CHARLES UNIVERSITY

Faculty of Physical Education and Sport

Department of Physiotherapy

The Effect of Kinesio Tape on the Muscle Activation of the Long Head of the Biceps in Baseball Players

Master's Thesis

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Prague, December 2020

I declare that I wrote my graduate dissertation independently, and that I have stated all the information sources and literature I used. Neither this thesis nor any substantial part of it have been submitted for the acquisition of another or the same academic degree.

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Abstrakt

Název:

Vliv Kinesiotapingu na svalovou aktivaci dlouhé hlavy bicepsu u hráčů baseballu.

Cíle:

Při baseballovém hodu v tzv., overhead pozici je v místě dlouhé hlavy bicepsu vyvíjena obrovská zátěž na rameno, která je příčinou četných zranění. Kinesiologická páska je jednou z několika léčebných technik v prevenci úrazů a léčbě pohybů s vysokou zátěží, jako je právě overhead pohyb při házení. Akutní efekt kinesiotapingu na svalvoou aktivitu dlouhé hlavy bicepsu však není příliš znám. Cílem této práce je ověřit, zda aplikace Kinesiotapingu na pokožku umístěnou povrchově na dlouhé hlavě bicepsu zvyšuje její aktivitu v pohybu imitujícím baseballový hod.

Metody:

Výzkumný soubor zahrnoval 21 aktivních českých extraligových baseballistů (21 mužů, ve věku 25,3 ± 5,9 let, výšky 183,2 ± 6,9 cm, o hmotnosti 83,8 ± 11,1 kg, let s tréninkovým věkem 17,1 ± 6,5 let), kteří neuváděli žádnou aktuální ani nedávnou bolest nebo zranění ramene. Svalová aktivita každého probanda byla zjištěna pomocí povrchového elektromyografu (sEMG), ME6000 (Bittium Inc. Oulu, Finsko). Markry EMG byly umístěny na: 1. dlouhé hlavě bicepsu (LHB), 2. dlouhé hlavě tricepsu (LHT), 3. velkém prsním svalu a 4. horní části trapézového svalu. Před každým ze tří opakovaných testování byla zaznamenána aktivita maximální volní izometrické kontrakce (MVIC) uvšech výše uvedených svalů. Měření bylo provedeno na pravé horní končetině (důvod omezení srdečních artefaktů) v 90° abdukci ramene bez podpory a 90° flexi lokte s dynamickou rotací ramene a s 1 m dlouhého žlutého Therabandu pro rezistenci vnitřní rotace. Mezi prvním a druhým měřením byla přibližně 20ti sekundová prodleva. Stabilita výsledků EMG byla hodnocena na základě korelace mezi každým měřením. Variabilita výsledků a možnost použití dat ze všech opakovaných měření byla ověřena Friedmannovým testem neparametrické ANOVY. Rozdíly mezi svalovou aktivitou před a po aplikaci kinesiotapingu u definovaných svalových skupin byly nalyzovány Wilcoxnovým neparametrikcým párovým T-testem.

Výsledek:

Výsledky naší studie ukázaly, že svalová aktivita v LHBM se po aplikaci Kinesiotapu snížila. Z klinického a statistického hlediska byl efekt Kinesiotapu neprůkazný. Na základě našich výsledků musíme zamítnout naši výzkumnou hypotézu. Aplikace Kinesiotape nevedla k významnému zvýšení svalové activity v LHBM. Jedinou významnou změnou bylo snížení svalové activity v horním trapézovém svalu $p<0.023$. Tato změna se však ukázala jako málo klinicky průkazná Effect size $r=0.26$

Závěr:

Výsledky této stuide ukázaly že aplikování KT nemusí vykazovat akutní účinek na svalovou aktivitu u svalu, na který je aplikován. I přes to, že současný výzkum řešil tuto aktuní odpověď organism, naše zjištění ukázala, že KT pravděpodobně není dostatečně citlivým podnětem pro zisk významné akutní odpovědi. Proto je pravděpodobné, že aplikace KT a sledování jeho účinku bude vyžadovat delší časový odstup. Dle našeho názoru by se měl budoucí výzkum v této oblasti zaměřit na pečlivějkší výběr probandl a také pohybového úkolu, protože se domníváme, že pohybová zkušenost mohal významně ovlivnit heterogenitu EMG výsledků i jejich samotnou variabilitu.

Klíčová slova:

Baseball, dlouhá hlava bicepsu, Kinesiologická páska, házení pohybem nad hlavou, RockTape, sEMG, povrchový elektromyograf

Abstract

Thesis Title:

The Effect of Kinesio Tape (KT) on the Muscle Activation of the Long Head of the Biceps in Baseball Players.

Objective:

KT is one of several treatment techniques in injury prevention and treatment for high demand movements, such as overhead throwing. The baseball throwing motion, or the overhead throwing motion, places tremendous stress on the shoulder where coordination of its subsequent musculature, such as the long head of the biceps, are crucial. As a result, injuries do occur. However, the acute effect of KT on the muscular activity of the LHB is not well known. The aim of this thesis is to verify that the application of KT to the skin located superficially to the Long Head of the Biceps increases its activity in the baseball throwing motion.

Methods:

The research sample included 21 active Czech Extraliga baseball players (21 male, aged 25.3 ±5.9 years, height 183.2 ±6.9 cm, weight 83.8 ±11.1 kg, years baseball of participation 17.1 ±6.5 years), which reported no current or recent shoulder pain or injury. The surface Electromyograph (sEMG) of the muscle activity from each subject was collected using a Bittium Biomonitor transmitter and receiver, model ME6000 (Bittium Inc. Oulu, Finland). There was recorded Maximum Voluntary Isometric Contraction (MVIC) activity of the Long Head of the Biceps (LHB), Long Head of the Triceps (LHT), Pectoralis major (PM), and Upper Trapezius (UT) before each of the three testing sessions. Measurement was taken with the right arm in 90º of unsupported shoulder abduction and 90º of elbow flexion with dynamic shoulder rotation with 1m of yellow Theraband for resisted internal rotation. First measurement was taken with no KT applied and then the second measurement with red RockTape brand KT applied to the skin from the proximal origin to the distal insertion of the LHBM. The right upper limb was used to limit possible cardiac crosstalk. There was approximately a 20 second lag time between the first and second measurement. Stability of EMG outcomes were evaluated by looking at the correlation between each trail. The variability of the results and the possibility of using data from all repeated measurements were verified by Friedmann's non-parametric ANOVA test. Differences in muscle activity between before and after application of KT were analyzed while looking at each muscle by non-parametric paired Wilcoxon signed-rank T-test.

Results:

Results of this study showed that muscle activity in the LHBM decreased after application of KT. However, from a clinical and statistical point of view, the impact of KT was rather ambiguous. Based on the results, the research hypothesis must be rejected. KT did not lead to a significant increase in muscle activity in the LHBM. The only significant change was a decrease in muscle activity in the UT, $p<0.023$. Nevertheless, the degree of measurable decrease in muscle activity proved to be of little clinical significance, Effect Size $r=0.26$

Conclusion:

The results of our study show that the application of KT need not have acute effect on the muscle activity of the muscle to which it is applied. This study addressed the acute response of the muscular system, but the results show that KT is not a sufficiently sensitive stimulus for the desired response. Therefore, it may be necessary to apply KT for a longer period of time to provide a more provable effect. For future research, we recommend a careful selection of participants and investigative movement patterns to be evaluated, as we assume that movement experience can bias the heterogeneity and variance of EMG.

Keywords:

Baseball, Long Head of the Biceps, Kinesio Tape**,** Kinesiology tape, RockTape, Overhead Throwing, sEMG, surface electromyograph

Table of Contents

List of Abbreviations

Ag - Silver

Al - Aluminum

BB – Biceps Brachii

bpm - beats per minute

Cl - Chloride

cm - centimeter

ECG - Electrocardiogram

EMG - Electromyography

Fig. - Figure

in – inch

KC – Kinetic Chain

kg - kilogram

KT - Kinesio Tape

LHB - Long Head of the Biceps

LHBM - Long Head of the Biceps Muscle

LHBT - Long Head of Biceps Tendon

LHT - Long Head of the Triceps

LHTM - Long Head of the Triceps Muscle

m - meter

m. - muscle

mm - millimeter

MVIC - Maximum Voluntary Isometric Contraction

N - Newton

ºC - Celsius

ºF - Fahrenheit

PM - Pectoralis Major

s - second

sEMG - Surface Electromyography

SLAP - Superior Labral Anterior to Posterior

UK FTVS - Charles University Faculty of Physical Education and Sport

UT - Upper Trapezius

1 INTRODUCTION

KT has been evolving as a unique treatment tool since its developed by Dr. Kenzo Kase in Japan in the 1970s. His objective was to create a therapeutic tape and taping technique which could support joints and muscles, without restricting range of motion. After developing and refining the KT Method, his method sparked interest throughout the health care community around the world.[1] It is claimed that KT facilitates the reduction of edema, improves lymph and blood circulation, and contributes, through proprioception, to the normalization of muscle function and the support of ligaments and tendons. It is claimed that the result is generally a rapid reduction of pain and improvement in the joint and muscle function.[2] KT use is now found in competitive sports, many areas of medicine and physiotherapy. This effective treatment method has become an integral component of prevention, rehabilitation, and part of the training therapy. Aftercare and treatment concepts in orthopedics, surgery, oncology, geriatrics, and pediatrics have been developed and introduced into hospitals and rehabilitation centers worldwide.[2]

The throwing motion, such as in baseball, is a complex movement pattern that requires flexibility, muscular strength, coordination, synchronicity of muscular firing, and neuromuscular efficiency. The thrower's shoulder must be loose enough to throw, but stable enough to prevent humeral head subluxation and to maintain control during the entire throwing motion, which includes acceleration and deceleration. The thrower's shoulder is in delicate balance between mobility and stability. The overhead throwing motion places tremendous demands on the shoulder joint complex musculature to produce functional stability. The surrounding musculature must be strong enough to assist in arm acceleration but must exhibit neuromuscular efficiency to produce dynamic functional stability. During the act of pitching, the angular velocity at the shoulder joint exceeds 7000º/sec and has been referred to as the fastest human movement. Tremendous forces are generated at the shoulder joint, sometimes up to one times the person's body weight. Because of these tremendous demands, at incredible angular velocities, various shoulder injuries may occur.[3] Due to its effects, KT appears to be a suitable means of therapy and prevention of the progression of pathological musculoskeletal processes. Although KT is popular and a relatively successful method, objective evidence of the principles of action and effects are still lacking. The results of previous studies aimed at research and confirmation of individual effects of KT are not always consistent.

The premise of this thesis is focused on the verification of whether application of KT increases the muscular activity of the LHB, during the overhead throwing motion in baseball players.

2 SUMMARY OF THEORETICAL KNOWLEDGE

2.1 Anatomy of the Shoulder

The glenohumeral joint combined with the scapulothoracic, sternoclavicular, and acromioclavicular joints comprise the shoulder joint complex. All these joints are critical to normal pain-free function of the most complex joint in the human body. The glenohumeral joint, composed of its bones, ligaments, muscles, tendons, arterial and nerve supply, allows it to have the greatest amount of motion of any joint in the human body.[4,5]

2.1.1 Bones

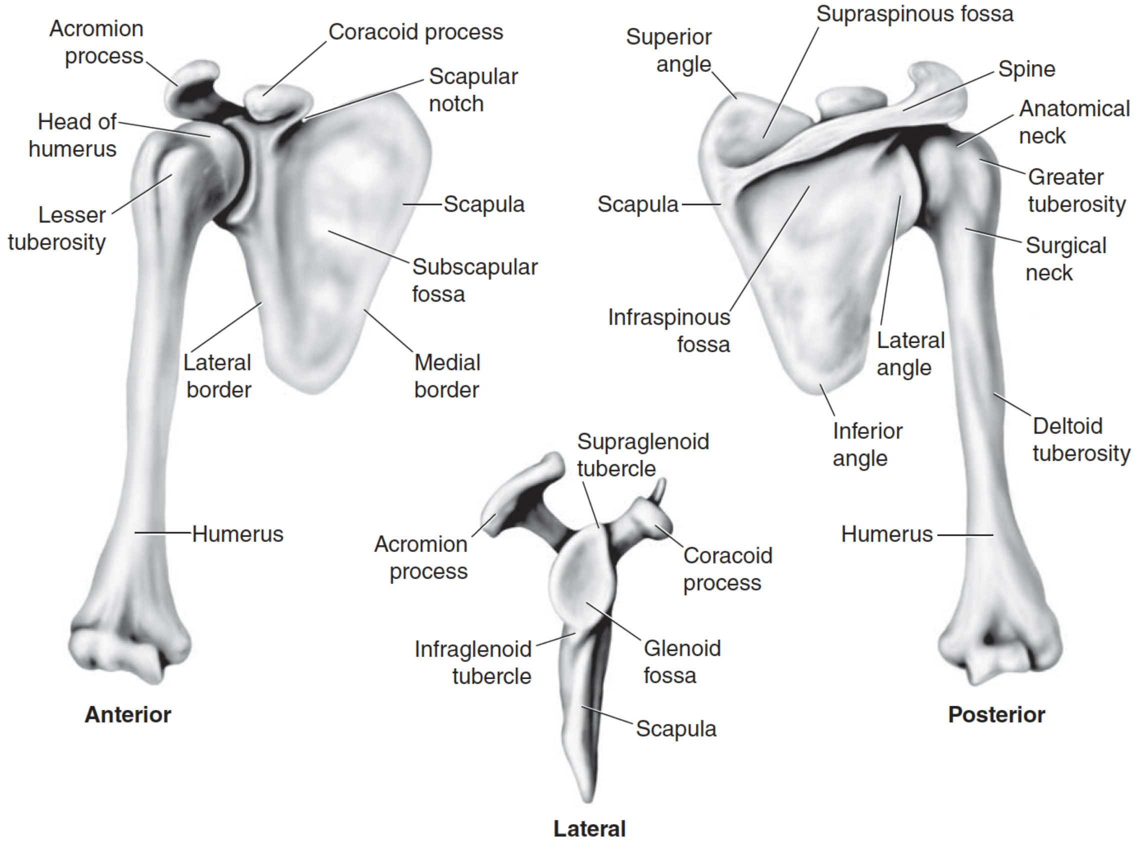


Fig. 1 Bones of the shoulder girdle[6]

2.1.2 Joints

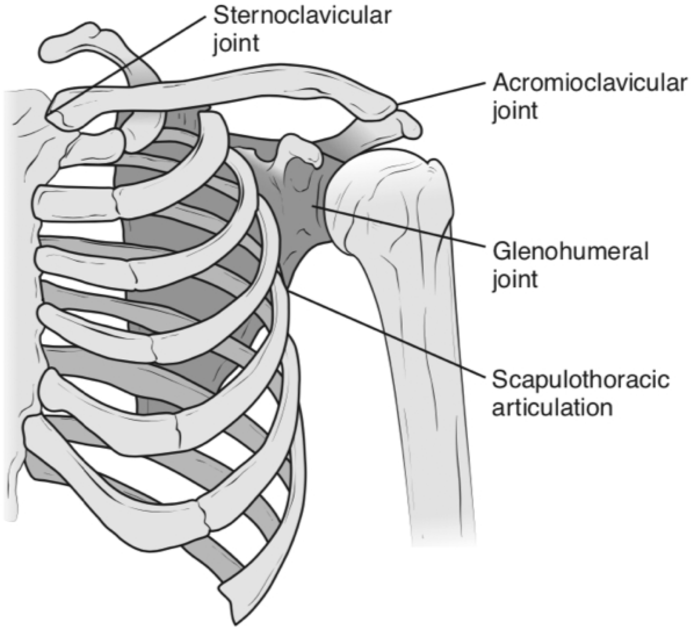


Fig. 2 Joints of the shoulder girdle[7]

Table 1 - Joints of the shoulder girdle[8]

Joint	Type	Closed Packed Position	Capsular Pattern
Glenohumeral	Spheroidal	Full abduction and external rotation	ER limited more than abduction, limited more than internal rotation and flexion
Sternoclavicular	Saddle	Arm abducted to 90º	Not reported
Acromioclavicular	Plane synovial	Arm abducted to 90º	Not reported
Scapulothoracic	Not a true articulation	Not available	Not available

2.1.3 Ligaments

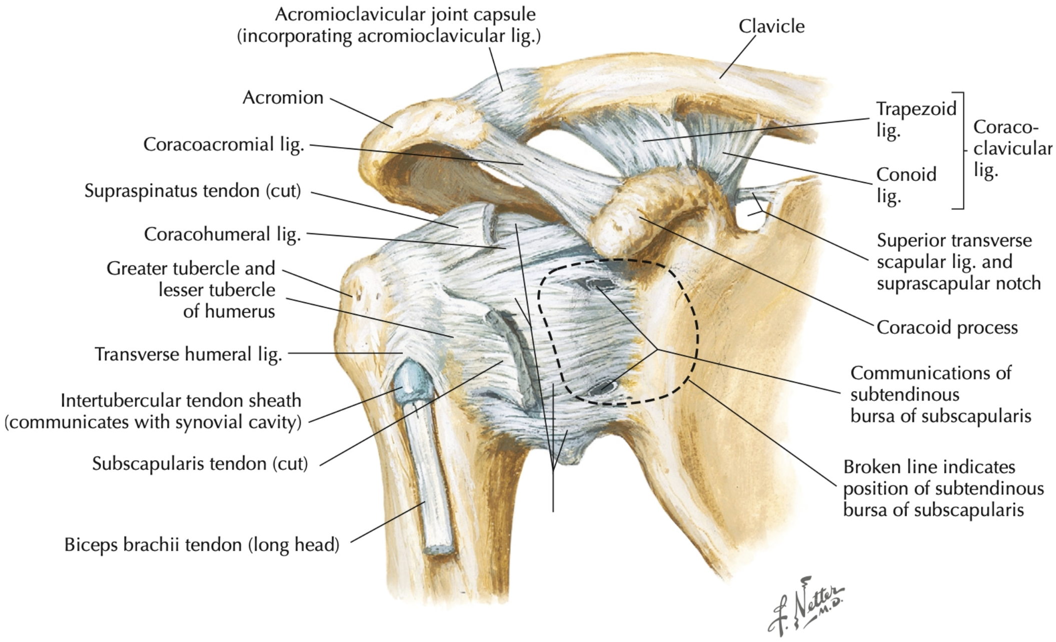


Fig. 3 Ligaments of the shoulder girdle – anterior view[8]

