Injuries and Prevention Strategies in Youth Baseball Athletes

Introduction

Over the past decade, youth sports and participation have grown and consequently sport related injuries have also increased. Overhead throwing and sport specific demands on the shoulder and elbow joints increase the risk and prevalence of such injuries. The number of injuries, which occur with overhead throwing athletes in baseball, tennis, volleyball, water polo, etc. is particularly concerning. Mautner et al[1], point out that although the number of injuries that are experienced by youth athletes has leveled off over the past several years, the demands on participants of youth baseball are still extreme and risk factors for injury still exist. This trend may be attributed to the increase in year-round participation, single-sport specialization, and increased exposure from participation in multiple leagues, and performance in showcases.[1] Recommendations have been created by USA Baseball to limit the risk of injuries, particularly pitchers in youth baseball leagues.[1] These restrictions have helped to decrease and limit exposure and occurrence of injuries experienced today in youth baseball associations.[1] However, more can and should be done in order to increase the knowledge and awareness on risk factors and related injuries of coaches, players and parents in order to continue to prevent the occurrence of injuries which can severely limit the participation of adolescents from future sports programs. This paper aims to examine the prevalence, risk factors, and prevention strategies that currently exist as well as future technology and prevention strategies that may help to limit injuries in youth baseball athletes.

According to Yang et al[2], approximately five million youth athletes, 6-17 years of age, participate in youth baseball organizations each year in the United States. More

importantly, risk factors still exist, which contribute to injuries of both the elbow and shoulder joints that require medical and/or surgical intervention still exist.[2] The authors point out that the single most important risk factor for serious injury is pitching with associated arm fatigue and has been associated with 36-fold increased risk of developing an injury associated with throwing demands of baseball.[2] This study designed by Yang et al, attempted to quantify the high demands placed on youth athletes and identified that over 40% of the study population reported pitching consecutive days in a row and 20% reported pitching in multiple games per day.[2] Additionally 66% of the subjects reported throwing a curveball during play, which many medical professionals have identified as an important contributor to a higher incidence of arm fatigue and pain related to the development of musculoskeletal injuries.[2]

Due to the biomechanical demands of throwing/pitching on the shoulder and elbow joints, physically immature youth baseball athletes are at risk for common injuries to these joints. These injuries may be associated with skeletal immaturity of the proximal humeral epiphyseal plate, the fusing of the medial epicondylar apophysis, and demands on the rotator cuff. It is important to examine the biomechanics of pitching and throwing (Fig. 1) in order to fully comprehend the significant stress that is imposed on both the shoulder and elbow. It is generally believed that the majority of injuries occur due to the demands of late cocking, acceleration, and deceleration phases of throwing. According to Calabrese et al[3], during the late cocking phase the glenohumeral joint (GHJ) assumes maximal external rotation. Skeletally immature youth athletes often experience symptoms associated with impingement during this phase, especially when anterior GHJ instability is present.[3] During the acceleration phase, arm acceleration reaches up to 42-58 m/s, which according to the

authors is one of the fastest movements in all sports activity. Furthermore, during the acceleration phase, youth athletes often exert three times greater force on the biceps and rotator cuff muscles.[3] This characteristic may be associated with higher fatigue and overuse injuries in younger athletes of these structures.[3] Finally, during the deceleration phase, the posterior (GHJ) musculature reaches peak activation in order to provide the eccentric forces required to complete the pitching motion.[3] Consequently muscle imbalance and weakness are often contributing factors that can increase fatigue, which as previously mentioned is the greatest risk factor for the development of pitching related injuries.[3]

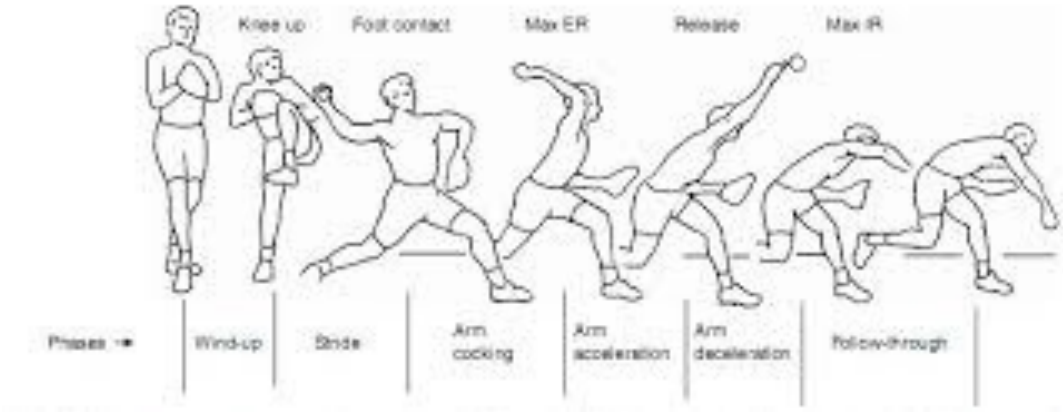

Figure 1. Illustration of a pitching motion. Injuries typically occur during arm cocking, arm acceleration, and arm deceleration phases. Adapted from Melnick et al[10]

