CHARLES UVINERSITY IN PRAGUE

Faculty of Physical Education and Sport

EMPIRICAL - THEORETICAL STUDY

MUSCLES ACTIVATION DURING „SHOULDER MOUNT“POLE ACROBATIC EXERCISE

Master’s thesis

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Prohlašuji, že jsem závěrečnou diplomovou práci zpracovala samostatně a že jsem uvedla všechny použité informační zdroje a literaturu. Tato práce ani její podstatná část nebyla předložena k získání jiného nebo stejného akademického titulu.

V Praze dne:……………………. ....…………………

Podpis studenta

Poděkování

V prvé řadě děkuji Ing. Miroslavu Vilímkovi, PhD za cenné rady, připomínky a podněty, které pomohly při zpracování mé diplomové práce. Za pomoc při přípravě a realizaci experimentu děkuji také Ing. Petru Kubovýmu a samozřejmě Ing. Miroslavu Vilímkovi, PhD. Tímto bych také chtěla poděkovat účastnicím, které se zúčastnily experimentu.

Content

ABSTRACT

Title:

MUSCLES ACTIVATION DURING „SHOULDER MOUNT"POLE ACROBATIC EXERCISE

Purpose:

This study is an empirical - theoretical study presents the literature review regarding to the topic of the shoulder function anatomy, kinesiology, biomechanics, non-traumatic injuries of the shoulder and their prevention by using the available literatures. Further, the study also compares by surface electromyography the amplitudes, shapes and durations of myoelectric signals of m. latissimus dorsi, m. pectoralis maior, m. biceps brachii, m. infraspinatus and m. supraspinatus of dominant shoulder in two healthy individuals during acrobatic exercise on vertical pole known as "Shoulder Mount". The purpose was monitor the changes in two different conditions; i.e. kinesiotape and elbow brace and compare with the control condition for the reason of finding out their ability to affect the myoelectric activities of selected muscles. Further, the Shoulder Mount exercise had recorded by six Qualisys cameras for motion analyses.

Methods and materials:

The potentially eligible scientific articles perform a search of studies on the topic of kinesiotapes and tennis elbow brace as measured by EMG mainly on myoelectric activity of the shoulder complex were seared from EbscoHost, BMJ, Embase, MEDLINE, PeDro and other databases . Grade stainless steel surface electrodes collected the EMG data. Electrodes with sizes 38mm x 19 mm x 17 mm were applied on the belly of m. pectoralis maior, m. latissimus dorsi, m. biceps brachii, m. supraspinatus and m. infraspinatus on dominant shoulder. Before the measuring of the myoelectric activities during Shoulder Mount exercise were participants performed the maximum voluntary isometric contraction (MVIC) for each muscles. Two healthy subjects (females) with a mean age of 23, 5 years participated in this study. They were informed about the experiment and had signed the agreement to publish their personal dates in the work. The movement components of selected segments were monitored by six Qualisys cameras recorded into computer. The methods were used for analyze the results included the graphic illustration of the EMG signals, bar charts, table contexts. The numerical results were achieved by calculation of the sample average and total peaks average in all submitted conditions within participants; also, the standard deviation value and two samples paired T tests were done. The materials used were Hg80 tennis elbow brace and kinesiotape from Mueller Sport Care.

Result:

Although the results were not statistically significant because there were a few amount of tested samples in experiment. The positive inter results within the subjects were achieved. There was proved the benefits of tennis elbow brace on myoelectric amplitude of m. biceps brachii. The decrease of the amplitude was occurred in both participants and subjectively described the negative feedback on the quality of the movement. The kinesiotape as was applied in the experiment increased the amplitude of m. infraspinatus and vice versa, decreased the activity of m. latissimus dorsi. Subjectively described both participants positive feedback on the movement quality. Generally, the outputs of the results were heterogeneous for other muscles.

Key Words:

Surface EMG, Shoulder Mount, shoulder injury, kinesiotape, elbow tennis brace.

ABSTRAKT

Název práce:

AKTIVACE SVALŮ BĚHEM "SHOULDER MOUNT" CVIKU NA VERTIKÁLNÍ TYČI.

Vymezení problému:

Tato empiricko- teoretická práce shrnující v teoretické části poznatky z funkční anatomie, kineziologie, biomechaniky ramenního komplexu a způsob vzniku netraumatických úrazů a možnosti jejich léčby využitím odborných literatur. Práce v praktické části porovnává pomocí povrchové elektromyografie amplitudy, tvary a průběhy myoelektrických signálů z m. latissimus dorsi, m. pectoralis maior, m. biceps brachii, m. infraspinatus a m. supraspinatus na dominantní horní končetině u dvou zdravých jedinců během Shoulder Mount cviku na vertikální tyči. Účel byl zaznamenat změny za použití dvou různých pomůcek tj. kineziotapu a ortézy na tenisový loket k zjištění jejich schopnosti ovlivnit výše uvedených parametrů elektromyografických signálů zvolených svalů. Dále je součástí záznam a analýza Shoulder Mount cviku k dalším zpracováním.

Metoda a materiály:

Potenciálně vhodné odborné články, zaměřující se na využití kineziotapů a tenisových ortéz, měřeno pomocí EMG se záměrem ovlivnit myoelektrickou aktivaci ramenního komplexu, byly pro tuto práci hledány z EbscoHost, BMJ, Embase, MEDLINE, PeDro a jiných databázích. Využity byly elektrody z nerezových povrchů velikosti 38mm x19mm x17mm, které byly aplikovány na svalová bříška m.pectoralis maior, m. latissimus dorsi, m. biceps brachii, m. supraspinatus a m. infraspinatus na dominantní paži. Před samotným snímáním svalových aktivit při Shoulder Mount cviku, byla potřeba u každého jedince provést maximální volnou kontrakci jednotlivých svalů. Dvě zdravé subjekty (ženy) s průměrným věkem 23,5 se zúčastnily tohoto studia, o průběhu byly řádně informované, s podmínkami souhlasily tím, že podepsaly informovaný souhlas ke zveřejnění jejich údajů pro účely v této práci. Součástí praktického výzkumu bylo úkolem provést analýzu Shoulder Mount pohybu, který byl zaznamenán pomocí šesti Qualisys kamer do počítače. Metody pro vyhodnocení výsledků byly používány grafickým znázorňováním EMG signálů, užitím sloupcových diagramů, tabulek, číselným ukázáním výsledků, pomocí výpočtů jednotlivých a celkových průměrů svalových signálů, které se mezi sebou porovnávaly. Využity byly také

výpočty směrodatných odchylek a dvou-výběrový párový T-test. Materiály použité v tomto studiu jsou mimo jiné Hg80 ortéza na tenisový loket a kinesiotape od společnosti Mueller Sport Care.

Výsledky:

Ačkoliv na výsledky nemohl z hlediska statistické významnosti brán zřetel, protože se studia účastnilo málo subjektů, k určitým pozitivním závěrům v rámci zkoumaných subjektů, se přeci jen docílilo. V rámci zkoumaných subjektů, bylo dokázáno, že tenisová ortéza snižuje svalovou amplitudu u m. biceps brachii přestože účastnice popisovaly pocitově negativní dopad na kvalitu pohybu. U kineziotapu byly subjektivní pocity účastnic pozitivní v rámci zlepšení kvality provedení pohybu, objektivně měl kineziotape, tak jak byl v tomto experimentu aplikován, vliv na zvýšení svalové amplitudy m. infraspinatu, a snížení svalové amplitudy u m. latissimus dorsi. Obecně byly výsledky pro zbylé svaly různorodé.

Klíčová slova:

Povrchová EMG, Shoulder Mount, úrazy ramenního pletence, kineziotape, tenisová ortéza na loket.

LIST OF ABBREVIATIONS

ABD	Abduction
AC	Acromio-clavicular
ACJ	Acromio-clavicular joint
CC	Coraco-clavicular ligament
FL	Flexion
GHJ	Glenohumeral joint
IR	internal rotation
kg	kilogram
lig	ligament
LD1	Latissimus dorsi of first participant
LD2	Latissimus dorsi of second participant
M.	Muscle
MVC	Maximum voluntary contraction
MVIC	Maximum voluntary isometric contraction
n	number
P1	Pectoral muscle of first participant
P2	Pectoral muscle of second participant
SCJ	Sterno-clavicular joint
STJ	Scapulo-thoracal joint
yrs	Years

1 Introduction

.....Non-traumatic damage to the shoulder joint is mostly caused by soft tissue disorders of the shoulder, which may not be directly related to the trauma of the shoulder. Muscle imbalances represent a frequent problem in our population. Increased muscle tension occurs after physical work, sports performance prolonged maintaining in static positions or because of psychological discomfort. Non-traumatic injuries to the shoulder frequency cause in 65% by disorders of the rotator cuff muscles.

Nodaway, we are surrounded by a myriad of sports where the athletes need to work frequently with the arms overhead so that leads to overuse of the rotator cuff muscles. Overload of these muscles is connected with increasing muscle tension and/or formation of trigger points. Muscle imbalance involves muscles of the whole body; the pattern of muscle imbalance produces typical changes in posture and motion. Muscle imbalance is a systematic change in the quality of muscle dysfunction that results in altered joint mechanics leading to pain. Muscle imbalance is the altered relationship and balance between muscles that prone to inhibition or weakness and those that prone to tightness or shortness. Moderately tight muscles are usually stronger than normal.

Functional problems represent the field of work for physiotherapist who improves performance and quality of movement. There exist many techniques to prevent the functional problems in many variations of strengthening and relaxation processes performed by physiotherapists as well as the therapeutic taping protocols what have demonstrated a well-established presence in the sporting world for years. Three main taping techniques accepted in Czech Republic are athletic taping, McConnell taping technique, and kinesiotaping technique. It has been theorized that taping may prevent acute injury acquisition by enhancing proprioception via coetaneous afferent stimulation of the skin. Kinesiotaping technique, employing the newest form of elastic tape developed in the 1970s by Dr. Kenzo Kase. Another possibility is to use the mechanical support of a brace to support, align, prevent, or improve function of movable parts of the body.

The purpose of this study is to compare the ability of kinesiotape applied for support of internal rotation in the shoulder (see figure n.3) and the tennis elbow brace, to affect the myoelectric activity of selective muscles on dominant shoulder. The use of the surface EMG may help to find out the meaning of the kinesiotaping and elbow bracing on amplitudes, shapes, and duration of EMG signals of the m. biceps brachii, m. pectoralis maior, m. latissimus dorsi, m. infraspinatus, and m. supraspinatus. The surface EMG may also determine whether the activation of the muscles with the brace or kinesiotape is lower.

2 Literature Review

2.1 Functional Anatomy of the Shoulder

The shoulder is most flexible joint in the human body. It allows movement in three planes of space around the three main axes that is a prerequisite for implementing many functional movements, such as: carrying, lifting, pushing, positioning, feeding, etc. The shoulder girdle is a functional unit that connects the arm, hence the upper limbs, trunk and allows movement of one component to the second component (Perry et al., 2001; Oatis et al., 2008). The shoulder girdle is formed by the clavicle, scapula and humerus. Everything is connected through joints. Shoulder function, however, are not determined only by articular structures, but also the degree of dynamic controls that provide muscle and nerve supply (Neumann et al., 2001). The most frequently occurring movement patterns of the shoulder girdle include elevation, rotation of the arm and holding a hanging arm against gravity, less often depressed and horizontal movements. Each of these movements has specific biomechanical requirements for passive and active structures (Perry et al., 2001).