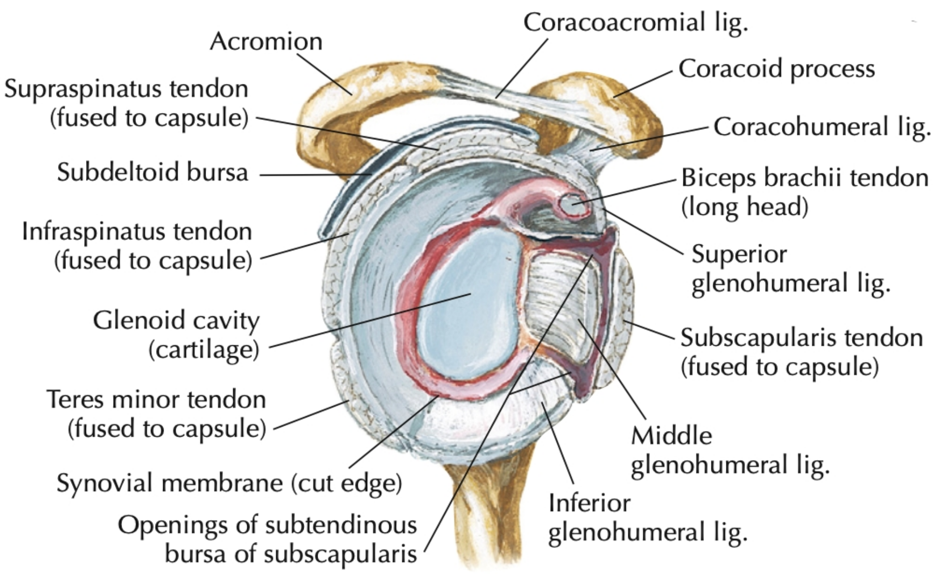


Fig. 4 Ligaments of shoulder girdle - lateral view[8]

Table 2 - Ligaments of the shoulder girdle[8]

Ligaments	Attachments	Function
Glenohumeral	Glenoid labrum to neck of humerus	Reinforces anterior glenohumeral joint capsule
Coracohumeral	Coracoid to greater tubercle of humerus	Strengthens superior glenohumeral joint capsule
Coracoclavicular		
Trapezoid	Superior aspect of coracoid process to inferior aspect of clavicle	Anchors clavicle to coracoid process
Conoid	Coracoid process to conoid tubercle on inferior clavicle	Anchors clavicle to coracoid process
Acromioclavicular	Acromion to clavicle	Strengthens AC joint superiorly
Coracoacromial	Coracoid process to acromion	Prevents superior displacement of humeral head
Sternoclavicular	Clavicular notch of manubrium to medial base of clavicle anteriorly and posteriorly	Reinforces sternoclavicular joint anteriorly and posteriorly
Interclavicular	Medial end of one clavicle to medial end of the other clavicle	Strengthens superior sternoclavicular joint capsule
Costoclavicular	Superior aspect of costal cartilage of first rib to inferior border of medial clavicle	Anchors medial end of clavicle to first rib

2.1.4 Muscles

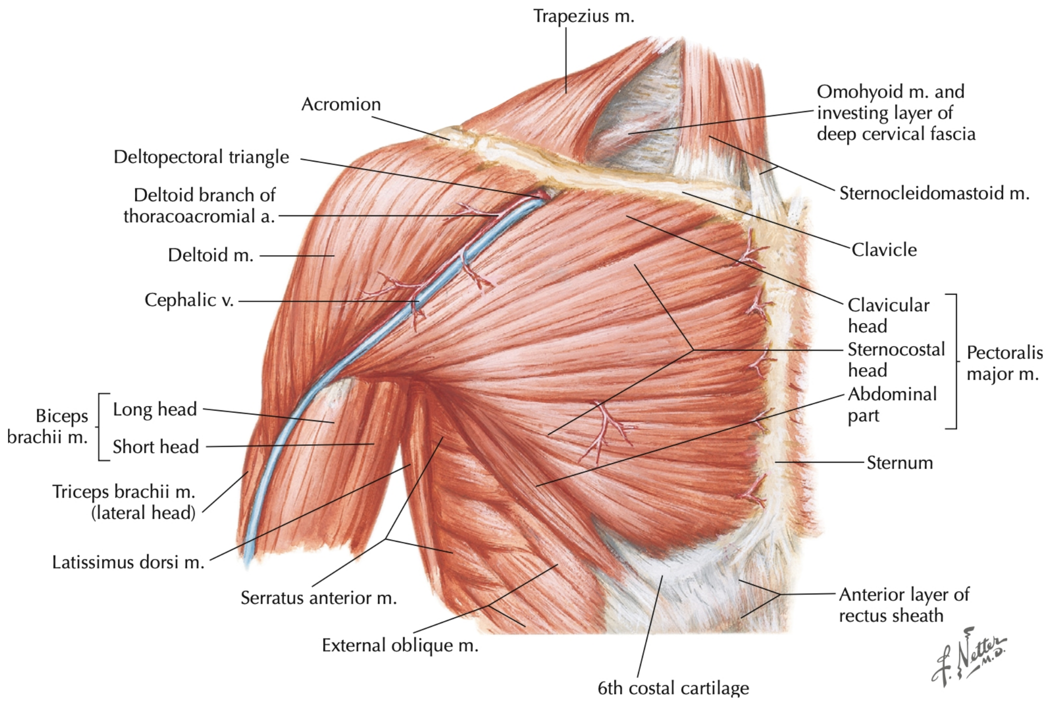


Fig. 5 Muscles of the shoulder girdle – anterior[8]

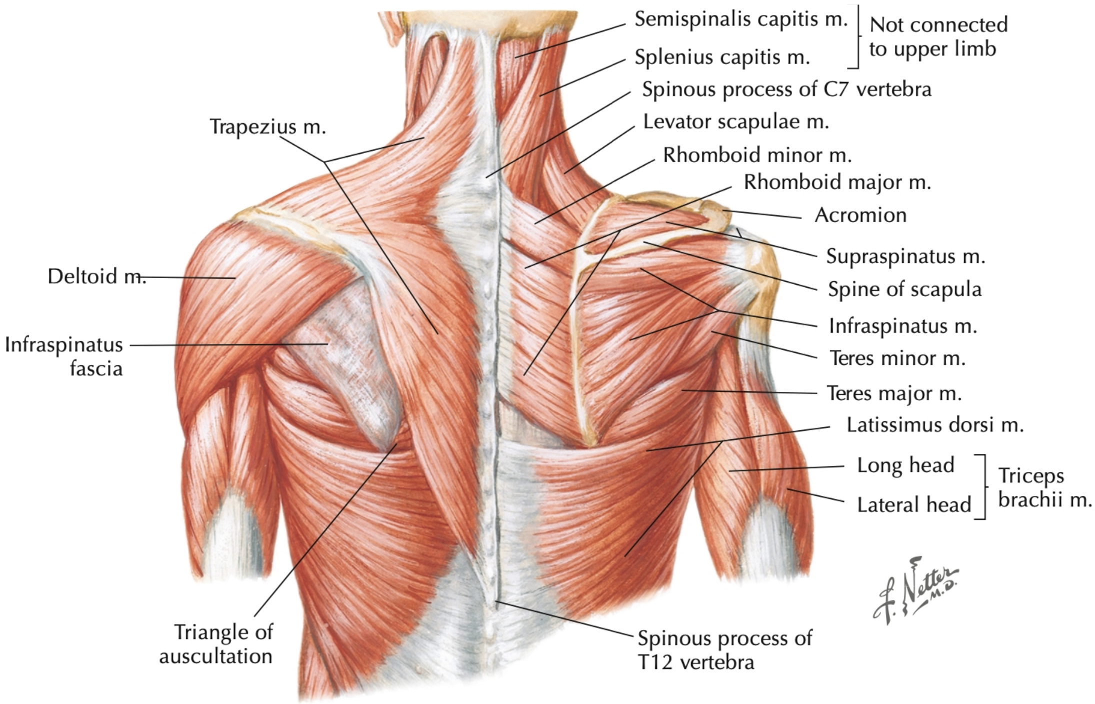


Fig. 6 Muscles of the Shoulder girdle – Posterior[8]

Table 3 - Shoulder muscles[8]

Muscles	Origin	Insertion	Action
Deltoid	Clavicle, acromion, spine of scapula	Deltoid tuberosity of humerus	Abducts arm
Pectoralis			
Clavicular head	Anterior medial clavicle	Intertubercular groove of humerus	Adducts and internally rotates humerus
Sternocoastal head	Lateral border of sternum, superior six coastal cartilages and fascia of external oblique muscle	Intertubercular groove of humerus	Adducts and internally rotates humerus
Pectoralis minor	Just lateral to coastal cartilage of ribs 3 to 5	Coracoid process	Stabilizes scapula
Biceps brachii			
Short head	Coronoid process of scapula	Radial tuberosity and fascia of forearm	Supinates forearm and flex elbow
Long head	Supraglenoid tubercle of scapula	Radial tuberosity and fascia of forearm	Supinates forearm, flex elbow, abducts humerus, stabilizes glenohumeral joint
Upper trapezius	Occipital protuberence, nuchal line, ligament nuchae	Lateral clavicle and acromion	Rotates glenoid fossa upwardly, elevates scapula
Middle trapezius	Spinous process of T1-T5	Acromion and spine of scapula	Retracts scapula
Lower trapezius	Spinous process of T6-T12	Apex of spine of scapula	Upward rotation of glenoid fossa, scapular depression
Levator scapulae	Transverse process of C1-C4	Superior medial scapula	Elevates and adducts scapula
Rhomboids	Ligamentum nuchae and spinous processes C7-T5	Medial scapular border	Retracts scapula
Latissimus dorsi	Inferior thoracic vertebrae, thoracolumbar fascia, iliac crest, and inferior ribs 3-4	Intertubercular groove of humerus	Internally rotates, adducts, and extends humerus
Serratus anterior	Ribs 1-8	Anterior medial scapula	Protracts and upwardly rotates scapula
Triceps Brachii			
Long head	Infraglenoid tubercle of scapula	Olecranon process of ulna	Extends elbow
Lateral head	Superior to radial groove of humerus	Olecranon process of ulna	Extends elbow
Medial head	Inferior to radial groove	Olecranon process of	Extends elbow

	of humerus	ulna	

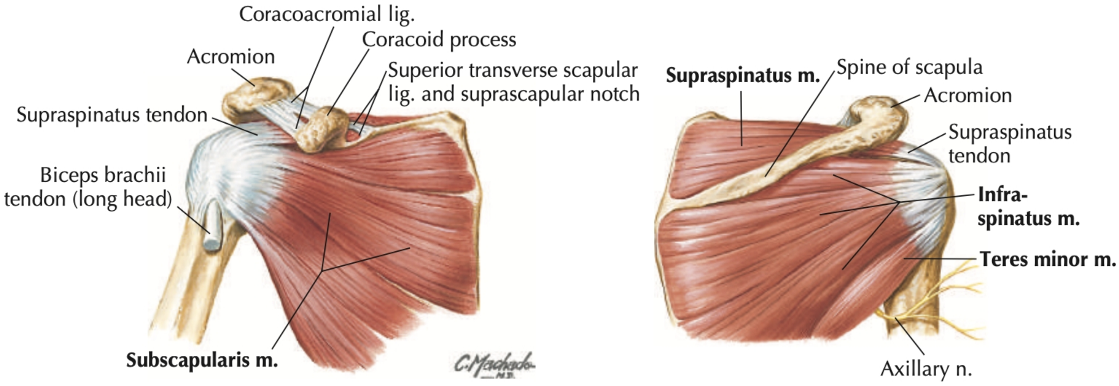


Fig. 7 Muscles of the rotator cuff - anterior and posterior[8]

Table 4 - Rotator cuff muscles 8

Muscles	Origin	Insertion	Action
Supraspinatus	Supraspinous fossa of scapula	Greater tubercle of humerus	Assists deltoid in abduction of humerus
Infraspinatus	Infraspinatus fossa of scapula	Greater tubercle of humerus	Externally rotates humerus
Teres minor	Lateral border of scapula	Greater tubercle of humerus	Externally rotates humerus
Subscapularis	Subscapular fossa of scapula	Lesser tubercle of humerus	Internally rotates humerus

2.1.5 -Nerves, Dermatomes, and Myotomes

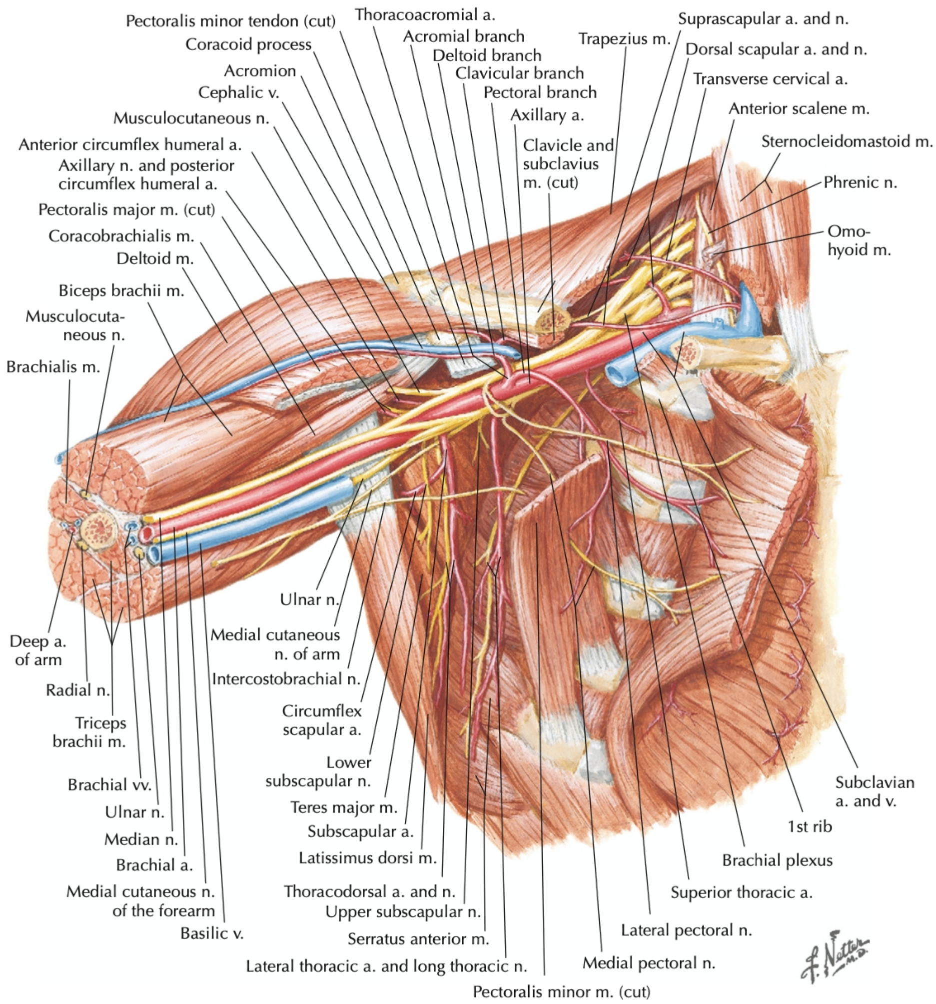


Fig. 8 Nerves and vascular system of the shoulder girdle[8]

Table 5 - Nerves of the Shoulder girdle[8]

Nerves	Segment Levels	Sensory (Dermatomes)	Motor (Myotomes)
Radial	C5, C6, C7, C8, T1	Posterior aspect of forearm	Triceps brachii, anconeus, brachioradialis, extensor muscles of forearm
Ulnar	C7, C8, T1	Medial hand, including medial half of digit 4	Flexor carpi ulnaris, medial half of flexor digitorum profundus, most small muscles in

			hand
Musculocutaneous	C5, C6, C7	Becomes lateral ante brachial cutaneous nerve	Coracobrachialis, biceps brachii, brachialis
Axillary	C5, C6	Lateral shoulder	Teres minor, deltoid
Suprascapular	C4, C5, C6	No sensory	Supraspinatus, infraspinatus
Dorsal scapular	Ventral rami of C4, C5	No sensory	Rhomboids, levator scapulae
Lateral pectoral	C5, C6, C7	No sensory	Pectoralis major, pectorals minor
Medial pectoral	C8, T1	No sensory	Pectoralis minor
Long thoracic	Ventral rami of C5, C6, C7	No sensory	Serratus anterior
Upper subscapular	C5, C6	No sensory	Subscapularis
Lower sub scapular	C5, C6	No sensory	Teres major, subscapularis
Medial cutaneous of arm	C8, T1	Medial arm	No motor

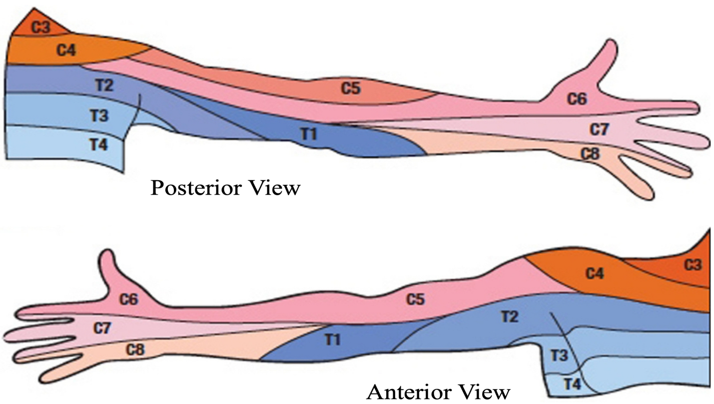


Fig. 9 - Dermatomes of Upper Extremities[9]

2.1.6 Vascular System

The long head of the biceps muscle receives its blood supply from the brachial artery (Fig. 8). Three arteries supply blood to the bicipital tendon. The distal portion of the tendon receives branches from the deep brachial artery. The proximal part of the tendon also receives branches from the anterior humeral circumflex artery. In the intertubercular sulcus a branch of this artery gives rise to two small branches running in cranial and caudal directions.[5] There may be a hypovascular area in the LHB tendon 1–3 cm from the proximal tendon attachment extending from the glenohumeral joint to the top end of the bicipital groove, which may account for the susceptibility of this area to rupture.[4]

2.2 Kinesiological Function of the Shoulder

The shoulder is the most complex joint in the human body, largely because it includes five separate articulations: the glenohumeral joint, the sternoclavicular joint, the acromioclavicular joint, the coracoclavicular joint and the scapulothoracic joint.[10] The glenohumeral joint is the articulation between the head of the humerus and the glenoid fossa of the scapula. The sternoclavicular and acromioclavicular joints provide mobility for the clavicle and the scapula, which make up the shoulder girdle.[11,12] The primary purpose of the shoulder is to put the hand in a position for function, which can include 16,000 different positions. Support and stabilization of the shoulder are primarily dependent on muscles and ligaments. Muscles acting on this complex structure do not act alone but rather in concert with other muscles to provide for its smooth motion.[7,13] It has three degrees of freedom to move in three axes, i.e. in the vertical, horizontal, and rotational directions. During normal activities, movement in the shoulder girdle is performed using a combination of all planes[14] frontal, sagittal, and transverse.[12]

2.2.1 Movements of the Shoulder Complex

The glenohumeral joint is the most freely moving joint in the human body, enabling flexion, extension, hyperextension, abduction, adduction, horizontal abduction and adduction, and medial and lateral rotation of the humerus.[11,12] Although some amount of glenohumeral motion may occur while the other shoulder articulations remain stabilized, movement of the humerus more commonly involves some movement at all three shoulder joints. Elevation of the humerus in all planes is accompanied by lateral rotation. As the arm is elevated in both abduction and flexion, rotation of the scapula varies due to anatomical variations among individuals, a general pattern persists. This important coordination of scapular and humeral movements, known as scapulohumeral rhythm, enables a much greater range of motion at the shoulder than if the scapula were fixed. When the hands support an external load, the orientation of the scapula and the scapulohumeral rhythm are altered, with muscular stabilization of the scapula reducing scapulothoracic motion as dynamic scapular stabilization provides a platform for upper extremity movements. Generally, scapulohumeral relationships are more fixed when the arm is loaded and engaged in purposeful movement as compared to when the arm is moving in an unloaded condition.[11,14]

Flexion and abduction of the shoulder will be addressed since the focus of this thesis is on the long head of the biceps and its properties.