Throwing Shoulder Injuries

The Throwers Shoulder, which is associated with soft tissue maladaptation and pathomechanics encompasses several injuries, which are often experienced by pitchers and baseball athletes across all skill levels. Factors that contribute to the development of The Thrower's Shoulder include anterior capsule constraints, posterior capsular contracture, development of scapular dyskinesis, breakdown of throwing/pitching mechanics, and repetitive contact of the posterior superior labrum and greater tuberosity.[4] According to

Kinsella et al, the anterior band of the inferior glenohumeral ligament is the primary limiting factor to anterior translation of the humerus during abduction and external rotation (ER) of the (GHJ).[4] Repetitive stress of this ligamentous structure along with the (ER) demands of the throwing motion is the primary contributor to the development of anterior capsule laxity of pitching and throwing athletes.[4] The progression of anterior capsular laxity along with the repetitive nature of pitching continually increases the contact of the humeral head with the posterior cuff and labrum consequently leading to the development of labral pathology and rotator cuff injury. [4] Common surgical procedures, which have demonstrated the ability to successfully return pitchers to pre-injury levels, include anterior capsule reconstruction and thermal shrinking procedures.[4] The posterior capsule, which is often associated with glenohumeral internal rotation deficit (GIRD) and posterior capsule and rotator cuff contracture is another important injury that may affect pitching and throwing athletes.[4] Furthermore, the authors discuss that GIRD is often believed to be the primary factor associated with development of pathology associated with posterior structures of the shoulder, including internal impingement and posterior labral pathology.[4] These deficits associated with the posterior capsule are easily manageable and often may be attenuated through conservative management. The authors discuss the effectiveness of stretching regiment during pre-, intra-, and postseason and note that internal rotation may be improved in the affected shoulder, especially with younger and more skeletally immature athletes.[4] Finally two other important biomechanical considerations, which may contribute to the development of injuries to the shoulder are scapular dyskenesis and kinetic chain breakdown. Scapular dyskenesis may develop over time due to muscular imbalance and can affect both the static and dynamic

positions of the scapula during a throwing motion.[4] This biomechanic abnormality may further lead to labral and rotator cuff pathology if not attenuated (Fig.2 & 3).

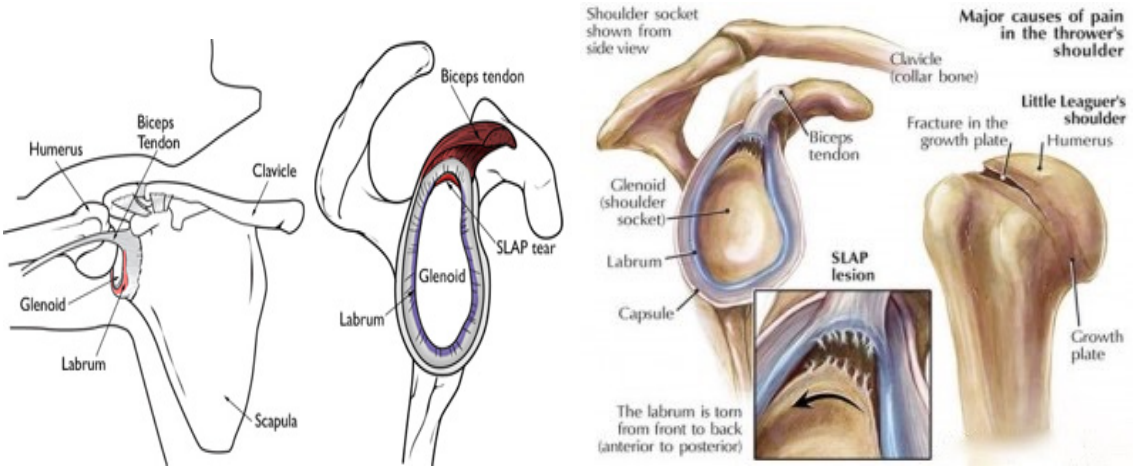

Fig. 2: illustrates the labrum and a SLAP tear, which is a common injury experienced by pitchers/throwers. Anderson et al[11]
Fig. 3: Further illustrates the anatomy of the shoulder as well as injuries commonly experienced by youth pitchers.[12]

