury.

Although baseball is considered a safe sport that has a relatively low injury rate when compared to contact sports like football, injuries to the shoulder and elbow are occurring in

baseball players at earlier ages, with potentially long-lasting consequences.[10] With the high percentage of upper extremity injuries sustained in baseball, specifically to the elbow and shoulder, finding ways to prevent injury or identify it early are paramount to the long-term health of these participants. Identifying and controlling risk factors such as pitch counts, innings pitched, pitch type, rest cycles, and complaints of pain or fatigue aid in preventing further injury to the shoulder or elbow. However, there is a gap in the literature that does not examine the relationship of how a prior history of shoulder or elbow injury influences the incidence of shoulder or elbow injury. Another gap in the literature is how a history of injury may influence self-reported pain, symptoms, or functional limitations. Even with the numerous studies that examine shoulder and elbow injuries among adolescent, youth, college and professional baseball players, there is a gap in the literature that focuses on baseball related injuries in advanced youth and high school age baseball players.

Significance of the Study

The significance of this study was to identify the prevalence of shoulder and elbow injuries, self-reported symptoms, and functional limitations among advanced baseball players (consisting of high school, legion ball, and college prep players). Identifying any limitations in self-reporting or properly identifying signs and symptoms of shoulder and elbow injuries may decrease the occurrence of shoulder and elbow injuries among advanced baseball players. With the literature focusing on professional and minor league baseball and pediatrics, a gap exists in currently published research. This study was essential in that it examined a sample of advanced baseball players that are in the age range where this gap exists. Even with the advancement of medical technology, knowledge of risk factors, and changing rules at different levels of play for baseball players, there is still a high rate of upper extremity injuries. Whether it be coaches,

parents or other medical professionals who interact with these baseball players, education on rules, regulations and recognizing signs and symptoms of upper extremity injuries will assist in decreasing the rate of upper extremity injuries among advanced baseball players while improving their overall quality of life. Positive re-enforcement of self-reporting upper extremity injuries and proper rest cycles are critical in avoiding any long-term deficits sustained from an upper extremity injury.

Purpose of Study

Baseball is one of the most popular sports in America with more than forty million participants at various levels. There is a large gap with little research in upper extremity injuries in advanced baseball players, which needs to be addressed and monitored.[1, 2, 14, 15, 17, 23, 24] There has been heavy focus on professional and minor league baseball players as well as collegiate baseball players, along with young adolescence baseball players. The literature is lacking in the area of high school and advanced youth baseball players.[1, 10, 14] This gap of knowledge, in an age-range where sport specialization is becoming more prevalent, may be limiting our ability to understand the increase of upper extremity injuries in this age group.[1, 10]

The purpose of the current study was to assess the prevalence of shoulder and elbow injuries in advanced youth baseball players (age 14-22) over the course of one season, and investigate the relationship between prior shoulder or elbow injury to the development of shoulder or elbow pain and injury over the course of a single season. A survey (Baseball Injury Questionnaire) and the Kerlan-Jobe Orthopedic Clinic (KJOC) Shoulder and Elbow Score form was provided pre- and post-season to baseball players age 14-22 to assess injury prevalence, history, and self-reported pain and symptoms.

Quantitative Research Question(s)

1. Was there a higher occurrence of shoulder related concerns (injury, self-reported symptoms or functional limitations), when compared to elbow-related concerns (injury, self-reported symptoms, or functional limitations) among advanced baseball players (consisting of high school, legion ball, and college prep players) during a single season?
    a. How many advanced baseball players reported a history of shoulder and/or elbow injury during a pre-season injury survey?
    b. How many advanced baseball players reported experiencing a shoulder and/or elbow injury, or self-reported symptoms consistent with a possible injury, during the course of a single season?
2. Did pitchers report a greater number of shoulder and elbow injuries, or self-reported symptoms and functional limitations, when compared to position players?
3. Did players with a history of shoulder and/or elbow injury report more shoulder and/or elbow injuries, or greater self-reported symptoms and functional limitations, over the course of a single season?

Quantitative Hypothesis

1. We hypothesized that there would be more injuries, self-reported symptoms, and functional limitations, to the shoulder when compared to the elbow.
    a. We hypothesized that advanced baseball players would report more injuries to their shoulder when compared to their elbow on the pre-season injury history questionnaire.

b. We hypothesized that advanced baseball players would report more injuries, self-reported symptoms, and functional limitations to their shoulder when compared to their elbow on the post-season questionnaire.

2. We hypothesized that the injury percentage would be greater among pitchers compared to position players.
3. We hypothesized that there would be a relationship between a history of injury, and experiencing an injury or experiencing increased symptoms and functional limitations, over the course of a single season.
    a. Players with a prior history of shoulder or elbow injury would report more injuries, self-reported symptoms, and functional limitations related to their shoulder or elbow, compared to those without a history of shoulder or elbow injury.
    b. Players with a history of shoulder injury will be at greater risk of developing an elbow injury over the course of a season; players with a history of elbow injury will be at greater risk of developing a shoulder injury over the course of a season.

Theoretical Framework

Athletes deal with many different risks on different levels of severity every time they practice or compete in an event or game. Baseball players are considered the extreme for overhead athletes' due to the torques and forces they repeatedly apply to their upper extremity. Meeuwisse's theory of the dynamic model of etiology in sport injury, also known as the Multifactorial Model, can be applied to overhead athletes such as baseball players.[23, 24] Meeuwisse's theory of dynamic model of etiology in sport injury states that numerous internal factors such as prior injuries, age, flexibility and strength, when coupled with external factors

like other players, environment/weather or equipment, make an athlete vulnerable for developing an injury.[23, 24] Once the provoking event occurs, the internal and external factors combine to potentially create an injury.[23, 24]

An injury to the ulnar collateral ligament (UCL) in a baseball pitcher may be explained by Meeuwisse's theory. External factors include throwing on short rest, throwing more than the recommended pitch counts, poor form, and throwing certain pitches like a curveball. These external factors all influence the forces placed on the ligament. Internal factors that may play a role include GIRD, weakened rotator cuff musculature, and repetitive stress on the UCL that causes microtears and gradual weakening of the ligament. Thus, an inciting event (throwing a particularly hard pitch, or throwing with significant fatigue) leads to macroscopic failure of the UCL.[23, 24] One of the most common issues in the multifactorial model is overuse injuries and overuse etiologies.[23, 24] Overuse injuries are the most likely contributor to overhead-related injuries due to unforeseen internal risk factors such as strained or stressed ligaments in the shoulder or elbow.[23, 24]

If a baseball pitcher is pitching in multiple games with minimal rest in between games and pitching bouts, that increases the risk of an upper extremity injury.[23, 24] The greater the exposure history, such as repeated pitching innings with minimal rest causes strain on the ligaments and muscles of the upper extremity, explaining that there are multiple factors leading up to athletic injuries.[23, 24] Maintaining and controlling external risk factors is understandable and acceptable, but the internal risk factors (change in ROM, weakening of certain muscles, micro tears, GIRD) are often overlooked and not addressed when dealing with athletes, especially overhead athletes who have a high risk of overuse injuries.[23, 24]

Definition of Terms

1. Upper Extremity: The region of the upper body (waist towards the head) extending from the deltoid to the hands, including the arms, axilla and the shoulders.[1, 2]
2. Self-reported Symptoms: Result from the KJOC survey, specifically difficulty getting loose, pain, weakness, fatigue and instability.
3. Self-reported Function: Result from the KJOC survey, specifically how arm problems have affected coach relationship, changing throwing motion, loss of velocity or control, loss of endurance, and how arm affects current level of competition.
4. Injury was defined as:[25]
   i) Patient was not able to continue for the remaining time of practice or competition, OR
   ii) Patient seen by a medical professional to evaluate or treat the injury, OR
   iii) Patient was not able to practice or compete for 1 day or more, OR
   iv) Patient had to miss 1 day or more from work or school
5. Prevalence: number of injuries at a specific time within a specific population or given sample.[1, 2, 10]
6. Ulnar Collateral Ligament (UCL) of the elbow: A thick triangular band located in the medial aspect elbow. It consists of three bundles, the anterior, posterior and transverse bundle.[1, 2, 14, 17]
7. Athletic Trainer (AT): A health care professional who specializes in recognizing, preventing, rehabilitating and managing injuries.[26]
8. Multifactorial Model: Meeuwisse theory of dynamic model of etiology in sport injury, states that multiple internal and external factors make athletes vulnerable for developing an injury.[23, 24]
9. Glenohumeral Joint: A multiaxial synovial ball-and-socket joint that comprises of articulation between the shoulder blade and the head of the humerus (upper arm).[1, 2, 14, 17]

10. Glenohumeral Internal rotation deficit (GIRD): Loss of internal rotation (IR) range of motion of 20 degrees or greater when compared to the contralateral side.[10, 27]
11. Ulnohumeral Joint: Also known as the trochlear joint, is part of the elbow joint consisting of the humerus and the ulna.[1, 2, 14, 17]
12. Radioulnar Joint: A pivot point where the distal end of the ulna and the distal end of the radius pivot.[1, 2, 14, 17]
13. Rotator Cuff: A group of muscles and their associated tendons that stabilize the shoulder. The four muscles are the supraspinatus muscle, infraspinatus muscle, teres minor muscle and the subscapularis muscle.[1, 2, 14, 17]
14. Humeral Retrotorsion: Twisting of the humeral shaft between the distal and proximal ends, causing the distal humerus to be rotated in a posterior direction in relation to the proximal end of the humerus.[10]
15. Range of Motion (ROM): Full movement of and around a joint region (flexion and extension).[1, 2, 14]
16. Laxity: Looseness in the muscles or joints.[1, 2]
17. Ball-and-Socket Joint: A synovial joint where there is a ball shaped surface of one bone that fits into a cup like depression of the other bone.[1, 2, 11, 27, 28]
18. Abduction: The movement of a limb away from the midline of the body.[1, 2, 10, 14, 17]
19. Adduction: The movement of a limb towards the midline of the body.[1, 2, 10, 14, 17]
20. Kinematics: The mechanics of motion related to objects, not connected to the forces that cause the motion.[10]
21. Biomechanics: The mechanical movements of living organisims.[10, 21]
22. Pitch count: Number of pitches thrown by a pitcher in a game.[1, 10]

23. Sport Specialization: The specific training and participation in one sport while excluding other sports.[1, 2, 17]
24. KJOC: Kerlan-Jobe Orthopaedic Clinic questionnaire for self-reporting shoulder and elbow injuries, which scores the symptoms of the patient.[22, 29]

Delimitations

We surveyed male advanced baseball players (14 to 22 years old). We limited our sample to those on the University of Montana club baseball team that is affiliated with the National College Baseball Association (NCBA) and those who participated in the Missoula, Montana Mavericks A, AA and B American Legion baseball league.

Limitations

There were limitations to consider when conducting this study. Population size and self-report limitations were the greatest limitations to this study. Gathering parent consent forms from the study participant's parents was another limitation to this study. Social pressure to not truthfully self-report all information may have also contributed to limitations of this study.

Threats to Internal Validity: Threats to internal validity include but are not limited to researchers disclosing additional information or assistance on the surveys. This threat comes from the researcher as well as from the coaches and parents of the study participants when completing the surveys, especially in the younger populations due to lack of understanding questions or formatting. Any errors in calculation or in the data entry into the Excel spreadsheet, which is done by hand, were a threat to internal validity.

Threats to External Validity: External validity is the ability to generalize study results to a larger population, situations or people used within the study.[30] Montana is located in the northwest and has long winters, and short spring and summer seasons. Compared to

many other states such as California, Nevada, and Texas that have year-round baseball seasons and large populations; Montana has a smaller population and not a true representation of the entire baseball population. The short length of baseball seasons in Montana posed a threat to external validity due to limited resources, time and availability of study participants. Another threat to external validity was the influence and behavior of the study participants.[30]

Social influences and other behavior influences cause a threat to external validity as participants may not have reported truthful information on the surveys, failed to fully complete the surveys, or participants left the study early. These were a threat to external validity due to a small sample size, which can skew the data and outcomes of the study, and not accurately represent the sample population.[30] Failing to report any possible or suspected upper extremity injury information due to fear of the inability to participate in the season was another threat to external validity. Geographic setting and climate were threats to external validity due to extreme weather conditions, long winter seasons, shortened spring and summers and rural nature of Montana. These threats made for a short season as well as a challenge to travel to gather and monitor study participants.

Chapter Summary

Baseball is known to be a safe sport, and many participants start at a young age. This chapter has illustrated that, even though baseball is considered a safe sport, there is a growing rate of upper extremity injuries. There is extensive literature on many other levels of baseball from young adolescence to the professional level, but there is minimal literature on advanced baseball players. Decreasing the rate of upper extremity injuries in this age group must be addressed to enhance and allow an overall good quality of life for these baseball players. There is

a significant need to detect and address the growing rate of upper extremity injuries in advanced baseball players. This study has provided the knowledge and structure to more effectively recognize and manage upper extremity injuries in advanced baseball players.

Chapter II

Review of Related Literature

Overview

Upper extremity injuries in overhead athletes are increasing, particularly in the youth population.[1, 19] Injuries to the shoulder and elbow are the most common injuries sustained in overhead athletes, with the highest prevalence in baseball players, specifically baseball pitchers.[1, 2, 10, 17, 19, 31] Baseball players apply increased bouts of repeated stresses to their shoulder and elbow causing many physiological adaptations starting at a young age.[14, 19] Baseball players create significant clinical challenges for medical professionals in addressing the adaptive and developmental changes in their upper extremities.[14] Within high school age baseball players there is minimal research and data on upper extremity injuries. Understanding this age range of baseball injuries is instrumental to effectively decrease the overall rise in upper extremity injuries in youth baseball.

