Complications of Little League Elbow Syndrome:

A Literature Review

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ABSTRACT

Background: Little League Elbow Syndrome is a condition that is caused by repetitive throwing motions, especially in children who play sports that involve an overhead throw. It is most often seen in young pitchers under the age of sixteen. The pitching motion causes a valgus stress to be placed on the elbow joint which can cause damage to the structures of the elbow.

Objective: This literature review provides an overview of the anatomy, biomechanics, kinematics, and commonly accepted treatments for little leaguer's elbow. An emphasis will be placed on etiology, prevention and current treatments.

Methods: PubMed and Sports Science were searched for sources related to Little League Elbow Syndrome. Preference was given to systematic reviews which give a more accurate representation of the current literature to date.

Conclusion: Research has shown that Little League Elbow Syndrome is primarily caused by a combination of poor mechanics, too many pitches per week, and throwing breaking balls. All three of these causes can be easily avoided but are commonly ignored by the athlete's coach(s) and or parents.

Key Words: medial epicondylitis, medial epicondyalr apophysitis, osteochondritis dissecans, elbow biomechanics, elbow kinematics, Little League Elbow Syndrome treatment, Little League Elbow Syndrome prevention

INTRODUCTION

Little league elbow syndrome is a valgus overload or overstress injury to the medial elbow that occurs as a result of repetitive throwing motions. Over the past several decades, the number of organized athletics available for the youth has grown significantly and millions of youth participate in these sports each and every year. Though it is great that today's youth have a wide variety of sports to choose from and many of them do in fact participate in different sports, the increase in participation has been paralleled by an increase in sports related injuries in the youth population (1). This increased number of sports and youth participants is not the only culprit responsible for the increase in injuries. Some other variables include: year-round training within a single sport, longer competitive seasons, higher intensity levels of training, and maybe the most important of all, training errors. Though there are many types of injuries that today's youth suffer from, this literature review will focus primarily on injuries seen in the elbow. Furthermore, injuries to the anterior, posterior, and lateral aspects of the elbow are different entities and should not be confused with medial elbow injuries referred to as little league elbow syndrome.

Little league elbow syndrome occurs predominantly in throwing athletes and refers mainly to baseball. There are more than 19,000,000 amateur baseball players, approximately 25% of which whom are pitchers or at least participate in pitching (2). The repetitive nature of baseball pitching results in a high risk for overuse injuries, and as a result of the repetitive nature of pitching, pitchers are at the greatest risk for sustaining an injury to their arm. The purpose of this literature review is to discuss the epidemiology, biomechanics, and prevention of little league elbow syndrome in youth baseball players.

DISCUSSION

Basic Elbow Anatomy and Biomechanics

The elbow joint is a complex structure that provides an important function as the mechanical link in the upper extremity between the hand, wrist and the shoulder. The elbow's functions include positioning the hand in space for fine movements, powerful grasping and serving as a fulcrum for the forearm. Loss of elbow function can severely affect activities of daily living. It is important to recognize the unique anatomy of the elbow, including the bony geometry, articulation, and soft tissue structures. The elbow joint is made up of three bones: the humerus proximally, the ulna distally and medially, the radius distally and laterally. It is innervated by the musculocutaneous nerve off of the lateral branch of the brachial plexus. The median, radial, and ulnar nerves also pass through the elbow on their way towards the hand. The elbow receives blood flow via the brachial artery.

The elbow acts as both a hinge joint and a pivot joint. The ulna articulates with the humerus in a “door hinge” motion and allows the forearm to be flexed and extended. The radius articulates with the humerus in a rational motion allowing the forearm to rotate inward (pronation) and outward (supination). Normal range of motion in the elbow joint allows for 145 degrees of flexion, 0 degrees of extension, 70 degrees of pronation, and 85 degrees of supination (3).

Secondary ossification centers are present in the elbows of younger individuals. They are located in the distal humerus, radial head, and in the olecranon of the ulna. These ossification centers are responsible for allowing bone growth and are not completely attached to the bone.

Bone growth begins in the first year of life and does not completely fuse with the body of the humerus until about age 20 (1, 3).

The biomechanics of the elbow joint can be divided into kinematics, static and dynamic stabilizing structures in elbow stability, and the transmission of force through the elbow joint. Flexion and extension are achieved through the axis of rotation found at the center of the trochlea. Pronation and supination are achieved through the axis of rotation found at the capitulum through the radial and ulnar heads. As previously stated, the normal range of motion for flexion and extension are 145 and 0 degrees respectively, while the normal range of motion for pronation and supination are 70 and 85 degrees respectively. The elbow joint has a normal carrying angle of 7 degrees in males and 13 degrees in females. Both values decrease with elbow flexion (5).