Due to muscular imbalance, especially with throwers, the scapula may assume an anterior tilted and protracted position. Due to this development, throwers may exhibit more susceptibility to internal impingement syndrome. Often the affects of GIRD and scapular dyskenesis go hand in hand and in combination can severely affect a throwers shoulder leading to injury and disability.[4] The kinetic chain, as described by Kinsella et al[4], is the combination of all phases of the throwing motion, simplified into the lower extremities, the trunk, and the upper extremities.[4] The authors discuss that more time spent in the lower extremity and trunk phases can lead to a decrease in pitch velocity. Consequently this may lead to upper extremity accommodation in order to increase speed, which may in turn put more stress on the shoulder and elbow joints.[4] This sequence of events can lead to further fatigue of the shoulder and elbow musculature and susceptibility to injury.[4] Because of the substantial influence of scapular dyskenesis and kinetic chain

breakdown on injury development, it is important that a physical therapist be able to recognize subtle abnormalities in order to correct these deficits and improve biomechanics especially in youth pitchers.

Throwing Elbow Injuries

In addition to the shoulder joint being highly susceptible to injury, The elbow is also a high risk joint for injury, which is often associated with improper throwing kinematics. Patel et al[5], discuss the large amounts of force that are experienced during at the elbow joint during a throwing motion, particularly with baseball players, much of the forces are distributed through both soft tissue and bony structures of the elbow.[4] Because of the repetitive nature of pitching and throwing, the elbow joint is particularly susceptible to many injuries. Furthermore the authors point out that although elbow joint injuries are relatively lower compared to shoulder injuries, due to the large number of participants in the sport of baseball per year, the number of injuries is still high.[5] Like the shoulder joint during the throwing motion, the elbow experiences the greatest amount of forces/stress during the late cocking, acceleration, and deceleration phases of the throwing motion. During late cocking, the elbow joint reaches maximal external rotation and abduction.[5]

During acceleration, the elbow can accelerate as fast as 600,000 degrees/second. The deceleration phase requires eccentric slowing at a rate of 500,000 degrees/second during 50 milliseconds.[5] These large forces in combination with extreme repetition are often what lead to the development of elbow injuries. In fact most elbow injuries typically occur during the acceleration phase of a throw. Valgus forces of up to 64 Nm are generated at the ulnar collateral ligament (UCL) of the elbow joint.[5] Additionally 300 N of shear force are placed on the UCL while 500 N of compressive forces are placed on the lateral

radiocapiteller joint of the elbow.[5] Because of the repetitive stressing nature of the baseball throw, it is believed that biomechanic modification of throwing may not be able to reduce the rate of injuries that are experienced at the elbow joint of throwers.[5]

One of the most common elbow injury experienced by baseball athletes, particularly pitchers, is a UCL (Fig. 4) injury also referred to as a Tommy John Injury. Shanley et al[6], discuss that over 28% of youth baseball athletes report experiencing elbow pain during season play, and Tommy John surgeries have more than doubled in high school baseball players. During the pitching motion the elbow experiences repetitive large valgus forces, which is countered by rapid elbow extension.[5] The repetitive shear stress can create a series of microtrauma events primarily to the ligamentous structures of the UCL. Over time, the build up of microtrauma can eventually lead to a partial tear or complete rupture of the ligament.[5]

Fig. 4: Ligaments of the elbow, medial collateral ligament (also referred to as ulnar collateral ligament). [13]

A more common injury experienced by younger athletes is termed Little League Elbow.[6] Shanley describes Little League Elbow (Fig. 5) as medial epicondylar apophysitis, which is caused by the same repetitive forces responsible for Tommy John injuries in older and more physically mature athletes.[6] It is reported that up to 39% of adolescent athletes report an injury involving the medial epicondyle at the elbow.[6] Medial epicondyle injuries often encompasses a spectrum of injuries, from irritation and pain in mild cases to avulsion injuries to the apophysis of the elbow in more extreme situations.[6]

Finally, lateral elbow injuries may also be commonly experienced by youth athletes. Both Panner's disease and osteochondritis dissecans (OCD) are common injuries with similar symptoms and presentation.[6] Panner's disease is a common injury in adolescents less than ten years of age. OCD involves extreme pain and ROM limitations of the elbow joint.[6] Both injuries are related to the amount of compression force experienced by the lateral elbow during throwing and pitching. OCD often involves subchondral blood flow disruption to the capitellum leading to the development of loose bodies within the joint.[6]