2.2.1.1 Flexion

It can be said that there are three phases of shoulder flexion, all with its contributing factors to gain full abduction, but all phases run into each other. This flexion takes place in the sagittal plane and around the transverse axis.[12,14]

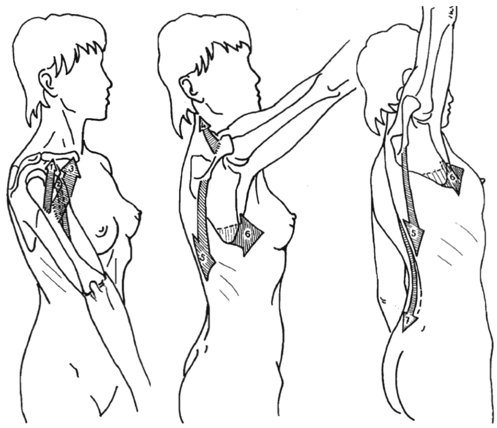


Fig. 10 Shoulder flexion[14]

The first phase, from 0º to 50º-60º, of flexion at the shoulder involves the muscles crossing the glenohumeral joint. The prime flexors are the anterior deltoid and the clavicular position of the pectorals major. The small coracobrachialis assists with flexion, as does the short head of the biceps brachii. Although the long head of the biceps also crosses the shoulder, it is not active in isolated shoulder motion when the elbow and forearm do not move.[4,11,14]

The second phase, from 60º to 120º, involves the trapezius and serratus anterior and is achieved through 60º of scapular rotation and axial rotation at the sternoclavicular and acromioclavicular joints, each joint contributing 30º. The third phase, from 120º to 180º, is achieved by movement of the final column through an increase in lumbar lordosis.[4,14]

2.2.1.2 Abduction

The shoulder can also be said to move through three phases of shoulder abduction. This movement of the shoulder takes place in the frontal plane.[14]

The first phase, from 0º to 90º, involves the middle deltoid and supraspinatus, which are the major abductors of the humerus. Both muscles cross the shoulder superior to the glenohumeral joint and in this joint is where movement of abduction starts. This first phase ends at 90º when the shoulder 'locks' as a result of the greater tuberosity hitting the superior margin of the glenoid. Lateral rotation of the humerus, by displacing the greater tuberosity posteriorly, delays this mechanical locking. Thus, abduction combined with 30º flexion and taking place in the plane of the scapula, is the true physiological movement of abduction.

The second phase, from 90º to 150º, can only proceed with participation of the shoulder girdle, where the scapula rotates 60º, while the acromioclavicular joint and sternoclavicular joint combined movement contribute 30º. The trapezius and serrates anterior are the muscles that contribute to movement in this phase.

The third phase, 150º to 180º, is accomplished by lateral displacement of the spinal column produced by the contralateral spinal muscles.4,[14]During the contribution of the middle deltoid (occurring from approximately 90º to 180º of abduction), the infraspinatus, subscapularis, and trees minor neutralize the superiorly dislocation component of force produced by the middle deltoid.[11,14] The long head of the biceps also participates in abduction since its rupture causes a 20% drop in the strength of abduction.[4,14]

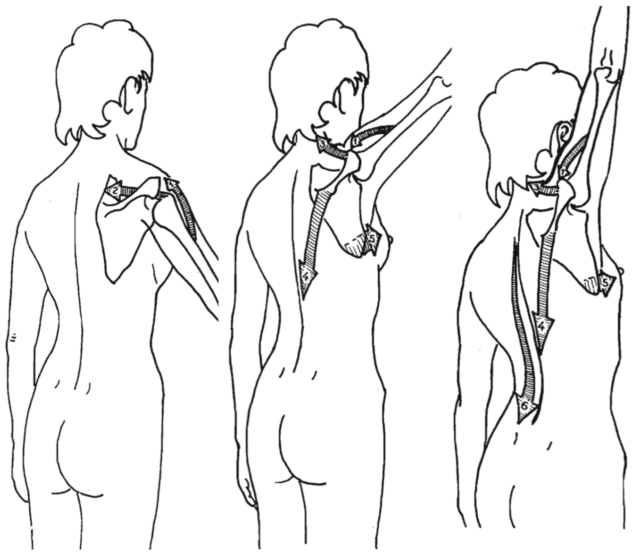


Fig. 11 Shoulder abduction[14]

2.2.2 Effect of Load on the Shoulder

Although the weight of the arm is only approximately 5% of body weight, the length of the horizontal extended arm creates large segment moment arms and therefore large torques that must be countered by the shoulder muscles. When these muscles contract to support the extended arm, the glenohumeral joint sustains compressive forces estimated to reach 50% of body weight. Although this load is reduced by about half when the elbow is maximally flexed due to the shortened moment arms of the forearm and hand, this can place a rotational torque on the humerus that requires the activation of additional shoulder muscles.[44]

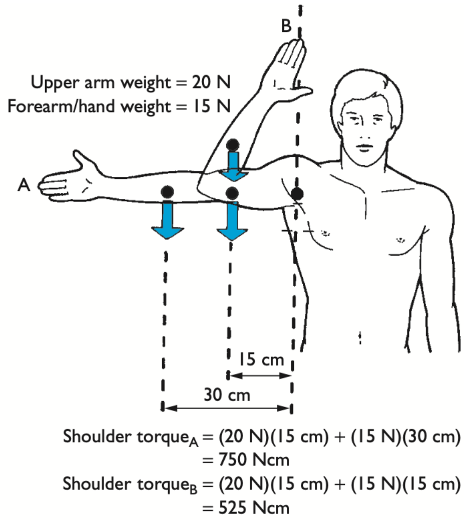


Fig. 12 The torque created at the shoulder by each arm segment is the product of the segment's weight and the segment's moment arm[11]

Muscles that attach to the humerus at small angles with respect to the glenoid fossa contribute primarily to shear as opposed to compression at the joint. These muscles serve the important role of stabilizing the humerus in the glenoid fossa against the contractions of powerful muscles that might otherwise dislocate the joint.[11]

2.2.3 Stabilization of the Shoulder

Stability of the shoulder is provided by the articulating surfaces, capsular and ligamentous structures, and synchronous activity of the rotator cuff, biceps, deltoid, and scapular muscles.[16]

The muscles that attach to the scapula are the elevator scapula, rhomboids, serrates anterior, pectorals minor, and subclavius, and the four parts of the trapezius. Scapular muscles have two general functions. First, they stabilize the scapula so that it forms a rigid base for muscles of the shoulder during the development of tension. Second, scapular muscles facilitate movements of the upper extremity by positioning the glenohumeral joint appropriately.[4,16,17]

There are several muscles that cross the glenohumeral joint and because of their attachment sites and lines of pull, some muscles contribute to more than one action of the humerus. A further complication is that the action produced by the development of tension in a muscle may change with the orientation of the humerus because of the shoulder's large range of motion. With the basic instability of the structure of the glenohumeral joint, a significant portion of the joint's stability is derived from tension in the muscles and tendons crossing the joint. However, when one of these muscles develops tension, tension development in an antagonist may be required to prevent dislocation of the joint.[11] Thus, there is a decrease in glenohumeral translation with active shoulder motion because muscular activity centralizes the humeral head when compared with passive motion.[18]

2.2.3.1 Force Couples

Force couples are two equal forces acting in opposite but parallel directions to produce rotatory motion. The shoulder complex has several force couples that function during shoulder motion. It is important that the muscles within each of these force couples are balanced to provide optimal function. The shoulder complex has four force couples, two for the glenohumeral joint and two for the scapulothoracic joint. In the glenohumeral joint, the infraspinatus and teres minor form a force couple with the subscapularis to produce downward translation of the humeral head in the glenoid. This movement prevents compression of the humeral head against the coracoacromial arch and allows for greater motion during overhead activities. The second glenohumeral force couple is between the entire rotator cuff and the deltoid. The anterior and posterior rotator cuff muscles depress the humeral head. The supraspinatus assists in the depression and compression force of the humeral head in the glenoid as the glenoid elevates the humerus. The rotator cuff depression and deltoid elevation work together to create humeral head rotation within the glenoid. The scapular force couples include the upper and lower trapezius and serratus anterior. These muscles work together to upwardly rotate the scapula.[7,19,26] The other scapular force couple includes pectoralis minor, levator scapulae, and rhomboids; these muscles work together to downwardly rotate the scapula against resistance. The muscles within each force couple must work

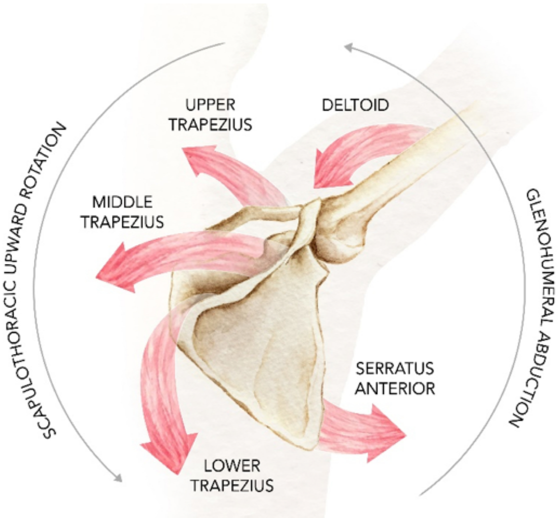


Fig. 13 Force couples of the shoulder girdle[19]

cooperatively both in timing and in level of intensity to produce the desired activity or injury results.[7,20,21,]

For example, if the UT is stronger than the lower trapezius and serratus anterior, the scapula is not positioned correctly during arm elevation, and impingement of the rotator cuff occurs.[7,22,23,24] Overhead athletes with impingement have delayed onset of middle and lower trapezius fibers in response to a sudden downward movement. If the lower trapezius reacts too slowly when compared to the upper trapezius, the UT may become overactive, leading to scapular elevation rather than upward rotation.[25] Scapular elevation alters the direction of the axis of the glenoid fossa; this change may be accompanied by increased and constant activity in the rotator cuff, leading to rotator cuff tendinitis.[26,27] If the UT and levator scapula overpower weaker shoulder muscles during scapular rotation movements, it is often a contributing factor to scapular muscle imbalances. If the rotator cuff is weak, the UT commonly substitutes for the rotator cuff and works with the deltoid to elevate the shoulder, further encouraging muscle imbalances and incorrect firing-sequence patterns and perpetuating a shoulder injury.[7] Such as, when paralysis or rupture of the supraspinatus has occurred,[28] the long head of the biceps is hypertrophied, possibly because the person is using the muscle as a depressor of the humeral head by placing the shoulder in external rotation.[5] Lack of

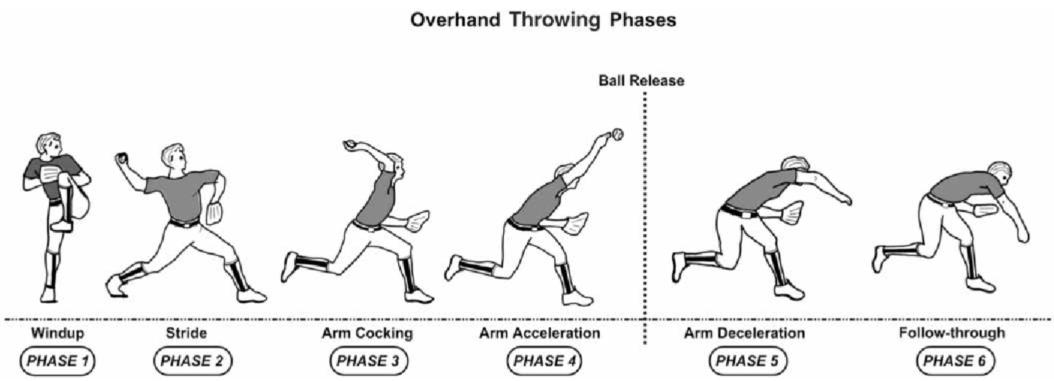


Fig. 14 Baseball throwing motion[43]

scapular protraction, upward rotation, and posterior tilting can lead to subacromial impingement.[21,30,31,33,34] Pain inhibition and fatigue can also provoke altered muscle patterns.[21] Specific exercises can be selected that recruit minimal levels of UT activity.[35,36,37]

2.3 Overhand Throwing

The overhead throw, as it relates to baseball pitching, has been divided into the following phases: windup, stride, arm cocking, acceleration, deceleration and follow-through.[3,39,40,41]

2.3.1 Windup

The purpose of the windup is to organize the body beneath the arm to form a stable platform. It is vital that the body perform in sequential links to enable the hand to be in the correct position in space to complete the assigned task. It is essential that the scapulohumeral rhythm please it in an optimum setting for the task of propulsion. The drawing of the humerus into the moment center of the glenoid fossa is accomplished during the first 30º of elevation as the arm is brought upward by the deltoid and supraspinatus. [3,39,40,42]

2.3.2 Stride

Stride is the period of time when the dominant hand is separated from the gloved hand and ends when the forward foot makes contact with the mound. The scapula is retracted and maintained against the chest wall by the serratus anterior. The humerus is brought into position of 90º of abduction and horizontal extension, with a minimal external rotation of approximately 50º. This is accomplished with the activation of the anterior, middle, and posterior deltoid. The external rotators of the rotator cuff are activated toward the end of the early cocking, with the supraspinatus being more active than the infraspinatus and the trees minor as it steers the humeral in the glenoid. The biceps brachii and brachialis act on the forearm to develop the necessary angle of the elbow.

As the body moves forward, the humerus is supported by the anterior and middle deltas as the posterior deltoid pulls the arm into approximately 30º of horizontal abduction. At this time the static stability of the humeral head becomes dependent upon the anterior margin of the glenoid, notably the inferior glenohumeral ligament and the inferior portion of the glenoid labrum. [3,39,42]

2.3.3 Arm Cocking

Arm cocking is the interval in the throwing motion when the foot makes contact with the mound and ends when the humerus begins internal rotation. The extreme of the external rotation, and additional 125º is achieved to provide positioning for the power phase or acceleration.[3,39,40,42] During this phase there is moderate activity of the LHBM.[43,44]

Supraspinatus, infraspinatus, and teres minor are active in this phase but become less engaged once external rotation is achieved. Deceleration of the externally rotating humerus is accomplished by the contraction of the subscapularis. It remains active until the completion of the late cocking. The serratus anterior and the clavicular head of the pectorals major have their greatest activity during deceleration. The biceps brachii aids in the maintaining the humerus in the glenoid by producing compressive axial load. At the end of this phase the triceps begins activity providing compressive axial loading to replace the force of the biceps. The capsule becomes wound tight in preparation of acceleration. [3,39,42]

2.3.4 Acceleration

Acceleration is a ballistic action lasting less than one-tenth of a second. This rapid acceleration produces angular velocities that have been reported as high as 9,198º/s. The scapula is protracted and rotated downward and held to the chest wall by the serratus anterior. The arm continues into forward flexion and is marked by a maximum internal rotation of the humerus. The humerus travels forward in 100º of abduction but adducts about 5º just prior to release. The primary movers and stabilizers of the shoulder are stressed.[39] The lattismus dorsi and pectorals major develop the power to the forward-moving shoulder. The subscapularis activity is at maximum levels as the humerus travels into medial rotation. The triceps develops strong action in accelerating the extension of the elbow.[3,39,42]

The forces developed in this instant reflect the body's amazing ability to develop power and encase itself in a protective mechanism. There has been reported peak accelerations approaching 600,000º/s. At the shoulder, there has been reported 14,000-inch pounds of rotatory torque produced. This torque develops 2,000-inch pounds of kinetic energy in the humerus.[3,39,42,45]

Control of the ball is lost approximately midway through the acceleration phase, when the humerus is positioned slightly behind the forward-flexing trunk and at an angle of about 110º of external rotation. The hand follows the ball after release and is unable to apply further force.[3,39,42]

2.3.5 Arm Deceleration and Follow-Through

The follow-through is the time beginning with the release of the ball. Within the first tenth of a second the humerus travels across the midline of the body and develops a slight external rotation before finishing in internal rotation. This is a very active phase for all glenohumeral muscles as the arm is decelerated. The deltoid and upper trapezius have strong activity as does the latissimus dorsi. The infraspinatus, teres minor, supraspinatus, and subscapularis are all active as eccentric loads are produced. The biceps develop peak activity in decelerating the forearm and imposes a traction force within the glenohumeral joint. [3,39,42]

2.4 Long Head of the Biceps

In humans, the biceps brachii has two origins in the shoulder and, because of the torsional changes in the humerus, is ineffective in shoulder elevation unless the arm is fully externally rotated. In this way it can be used as an abductor.[5] The long head originates from the bicipital tubercle at the superior rim of the glenoid and along the posterior superior rim of the glenoid and labrum. Much of the origin of the long head is via the superior labrum and that the size of the bicipital tubercle does not reflect the size of the biceps tendon.[5,18] The tendons of the long head of the biceps muscle contribute to the structure and reinforcement of the labrum. It passes from the supraglenoid tubercle over the superior aspect of the head of the humerus and lies within the capsule, emerging from the joint at the inter tubercle groove. The tendon is covered by a synovial sheath to

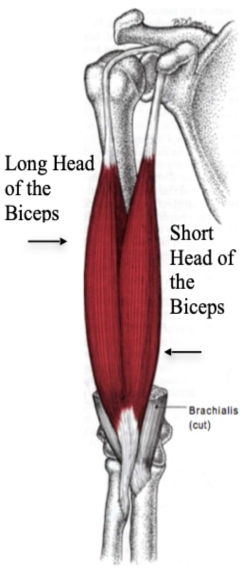


Fig. 15 - Long Head of the Biceps[144]

facilitate movement of the tendon within the joint.[18] The muscle has two distal tendinous insertions. The lateral insertion is to the posterior part of the tuberosity of the radius, and the medial insertion is aponeurotic and passes medially across and into the deep fascia of the muscles of the volar forearm.[5] The biceps tendon is of notable strength, approximately four times stronger than the subscapularis.[47]