Epidemiology of Shoulder and Elbow Injuries

In baseball, specifically pitching, a great number of injuries and time on the disabled list are from upper extremity injuries such as shoulder impingement, rotator cuff injuries, shoulder instability and elbow ulnar collateral ligament (UCL) injuries.[10] A review was conducted by Hibberd and colleagues on ulnar collateral ligament injuries in baseball pitchers in Major League Baseball (MLB) and the National Collegiate Athletic Association (NCAA).[10] This review found that 67% of all injuries sustained by pitchers were upper extremity injuries.[11] MLB injury data showed injuries to the throwing elbow made up ~16% of all injuries in baseball players and ~25% of all injuries sustained by pitchers, and ~21% of all injuries to pitchers were to the shoulder.[10] In MLB, pitchers make up approximately half of the disabled list spending an

average of 39 days on the disabled list while position players spent an average of 27 days on the disabled list.[10]

In collegiate baseball players, 45% of shoulder and elbow injuries sustained in practice or game situations were reported as ligament sprains.[9, 10] In collegiate baseball players who sustained shoulder and elbow injuries, 14.3% of had time loss of greater than 10 consecutive days.[9] Shoulder injuries received in practice accounted for the majority of severe time loss injuries compared to that of any other upper extremity injury.[9] A reporting system, known as the National Collegiate Athletic Association's Injury Surveillance System (NCAA ISS), there was found to be an increased amount of overuse injuries at the colligate level, that accounted for an average loss of 21 days from competition and practice.[32, 33]

There is not a complete data base to track injuries to the upper extremity for high school aged and younger athletes.[7] What is used for participating high schools is a reporting information online (RIO) system is used to track and monitor baseball injuries.[7] Clinical evidence from the American Sports Medicine Institute suggest a significant increase in UCL tears in younger population of baseball players.[10] The largest and most recent in-depth study that was performed on high school baseball player injuries was conducted approximately 10 years ago.[7]

The Reporting Information Online (RIO) database provides epidemiological data for high school athletes.[32, 33] RIO data showed that overuse injuries (or gradual onset injuries) had the highest incidence rate among high school athletes.[32, 33] The RIO data along with other studies have shown that injuries sustained to the shoulder and elbow are rarely acute, but more chronic and overuse injuries, that develop over time into severe injuries if not treated.[10, 32, 33] The American Sports Medicine Institute reports between 1994 and 1998 that 7% of UCL reconstructive surgeries were performed on the younger population, though by 2004-2008, 26%

of UCL reconstructive surgeries at clinics were performed on high school aged patients or younger.[10] The increases in these injury rates and reconstructive surgeries may be due to the improvement in diagnostic capabilities, changes in training methods, or an increase in participation time.[10, 31]

Shoulder Anatomy and Mechanics

Overhead athletes such as baseball players rely on full range of motion (ROM) through the shoulder and elbow to assist in preventing in injuries to the upper extremity.[10, 19, 34] Adaptations to the glenohumeral joint affect a baseball player's ability to maintain stability while pitching or throwing a baseball.[10, 19, 34] The shoulder, specifically the rotator cuff, is involved in multiple functions during shoulder movements and actions such as glenohumeral abduction, external rotation (ER) and internal rotation (IR).[18, 19, 31] Coordinated movements between the humerus, humeral head and the scapula come from force coupling of the rotator cuff and the glenohumeral joint which is a ball-and-socket joint, allowing full range of motion for throwing.[28]

The rotator cuff acts as a stabilizer for the glenohumeral joint and regulates humeral head translation.[18, 19] Muscles such as the infraspinatus and subscapularis play key roles in scapular plane abduction (scaption), that generate forces equal or greater than two to three times that of the supraspinatus force.[18, 19] Even though the infraspinatus and subscapularis have a significant role in scapular abduction, the supraspinatus is the most effective shoulder abductor due to its more effective lever arm.[18, 19]

The deltoid and rotator cuff work together to initiate abduction torque of approximately 35-65% from the middle deltoid, 30% by the subscapularis, 25% by the supraspinatus, 10% from the infraspinatus and 2% from the anterior deltoid.[18] At higher angles of abduction the deltoid is more effective, where the rotator cuff muscles are more efficient abductors at lower angles.[18] The

forces that are generated are not solely to abduct the shoulder but to stabilize the glenohumeral joint and offset the superior humeral migration due to the action of the deltoid muscle, which may cause injury to the shoulder region.[18] The relative high force generated from the rotator cuff neutralizes the superior force from the deltoids at lower abduction angles, thus protecting shoulder structures from impingement and injury.[18]

The scapula upwardly rotates 45-60°, posteriorly tilts at 20-40° and externally rotates at 15-35° through maximum humeral elevation.[18] During these movements the scapular muscles play a vital role for humeral elevation, especially the serratus anterior, which helps stabilize the medial border and the inferior angle preventing scapular winging.[18, 28] These coordinated movements keep the angle between the humerus and the glenoid within a physiologically bearable range, known as the "safe zone".[28] The safe zone is when actions of the glenohumeral joint fall approximately within 30° of extension or flexion from the neutral position in the scapular plane.[28] The safe zone allows for a stable controlled center of rotation permitting the glenohumeral joint to have full movement.[28]

Scapula malposition, which is when the scapula is not set in its anatomically correct position, is known as scapular dyskinesis. This can affect glenohumeral rotation, increasing the risk of injury during humeral elevation.[18, 28, 36-41] The largest factor that contributes to shoulder joint injuries is the biomechanics of overhead throwing motion, especially in the late cocking phase of throwing. In this phase, the arm is in extreme external rotation and external abduction, putting the humeral head in an abnormal motion increasing the risk of injury to the labrum.[17]

Overhead athletes rely on fluid biomechanics of the scapula, glenohumeral joint and the elbow to perform at full potential. Proper alignment of the glenoid is critical for maximal function of the glenohumeral joint and musculature, allowing the most effective glenohumeral

motion.[28] The intrinsic muscles of the rotator cuff compress the glenoid socket thereby enhancing the muscular constraint systems throughout the shoulder and scapula.[28] Balanced intra-articular pressure from the position of the glenoid in correlation to the humerus, and proper muscle activity is needed to maintain smooth ball-and-socket kinematics.[28] If the scapula cannot retract properly it will affect the cocking position during sports such as baseball, not allowing for the contraction from eccentric to concentric of the anterior muscles and concentric to eccentric of the posterior muscles.[26] Any variations from normal ROM standards or musculoskeletal limits within the glenohumeral joint or scapula will have a severely negative impact on the biomechanics of the upper extremity increasing the risk of injury.[26, 28]

It is critical that the clinician be familiar with scapular asymmetry and glenohumeral functions and adaptations in overhead athletes and non-overhead athletes. This familiarity allows for proper recognition of any true abnormalities or dysfunctions of the elbow, scapula (scapular dyskinesis) and glenohumeral joints, ligaments and muscular structures.[14] When palpating the shoulder region, palpation should occur around the full scapula region, including the spine of the scapula and all borders as well as identifying the resting position of the glenohumeral joint.[17] If the glenohumeral joint is found to be resting anteriorly, then the scapula is misaligned and if the glenohumeral joint is resting anteriorly with a corrected scapula position then further investigation of surrounding muscular structures is needed.[17]

Baseball players, specifically pitchers put a large of amount of torque on their shoulder while pitching.[35-37] Due to the repeated overuse and excessive joint loading, shoulder and elbow injuries remain the most common injury among all levels of baseball.[35] The greatest torque applied to the shoulder is internal rotation torque, which had a peak average of 35 N•m among youth baseball pitchers and 65 N•m in high school pitchers.[35, 37] The highest internal torque

found was among college baseball pitchers who had an average internal rotation torque of 80 N•m, compared to the average peak internal rotation torque of MLB players of 50 N•m.[35, 37] There was only a 15 N•m difference between professional baseball pitchers and youth baseball pitchers.[35, 37] The same study found that normalizing the data by using the percentage of body weight of the athlete minus their height (%BW-H), showed that high school baseball pitchers had the highest percentage of internal rotation torque, equivalent to 50% of their body weight.[35] These increased torque and forces due to high repetitions increase the risk factors associated with shoulder injuries, particularly among younger baseball players and pitchers.

Risk Factors for Shoulder Injuries

There are a number of risk factors that play a role in shoulder injuries in baseball players. Glenohumeral internal rotation deficit (GIRD) is a loss of internal rotation, which effects the total arc of ROM for baseball players, particularly pitchers.[10, 22, 27] GIRD is most commonly defined by clinicians as significant if there is an internal rotation (IR) deficit of 20° or greater in the dominant shoulder (throwing arm), compared to non-dominant shoulder.[27, 39] GIRD is believed to be one of the primary risk factors for shoulder injuries in baseball players.[27, 38, 39] Along with GIRD, a deficit of 5° or greater deficit in the total range of motion (TRM) had a 2.5 times greater risk of sustaining a shoulder injury.[27, 38, 39] Another risk factor related to shoulder injuries is humeral retrotorsion.[10, 34] Humeral retrotorsion is the amount of torsion and twist between the distal humerus and proximal humerus causing a bony rotational deformity of the distal humerus in a posterior direction.[10, 34] In young growing overhead athletes overhead throwing creates sheer stresses causing skeletal adaptations such as retrotorsion of the humerus in the dominant limb compared to their non-dominant limb.[22] Overhead throwing movements increases the stresses from this sport specific movement, increasing the rate of injuries to the

shoulder, compared to those of non-overhead athletes.[34] This evidence suggest that the specific movements associated with overhead activities can lead to skeletal adaptations that may increase the risk of shoulder injury compared to those of non-overhead activities.[34]

Pitching requires repetitive external rotation (ER), along with the fastest shoulder internal rotation (IR) of human movement recorded, which causes extreme torque to the shoulder increasing the amount of ER on the shoulder joint complex.[38] The large forces generated, combined with high repetitions, explain why shoulder injuries are the most common injury in baseball players, especially pitchers.[38] The lack of monitoring or abiding by pitch counts for the current league(s) that pitchers are pitching in increase the risk of overuse injuries to the shoulder.[1] Allowing a pitcher to pitch more than the league maximum per game for their specific age group increases the likelihood of an overuse injury.[1] Many baseball players compete in multiple leagues during a single season, so while they might be monitored in one league, the other league may not monitor pitch counts and rest cycles which could lead to increased risk of an overuse injury to the shoulder. Knowing how often an athlete is playing and pitching overall, rather than just what they are pitching for one league, could reduce the risk of shoulder injuries by allowing proper rest cycles.[1] Lack of proper rest cycles could lead to increased laxity within the shoulder region and joint, increasing the risk for injury.[2] Athletes who play baseball year round, especially at an early age, known as sport specialization, also increase their risk of injury to the shoulder or elbow due to shorter rest cycles and increased exposure to pitching and throwing.

Sport specialization at a young age increases the risk of shoulder injury do to tissue immaturity and muscle imbalance.[1] Adolescent overhead athletes have an increased risk of shoulder overuse injuries due to their quick periods of growth.[1] The pressure from parents,

coaches and peers to compete with minimal rest also increase the risk of shoulder injury by lack of rest which increases fatigue.[1] The overall fatigue that occurs in the rotator cuff muscles, trapezius, infraspinatus and serratus anterior due to lack of proper rest cycles cause an unstable scapular base.[34] This unstable scapular base does not allow for the muscles to properly activate to resist the forces and stresses applied during baseball activities.[34] Other factors are anatomical adaptations (such as retrotorsion) which occur in overhead athletes by repeated overhead motions that cause stress on the glenohumeral joint, and certain pitching styles.[1, 2]

Pitching styles such as curveballs, sliders, breaking balls and fastballs all apply different amounts of stress on the shoulder, and may increase the risk of shoulder or elbow injury.[1, 40] If a young baseball pitcher is in an active growth period, the rest of their body may not be physically ready to handle the stresses of different pitching styles, and could damage the shoulder due to decreased skeletal muscle mass and lack of joint stability.[40] In young adolescent baseball pitchers, throwing pitch types such as the curveball and slider apply the greatest amount of stress on the shoulder and elbow joints compared to that of a change-up.[4] Pitch types such as the split-finger, forkball, sinker or splitter increased the probably of having elbow pain, and it was found that if a change-up was thrown more it decreased the odds of elbow pain in 11-12 year-olds.[4] There was no specific pitch type or style that was found to any significant association with shoulder pain.[4]

Lower extremity tightness decreases balance and takes away from proper pitching mechanics, causing added stress to the shoulder region by limiting the total arc ROM of the shoulder.[40] Lower extremity tightness negatively impacts the kinetic chain during throwing activities.[42-49] Muscle tightness in the legs or trunk cause a strain on the trunk up through the posterior region of the upper extremity, restricting the scapula and shoulder kinetic

movements.[43, 49] To maximize the shoulder and arm function depends on the activation of the legs, pelvis, and spine for proper kinetic chain movements.[50] All movements start with force generating from the feet and traveling up through hip extension or flexion which requires activation of both ipsilateral and contralateral patterns.[50]

Throwing requires diagonal movements and if the proximal segments, including the legs, do not activate properly, there will be increased stress put on the upper extremity, specifically the shoulder and elbow.[50] Any faults within the lower extremity while performing throwing motions will directly affect the ability to achieve full ROM due to the lower extremity segment resisting against the upper extremity.[50] The resistance that is produced from the lower extremity musculoskeletal system (legs, hip, pelvis, etc.) pulls against the upper extremity musculoskeletal system, specifically the scapula and shoulder inhibiting full ROM in the glenohumeral region.[50] Maintaining flexibility throughout the entire body, especially the lower extremity, will allow for baseball players to utilize full unrestricted trunk rotation while decreasing the stress on the posterior chain of the shoulder and scapula region.[41, 49]

Elbow Anatomy and Mechanics

Overhead activities produce an enormous amount of valgus stress on the elbow and resistance from these extreme valgus forces come from bony, ligamentous and muscular structures.[43] The elbow is a multifaceted hinge joint that consist of three individual articulations: ulnohumeral, radiocapitellar, and proximal radioulnar joints.[20] These corresponding bony articulations function in tandem with the ligaments and surrounding muscles providing static and dynamic stability to the elbow, as well as allowing flexion-extension and pronation-supination.[20] The main ligament that is critical for elbow stability is the ulnar collateral ligament (UCL) (also known as the medial collateral ligament (MCL) complex) that consists of an anterior bundle,

posterior bundle and transverse bundle.[20, 43] Overhead sports such as baseball put a great deal of valgus stress on the UCL of the elbow due to throwing biomechanics.[43] The primary bundle that protects the elbow against valgus forces is the anterior bundle. This portion also has the highest rate of injury, since overhead throwing may exceed the tensile strength of the ligament.[43] Pitching and overhead throwing is a complex kinetic series that transfers energy from the lower extremity up through the pelvis and trunk, and then releases the energy through the upper extremity.[17, 41, 49]

Common causes of a medial elbow injuries are from extensive repeated overhead motions, such as throwing, along with increased training loads, increased throwing or pitching repetitions, shorter rest periods and a trend of single sport specialties that compete year-round.[10, 29] The increasing amounts of microtrauma gradually weaken the ligament, allowing a single motion such as throwing or pitching a baseball to create macrotears. This results in a tearing or a popping sensation that causes medial elbow pain.[10] Other conditions often occur due to the increased laxity in the medial elbow, including osteochondral defects (OCDs) and articular loose bodies.[15]

The increased valgus stress and torque that is placed on the elbow during pitching occurs in the late cocking phase of throwing.[44] Baseball players can apply valgus stresses to the elbow that reach 60 to 65 N•m at youth levels and 125 N•m at the professional level.[20, 45] These forces exceed the tensile strength of that tissue, which has been found to be 33 N•m.[20] The force loads to the elbow are the valgus stress that generates the tensile loads to the medial aspect of the elbow and the compressive loads on the lateral and posterior regions of the elbow when throwing.[20, 45] These combined forces and torques cause injury to the medial aspect of the elbow, and increasing the risk of valgus extension overload (VEO).[20, 45]

If laxity or instability is present in the UCL or medial elbow, this leads to increased ulnar nerve irritation or impingement that are known as ulnar neuropathy and cubital tunnel syndrome.[14, 44, 45] If the patient complains of paresthesia in the ring and little fingers of the hand, weakness of the hand intrinsics or grip, there is possible ulnar nerve irritation. The most common damage is to the ulnar nerve as it goes through the ulnar notch and is very superficial. Great attention must be given to the ulnar nerve during compression wraps or when applying ice to this region, ensure there is a protective layer to prevent any damage to the ulnar nerve from the extreme cold. During increased elbow flexion, there is an increased risk of subluxation of the ulna nerve.[45] Visual inspections of the hand, specifically the first dorsal interossei region if any muscle wasting (atrophy) is linked to an ulnar nerve lesion.[45]

The normal ROM of the elbow is 0° of extension and approximately 140° of elbow flexion.[20] Extension that is recorded to be greater than 0° is classified as hyperextension.[20] Most activities of daily living (ADL's) require a functional ROM of approximately 30° to 130°.[20] Wrist and forearm pronation and supination ROM is approximately 80° for both directions.[20] If hyperextension is present in the elbow it is related to increased ligamentous laxity, and any pain detected with hyperextension may be linked to overload or posterior impingement at the olecranon and olecranon fossa.[20] The ability to achieve full extension is the first motion that is commonly lost due to injuries, impingements or other pathologies of the elbow or shoulder.[20]

Risk Factors for Elbow Injuries

Pitch count is critical to maintaining healthy elbows, and disregarding recommended pitch counts could lead to an overuse injury of the elbow by microtrauma due to overuse and shortage of proper recovery time.[10, 27, 47, 46]Another risk factor for elbow injury is glenohumeral ROM changes. Athletes that display glenohumeral internal deficit (GIRD) have an increased risk

of UCL elbow injury, due to the increased valgus instability caused by GIRD.[10, 27, 43, 46] Total arc ROM (TROM) is also correlated to increased risk of elbow injury. Pitchers who have a deficit of 5° or more in total range of motion (TROM) are 2.5 times more likely to sustain an elbow injury.[10, 27, 35-41] The action of throwing a baseball is a violent motion which applies many forces to the elbow.[46]