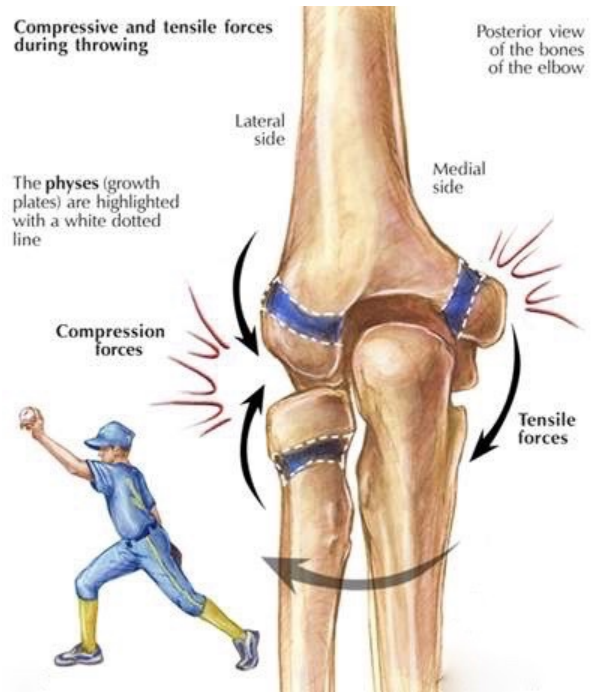

Fig. 5: illustrates a posterior view of the elbow joint and the locations of forces on the elbow during throwing/pitching. Rehak et al[14]

Risk Factors and Injury Prevention

In order to identify injury mechanisms as well as prevent an injury from developing, it is important to be able to identify risk factors associated with the development of pathology. Risk factors exist for both shoulder and elbow injuries that are experienced by youth and adolescent baseball athletes, which may predispose them to injury susceptibility. Shoulder and elbow injuries are influenced by both modifiable and non-modifiable risk factors. Non-Modifiable risk factors include age, weight and height, coaching habits, and satisfaction with pitching performance.[6] Modifiable risk factors associated with shoulder injuries include pitching mechanics, frequency/volume of pitching, altered shoulder range of motion, decreased

posterior shoulder flexibility, rotator cuff weakness and imbalance, and poor neuromuscular control of scapular, core, and lower extremity musculature.[6] These modifiable risk factors should be of utmost importance during evaluation, treatment, and prevention programs in order to prevent the development of injury and/or re-injury.[6] Programs designed for prevention of injury are important and in order to be successful must stress patient education, identification of athletes at high risk, complete and holistic rehabilitation of current and previous injuries that can influence the development of future injury, and close continuous monitoring of all participating athletes for early warning signs of injury.[6] USA baseball[7] has created several recommendations, which aim to reduce the development of injury based on age appropriate pitching guidelines. These guidelines exist for players of various ages ranging from 8 years of age and younger to players of 15-18 years of age. Key guidelines include but are not limited to taking a 4 month break from throwing (with 2-3 months being continuous), limiting the number of combined innings pitched during 12 month period based on age, and limiting the types of pitches that may be thrown by players of a certain age.[7] Additionally Cools et al[8], make several suggestions to address as a clinician in order to prevent injury as well as help players return to sport after injury. These recommendations include but are not limited to increasing glenohumeral joint range of motion specifically internal rotation, increasing rotator cuff strength and stability, and improving scapular performance while reducing dyskenesis.[8] Furthermore the authors strongly recommend using reliable assessment tools in order to increase the efficacy of treatment and documentation.[8]

Interventions and Clinical Implications

Because the effects of sustaining an injury, particularly at a young age, can hinder performance and participation in organized sports it is important to understand the impact that physical therapy and interventions/treatments can provide for the youth athlete. Current research has demonstrated some exercises and treatments more effective when managing shoulder and elbow injuries sustained in the sport of baseball. Moore et al[15], designed a cohort study to examine a baseball-specific strengthening programs in high school baseball players for improving shoulder and upper extremity strength as well as muscle endurance for regular season play. In this study, the authors used a two-phase strengthening program. During the first phase (weeks 1-10) the participants focused on fixing musculature imbalances and correcting biomechanic errors that could possibly contribute to injury, while the second phase (weeks 11-20) utilized a generalized strengthening program specific to the demands of throwing/pitching for baseball.[15] Additionally all participants of this study followed a stretching program designed increase internal rotation range of motion, which is a common limitation observed among baseball athletes.[15] Strengthening exercises of this program initially focused on endurance of the posterior shoulder muscles, utilizing multiple sets with high repetitions.[15] Once endurance was improved, the number of reps was reduced, while the resistive loads increased in order to improve strength of rotator cuff and upper extremity musculature.[15] The authors found that overall, this training program was able to improve posterior shoulder endurance, which lasted over a 20 week follow up period.[15] Although the authors noted, that no significant improvements in range of motion or strength were achieved, they discussed that the observed increase in endurance was valuable, due to the fact that adolescent and youth athletes often experience fatigue contributing to injury over shoulder

weakness.[15] Furthermore the authors utilized exercises from the Thrower's Ten, a program that has previously been designed to be used during pre-season strength and conditioning periods.[15]