Under normal conditions, not only are the actions of the biceps flexion and supination at the elbow, it can be an effective elevator and functions to stabilize the humeral head in the glenoid, preventing upward migration. Humeral external rotation places the long head laterally, causing it to act like a pulley and assisting in arm elevation.[18,48,49,] The long head of the biceps actively compresses the humeral head into the glenoid cavity, along with the outer sleeve of other shoulder muscles.[18,43] In certain conditions, particularly when paralysis or rupture of the supraspinatus has occurred,[28] the long head of the biceps is hypertrophied, probably because the patient is using the muscle as a depressor of the humeral head by placing the shoulder in external rotation.[5] There is a 20% loss of elevation strength in external rotation with rupture of the long head of the biceps.[14,50]

The long head of the biceps has an important role as a dynamic restraint to external rotation in the abducted shoulder. Is has been suggested that the biceps becomes more important than the rotator cuff as an anterior stabilizer and decreases stress placed on the inferior glenohumeral ligament with decreased stability of the capsuloligamentous structures.[43,49,51] The anterior displacement of the humeral head under 1.5 kg force was significantly decreased by both the long and short head of the biceps loading in all capsular conditions when the arm was in 60º or 90º of external rotation and abduction,[7,52] or when the shoulder was placed in 45º of elevation and neutral rotation, application of 55 N force to the biceps tendon reduced anterior translation, inferior translation, and superior translation.[53] Injury may represent a traction phenomenon, secondary to activity in the biceps, or possibly a compression phenomenon. Some believe that it contributes to stability of the glenohumeral joint by preventing upward migration of the head of the humerus during powerful elbow flexion and forearm supination. Lesions of the long head of the biceps, therefore, may produce instability and shoulder dysfunction.[18]

Basmajian et al.[53] characterized the action of the biceps brachii muscle as flexion of the elbow joint when the forearm is in the neutral or supinated position but contributing little when the forearm is in a pronated position. They also considered the biceps to be important in decelerating the rapidly moving arm, such as occurs during forceful overhand throwing.[6] There is now general agreement that the biceps brachii is in fact a strong supinator of the forearm and only a weak flexor of the elbow. Debate continues, however, on the exact function of the biceps proximally at the shoulder, and the function of the biceps in connection with the superior labrum.[55] Most anatomy texts regard the biceps as a weak flexor of the shoulder.[4,39]

Andrews et al.[41] hypothesized that the incident of injury to this region of the glenoid labrum was due to the tremendous eccentric stresses placed on the biceps in an attempt to decelerate the arm during the follow-through phase of the overhand throw. In their one study of 3 throwing athletes, none of them demonstrated a significant weakness of either the rotator cuff or LHBM This lesion gives the athlete a sensation of instability, however, this instability does not exist anatomically.[41]

Rodosky et al.[55] investigated the role of the LHB and its attachment to the superior labrum in a laboratory model of the glenohumeral joint positioned in abduction and external rotation as experienced by the overhead thrower. They hypothesized that the presence of the LHB acted to help limit external rotation of the shoulder. The biceps compressed the humeral head against the glenoid resisting the rotation. The LHB withstood higher external rotational forces without the inferior glenohumeral ligament experiencing a greater strain. This suggested that the biceps has a role in the provision of anterior stability. The glenohumeral joint demonstrated a heightened torsional stiffness as force was increased through the long head.

When a surgical SLAP lesion was created, the strain produced upon the inferior glenohumeral ligament was significantly increased. This model suggests that the shoulder is thus dependent upon the long head of the biceps to provide dynamic stability to the glenohumeral joint in the cocking, acceleration, and follow-through phases. This dynamic stability ensures a consistent stress upon the inferior glenohumeral ligament. The LHB acts as a continual provider of axial tension as a protective mechanism for the humerus and the inferior glenohumeral ligament. Once the integrity of the glenohumeral joint is reduced due to occupant subluxations, the LHB becomes a larger player in the attempt to achieve stabilization to the glenohumeral joint.[55]

Sakurai et al.[56] studied EMG activity in the biceps while maintaining the elbow in neutral rotation in a brace. Surface electrodes were used to measure EMG activity of the deltoid and biceps muscles. Their results showed there to be EMG activity in both the long and short heads of the biceps with all types of motion of the shoulder, independent of elbow position. This indicated that the biceps acted as an active flexor and abductor of the shoulder. There was also activity with rotation, and external rotation induced more activity than internal rotation did. In addition, they demonstrated greater fatigability of the biceps compared with the deltoid. Accordingly, they considered the biceps at higher risk of injury than the deltoid.[5,56]

Conversely, other physicians have reported performing biceps tenotomy in patients with refractory biceps pain. Once the biceps was released, pain was eliminated in over 70% of patients and no functional limitations, instability, or weakness were reported.[18,52] The function of the long head of the biceps, along with its proximal attachment, is and has been controversial, and most likely will be for some time.[55]

2.4.1 Clinical Picture

An accurate history and physical examination are vital.[5] Typically, the patient will complain of anterior shoulder pain, usually with activity. This may be insidious in onset, follow a single traumatic incident or, as usually occurs in the athletic population, frequently occurs as an overuse phenomenon as a consequence of repetitive micro trauma or secondary to impingement. It may occur as an isolated entity but usually is secondary to some other pathologic process. It is important to note the presence of other shoulder pathologies, particularly rotator cuff pathology, glenohumeral instability, impingement, or generalized inflammatory conditions of the shoulder as the cause. It is believed that in those patients with chronic rotator cuff tendinitis, the long head of the biceps acts in a prolonged fashion to depress and steer the humeral head and provide more room for the inflamed bursa and cuff.[7,43] Thus, these patients will be more susceptible to the development of a painful tendinitis-type syndrome.[18]

The most common physical examination finding is tenderness to palpation over the

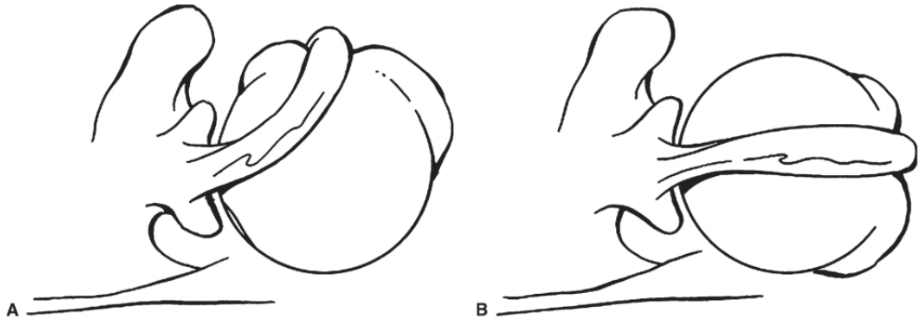


Fig. 16 Variation in LHBT position affects stabilizing function: As the arm moves from internal rotation (A) to external rotation (B), the proximal LHBT moves from an oblique course to a fully transverse path across the top of the humeral head, theoretically providing a “static line” stabilizer against superior migration.[58]

bicipital groove. The LHBT attaches to the supraglenoid tubercle of the scapula and arches over the head of the humerus to descend in the inter tubercular groove of the humerus. During motions of the shoulder, the head of the humerus slides on the undersurface of the tendon so the bone moves under the tendon. When the glenohumeral joint is in full external rotation, the proximal and distal attachments of the tendon are in a straight line, but in all other positions the medial wall of the groove. Thus, the LHBT is subject to not only wear and injury with time, but to impingement injuries as well.[7]

2.4.2 Etiology of Injury

Lesions of the LHBT are not infrequent about the shoulder, whether related to a single traumatic incident, repetitive microtrauma, or impingement. These lesions can be divided into three main categories - bicipital tendinitis, primary or secondary, instability of the biceps tendon, and biceps tendon rupture. Biceps tenosynovitis has been said to be the most common cause of shoulder pain. Bicipital tendinitis and subluxation have been commonly found in baseball players. Occasionally, patients with superior labral anterior-posterior (SLAP) lesion, partial- to full-thickness rotator cuff tears, or both, present with biceps tendon pain.

Abnormal motion of the scapula may contribute to a variety of shoulder pathologies, including shoulder impingement, rotator cuff tears, glenohumeral instability, and stiff shoulder.[11,41]

When the rotator cuff tendons become stretched and weakened, they cannot perform

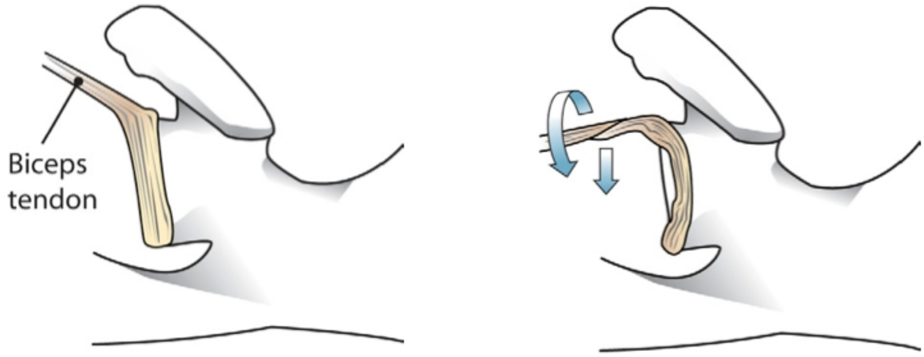


Fig. 17 SLAP lesions caused by a "peel-back" mechanism. The image on the left shows the biceps tendon and biceps anchor at the superior aspect of the labrum in a resting position. The image on the right shows a view from superior with the biceps-labrum complex in an abducted-externally rotated arm position. The posterior rotation of the biceps tendon peels the biceps anchor and the superior aspect of the labrum from the superior part of the glenoid rim.[59]

their normal function of holding the humeral head in the glenoid fossa.[28] Consequently, the deltoid muscles lift the humeral head up too high during abduction, resulting in impingement and subsequent wear and tear on the rotator cuff. If the attaching muscles do not sufficiently stabilize the humerus, it can articulate with the glenoid labrum rather

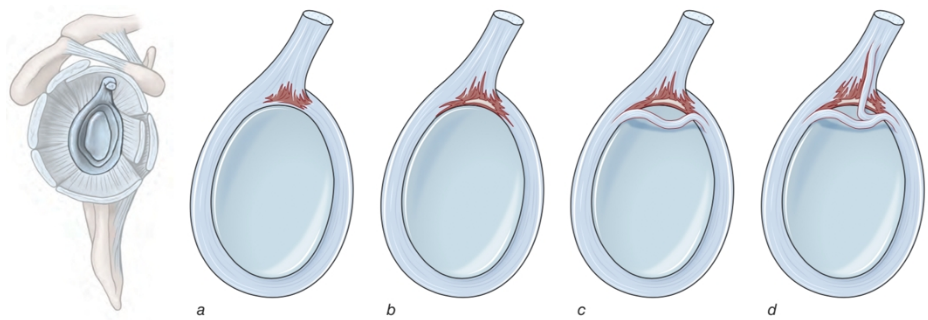


Fig. 18 SLAP lesions (a) I, (b) II, (c) III, and (d) IV[39]

than with the glenoid fossa, contributing to wear on the labrum. Tears of the biceps brachii tendon at the site of its attachment to the glenoid fossa may result from the forceful development of tension in the biceps when it negatively accelerates the rate of elbow extension during throwing.[11]

2.4.3 Diagnosis

The LHBT is intimately related, both anatomically and pathologically, to the superior labrum proximally and to the bicipital groove and beyond distally. Understanding these relationships is crucial to making an accurate diagnosis and devising an appropriate treatment plan for patients with shoulder problems. Pathology of the biceps labral complex should be considered in throwing athletes who report popping or clicking of the glenohumeral joint and can reproduce these symptoms in the forward-flexed and extreme abduction position.[11] Diagnosis is reached via various physical examination maneuvers,[60,61] even though they and MRI effectiveness is debated and uncertain.[62,63]

2.4.4 Treatment Approaches

2.4.4.1 Non-Invasive

It is well established that initially conservative management is preferred for isolated biceps lesions. This includes activity modification, rest, non-steroidal anti-inflammatory medication, physical therapy, modalities and occasionally steroid injections.[5,34,37,41,42,59,60,62,64,65,66,67,68,69,98,70,71,72,73,146] The treatment program must be individualized with a rehabilitation program designed to restore strength and flexibility and restore normal tendon mechanics.[73,74]

2.4.4.2 Invasive (Surgical)

The most common indications for surgery of the biceps are partial tearing, instability, tenosynovitis, and SLAP tears. Where a trial of nonoperative treatment has failed, there are several surgical treatment options, including SLAP repair, tenotomy, and tenodesis.[75,76,77,78,79,80]Treatment is individualized to each patient depending on age, activity levels, and operative findings.[55,57,76,77,81,82,83] More recently, biceps tenodesis has been suggested as a potential option for the treatment of SLAP lesions in overhead athletes. This option is controversial, and data on return to play in overhead athletes are limited by the level of evidence and confounding factors, such as concomitant rotator cuff tear.[55,75,77,80,83,84,] On the other hand, a systematic review and meta-analysis by Hurley et al.[81] looked at biceps tenodesis versus labral repair for superior labrum anterior-to posterior tears. Five studies with 234 patients were included. It was found that biceps tenodesis resulted in higher rates of patient satisfaction and return to sport in the studies published in the literature.[81] Lee et al.[75] compared the outcomes of tenotomy with outcomes of tenodesis for treatment of LHBT lesions with rotator cuff tears through a prospective randomized clinical trial. In their conclusion, the treatment of

LHBT lesions with rotor cuff tear, patients with tenotomy and tenodesis both showed significant improvements in functional scores. It was stated that there was no significant differences in elbow motor power,[75] implying the elbow, not the shoulder, was the focus of this study.

2.5 Kinesio Tape

The application of KT follows the path of a muscle or nerve, can be freely applied to any part of the body, and does not limit the person's freedom of movement. Every process in mechanics, dynamics, physics, and in medicine depends upon the interaction of all the components. Thus, the smallest defective cog can disrupt a complex functional chain reaction. This is also true for the human body. Only when muscle force, moment arm, and ligaments around a joint are working in balance is the individual free from discomfort. With injuries, not only is the balance disrupted but the performance of protective contraction reflexes is reduced. Edema and swelling disrupt the process of physiological movement and lead to pain.[2]

KT simultaneously facilitates the reaction of edema, improves lymph and blood circulation, and contributes, through proprioception, to the normalization of muscle function and the support of ligaments and tendons. The result is generally a rapid reduction of pain and an improvement in the joint and muscle function1[2,85,86]

2.5.1 Properties of Kinesio Tape

The thickness of KT is approximately the same as the epidermis of the skin. This was intended to limit the body's perception of weight and avoid sensory stimuli when properly applied. After approximately 10 minutes, the patient will generally not perceive there is tape on their skin.[1]

2.5.1.1 Material

KT usually is comprised of polymer elastic strand wrapped by 100% cotton fibers. The cotton fibers allow for evaporation of body moisture, which allows for quick drying.[68] There is no latex in KT. The adhesive is 100% acrylic and is heat activated. The acrylic adhesive becomes more adherent the longer the KT is worn. The acrylic adhesive is applied in a wave-like pattern longitudinally to the tape, forming a sine wave, which has a transverse stretching effect. The longitudinal forces follow the acrylic curves and thus effect a resolution of force into a longitudinal, or horizontal and a transverse, or vertical component. This not only assists in the lifting of the skin, but also allows for zones in which moisture can escape. Depending upon the extent to which the tape is stretched, there is an associated transverse force which works evenly over the entire length of the tape.[1,2]

2.5.1.2 Shape

KT can be applied in several different shapes, all dependent on the shape and size of the treated body area and the desired effect. The most commonly used shapes are in the form of a “Y”, “I”, “X”, “fan”, “web”, “donut”. The “Y” shape is used both in basic techniques to influence muscles by surrounding the muscle belly and in corrective techniques. The “I” shape is the most universal shape and can be used in place of the “Y” shape. The “I” shape is applied directly over the area of injury or pain. The “X” shape is generally used for a muscle which crosses two joints and can better dissipate tension on the skin. The “fan” shape is used for lymphatic correction and is laid over the

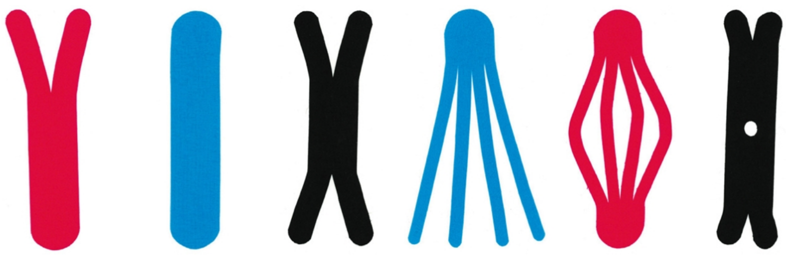


Fig. 19 - KT shapes “Y”, “I”, “X”, “fan”, “web”, “donut”[143]

area of edema or swelling, with its base located in the area of a lymphatic duct. The “web” shape is used to create more space directly above the area of pain, inflammation, swelling, or edema by lifting the skin and resulting in reduced pressure in the area. The “donut” shape is used in similar application as the “web” shape. The hole in the middle of the tape is place directly above the desired treatment area, such as, a bony protrusion to ‘relieve’ and locally reduce swelling. [1,87,88]

2.5.2 Application of Kinesio Tape

The skin should be free of oils and lotions and should be cleaned prior to tape application. Anything that limits the acrylic adhesive's ability to adhere to the skin will limit both effectiveness and length of application. Body hair may limit adhesion and may need to be removed.[1] The beginning and end points of KT should be applied directly to the skin without stretching. The beginning and end points should be approximately 3-5 cm in length.[89]

2.5.2.1 Tape Stretch/Tension

For all basic application techniques, the muscle/tissue to be treated should be put in a stretched position in combination with the stretch capabilities of the KT, which will create convulsions as the skin is lifted. The convolutions aid in the normal flow of blood and lymphatic fluids.[17,90] The proper tension during tape application is critical and is different with each desired application.[1]

Over many years and with the input of thousands of practitioners, it has determined that specific responses are obtained from the following tensions:

• 0–15%: lymphatic and pain applications

• 15–25%: muscle lengthening/relaxation. Also appropriate for restoring muscle strength when a

muscle is both short and weak on testing

• 25–35% muscle strengthening/facilitation

• 50–75%: mechanical correction techniques

• 75–100%: ligament techniques

The percentages stated above are the proportion of the available stretch that a strip of KT has. It is not the proportion of the length of tape itself.[91]