2.1.1 The Components

The classical anatomical point of view, the shoulder consists of three joints: sternoclavicular (SCJ), acromioclavicular (ACJ), and glenohumeral (GHJ). Most authors dealing with the biomechanics of the shoulder complex in addition to the above three, also mention joint scapulothoracal (STJ), which does not belong to the so-called "true/right joints", but in a clinical context plays an important role. The representatives of "false functional" joints of the shoulder according to Kapandji (2006) also include subdeltoideal joint.

<u>The Sternoclavicular Joint</u>

The joint between the clavicle and sternum bone is the only connection between the upper limb and trunk. Its shape is rather a saddle, incongruent, where the collarbones upwardly beyond the shallow bearing shell at the chest bone. The joint is easily traceable at palpation. This incongruence and compensates for ligament instability cartilaginous disc, extending into the cranial side of the joint, which is also the widest caudal direction and then narrows. The inherent feature of this disc also includes the absorption of shocks transmitted from the upper limb (Levangie and Humphrey, 2000; Janura et al., 2004).

Joint capsule is clamped near the articular surfaces of the sternum and clavicle. It is fixed, and in particular of the anterior, superior and posterior sides. This gain is also involved lig. sternoclaviculare anterior and posterior, limiting slip clavicle backwards and forwards (Lippert, 2011). The joint is further stabilized from front by sternal sternocleidomastoid muscle and from behind by m. sternothyroideus and sternohyoideus. Other ligaments in this area include lig. interclaviculare which is unbuttoned between the medial end of both collar bones and lig. costoclaviculare limiting every extreme movements of the clavicle. The lig. costoclaviculare is clamped on the first rib near the sternum and the lower part of the clavicle (Neumann et al., 2010).

Movement in the SCJ is characterized by three degrees of freedom in three basic levels. Around the antero-posterior axis of the proceeds of elevation and depression in the frontal plane. Around superioinferior axis runs, protraction and retraction in the transverse plane and around the longitudinal axis extend axial rotation of the clavicle. These movements, however, are small and cannot be made in isolation. Typically complement complex movement patterns, of which is considered the most significant axial rotation of the clavicle in the abduction of the upper limb. Bartoníček and Heřt (2004) describe a term clavicle rhythm, that says: the movement up to 90 ° of abduction in GHJ leads to elevation of the clavicle in a ratio of 5:2, 90 ° followed by only the rotation of the clavicle in the ACJ, because the elevation limits by lig costoclaviculare (Čihák, 2011; Janura et al., 2004; Sagar, 2008).

Acromioclavicular Joint

The ACJ is usually described as a flat joint. It is the only connection between the clavicle and scapula. Articular facets are usually straight, but may have a slightly concave curvature. They are covered with the most of fibrous slightly hyaline cartilage (Oatis et al., 2008). Weak joint capsule amplifies inferiorly and superiorly lig. acromioclavicular superior and inferior. Lig. coracoclaviculare is among other stabilizing element of the ACJ, the ligament is formed by lig. trapezoideum and lig. conoideum extending from the processus coracoideus of the scapula to the inferior surface of the clavicle (Sagar, 2008). ACJ includes intra-articular meniscus shaped with many variations in the general population (Oatis et al., 2008).

Although the movement in the ACJ and SCJ must be done simultaneously, there are some differences in the mobility of these segments. SCJ allows the clavicle relatively large momentum, which in turn indicates the path of the blade through the ACJ. In contrast, however, the movement of the ACJ represents only slight skimming blade against clavicle. The challenge, however, is crucial for maximum mobility of the STJ, and the entire shoulder girdle (Neumann et al., 2010). Movements in the ACJ are therefore described in three degrees of freedom. Shoulder blade scoops the ACJ rotates on a vertical axis, along a horizontal axis in the frontal plane and along a horizontal axis in the sagittal plane (Janura et al., 2004).

Glenohumeral Joint

The glenohumeral joint is a freely mobile, ball-and-socket joint. Oatis et al. (2008) argue that due to a very similar degree of curvature of the humeral head and socket the GHJ exhibits a high degree of congruence. The articular surface on the glenoid fossa of the scapula is shallow, but is deepened by a rim of the glonoid labrum. In that way, the humerus can move in any plane with respect to the scapula. The capsule of the joint is attached round the glenoid labrum and to the anatomical neck of the humerus, except inferiorly where the attachment passes downward on to the shaft. The capsule is loose inferiorly and thus, with the shallow articular surfaces, permits a wide range of movements (MacKinnon and Morris, 2005). The synovial membrane, lines the inside of the joint capsule and also surrounds the tendon of the long head of biceps brachia, which takes place inside the joint in the sulcus intertuberculare (Neumann et al., 2010). In the caudal part - in fossa axillary, is the joint capsule crinkled, when the maximum excursion of the shoulder is restricting the movement voltage (Huei-Ming Chai et al., 2004). Fibrous sheath fibers have twisted anterior and medial direction. This twist is increased when arm abduction, but on the flexi arm is lowered (Oatis et al., 2008).

On the front of the joint capsule are stretched three-glenohumeral ligaments: lig. glenohumerale superior, medium and inferior; according to Kapandji (2006) are formed into the shape of Z and while the extension and external rotation stress protect the GHJ. The superior glenohumeral ligament is associated with the lig. coracohumerale also stabilizing the GHJ, and the joint capsule on the inner side, the space between the tendons of supraspinatus and subscapularis. At this point, therefore, is to link the above ligaments, joint capsules, tendons, rotator cuff and the tendon of the long head of biceps brachia, which are also in progress. The rotator interval of the joint capsule is in Old English literature called an area of the triangular shape of the joint capsule and provides the necessary protection against inferior subluxation of the humeral head in a neutral position of the GHJ (0 °). In the event that the upper limb is hanging freely without the burden, sides of passive structures rotator interval are able to keep the upper limb against gravity without additional muscle activity. When the elevation of the arm arise, superior fibrous components are released and protection against inferior translation of the humeral take toward inferior fibrous structures (Levangie and Humphrey, 2000; Oatis et al., 2008).

However, the muscles focusing the stability of the shoulder joint. To keep the head in the acetabulum are of great importance to the transverse process of the rotator cuff muscles (Dylevský, 2009). Basmajian (1967) in this context called dynamic stabilizers. As the most stable position is described abduction with mild elevation of the arm. The GHJ appears to be a universal joint, in which the movement takes place along three axes in three degrees of freedom. Records of the values of range of motion (enclosure n. 5 in the joints between the various authors are differ (Tab. 1).

Motion	**Janda (1993) gives the following values:**	**Values by Kapandji (2006):**
Flexion	100°	180°
Extension	60°	50°
Adduction (horizontal plane)	40°	45°
Abduction	180°	180°
Internal Rotation	90°	110°
External Rotation	90°	90°

Table 1: The ROM in the Shoulder.

However, we cannot simply say that these ranges are achieved purely in the GHJ. Instead, as mentioned above, movement of the shoulder girdle is highly specific complex process in which the movement must take place even in the SCJ, ACJ, STJ and subdeltoideal joint. Another condition of full range of motion in the GHJ is the presence of so call roll and slide - i.e. rolling and glider movements in the joint during motion. Due to the different diameters of the head and socket, have both units a different rotational axis during the movement. This fact causes that when moving around the three principal axes there is no clean rotation, but the center of rotation changes and to prevent subluxation of one of the segments need to move joint surfaces against each other. (Neumann et al., 2010; Oatis et al., 2008; Sagar, 2008).

Scapulothoracal Joint

The STJ belongs to the so-call false joints that lack traditional characteristics of joint connection except one - and that is movement. The main role of the STJ namely increases range of motion in the GHJ thus allowing various momentums of the limbs to the trunk (Oatis et al., 2008). Therefore, it is a link between the anterior convex surface of the blade and the concave back wall of the chest. Irreplaceable role in this joint are ligaments and muscles clamping the blades that provide joint stability and, of course, allow moving the blades past chest wall.

For the neutral position of the scapula is usually referred to a position where the blade forms an angle with the frontal plane and is slightly retracted backward (Čihák, 2011), corresponding to the localization of 6 cm lateral to the spine and between the second and the seventh rib (Neumann et al., 2010), according Dylevský (2009) eighth rib. The position of the scapula of course differs from individual to individual. For reasons described above, the position of the blades occurs most frequently in the elevation plane of the humerus being diverted 30 ° from the frontal plane - the plane of the blade (Neumann et al., 2010). The main function of the blade is then considered adapting the acetabulum of the shoulder joint, located just to the scapula, humerus head movement so that in every situation for optimum contact these segments (Janura et al., 2004).

The movement of the blades on the chest is a result of activity in all three joints: STJ, ACJ and SCJ. This is an elevation/ depression, protraction/ retraction of internal and external rotation of the scapula. The slope of the acetabulum on the blade during rotation varies by up to 50 ° (Dylevský, 2009), according to other authors; up to about 60 ° (Janura et al., 2008; Neumann et al., 2010; Oatis et al., 2008). No rotation of the clavicle in ACJ and SCJ, no elevation in the SCJ, however, of such magnitude could ever be achieved, and such elevation arm would be limited to 120 ° (Janura et al., 2004). Acromial and coracoideus prongs are greatly overloaded because of exposed muscle strength to them attachment. Among these protrusions extends about 1, 5 cm wide lig. coracoacromiale (in literature also known as the fornix humeri), which appears to enhance and stabilize the bone structure. According Dylevský (2009) is not included in any joint. The space between the humeral head and fornix humeri create a gap, where run the rotator cuff muscle tendons. During abduction of the GHJ there creates the contact between the front of the ligament and the greater tubercle of the humerus (Dylevský, 2009).

Subdeltoideal joint

In the space below the deltoid muscle is another false functional joint- subdeltoideal. Inferior articular capsule is bounded by GHJ and muscles of the rotator cuff as infraspinatus, supraspinatus and teres minor. There is a thin bursa subdeltoidea, which often communicates with bursa subacromialis. These two bursas allow movement of the deltoid muscle to the structures stored below (Dylevský, 2009; Kapanji, 2006).

Vascular and Nerve Supply

Arterial supply to the shoulder joint is via the anterior and posterior circumflex humeral arteries, and the suprascapular artery. Branches from these arteries form an anastomotic network around the joint. The joint is supplied by the axillary, suprascapular and lateral pectoral nerves. These nerves are derived from C5 and C6 roots of the brachial plexus. Thus, an upper brachial plexus injury (Erb's palsy) will affect shoulder joint function (Čihák, 2011).

