A BIOMECHANICAL ANALYSIS OF INJURY, PREVENTION, AND REHABILITATION EXERCISES FOR LATERAL EPICONDYLITIS: A REVIEW

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The purpose of this research paper was to disseminate the importance of understanding the biomechanics of lateral epicondylitis (LE), analysis of prime movers and accessory muscles of the elbow joint and wrist, and evaluation of therapeutic exercises. This review will focus on the development of exercises based on the functional muscle analysis, mechanical levers, and actual movement patterns that may lead to injury. Based on the theoretical and experiential knowledge, the suitable exercise for treating and preventing LE is reverse biceps curls. This knowledge is very beneficial for coaches, therapist and trainers in the battle to prevent lateral epicondylitis injury, specifically for tennis players and develop appropriate therapeutic intervention.

KEY WORDS: lateral epicondylitis, elbow injury, prevention, biomechanics.

INTRODUCTION: Inflammation of the tissue at the lower end of the humerus at the elbow joint, caused by the repetitive flexion and extension of the wrist against resistance is called lateral epicondylitis (LE). It may result from athletic activity or manual manipulation of tools producing a pain that radiates from the elbow joint to the wrist. Several studies stated that LE is generally associated with repetitive overuse related to athletics, vocation, or the performing arts (Nirschl et al. 1992).

The patients are typically 35 to 50 years of age and are often quite debilitated by the malady. The pathologic changes have been well described and are termed angiofibroblastic hyperplasia, a characteristics invasion of fibroblasts and atypical granulation-like tissue (Nirschl, 1992). These changes appear to represent failed tendon healing and are likely to undergo degenerative process secondary to tensile overuse. Microscopically the pathological evaluation showed universal mucoid degeneration, avascular area, and chronic inflammatory cells at all tissue sites Almquist et al. (1998)

The area affected by LE involves the extensor carpi radialis brievis (ECRB) tendon origin. In addition, the anterior aspect of the extensor digitorum communis tendon origin is involved in approximately 35% patients who have primary surgical intervention. A physical examination study by Cabot (1987) revealed that increased pain with resisted wrist extension occurs particularly when the elbow was extended. An extensive study of 139 limbs by Briggs and Ellicott (1985) revealed that ECRB muscle while under tension across the elbow, forearm and wrist revealed the greatest muscle lengthening in pronation of the forearm with palmar flexion and ulnar deviation. Therefore, the research hypothesized that tennis elbow is primarily a mechanically-induced condition. Furthermore, it is concluded that when performing movements at the wrist with the forearm in pronation, the muscle is at its maximal length. This may cause microrupture of muscle fibers. Lieber et al. (1999) studied the morphologic changes of extensor carpi radialis brevis, and reported significant degradation associate with fiber necrosis, and higher percentage of fast-oxidative (type 2A). They concluded that cumulative effect of mechanical and/or metabolic overload limits the performance due to elbow pain and damage to the muscle tissue. Pfahler et al. (1998) studied the histopathological analysis using MRI images of extensor tendons and concluded that degenerative tendon tissue and microruptures of collagenous fibers. Most studies reported that the muscle tendons involved in LE are extensor carpi radilais brevis (ECRB) and extensor carpi radialis longus (ECRL) and some elbow joint inflammation.

Several studies outlined the mechanism of injury and treatment of LE. The conservative treatment varied considerably, but always included complete or near-complete relief of discomfort with local anesthetic injections in the lateral epicondylar area. Other modalities included physical therapy, reduction of both work and non-work activities, non steroidal anti-inflammatory medications, splinting, and various physical therapy modalities. Leach and

Mider (1987) recommended that conservative treatment including decreased activity, ice, nonsteroidal anti-inflammatory medication and muscle strengthening all helped most people. Binder and Hazleman (1983) found that steroid injection (89%) is effective compared with ultrasound (53%).

The study by Kelley et al. (1994) reported that the injured tennis players had significantly greater activity for the wrist extensors and pronator teres muscles during ball impact and early follow through and concluded that abnormal mechanics of the elbow and wrist joint may have contributed to the injury. Field and Savoie (1998) suggested that athletes participating in sports involving overhead arm motion are susceptible to LE injuries.

Treatment includes rest, correction of body mechanics, infiltration of a long-acting anesthetic, or serial injections of hydrocortisone, depending on the severity of the condition. Surgical treatments were recommended by Almquist et al. (1998) for treating LE. Gabel (1999) emphasized that the prognosis for lateral epicondylitis is good, but requires 3 to 6 months to resolve. The author recommended patient education, activity modification, splinting, and corticosteroid injections.