In another study by Moore et al[16], the authors investigated the use of muscle energy techniques (MET) on improving glenohumeral joint range of motion. The authors performed MET on both the horizontal abductors as well as glenohumeral joint internal and external rotators. The authors were able to improve horizontal adduction range of motion through use of MET, however noted that no significant improvements to internal and external rotation were achieved with similar techniques.[16] Although use of MET for improvements in internal and external rotation were not significant, the authors did provide information on the use of the "sleeper stretch" and its benefits on improving internal rotation. This stretch, while typically performed in a sidelying position, may be a beneficial intervention to baseball athletes of all ages as it can be performed independently and has shown to improve and attenuate range of motion loss associated with injuries of the shoulder and elbow joint.

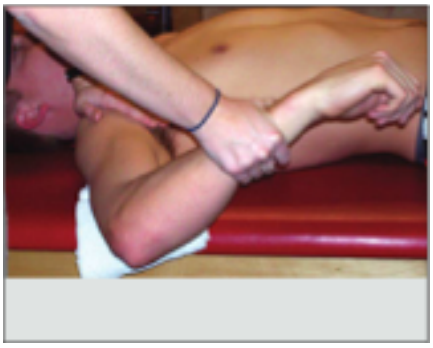

FIGURE 6. Muscle energy technique for the glenohumeral joint external rotators.[16]

The data collected from these studies shows that it may be beneficial to focus on improving endurance of upper extremity musculature as well as provide stretching exercises aimed at restoring losses in range of motion in order to decrease risk of injury in

baseball athletes. Through the use of high repetition strengthening exercises as well as self-administered stretching techniques it is possible to improve shoulder dysfunction associated with pitching and throwing mechanics of baseball.

Future Advancements

In addition to recommendations and prevention programs, technology can play an important role in helping to identify individuals at risk for injury. Motus Global, is a biomechanic technology company that specializes in injury prevention and performance analysis. Motus Global has created a device aimed at specifically monitoring the forces the UCL sustains during pitching and throwing activity. This device closely monitors players during both play and practice and identifies those at risk for developing serious and potentially career ending injuries.[8] This device, which monitors workloads of the throwing arm makes recommendations on throw limits based on data that is athlete specific. Currently 27 Major League Baseball (MLB) organizations are utilizing this technology. In addition to monitoring for potential injuries, this technology also comes with preloaded pitcher training programs, which are designed to improve strength, endurance, and mechanics.[8] This technology has the potential to be implemented into pre-season throwing programs in order to strengthen and condition athletes while limiting injury development due to fatigue and weakness.[8]

Resources for Parents, Coaches, and Players

These references aim to better serve those at risk for injury or interested in early prevention of potential injury. Coaches, parents, and athletes who participate in baseball regularly may use these resources. In addition to the Pitch Smart recommendations, which have been created by USA baseball, there also exists preseason throwing programs

specifically designed with age appropriate guidelines that help to safely build arm strength and endurance required by regular season demands on an athlete.[9] These programs are designed for age specific athletes ranging from 8 to 18 years of age. Free PDF calendars are available which provide a detailed schedule of preseason throwing programs that are designed to safely build arm strength and endurance prior to regular season play.[9] USA baseball has also created a free mobile app that is designed for coaches. This app provides drills and exercises that may help to improve coaching techniques regarding pitching and throwing mechanics.[9]

Conclusion

In any sport, athletes and participants are susceptible to injury. In baseball, specifically with biomechanical stresses involved in throwing a baseball, the shoulder and elbow joint are highly susceptible to injury. With participation in baseball reaching upwards of 5 million players annually, ages 6-17[1], it is important that injury prevention be one of the main focuses for youth sports organizations, coaches, parents, and players. In order to prevent injury, education must be stressed and risk factors need to be understood and identified so that early intervention may be successfully employed. With improvements in technology, there exists the potential to improve the monitoring of these risk factors, and improve the efficacy of injury prevention at an earlier age.

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