2.2 Biomechanics and Kinesiology of the Shoulder

2.2.1 Basic Biomechanical Properties of the Shoulder

Scapulohumeral Rhythm

Scapulothoracal or scapulohumeral rhythm is a concept that further describes the movement relationship between the shoulder girdle and shoulder joint. The first 30 degrees of shoulder joint motion is pure shoulder joint motion. However, after that, for every 2 degrees of shoulder flexion or abduction that occurs, the scapula must upwardly rotate 1 degree. This fact can be expressed by the ratio of 2:1 (Lippert, 2011). Inman (1944) study however, preoccupied with movement of the SCJ and ACJ. 180 ° abduction divided into two phases:

a. Early phase: abduction to 90°

The movement begins in the GHJ, where for every 3° of abduction attributed 2 ° to GHJ and 1° attributed to the rotation of the blades. Logically it follows that the blade should start to rotate in the ACJ. Strain lig. coracoclaviculare but does not allow rotation, therefore occurs in a possible further movement of the joint and in the SCJ. There is therefore the clavicle elevation. Inman gives clavicle elevation of 25°, further movement impossible lig. costoclaviculare. This time has been moved to the movement of the ACJ clavicle rotated by 10°. Abduction at this stage is again summation 60° in GHJ and 30 ° rotation of the scapula.

Clavicle in SCJ elevates only about 5 °, unlike the blade, which rotates in the ACJ about 25 °. At the end of the movement, thus scapula rotated by 60 °, with 30 ° rotation took place in the ACJ and 30 ° with elevation of the clavicle in the SC joint.

<u>b. Later phase: abduction from 90 ° to 180 °</u>

During the late phase of the abduction of the shoulder occur gradually tensions both ligaments costoclaviculare and coracoclaviculare, or are already, this ligament stretches. However, in order to scapula rotation of the last 30 ° must be tension lig. coracoclaviculare partly allowed. This authorization is obtained posterior rotation of the clavicle, which occurs in the last phase of abduction. Lateral end of clavicle is closer to the processus coracoideus, ligament strain is deprived of and blade can continue to rotate. No posterior rotation of the clavicle could not be abduction of the shoulder girdle never fully implemented (Inman, 1944; Neumann et al., 2010; Sagar, 2008).

2.2.2 The Kinesiology of the Shoulder Girdle

The muscles of the shoulder girdle perform two main functions: movement of the upper limbs to the trunk and vice versa, and dynamic stabilization of the GHJ. From the didactic point of view can be divided into the following groups:

- The first three parts of the deltoid muscle (anterior, medius, posterior)
- Second rotator cuff muscles (m. supraspinatus, m. subscapularis, m. infraspinatus, m. teres minor) it can also include the long head of biceps and triceps brachia muscles)
- Third axilo-humeral muscles (m. pectoralis major, m. latissimus dorsi, m. teres major)
- Fourth scapulothoracal muscles (m. serratus anterior, m. trapezius, m. rhomboideus major and minor, m. levator scapulae, m. pectoralis minor), (Perry et al., 2001).

Most of the muscles of the shoulder complex can also be divided into the following categories: proximal muscles provide stability (clamping the vertebrae, ribs, or skull and continuing the scapula or clavicle) and distal muscles ensuring mobility (clamping the blade and collarbone and on continuing the humerus). The mutual balance between the muscles of these two categories is based optimal function of the shoulder girdle (Neumann et al., 2010).

The following text will be closely involved only muscles important for the practical part of the thesis (Figure n. 1).

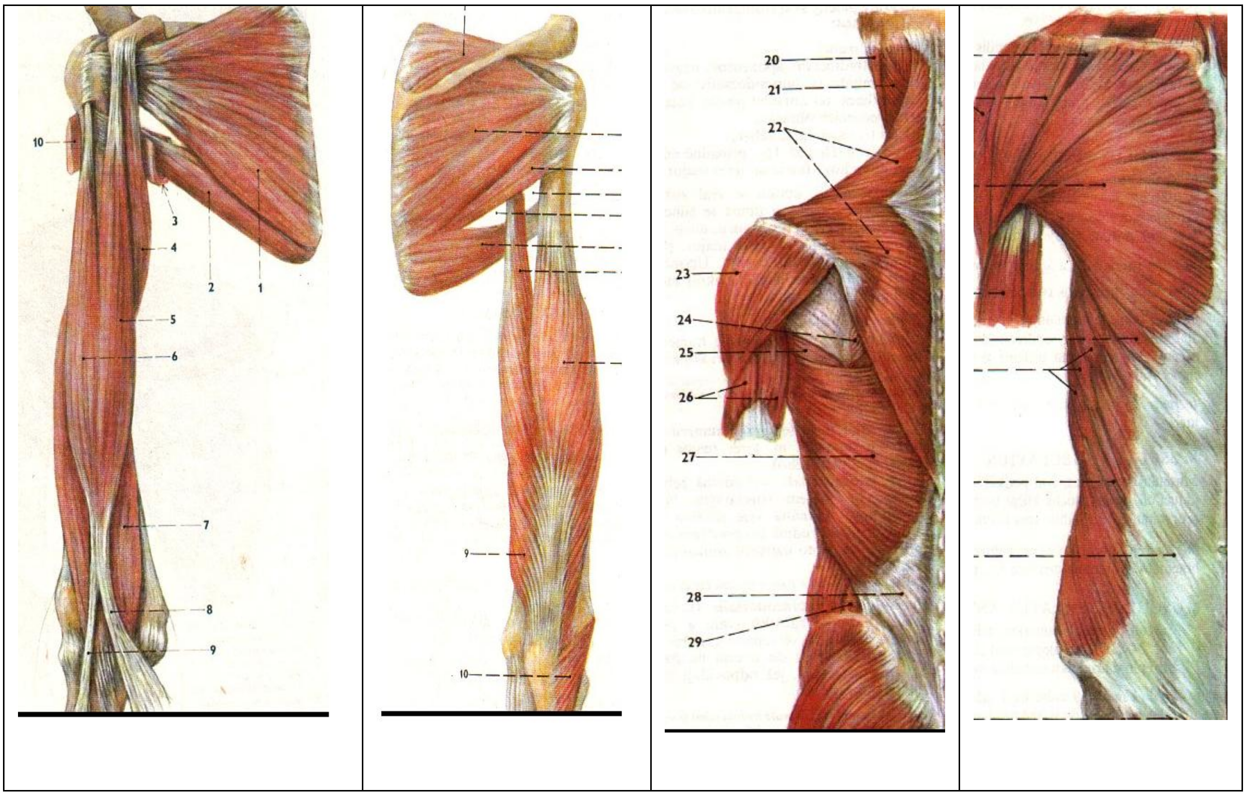


Figure n. 1: Anatomy of the muscles of interest important for the practical part of the thesis.(Čihák, 2011).

<u>Pectoral Major Muscle</u>

Musculus pectoralis major covers the front surface of the chest and attaches to the arm. It is divided into three parts: the pars clavicularis, sternocostalis pars, pars abdominalis. Pars clavicularis helps deltoid muscle to flex the GHJ; the other two parts are then extensors. Muscle as a whole performs an abduction and internal rotation of the arm, complementing the work of dorsal latissimus muscle. The interplay of these two muscles causes the strength of the internal rotators is seven times greater than the strength of the external rotators (Dylevský, 2009; Neumann et al., 2010; Sagar, 2008).

Together with the pectoralis minor and serratus anterior muscles, mediates the horizontal flexion of the arm with most active part of clavicular portion (Pearl et al., 1992). During fixed upper limb, pectoralis major helps to breathe while allows the rotate the trunk leaning to deltoid muscle (Dylevský, 2009; Perry et al., 2001; Véle, 2006).

<u>Latissimus Dorsi Muscle</u>

A large flat triangular muscle connects the humerus to the trunk. It affects not only the momentum of the upper limbs, but also contributes significantly to the trunk because of their insertions on the pelvis, lumbar spine and thoracic part of the spine. In some of individuals is also connected to the lower angle of the blade (Dylevský, 2009; Véle, 2009).

The function of this muscle includes extension, adduction and internal rotation of the arm, lateroflexion and trunk rotation, or depression of the blades. The massive contraction of the latissimus dorsi muscle tends to deploy humerus caudal direction; a synergist in extension and adduction to m. triceps brachii, or its long head that his move cranial direction keeps the head in the pocket (Kapandji, 2006) hampers this phenomenon. In the case of fixed humerus, the activity of m. latissimus dorsi elevates the pelvis. This activity can be put to good use when walking on crutches in paraplegics, when the latissimus able to compensate for paretic flexors of the hip. EMG studies show that along with the sternal pectoralis major part and the lower part of the trapezius is one of the main muscles enabling movement mainly in the vertical direction (Neumann et al., 2010; Perry et al., 1996).

Supraspinatus Muscle

The supraspinatus muscle arises from medial two-third of the supraspinous fossa of the scapula and attaches laterally to the superior facet of the grater tubercle of the humerus (Čihák, 2011). The supraspinatus muscle abducts the arm and pulls the head of humerus inward toward the glenoid fossa, which prevents downward displacement hanging down at the side. The supraspinatus muscle stabilizes the head of humerus in the glenoid cavity when one uses the arm. The activity of this muscle during abduction of the arm increases almost linearly from resting to vigorous activity at 150° of ABD. During flexion, the activity increases rapidly at first, reaches a plateau, and again increases as flexion approaches 150° (Ito, 1980). During sustained flexion or abduction to 90°, the supraspinatus muscle is first to show evidence of fatigue compared with other shoulder muscles (Herberts, 1976). The muscle is synergist with middle deltoid, upper trapezius and rhomboid muscles during abduction of the arm (the latter two acting on the scapula); these muscles are also active at varying degrees during flexion (Ito, 1980). The latissimus dorsi, teres major, and lower fiber of the pectoralis major muscle can act as antagonists to the supraspinatus.

Infraspinatus Muscle

The infraspinatus attaches medially to the medial two - third of the infraspinous fossa below the spine of the scapula and to adjacent fascia. Laterally it fastens to the posterior aspect of the greater tubercle of humerus (Čihák, 2011). The infraspinatus muscle laterally rotates the arm at the glenohumeral joint with the arm in any position, and helps to stabilize the head of the humerus in the glenoid cavity during movements of the arm (Kendall, 1993; Cailliet, 1977). Its activity increasing abduction, with additional peaks of activity during flexion. In compared to the supraspinatus is its activity relatively low that gradually and steadily increased throughout both abduction and flexion. The one exception was a marked but variable increase at 140° that usually reached only moderate levels of contraction (Inman, et al, 1944). The studies show that the infraspinatus and teres minor muscles have nearly identical actions, but different innervations. The infraspinatus muscle functions in parallel with the teres minor and posterior deltoid for lateral rotation of the arm (Basmajian, 1985). The infraspinatus also functions synergically with the supraspinatus and other rotator cuff muscles by stabilizing the head of the humerus in the glenoid cavity during abduction and flexion of the arm. The subscapularis, pectoralis major and anterior deltoid muscles act as antagonists to the infraspinatus and posterior deltoid for rotation of the arm.