2.5.2.2 Tape Direction

There are two basic KT application directions for treatment of muscles. Inhibition of muscle function is said to be achieved through applying KT from insertion to origin of the desired muscle. Facilitation of muscle function is achieved through applying KT from origin to insertion of the desired muscle.[1,2,27,91,92,94,95] This concept is followed by most of those applying KT. However, according to muscle movement and function, origin and insertion can change, and so the muscle applications are carried out contrary to the rules mentioned above. Understanding punctum fixum (fixed end) and punctum mobile (mobile end) is helpful since according to the function of the muscle, the fixed and mobile ends can change.[2,96]

The tape tension and where to start and finish taping is not an absolute science, as not all clients respond to direction-based receptor stimulation. The guidelines that specify direction of tape application therefore exist for those clients who demonstrate an increase in neural control over muscle activity when the skin is stimulated in one direction, compared to the opposite effect when stimulated in the other direction.[91,92]

2.5.3 Mechanism of action Kinesio Tape

KT is a modality treatment based on the body's own natural healing process. The Kinesio Taping method exhibits its efficacy through the activation of the neurological and circulatory systems. Recognizing the importance of body and muscle movement in rehabilitation and everyday life. Muscles attribute not only to the movements of the body, but also controls the circulation of venous and lymph flows, body temperature, and more. Therefore, the failure of the muscles to function properly may induce various kinds of health ailments.[87]

2.5.3.3 Improvement of muscle function

The intention of Kinesio Taping to restore length and strength to the muscles primarily focuses on restoration of the functional efficiency of a muscle via stimulation of all the structures below, adjacent and related to the tape placement.[84,90] Fratocchi et al. investigated the effect of KT applied over the biceps brachii and maximal isokinetic elbow torque. The study followed a single-blinded, placebo controlled, repeated measures design in 20 healthy participants. It was concluded that when applied over the biceps brachii, KT increases concentric elbow peak torque in a population of healthy participants, if compared to placebo tape.[96]

Vithoulk et al.[97] studied the effects of KT on quadriceps strength at maximum concentric and eccentric isokinetic exercise in healthy non-athlete women in order to examine the KT effect in increasing or decreasing the quadriceps strength. Three different groups were compared with no tape, placebo tape, and KT. It was concluded that the application of KT on the anterior surface of the thigh, in the direction of the vastis medialis, laterals and rectus femurs, could increase the eccentric muscle strength in healthy adults.[97]

Mendez-Rebolledo et al.[98] analyzed the short-term effect of KT on height and ground reaction force during a vertical jump, in addition to trunk and lower limb muscle latency and recruitment order in healthy male athletes. They completed a single squat and countermovement jump at basal time (no KT), 24, and 72 hours of KT application on gluteus maximus, biceps femoris, rectus femoris, gastrocnemius medialis, and longissimus. It was found that the KT and no effect after 24 hours. However, at 72 hours, the KT increased the jump and normalized ground reaction force during the countermovement jump. Also, at 72 hours there was reduced longissimus onset latency and improved muscle recruitment order during a countermovement jump.[98]

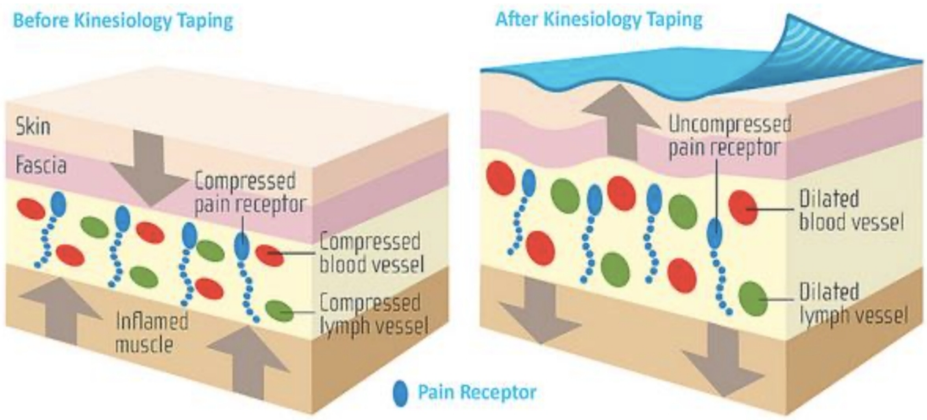


Fig. 20 Kinesio Taping Influence on Underlying Tissue[151]

Muscle injuries can result from overloading the muscle, which causes ruptures in the muscle connective tissue. The resultant fluid in the interstitial spaces causes increased pressure, with concomitant stimulation of pressure and pain sensors. The consequences may include pain, stiffness, swelling and increased tonus.[2]

In hypertonus muscles, a reflexively increased, persistent tonus leads to a change in the consistency of the muscle, which generally affects the entire muscle. Muscle shortening can result and may be reflexive or functional in nature. Reflexive muscle shortening can have a number of origins, such as, protective reaction to pain, alterations in balance due to degenerative joint changes, overloading the musculature through one-sided work.[2] Davison et al.[99] studied the inhibitory effect of KT on the gastrocnemius muscle of athletes using sEMG and a Vertex vertical jump device while performing repeated single leg jump on their dominate leg. Based on the research, it was concluded there was statistical evidence to show a difference in muscle activity after application of KT. The values obtained from the sEMG showed a majority of the participants had a decrease in muscle activity during a single leg vertical jump after taping.[99]

Hypotonus muscles are generally caused by reflexive inhibition due to hypertonic antagonist, pathological joint processes, or paresis. Complete atrophy only occurs with interruption of the nerve signal. The consequences are disrupted muscle activity resulting in reduced strength and muscle activity. Hypotrophy and atrophy can occur rather rapidly.[2]

Hsu et al.[100] investigated the effect of KT on kinematics, muscle activity and strength of the scapular region in baseball players with shoulder impingement. KT and placebo tape were placed on the lower trapezius on all subjects. Measurement with 3-dimensional scapular motion and sEMG of upper and lower trapezius and serratus anterior. It was concluded that KT resulted in positive changes in scapular motion and muscle performance, which supports its use as a treatment option in managing shoulder impingement problems.[100]

The muscle tonus is a state of tension maintained by impulses from the CNS as well as through peripheral signals as peripheral feedback regulation. Skin receptors are activated by the KT, thereby strengthening additional peripheral afferent signals. Influence can be exerted on tonus regulation via these mechanisms.[93,101]

Proprioception is conveyed to all levels of the central nervous system. It serves fundamental roles for optimal motor control and sensorimotor control over the dynamic restraints.[148] Through the mechanoreceptors, we sense the position and movement of our joints. The proprioceptive afferents of mechanoreceptors are involved in the control of the postural Moto system and directed motility. The sensors are in the joints, muscles, tendons, and in the skin. The proprioceptors in the skin are reached by means of the KT. In this way, more information on position and exertion of the extremities and the body is transmitted.[2,102]

Lee et al.[103] conducted a case report to investigate the effect of combined application of balance taping using KT on a part-time worker with shoulder impingement. The KT tape was applied for 3 weeks, on average 16 hours per day. By the end of the 3 weeks the Visual Analogue Scores decreased from 7 to 0 for shoulder flexion and from 8 to 0 for abduction and range of motion increased to normal. It was concluded that KT is suggested for someone with shoulder impingement.[103]

2.5.3.2 Pain Reduction

Nociceptors form the basis of the sense of pain. Nociceptors are free nerve endings found in the dermis, partially penetrating the epidermis. They are distributed fairly evenly over the body and are of crucial importance for the skin's function as a protective layer for the organism.[2]

Nociceptors are likewise found in the musculature, the internal organs, and in all types of body tissues. Nociceptors react to thermal, mechanical, and chemical stimuli. The transmission of the nociceptive signals occurs on the one hand via the myelinated Aγ-fibers, which, because of their rapid stimulus transmission, trigger the so-called first pain sensation (bright, sharp, piercing, or incisional pain) and on the other hand via the unmyelinated C-fibers, which can only slowly transmit the stimulus and trigger the second pain (dull, burning, boring, or tearing pain). The first pain receptors are distributed in the skin, the second pain receptors in the joint capsules, ligaments, tendons, and inner organs.[2]

The nociceptive afferents are switched in the dorsal horn to a second neuron and relayed divergently by numerous synaptic connections. The first filtering and influence of the incoming nociceptive and proprioceptive signals occurs at the spinal level prior to transmission to the cranial level. In principle, however, the important information, such as nociceptive afferents for the superordinate centers, cortex and brain stem, is relayed.

The nociceptive afferents running to the dorsal horn come from joints, muscles, skin, and inner organs. Like- wise, afferents run from the cortex and brain stem to the dorsal horn. These centrally descending pathways can be inhibitory as well as channeling.[2]

The nociceptive afferents, also, pass to the ventral horn and the lateral horn. The motor nocireaction takes place in the ventral horn, which can be, reflexive increase in muscle tonus, hypertonus, myogelosis. Whereas, autonomic nociception takes place in the lateral horn and can result in connective tissue changes, selling, and hypoxemia.[2]

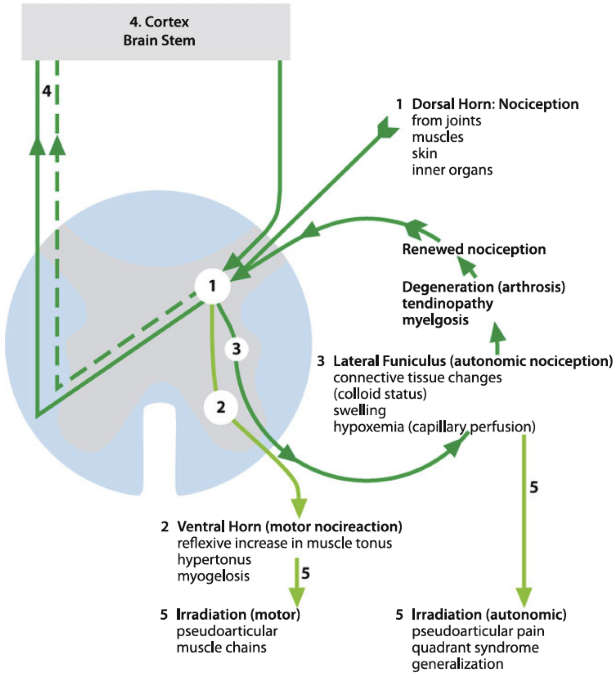


Fig. 21 Transmission of nociception and pathway of nocireaction[2]

Degeneration, tendinopathy, and myelgosis give rise to repeated nociceptive afferent signals to the dorsal horn. Motorically as well as autonomically, this leads to radiation. Motorically, it causes pseudoradicular radiation and radiation in the muscle chain. Autonomically, it leads to pseudoradicular pain, quadrant syndrome, and generalization.

Thus, the first nocireaction in supraliminal nociceptive afferents occurs at the spinal level.[2]

The adhesion of the KT to the skin, and the resulting mechanical displacement caused by body movement, leads to stimulation of the mechanoreceptors in the skin. Like the nociceptive afferents, these proprioceptive afferents also run to the dorsal horn and inhibit the relaying of nociception.[2]

Thelen et al.[104] conducted a randomized, double-blind, clinical trial to determine the short-term clinical efficacy of KT to sham tape when applied to college students with shoulder pain. The KT group showed immediate improvement in pain-free shoulder abduction. It was concluded that KT may be of some use for clinicians in improving pain-free active ROM immediately after tape application for patients with shoulder pain.[104]

Gonzalez-Iglesias et al.[105] studied the short-term effects of cervical KT on pain and cervical range of motion in patients with acute whiplash injury. A randomized controlled trial collected data from one group with KT and the second group received sham tape immediately after KT application and at a 24-hour follow-up. Patients with acute whiplash receiving an application of KT, applied with proper tension, exhibited statistically significant improvements immediately following application of the KT and at a 24-hour follow-up.[105]

Tsai et al.[106] investigated the therapeutic effects of KT on plantar fasciitis. Two groups were randomly selected. One group received KT and traditional physical therapy, while the second group received only traditional physical therapy. The KT was applied to the gastrocnemius and the plantar fascia continuously for one week. After one week, there was found reduced pain scores and reduced thickness of plantar fascia at the insertion site in the experimental group. It was concluded that the additional treatment with continuous KT for one week might alleviate the pain of plantar fasciitis better than a traditional physical therapy program only.[106] van de Water et al.[107] also looked at the effect of KT as treatment of plantar fasciitis and performed a systematic review of controlled trials. Only five controlled trials met the inclusion criteria. There was found strong evidence of pain improvement at 1-week follow-up, but was concluded that there is limited evidence that KT can reduce pain in the short term in patients with plantar fasciitis.[107]

Paoloni et al.[108] studied the effects of KT on pain, disability and lumbar muscle function in suffers of chronic low back pain, both immediately and at a one-month follow-up examination. The study compared KT plus exercise, KT alone, and exercise alone. It was concluded that KT does lead to pain relief and lumbar muscle function normalization shortly after application and persists over a short follow-up period.[108]

Homayouni et al.[109] studied the effects of KT in comparison with naproxen and physical therapy in treatment of pes anserinus tendon-bursitis. One group received KT application which was repeated for three times with a one-week interval, while the other group received naproxen and daily physical therapy for ten days. They concluded that KT is more effective than naproxen plus physical therapy in reduction of pain and swelling patients with pes anserinus tendino-bursitis.[109]

2.5.3.3 Support of Joint Function

Joints are moveable connections between bones. The capsular ligament apparatus and the musculature are also involved in the control of joint movement. The mobility of a joint depends upon the type of joint and the surrounding structures (muscles, ligaments, and capsule).

There are several different causes of movement disorders in the joints. Some of which can result from imbalance in the musculature around the joint, damage to the joint surface due to arthritis or arthritis with shrinkage in the capsular ligament apparatus due to faulty posture and repetitive strain, blockages due to compression, and nocireceptions from other structures outside the joint.

The joint functions can be supported using different KT applications. By influencing the muscle tone, imbalances can be corrected and balance restored to the muscle group. A better sense of movement can be attained by stimulating proprioception. Corrective functional and fascial applications, like passive support, result in improvement of joint function, lead to pain attenuation and consequently to a shorter healing process.[2]

Yoshida et al.[110] studied the effect of KT on lower trunk range of motion in flexion, extension and right lateral flexion. It was concluded that KT applied over the lower trunk may increase active lower trunk flexion range of motion. This could be deemed useful for patients during or after treatment and rehabilitation to support low back musculature, to encourage the tissue healing process, and to avoid limiting the enhancement of improved trunk flexion ROM.[110]

2.5.4 Indications

The four main areas of KT use involve the improvement of muscle function, elimination of circulatory impairments, pain reduction, and support of joint functions.[1,2] KT use is now found in competitive sports, many areas of medicine and physiotherapy. In world championships, Olympic games, and diverse competitive sports, this treatment method has become an integral component of prevention, rehabilitation, and part of the training therapy. Aftercare, and treatment concepts in orthopedics, surgery, oncology, geriatrics, and pediatrics have been developed and introduced into hospitals and rehabilitation centers.[2]

KT range of application will continue to expand in the coming years. It can be used in the treatment of scoliosis, whiplash, impingement, bursitis, joint instability, finger and toe deformities, peripheral and central paresis, diastasis recti, scar care and many more.

2.5.5 Contraindications

To present, there are no known side-effects of KT. However, Kinesio Taping should not be used on open wounds; scars which have not yet healed; neurodermatitis or psoriasis; genitals; those with allergies to acrylic and silicon. Those taking anticoagulants should be cautious and be aware that there may be skin reactions from the KT.[2]

2.6 Electromyograph (EMG) - Basic Information

Electromyography (EMG) is an electrophysiological method that allows for an assessment of the condition of the skeletal musculature and its CNS control. It is based on scanning the electrical manifestation of muscle tissue by electrodes that serve as an antenna. A surface EMG (sEMG) is where the electrodes are placed on the surface of the body, while an intramuscular (finewire) EMG has the electrodes placed directly in the muscle. sEMG electrodes adhered to the skin scan the sum of potentials of many muscle fibers underneath them and provide global information about the activity of the entire muscle or its major portion.[48,123,113] The EMG signal is based upon action potentials at the muscle fiber membrane resulting from depolarization and repolarization.[114]

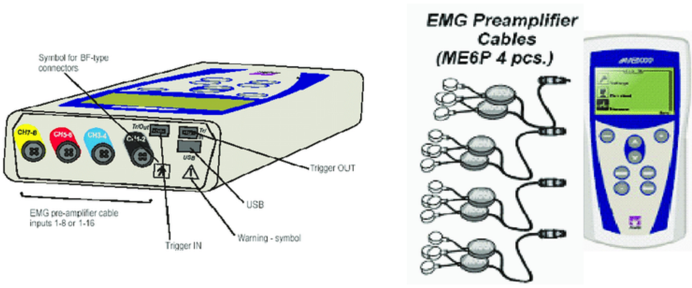


Fig. 22 - Bittium Biomonitor transmitter and receiver, model ME6000 (Bittium Inc. Oulu, Finland)[111]

A signal from the electrodes pass through an electronic instrument and is led to a computer where, deviation of the potential, pertaining information about muscle activity can be read. Mathematical data processing by established methods will yield quantitative parameters of the EMG signal that can be further compared. An amplitude analysis and frequency analysis are performed.[48,112,115,116] The raw data signal analysis may include ECG (electrocardiogram) reduction, filtration, rectification and smoothing.[116,117] The EMG can be equipped by up to 16 channels that allow for observation of muscle activity in more muscles at the same time.[114] The electrical signal can be affected by multiple factors. The signal conduction varies according to physiological, anatomical, and technical factors. The subject's mental/emotional state, the electrode configuration and placement over the target muscle fibers, the amount of tissue between the surface of the muscle and the electrode and others can affect data recording.[115,116] Also, sEMG recorded from dynamic contractions typically reduce the stability of the signals, largely as a consequence of recruitment and derecruitment of different motor units.[117]

In rehabilitation, EMG can be used for biomechanics analysis of motor skills. Information that can be collected, such as, indicator of muscle coordination, indicator of force developed by a muscle contraction, and indicator of muscle fatigue. It can also be used as an assessment of the percentage distribution of muscle activation. This means that to what extent the muscle is activated under various situations and in various positions can be observed.[112,115,116,118,108] But, EMG can only answer its specific categories of questions. Like any other biomechanics method, it acts like a lens by focusing on one selected subsystem or component of a very complex overall biological system. EMG of a muscle alone can never answer a "Why?"[74]

Gowan et al.[120] conducted a study using EMG to determine if the muscle-firing sequence of professional pitchers was significantly different from that of amateur pitchers. No significant differences were noted in the first three phases of the pitch, the windup, early and late cocking. There were no significant differences in the follow-through, where muscle activity was described as general.[120]