Any deficit or limitation to the ability to reach full extension and full flexion will increase the risk of valgus forces to the elbow.[1, 2, 36, 37, 46] Each pitching style applies different amount of torque and force to the medial or posterior region of the elbow, such as a curve ball to a fast ball.[1, 2, 36, 37, 46] A curve ball applies a large amount of valgus force to the medial elbow, and is amplified with the violent action at the elbow that is required to execute a proper curve ball; where a fast ball applies an increased force to the posterior aspect of the elbow.[1, 2, 36, 37, 46] Like any muscle or ligament muscle fatigue will occur if proper rest is not provided, increasing the risk of an elbow injury due to the lack of ability for the stabilizer muscles to resist the necessary forces to prevent injury.[2] Maintaining rest cycles will reduce muscle fatigue, decreasing the risk of elbow injury. [1, 2, 36, 37, 46]

Like shoulder risk factors, sport specialization is a risk factor for elbow injuries as well.[1] Sport specialization at a young age has increases the risk of elbow injuries, due to growth bouts that youth go though, as well as soft tissue damage to the immature tissue.[1, 2] Sport specialization is hypothesized to be one of the leading causes of overuse injuries in youth and adolescent baseball players. This specialization typically reduces rest periods below recommended levels, which may lead to muscular fatigue and cumulative microtrauma to tissues.[1, 2, 39, 49]

Proper throwing kinetics involves the lower extremity to work as on fluid unit with the upper extremity.[39, 49] If the body encounters restrictions in motion while performing a pitch or

throwing a baseball, there is potential to have an adverse reaction to the velocity of the pitch, and to the baseball players elbow. For example if a pitcher has tight hamstrings and throws a baseball, their posterior kinetic chain will be limited and there will be strain present from the legs up through the truck, shoulder and elbow.[39, 49] The elbow is the last joint that receives all the forces generated from the lower body, and if muscle tightness is present in the lower extremities, upper back and shoulder, this may increase the forces at the elbow.[39, 49] Increased forces at the elbow, coupled with the limitations of the kinetic chain, will decrease the elbow's ability to handle the extreme stresses due to muscle tightness in the posterior chain.[19, 49] Maintaining a stretching protocol will sustain flexibility at the elbow and throughout the body, and improve the ability for the body to work as one kinetic chain while throwing a baseball.[39, 49]

Shoulder Injuries Influence on Elbow Injuries

Injuries to the shoulder complex are likely to influence the risk of injury to the elbow. The presence of GIRD has a high correlation with elbow and shoulder injuries in overhead athletes, and is probably one of the greatest risk factors for elbow and shoulder injuries in baseball players.[10] The presence of GIRD has also been found to increase the risk of medial/UCL tears due to the increased valgus forces.[10] Any shoulder dysfunction, such as scapular dyskinesis, predispose the elbow to increased risk of injuries.[10, 45] Shoulder impingement decreases the ROM causing limitations on the biomechanics of the elbow's functional capability.[10, 14, 18] The decrease in functional capability increases the risk of injury due to the excess valgus forces during overhead activities such as pitching or throwing a baseball.[1, 10, 38] Other adaptations in the glenohumeral joint may apply strain to the surrounding muscles, decreasing the dynamic stability of the shoulder. The decreased stability increases the stress at the elbow joint causing ligament laxity.

Weakened musculature surrounding the shoulder may predispose the elbow to injury, as these muscles may not be able to adequately attenuate the high forces that are generated in overhead activities.[18] The loss of full total arc of ROM increases the risk of an elbow injury due to the disruption of the kinetic chain.[1, 10, 38] Posterior upper extremity tightness in the shoulder region cause restrictions on proper overhead mechanics such as throwing a baseball.[1, 10, 38, 39] Tightness in the shoulder region decreases the functional capability of the elbow during overhead activities by increasing valgus stress to the medial elbow.[1, 10, 31, 33, 39] Muscle tightness in the posterior chain directly affects the performance of the elbow function by restricting the elbow's ROM due to muscle tightness inhibiting the elbow to fully extend to properly distribute the generated forces.[1, 10, 38, 39] Restrictions that decrease the functional capability of the shoulder directly affect the performance and ability of the elbow due to the adverse reaction of the kinetic chain.[1, 10, 31, 33, 38]

Elbow Injury's Influence on Shoulder Injuries

Elbow injuries that limit full ROM cause an added biomechanical stress on the shoulder.[20, 49] If the elbow is lacking any ROM the shoulder will take up the extra pressure and torque due to the decreased ROM from the elbow joint.[20, 49] Elbow joints that have an increased ROM such as hyperextension, or have an increase in elbow ligament laxity cause added stress on the glenohumeral joint and shoulder region creating instability in the kinetic chain.[20, 49] Increased laxity in the elbow joint is related to overload or posterior impingement at the olecranon or olecranon fossa, causing a firm mechanical block in the ROM.[20, 36, 37, 39] This firm mechanical block directly affecting shoulder function by inhibiting the glenohumeral joint to move within its normal ROM limits.[20, 36, 37, 39] This decrease in the shoulder ROM is due to the increases forces and torques causing overcompensation for the elbow at the glenohumeral joint.[20, 36, 37, 39]

Full elbow extension is the first ROM that is lost with elbow injuries, causing a negative effect on the kinetic chain from the shoulder through the hand in overhead activities, particularly baseball players.[1, 10, 45] This negative effect on the kinetic chain is caused by overcompensation at the shoulder to maintain full ROM and total arc, which increases stress and torque at the shoulder.[1, 10, 38, 39, 45] Damage to the nerves, such as the ulnar nerve at the elbow may also affect muscle strength and tendon reflexes which increase the risk of shoulder injuries due to overuse or overworking the muscles and tendons in the shoulder region.[10, 34, 43]

Players who have a prior history of elbow pain or injury are at increased risk of shoulder pain or injury.[45, 51-53] It has also been found that there is a higher frequency of self-reported elbow pain compared to that of shoulder pain in youth baseball players, which may precede a shoulder injury.[51] Young players who are developing elbow pain or early signs of injury, may alter their throwing mechanics to decrease stress on the elbow. This may decrease their overall performance and/or apply increased stress to their shoulder.[51] Pain in the elbow can create changes at the shoulder including a greater amount of lateral humeral joint force.[53] These mechanical changes increase tissue stresses which may cause injuries such as an anterior glenolabral tear, or possible rotator cuff injury.[53] Thus, it has been found that self-reported elbow pain, especially at a younger age has a direct correlation with shoulder pain or injury.[51, 53]

Patient Reported Outcomes for the Shoulder and Elbow

To identify shoulder and elbow injuries, medical professionals associated with baseball teams have implemented the use of Patient Rated Outcomes (PRO). These PRO's allow baseball players to self-report any suspected injuries or functional limitations, allowing medical professionals to identify and monitor shoulder and/or elbow injuries to prevent any further injury. A study performed by Fronek, looked at shoulder functional performance status of 366

Minor League professional baseball pitchers using the Kerlan-Jobe Orthopaedic Clinic (KJOC) questionnaire. The KJOC is an assessment tool specifically for overhead athletes such as baseball players.[54] The authors used the KJOC to assess the functional ability and reported disabilities before and after elbow and shoulder injuries.[54] The KJOC was able to identify shoulder injuries in those who currently or previously had shoulder injuries as well as identify those who had no current or previous injuries.[54] This study found that this assessment tool could be used to identify risk factors such as shoulder pain, weakness or any other aliments by self-reporting before the season for a baseline function and performance levels in the shoulder and elbow to aid with monitoring baseball pitchers and baseball players.[54] The KJOC was used multiple times throughout the season to allow the players to self-report any discomfort or injuries, allowing for identification of possible shoulder injuries and proper management of any pain.[54]

Using the KJOC and other PRO's such as the Disabilities of the Arm, Shoulder and Hand (DASH) were found to assist medical providers in successfully employing preventative and treatment plans for baseball players.[54] The implementation of the KJOC or other PRO's promotes safe participation and decreases shoulder and elbow injuries in MLB.[54] Further studies of KJOC in pediatric and adolescent baseball players needs to be analyzed along with examining the use of this assessment tool on the health and wellbeing in youth baseball players.[54] A study performed by Alberta found the KJOC to be valid and reliable in assessing shoulder and elbow injuries in those athletes who had injuries and identifying those who did not have shoulder or elbow injuries.[22]

Chapter Summary

There are an estimated thirty to forty million youth that compete in organized sports and activities each year with a steady increase of participation.[1] Since shoulder and elbow injury

rates are rising in the youth and high school age populations, steps need to be taken to recognize symptoms and adaptations that increase the risk of shoulder and elbow injuries in the youth baseball players. Sport specialization is also becoming more prevalent at a young age, contributing to overuse injuries due to insufficient rest between games and seasons.[1, 2, 10, 14] Half of pediatric patient complaints coincide with overuse/chronic injuries compared to acute injuries and approximately half of the pediatric sport related injuries are caused from repetitive biomechanical trauma.[1] There is a direct correlation with increased prevalence of risk factors, such as improper pitch counts, rest cycles, and identifying signs and symptoms of upper extremity injuries, and increased injury rates.[1, 10, 45] The purpose of the current study was to assess the prevalence of shoulder and elbow injuries in advanced youth baseball players over the course of one season, and investigated the relationship between prior shoulder or elbow injury to the development of shoulder or elbow pain and injury.

Chapter III

Materials and Methods

Introduction

A survey of advanced baseball players was conducted in Missoula, MT. This survey was used to examine the prevalence of shoulder and elbow injuries among advanced baseball players over a single season, with consideration to prior history of injury and playing position. A patient rated outcome (PRO), the KJOC, was utilized to allow self-reporting of any pain, symptoms of injury, and functional limitations over the course of a single season.

Participants

Participant Population: There are an estimated one million high school age baseball players in the U.S.A. Of that one million high school age baseball players, there is approximately 2,000 high school age high school age baseball players in Montana, that makes up ~0.2% of the total U.S. high school age baseball players.[52, 55] There are a limited number of high school age baseball players, advanced (including legion and college club baseball) level baseball teams in Montana, due to inclement weather that includes long winters and short summers. These factors also prevent the state from sanctioning high school baseball teams. Since there are no specific high school teams, there are alternate leagues for advanced baseball players to participate in. There are approximately 100 teams in Montana for advanced baseball players, which consist of American Legion (AA, A, B), Senior Babe Ruth and travel teams.

Participants: A combined sample of convenience of fifty-eight male baseball players were approached to participate in this study. Approximately fifty male baseball players were from the Missoula Mavericks, an organization that includes AA, A, and B

American Legion Baseball teams, with an age range of 14 to 18 years old. Approximately fifteen male baseball players with an age range of 18 to 22 years old were from the University of Montana club baseball team, which is affiliated with the National College Baseball Association (NCBA).

Instruments

Injury Survey: A retrospective survey, the "Baseball Injury Questionnaire", was used to collect injury history data, and was slightly modified for the pre-season (68 closed ended questions) and post-season (32 closed ended questions) data collection periods (see appendix A). Both of these surveys involved a self-report of any shoulder and elbow injuries, in addition to demographic information. This survey was modified from existing studies focusing on NCAA Division I baseball players and Brazilian Jujitsu (BJJ) athletes.[56-60] The survey was a paper survey as it was easier to monitor and maintain record data and quality of questions answered. A paper-based survey allowed for an increased sample size by permitting us to go to the teams and hand out the surveys, and then have them complete it at that time. Using an online survey would reduce the number of participants due to the fact it can easily be ignored. Studies have shown that a paper based survey is typically returned at a higher rate.[59] Due to the small sample size of approximately 65, data entry errors were less likely, thus a paper survey was preferable.

The pre-season survey focused on injuries suffered from the age of 14 through the time the survey was completed. The first part of the survey collected basic demographic information including age, height, weight (height and weight are needed as they were identified as factors that increase the risk of injury)[4,8], sex, team(s) or university the study participant played for, and their dominant hand (hand they throw with). The second part

contained specific questions pertaining to baseball history such as position(s) played, age began competitively playing baseball, number of leagues and teams played for, number of years playing baseball, pitcher or position player or both and other applicable information specific to baseball. The third part of the survey gathered information on the study participant's current injury history to their shoulder or elbow. The survey also gathered information on how injury may have limited their sport participation, such as any games or practices missed or had restricted participation in and the extent of time restricted participation occurred and the number of restricted participation events that transpired. The final part of the survey gathered information on the participant's history of injury to their shoulder or elbow. The injury history was gathered from the age of 14 to current age, documenting injuries that required a physician's visit and those that did not, along with the treatments and outcomes for each injury. The age of 14 was used since study participants would potentially have difficulty remembering prior injuries before high school, and high school is when new pitches are typically introduced, velocity increases, and exposure increases which all influence the risk of possible injury. The survey also examined how the injury limited their participation.

The post-season injury survey was similar to the pre-season injury survey except it was altered to focus on information from the most recent baseball season, compared to that of the pre-season injury survey that focused on information from the age of 14 to the start of the current season. The post-season injury survey still obtained basic demographic information to provide a rough measure of survey reliability. The KJOC was also repeated, in order to assess complaints of shoulder or elbow pain and disability.

The KJOC was also used to examine validity of post-season survey information about injury.

Patient Rated Outcome

A patient rated outcome (PRO) was utilized to assess for shoulder and/or elbow pain and disability that may not be reported in the Baseball Injury Questionnaire. Patient rated outcomes (PRO's) allow for the patient to self-report the status of their health or medical concerns without any interpretation from a medical professional or any other clinical personnel. PRO's were used to track complaints of shoulder or elbow pain, functional limitations, or other symptoms that may indicate an injury over the course of a season, so that those patients who never saw a healthcare provider for pain or disability were still captured for analysis.[22, 61, 62] The PRO used was the Kerlan-Jobe Orthopaedic Clinic (KJOC) score questionnaire comprised of 18 questions (see Appendix B). The first portion of the KJOC consisted of 8 questions related to history of shoulder or elbow injuries, current activity involvement, any games or practice missed due to a shoulder or elbow injury and if the individual received treatment for shoulder or elbow injury and if so, what the diagnosis was. The KJOC also identified the level of competition. The second part of the KJOC, consisting of 10 questions allowed the subject to convey any changes in their functional capability of their shoulder or elbow such as pain, weakness, feeling of instability, limitations, and how their shoulder or elbow pain affected their overall level of competition. The KJOC had ten questions in the second part, all had a 10cm line, with the far left being the most severe pain, complications or problems they have with their shoulder or elbow, and the far right of the line is no issues at all with their

shoulder or elbow. The subject put an "X" on the line that is most relevant to what level of pain, injury or discomfort they were currently feeling.

Validity of Surveys

Content and construct validity were established by expert (3 academic faculty) review to accurately assess content and construct of questionnaires. Face validity and accuracy of the Baseball Injury Questionnaire was determined by having five high school players complete the Baseball Injury Questionnaire, prior to the study commencing, and revising any sections based on their feedback. There were no suggested edits provided and subsequently, no changes were made.

Concurrent validity of the Baseball Injury Questionnaire was examined by comparing certain questions to a corresponding question on the KJOC (current arm injury). The KJOC has already been found to be a valid (ICC: 0.86-0.88) and reliable (ICC: 0.85-0.94) patient reported outcome for shoulder and elbow injury, pain, and function.[22, 61, 62] There was an 81% (21/26) agreement between the Baseball Injury Questionnaire and KJOC questions on "is your arm currently hurt/injured". Of the study participants, 4 reported a shoulder or elbow injury on the Baseball Injury Questionnaire but did not report an injury on the KJOC, while 1 out of 26 did not report an injury on the Baseball Injury Questionnaire, but did on the KJOC. Thus, the Baseball Injury Questionnaire demonstrated greater detection in reporting current injuries than a corresponding question on the KJOC. We believe this occurred due to a stricter/clearer injury definition on the Baseball Injury Questionnaire. Thus, the Baseball Injury Questionnaire picked up more detail about injury than the demographic section of the KJOC, and didn't miss injuries reported on the KJOC.

The Baseball Injury Questionnaire appears to be a more sensitive tool at picking up injury information. The KJOC is not designed as an injury history questionnaire, but designed to determine current arm function, not prior injury. The Baseball Injury Questionnaire is appropriate for obtaining injury history and information, and the KJOC is appropriate for evaluating current arm function.