Biceps Brachia Muscle

This double-jointed muscle closes the front of the arm between the shoulder blade and radius. It has a short and a long head. Both heads are combined in a single muscle belly, which significantly contributes to flexion and supination of the elbow. The elbow is the main place of muscle, the shoulder joint biceps brachia acts more as an assistant and fiscal muscle. M. biceps brachia is able elevate humeral head and thus eliminate inferior dislocation of the shoulder joint (Čihák, 2001; Dylevský, 2009; Véle, 2006).

The caput longum is referred to as the abductor muscle of the shoulder joint, caput breve as flexor and adductor. Caput longum begins in supraglenoidal tubercle or at the labrum glenoideale. The tendon runs over the upper surface of the humeral head ventro-laterally direction, passes through the distal sulci intertubercularis. In place of the tendon during joint capsule is covered by a synovial tendon sheath that accompanies it and the output of the joint. The tendon of the caput longum therefore undergoing intra-articularly, but extrasynovialy (Bartoníček and Heřt, 2004; Kapanji, 2006). Caput longum provides compression head into the wells and especially during abduction. When the rupture is abduction altered by up to 20% (Itoi et al., 2009; Perry et al., 2001). Habermeyer et al. (1987) EMG studies have shown that the most effective way caput longum stabilizes the shoulder joint during external rotation. Levy et al. (2001) and Yamaguchi et al. (1997) have pointed out in their EMG studies on the minimum activation of biceps brachia in movements in shoulder joint, and particularly in the abduction. Its main function find in controlling the movement at the elbow joint. M. biceps brachia play an important role in the body as proprioceptive neuromuscular control and coordination of movements of the shoulder joint, depending on the movements in the elbow joint.

Abduction Stereotype

The main abductors of the GHJ include deltoid and supraspinatus. Abduction arm, however, is realized not only the muscles performing the actual movement of the humerus to the blade but also the muscles of intermediate mobility of the blades, which is essential for achieve maximum range, and the muscles of the rotator cuff to ensure dynamic stability of GHJ Véle (2006) divided the course into four phase's abduction. The first phase is applied during movement especially the supraspinatus. From 45 ° increase in activity deltoid. Above 90 ° is a significantly involved muscle performing the movement of the blades. From 150 ° causes increased lumbar lordosis and trunk inclination due to the activation of the trunk muscles.

Role of the deltoid and supraspinatus during abduction is often discussed. Neumann et al. (2010) argues that the deltoid and supraspinatus contribute implementing abduction equally. It states that in paresis of the deltoid, supraspinatus is not able to make full abduction, but in paresis or rupture of the supraspinatus is limited the extent of abduction. Véle (2006) and Dylevský (2009) believe that the supraspinatus abducts only arm to 90 °. According Janura et al. (2004) above each muscle is able to perform abduction separately. It also questioned the fact that the supraspinatus initiates abduction. The beginning of this movement is usually associated with the position of the upper limbs dangle. The head of the humerus is located in the upper part of the acetabulum. The tensile strength of the deltoid muscle in this position tends to move the humerus more cranially. In that prevents it from media compression head into the socket the rotator cuff muscles, which include the supraspinatus (Janura et al., 2004; Neumann et al., 2010; Sagar, 2008).

Janura et al (2004) indicates that the most significant compression contributes the m. teres minor, which often limits the deltoid muscle. According to Kapandji (2006), the supraspinatus effectively involved at the beginning of abduction, however, is not the only initiator. This view is shared by Itoi et al. (2009). Peat and Graham in their study in 1977 proved that the mutual involvement of the muscles is very individual depending on the presence or absence of pathology. This is favored by the Véle (2006).

The essential components of the abduction of the arm also include the external rotation of the lower angle of the scapula. This is made possible by cooperation between m. serratus anterior and trapeze muscle. Depending on the plane in which the abduction takes place, are also involved rhombic muscles that eliminate protraction activity of m. serratus anterior. M. trapezius and m. serratus anterior are therefore synergists during external rotation of the lower angle, but also as necessary antagonists, who mutually limiting protraction and retraction of the blade. M. serratus anterior activity gradually increases during the entire movement, the lower part of the trapezius muscle has the highest activity in the late stage of abduction. Both muscles are also needed to create Punctum Fixum of distal muscles ensuring the mobility of the humerus (Neumann et al, 2010). In the case of upper limb abduction takes place over the horizontal, requires the presence of external-rotation activity that eliminates contact of large bumps in the humerus and the acromion, coracoacromial ligament. Move to abduction therefore can never be fully implemented if the external rotation insufficiency (Janura et al., 2004).

2.3 Shoulder in Pole Dance

Pole dance is a modern form of performance art, the activity of "pole dancing" has recently been transformed from an act performed exclusively in strip clubs to one currently marketed as a form of aerobic exercise. While much feminist academic work (Giuffre, 2011); has investigated aspects of the sex industry, such as stripping, very little research has been conducted into this recent social phenomenon of pole dancing as a recreational activity (Whitehead, 2009), so far there are no studies and literature from the perspective of biomechanics, physiotherapy or/and sports in the Scientific databases.

This art form has recently gained popularity as a form of fitness and mainstream entertainment, practiced by many enthusiasts in gyms and in dedicated dance studios. Since the mid of years 2000 promoters of pole dance fitness competitions have been trying to change people's perception of pole dance and to promote it as a non-sexual form of dance and acrobatics centered on a vertical pole. Materials of which poles are made include steel, brass, and titanium coating. Pole with a circular cross section and diameter usually with 5cm, running from floor to ceiling.

Pole dance requires significant strength, flexibility and endurance; it involves athletic moves such as climbs, spins, and body inversions using the limbs to grip. Upper body and core strength are required to attain proficiency, and rigorous training is necessary.

Many sports activities that involve the upper extremity entail similar patterns of movement. Analysis of these activities, a better understanding of the overhead motion, and an awareness of shoulder diseases or injuries have led to a rational plan for investigation and management of shoulder problems. Evaluation often extends beyond the usual medical boundaries and must be based on information obtained from an analysis of sports mechanics, a review of training methods, and a physical examination directed at determination of flexibility, strength, endurance, and the presence of inflammation.

The common injuries to the shoulder presented in the professional pole dance are damage to the acromioclavicular joint (shoulder separation), instability of the glenohumeral joint, and a spectrum of pathologic changes in the rotator cuff. An injury to the shoulder occurs when the stress applied to a tissue is greater than its ability to 'absorb' the stress acutely or chronically, or because of history of the fall from the vertical pole.

2.3.1 Acromioclavicular dislocation

AC dislocation is commonly referred to as AC separation. The classification of AC dislocation has evolved throughout the years; here we present the commonly used classification described by Rockwood and Green (Rockwood, 1984).

Type I

Type I AC dislocations are by far the most common. There is no tearing of the AC or CC ligaments and no instability. The radiographic examination is normal. Initially, interventions such as ice, analgesics, sling, and relative rest should be employed. As pain decreases, range of motion and strengthening exercises can begin and the sling may be discontinued. Resumption of activities is appropriate when the patient achieves painless range of motion and can perform activity specific movements without pain or instability.

Type II

Type II dislocations result from rupture of the AC ligaments and capsule, but spare the CC ligaments. The clavicle is unstable and painful to direct stress examination, cross-body adduction, and with any arm movement. On radiographs, the lateral end of the clavicle may appear slightly elevated but there is less than 100% separation of the clavicle and acromion.

Type III

Anatomically, there is disruption of both AC and CC ligaments without significant disruption of the deltoid or trapezial fascia. On radiographs, the acromion appears depressed while the clavicle appears high riding. In reality, the acromion is displaced inferior to the horizontal plane of the lateral clavicle, which is fixed in place by the strong connections of the sternoclavicular joint. The clavicle is unstable in both the horizontal plane and the vertical plane, and radiographic examination of both is abnormal. Pain with any motion or everyday use is severe, typically for the first 1 to 3 weeks.

Type IV

The clavicle is posteriorly displaced into the trapezius and may tent the skin posteriorly. The posteriorly displaced clavicle is best seen on an axillary radiograph. The sternoclavicular joint may be anteriorly dislocated; therefore, clinical evaluation is important.

Treatment

A varied and wide spectrum of literature and opinions regarding the optimal treatment of AC joint injuries exists. Patient-centered treatment is the most important consideration, as treatment can be directed at correcting deformity, functional impairment, or pain. Generally, partial dislocation s (types I and II) are treated non-operatively with a sling, ice, and a brief period of immobilization lasting 3 to 7 days. Complete AC joint injuries (types IV, V, and VI) are usually treated surgically. The greatest degree of contention regarding treatment is in regard to type III dislocations.

2.3.2 Glenohumeral Instability

SLAP lesion

The superior labral anteroposterior (SLAP) lesion is a superior labral tear that extends both anterior and posterior to the biceps tendon attachment. This most commonly results from repetitive traction to the biceps tendon, as seen in overhead athletes. The original classification described four types of SLAP lesions, depending on the extent of injury to the superior labrum and biceps anchor.

- Type 1 is characterized by superior labral degeneration and fraying.
- Type II, the most common of all SLAP lesions, consists of avulsion of the superior labrum and long head of biceps tendon from the glenoid.
- Type III is seen as an inferiorly displaced bucket-handle superior labral tear with an intact biceps anchor.
- Type IV involves extension of a bucket-handle superior labral tear into the proximal long head of the biceps tendon.

This classification has subsequently been extended to include the so-called ‘extended’ SLAP tears, in which the labral tear extends into other structures. Despite the complex classification, surgical treatment is based on compromise of the biceps anchor, and as far as the surgeon is concerned, precise classification is less useful than knowledge about the presence and extent of biceps tendon involvement (Beltran, 1997; Robinson et al., 2006).

2.3.3 Rotator Cuff Muscles Injuries

Rotator cuff pathology can result from extrinsic (outside) or intrinsic (from within) factors. Extrinsic examples include a traumatic tear in tendons from a fall or accident. Overuse injuries from repetitive lifting, pushing, pulling, or throwing are also extrinsic in nature. Intrinsic factors include poor blood supply, normal attrition or degeneration with aging, and calcific invasion of tendons (Bigliani, 1986).

Rotator cuff tendinitis is the term used to describe irritation of tendons from excessive pressure either on the acromion or, less commonly, from intrinsic tendon pathology. Irritation of the adjacent bursa is known as subdeltoid or subacromial bursitis. Repetitive overhead activities resulting in irritation of tendons and bursae from repeated contact with the undersurface of the acromion is termed impingement syndrome (Gerber, 1991; Sallay, 2007).

Rotator cuff dysfunction is typically a continuum of pathology ranging from tendinitis and bursitis, to partial tearing, to a complete tearing in one or more of the tendons. Although the earlier stages may resolve with conservative care, actual tearing of the tendon can be more problematic. These tears most commonly occur at the tenoperiosteal (tendon-to-bone) junction. Because this area has a relatively poor blood supply, injury to the tendon at this location is very unlikely to actually heal (Bigliani, 1986; Via, 2013). Additionally, the constant resting tension in the muscle-tendon unit, or muscle tone, pulls any detached fibers away from the bone, preventing their reattachment. Finally, joint fluid from within the shoulder may seep into the tear gap and prevent the normal healing processes from occurring.