The static and dynamic stabilizers provide biomechanical stability in the elbow joint. The primary static stabilizers consist of two main complexes: medial (ulnar) collateral ligaments and lateral (radial) collateral ligaments. The lateral aspect of the elbow is supported by the radial collateral ligaments, while the medial aspect is supported by the ulnar collateral ligaments. The ulnar collateral ligament complex consists of three separate bundles, the anterior oblique bundle, a posterior bundle, and a transverse bundle. Collectively, these bundles make up the ulnar collateral ligament complex and serve as primary medial stabilizer of the elbow joint. Dynamic stabilizers include muscles that cross the elbow joint, such as the triceps brachii, biceps brachii, and anconeus. These dynamic stabilizing muscles support the elbow joint with contractile forces, providing compressive stability.

The elbow endures large forces throughout the joint when a force is applied. During the axial loading of an extended elbow joint, the radiohumeral joint bares 60% of the weight while the ulnarhumeral joint takes on the remaining 40%. The lever arms around the elbow are short and inefficient which produces large joint reaction forces and can lead to degenerative changes of the joint thus jeopardizing the elbow's structural integrity (4). Knowledge of both the anatomy and biomechanics is not only essential for proper diagnosis and treatment of elbow disorders but also in prevention of potential disorders.

Biomechanics of Throwing

The biomechanics of throwing and pitching are critical components when examining elbow injuries in youth baseball players. Biomechanics are considered to be one of the most important factors that affect throwing performance and injury potential. The complex movement pattern of throwing requires flexibility, muscular strength, coordination, synchronicity of muscular firing, and neuromuscular efficiency. The following paragraphs will discuss the six phases of throwing, the kinematics of throwing, and the relationship of biomechanics and kinematics to injury.

Pitching is one of the most dynamic movements in sports. Take an 85 mile per hour fastball, for example. The average time from initial foot contact of the stride leg to ball release for a pitch of this speed is just 0.145 seconds. The ball is accelerated from 4 to 85 miles per hour during this fraction of a second (6, 8). The most dynamic movements of the human body are the external and internal rotation of the shoulder during throwing which is why it is important to differentiate the six phases that comprise the motion of throwing. The six phases are windup, stride, arm cocking, arm acceleration, arm deceleration, and follow-through.

During the windup phase, the pitcher must achieve a balanced position as the knee of the stride leg raises. The delivery of the ball from the pitcher is then initiated from this position. During the windup phase, minimal elbow movements and kinematics are present. The stride phase begins as the hands separate and ends as the front foot contacts the mound. The elbow reaches eighty-five degrees of flexion with foot contact. The most important part of the stride phase is the location of the front foot. The stride foot should land directly in front of the back foot with toes slightly inverted. However, it is when the toes are turned too far in that the pitcher throws across his or her body and reduces the energy contributed by the lower body. This predisposes a pitcher to upper extremity injury. The third phase, or arm cocking phase, begins when the front foot contacts the pitching mound and ends when the arm is in maximum external rotation. At the end of the phase, one of the pitcher's arms is cocked and the legs, hip, and trunk have been accelerated. The fourth phase of pitching is arm acceleration, a short and dynamic process. This arm acceleration phase occurs when the humerus begins to internally rotate about the shoulder. The release of the ball signifies the end of this phase. The next phase of pitching is arm deceleration. This phase starts with the ball release and ends when the arm reaches its maximum internal rotation. Follow-through, the sixth and final phase, is marked at the beginning by the arm reaching maximum internal rotation and at the end when the pitcher attains a balanced field position. Larger body parts, especially the trunk and legs, assist in dissipating energy in the throwing arm. The follow-through is critical in minimizing the risk of injury in the baseball pitcher. Follow-through is complete with extension of the stride leg, continued hip flexion, shoulder adduction, horizontal adduction, elbow flexion, and forearm supination. (5, 6, 11, 14)

Kinematics of Throwing

The kinematics of throwing a baseball are also very important in baseball biomechanics. Kinematics includes the kinetic chain that encompasses a coordinated human movement. It is within this human motion that both energy and momentum are transferred through body segments to achieve maximum magnitude in the final segment. During pitching, the shoulder exceeds 7,000 degrees per second for adult pitchers. This has been referred to as the fastest human movement (6, 10). The concept of a kinetic chain is developed from the idea that this energy is being created with large segments and muscles, and is then transferred through the legs and trunk, out to the throwing arm, wrist, and then eventually the ball. For example, the kinetic chain for throwing consists of the legs, hip, trunk, upper arm, forearm, hand, and the baseball. This kinetic chain for throwing includes the mentioned sequence of motions: stride, pelvis rotation, upper torso rotation elbow extension, shoulder internal rotation, and wrist flexion (7, 9, 12).