There were potential subject reporting discrepancies that may have affected the reliability of the survey. The research team did not have access to each subject's medical records so subject honesty was critical to the study. Utilizing the KJOC to validate certain items on the injury questionnaire, and performing pilot testing prior to data collection, helped reduce errors that would be due to the format of the questionnaire itself.

Procedures

Ethical Nature of Data Collection: All study participants data were collected and utilized in agreement with ethical standards for human research. IRB approval was obtained prior to any data collection for this study. There was no expected distress or risk associated with this study. Each study participant completed informed consent and for those under the age of 18, a minor assent form was completed in addition to the informed consent that was filled out by their parent or legal guardian. All data collected was de-identified and contained no personal identification and was entered into an excel database.

*Research Paradigm***:** The research paradigm was created off of a set of assumptions, concepts, values and practices that were established by the community of researchers.[60] A quantitative paradigm was utilized in this study, which used an inductive approach based on prior research.[60] The purpose of quantitative research is to test and

provide data to support or reject the hypothesis or theory that was proposed by the researchers.[60] A quantitative approach was chosen for this survey because it allowed for detachment in analysis of the data, and findings could be more easily generalized in an attempt to describe, explain and predict the outcomes of the study.[60] Within athletic training and related fields, survey-based designs similar to this have been deemed quantitative rather than qualitative.

Study Design: A retrospective survey was administered at two times during a single season. The pre-season survey gathered prior injury history from the age of 14 to present day, while a post-season survey gathered data on any injuries sustained from the present season.

Data collection procedures: Each study participant was randomly assigned a three-digit number. The three-digit numbers represented preseason (101 and up) and post-season (201 and up) data collection. The study participant who was assigned 101 received 201 and so on for each study participant, in order to link pre-season and post-season data. The study participants were given a paper survey packet during the first week of practice at the start of the season, on a set day that was agreed upon by the league president, coach and primary researcher. The primary researcher attended this practice(s) to explain the study, and also distributed the surveys and answered any questions. The athletes took the survey packets home and filled them out if they were 18 years old or older. If they were under the age of 18 they filled the survey packets out with their parents. The primary researcher returned the following week on a set day agreed upon by the coach and primary researcher and collected the survey packets and answered any questions. The survey packet contained a cover sheet, survey (parts I-IV), and the KJOC. The cover

sheet remained with the study participants and contained the contact information for the research team.

The study participants were given a post-season survey (survey cover sheet, parts I-IV) as well as the KJOC again within seven days of the last game of the regular season. Any study participant who left the team for any reason was given the opportunity to complete the post-season survey upon their exit from their respective team; however, there were no study participants who left their prospective team prior to the conclusion of the season.

The survey cover page contained the randomly assigned three-digit number for the study participant, the study participant's full name, phone number and email address. All surveys were de-identified and contained no personal identification information on or within them.

Data Reduction: All data collected for preseason and post-season was entered into an excel database, which did not contain any personal identification information. All print outs of the excel data were stored with other de-identified information and not with the survey cover pages that contained personal identification information.

Scoring: There was a 10cm line on the KJOC and the baseball player made a mark on the line that corresponded to their current level of pain or discomfort.[24] The distance from the furthest left border to their mark was measured in centimeters and recorded in an excel spreadsheet. This was done for each of the 10 questions on the KJOC.[22, 61, 62] The larger numbers (closer to 10cm) indicated higher functioning, lower pain, and fewer reported disabilities. A total KJOC score was calculated by summing the 10 questions into a single score (maximum score=100). All other items from the injury

survey were recorded as written on the excel spreadsheet. The injury survey data included nominal data (sex, playing position, body part injured, mechanism of injury, etc.), ordinal data (year in school), and interval data (age, years playing, pitch counts, etc.).

Quantitative Analysis

Descriptive statistics, including frequency, means, and measures of variability were computed for all variables. Most responses in the Baseball Injury Questionnaire were categorical data so non-parametric methods were used, using SPSS software (IBM SPSS Version 22.0, Armonk, NY), to analyze the data. For injury status, we combined reported shoulder or elbow injury into a single variable ("current arm injury"). We also collapsed prior history of shoulder or elbow injury into a single variable ("Prior arm injury"). Fisher exact tests were used to compare arm injury status between groups (pitchers vs. position players, prior history vs. no prior history). Mann-Whitney U tests were used to compare KJOC scores (total and each individual question) between groups, and Wilcoxon signed-rank tests compared KJOC scores from pre-season to post-season. Alpha was set *a priori* at 0.05.

Research question one related to demographic information (level of play/competition, team(s) played for, grade level (high school or college), sex as well as the age of the subject). Part two of the survey established arm dominance, years played, positions played, and whether the subject played on multiple teams/leagues over the course of one season. Parts one and two of the survey supplied the basic foundation for research question one. Parts three and four of the survey, and the PRO supported research question one by identifying the number of Participants who reported shoulder or elbow injuries, prior injuries to shoulder or elbow, Participants who reported limitations with shoulder or elbow pre-season and post-season.

Research question two gathered information on whether pitchers reported a greater number of shoulder and elbow injuries compared to position players. Part III (and Part IV of the pre-season survey) along with PRO supported this research question by gathering categorical data that identified the number of self-reported shoulder and elbow injuries, symptoms and functional limitations of pitchers compared to position players. Primary position was determined in Part II of each survey.

Research question three examined whether baseball players with a previous shoulder or elbow injury reported more shoulder or elbow injuries, or a greater self-report symptoms of limitations over the course of a single season. This research question was supported by questions seventeen through sixty in the pre-season survey and questions nine through thirty-two in the post-season survey. These questions related to history questions (past from age 14 to current).

References

1. Myrick KM. Pediatric Overuse Sports Injury and Injury Prevention. *J Nurse Pract*. 2015;11(10):1023-1031.
2. Sgroi T, Chalmers PN, Riff AJ, et al. Predictors of throwing velocity in youth and adolescent pitchers. *J Shoulder Elb Surg*. 2015;24(9):1339-1345.
3. Sauers EL, Dykstra DL, Bay RC, Bliven KH, Snyder AR. Upper extremity injury history, current pain rating, and health-related quality of life in female softball pitchers. *J Sport Rahabil*. 2011;20(1):100-14.
4. Lyman S, Fleisig GS, Waterbor JW, Funkhouser EM, Pulley L, Andrews JR, Osinski ED, Roseman JM. Longitudinal study of elbow and shoulder pain in youth baseball pitchers. *Med Sci Sports Exerc*. 2001;33(11):1803-10.
5. Urbin MA, Fleisig GS, Abebe A, Andrews JR. Associations Between Timing in the Baseball Pitch and Shoulder Kinetics, Elbow Kinetics, and Ball Speed. *Am J Sports Med*. 2013;41(2):336-342.
6. Shanley E, Michener LA, Ellenbecker TS, Rauh MJ. Incidence of Shoulder and Elbow Injuries in High School Softball and Baseball Players. *J Athl Train*. 2011;45(4):648-659.
7. Collins CL, Comstock RD. Epidemiological Features of High School Baseball Injuries in the United States, 2005-2007. *Pediatrics*. 2008;121(6):1181-1187.
8. Bonza JE, Fields SK, Yard EE, Comstock RD. Shoulder injuries among United States high school athletes during the 2005-2006 and 2006-2007 school years. *J Athl Train*. 2009;44(1):76-83.
9. Dick R, Sauers EL, Agel J, et al. Descriptive Epidemiology of Collegiate Men's Baseball Injuries : National Collegiate Athletic Association Injury Surveillance System, 1988 – 1989 Through 2003 – 2004. *J Athl Train*. 2007;42(2):286-294.
10. Hibberd EE, Brown JR, Hoffer JT. Optimal management of ulnar collateral ligament injury in baseball pitchers. *Open Access J Sport Med*. 2015;6:343-357.
11. Yukutake T, Kuwata M, Yamada M, Aoyama T. A Preseason Checklist for Predicting Elbow Injury in Little League Baseball Players.*Orthop J Sports Med.* 2015;3(1):2325967114566788.
12. Shanley E, Rauh MJ, Michener L a, Ellenbecker TS, Garrison JC, Thigpen C a. Shoulder range of motion measures as risk factors for shoulder and elbow injuries in high school softball and baseball players. *Am J Sports Med*. 2011;39:1997-2006.
13. Olsen, S. Fleisig, G. Dun, S. Loftice, J. Andrews J. Risk Factors for Shoulder and Elbow Injuries in Adolesent Baseball Pitchers. *Am J Sports Med*. 2006;34(6):905-912.
14. Limpisvasti O, ElAttrache NS, Jobe FW. Understanding shoulder and elbow injuries in baseball. *J Am Acad Orthop Surg*. 2007;15(3):139-147.
15. Paz DA, Chang GH, Yetto JM, Dwek JR, Chung CB. Upper extremity overuse injuries in pediatric athletes: Clinical presentation, imaging findings, and treatment. *Clin Imaging*. 2015;39(6):959-964.
16. Leahy I, Schorpion M, Ganley T. Common medial elbow injuries in the adolescent athlete. *J Hand Ther*. 2015;28(2):201-211.
17. Valovich McLeod TC, Decoster LC, Loud KJ, Micheli LJ, Parker JT, Sandrey MA, White C. National Athletic Trainers' Association Position Statement: Prevention of Pediatric Overuse Injuries. *Journal of Athletic Training* 2011;46(2):206–220

18. Escamilla RF , Andrews JR. Shoulder muscle recruitment patterns and related biomechanics during upper extremity sports. *Sport Med*. 2009;39(7):569-590.
19. Tyler TF, Mullaney MJ, Mirabella MR, Nicholas SJ, McHugh MP. Risk Factors for Shoulder and Elbow Injuries in High School Baseball Pitchers: The Role of Preseason Strength and Range of Motion. *Am J Sports Med*. 2014;42:1993-1999.
20. Hsu SH, Moen TC, Levine WN, Ahmad CS. Physical Examination of the Athlete's Elbow. *Am J Sports Med*. 2012;40(3):699-708.
21. Fleisig GS, Barrentine SW, Zheng N, Escamilla RF, Andrews JR. Kinematic and kinetic comparison of baseball pitching among various levels of development. *J Biomech*. 1999;32(12):1371-5
22. Alberta FG, ElAttrache NS, Bissell S, et al. The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. *Am J Sports Med*. 2010;38:903-911.
23. Meeuwisse W. Meeuwisse_1994_Assessing causation in sport injury A multifactorial model.pdf. *Clin J Sport Med*. 1994;4(3):166-170.
24. Meeuwisse W, H MD P, Tyreman H, Hagel B, Emery C, BScPT P. A Dynamic Model of Etiology in Sport Injury: The Recursive Nature of Risk and Causation. *Clin J Sport Med*. 2007;17(3):215-219.
25. Jette AM. Physical disablement concepts for physical therapy research and practice. Phys There. 1994;74(5):11-18.
26. Prentice W. *Principles of Athletic Training*. 14th ed. McGraw Hill; 2011.
27. Ryan J, Fening SD, Soloff L, Schickendantz MS, Jones M. Deficits , Total Range of Motion , and. *Jaaos*. 2015;23(12):789-796.
28. Kibler W Ben. The Role of the Scapula in Shoulder Function. *Am J Sports Med*. 1998;26(2):325-337.
29. O'Brien DF, O'Hagan T, Stewart R, et al. Outcomes for ulnar collateral ligament reconstruction: A retrospective review using the KJOC assessment score with two-year follow-up in an overhead throwing population. *J Shoulder Elb Surg*. 2015;24(6):934-940.
30. Thomas JR, Nelson JK, Silverman SJ. Research methods in physical activity. 7th. Champaign, IL: Human Kinetics; 2015:351-369.
31. Escamilla RF, Yamashiro K, Paulos L, Andrews JR. Shoulder Muscle Activity and Function in Common Shoulder Rehabilitation Exercises.pdf. *Sports Med*. 2009;39(8):663-685.
32. Mitchell J, Magnussen R a., Collins CL, et al. Epidemiology of Overuse Injuries Among High School Athletes in the United States. *Am J Sports Med*. 2015;43(7):1676-1682.
33. Schroeder AN, Dawn Comstock R, Collins CL, Everhart J, Flanigan D, Best TM. Epidemiology of overuse injuries among high-school athletes in the united states. *J Pediatr*. 2015;166(3):600-606.
34. Oyama S, Hibberd EE, Myers JB. Changes in humeral torsion and shoulder rotation range of motion in high school baseball players over a 1-year period. *Clin Biomech*. 2013;28(3):268-272.
35. Aguinaldo AL, Buttermore J, Chambers H. JAB Aguinaldo Effects of upper trunk rotation on shoulder joint torque among baseball pitchers of various levels. *J Appl Biomech*. 2007;23(1):42-51.

36. Joshi M, Thigpen CA, Bunn K, Karas SG, Padua DA. Shoulder external rotation fatigue and scapular muscle activation and kinematics in overhead athletes. *J Athl Train*. 2011;46(4):349-357.
37. Hurd WJ, Kaufman KR. Glenohumeral rotational motion and strength and baseball pitching biomechanics. *J Athl Train*. 2012;47(3):247-256.
38. Wilk KE, Macrina LC, Fleisig GS, et al. Correlation of glenohumeral internal rotation deficit and total rotational motion to shoulder injuries in professional baseball pitchers. *Am J Sports Med*. 2011;39(2):329-335.
39. Wilk KE, Macrina LC, Fleisig GS, et al. Deficits in Glenohumeral Passive Range of Motion Increase Risk of Shoulder Injury in Professional Baseball Pitchers: A Prospective Study. *Am J Sports Med*. 2015;43(10):2379-2385.
40. Sakata J, Nakamura E, Suzukawa M, Akaike A, Shimizu K. Physical Risk Factors for a Medial Elbow Injury in Junior Baseball Players: A Prospective Cohort Study of 358 Players. *Am J Sports Med*. 2016;45(1):135-143.
41. Kibler W Ben, Sciascia A. The role of the scapula in preventing and treating shoulder instability. *Knee Surgery, Sport Traumatol Arthrosc*. 2016;24(2):390-397.
42. Moore SD, Uhl TL, Kibler W Ben. Improvements in shoulder endurance following a baseball-specific strengthening program in high school baseball players. *Sports Health*. 2013;5(3):233-238.
43. Rettig AC, Mieling P. Numerous tests aid in the diagnosis of ulnar collateral ligament injuries -- Managing elbow problems in throwing athletes Arthur C. Rettig and Paul Mieling. *J Musculoskelet Med*. 2007;(24):129-135.
44. Post EG, Laudner KG, McLoda T a., Wong R, Meister K. Correlation of Shoulder and Elbow Kinetics With Ball Velocity in Collegiate Baseball Pitchers. *J Athl Train*. 2015;50(6):629-633.
45. Anz AW, Bushnell BD, Griffin LP, Noonan TJ, Torry MR, Hawkins RJ. Correlation of torque and elbow injury in professional baseball pitchers. *Am J Sports Med*. 2010;38(7):1368-1374.
46. Copas D, Talbot JC. Clinical assessment of the elbow. *Orthop Trauma*. 2016;30(4):291-300.
47. Soma DB. Opening the Black Box: Evaluating the Pediatric Athlete With Elbow Pain. *PM R*. 2016;8(3 Suppl):S101-12.
48. Werner SL, Fleisig GS, Dillman CJ, Andrews JR. Biomechanics of the elbow during baseball pitching. *J Orthop Sports Phys Ther*. 1993;17(6):274-278.
49. Li X, Zhou H, Williams P, et al. The epidemiology of single season musculoskeletal injuries in professional baseball. *Orthop Rev (Pavia)*. 2013;5(1):e3.
50. Kibler W Ben, McMullen J, Uhl T. Shoulder Rehabilitation Strategies, Guidelines, and Practice. *Oper Tech Sports Med*. 2012;20(1):103-112.
51. Matsuura T, Iwame T, Suzue N, Arisawa K, Sairyo K. Risk factors for shoulder and elbow pain in youth baseball players. *Phys Sportsmed*. 2017;45(2):140-144.
52. Yang J, Mann BJ, Guettler JH, et al. Risk-Prone Pitching Activities and Injuries in Youth Baseball. *Am J Sports Med*. 2014;42(6):1456-1463..
53. Grana WA, Boscardin JB, Schneider HJ, Takao SH, Vera T, Goin SG. Evaluation of elbow and shoulder problems in professional baseball pitchers. *Am J Orthop (Belle Mead NJ)*. 2007;36(6):308-313.