2.3.4 Injury Prevention

Effectively injury prevention programs typically attempt to optimize the balance of applied and absorbed stress. Prevention programs designed to decrease stress applied to a tissue can be categorized according to the cause that is being addressed. One can grossly categorize intervention strategies into three groups: (1) equipment related (e.g., braces, orthoses, taping), (2) training (e.g., muscular strength and endurance, range of motion, reaction time, and proprioception) and (3) rules and regulations (which lead to a change in sport culture). For the strategy, prevention is important to balance the upper body strength, the core stability providing a stable strong support for the shoulder to work off. A good shoulder needs a good foundation. The core also provides the kinetic chain for overhead activities, allowing the trunk muscles to transfer energy and momentum to the shoulder. For the shoulder is the critical areas the lumbar and cervical spine and scapulothoracic joint, if these areas are not stable, significant extra loading and strain is passes on the shoulder joint. The further, important thing is a good balance of rotator cuff muscles which centering the humeral head on the glenoid, this requires equal strength and flexibility of the force couples of them. General flexibility allows freedom movement for the joint (Kellen, 2014).

2.4 Electromyography

Electromyography (EMG) is one of the electrophysiological investigation techniques, in which the recorded change in electrical potential that occurs during muscle activation. This technique is based on sensing muscle activity of either the body surface or intramuscularly (Otáhal, 1999). This method is widely used across medical disciplines, such as is used in neurology, orthopedics, surgery, physiotherapy. In the context of medicine is mainly used for diagnosis and for the opportunity to document the success of treatment. Another area, where the use of electromyography is a sport. Here it helps to analyze the movement of athletes' strategy, measuring muscle performance. His foundation has also ergonomics, we can evaluate it using, for example, load the body in the work environment, and then try to reduce risk factors (Konrad, 2005).

2.4.1 History of Electromyography

The origins of the current Electromyography and Kinesiology are associated with Renaissance and their interest in science. Morphology and physiology of the musculoskeletal system are significantly engaged Leonardo da Vinci (1452-1519), often also called the first kinesiologist. The first mention of the context of electricity and muscle activity emanating from the 17th century. Jan Swammerdam in 1646 demonstrated the response of the muscle preparation in contact with silver wire. In 1668, Francesco Redi mentions its consideration of the electrical discharges of marine eels and their association with muscle activity (Krobot, 2011). The relationship between muscle contraction and electricity described in the 70 years of the 18th century, Luigi Galvani. His experiments are considered the first step towards electro-neuro-physiology. The first person ever precisely measure the electrical activity of the muscle is considered Matteuscci Carlo (1811-1868). The electrical activity of muscles during voluntary contraction recorded Emil Du Bois-Reymond (1818-1896). On Galvani's experiments followed by French neurologist Duchenne, who studied the dynamics and function of muscles after electrical stimulation of muscles and nerves (Krobot, 2011). In the early 20th century perfected the possibility of electromyography recording Hans Piper (1877-1915). He began to use the surface of a metal electrode and documented the typical oscillation frequency of action potentials, depending on the applied force. In 1922, Joseph Erlanger and Herber Gasser used oscilloscope to register biopotentials.

2.4.2 Surface Electromyography

Surface electromyography significantly engaged Edmund Jacobson and Verne T. Inman. Other important personalities from the point of view of today electromyography are John V. Basmajin (1921-2008) and Charles Scott Sherrington (1857-1952), both dealt with human movements and physical rehabilitation using poly-electromyography. Surface electromyography, as the name implies, senses the electrical activity of the muscles of the body surface. Unlike needle electromyography, mainly used in neurology, it is an invasive method. Surface electromyography is used primarily in rehabilitation - the examination of muscle coordination, strength and contraction rate of fatigue (Kolář, 2009). With the help of surface electromyography gain access to physiological processes that are in direct relation with the emergence of motion and producing power. Using surface electrodes (monopolar, bipolar or multi-electrode) can be registered speeches electrical activity of muscles (Rodová, 2001). Surface electromyography requires examining knowledge of anatomy, physiology and instrumentation. The reward for his knowledge he brings many advantages to its use. Surface electromyography provides a safe, simple and non-invasive objectification of energy in the muscle without having to break the skin cover. We observe muscle activity in the idle state and its gradual changes during the ongoing movement. Using this method, we can find answers to questions such as: Enables the movement of the monitored muscle? There is no substitute motion pattern? Recruitment of motor units early or late? Just as you can find a number of advantages, occurs a number of disadvantages. The main limitations base on the anatomy of the human body, the instruments and methods (Criswell, 2011). We note poly-electromyography if at one time the potentials of a plurality of muscles, it is a method called poly-electromyography. More than the exact shape of the action potentials, we are interested in temporal relationships between the works of several different muscles. Recording is done with 4, 8 or 16 leads. We evaluate the muscle patterns that occur when individual movements. Non-ideal formula we can use this method to detect and refurbish the optimal formula, so often encounter poly-electromyography in rehabilitation medicine and sports medicine (Trojan, 2005).

2.4.3 Electrodes

Electrodes surface are used to measure the speed of nerve conduction at kinesiology and reflexology studies. They capture the potential of larger areas, thus they are not suitable for assessing the action potentials of individual motor units. The most commonly used are smaller disks with Ag / AgCl surface (Otáhal, 1999). Electrodes can be divided into three types. Registration electrodes are placed directly over the belly of the muscle and sense the electrical activity. The pacing electrodes are adapted to generate stimulation. Grounding electrodes are zero reference point for the amplifier also serves as a shorting circuit for noise currents from the power supply (Otáhal, 1999; De Luca, 2002).

Electrode placement should be at the center of the muscle bellies in parallel with the process of muscle fibers, between the motor point and the tendon insertion or between two motor points. In case that an electrode is placed directly over the tendon or in its immediate vicinity, the resulting amplitude of the EMG signal will be lower. The second erroneous placement of electrodes is near the motor point. In this case, theoretically, the resulting value is equal to zero. If the electrode is placed on the edge of the muscle belly place at its center, there is an increased risk of increased signal sensing area laying muscles (De Luca, 2002). The optimum is considered De Luca (2002) electrodes of 1 cm diameter and 1 mm in width. The distance between the electrodes should be 1 cm. The skin electrodes can be attached by various means. Currently using conductive adhesives, allowing reducing the number of artifacts caused by non-ideal contact between the electrode and the skin. Impedance surface electrodes is high (about 300 kΩ), its reduction is achieved through fixed contact between the electrode and the skin, washing the skin or its abrasion using electrode gel (Deuschel, 1999).

2.4.4 Electromyography Signal Processing

The raw signal sensing electrodes is called raw. It should be free from various artifacts and external noise, which is necessary to minimize technical camera settings and the correct application of the electrodes. The raw record, we can see unevenly arranged showing the amplitude interference pattern scanned action potentials. If, random relatively high peak amplitudes, it is a synchronous discharges more motor units that distort information about muscle activity (Konrad, 2005). The interpretation requires further processing of raw record. With dual band filter are filtered off frequencies lower than 20 Hz and higher than 500 Hz, it is also necessary to remove the frequency of the alternating electric voltage (in our country regards frequency of 50 Hz). Within rectification occurs a converting negative value to positive creation of the absolute values. The final step is to smooth the amplitude; it is a smoothing of sharp peaks resulting from the superposition of motor unit action potentials. Smoothing can be achieved e.g. by averaging amplitude values in the window, the size of which depends on the experience of the experimenter (Otáhal, 1999; Krobot, 2011).

To be able to compare results between different muscles and different participants is required in addition to smoothing the signal and normalization. Typical normalized relative to the maximum voluntary contraction (MVC), which can develop test. When measuring MVC and when measured at the analysis of movement of the electrode should be placed at an identical site in the same manner should then be processed results. According Otáhal and Tlapáková (1999) retrieving MVC select the highest value of three consecutive measurements short duration maximal voluntary isometric contraction, among which at least two-minute pause for regeneration. Factors affecting of the electromyography signal. A relatively large number of factors, both external and internal, can affect electromyography signal. Internal factors are based on the anatomical, physiological and biomechanical properties of the muscle, and therefore cannot be self-sensing control. These include muscular activity measured muscle - the properties of active muscle fibers (type and radius), the number of active muscle fibers, placing the active electrode to the muscle fibers (depth and location within the muscle). Furthermore, assign between internal factors surrounding muscle activity, the cross-talk, the electrical activity of other tissues and properties of the tissue between the electrodes and the surface of muscle (Rodová, Mayer, Janura, 2001). External factors can be influenced, so it is advisable to pay attention to them. One of the key factors for the quality of the measured signal is the location of the electrodes, their size and distance, the contact between the electrode and the skin. Violation of the electromagnetic field approximately the subject arise external noises. They can cause an external device or motion artifacts caused by motion sensing cable or sudden movements of the body. To prevent them, we can use differential preamplifiers and good fixation (Krobot, Kolářová, 2011).

2.4.4.1 Normalization of the EMG signals

To be able to compare EMG activity in the same muscle on different days, in different individuals, or to compare EMG activity between muscles, the EMG must be normalized. Normalization of EMG signals is usually performed by dividing the EMG signals during a task by a reference EMG value obtained from the same muscle. By normalizing to a reference EMG, value collected using the same electrode configuration; factors that affect the EMG signals during the task and the reference contraction are the same. Therefore, one can validly obtain a relative measure of the activation compared to the reference value. The common consensus is that a “good” reference value to which to normalize EMG signals should have high repeatability, especially in the same subject in the same session, and be meaningful (Rodová, 2001).

By choosing a reference value repeatable within an individual, one can compare the levels obtained from any task to that reference value. The choice of reference value should allow comparisons between individuals and between muscles. To be able to do so, the reference value should have similar meaning between individuals and between muscles. The choice of normalization method is critical in the interpretation of the EMG signals, as it will influence the amplitude and pattern of the EMG signals. Unfortunately, there is no consensus as to a single “best” method for normalization of EMG data and a variety of methods have been used to obtain normalization reference values:

1. Maximum (peak) activation levels during maximum contractions
2. Peak or mean activation levels obtained during the task under investigation
3. Activation levels during submaximal isometric contractions
4. Peak to peak amplitude of the maximum M-wave (M-max)

In summary, only the normalization method that uses MVICs as the reference level can be validly used to compare muscle activity levels and activation patterns between muscles, tasks and individuals, if maximum neural activation is achieved in all muscles and individuals tested. The use of peak or mean activation levels obtained during the task under investigation as the reference EMG level can be used to compare patterns of muscle activation between individuals over time with high reliability but does not allow comparisons of activity levels between muscles, tasks or individuals. The normalization methods of submaximal isometric contractions or maximum activation during the task under investigation performed at maximum effort also do not allow valid comparisons of muscle activity levels between muscles or individuals, and in addition, muscle activation patterns between individuals are potentially more variable because different individual motor control strategies may be used. Finally, the use of maximum activation levels obtained under maximum effort during dynamic contraction and the M-max methods to normalize EMG signals are associated with low within subject reliability and cannot be recommended (Otáhal, 1999; Rodová, 2001).