Most researchers outlined that the causes of lateral epicondylitis injury among tennis players is due to the racket, improper skill, string tension, vibration and overuse. AN exercise program and therapy were recommended for rehabilitation. It is not clear from the previous research what type of exercise therapy is needed for this condition. Therefore, the purpose of this research is to establish the fundamental biomechanical and structural principles involved in developing rehabilitation exercises for treating and preventing LE.

METHOD: It is important for therapists, coaches, and trainers understand the mechanism of muscle and tendon injury for a prudent intervention of therapy and prevention. A muscle is capable of increasing size and strength necessary to perform a maximal contraction and generate force, provided it is not overstressed due to lack of nutrition, rest, blood supply, oxygen, and removal of waste products. If a muscle or muscle group is injured due to fatigue and it is unable to generate maximal required force, then we need to increase the strength and muscular endurance of accessory muscles with similar functional capabilities. Therefore, to generate maximal force, increased number of muscle group involvement is necessary for a given amount of resistance and there is a need to strengthen the accessory muscles rather than the prime movers. In this case, by increasing the accessory muscle involvement such as biceps, brachioradialis, and brachialis for elbow flexion and supination to alleviate stress on prime movers of the wrist. Muscle size also play an important role in reducing injury. The ECRB and ECRL muscles are very small in size compared with biceps, brachialis and brachioradialis. It is much easier to increase the strength and force of contraction of a larger muscle than a smaller one must be able to do the same task.

Generally, novice tennis players complain of pain in the lateral part of the elbow during serving, one-handed backhand and forehand. Majority of the players complained of pain during the deceleration phase of the skill. In serving and forehand, the movement pattern during this phase of cycle is flexion to extension and supination to pronation of the radio–ulnar joint, shoulder flexion and internal rotation and slight wrist extension. As the racket is moving away from the player with great force, the tendency is that the player has to extend the wrist to grip it harder**.** Wrist extension is mainly caused by ECRL and ECRB contraction. Furthermore, to decelerate the racket, the elbow has to be flexed, supinated and shoulder has to move from flexion to extension. This movement reduces the lever arm of the segment and racket in which shoulder joint is the axis of rotation. This analysis is consistent with the results of Cabot (1987). The hypothesis is that if the elbow flexors are strengthened, specifically biceps (flexion and supination), the stress on ECRL and ECRB lessened. Further, reducing extreme extension at the elbow reduces resistance lever during deceleration phase. Moreover, at the recovery phase of tennis movement, the ECRB and ECRL are at their maximal stretched length and simultaneously concentrically contracting for wrist extension and gripping. This type muscle function, two forces acting in different directions, will eventually lead to micro-tear in the sarcomere if the contraction is produced repetitively without rest.

The structural and mechanical analysis indicate that lack of strength in the biceps, brachialis, and brachioradialis may contribute to LE. Therefore, it can be suggested that converting the third class lever system of the elbow (flexion, concentric contraction) into second class lever system (extension, eccentric contraction) would help to improve muscle strength tremendously. The purpose of second class lever is to increase force at the expense of displacement. Further, this will reduce the pain due to less displacement of resistance.

Recommended specific exercise program. A low and comfortable weight held on completely flexed elbow with neutral wrist position close to the body and extend the elbow as tolerated. The shoulder should also be in the neutral position to reduce the gravitational torque. This exercise can performed twice a day as tolerated to increase muscular endurance for first few weeks. Then increase resistance and decrease repetition to increase muscular strength. This may be called reverse arm-curl. Our practical knowledge on treating LE suggests that reverse arm curl is the exercise to be given to lessen pain, discomfort, and maximum increase in strength.

Stretching. To stretch ECRB and ECRL the elbow should be extended and pronated, shoulder flexed and internally rotated, and slight wrist flexion and apply force against any object on the back of the metacarpals specifically on 1st and 2nd. The position has to be held as tolerated.

CONCLUSION AND RECOMMENDATIONS: Understanding the proper mechanics of LE injury would help to set-up a proper rehabilitation exercise program and prevent future injuries. The elbow extension exercise, mentioned above, should be part of the training program rather than giving these exercises only after injury for rehabilitation purposes. This way one can prevent the injury and save valuable time of training.

Most coaches emphasize push-ups to increase upper extremity strength as part of the training program. This exercise should be avoided and is not recommended because the push-up phase includes the movement of wrist extension, elbow extension and shoulder flexion. Forward grip pull-up exercise is recommended but not the reverse grip. Finally, any functional training which involves heavy and repetitive loading of structures involved in extension of elbow, pronation, shoulder flexion and wrist extension should also be avoided. Not only should one reduce stress on the repeatedly used muscles, but also one has to develop the strength and endurance of antagonistic muscles of the desired movement.

Further investigation of the short and long-term eccentric biceps contraction training on ECRB and ECRL muscles using electromyography and telemetry is recommended.

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