During the acceleration phase, professional pitchers recorded increased activity of the pectorals major and latissimus dorsi. There was also increased activity in the serratus anterior muscle. The professional pitchers had decreased activity in the supraspinatus, infraspinatus, and teres minor during acceleration. Professional pitchers used the subscapularis predominately during acceleration and internal rotation. Activity in the biceps brachii was also lower in the professional than in the amateurs.[120] Nonetheless, this does imply that the glenohumeral control and scapula stabilization are imperative during the acceleration phase. These findings may suggest that professional pitchers better coordinate segmental motion, therefore enhancing the efficiency of the rotator cuff muscles in the stabilization of the glenohumeral joint during the act of throwing.[3]

Hall and Quinter[122] study used sEMG and other techniques to evaluate muscle activity while stimulating the innervating nerve trunk. This study looked at the EMG responses that were recorded from the ipsilateral biceps, triceps, deltoid, and upper trapezius muscles on the side of the arm being tested.[122,123]

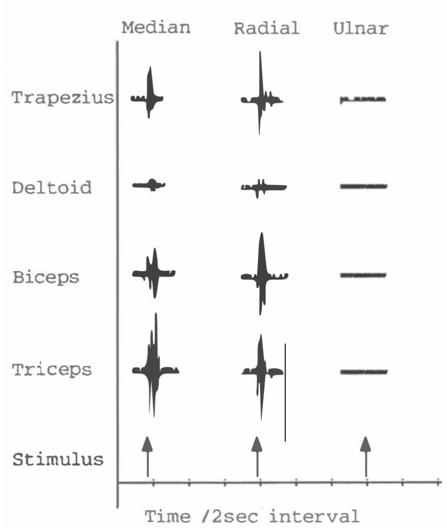


Fig. 23 EMG response to medial and radial nerve palpation[121]

Sakurai et al.[56] studied EMG activity in the biceps while maintaining the elbow in neutral rotation in a brace. Surface electrodes were used to measure EMG activity of the deltoid and biceps muscles. Their results showed there to be EMG activity in both the long and short heads of the biceps with all types of motion of the shoulder, independent of elbow position. This indicated that the biceps acted as an active flexor and abductor of the shoulder, and that the LHB can act as a humeral head stabilizer in superior and anterior directions. There was also activity with rotation, and external rotation induced more activity than internal rotation did. In addition, they demonstrated greater fatigability of the biceps compared with the deltoid. These findings suggest that the long head of the biceps must increase its mechanical output to keep the arm in elevation to a greater extent than do the short head and the deltoid muscle. This may be one of the causes of tendinitis or rupture of the long head.[5,56]

Chalmers et al.[61] studied the LHBM and its glenohumeral function using sEMG. Their results showed that LHBM activity was significantly increased by flexion and abduction. When a distal humeral load was added there was a significant increase in LHBM activity in 45º of abduction and 90º of flexion. It was concluded that the LHBM may play a dynamic roll in glenohumeral motion with higher demand activities.[61]

Saracoglu et al.[123] conducted a systematic review to determine whether any taping technique in addition to physiotherapy care is more effective than physiotherapy care alone in patients with shoulder impingement syndrome. Three randomized controlled trials and one controlled trial were included. It was concluded that clinical taping in addition to physiotherapy interventions might be an optional modality for managing patients with shoulder impingement syndrome, especially for the initial stage of treatment.[123]

Gowan et al.[120] conducted a study using EMG to determine if the muscle-firing sequence of professional pitchers was significantly different from that of amateur pitchers. He found that they were. Activity in the biceps brachii was lower in the professional than in the amateurs.[120,144] This lead Ellenbecker et al.[3] to conclude that the glenohumeral control and scapula stabilization are imperative during the acceleration phase. These findings may suggest that professional pitchers better coordinate segmental motion, therefore enhancing the efficiency of the rotator cuff muscles in the stabilization of the glenohumeral joint during the act of throwing.[3]

3 OBJECTIVES AND HYPOTHESIS

Many athletes, such as baseball players, and non-athletes alike are looking for ways to prevent and/or treat shoulder pain, oftentimes arising from the LHBM. One of the many ways to accomplish this is through the application of KT. As the popularity of KT has increased, so has the frequency of individuals taking it upon themselves to apply this colorful tape without professional knowledge or training. The manner of which KT is applied is most often, if not always, applied from the proximal to distal end of the LHBM. Does the application of KT to the LHBM in this direction provide the result that is desired?

The aim of this thesis is to verify that the application of KT to the long head of the biceps increases its activity in baseball players.

3.1 Objectives

Does applying KT to the long head of the biceps cause its muscular activity to increase? The proximal LHBT and its attachment at the superior glenoid tubercle and labrum are subject to a spectrum of disorders in overhead throwing athletes. Optimal treatment of the LHBT is controversial and its role in the glenohumeral joint is unclear.[61] Literature shows that the LHBM can assist in stabilizing the humeral head in the glenohumeral joint,[42] while rupture of proximal LHBT can reduce shoulder abduction by up to 20%.[14] Operative treatment remains controversial and return to play can be unpredictable[61]

According to the KT method, proximal-to-distal application of KT should facilitate muscle activity, while distal-to-proximal should decrease muscle activity.[1,87,92,124] Can KT be used as a less invasive option for LHB treatment?

3.2 Research Questions

1. Does the application of KT to the proximal origin of the LHBM to its distal insertion influence the muscular activity of the LHBM?
2. Does the application of KT to the proximal origin of the LHBM to its distal insertion influence the muscular activity of surrounding musculature?

3.3 Research Hypothesis

H01: Muscle activity of the LHBM will significantly increase after application of KT to the proximal origin of the LHBM to its distal insertion, $p<0.05$, effect size $r \geq 0.03$.
H02: Muscle activity in the surrounding musculature will not lead to significant change after application of KT to the proximal origin of the LHBM to its distal insertion, $p<0.05$, effect size $r \geq 0.03$.

4 METHODOLOGY

This study was approved by Ethical committee of UK FTVS No. 193/2019. All participants or their legal representative (in case participant was younger than 18 years) signed informed consent forms. Participants were a convenience sample of normal, healthy volunteers without current nor recent shoulder pain or pathology. Exclusion criteria included complaints of shoulder pain. Participants sex, age, weight, height, and years of baseball participation was also collected. No participants were aware of the hypothesis of the study. In all cases the right upper extremity was tested. All testing was performed in two indoor baseball training facilities. No pre-hoc power analysis was possible as no data exist comparing the influence on the LHB of KT before and after application in the throwing motion for this experimental model.

4.1 General Description of Research Sample

A total of twenty-one active baseball players aged 18-40 were included in the study. All twenty-one players were free of acute musculoskeletal injuries of the shoulder and arm. One was excluded due to pathology after the first testing. Six others did not participate in all three measurements and so were excluded from the final statistical analysis. The participants were aged 25.3 ±5.9 years, height 183.2 ±6.9 cm, weight 83.8 ±11.1 kg, years baseball of participation 17.1 ±6.5 years.

4.2 Data Collection

Measurements were performed at two indoor baseball training facilities, one at Kotlarka Praha and the other at Tempo Praha. Since a sEMG is a non-invasive technique and is generally acceptable for the purposes of a study such as this,[122] a 16-channel surface electromyography device, Biomonitor ME6000 (Bittium Finland)[111] was used.

The skin surface was cleaned and dried prior to electrode application. The electrodes were placed according to the SENIAM project.[125] The right arm was actively abducted to 90º, externally rotated with the elbow flexed to 90º and then the electrodes were applied on the LHB, LHT, PM, and UT muscle bellies. Medico Lead-Lok, H925G, foam, hydrogel, disc, 57mmx34mm, Al/AgCl bipolar surface electrodes were placed longitudinally 2cm apart over the midbelly of the four target muscles.[122,125,126]The reference electrode for each muscle was attached to electrically neutral tissue.[116] The electrode cables were fixed to the body surface near the electrode to minimize motion artifacts and electrodes separating from the skin. During the measurement it was attempted to eliminate the possibility of artifacts through minimizing unnecessary movement, talking and any other external attributes.

Prior to measuring activity with the testing protocol, the maximal amount of muscle activity in each subject's biceps, triceps, PM, and UT was determined to serve as an internal control. Three consecutive trials of 3- to 5-second maximal voluntary isometric contraction (MVIC) were performed. The positions selected for the MVIC testing was according to manual muscle testing by Kendall et al.[127] For the LHB, LHT and PM, each subject was laying supine on a portable treatment table. For the LHB, a maximal isometric elbow flexion force with right shoulder flexed 90º, fixated elbow flexed 90º, and forearm supinated. For the LHT, a maximal isometric elbow extension force with right shoulder flexed 90º, fixated elbow extended 120º, and forearm supinated. For the pectorals major, a maximal isometric shoulder horizontal adduction force with right shoulder flexed 90º, extended elbow, neutral forearm and fixated left shoulder. For the upper trapezius, each subject was sitting on a portable treatment table with elevation of the acromial end of the clavicle and scapula, and posterolateral extension of the neck, bringing the occiput toward the elevated shoulder with the face turned in the opposite direction, a maximal isometric force against the shoulder, in the direction of depression, and against the head, in the direction of flexion anterolaterally.[127] Each subject showed activity in the biceps with resisted flexion, and this activity was defined as 100% as follows: the 3- to 5-second interval with the highest sEMG activity was selected as the maximal MVIC representing 100% LHB muscle activity.

Measurement was taken with each subject standing in a stager stance, with left foot forward and right foot behind. A small piece of tape was placed on the floor to line up where the right shoulder should be directly above for consistent placement for each participant. The right arm actively placed in and maintained at 90º of shoulder abduction and 90º of elbow flexion[3] with dynamic shoulder rotation with 1m of yellow Theraband[128] used for resisted internal rotation. One end of the 1m of non-stretched yellow Theraband was held in the right hand between the proximal ends of the second and third fingers, while the other end of the Theraband was connected to a carabiner that was then clipped onto an eyebolt in the wall at the height of 175cm(68.8in). A metronome set at 70bpm was used to maintain a consistent pace for 10 shoulder internal and external rotations.

First measurement was taken with no KT applied to the LHB and then the second measurement was taken with red RockTape brand KT applied to the skin along the muscle fibers of the LHB. The KT was applied by a RockTape certified Physiotherapist. There was a 20 second lag time between the first and second measurement.

The 5cm wide KT “I” stripe was applied from the right acromion to the insertion of the LHB in the proximal radius. The right arm was placed in 30º of shoulder abduction, 15º of shoulder extension, 5º of supination for KT application. The length of the KT was measured from the acromion to the crook of the elbow. There was no tension applied to the ends, 3-5cm, of the “I” strip KT. There was approximately 50% stretch applied to the KT upon application.

4.3 Description of Facility

Measurements were performed at the indoor baseball training facilities of Kotlarka Praha and Tempo Praha. Both facilities are enclosed, with artificial turf floors, open floor plan and with moderate temperature of approximately 18.3ºC (65ºF).

4.4 Additional Equipment

A minimally padded portable treatment table was used for measuring MVIC. 1m of yellow Theraband for resisted internal shoulder rotation. One carabiner to attach the Theraband to the wall eyebolt. An iPhone with a Metronome App for maintaining the pace of shoulder internal and external rotation.

4.5 Timing and rest of conditions

Measurement for one subject took approximately 20 minutes. Measurement included the cleaning and drying of the right arm, applying electrodes and cables, positioning the subject, measuring MVIC of the LHB, LHT, PM, and UT, 10 repetitions of shoulder internal and external rotation, placing the KT on the LHB, and repeating 10 more repetitions of shoulder internal and external rotation.

4.6 Analysis and Statistical Data Processing

For evaluation and processing of sEMG signal, MegWin 3.1[111] system was used. The recorded data was further rectified, converting all negative deflections to positive ones of the same size. The average of the muscles during a particular movement was analyzed from the middle four repetitions of the total ten repetitions. The obtained data were rewritten in MatLab.

For data analysis, NCSS2007[129] was used and several statistical procedures had to be applied. First, distribution of data were tested using the Kolmogorov-Smirnov test and inferential statistics non-parametric tests were used since the majority of variables were not normally distributed. The degree of association between pre- and post- EMG measurement on certain muscles was carried out by Kendal's Tau Correlation. Acceptable strength of association between pre- and post- EMG measurement of each muscle was determined as R^2 (effect size) >0.5[130]. In pre- and post- testing of our quasiexperiment, it was measured three times EMG activity of each selected muscle. To use data from all three measurements together we had to verify whether three repeated EMG sessions did not differ significantly from the before and after treatment period. For this purpose, the Friedman non-parametric repeated measure for Analysis of Variance was conducted with statistical significance level of $p<0.05$. Finally, to evaluate for possible changes in muscle activity between pre- and post-EMG measurement the paired non-parametric Wilcox rank T-test with statistical significance level of p¿0.05, effect size $r \geq 0.3$ was used.[131]

5 RESULTS

In the first step, the initial statistical analysis, we analyzed associations of EMG values between each trial with the aim to verify the stability of muscle activity during the required movement which can be addressed to reliability (method tests-retest) of current EMG measurement. Tables 7 and 8 provides the results, according to Kendal's Tau Correlation, showing the associations between each of the three trials of muscle testing before and after the application of KT.

Table 6 - Correlation of Muscle Activity between each Trial before Kinesio Tape

Muscle	LHBM 1	LHBM 2	LHBM 3
LHBM 1	1.00		
LHBM 2	0.69**	1.00	
LHBM 3	0.70**	0.80**	1.00
Muscle	LHTM 1	LHTM 2	LHTM 3
LHTM 1	1.00		
LHTM 2	0.53*	1.00	
LHTM 3	0.69**	0.32	1.00
Muscle	PM 1	PM 2	PM 3
PM 1	1.00		
PM 2	0.74**	1.00	
PM 3	0.45	0.41	1.00
Muscle	UT 1	UT 2	UT 3
UT 1	1.00		
UT 2	0.75**	1.00	
UT 3	0.37	0.48	1.00

*p<0.05
**p<0.01

Legend: LHBM - long head of the biceps muscle, LHTM - long head of the triceps muscle, PM - pectorals major, UT - upper trapezius

The data values collected from the three trials before KT for the four muscles showed high variability. Only seven from twelve correlations were statistically significant and only two test re-test correlations displayed acceptable values (LHBM2 and LHBM3; UT1 and UT2). Therefore, measurement of muscle activity seemed to have low reliability in our study. Overall, the poorest reliability (least stable) according to muscle was the UT. While the highest reliability (most stable) between testing trails before taping was between the second and third testing trial of the PM. The highest reliability (most stable) according to muscle was the PM. (Table 6)

Table 7 - Correlation of Muscle Activity between each Trial after KT

Muscle	LHBM 1	LHBM 2	LHBM 3
LHBM 1	1.00		
LHBM 2	0.74**	1.00	
LHBM 3	0.77**	0.80**	1.00
Muscle	LHTM 1	LHTM 2	LHTM 3
LHTM 1	1.00		
LHTM 2	0.83**	1.00	
LHTM 3	0.49*	0.39	1.00
Muscle	PM 1	PM 2	PM 3
PM 1	1.00		
PM 2	0.77**	1.00	
PM 3	0.87**	0.81**	1.00
Muscle	UT 1	UT 2	UT 3
UT 1	1.00		
UT 2	0.56*	1.00	
UT 3	0.22	0.30	1.00

*p<0.05
**p<0.01

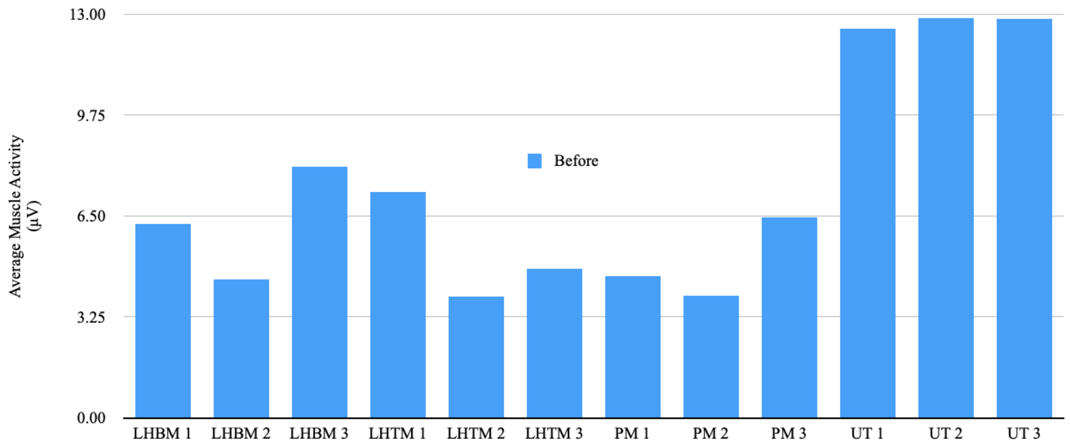
Legend: LHBM - long head of the biceps muscle, LHTM - long head of the triceps muscle, PM - pectorals major, UT - upper trapezius

From Table 7 the data values collected from the three trials after KT for the four muscles showed stronger association in comparison with data collected before KT. In six cases values of test re-test correlation was higher than 0.75 which is accepted as the lowest acceptable level of reliability. Even though, correlations between each trial were higher compared to before KT state we still found high range of correlation coefficients. The poorest reliability (least stable) between testing trails was found between the second and third testing trail of the LHTM after taping. The poorest reliability (least stable) according to muscle was the UT. While the highest reliability (most stable) between testing trails after taping was between the first and second testing trial of the pectorals major. The highest reliability (most stable) according to muscle was the LHBM.

It is evident that the data received by the sEMG need not to be stable in time. The reliability was found to be acceptable only in some cases (all trials of the LHBM – 0.74; 0.77; 0.80 and PM – 0.77; 0.87; 0.81, while in trial 2 LHTM – 0.83 and UT – 0.56).

Further, we evaluated whether the values from each trail significantly differ. The main reason for this analysis was to determine if all collected data could be processed together. In this case, Friedman non-parametric repeated measure for analysis of variance was used. Even though it appears that there was a large change in muscular activity, there were no statistically significant differences (p=0.12–0.46; ES r=0.06–0.17). The main cause of non-significant differences is evident due to large values of standard deviations found in all muscles (Graph 1).