3 GOALS, TASKS, QUESTIONS, LIMITATION AND HYPOTHESIS

3.1 Goals of the Thesis

The main objective of this Thesis was to compare by surface electromyography the myoelectrical activity of m. biceps brachii, m. infraspinatus, m. latissimus dorsi, m. pectoralis maior, and m. supraspinatus in healthy individuals performed the Shoulder Mount within two different conditions i.e. kinesiotaping for the shoulder and tennis elbow brace conditions. Further goal was to record and analyzed the motion during the Shoulder Mount.

3.2 Tasks of the Thesis

1. Summary of the available information about the shoulder complex, pathophysiology of its soft tissue injuries, manifestations and methods used to prevent its injuries in healthy vs. non-healthy subjects.
2. Perform a search of the available studies on the topic of shoulder kinesiotaping and the effects of tennis elbow brace on musculoskeletal system as measured by EMG on myoelectric activity of the shoulder's muscles.
3. Establish measured muscles suitable for evaluation of their involvement in the Shoulder Mount exercise.
4. Find suitable participants and provide space for the experiment.
5. Ensure material needed to perform the experiment.
6. Perform experiment in which will acquired EMG recordings of m. infraspinatus, m. supraspinatus, m. pectoralis major, m. biceps brachii and m. latissimus dorsi on dominant shoulder with kinesiotape and elbow brace conditions in compare with control condition.
7. Evaluate and compare the measured values under different conditions.
8. Process discussion and evaluate the conclusion.

3.3 Research Questions

Que. n. 1: Will be the amplitudes, durations, and shapes of the myoelectric signals of the m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder the same or at least similar for both participants in each condition?

Que. n. 2: How will significantly change the amplitudes, and peaks of myoelectric signals of m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder inside two conditions i.e. kinesiotape for shoulder and tennis brace with the control condition?"

3.4 Hypothesis

First research question

Ho1: The EMG amplitudes, durations and shapes of the myoelectric signals of the m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder is differing within the conditions and participant.

Second research question

Ho1: At least one of the selected muscles i.e. m. pectoralis maior, m. biceps brachii, m. latissimus dorsi, m. supraspinatus, or m. infraspinatus has the highest peaks averages within all conditions.

Ho2: At least one of the selected muscles i.e. m. pectoralis maior, m. biceps brachii, m. latissimus dorsi, m. supraspinatus, or m. infraspinatus has the lowest amplitude average within all conditions.

Ho3: If there are differences in average peaks including all conditions of same muscles within the participants there might be different standard value deviations for every muscle so that, the mean value of the standard deviation would have significance level.

Ho4: There occurs decrease of the average of the peaks values for m. latissimus dorsi and m. pectoralis maior, if there is kinesiotape application.

Ho5: Minimal one of the selected muscles i.e.; m. pectoralis maior, m. biceps brachii, m. latissimus dorsi, m. supraspinatus, or m. infraspinatus would have similar peak average value within participants in brace condition.

4 Methodology of the Work

Participants

Two healthy woman individuals characterized by mean values (x) and standard deviation (s) calculated from participant's age, height, body mass and BMI (table number two) volunteered for this study. Inclusion criteria were no previous history of surgery to the upper body, and no previous history of upper body injury within 12 months prior to testing. Participants were right - handed performing pole dancing as lectures of pole dance classes in Pole Heaven Studio in Prague over 1 year. Both participants read and signed an informed consent form approved by the Ethics Board Review of the Faculty of Physical Education and Sport of Charles University in Prague.

Parameters/ n=2	**x**	**s**
Age (yrs)	23,5	1,5
Height (cm)	170	3
Body Mass (kg)	63,5	3,5
BMI	21,95	0,44

Table 2: The characteristic of the participants.

Methods and Materials

One day measured experiment to investigate the immediate effects of kinesiotaping of the shoulder into internal rotation and supporting the elbow by tennis brace on the activity of the m. biceps brachii, m. latissimus dorsi, m. infraspinatus, m. pectoralis maior, and m. supraspinatus on dominant shoulder.

As a first, the participants performed an upper body warm up of pushups against a wall. The warm -up was complete when the participant felt warm and ready to perform maximal effort contractions (Table 3). Electromyography (EMG) electrodes secured over belly of m. biceps brachii, m. latissimus dorsi, m. infraspinatus, m. pectoralis maior, and m. supraspinatus on dominant shoulder and three maximal voluntary isometric contractions (MVIC) performed to normalize the EMG data. Each condition applied to the dominant shoulder; the participant as either left or right reported dominance. The order of conditions was randomized between participants and at least five minutes of rest were provided between conditions. Each testing condition included the acrobatic exercise; Shoulder Mount on vertical pole for three times with the kinesiotape, three times with the tennis elbow brace and three times with nothing-control condition.

Muscles	MVIC
Infraspinatus	External Rotation 0° and 90° ABD at shoulder against the resistance of the researcher
Supraspinatus	0° of Rotation, 90° elevation in scapular plane and elbow extended against the resistance of the researcher
Biceps Brachii	Palm up, elbow in 90°of FL, resistance on the wrist
Pectoralis Maior	ABD with shoulder in 90°of FL and palms together, resistance applied by subject by pressing palms together
Latissimus dorsi	Internal rotation and extension with shoulder in 30°ABD and elbow extended, resistance applied at distal forearm

Table 3: The implementation of maximum voluntary isometric contractions (MVIC).

The data analyses were performed on the best effort of the three movements in each condition. The experiment also included the recording of the Shoulder Mount exercise for further motion analyzes by six video cameras which precise data collection during the exercise for these purposes were on participants stuck the markers.

The tape used for kinesiotape condition was "pre - cut kinesiology tape" from Mueller Company, for elbow brace condition was use Hg 80 Tennis elbow brace also from Mueller Company. Safesport s.r.o. seated in Chorvatská 1969/7, Prague 10 supported the experiment by donation of the materials above.

Instrumentation

The surface medical grade stainless steel bar electrodes (MA-411-003, Motion Lab Systems, Inc., Baton Rouge, LA USA) with two sensor contacts sizes 12 mm of the disks to the fibers of m. biceps brachii, m. latissimus dorsi, m. infraspinatus, m. pectoralis maior, and m. supraspinatus on dominant shoulder were placed. Electrode size was 38mm x 19 mm x 17 mm prior to electrode placement the skin was cleansed using alcohol and sand paper. EMG date from the surface electrodes were captured at 1000Hz using Data Pac 2k2 (Run Technology. Mission Viejo, CA, USA). The EMG electrodes were interfaced into a Bagnoli 4 amplifier (Delsys, Inc. Boston, MA. USA). System bandwidth was 20-450 Hz with a gain of 1000 for the surface electrode. EMG signal was notch filtered at 60 Hz and processed via a root mean square technique using a 10 ms window within Data Pac 2k2.

These data were then exported and further processed within an EMG Analysis (Basic Graphic Verision, Motion Lab Systems, Inc.,), and normalized to maximum voluntary isometric contractions (MVIC).

Six Qualisys cameras (Oqus 3+) with 128 x 64 graphical high contrast OLED and maximum frame buffer size of 1152 Mbyte were located at on distance of 1 - 1,5 m from the tested subjects ensuring fast and precise data collection of movement. The cameras made from convection cooled, custom die-cast aluminum and body sizes of 200 x 145 x 155 mm support active and passive markers. Nineteen markers placed on selected bony structures and the data from the cameras were processed in Qualisys motion system what allowed to perform 2D and 3D capture of data in real time, with minimal latency.

Procedures

All testing procedures for each participant completed approximately in one hour. Participants performed an upper body warm up of pushups against a wall until they felt warm and ready to perform maximal contractions. The markers were applied bilaterally on; acromions, lateral epicondyle of humeri, processes styloidei radii and processes styloidei ulnea, on all pelvis spines, trochanters maior, and unilaterally on; lateral condyles of femur, lateral malleolus and seventh cervical vertebra the total sum of the markers were 19which remained in place throughout testing of all conditions.

Further, were applied the EMG electrodes to the skin in manner previously described. Before application of the kinesiotape to test the kinesiotape condition, the electrode on m. latissimus dorsi took off and after application of the kinesiotape was applied again. The MVIC from each muscle measured according to the table number three.

Exercise protocol -Shoulder Mount

The Shoulder Mount is an acrobatic exercise in which the participants stood with their back to the vertical pole and gripped it in cup grip (Wilkerling, 2011), (Figure n. 2). Participants placed their head laterally beside the pole thus; the pole was on one shoulder. Lever power was created in the arms to enable the participants to roll the body up without slipping from the pole. Arms must was bent at an angle of almost 90°. Then swung one leg backwardly, so that they initiate the movement. Then swung both legs up toward the ceiling, and after this was the turn of the buttocks to be swung up and held in the position (Figure n.3). The first measure was a control condition with no utility.

After three times performing of the Shoulder Mount exercise for a control condition, there were applied on dominant arms the tennis elbow brace (Figure n. 4) and participants then were asked to performed for three times the exercise again.

At the end were applied the kinesiotape how was recommended in "Tejpovánní jako samoléčba" (Langendoen, 2012) as for supporting the internal rotation in the shoulder (Figure n.5).

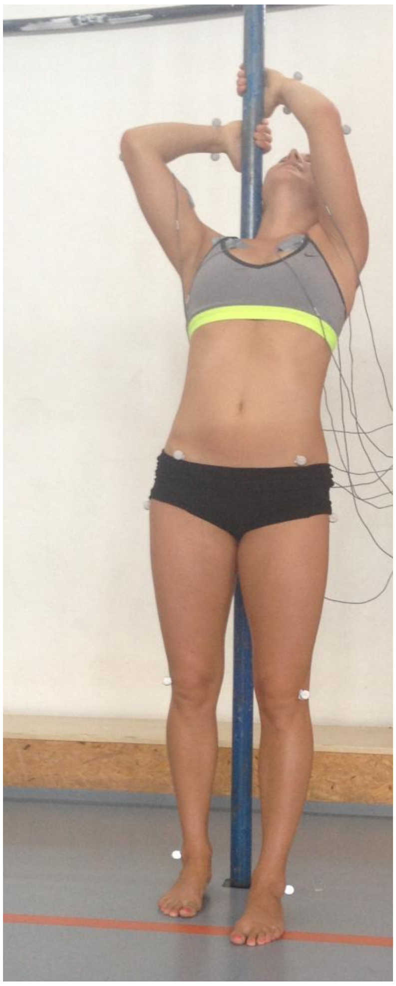
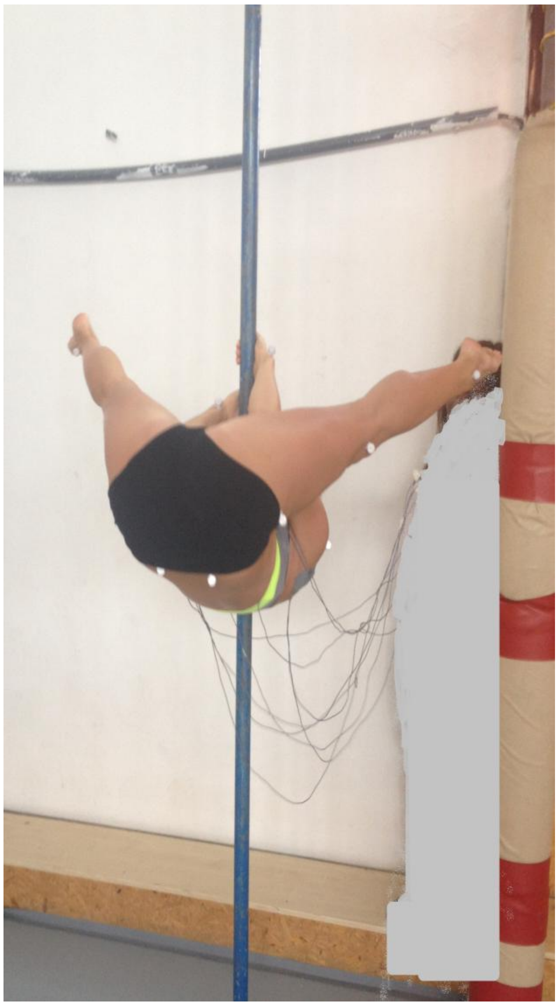
Figure n. 2	**Figure n. 3B**
	

Figure n. 2: Starting position of the Shoulder Mount exercise performance (own photo documentation). Figure n. 3: Ending position of the Shoulder Mount exercise.