54. Fronek J, Yang J, Osbahr DC, et al. Shoulder functional performance status of Minor League professional baseball pitchers. *J Shoulder Elb Surg*. 2015;24(1):17-23.
55. http://mtlegion.org/department/baseball.html
56. Turocy PS. Survey Research in Athletic Training: The Scientific Method of Development and Implementation. *J Athl Train*. 2002;37(4 suppl):S-174-S-179.
57. Usuki H. Injury history, severity, and medical care for athletes participating in brazilian jiu-jitsu [master's thesis]. [Omaha (NE)]: University of Nebraska at Omaha; 2016. 69 p.
58. Wilkins SJ. The relationship between sport specialization in baseball and glenohumeral internal and external rotation and functional movement screen scores [master's thesis]. [Omaha (NE)]: University of Nebraska at Omaha; 2012. 63 p.
59. Kongsved SM, Basnov M, Holm-Christensen K, Hjollund NH. Response rate and completeness of questionnaires: a randomized study of Internet versus paper-and-pencil versions. *J Med Internet Res*. 2007;9(3):e25.
60. Johnson B, Christensen LB. Educational research: quantitative, qualitative, and mixed approaches. 2nd ed. Boston : Pearson; 2005.
61. Alberta FG, ElAttrache NS, Bissell S, et al. The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. *Am J Sports Med*. 2010;38:903-91.
62. Franz JO, McCulloch PC, Kneip CJ, Noble PC, Lintner DM. The utility of the KJOC score in professional baseball in the United States. *Am J Sports Med.* 2013;41(9):2167-73.

Examining Upper Extremity Injuries In Male Baseball Players Between The Ages Of 14 To 22 Years Old

Abstract

Purpose: To assess the prevalence of shoulder and elbow injuries and the relationship between prior shoulder or elbow injury to the development of arm pain, disability, and injury over the course of one baseball season. **Methods**: A retrospective paper survey assessing shoulder and elbow injury history, current injury status, and self-reported arm function was administered to advanced baseball players at the beginning and at the end of a single spring season. **Results:** There was no significant difference in reported injuries between participants with prior injury history to those without, and no differences in reported injury between those who pitched and those who did not. Self-reported arm function was significantly lower in participants with a history of arm injury at both pre-season and post-season. **Conclusion:** Clinicians should identify baseball players with prior injury history and tailor in-season training and injury prevention protocols to players already reporting impairments in arm function.

Keywords: arm injuries, KJOC, pitching

Introduction

Baseball is one of the most popular sports in America with more than forty million participants at various levels. While there has been a great deal of published research on injuries to youth players (under age 14) and to collegiate and professional-age players (over age 18), there has been less attention to advanced baseball players (consisting of high school, legion ball, and college prep players). This is concerning, as this age range typically corresponds with a time of increased specialization in sport, as well as significant growth associated with puberty. Research that focuses on this age range may help us to fully understand the prevalence and risk of injury in baseball players across their competitive career.[1, 2, 3, 4, 5, 6]

Upper extremity injuries in overhead athletes are increasing, particularly in players under the age of 18.[7, 8] Injuries to the shoulder and elbow are the most common injuries sustained in overhead athletes, with the highest prevalence in baseball players, specifically baseball pitchers.[1, 7, 9, 10] Baseball players apply large amounts of repeated stresses to their shoulder and elbow causing many physiological adaptations starting at a young age.[3, 7] The most common physiological adaptations consist of humeral retrotorsion and glenohumeral internal rotation deficit (GIRD). Humeral retrotorsion and GIRD have been linked to changes in total ROM at the shoulder, as well as increased risk of shoulder and elbow injuries.[11, 12, 13] Baseball players create significant clinical challenges for medical professionals in addressing the adaptive and developmental changes in their upper extremities.[3] High school and young adulthood are when many of these physiological adaptations become relatively permanent, and are coupled with rapid increases in strength and throwing velocity.[3] Thus, understanding injury patterns in this age range is instrumental to effectively decrease the overall rise in upper extremity injuries in youth baseball.

One important factor in the development of a shoulder or elbow injury may be a prior history of injury. There is also a strong correlation between self-reporting and playing despite arm pain or fatigue during pitching, and suffering a subsequent injury in baseball players.[14, 15] Several studies, in both softball players and baseball players, have found that prior injury is a significant predictor of suffering pain and injury.[2, 8, 16] Other current studies have found that playing baseball with increased pain or fatigue was associated with increased risk of injury.[6, 14, 15] A key factor among all these studies was the importance of avoiding any risk-prone pitching activities to prevent and reduce the risk of injury.[6, 14, 15] Two significant risk factors for both shoulder and elbow injury that were identified among these studies was self-reported fatigue and overuse, and that any player that demonstrates signs of fatigue or overuse should be removed immediately from the game to prevent an injury.[6, 14, 15] Thus, it appears that prior injury, or playing despite possible signs of injury, does impact the risk of injury in baseball players and other overhead athletes.[8, 17]

Baseball players often report pain or fatigue while throwing, without receiving care or being evaluated for a potential injury.[2, 14, 15, 16] Over 30% of baseball pitchers experienced some type of elbow or shoulder pain while playing baseball.[2, 18] Many baseball players fail to report pain to coaches or medical providers, when they initially recognize shoulder or elbow pain.[9, 19, 20] Many youth and high school baseball players who experience elbow pain or discomfort continue to play despite these symptoms, which may increase the risk of suffering a more serious injury.[9, 19, 21] Over a two year study, 47% of youth baseball pitchers reported shoulder or elbow pain. These players reported that their pain limited their pitching capability, velocity and overall performance throughout the season.[15] There is a growing demand to control the rise of shoulder and elbow injuries among adolescent, youth and high school age baseball players, thus properly

monitoring players' self-reported symptoms of pain and fatigue may be critical in preventing injury.

Although baseball is considered a safe sport that has a relatively low injury rate when compared to contact sports like football, injuries to the shoulder and elbow are occurring in baseball players at earlier ages, with potentially long-lasting consequences.[9] Finding ways to prevent injury or identify shoulder and elbow injuries early, before tissue damage becomes severe or disabling, are paramount to the long-term health of these participants. Identifying known risk factors such as pitch counts, innings pitched, biomechanical risk factors, GIRD, pitch type, rest cycles, and complaints of pain or fatigue assist in preventing further injury to the shoulder or elbow. However, there is a gap in the literature regarding the relationship of how a prior history of shoulder or elbow injury influences the incidence of shoulder or elbow injury. Another gap in the literature is how a history of injury may influence self-reported pain, symptoms, or functional limitations over the course of a single season.

The purpose of the current study was to assess the prevalence of shoulder and elbow injuries in advanced baseball players (age 14-22) over the course of one season, and investigate the relationship between prior shoulder or elbow injury to the development of shoulder or elbow pain and injury over the course of a single season. A survey (Baseball Injury Questionnaire) and the Kerlan-Jobe Orthopedic Clinic (KJOC) Shoulder and Elbow Score form was provided pre- and post-season to baseball players age 14-22 to assess injury prevalence, history, and self-reported pain and symptoms. We hypothesized that there would be more injuries, self-reported symptoms, and functional limitations, to the shoulder when compared to the elbow on the pre-season and post-season injury history questionnaire. We hypothesized that there would be more elbow and shoulder coupled injuries compared to isolated elbow or shoulder injuries, and that the

injury percentage would be greater among pitchers compared to position players. We hypothesized that players with a prior history of shoulder or elbow injury would report more injuries, and poorer arm self-reported function, than players without a history of arm injury.

Materials and Methods

Participants

Participants: A combined sample of convenience of fifty-eight male baseball players were approached to participate in this study. Players were from the Missoula Mavericks, an organization that includes AA, A and B American Legion Baseball teams (age range: 14-18 years), as well as from the University of Montana club baseball team (age range:18-22), which is affiliated with the National College Baseball Association (NCBA).

Instruments

Injury Survey: A retrospective survey, the "Baseball Injury Questionnaire" (BIQ), was distributed to local baseball teams to collect injury history data. The BIQ was modified from prior studies focusing on NCAA Division I baseball players and Brazilian Jujitsu (BJJ) athletes.[22, 23, 24, 25] The paper-based survey was slightly modified for the pre-season (68 closed ended questions) and post-season (32 closed ended questions) data collection periods (see appendix A and B).

The pre-season BIQ focused on injuries suffered from the age of 14 through the time the Baseball Injury Questionnaire was completed. An injury was defined as:

i) Patient was not able to continue for the remaining time of practice or competition, OR

ii) Patient seen by a medical professional to evaluate or treat the injury, OR

iii) Patient was not able to practice or compete for 1 day or more, OR

iv) Patient had to miss 1 day or more from work or school

The first part of the BIQ collected basic demographic information. The second part contained specific questions pertaining to baseball history such as position(s) played, age began competitively playing baseball, number of leagues and teams played for, number of years playing baseball, primary position (pitcher, positional) and other applicable information specific to baseball. The third part of the BIQ gathered information on any current injury to the participant's shoulder or elbow. The BIQ also gathered information on how this injury may have limited their sport participation. The final part of the BIQ gathered information on the participant's history of injury to their shoulder or elbow. The injury history was gathered from the age of 14 to current age, documenting injuries that required a physician's visit and those that did not, along with the treatments and outcomes for each injury. The age of 14 was used since study participants would potentially have difficulty remembering prior injuries before high school, and high school is when new pitches are typically introduced, velocity increases, and exposure increases which all influence the risk of possible injury.[1, 4, 5, 9, 15] The BIQ also examined how much each prior injury limited their participation.

The Kerlan-Jobe Orthopaedic Clinic (KJOC) Shoulder and Elbow score questionnaire was also administered with the BIQ. This patient rated outcome (PRO) was utilized to assess patient-reported shoulder and/or elbow pain and disability that may not be captured in the BIQ. The KJOC allowed the participant to convey any changes in the functional capability of their shoulder or elbow such as pain, weakness, feeling of instability, activity limitations, and how their shoulder or elbow pain affected their

overall level of competition. Each question utilized a 10cm line, with the far left being the most severe pain, complications or problems they have with their shoulder or elbow, and the far right of the line is no issues at all with their shoulder or elbow. The subject put an "X" on the line that is most relevant to what level of pain, injury or discomfort they were currently feeling. Higher scores indicate greater function, fewer limitations, and less pain.

The post-season injury BIQ was similar to the pre-season Baseball Injury Questionnaire except it was altered to focus on information from the current baseball season, compared to that of the pre-season injury BIQ that focused on information from the age of 14 to the start of the current season. The KJOC was also repeated, in order to assess complaints of shoulder or elbow pain and disability.

Validity of Surveys

Content and construct validity were established by expert (3 academic faculty) review to accurately assess content and construct of questionnaires. Face validity and accuracy of the Baseball Injury Questionnaire was determined by having five high school players complete the Baseball Injury Questionnaire, prior to the study commencing, and revising any sections based on their feedback (Subsequently no edits were provided and no changes were made.

Concurrent validity of the Baseball Injury Questionnaire was examined by comparing certain questions to a corresponding question on the KJOC (current arm injury). The KJOC has already been found to be a valid (ICC: 0.86-0.88) and reliable (ICC: 0.85-0.94) patient reported outcome for shoulder and elbow injury, pain, and function.[18, 26, 27, 28] There was an 81% (21/26) agreement between the Baseball Injury

Questionnaire and KJOC questions on "is your arm currently hurt/injured". Of the study participants, 4 reported a shoulder or elbow injury on the Baseball Injury Questionnaire but did not report an injury on the KJOC, while 1 out of 26 did not report an injury on the Baseball Injury Questionnaire, but did on the KJOC. Thus, the Baseball Injury Questionnaire demonstrated greater detection in reporting current injuries than a corresponding question on the KJOC. We believe this occurred due to a stricter/clearer injury definition on the Baseball Injury Questionnaire. Thus, the Baseball Injury Questionnaire picked up more detail about injury than the demographic section of the KJOC, and didn't miss injuries reported on the KJOC.

The Baseball Injury Questionnaire appears to be a more sensitive tool at picking up injury information. The KJOC is not designed as an injury history questionnaire, but designed to determine current arm function, not prior injury. The Baseball Injury Questionnaire is appropriate for obtaining injury history and information, and the KJOC is appropriate for evaluating current arm function.

Procedures

This study was reviewed and approved by University of Montana IRB. Each study participant completed informed consent and for those under the age of 18, a minor assent form was completed in addition to the informed consent that was obtained by their parent or legal guardian. All data collected was de-identified and contained no personal identification and was entered into an excel database.

Study Design: A retrospective survey (Baseball Injury Questionnaire and KJOC) was administered at two times during a single season. The pre-season Baseball Injury Questionnaire and KJOC were distributed during the first two weeks of each team's

spring season. The post-season Baseball Injury Questionnaire and KJOC were completed in a two-week window at the conclusion of the regular season.

Data collection procedures: During the pre-season data collection period, the primary researcher attended a team practice to distribute the survey packet. The paper survey packet contained informed consent forms, as well as the pre-season Baseball Injury Questionnaire and the KJOC. The athletes took the survey packets home and filled them out if they were 18 years old or older. If they were under the age of 18 they filled the survey packets out with their parents. The primary researcher returned to a team practice after 1-2 weeks, and collected the completed survey packets and answered any questions.

At the conclusion of each participating team's regular season, the post-season survey packet (post-season Baseball Injury Questionnaire and KJOC) was distributed. The primary researcher followed up with participants to collect completed survey packets within 1-2 weeks.

Data Reduction: All data collected for preseason and post-season was entered into a spreadsheet (Microsoft Excel 14.7.1, Santa Rosa, CA). The Baseball Injury Questionnaire data included nominal data (sex, playing position, body part injured, mechanism of injury, etc.), ordinal data (year in school), and interval data (age, years playing, pitch counts, etc.). The KJOC was scored by measuring the distance, in mm, from the far-left edge of the 10cm line to the "X" marked by the participant. This distance was then recorded in the excel spreadsheet for each of the 10 questions. A total KJOC score was calculated by summing the 10 questions into a single score (maximum score=100).

Quantitative Analysis

Descriptive statistics, including frequency, means, and measures of variability were computed for all variables. Most responses in the Baseball Injury Questionnaire were categorical data so non-parametric methods were used, using SPSS software (IBM SPSS Version 22.0, Armonk, NY), to analyze the data. For injury status, due the small sample size and small number of injuries reported we combined reported shoulder or elbow injury into a single variable ("current arm injury"). We also collapsed prior history of shoulder or elbow injury into a single variable ("Prior arm injury") due to the small sample size and the small number of injuries reported. Fisher exact tests were used to compare arm injury status between groups (pitchers vs. position players, prior history vs. no prior history). Mann-Whitney U tests were used to compare KJOC scores (total and each individual question) between groups, and Wilcoxon signed-rank tests compared KJOC scores from pre-season to post-season. Alpha was set *a priori* at 0.05.

Results

A total of 58 Baseball Injury Questionnaires were distributed during the pre-season data collection period and 26 were completed (45% completion rate). A total of 26 Baseball Injury Questionnaires were distributed to the 26 study participants who completed the pre-season Baseball Injury Questionnaires during the post-season data collection period and 26 were completed (45% completion rate), thus our total of study participants was 26. Study Participants demographic information can be found in Tables 2-5.

Shoulder and Elbow Injury: Participants self-reported more shoulder injuries than elbow injuries on both the pre-season and post-season Baseball Injury Questionnaires. The percentage of reported pre-season shoulder and elbow injury, history of shoulder and elbow, and post-season shoulder and elbow injuries, as well as detailed information about the injuries, are outlined in

Tables 6-8. There were more isolated shoulder injuries (n=6 both at pre-season and post-season) compared to isolated elbow injuries (n=2 both at pre-season and post-season) or concurrent injuries to the shoulder and elbow (n=1 at post-season) during both pre-season and post-season. Once data was collapsed into "arm injury", 8 injuries were reported both at pre-season and post-season. Statistics could not be run to compare isolated vs. coupled injuries due to a low reported number of injuries.