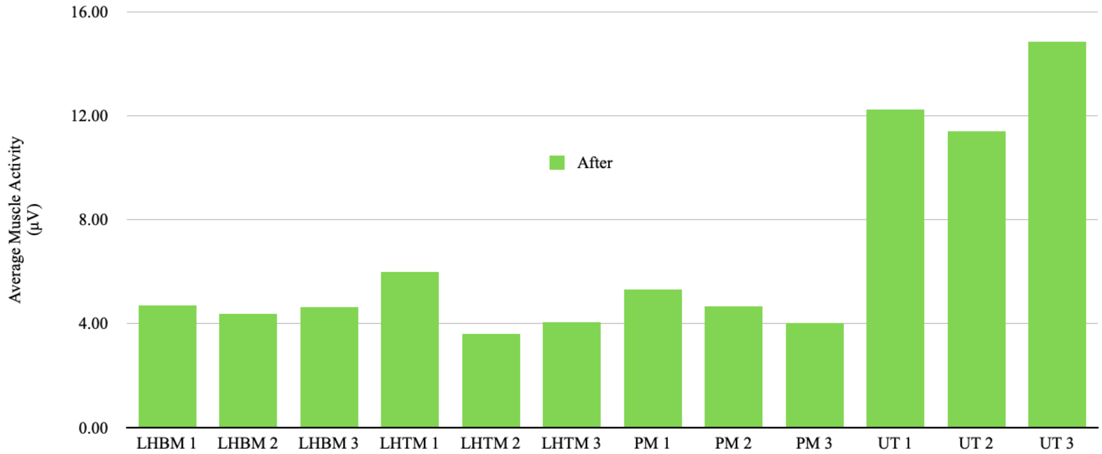
Graph 1 - Descriptive Statistics of Muscle Activity, Each Trial before KT - All values expressed as mean ± SD



LHBM 1	LHBM 2	LHBM 3	LHTM 1	LHTM 2	LHTM 3	PM 1	PM 2	PM 3	UT 1	UT 2	UT 3
6.26±8.16	4.47±3.52	8.10±16.91	7.28±7.29	3.92±2.12	4.80±6.04	4.57±5.20	3.94±2.27	6.45±13.10	12.54±11.60	12.89±10.68	12.85±10.78

Legend: SD - Means and Standard Deviation; LHBM - Long Head of the Biceps Muscle; LHTM - Long Head of the Triceps Muscle; PM - Pectoralis Major; UT - Upper Trapezius

Graph 2 - Descriptive Statistics of Muscle Activity, Each Trial after KT - All values expressed as mean ± SD

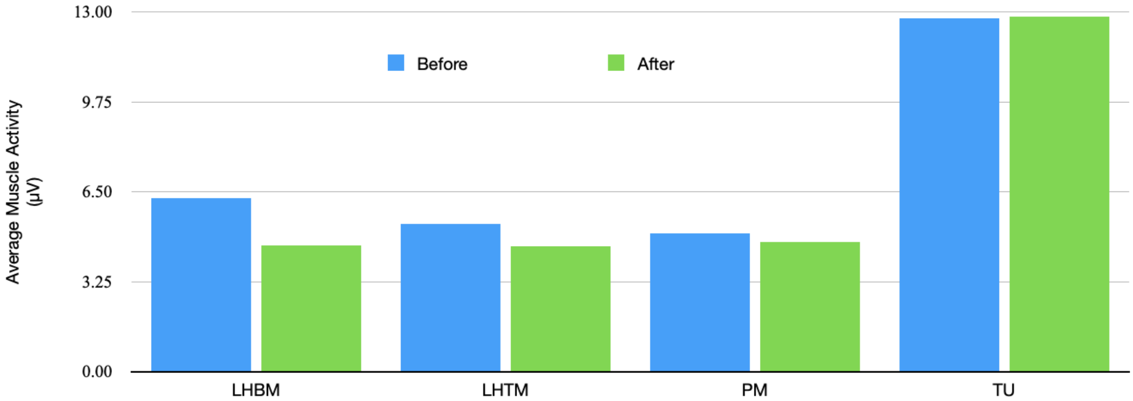


LHBM 1	LHBM 2	LHBM 3	LHTM 1	LHTM 2	LHTM 3	PM 1	PM 2	PM 3	UT 1	UT 2	UT 3
4.69±6.23	4.38±3.47	4.63±4.19	5.98±4.36	3.59±1.96	4.04±2.44	5.30±4.60	4.68±3.46	4.03±2.35	12.25±11.82	11.41±9.48	14.85±10.37

Legend: SD - Means and Standard Deviation; LHBM - Long Head of the Biceps Muscle; LHTM - Long Head of the Triceps Muscle; PM - Pectoralis Major; UT - Upper Trapezius

Based on the results from Graph 1 and Graph 2 we decided to use data from all trials together for further analysis where we investigated the differences in muscle activity between the pre-KT and post-KT state.

Graph 3 - Differences of Muscle Activity, All Trial before and after KT - All values are expressed as mean ± SD

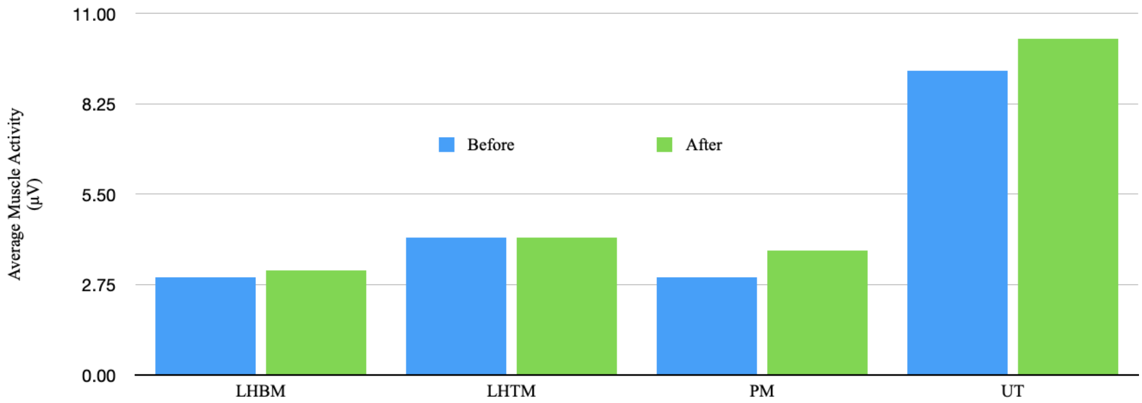


	LHBM	LHTM	PM	TU
Before	6.28±9.53	5.33±5.15	4.99±6.85	12.76±10.02
After	4.57±4.63	4.54±2.92	4.67±3.47	12.84±10.56

Legend: SD - Means and Standard Deviation; LHBM - Long Head of the Biceps Muscle; LHTM - Long Head of the Triceps Muscle; PM - Pectoralis Major; UT - Upper Trapezius

Results of paired T-tests did not show any significant differences in muscle activity between pre-KT and post-KT state (Graph 3) (p=0.15–0.67; ES r=0.04–0.16). Even though in LHBM, LHTM and PM muscle activity decreased in post KT state, due to large standard deviations, these differences were not provable. For this reason, we decided to use the median values and non-parametric T-test, Wilcox Rank test, which is a statistical method more resistant to extreme values, referred to as an outlier.

Graph 4 - Median Statistics of Muscle Activity, All Trials before and after KT



	LHBM	LHTM	PM	UT
Before	2.96	4.17	2.96	9.25
After	3.17	4.17	3.79	10.22

Legend: LHBM - Long Head of the Biceps Muscle; LHTM - Long Head of the Triceps Muscle; PM - Pectoralis Major; UT - Upper Trapezius

Although profile of graph markedly changed, the results from median non parametric paired T-test did not show any significant differences (Graph 4).

When the raw data was compared, especially looking at the range of values, it was found that many of the values exceeded double the average. These values were defined as outliers. Therefore, the next aim was to identify the outliers, remove them from the data sheet and perform new analysis without outliers.

While conducting the data analysis, it was discussed if whether the values of some muscle activity could be removed from the EMG data. In earlier studies it was stated that EMG data may be inconsistent when measuring dynamic movements.[24] Therefore, the EMG data from each of the participants were evaluated for any possible outlier values. After evaluating for outlier values, there was removed at least one outlier value in 40% of the participants. It was considered according to research recommendation (Pollet, & van der Meij, 2017)[147] that an outlier value to be greater than 2.5 standard deviation higher than the mean. There was a reanalysis of the normality of data and the Kolmogorov-Smirnov Test still showed a non-normal distribution.

In the subsequent step, we replicate correlation analysis as well as median non parametric form of paired T-test.

Correlation of test re-test analysis (Table 8 and Table 9) showed overall more consistent associations of values between each trial compared to results from previous correlation matrix. In this case more acceptable values of reliability were obtained. When comparing the results from Table 8 to Table 6, it is clear that the results for LHBM, LHTM, and PM remained relatively similar. On the other hand, the results for correlation of the UT decreased in each trail, but remained statistically significant in Trail 2 with a value of 0.46, p<0.01.

Table 8 - Correlation of Muscle Activity between each Trial before Kinesio Tape, Without Outliers

Muscle	LHBM 1	LHBM 2	LHBM 3
LHBM 1	1.00		
LHBM 2	0.60**	1.00	
LHBM 3	0.73**	0.74**	1.00
Muscle	LHTM 1	LHTM 2	LHTM 3
LHTM 1	1.00		
LHTM 2	0.79**	1.00	
LHTM 3	0.46	0.29	1.00
Muscle	PM 1	PM 2	PM 3
PM 1	1.00		
PM 2	0.74**	1.00	
PM 3	0.80**	0.87**	1.00
Muscle	UT 1	UT 2	UT 3
UT 1	1.00		
UT 2	0.46**	1.00	
UT 3	0.09	0.12	1.00

*p<0.05
**p<0.01

Legend: LHBM - long head of the biceps muscle, LHTM - long head of the triceps muscle, PM - pectorals major, UT - upper trapezius

The least stable relationship between testing trails was found between the first and third testing trail of the UT before taping. The poorest reliability according to muscle was the UT. While the highest reliability (most stable) before taping was between the first and third testing trial of the PM. The highest reliability (most stable) according to muscle was the PM. (Table 8)

Table 9 - Correlation of Muscle Activity between each Trial after Kinesio Tape, Without Outliers

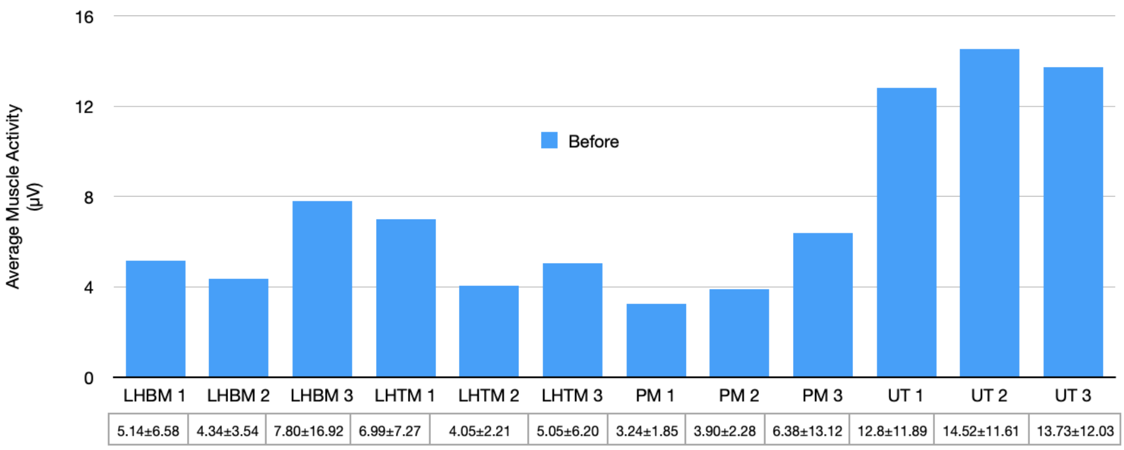
Muscle	LHBM 1	LHBM 2	LHBM 3
LHBM 1	1.00		
LHBM 2	0.65**	1.00	
LHBM 3	0.73**	0.81**	1.00
Muscle	LHTM 1	LHTM 2	LHTM 3
LHTM 1	1.00		
LHTM2	0.61*	1.00	
LHTM3	0.68**	0.25	1.00
Muscle	PM 1	PM 2	PM 3
PM 1	1.00		

PM 2	0.89**	1.00	
PM 3	0.52*	0.57*	1.00
Muscle	UT 1	UT 2	UT 3
UT 1	1.00		
UT 2	0.75**	1.00	
UT 3	0.32	0.45	1.00
*p<0.05 **p<0.01			
Legend: LHBM - long head of the biceps muscle, LHTM - long head of the triceps muscle, PM - pectorals major, UT - upper trapezius			

Similar pattern of changes in muscle activity associations between each trial was also found in correlation matrix devoted to after KT state. After removing outliers, results seemed to be more consistent compared to table 8. However, again we revealed low ambiguous reliability. The poorest reliability was found between the second and third testing trail of the LHTM after taping. The poorest reliability according to muscle was at the UT. While the highest reliability (most stable) after taping was between the first and second testing trial of the PM. The highest reliability (most stable) according to muscle was the LHBM.

The reliability was found to still be acceptable only in some cases (all trials of the LHBM – 0.65; 0.73; 0.81 and PM – 0.89; 0.52; 0.57, while in the LHTM trial 3 – 0.68 and UT trial 2 – 0.75). When comparing the results from Table 9 to Table 7, it is again clear that the results for LHBM, LHTM, and PM remained relatively similar. On the other hand, the results for correlation of the PM increased in each trail, especially in Trail 2 with a value of 0.89, p<0.01. (Table 9)

Graph 5 - Differences of Muscle Activity, Each Trial before KT - Without Outliers - All values are expressed as mean ± SD

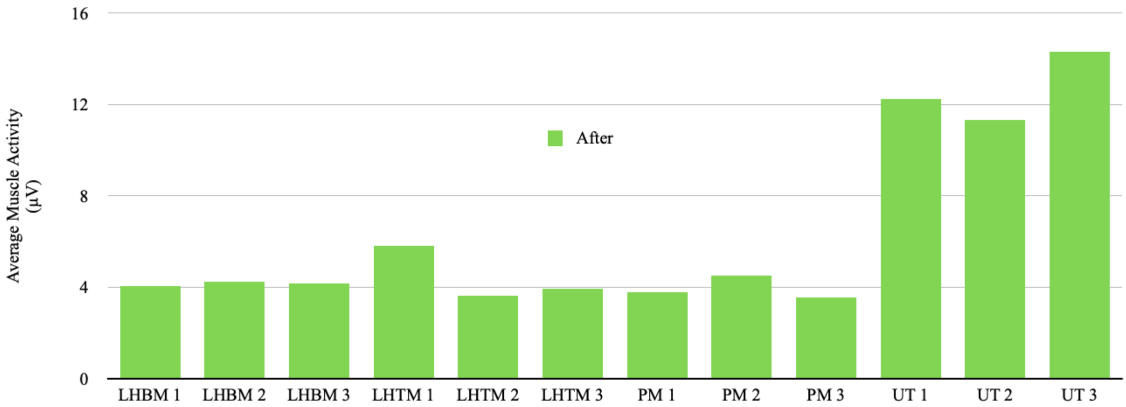


Legend: SD - Means and Standard Deviation; LHBM - Long Head of the Biceps Muscle; LHTM - Long Head of the Triceps Muscle; PM - Pectoralis Major; UT - Upper Trapezius

Graph 5 provides the data where Friedman test evaluated whether the values from each trail significantly differ with the removal of outliers When we compare Graph 1 and Graph 5 it is evident that values of standard deviations were significantly reduced.

Nevertheless, in certain trials and muscles even removing outliers, SD still remained large and very different between before and after KT (LHBM3, LHTM3, PM3). Friedman non-parametric repeated measure for Analysis of Variance showed no significant differences (Graph 5) between each trial before KT (p=0.14 – 0.52; ES r =

Graph 6 - Descriptive Statistics of Muscle Activity, Each Trail after KT - Without Outliers - All values are expressed as mean ± SD



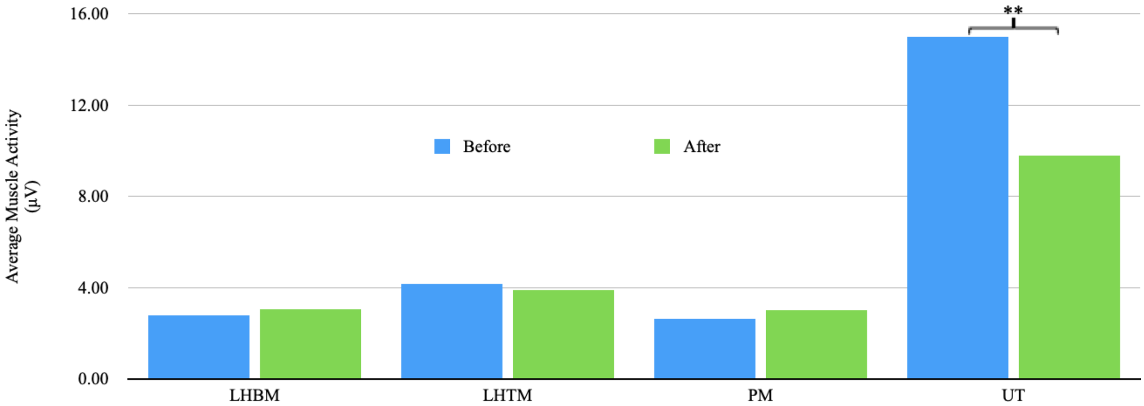
LHBM 1	LHBM 2	LHBM 3	LHTM 1	LHTM 2	LHTM 3	PM 1	PM 2	PM 3	UT 1	UT 2	UT 3
4.04±4.39	4.23±3.18	4.15±3.41	5.81±4,32	3.62±1.95	3.93±2.29	3.78±2.81	4.5±3.31	3.54±2.06	12.25±11.90	11.34±9.50	14.3±10.29

Legend: SD - Means and Standard Deviation; LHBM - Long Head of the Biceps Muscle; LHTM - Long Head of the Triceps Muscle; PM - Pectoralis Major; UT - Upper Trapezius

0.11–0.19). The same was found in comparison of each trial at each muscle in after KT data (Graph 6).

Since data normality was rejected, even with outliers removed in all muscles in before and after application of KT, median non parametric paired t-test was used. Results from the non-parametric paired Wilcoxon signed-rank T-test showed a slight LHBM increase in activity, however not significantly (p=0.31; ES r=0.12). Further, KT lead to statistically significant decrease in UT muscular activity (Graph 7).

Graph 7 - Median Statistics of Muscle Activity, All Trials before and after KT - Without Outliers



	LHBM	LHTM	PM	UT
Before	2.78	4.16	2.63	15.00
After	3.04	3.90	3.00	9.80

Legend: **p<0.05; LHBM - Long Head of the Biceps Muscle; LHTM - Long Head of the Triceps Muscle; PM - Pectoralis Major; UT - Upper Trapezius

The statistical analysis initially showed no significant differences in the four measured muscles from before application of KT to after application of KT (Graph 3). However, once outliers were addressed, there was found one statistically significant change in muscle activity, which was revealed in the decrease of UT muscle activity (Graph 7) with p=0.023 and ES r=0.26.