Three pieces of the kinesiotapes were cut at 1/4 shorter than were the distances toward their attachment. First piece run with distinctive tension (75%) from lower edge of the blade toward the armpit, where was applied another piece of tape, approximately 5-7 cm long so that the adhesive sides of both pieces came together, then the first tape was run obliquely upwards and attached on upper side of the arm as seen in figure number three. The second piece of the kinesiotape was running from iliac crest and third from the edges of the lumbar vertebras with distinctive tension (75%) toward the armpit so that, they overlaid on first tape. Both participants received at least five minutes of rest provided between conditions.

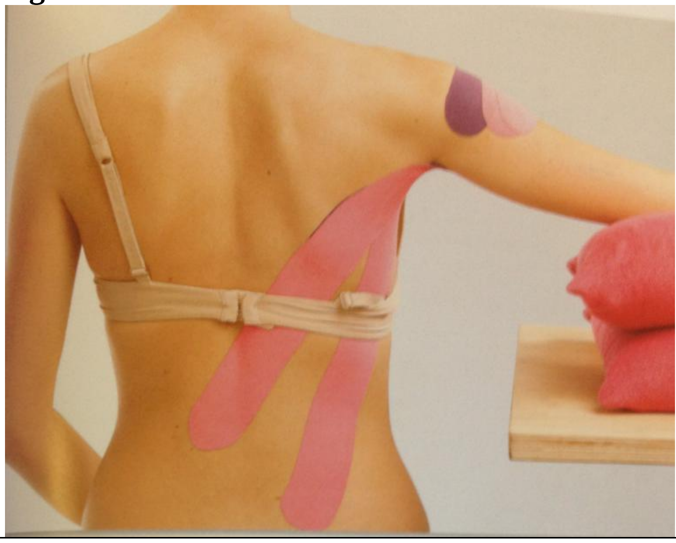
Figure n. 4	**Figure n. 5**
	

Figure n. 3: Ending position of the Shoulder Mount exercise performance (own photo documentation).

A- Tennis elbow brace application; B. Kinesiotape application. Figure n. 5: Taping of the shoulder into IR

Data Analysis

All data analyses were performed using the Microsoft Excel with a supplement XLSTAT - RIB 2015. The graphs, bar charts illustrations, tables were used. The sample averages of the peak values, the total averages of the peak values, standard deviations, p-value assessment done by T-test. All hypotheses were tested at a significance level of 95%, which means that if the *p*-value less than 0.05.

Limitations of the work

1. This study only assessed the short-term effects of kinesiotape; therefore, the results cannot be applied to the long-term effects of kinesiotape.
2. Subjects used for this study were healthy athletes' who had no injury to their shoulder in the past six months. The study should be done on non -healthy subjects as well.
3. There was small sample of the subjects, so the results are not statistically significant; there will be needed to apply the study on more amount of tested subjects.

5 Results

The results of this work have been divided into three main chapters; first chapter include the motion analysis of Shoulder Mount exercise, second chapter answered the first research question and proved the hypothesis that was done for this question. Mainly the graphical illustrations of myoelectric signals of m. pectoralis maior, m. latissimus dorsi, m. biceps brachii, m. infraspinatus and m. supraspinatus were used; the EMG data were compared accordingly to the peaks, shapes and durations of the myoelectric activities (% MVIC) within three conditions that were described at the part with the methodology of the work. The third chapter answered the second research question and demonstrated the validities of its five determine hypothesis. The methods used at this part included the graphically illustrations by bar charts and tables, numerically by sample averages of the peak values, the total averages of the peak values, standard deviations, p-value assessment done by T-tests. It is important to notice, that the p-value could not be truly valid because the work had a small amount of the samples. The achieved results from the tests were valuable only for this study, they were taken because of the researcher's interest but they might not have the statistical significant. All data were analyzed in Microsoft Excel with a complement XLSTAT 2015 from the same company. All hypotheses were tested at a significance level of 95%, which means that if the *p*-value less than 0.05.

5.1 Motion Analysis

The 3D full video motion analysis is available in an enclosure n. 5. The motion captured by Qualisys cameras and recorded into computer for further processing. On figure n. 5, are schematic illustrations of 2D motion analysis from fifth Qualisys camera. The aim is to analyze the motion of Shoulder Mount exercise, notice, and assign the certain phases of the exercise that would be important for the activity of the shoulder muscles. On same figure (5) is seen division of the motion into eight parts lettered from A-H. To be able to read the motion there is identification of each segment by the number; some segments that lay near each other are connect by red line for better visualization during the motion. As the criteria, points are chosen the acromion and lateral femoral epicondyle segments. The distance from these two points are highlight by yellow line to see the movement trajectory. When looking at the pictures from the beginning to the end, the trajectory of the circle is seen with the ending of the movement in the horizontal. The movement from vertical position into horizontal presents 1/4 of the circumference. Shoulder as a fixum punctum around which moves the knee.

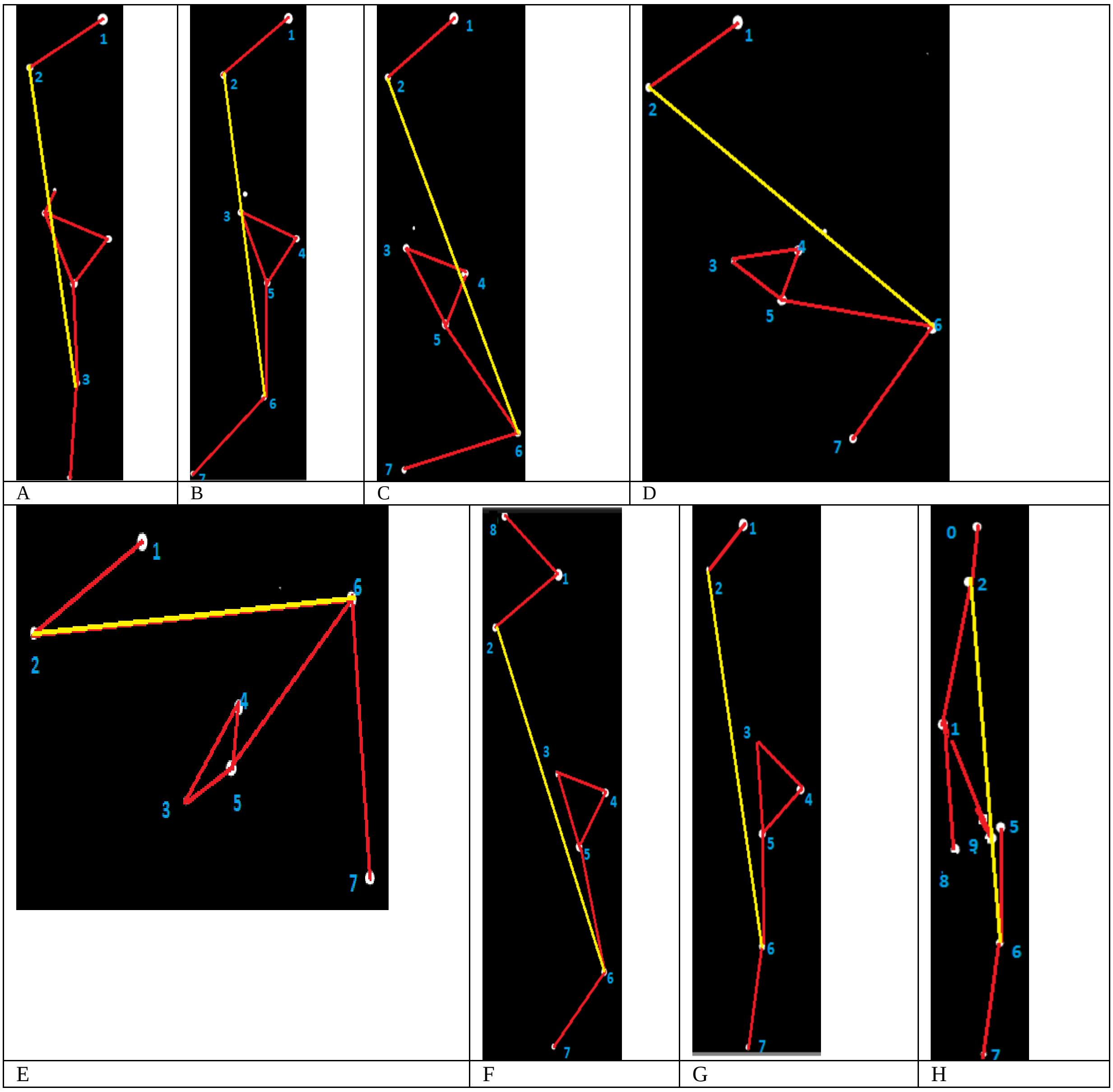


Figure n. 4:Brace condition (web)

Figure n. 5: Kinesiotape application (Lamontagne, 2001)

Figure n.6 Motion Analysis (Qualisys Tractk manager, own photo documentation)

Blue numbers are for the markers positions **- 1**-lateral epicondyle of humeri, **2-** acromion, **3-** SIPS, **4-** SIAS, **5-** trochanter maior, **6 -** lateral femoral condyle, **7-** lateral malleolus, **8 -** processus ulnae, **9-** processus radii, **0-** C7 vertebral spinous process.

The picture A represents the starting position with the shoulder bent an angle of almost 90 degrees and is almost in vertical position with the knee. On picture B the movement gets started, it is the initiation of the movement. Picture C shows the continuing of the movement with the visible swinging mechanism of the lower limb. On picture D, gets lifted the pelvis up as well. The horizontal position of the shoulder and knee are reach on the picture E. Further phases of the Shoulder Mount exercise are the reversal motions. On pictures, F and G are the leg and buttocks turning back to the vertical position of the shoulder and knee. The position F have has not the contact of the lower extremity with the floor and on picture G is presents the full contact of the lower limb with the floor. The picture H is ending of the exercise and placing of the upper extremity along the body. The motion has measured at the interval of 10s, normally the athletes practicing the Shoulder Mount try to stay in the vertical position as long as possible and the ability to stay for longer duration requires great pole acrobatic skills and good core muscles and shoulder strength.