A Wilcoxon Signed-Rank test was used to compare the pre-season and post-season KJOC scores and it revealed the post-season KJOC scores did not significantly change from pre-season values, indicating that self-rated arm function was relatively stable (see Table 9). KJOC scores decreased slightly in 6 of the 10 scales, but increased slightly in 4 of 10.

Pitchers vs. Position Players: Seventy-seven percent of participants (n= 20/26), indicated they pitched at some point during the season, and 19% (n=5/26) indicated their primary position was pitcher. Twenty-five percent (n= 5/20) of those who pitched at any point in the season reported a shoulder or elbow injury at the end of the season, while 33% (n= 2/6) who did not pitch reported a shoulder or elbow injury at post-season. Fisher exact tests revealed no difference in post-season injury count between players who pitched vs. those who did not (p=0.529), and no difference in those who identified their primary position as pitcher to those who did not (p=0.589). Mann-Whitney U tests on each of the post-season 10 KJOC questions revealed no difference in KJOC score between those who pitched during the season to those who did not (p-value range 0.494-0.929). When using Mann-Whitney U tests to explore post-season KJOC scores between those who identified primarily as pitchers to those who did not, no significant differences were found (p-value range 0.105-0.850) which are outlined in Table 10 and 11.

Influence of Prior Injury on Injury and Arm Function: When comparing the relationship between a prior history of arm injury and suffering an arm injury during the season, the Fisher exact test revealed no significance between a prior history of an arm injury and suffering an arm injury during the season (p=0.230). The Mann-Whitney U Test revealed there was a relationship between the pre-season KJOC and history of arm injury as well as a relationship between the post-season KJOC and history of arm injury (see Table 8 and Table 9). The total KJOC score was lower, at both pre-season and post-season, in players with a history of prior arm injury. When the individual KJOC questions were analyzed significant differences were found between those who reported a prior history of arm injury, and those who did not, in the several variables outlined in Tables 8 and 9.

When examining self-reported arm function in participants who reported currently being injured, either at pre-season or post-season, differences were less noticeable. Participants who reported a current arm injury at pre-season had lower overall KJOC scores (61.3cm ± 20.4cm) compared to those who did not report a current arm injury (79.7cm ± 16.3cm) (p=0.028). However, at post-season total KJOC scores were not different in those who reported a current arm injury at pre-season (73.0cm ± 19.6cm) compared to those who did not (76.5cm ± 19.9cm) (p=0.733). For participants who reported a current injury at the time of the post-season survey, KJOC scores were not different than those who did not report an injury, regardless of when function was assessed (pre-season: current injury @ post-season KJOC= 76.6cm ± 14.3cm; no injury @ post-season KJOC= 74.8cm ± 20.5cm; p=0.735) (post-season: current injury @ post-season KJOC= 73.1cm ± 18.1cm; no injury @ post-season KJOC= 76.7cm ± 20.5cm; p=0.657).

Discussion

The purpose of the current study was to assess the prevalence of shoulder and elbow injuries in advanced youth baseball players over the course of one season, and investigated the relationship between shoulder or elbow injury history to the development of shoulder or elbow pain and injury. As hypothesized, there were more self-reported injuries to the shoulder when compared to the elbow, both at the beginning of the season as well as at the conclusion. However, there was not a significant decline in self-reported arm function over the course of a season. We did not find that pitchers had a greater prevalence of injury, and they also did not report differences in self-reported arm function compared to non-pitchers. While there was no difference in injury prevalence between players with a history of arm injury to those without, several KJOC variables were significantly lower in the participants who had a history of arm injury at both pre-season (p-value range: 0.001-0.003) and post-season (p-value range: 0.016-0.047).

We observed that study participants self-reported more shoulder injuries than elbow injuries on the pre-season and post-season Baseball Injury Questionnaires, which matches current literature on other overhead athletes.[2, 29, 30] Schroder and colleagues found that 43.4% of baseball players reported a history of shoulder injury, compared to 24.6% who reported a history of elbow injury.[29] Sauers and colleagues also found that 63% of softball players reported a history of shoulder injury, compared to 26% who reported a history of elbow injury.[2] In addition, we found no significant change in the pre-season to post-season KJOC scores with only a slight decrease in six of the ten post-season KJOC scores, but an increase in four of the ten. This corresponds to previous research that shows that KJOC scores do not change significantly throughout a season.[18, 28, 31] Studies performed by Alberta, Fronek and Franz found that there was

KJOC scores remain stable throughout the season in intercollegiate, minor league, and major league players (both pitchers and field positions).[18, 28, 31] While we hypothesized that we would see significant changes in KJOC scores in our current study, our findings support previous research that KJOC scores remain stable over time.

We also observed that pitchers did not have more self-reported injuries compared to position players during the pre-season and post-season surveys. This conflicts with prior research that has found increased rates of injury in pitchers. One study found that 64% of pitchers have self-reported an injury compared to that of 26% of position players.[29] Another study found that 73% of shoulder injuries in collegiate baseball players are due to pitching, while 78.4% of elbow injuries are due to pitching.[32] Our results could be different than prior research for several reasons. We did have a small sample size from just two different leagues in a single geographic area. Also, only 38.5% of participants in this survey said they participated on a second baseball team, and none reported any overlap in baseball seasons. This may limit the overall exposure to throwing and pitching, providing appropriate rest to prevent injuries. Anecdotally, many of the participants also participate in other sports during the year ("multi-sport athletes"). With less sport specialization, decreased volume (particularly from winter into spring) allows for more rest.

In addition, there was no significant difference found between pitcher KJOC scores and position player KJOC scores. This could be due the fact that all of the participants in our study who pitched also played other positions, and there were none that reported solely participating as a pitcher. Thus, we were unlikely to find any true positional differences because of the small number of designated pitchers compared to position players. The Franz study found differences between minor and major league professional baseball position players compared to pitchers,

with pitchers having the lowest scores over a single season.[28] This study hypothesized that the lower KJOC scores among pitchers was related to the greater repetition of high velocity pitches, which causes an increase in tissue microtrauma.[28] Franz also concluded that because healthy KJOC scores were lower in certain position groups, that the difference in "baseline" scores should be taken into consideration when evaluating players, especially pitchers or those with prior injury.[28] Further research should examine differences in arm function, self-reported injury and KJOC scores across different positions, at varying levels of competition.

Participants with prior history of arm injury did not have a greater chance of reporting an injury during pre-season or post-season. However, players with a prior history of arm injury did report lower KJOC scores than those without a prior injury history. This partially agrees with prior literature, which found that those with prior arm injury report an increased likelihood of injury, as well as lower KJOC scores, compared to those with no prior history of arm injury.[2, 8, 16, 18, 28, 30, 31] There are several reasons why we did not find a difference in incidence rates between those with prior injury history and those without. We did not assess the specific timeframes since prior injuries, which may impact the risk of injury. In addition, as noted above, our sample may have more rest and less sport specialization compared to baseball players in other regions of the country.

The participants in the present study had significantly lower KJOC scores than baseball players in other studies.[18, 28, 31] If we compare our recorded KJOC scores, to the standards set in the Fronek study among professional baseball players (KJOC score >90% indicates healthy, normal arm function), then only 8 of our players at pre-season, and 7 at post-season, met that criteria.[31] This is concerning because the participants perceived their arm was not a full capability, both early in the season as well as at the end. These lower scores could be due to

underlying issues affecting performance, potentially including pain or fatigue at post-season while at pre-season there may be other factors such as a short pre-season and decreased preparation time prior to the start of the season. However, most studies that used the KJOC to examine arm function among baseball players used players at the professional level. It is possible that younger players may not have the same healthy baseline values on the KJOC. Further research should be performed using the KJOC to examine arm function in younger populations.

One unique finding from this study is the detailed examination of arm function, using the 10 individual questions from the KJOC. Those study participants who reported a lower KJOC score, who also reported an arm injury, also reported increased fatigue at both pre-season and post-season. The KJOC variables that were affected most, at both at pre-season and post-season, were velocity, endurance (fatigue) and control. This is a critical result, because if a player begins the season with increased fatigue, decreased control or velocity, they are beginning the season with a potentially increased risk of sustaining an injury. Recent studies have found that players who reported greater fatigue had almost 8 times greater risk of injury.[6] In a similar studies they found that those who reported more fatigue also reported more injuries and also found that fatigue significantly impacted pain.[14, 15] One study found that the fatigue decreased shoulder external rotation (ER) during pitching.[33] Decreased shoulder ER during throwing has be found to lead to greater elbow valgus torque.[34] Finally, increased valgus torque is correlated to greater risk of elbow injury.[35] Thus, we can state that there is likely a link between self-reported feelings of fatigue and increased likelihood of injury.[33, 34, 35]

There are a few limitations that need to be acknowledged in this study. The small sample size, as well as the limited number of available teams for this age group, all have an impact on the ability to find statistical significance in some comparisons. There are no high school baseball

teams in the state of Montana, only Babe Ruth, little league, travel teams and American legion teams. The ratio of the sample size in relation to other fair-weather locations that have longer seasons, increased league overlaps and players who play on multiple teams during a single season does not represent the most accurate depiction of upper extremity injuries in this age range. There was also no verification of injuries, as the study relied on the study participants self-reporting all injuries.

The implications of this research for clinical practice demonstrated that those who reported prior arm injuries also reported worse arm function, increased fatigue, decreased velocity and control. Self-reported poorer arm function persisted through the season in those participants with prior arm injury. There needs to be measures to address arm function, particularly with adolescents with prior injury history. Measures and practices should be implemented to attempt to "bring them up" to the same self-perceived functional level of their healthy teammates. Such measures as strength and conditioning, biomechanical/techniques assessment and targeted injury prevention work should be employed as preventive injury measures. Any signs of fatigue should be immediately addressed to prevent an injury, and all measures should be taken to abide by pitch count rules, innings pitched rules and proper rest cycles to prevent any overuse injuries.

References

1. Sgroi T, Chalmers PN, Riff AJ, et al. Predictors of throwing velocity in youth and adolescent pitchers. *J Shoulder Elb Surg*. 2015;24(9):1339-1345.
2. Sauers EL, Dykstra DL, Bay RC, Bliven KH, Snyder AR. Upper extremity injury history, current pain rating, and health-related quality of life in female softball pitchers. *J Sport Rehabil*. 2011;20(1):100-14.
3. Limpisvasti O, ElAttrache NS, Jobe FW. Understanding shoulder and elbow injuries in baseball. *J Am Acad Orthop Surg*. 2007;15(3):139-147.
4. Paz DA, Chang GH, Yetto JM, Dwek JR, Chung CB. Upper extremity overuse injuries in pediatric athletes: Clinical presentation, imaging findings, and treatment. *Clin Imaging*. 2015;39(6):959-964.
5. Leahy I, Schorpion M, Ganley T. Common medial elbow injuries in the adolescent athlete. *J Hand Ther*. 2015;28(2):201-211.
6. Yang J, Mann BJ, Guettler JH, et al. Risk-Prone Pitching Activities and Injuries in Youth Baseball. *Am J Sports Med*. 2014;42(6):1456-1463.
7. Tyler TF, Mullaney MJ, Mirabella MR, Nicholas SJ, McHugh MP. Risk Factors for Shoulder and Elbow Injuries in High School Baseball Pitchers: The Role of Preseason Strength and Range of Motion. *Am J Sports Med*. 2014;42:1993-1999.
8. Matsuura T, Iwame T, Suzue N, Arisawa K, Sairyo K. Risk factors for shoulder and elbow pain in youth baseball players. *Phys Sportsmed*. 2017;45(2):140-144.
9. Hibberd EE, Brown JR, Hoffer JT. Optimal management of ulnar collateral ligament injury in baseball pitchers. *Open Access J Sport Med*. 2015;6:343-357.
10. Escamilla RF, Yamashiro K, Paulos L, Andrews JR. Shoulder Muscle Activity and Function in Common Shoulder Rehabilitation Exercises.pdf. *Sports Med*. 2009;39(8):663-685.
11. Wilk KE, Macrina LC, Fleisig GS, et al. Deficits in Glenohumeral Passive Range of Motion Increase Risk of Shoulder Injury in Professional Baseball Pitchers: A Prospective Study. *Am J Sports Med*. 2015;43(10):2379-2385.
12. Sakata J, Nakamura E, Suzukawa M, Akaike A, Shimizu K. Physical Risk Factors for a Medial Elbow Injury in Junior Baseball Players: A Prospective Cohort Study of 358 Players. *Am J Sports Med*. 2016;45(1):135-143.
13. Shanley E, Michener LA, Ellenbecker TS, Rauh MJ. Incidence of Shoulder and Elbow Injuries in High School Softball and Baseball Players. *J Athl Train*. 2011;45(4):648-659.
14. Olsen, S. Fleisig, G. Dun, S. Loftice, J. Andrews J. Risk Factors for Shoulder and Elbow Injuries in Adolescent Baseball Pitchers. *Am J Sports Med*. 2006;34(6):905-912.
15. Lyman S, Fleisig GS, Waterbor JW, Funkhouser EM, Pulley L, Andrews JR, Osinski ED, Roseman JM. Longitudinal study of elbow and shoulder pain in youth baseball pitchers. *Med Sci Sports Exerc*. 2001;33(11):1803-10.
16. Yukutake T, Kuwata M, Yamada M, Aoyama T. A Preseason Checklist for Predicting Elbow Injury in Little League Baseball Players. *Orthop J Sports Med*. 2015;3(1):2325967114566788.
17. Grana WA, Boscardin JB, Schneider HJ, Takao SH, Vera T, Goin SG. Evaluation of elbow and shoulder problems in professional baseball pitchers. *Am J Orthop (Belle Mead NJ)*. 2007;36(6):308-313.

18. Alberta FG, ElAttrache NS, Bissell S, et al. The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. *Am J Sports Med*. 2010;38:903-911.
19. Valovich McLeod TC, Decoster LC, Loud KJ, Micheli LJ, Parker JT, Sandrey MA, White C. National Athletic Trainers' Association Position Statement: Prevention of Pediatric Overuse Injuries. *J Athl Train* 2011;46(2):206–220
20. Hsu SH, Moen TC, Levine WN, Ahmad CS. Physical Examination of the Athlete's Elbow. *Am J Sports Med*. 2012;40(3):699-708.
21. Fleisig GS, Barrentine SW, Zheng N, Escamilla RF, Andrews JR. Kinematic and kinetic comparison of baseball pitching among various levels of development. *J Biomech*. 1999;32(12):1371-5.
22. Turocy PS. Survey Research in Athletic Training: The Scientific Method of Development and Implementation. *J Athl Train*. 2002;37(4 suppl):S-174-S-179.
23. Usuki H. Injury history, severity, and medical care for athletes participating in brazilian jiu-jitsu [master's thesis]. [Omaha (NE)]: University of Nebraska at Omaha; 2016. 69 p.
24. Wilkins SJ. The relationship between sport specialization in baseball and glenohumeral internal and external rotation and functional movement screen scores [master's thesis]. [Omaha (NE)]: University of Nebraska at Omaha; 2012. 63 p.
25. Kongsved SM, Basnov M, Holm-Christensen K, Hjollund NH. Response rate and completeness of questionnaires: a randomized study of Internet versus paper-and-pencil versions. *J Med Internet Res*. 2007;9(3):e25.
26. Gummesson C, Ward MM, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. *BMC Musculoskelet Disord*. 2006;7:44.
27. Ebersole GC, Davidge K, Damiano M, Mackinnon SE. Validity and responsiveness of the DASH questionnaire as an outcome measure following ulnar nerve transposition for cubital tunnel syndrome. *Plast Reconstr Surg*. 2013;132(1):81e-90e.
28. Franz JO, McCulloch PC, Kneip CJ, Noble PC, Lintner DM. The utility of the KJOC score in professional baseball in the United States. *Am J Sports Med.* 2013;41(9):2167-73.
29. Schroeder AN, Dawn Comstock R, Collins CL, Everhart J, Flanigan D, Best TM. Epidemiology of overuse injuries among high-school athletes in the united states. *J Pediatr*. 2015;166(3):600-606.
30. Sciascia A, Haegele LE, Lucas J, Uhl TL. Preseason perceived physical capability and previous injury. *J Athl Train*. 2015;50(9):937-943.
31. Fronek J, Yang J, Osbahr DC, et al. Shoulder functional performance status of Minor League professional baseball pitchers. *J Shoulder Elb Surg*. 2015;24(1):17-23.
32. Dick R, Sauers EL, Agel J, et al. Descriptive Epidemiology of Collegiate Men's Baseball Injuries : National Collegiate Athletic Association Injury Surveillance System , 1988 – 1989 Through 2003 – 2004. *J Athl Train*. 2007;42(2):286-294.
33. Grantham WJ, Byram IR, Meadows MC, Ahmad CS. The Impact of Fatigue on the Kinematics of Collegiate Baseball Pitchers. *Orthop J Sport Med*. 2014;2(6):232596711453703.
34. Aguinaldo AL, Chambers H. Correlation of Throwing Mechanics With Elbow Valgus Load in Adult Baseball Pitchers. *Am J Sports Med*. 2009;37(10):2043-2048.