The potential velocity at the distal end where the object is released is greater if more body segments contribute to the total overall force. Less energy is required if the kinetic chain is executed properly. Also, the performance of the throw, either the velocity or distance, should ultimately be increased. Seven segments have been identified which incorporate movements during the overhand throwing motion. These segments include the lower extremity, pelvis, spine, shoulder girdle, upper arm, forearm, and the hand (4, 12, 13).

Biomechanics and Kinematics in Correlation with Throwing

The information previously presented provides a background into why biomechanics and kinematics are important in examining youth pitching injuries in baseball players. A related biomechanical issue includes the relationship of biomechanics and kinematics to upper extremity injury. Based on the six phases of throwing, most overuse throwing injuries at the elbow and shoulders are believe to occur during the arm cocking and arm deceleration phase. It is during the arm deceleration phase that large loads are produced to decelerate the moving arm and prevent elbow and shoulder distraction (14, 17, 18).

For elbow injuries, the shoulder is in extreme external rotation near the end of arm cocking and the elbow is in flexion. This produces a large amount of stress on the ulnar collateral ligament (UCL) of the medial elbow. Valgus stress applied to the forearm can lead to medial elbow injury including muscle tears, avulsion fractures, medial collateral ligament spurs, and possibly ulnar nerve damage. Also, the lateral elbow is susceptible to injury at the end of the arm-cocking phase. Compressive forces are created between the radial head and the humerus that contributes about one-third of the torque to the elbow. The compression that results may eventually lead to avascular necrosis, osteochondritis dissecans or osteochondral chip fractures. Increased risk of injury is also prevalent when a significant varus torque is placed on the posterior elbow during the arm acceleration phase. In this case, impingement is combined with extreme elbow extension to produce an increased susceptibility to injuries. These possible injuries include osteophytes at the posteromedial olecranon tip, chondromalacia or the formation of loose bodies (12, 16, 17).

Biomechanics also play a major role in shoulder injuries. Most throwing injuries to the shoulder include the rotator cuff. These injuries are the result of the rotator cuff muscles (supraspinatus, infraspinatus, teres minor, and subscapularis) attempting to resist distraction, horizontal adduction, and internal rotation of the shoulder during arm deceleration. Humeral translation can cause entrapment of the labrum, which may result in labral tearing. Prevention of humeral translation is difficult due to the large rotations, forces, and torques produced in the shoulder during throwing. Specifically, during the arm deceleration phase, an inferior force and adduction torque are produced. This may lead to superior translation of the humerus and eventually tendonitis of the supraspinatus, infraspinatus, and bicipital tendonitis (5, 12).

The kinematics of baseball pitching is important when examining the type of pitch utilized. Several studies conducted by Fleisig and Escamilla were conducted to compare four commonly thrown pitches including the fastball, change-up, curveball, and slider. Conclusions included that higher stress loads are produced in the fastball, curveball, and slider pitches than in the change-up. However, the curveball was found to produce the greatest elbow medial force and elbow varus torque (15).

Prevention: Trends and Issues

The prevention of elbow injuries is important when examining youth baseball players. Approximately twenty-five percent of amateur baseball players participate in pitching (17). In a recent study of collegiate males in the United States, fifteen percent of the players who had pitched in youth baseball reported pain, tenderness, or limited motion, which compromised their ability to throw (2, 9). This demonstrates the need for early prevention of elbow injuries. This

section will provide information pertaining to the trends and issues in the prevention of elbow injuries in youth baseball players.

Several landmark research studies help explain the beginning ideas behind preventing elbow injuries in youth baseball players. The Houston Study in 1976 attempted to define the acute and chronic effects of Little League participants (13).

Five hundred and ninety-five pitchers were questioned concerning age, number of years pitched, symptoms of elbow injuries, and any known injuries. Also, each pitcher was x-rayed and examined by a physician. This particular study attempted to correlate the number of years pitched with injury. The Eugene Study, also in 1976, used the same evaluation form and examined 120 pitchers. Neither study found statistically significant correlations relating to pitching experiences, presence of symptoms, or x-ray findings and elbow injuries. Thus, the conclusion from the beginning research studies was that the problem of abuse to the pitching arm remains on the practice field rather than during competition (13, 15, 17).