6 DISCUSSION

In this study, sEMG responses were recorded in healthy baseball players, with no reported shoulder or arm pain. It was hypothesized that in this population that the application of KT to the skin located superficially to the LHBM increases its activity in the baseball throwing motion.

In the formulation of this study, there were three main areas of focus: LHBM activity in overhead throwing motion, such as in the baseball throwing motion; the use of KT to facilitate an increase of muscular activity in the LHBM; and the use of sEMG in the measurement of dynamic activity of the LHBM, LHTM, PM, and UT. Research results established that there are several recent studies that involved all three areas, but none were identified as focusing on all three parameters together, such as in this study.

These studies showed similar results, such as in sEMG measured activity in LHBM, UT; KT decreased muscle activity and also those that increased muscle activity; and the contribution of the LHBM in the overhead throwing motion.

6.1 Difference in muscle activity before and after KT application

6.1.1 Verification of hypothesis H01

The hypothesis H01 stated "Muscle activity of the LHBM will significantly increase after application of KT to the proximal origin of the LHBM to its distal insertion" was refused because of the lack of statistical significance. The differences in mean muscle activity of the shoulder before and after the application of KT are shown in Graphs 1 and 2 and also Graphs 5 and 6 were $p>0.05$, effect size r¿0.03.

6.1.2 Verification of hypothesis H02

The hypothesis H02 stated "Muscle activity in the surrounding musculature will not lead to significant change after application of KT to the proximal origin of the LHBM to its distal insertion" was refuted because of a statistically significant change in muscle activity of the Upper Trapezius shown in Graph 7. The significant level of these changes is $p=0.023$, effect size r¿0.26.

In this study, the LHBM activity was measured using sEMG, which showed that there is LHBM activity during the overhead throwing motion, although does not provide the information on how much the LHBM contributes to glenohumeral movement or stability. It was also shown that with the application of KT to the LHBM there was a reduction in LHBM activity, but was not of statistical significance.

The initial and main finding from our results showed that KT is not an effective method in changing the activity in the LHBM, LHTM, PM, and UT muscles when applied from proximal to distal of only the LHBM. There was found a reduction of activity in all four muscles, but not of statistical significance, so therefore we must conclude that KT does not influence the muscles studied in the expected manner according to how this study was set up and performed. However, we found great variability in results. One possible reason for not finding plausible differences may lie in the methodology and shortcomings in the use of sEMG. The electrical signal can be affected by multiple factors. The signal conduction varies according to physiological, anatomical, and technical factors. The subject's mental/emotional state, the electrode configuration and placement over the target muscle fibers, the amount of tissue between the surface of the muscle and the electrode and others can affect data recording.[115,116] Also, sEMG recorded from dynamic contractions typically reduce the stability of the signals, largely as a consequence of recruitment and de-recruitment of different motor units.[117] So, as one would expect, artifacts or, as we can say, outliers were present in this study's outcomes. As a result, some of the initial testing data proved to show large standard deviations, but was greatly reduced with the application of KT to the LHBM. It does appear to demonstrate that KT aids in the normalization of muscle activity, with almost across the board, reduction in data standard deviation. For example, the initial testing data for 'Differences of Muscle Activity' for the LHBM was 6.28 with standard deviation of 9.53 before the application of KT and 4.57 with standard deviation of 4.63 after the application of KT. This is a reduction in 4.9 standard deviation points. After the removal of the 'outliers' from the data, the LHBM was 5.76 with standard deviation of 9.01 before application of KT and 4.14 with standard deviation of 3.66 after the application of KT. That is a reduction of 5.35 standard deviation points. This reduction in standard deviation proved true in almost all trails for all four muscles, whether outliers were included or not.

When considering and thus removing the outliers that had been recorded in the initial data collection of approximately 40% of the participants, we found differing results. The UT was found to have a reduction in muscle activity with statistical significance of $p=0.023$, while the LHBM, LHTM, and the PM had a reduction of muscle activity, but neither of statistical significance nor clinical significance. This reduction in muscle activity may be of clinical significance when considering the shoulder force couples and the relationship between the UT and LHBM in the overhead throwing motion. The UT and LHBM can become overactive[25] with decreased activity of the rotator cuff[7] and so application of KT to the LHBM can decrease it and the UT's activity, allowing the rotator cuff the opportunity to be strengthened, so to potentially improve the shoulder complex moment pattern.

Much of the work with the (biceps brachii) BB has focused on how the LHBM affects glenohumeral kinematics, stability, etc., and the evidence shows that this activity is significant. Gowan et al.[120] concluded that the muscle-firing sequence of professional pitchers was significantly different from that of amateur pitchers, in that the activity in the biceps brachii was lower in the professional than in the amateurs.[120,144] Similarly, Ahamed et al. studied the activity of the biceps brachii, but of cricket players while comparing fast bowlers to spin bowlers using sEMG. The authors found statistically significant biceps brachii activity while throwing.[134] Rodosky et al.[55] investigated the role of the LHBM and its attachment to the superior labrum in a laboratory model of the glenohumeral joint positioned in abduction and external rotation as experienced by the overhead thrower. The long head of the biceps withstood higher external rotational forces without the inferior glenohumeral ligament experiencing a greater strain, which aided in resisting the rotation. This suggested that the biceps has a role in the provision of anterior stability. The glenohumeral joint demonstrated a heightened torsional stiffness as force was increased through the LHBM, which becomes a larger player in the attempt to achieve stabilization to the glenohumeral joint. This model suggests that the shoulder is thus dependent upon the LHBM to provide dynamic stability to the glenohumeral joint in the cocking, acceleration, and follow-through phases.[55] Along the same lines, Chalmers et al.[134] studied the glenohumeral function of the LHBM using sEMG while the shoulder was placed in several angles with and without elbow immobilization. It was found that the LHBM activity was significantly increased by flexion and abduction in all cases. When compared with the unloaded state, the addition of a distal humeral load significantly increased LHBM activity in 45º abduction and 90º flexion despite forearm and elbow immobilization. This suggests that this muscle plays a dynamic role in glenohumeral motion with higher demand activities,[134] such as the overhead throwing motion. When looking at the influence of KT, Vered et al.[94] studied its application on peak force of biceps brachii in healthy subjects. KT was applied randomly on both anterior arms as follows: no KT; Proximal-to-Distal; Distal-to-Proximal; or two horizontal stripes. An increase in peak force was found only after the horizontal application. It was confirmed that applying KT in various directions differently effects muscle strength.[94]

In direct contrast to what many studies have found, including ours, Landin et al.[135] studied the biceps brachii at the shoulder through externally stimulating the biceps brachii and measuring the shoulder elevation isometric torque it produced across specific combinations of shoulder and elbow angles. Shoulder elevation occurred within the scapular plane. It was concluded that the LHBM enhances the dynamic stability of the shoulder joint but only in the initial 30º of elevation. Beyond 30º, the LHBM, even though contracting, does not create a noteworthy elevation moment, which suggests that it cannot serve as a dynamic shoulder stabilizer in higher ranges of elevation.[135] And, Yamaguchi et al.[57] concluded that no significant biceps activity was observed in any shoulder, including patients with rotator cuff tears. But in their research, the LHBM, brachioradialis, and supraspinatus activity were compared in subjects with healthy shoulders to those with rotator cuff tears, [124] where as we included only healthy subjects. This is an interesting finding, since in our study, looking at the overhead throwing motion, there is detectable LHBM activity, along with altered muscle activity with the application of KT.

Could the application of KT to the LHBM help to reduce the occurrence or treat shoulder pain and/or injuries in this population? Ahamed et al.[133], Gowan et al.[120], Rodosky et al.[55], Chalmers et al.[134], and Landin et al.[135] found that the LHBM is active during this type of throwing, as did we. So, if the LHBM is active in the overhead throwing motion and can be a pain generator, would less or more LHBM activity be ideal? If so, through our study we found that with the application of KT, this reduction of muscle activity does occur. Can the application of KT be a part of a complementary approach to address those with shoulder pain, especially overhead throwers?

When looking at the influence of KT on muscle activity, our study focused on the application of KT from the proximal to distal end of the LHBM. Many books and articles pertaining to the application of KT, state that this application should result in a faciliatory effect of the muscle in which the KT is applied.[2,9,27,90,91,92,94] Our study did find a reduction in LHBM activity with the application of KT, but not of statistical significance and so cannot support this common line of thinking. Several studies have shown the same or similar results. On the other hand, there was found that UT muscle activity decreased with the application of KT to the LHBM. This is important to consider and can reinforce the understanding of the LHBM and UT relationship and the relating neuromuscular control and proprioceptive feedback factors.[147]

Vithoulk et al.[97] studied the effects of KT on quadriceps strength at maximum concentric and eccentric isokinetic exercise in healthy non-athlete women in order to examine the KT effect in increasing or decreasing the quadriceps strength. It was concluded that the application of KT on the anterior surface of the thigh, in the direction of the vastis medialis, laterals and rectus femurs, could increase the eccentric muscle strength in healthy adults.[97] Similarly, Choi et al.[91] studied the effect of KT application direction on quadriceps strength on healthy volunteers. There was a significant increase in muscle strength after taping, regardless of the KT application direction. Application of KT to three of the muscles of the quadriceps was recommended.[91] While Davison et al.[99] studied the inhibitory effect of KT on the gastrocnemius muscle of athletes. It was concluded there was statistical evidence that the values obtained from the sEMG showed a majority of the participants had a decrease in muscle activity during a single leg vertical jump after taping.[99] Although, this study did not focus on the faciliatory effects of KT, it did reenforce what is typically taught as the effect of KT dependent on the direction of application. However, in contrast, Cai et al.[137] compared the neuromuscular activity of the wrist extensor muscles and maximal grip strength with KT and tapeless condition in healthy adults who were ignorant about KT. The authors concluded that neither facilitatory nor inhibitory effects were observed between different application techniques of KT.[137]

Alternatively, Callaghan et al.[138] studied the effects of patellar taping on brain activity during knee joint proprioception tests while using functional magnetic resonance imaging. The study demonstrated that patellar taping modulates brain activity in several areas of the brain. It has been demonstrated that patellar taping can improve proprioception of the knee in people who are healthy and in patients with Patella Femoral Pain Syndrome (PFPS). [138] Even though this study did not focus on the direction of tape application, it did demonstrate that tape applied to the body can have an effect on the brain, which in turn can result in altered biomechanical movement and thus a reduction in pain.

When considering if the application of KT is time dependent, several studies looked at, if over time, there was more of an effect produced from the application of KT. Thelen et al.[104] conducted a randomized, double-blind, clinical trial to determine the short-term clinical efficacy of KT to sham tape when applied to college students with shoulder pain. The KT group showed immediate improvement in pain-free shoulder abduction. It was concluded that KT may be of some use for clinicians in improving pain-free active ROM immediately after tape application for patients with shoulder pain.[104] Mendez-Rebolledo et al.[98] analyzed the short-term effect of KT on height and ground reaction force during a vertical jump, in addition to trunk and lower limb muscle latency and recruitment order in healthy male athletes. It was found that the KT had no effect after 24 hours. However, at 72 hours, the KT increased the jump and normalized ground reaction force during the countermovement jump. Also, at 72 hours there was reduced longissimus onset latency and improved muscle recruitment order during a countermovement jump.[98] Similarly, Lee et al.[103] conducted a case report to investigate the effect of combined application of balance taping using KT on a part-time worker with shoulder impingement. The KT tape was applied for 3 weeks, on average 16 hours per day. By the end of the 3 weeks the Visual Analogue Scores decreased from 7 to 0 for shoulder flexion and from 8 to 0 for abduction and range of motion increased to normal. It was concluded that KT is suggested for someone with shoulder impingement.[103] While Paoloni et al.[108] also studied the effects of KT on pain, disability and lumbar muscle function in suffers of chronic low back pain, both immediately and at a one-month follow-up examination. It was concluded that KT does lead to pain relief and lumbar muscle function normalization shortly after application and persists over a short follow-up period.[108]

In contrast, Fu et al.[136] conducted a pilot study focusing on the effect of KT on quadriceps and hamstring muscle strength in Athletes. The result revealed no significant difference in muscle power, decrease nor increase.[136] Similar results were found by Jesus et al.[139], who studied the effect of KT on Quadriceps strength and lower limb function of healthy individuals over a 7-day period. Measurements were taken at baseline, immediately after KT application, 3 and 5 days after KT application and 72 hours after KT removal. It was concluded that KT did not improve quadriceps strength and lower limb function of healthy individuals.[139]

While considering the research, it may be necessary for KT to be applied for a longer period of time to provide a stronger or provable effect.[39,50,95,104,126,128,131] And since it is more common to apply multiple strips of KT when addressing shoulder pathology, it may be feasible to conduct research into comparing the application of multiple strips of KT[133,134] to only a single “I” strip.

Through the conducting systematic reviews and meta-analysis better decisions can be made through making maximally informed and minimally biased information widely available[140] by assessing the strength of evidence present.[141] Drouin et al.[84], Kalron et al.[142], Csapo et al.[92], Saracoglu et al.[123] and Richardson et al.[36] all conducted systematic reviews or meta-analysis focusing on KT or muscle recruitment in the upper extremity. KT was found to be lacking evidence that supports improving sports performance[84] or strength gains in healthy people[84,92], while it did show to be effective in aiding short-term pain[142] and it may have some therapeutic benefits[92] Many of the results were conflicting and weak, but can be concluded that clinical taping in addition to physiotherapy interventions might be an optional modality for managing patients with shoulder impingement syndrome, especially for the initial stage of treatment.[123]

It is becoming more commonplace to address more than the location of pain or injury and looking at the system as a whole. When considering the shoulder, incorporating multiregional kinetic chain (KC) shoulder exercises[36] or even as in our study, KT applied to the LHBM, trapezius ratios can be improved, which should reduce the demands on the rotator cuff[36], LHBM and result in better outcomes.

When considering the LHBM and UT relationship and the relating neuromuscular control and proprioceptive feedback factors[147], one can look at Richardson et al.[36] systematic review of EMG studies focusing on the influence of trunk and lower limb muscle activity and recruitment patterns around the shoulder. The authors investigated both multiregional kinetic chain (KC) shoulder exercises and localized non-kinetic chain (nKC) shoulder exercises in healthy subjects. KC exercises may increase axioscapular muscle recruitment, produce lower trapezius muscle ratio in all studies, which should reduce the demands on the rotator cuff.[36]

When considering treatment of the shoulder, there are many possibilities that can and should be addressed. What imbalances, injuries, distortions, or pain generators can impact the shoulder? Many athletes, such as baseball players, and non-athletes alike are looking for ways to prevent and/or treat shoulder pain, oftentimes arising from the LHBM. Frequently they take it upon themselves to treat this area with KT. Many times, applying it from the proximal to distal end of the LHBM. Does the application of KT in this direction provide the result that is desired? Does it reduce pain or even prevent injury? There are many ways to approach the shoulder in physiotherapy. As stated in our study and in others, KT may have a positive effect on the shoulder.

6.2 Study Limitations

This study had several technical limitations. The use of normal controls may not replicate the role of the LHBM in a population with pathology of this muscle. Ideally, these findings would be replicated in a study group with SLAP lesions, bicipital tendonitis or other LHBT pathology.

Also, the relatively small number of participants used can only provide a limited view of the impact of KT. A study with a larger sample size may provide a more comprehensive understanding of the effect of KT and its statistical significance.

Another limitation of the study is that the shoulder motion used is not exactly the same as in the baseball throwing motion, but similar. All pro bands had differing levels of knowledge, experience, and expertise of the throwing motion, which would have been carried into their ability to perform the studied shoulder motion. The use of wireless sEMG would allow the pro bands more freedom to perform an unabated baseball throwing motion.

Finally, the use of sEMG is another of the study's limitations. However, there are several previous studies which have described the use of sEMG for the LHBM.[55,56,122,133,135,143] There are many factors that can affect what data is recorded through sEMG, such as the many physiological, anatomical, and technical factors. The pro bands mental/emotional state, the electrode configuration and placement over the target muscle fibers, the amount of tissue between the surface of the muscle and the electrode and others can affect data recording. Taking all established precautionary measures, following the SENIAM[125] protocols for EMG use, and ideally, the use of fine wire EMG would minimize possible discrepancies in data collection.

7 CONCLUSION

This study showed that a single "I" strip of KT seems not to increase the muscle activity of the LHBM as an acute response when applied from its proximal origin to its distal insertion during the overhead throwing motion. On the other hand, a single "I" strip of KT reduced the muscle activity of the ipsilateral upper trapezius. Based on these findings, it is not suggested to apply KT with expectations of an acute muscle activity effect, but it is within reason, since it is well documented that sEMG requires strict and appropriate design methodology, which may significantly bias collected data when not carried out perfectly. Current results implicate that the mechanisms by which KT induces effects can be explained by neuromuscular control and proprioceptive feedback factors.

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9 ATTACHMENTS

9.1 Application for Approval by UK FTVS Ethics Committee

9.2 Informed Consent

9.3 Confirmation of the Workplace

9.4 Photos

Photo 1 – sEMG electrode placement; KT application direction from proximal-to-distal (red arrow); KT retractility direction (blue arrow)

Photo 2 – Initial 10 repetitions before KT application

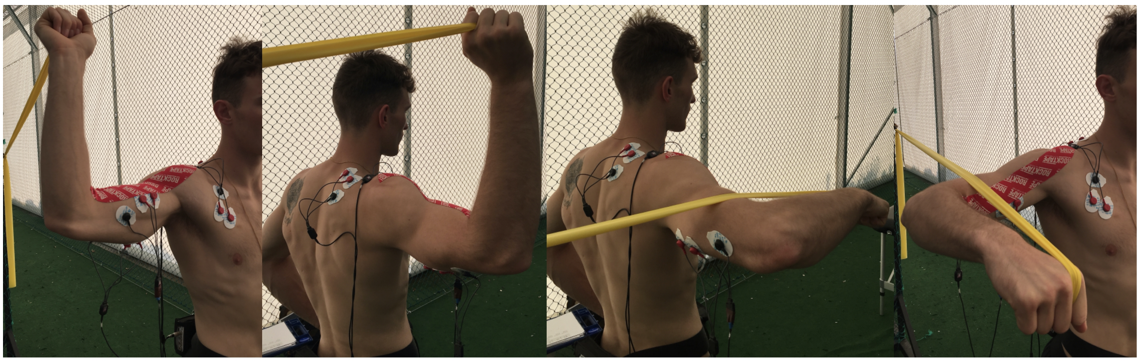

Photo 3 – 10 repetitions after KT application

9.5 List of Tables

9.6 List of Graphs

9.7 List of Figures