35. Anz AW, Bushnell BD, Griffin LP, Noonan TJ, Torry MR, Hawkins RJ. Correlation of Torque and Elbow Injury in Professional Baseball Pitchers. *Am J Sports Med*. 2010;38(7):1368-1374.

Appendix A

Data Collection Instruments

University of Montana
ATHLETIC TRAINING
Rising Above

Survey Cover Sheet: Pre-Season

Name (Last, First, Middle Initial): _____

Survey #: _____

Email: _____

Phone #: _(_____)_____

University of Montana
ATHLETIC TRAINING
Rising Above

Baseball Injury Questionnaire
Pre – Season

Instructions: Please complete the following survey regarding your athletic activities. All information will be kept confidential. PLEASE WRITE LEGIBLY.

Part 1: Demographic Information

1) What Team(s) or University are you currently playing for (check all that apply):

☐Mavericks A ☐Mavericks AA ☐Mavericks B ☐Pioneers ☐U of M Club Baseball team

2) What year are you in high school: ☐Freshman ☐Sophomore ☐Junior ☐Senior ☐Not in High school

3) What year are you in college: ☐Freshman ☐Sophomore ☐Junior ☐Senior ☐Not in college

4) Sex: ☐ Male ☐ Female

5) How old are you (in years):

☐16 ☐17 ☐18 ☐19 ☐20 ☐21 ☐22

Part II: Baseball History

6) What is your hand dominance (the hand you throw with) ☐Right ☐Left

7) What hand do you catch with: ☐Right ☐Left

8) What side do you bat from: ☐Right ☐Left ☐Both

9) What age did you start playing baseball competitively? _____

10) Do you pitch? ☐Yes ☐No

10.a) If yes to number 10, at what age did you start pitching: _____

10.b) If yes to number 10, what is the number of innings you typically pitch per game in a season?

☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9

10.c) If yes to number 10, how many games did you pitch last year (2016)?

☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 ☐12 ☐13 ☐14 ☐15 ☐16 ☐17 ☐18 ☐19

☐20 ☐21 ☐22 ☐23 ☐24 ☐25 ☐26 ☐27 ☐28 ☐Other specify_____

10.d) If yes to number 10, which team(s) do you pitch for (check all that apply)?

☐Mavericks A ☐Mavericks AA ☐Mavericks B ☐Pioneers ☐U of M Club Baseball team

11) What is your current primary position?

☐1st base ☐2nd base ☐3rd base ☐Shortstop ☐Catcher ☐Outfield ☐Pitcher

12) What is your secondary position (check all that apply)?

☐1st base ☐2nd base ☐3rd base ☐Shortstop ☐Catcher ☐Outfield ☐Pitcher

13) How many innings per game did you play at your primary position last year (2016)?

☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9

14) How many innings per game did you play at your secondary position last year (2016)?

☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9

15) In the past year (since March 2016) have you participated in any other competitive baseball leagues (i.e. Little league, College club, legion)? ☐Yes ☐No

15.a) If yes to 15, which leagues?

☐ Babe Ruth ☐Little League ☐Travel team ☐Legion Team ☐Other specify_____

16) Do these leagues overlap each other? ☐Yes ☐No

16.a) If yes to 16 by how many months do they overlap?

☐1 ☐2 ☐3 ☐4 ☐5

Part III: Current Injury History

An ***injury*** will be defined as:

a) You were injured and not able to continue participating in that practice or competition, OR
b) You were seen by a medical professional to evaluate or treat the injury, OR
c) You were not able to practice or compete for 1 day or more, OR
d) You had to miss 1 day or more from work or school due to the condition

17) Do you currently have any injuries to your shoulder?
- ☐ Yes (If you answered yes, please answer questions 18- 28)
- ☐ No (If you answered no, skip to question 29)

18) Was this shoulder injury due to playing baseball? ☐Yes ☐No

19) When did this shoulder injury first occur:
- ☐ In the last 7 days
- ☐ In the past month
- ☐ In the past 3 months
- ☐ In the past 6 months
- ☐ In the past 12 months
- ☐ Over 1 year ago
- ☐ I don't remember

20) Did this shoulder injury occur during practice or competition?
- ☐ Practice
- ☐ Competition
- ☐ Neither (please describe when the injury occurred): _____

21) What type of shoulder injury do you currently have? (mark all that apply)
- ☐ Sprain (damage to the ligaments in a joint)
- ☐ Strain (damage to a muscle, often called "pulling" a muscle)
- ☐ Bruise (also called a contusion)
- ☐ Fracture (a broken bone)
- ☐ Dislocated joint
- ☐ "Overuse" injury (tendinitis, bursitis, or similar injuries)
- ☐ Other (please describe) _____
- ☐ I don't remember, or I am not sure

22) How did your current shoulder injury occur (only if baseball related)?

☐ Throwing (position playing)
☐ Pitching
☐ Running (i.e.; running bases/outfield making a play/catch/Infield making a play)
☐ Sliding into a base
☐ Contact with another player
☐ Other (please describe) _____
☐ I don't remember

23) Did you seek medical care for your current shoulder injury? ☐Yes ☐No

24) Did you have surgery for your current shoulder injury? ☐Yes ☐No

25) Have you ever had this shoulder injury before: ☐Yes ☐No

26) How many days of practice have you missed (if any) since this shoulder injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐15-30 ☐More than 30

27) How many games have you missed (if any) since this shoulder injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐More than 14

28) How many days of school or work have you missed (if any) since this shoulder injury occurred?
☐0 ☐1-2 ☐3-4 ☐5-7 ☐8-14 ☐More than 14

29) Do you currently have any injuries to your elbow?

☐ Yes (If you answered yes, please answer questions 30- 40)
☐ No (If you answered no, skip to question 41)

30) Was this injury due to playing baseball? ☐Yes ☐No

31) When did this elbow injury first occur:

☐ In the last 7 days
☐ In the past month
☐ In the past 3 months
☐ In the past 6 months
☐ In the past 12 months
☐ Over 1 year ago
☐ I don't remember

32) Did this elbow injury occur during practice or competition?
- ☐ Practice
- ☐ Competition
- ☐ Neither (please describe when the injury occurred): _____

33) What type of elbow injury do you currently have? (mark all that apply)
- ☐ Sprain (damage to the ligaments in a joint)
- ☐ Strain (damage to a muscle, often called "pulling" a muscle)
- ☐ Bruise (also called a contusion)
- ☐ Fracture (a broken bone)
- ☐ Dislocated joint
- ☐ "Overuse" injury (tendinitis, bursitis, or similar injuries)
- ☐ Other (please describe) _____
- ☐ I don't remember, or I am not sure

34) How did your current elbow injury occur (only if baseball related)?
- ☐ Throwing (position playing)
- ☐ Pitching
- ☐ Running (i.e.; running bases/outfield making a play/catch/Infield making a play)
- ☐ Sliding into a base
- ☐ Contact with another player
- ☐ Other (please describe) _____
- ☐ I don't remember

35) Did you seek medical care for your current elbow injury? ☐Yes ☐No

36) Did you have surgery for your current elbow injury? ☐Yes ☐No

37) Have you ever had this elbow injury before: ☐Yes ☐No

38) How many days of practice have you missed (if any) since this elbow injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐15-30 ☐More than 30

39) How many games have you missed (if any) since this elbow injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐More than 14

40) How many days of school or work have you missed (if any) since this elbow injury occurred?
☐0 ☐1-2 ☐3-4 ☐5-7 ☐8-14 ☐More than 14

Part IV: Past Injury History

An ***injury*** will be defined as:

a) You were injured and not able to continue participating in that practice or competition, OR
b) You were seen by a medical professional to evaluate or treat the injury, OR
c) You were not able to practice or compete for 1 day or more, OR
d) You had to miss 1 day or more from work or school due to the condition

41) Have you ever sustained an injury to your shoulder in the past (since the age of 14) from playing baseball?

☐ Yes (If you answered yes please answer questions 42 - 50)
☐ No (If you answered no, please answer question 51)

42) How many prior injuries have you had to your shoulder?

☐ 0
☐ 1
☐ 2
☐ 3
☐ If more than 3, how many_____

43) What types of injuries have you had in the past to your shoulder? (Mark all that apply)

☐ Sprain (damage to the ligaments in a joint)
☐ Strain (damage to a muscle, often called "pulling" a muscle)
☐ Bruise (also called a contusion)
☐ Fracture (a broken bone)
☐ Dislocated joint
☐ "Overuse" injury (tendinitis, bursitis, or similar injuries)
☐ Other (please describe) _____
☐ I don't remember, or I am not sure

44) Did this injury to the shoulder occur during practice or competition?

☐ Practice
☐ Competition
☐ Both
☐ Neither (please describe when the injury occurred): _____

45) How did your shoulder injury occur? (mark all that apply)

☐ Throwing (position playing)
☐ Pitching
☐ Running (i.e.; running bases/outfield making a play/catch/Infield making a play)
☐ Sliding into a base
☐ Contact with another player
☐ Other (please describe) _____
☐ I don't remember

46) Did you seek medical care for any of your prior shoulder injuries? ☐Yes ☐No

47) Did you have surgery for any of your shoulder injuries? ☐Yes ☐No

48) How many days of practice did you miss (if any) as a result of your shoulder injury?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐15-30 ☐More than 30

49) How many games did you miss (if any) as a result of the shoulder injury?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐More than 14

50) How many days of school or work did you miss (if any) as a result of the shoulder injury?
☐0 ☐1-2 ☐3-4 ☐5-7 ☐8-14 ☐More than 14

51) Have you ever sustained an injury to your elbow in the past (since the age of 14) from playing baseball?

☐ Yes (If you answered yes please answer questions 57 - 60)
☐ No (If you answered no to questions 41 and 51 you are done with the survey. Thank you for your time.)

52) How many prior injuries have you had to your elbow?

☐ 0
☐ 1
☐ 2
☐ 3
☐ If more than 3, how many_____

53) What types of injuries have you had in the past to your elbow? (Mark all that apply)

☐ Sprain (damage to the ligaments in a joint)
☐ Strain (damage to a muscle, often called "pulling" a muscle)
☐ Bruise (also called a contusion)
☐ Fracture (a broken bone)
☐ Dislocated joint
☐ "Overuse" injury (tendinitis, bursitis, or similar injuries)
☐ Other (please describe) _____
☐ I don't remember, or I am not sure

54) Did this injury to the elbow occur during practice or competition?

☐ Practice
☐ Competition
☐ Both
☐ Neither (please describe when the injury occurred): _____

55) How did your elbow injury occur? (mark all that apply)

☐ Throwing (position playing)
☐ Pitching
☐ Running (i.e.; running bases/outfield making a play/catch/Infield making a play)
☐ Sliding into a base
☐ Contact with another player
☐ Other (please describe) _____
☐ I don't remember

56) Did you seek medical care for any of your prior elbow injuries? ☐Yes ☐No

57) Did you have surgery for any of your elbow injuries? ☐Yes ☐No

58) How many days of practice did you miss (if any) as a result of your elbow injury?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐15-30 ☐More than 30

59) How many games did you miss (if any) as a result of the elbow injury?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐More than 14

60) How many days of school or work did you miss (if any) as a result of the elbow injury?
☐0 ☐1-2 ☐3-4 ☐5-7 ☐8-14 ☐More than 14

You have completed the survey. Thank you for your time and patience.

Survey Cover Sheet: Post-Season

Name (Last, First, Middle Initial): _____

Survey #: _____

Email: _____

Phone #: _(_____)_____

University of Montana
ATHLETIC TRAINING
Rising Above

Baseball Injury Questionnaire
Post – Season

Instructions: Please complete the following survey regarding your baseball activities *over the past season*. All information will be kept confidential. PLEASE WRITE LEGIBLY.

Part I: Baseball History

1) What side do you bat from: ☐Right ☐Left ☐Both

2) Did you pitch this season? ☐Yes ☐No

4.a) If yes to number 4, how many games did you pitch in this season (2017)?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 ☐11 ☐12 ☐13 ☐14 ☐15 ☐16 ☐17 ☐18
☐19 ☐20 ☐21 ☐22 ☐23 ☐24 ☐25 ☐26 ☐27 ☐28 ☐Other specify_____

4.b) If yes to number 4, how many innings did you pitch per game this season?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9

4.c) If yes to number 4, which team(s) do you pitch for this season (check all that apply)?

☐Mavericks A ☐Mavericks AA ☐Mavericks B ☐Pioneers ☐U of M Club Baseball team

3) What was your primary position this season?

☐1st base ☐2nd base ☐3rd base ☐Shortstop ☐Catcher ☐Outfield ☐Pitcher

4) What was your secondary position this season (check all that apply)?

☐1st base ☐2nd base ☐3rd base ☐Shortstop ☐Catcher ☐Outfield ☐Pitcher

5) How many innings per game did you play at your primary position this season (2017)?

☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9

6) How many innings per game did you play at your secondary position this season (2017)?

☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9

7) Did you participate in any other competitive baseball leagues this season (since March 2017)? ☐Yes ☐No

7.a) If yes to 7, which leagues?

☐ Babe Ruth ☐Little League ☐Travel team ☐Legion Team ☐Other specify_____

8) Did these leagues overlap each other? ☐ Yes ☐No

8.a) If yes to 8, by how many months did they overlap?

☐ 1 ☐2 ☐3 ☐4 ☐5

Part III: Current Injury History From Past Season (2017)

An ***injury*** will be defined as:

a) You were injured and not able to continue participating in that practice or competition, OR
b) You were seen by a medical professional to evaluate or treat the injury, OR
c) You were not able to practice or compete for 1 day or more, OR
d) You had to miss 1 day or more from work or school due to the condition

9) Do you currently have any injuries to your shoulder?
☐ Yes (If you answered yes, please answer questions 10- 20)
☐ No (If you answered no, skip to question 21)

10) Was this shoulder injury due to playing baseball? ☐Yes ☐No

11) When did this shoulder injury first occur:
☐ In the last 7 days
☐ In the past month
☐ In the past 3 months
☐ In the past 6 months

12) Did this shoulder injury occur during practice or competition?
☐ Practice
☐ Competition
☐ Neither (please describe when the injury occurred): _____

13) What type of shoulder injury do you currently have? (mark all that apply)

☐ Sprain (damage to the ligaments in a joint)
☐ Strain (damage to a muscle, often called "pulling" a muscle)
☐ Bruise (also called a contusion)
☐ Fracture (a broken bone)
☐ Dislocated joint
☐ "Overuse" injury (tendinitis, bursitis, or similar injuries)
☐ Other (please describe) _____
☐ I don't remember, or I am not sure

14) How did your current shoulder injury occur (only if baseball related)?