The USA Baseball Medical and Safety Committee in collaboration with the American Sports Medicine Institute conducted the next group of significant studies concerning elbow injuries. The purpose of these studies was to investigate the relationship between arm injuries and pain and factors believed to be related to injury. These factors include types of pitches, number of pitches, and the quality of the mechanics. The 1996 study included surveying nationally recognized baseball coaches and physicians. The conclusions were that coaches at all levels of baseball should monitor the number of pitches thrown and not the number of innings pitched. A second recommendation was that pitchers should not use breaking pitches until their bones are completely finished growing (17, 19).

The same study in 1997 and 1998 included monitoring 300 youth baseball pitchers in the Birmingham, Alabama area. Almost half of these youth baseball pitchers, ages 8-12, reported elbow pain at least once during the study. The increase in the number of pitches thrown per game and the number of pitches thrown per season resulted in an increase in the risk of elbow and shoulder pain. Thus, the recommendations based on this study included limiting a youth baseball pitcher to 75 pitches per game for this age group (16). The 1999 study again monitored 500 youth baseball pitchers throughout the state of Alabama. This study again showed that half of all youth pitchers have elbow pain during the season and the risk of pain increases with the number of pitches thrown. Recommendations included limiting the number of pitches to 75 per game and 600 pitches per season. The study also demonstrated that youth pitchers who use curveballs and sliders increase their risk of pain (11, 16). The 2000 and 2001 studies consisted of conducting end of the year interviews of the 1999 subjects. These data will be used in the future to identify trends and to relate career cumulative pitching characteristics with serious elbow and shoulder injuries.

Several guiding principles are related to preventing elbow and shoulder injuries in youth baseball pitchers. These include the idea that prevention is participatory, dependent upon rules and regulations, and multidimensional. First, prevention is participatory. This includes the idea that preventing injuries needs to include the league personnel, parents, coaches, and any other pertinent members. For example, the parents can identify early recognition of injuries. Simultaneously, coaches are responsible for knowing the fundamentals of baseball and teaching the proper mechanics of throwing and pitching (20, 21).

Secondly, prevention is dependent upon the Little League rules and regulations. For example, Little League rules state that 9-12 year olds can pitch up to six innings per week and

13-14 year olds are allowed to pitch up to 9 innings per week. Also of interest, is the age cut off for teams. If a child's skeletal maturations is delayed and participation is based upon an age-determined team, then the child may pitch beyond their physical tolerance and develop secondary problems (4, 17, 21).

Finally, prevention is multi-dimensional. The term "overuse" is often used and is an oversimplification. It implies that the solution to youth pitching injuries is for players to pitch and throw less. However, prevention much also include several other dimensions. These prevention strategies include monitoring the number of pitches or throws, the frequency of the play, the velocity or speed, throwing mechanics, the player's age, and the implementation of an interval throwing program (17, 21).

The interval-throwing program is a recently developed distance-based throwing program based on distance and speed. The program is progressive as it loads the upper extremity either by increasing the intensity, duration, or both. Two components make up the program. The short component simulates the physical demands of the player that occur in a game situation. The long component is designed to provide low-intensity, long duration stimulation to throwers to increase arm strength. Criteria necessary to implement the interval-throwing program include the program being functional, personal, safe, and practical (2, 15, 21).

Summary

Overall, several important areas need to be examined to understand elbow injuries in youth baseball players. These areas include but are not limited to epidemiology, biomechanics, and prevention of elbow injuries in youth baseball pitchers. First, most injuries occur to the elbow, with Little League Elbow being the most common injury. The anatomy of the elbow

allows for instability that is a predisposing factor to injury, however the shoulder can also be injured with pitching and throwing in youth baseball players.

Secondly, the ability to pitch correctly requires proper biomechanics. Improper mechanics may lead to a decrease in performance or an increase in the risk of injury. Information concerning throwing injuries and the six phases of throwing can help teach techniques to improve treatment and prevention of throwing injuries.

Finally, prevention is another aspect of elbow injuries. Prevention is multi-dimensional and includes all personnel involved. Additionally, the major concern is the number of pitches not the number of innings pitched per youth baseball player. The information above indicates that researching elbow and shoulder injuries in youth baseball players requires a comprehensive approach. Many components, including epidemiology, biomechanics and prevention bust be examined to completely understand the significance and severity of injuries to a youth baseball pitchers arm.

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