☐ Throwing (position playing)
☐ Pitching
☐ Running (i.e.; running bases/outfield making a play/catch/Infield making a play)
☐ Sliding into a base
☐ Contact with another player
☐ Other (please describe) _____
☐ I don't remember

15) Did you seek medical care for your current shoulder injury? ☐Yes ☐No

16) Did you have surgery for your current shoulder injury? ☐Yes ☐No

17) Have you ever had this shoulder injury before: ☐Yes ☐No

18) How many days of practice have you missed (if any) since this shoulder injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐15-30 ☐More than 30

19) How many games have you missed (if any) since this shoulder injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐More than 14

20) How many days of school or work have you missed (if any) since this shoulder injury occurred?
☐0 ☐1-2 ☐3-4 ☐5-7 ☐8-14 ☐More than 14

21) Do you currently have any injuries to your elbow?

☐ Yes (If you answered yes, please answer questions 22- 32)
☐ No (If you answered no, you have completed this survey. Thank you for your time and patience).

22) Was this injury due to playing baseball? ☐Yes ☐No

23) When did this elbow injury first occur:
- ☐ In the last 7 days
- ☐ In the past month
- ☐ In the past 3 months
- ☐ In the past 6 months

24) Did this elbow injury occur during practice or competition?
- ☐ Practice
- ☐ Competition
- ☐ Neither (please describe when the injury occurred): _____

25) What type of elbow injury do you currently have? (mark all that apply)
- ☐ Sprain (damage to the ligaments in a joint)
- ☐ Strain (damage to a muscle, often called "pulling" a muscle)
- ☐ Bruise (also called a contusion)
- ☐ Fracture (a broken bone)
- ☐ Dislocated joint
- ☐ "Overuse" injury (tendinitis, bursitis, or similar injuries)
- ☐ Other (please describe) _____
- ☐ I don't remember, or I am not sure

26) How did your current elbow injury occur (only if baseball related)?
- ☐ Throwing (position playing)
- ☐ Pitching
- ☐ Running (i.e.; running bases/outfield making a play/catch/Infield making a play)
- ☐ Sliding into a base
- ☐ Contact with another player
- ☐ Other (please describe) _____
- ☐ I don't remember

27) Did you seek medical care for your current elbow injury? ☐Yes ☐No

28) Did you have surgery for your current elbow injury? ☐Yes ☐No

29) Have you ever had this elbow injury before: ☐Yes ☐No

30) How many days of practice have you missed (if any) since this elbow injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐15-30 ☐More than 30

31) How many games have you missed (if any) since this elbow injury occurred?
☐0 ☐1-3 ☐4-7 ☐8-14 ☐More than 14

32) How many days of school or work have you missed (if any) since this elbow injury occurred?
☐0 ☐1-2 ☐3-4 ☐5-7 ☐8-14 ☐More than 14

You have completed the survey. Thank you for your time and patience.

Appendix B

Patient Rated Outcomes (PRO): KJOC

Kerlan-Jobe Orthopaedic Clinic Shoulder & Elbow Score

Please answer the following questions related to your history of injuries to **YOUR ARM ONLY:**

	YES	NO
1. Is your arm currently injured?	☐	☐
2. Are you currently active in your sport?	☐	☐
3. Have you missed game or practice time in the last year due to an injury to your shoulder or elbow?	☐	☐
4. Have you been diagnosed with an injury to your shoulder or elbow other than a strain or sprain?	☐	☐
If yes, what was the diagnosis? _____	☐	☐
5. Have you received treatment for an injury to your shoulder or elbow?	☐	☐
If yes, what was the treatment? (Check all that apply)	☐	☐

☐ Rest ☐ Therapy ☐ Surgery (please describe): _____

Please describe your level of competition in your current sport:
(Use Professional Major League, Professional Minor League, Intercollegiate, High School as the choices)

6. What is the highest level of competition you've participated at?_____

7. What is your current level of competition? _____

8. If your current level of competition is not the same as your highest level, do you feel it is due to an injury to your arm?	☐	☐

Please check the ***ONE category only*** that best describes your current status:

☐ Playing without any arm trouble ☐ Playing, but with arm trouble
☐ Not playing due to arm trouble

Instructions to athletes:
The following questions concern your physical functioning during game and practice conditions. Unless otherwise specified, all questions relate to your **shoulder or elbow**. Please answer with an **X** along the horizontal line that corresponds to your current level.

1. How difficult is it for you to get loose or warm prior to competition or practice?

Never feel loose during games or practice — Normal warm-up time

2. How much pain do you experience in your shoulder or elbow?

Pain at rest — No pain with competition

3. How much weakness and/or fatigue (ie, loss of strength) do you experience in your shoulder or elbow?

Weakness or fatigue preventing any competition — No weakness, normal competition fatigue

4. How unstable does your shoulder or elbow feel during competition?

"Popping out" routinely — No instability

5. How much have arm problems affected your relationship with your coaches, management, and agents?

The following questions refer to your level of competition in your sport. Please answer with an **X** along the horizontal line that corresponds to your current level.

6. How much have you had to change your throwing motion, serve, stroke, etc, due to your arm?

7. How much has your velocity and/or power suffered due to your arm?

8. What limitation do you have in endurance in competition due to your arm?

9. How much has your control (of pitches, serves, strokes, etc.) suffered due to your arm?

10. How much do you feel your arm affects your current level of competition in your sport (ie, is your arm holding you back from being at your full potential)?

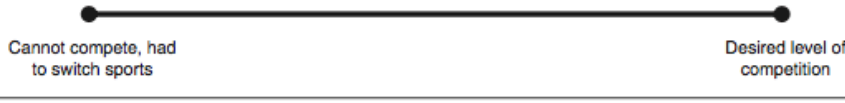

Table 1: Patient Rated Outcome

Element	KJOC	Decision
Reliability	Test-Retest: 0.861[22, 61, 62] Intraclass correlation coefficient (ICC) (Alpha): 0.881[22, 61, 62]	Both test have equal reported reliability.
Validity		
Construct	Compared groups that changed with groups that did not change, yielding a significantly higher intraclass correlation coefficients.[22, 61, 62]	Both test have acceptable reported validity.
Criterion	Evaluated by Pearson *r* coefficient for KJOC responses.[22, 61, 62]	
Responsiveness and Interpret-ability	Standard Deviation (SD): 1.33 [22, 61, 62] Standardized Response Means (SRM): 0.92 [22, 61, 62]	KJOC is better suited and designed for overhead athletes.[22, 61, 62]
Precision	Suited for clinical and field examinations not favored for clinical setting and preferred for overhead throwing injuries.[22, 61, 62]	KJOC allows sensitivity to illuminate disguising of specific injury.[22, 61, 62]

Table 2: Study Participant's Demographic Information

	Mean ± SD (range)
Average age (range) in years	17.8±2.5 (14-22)
Age (range) began playing baseball competitively	7.7±2.6 (5-14)
Innings at primary position	6.5±1.6
Innings at secondary position	4.5±2.5

Table 3: Frequency of Playing Level and Baseball Information (n=26)

	N (Percent)
High School Mavericks A Mavericks B	16 (61.5%) 15 (57.7%) 1 (3.8%)
College (University of Montana Club)	10 (38.5%)
Hand Dominance (Right)	23 (88.5%)
Hand Dominance (Left)	3 (11.5%)
Batting Dominance (Right)	20 (76.9%)
Batting Dominance (Left)	6 (23.1%)
Played on other baseball teams in past year	10 (38.5%)

Table 4: Baseball Pre/Post-Season Primary Position Information (n=26)

Primary Position	**Pre-season N (Percentage)**	**Post-season N (Percentage)**
Pitcher	4 (15.4)	5 (19.2)
Catcher	3 (11.5)	3 (11.5)
First Base	4 (15.4)	4 (15.4)
Second Base	3 (11.5)	3 (11.5)
Third Base	1 (3.8)	1 (3.8)
Shortstop	3 (11.5)	2 (7.7)
Outfield	8 (30.8)	8 (30.8)

Table 5: Baseball Pre/Post-Season Secondary Position Information (n=26)

Secondary Position	**Pre-season N (Percentage)**	**Post-season N (Percentage)**
Pitcher	7 (26.9)	10 (38.5)
First Base	3 (11.5)	1 (3.8)
Second Base	5 (19.2)	4 (15.4)
Third Base	7 (26.9)	4 (15.4)
Shortstop	0 (0.00)	1 (3.8)
Outfield	4 (15.4)	5 (19.2)
Second, Third, Shortstop	0 (0.00)	1 (3.8)

Table 6: Pre-Season Shoulder and Elbow Injury Data (n=26)

Pre-Season:	
Current Shoulder Injury [n(%)]	6 (23.1%)
Injury type: Overuse [n(%)]	4 (15.4%)
Sprain [n(%)]	1 (3.8%)
Strain [n(%)]	1 (3.8%)
Mechanism of Injury: Throwing [n(%)]	4 (15.4%)
Pitching [n(%)]	1 (3.8%)
Could not recall [n(%)]	1 (3.8%)
Practices Missed [median(range)]	3 (0-7)
Games Missed [median(range)]	0 (0-3)
School/Work Days Missed [median(range)]	2 (0-4)
Sought Medical Care? [n(%)]	3 (11.5%)
Current Elbow Injury [n(%)]	2 (7.7%)[1]
Injury type: Overuse [n(%)]	1 (3.8%)
Strain [n(%)]	1 (3.8%)
Mechanism of Injury: Throwing [n(%)]	2 (7.7%)
Practices Missed [median(range)]	0 (0-0)
Games Missed [median(range)]	0 (0-0)
School/Work Days Missed [median(range)]	0 (0-0)
Sought Medical Care? [n(%)]	1 (3.8%)

[1] Both players also had current shoulder injuries

Table 7: History Shoulder and Elbow Injury Data (n=26)

History of:	
Shoulder Injury [n(%)]	7 (26.9%)
Injury type: Overuse [n(%)]	5 (19.2%)
Sprain [n(%)]	1 (3.8%)
Unknown [n(%)]	1 (3.8%)
Mechanism of Injury: Throwing [n(%)]	3 (11.5%)
Pitching [n(%)]	2 (7.7%)
Throwing and Pitching [n(%)]	2 (7.7%)
Practices Missed [median(range)]	3 (0-30)
Games Missed [median(range)]	3 (0-14)
School/Work Days Missed [median(range)]	0 (0-2)
Sought Medical Care? [n(%)]	5 (19.2%)
Elbow Injury [n(%)]	4 (15.4%)[1]
Injury type: Overuse [n(%)]	2 (7.7%)
Strain [n(%)]	2 (7.7%)
Mechanism of Injury: Throwing [n(%)]	4 (15.4%)
Practices Missed [median(range)]	0 (0-14)
Games Missed [median(range)]	0 (0-7)
School/Work Days Missed [median(range)]	0 (0-0)
Sought Medical Care? [n(%)]	3 (11.5%)

[1] One player also had a history of shoulder injury

Table 8: Post-Season Shoulder and Elbow Injury Data (n=26)

Post-Season:	
Shoulder Injury [n(%)]	6 (23.1%)
Injury type: Overuse [n(%)]	5 (19.2%)
Strain [n(%)]	1 (3.8%)
Mechanism of Injury: Throwing [n(%)]	5 (19.2%)
Pitching [n(%)]	1 (3.8%)
Practices Missed [median(range)]	0 (0-7)
Games Missed [median(range)]	0 (0-3)
School/Work Days Missed [median(range)]	0 (0-0)
Sought Medical Care? [n(%)]	2 (7.7%)
Elbow Injury [n(%)]	2 (7.7%)[1]
Injury type: Overuse [n(%)]	2 (7.7%)
Mechanism of Injury: Throwing [n(%)]	1 (3.8%)
Pitching [n(%)]	1 (3.8%)
Practices Missed [median(range)]	0 (0-0)
Games Missed [median(range)]	0 (0-0)
School/Work Days Missed [median(range)]	0 (0-0)
Sought Medical Care? [n(%)]	0

[1] One player also had a current shoulder injury

Table 9: Pre-season KJOC scores compared to Post-season KJOC scores (n=26)

	Pre-season $\bar{x}$ cm ± SD cm	Post-season $\bar{x}$ cm ± SD cm	P-value
1. Difficulty getting arm loose prior to games or practices	7.6 ± 2.8	7.3 ± 2.8	0.307
2. Pain in the elbow or shoulder	7.0 ± 2.6	6.9 ± 2.7	0.594
3. Weakness in shoulder or elbow	6.9 ± 2.7	6.8 ± 2.7	0.464
4. Shoulder or elbow instability during competition	8.0 ± 2.2	7.7 ± 2.3	0.390
5. How much has arm affected your relationships	9.2 ± 1.2	8.9 ± 1.6	0.097
6. How much have you changed your arm motion	8.1 ± 2.2	8.0 ± 1.8	0.987
7. How has your velocity changed?	7.3 ± 3.0	7.5 ± 2.7	0.523
8. How much limitation in endurance do you have	7.0 ± 3.1	7.4 ± 2.4	0.782
9. How much loss of control have you experienced	7.1 ± 3.2	7.6 ± 2.6	0.824
10. How much does your arm affect your level of play	7.9 ± 2.4	7.9 ± 1.8	0.903

Table 10: Pre-season KJOC Scores: Prior History of Arm injury compared to No Prior History (n=26)

Pre-season KJOC scores	Pre-season History of Arm Injury $\bar{x}$ cm ± SD cm	No Prior History of Arm Injury $\bar{x}$ cm ± SD cm	P-value
Total KJOC Score	63.0 ± 19.0	83.5 ± 13.7	0.004*
1. Difficulty getting arm loose prior to games or practices	6.6 ± 3.6	8.2 ± 1.9	0.421
2. Pain in the elbow or shoulder	5.9 ± 2.8	7.7 ± 2.5	0.060
3. Weakness in shoulder or elbow	5.9 ± 2.6	7.6 ± 2.7	0.087
4. Shoulder or elbow instability during competition	6.6 ± 2.0	8.8 ± 1.8	0.002*
5. How much has arm affected your relationships	8.7 ± 1.8	9.6 ± 0.5	0.310
6. How much have you changed your arm motion	7.7 ± 2.6	8.3 ± 2.0	0.660
7. How has your velocity changed?	4.8 ± 3.0	8.9 ± 1.4	0.001*
8. How much limitation in endurance do you have	4.6 ± 2.8	8.6 ± 2.3	0.000*
9. How much loss of control have you experienced	4.9 ± 3.1	8.6 ± 2.3	0.003*
10. How much does your arm affect your level of play	7.3 ± 2.8	8.2 ± 2.0	0.421

* statistically significant ($p \leq 0.05$)

Table 11: Post-season KJOC Scores: Prior History of Arm injury compared to No Prior History (n=26)

Post-season KJOC scores	Pre-season History of Arm Injury $\bar{x}$ cm ± SD cm	No Prior History of Arm Injury $\bar{x}$ cm ± SD cm	P-value
Total KJOC Score	63.9 ± 21.9	83.5 ± 13.4	0.026*
1. Difficulty getting arm loose prior to games or practices	7.2 ± 3.3	7.9 ± 2.3	0.165
2. Pain in the elbow or shoulder	6.0 ± 2.3	7.3 ± 2.9	0.109
3. Weakness in shoulder or elbow	5.9 ± 2.2	7.3 ± 2.9	0.150
4. Shoulder or elbow instability during competition	6.3 ± 2.4	8.6 ± 1.8	0.020*
5. How much has arm affected your relationships	8.0 ± 2.3	9.4 ± 0.5	0.109
6. How much have you changed your arm motion	6.9 ± 2.2	8.7 ± 1.1	0.047*
7. How has your velocity changed?	5.8 ± 3.3	8.6 ± 1.6	0.031*
8. How much limitation in endurance do you have	5.9 ± 2.9	8.5 ± 1.4	0.027*
9. How much loss of control have you experienced	5.9 ± 3.1	8.8 ± 1.1	0.016*
10. How much does your arm affect your level of play	7.0 ± 1.9	8.5 ± 1.6	0.053

* statistically significant ($p \leq 0.05$)