5.2 Results of the first research question view of the results

The first research question was interest if the amplitudes, durations, and shapes of the myoelectric signals of the m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder would be similar for both participants in each condition. The following hypothesis was set: "There EMG amplitudes, shapes and durations of the myoelectric signals of the m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder will differ within the conditions and participant," The results below are obtained.

To facilitate interpretation of EMG amplitude results, some literature has categorized EMG amplitude as low (<20% MVIC), moderate (20-50% MVIC), and high (> 50% MVIC) which was used in this study as well. At the first, are noticed the errors in the EMG signals these situations could be explained by reaction of the artifact. These situations made EMG signals measurement inaccurate in certain section. At the table n. 4, is listed the duration of each sections for both participants. The movement is subdivided into four parts. First part in the initiation of the movement and swinging of the legs and buttocks up, the second part keeping of the legs horizontal position, third part is the movement of the legs down with final contact with the floor, and last fourth part is end of the movement until placing of the arms along the body.

Movement duration (s)						
	Participant 1			Participant 2		
	Control	Brace	Tape	Control	Brace	Tape
Movement	0-3,60	0-2,86	0-2,82	0-3,24	0-2,49	0-3,29
Horizontal position of the legs up	3,60-5,57	2,86-5,20	2,82-5,58	3,24-5,55	2,49-5,59	3,29-5,59
Movement down	5,57-8,86	5,20-8,03	5,58-8,26	5,55-8,95	5,59-7,83	5,59-8,24

End of the movement	8,86	8,03	8,26	8,95	7,83	8,24

Table n. 4: Duration of the movement in control condition (s).

5.2.1 Control Condition

On the beginning of the measure is occurred the error for m. biceps brachii, further at the end there is from 5,5s occurred the errors for m. supraspinatus. The starting position is characterized by low or moderate amplitudes of the muscles. On figure n.7 is visible the highest EMG amplitude for m. biceps brachii, second higher is m. infraspinatus, third is m. pectoralis maior, fourth the m. latissimus dorsi and the lowest EMG amplitude has m. supraspinatus. At the initial movement there were increasing of all muscles except for m. pectoralis maior. Its activity in compare with the m. latissimus dorsi and m. supraspinatus has still the moderate character while the activities of these muscles are very low. At the position horizontal position are not seen the big changes in the activity, the peaks of the activity are almost constant in all duration for all muscles, but then when participant moving down, has be seen decreasing activity in m. biceps brachii and increasing activity of m. infraspinatus. At the end of the movement when legs are in contact with the floor and arms are placing along the body, decreasing of the m. biceps brachii and increasing of the m. infraspinatus together with the m. pectoralis maior are presented.
On the figure n. 8 is visible that the highest amplitude belongs to the m. biceps brachii, the second higher amplitude belongs to the m. pectoralis maior, third higher amplitude has m. infraspinatus and lower amplitude have m. latissimus dorsi and m. supraspinatus. At the beginning of the movement is only m. pectoralis maior that has the moderate amplitude value the rest of the muscles having low amplitude value. With the movement initiation there are increasing of all muscle activities, which are stabilized at the horizontal position. With the reversing of the legs back down are decreasing the activity of each muscles.

Accordingly, to those facts above, the highest activity is for m. biceps brachii that is valid for both participants. Where are most differs are the amplitudes of the m. pectoralis maior and m. infraspinatus in some movement sections. For first participant the second highest amplitude belongs to m. infraspinatus whereas at the second participant it is for m. pectoralis maior. The results then meet again for the lowest activated muscles that are m. latissimus dorsi and m. supraspinatus.

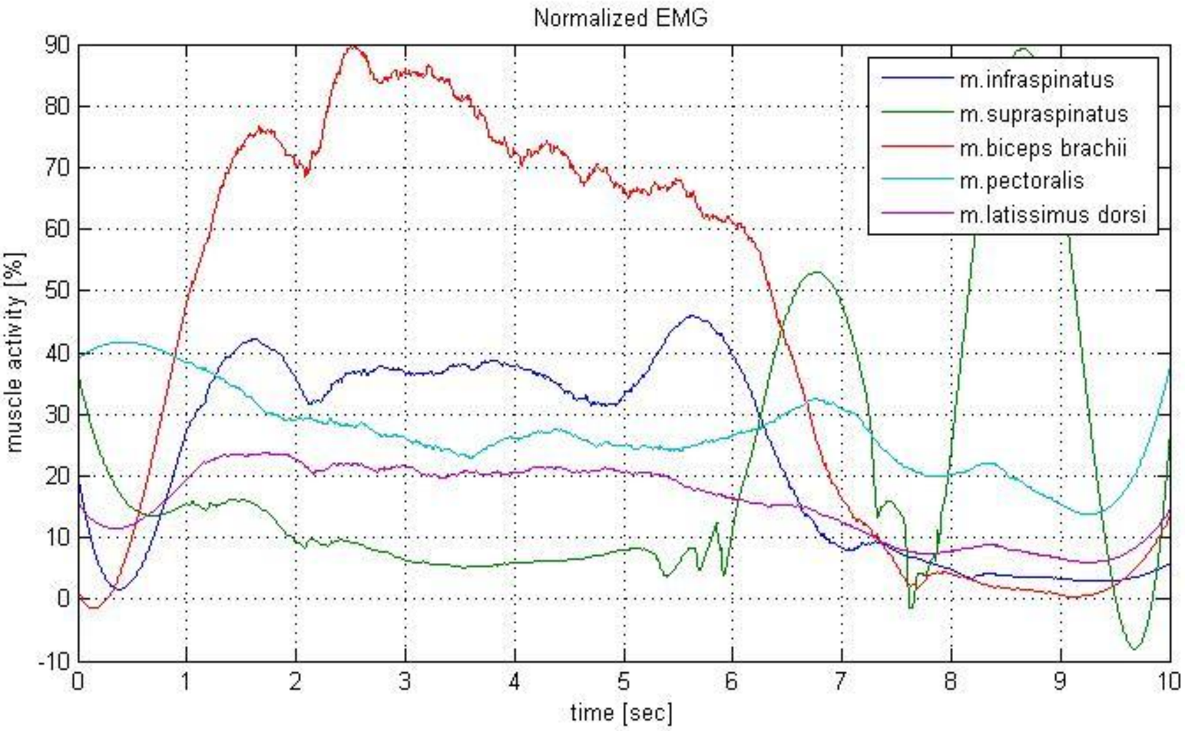


Figure n. 7: Graph of EMG signals during control condition of first participant.

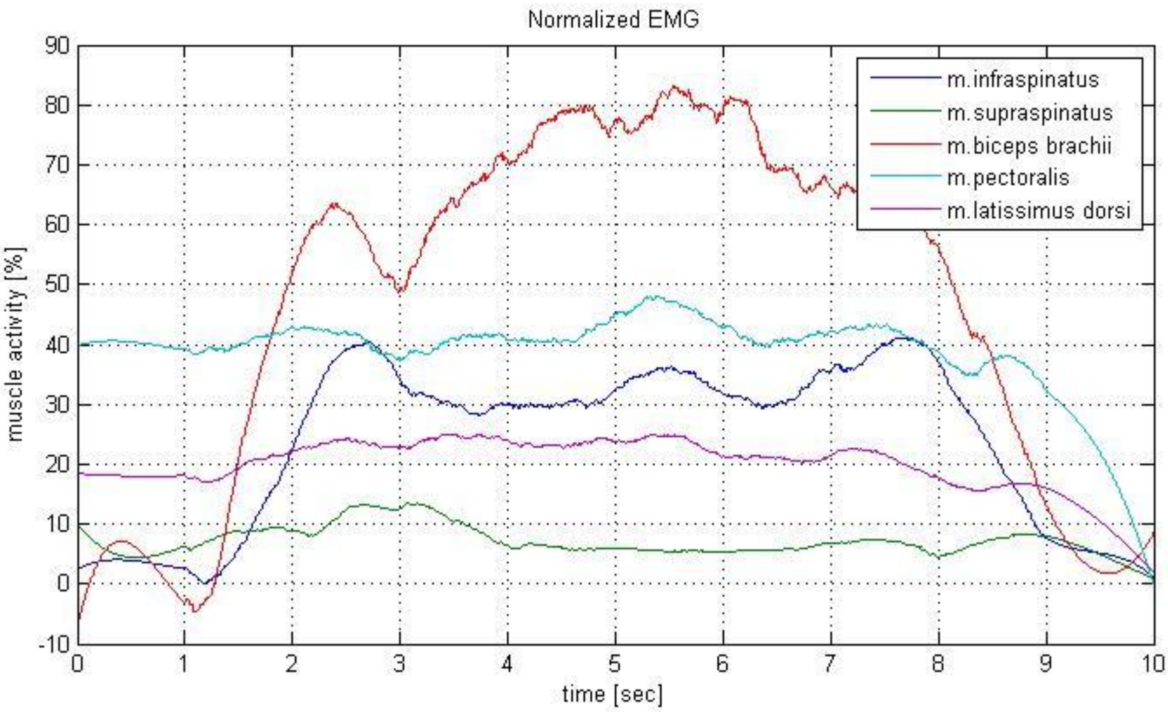


Figure n. 8: Graph of EMG signal of second participant during control condition.

5.2.2 Tennis Elbow Brace Condition

On the figure n. 9 with the graphical illustration of the EMG signal of first participant during brace condition are seen the measure errors at the beginning of the movement for m. biceps brachii. It is seen the highest amplitude for m. biceps brachii again, second higher amplitude has m. infraspinatus; third higher amplitude has m. pectoralis maior as the lowest activity are for m. latissimus and m. supraspinatus. The starting position is again characterized by low muscles activations the only muscle with moderate amplitude is m. pectoralis maior. Then the initiation of the movement brings the increasing of the activity for all muscles except the m. pectoralis maior which decreasing its activity. At the position with the legs up there are minor changes of the peaks activation that are falling down with the finishing of the movement. With comparing of the EMG signal of brace and control condition of first participant there, result the dropping of m. biceps brachii amplitude but on the other hand, there occurs increasing of the amplitude for m. infraspinatus and m. pectoralis maior. There is no big impact of brace condition on m. latissimus dorsi and m. supraspinatus amplitudes.

At the graph on the figure n. 10, which belongs to the participant two are more errors occur, there are at the beginning of the exercise from 0-3s and at the end of the exercise from 7s for m. supraspinatus. Regardless to these errors are see at the starting position low activities of the muscles which increasing with the initiation of the movement and the changing stabilized at the horizontal position. Only m. pectoralis maior has decreasing character at the initial movement phase, but the changes in the myoelectric activities are minimal at horizontal position. After, are seen at the end of the movement decreasing of all muscles activities. In compare, the brace condition with the control condition of the second participant there is decreasing of the m. biceps brachii, m. pectoralis maior amplitudes but increasing of the m. infraspinatus amplitude.

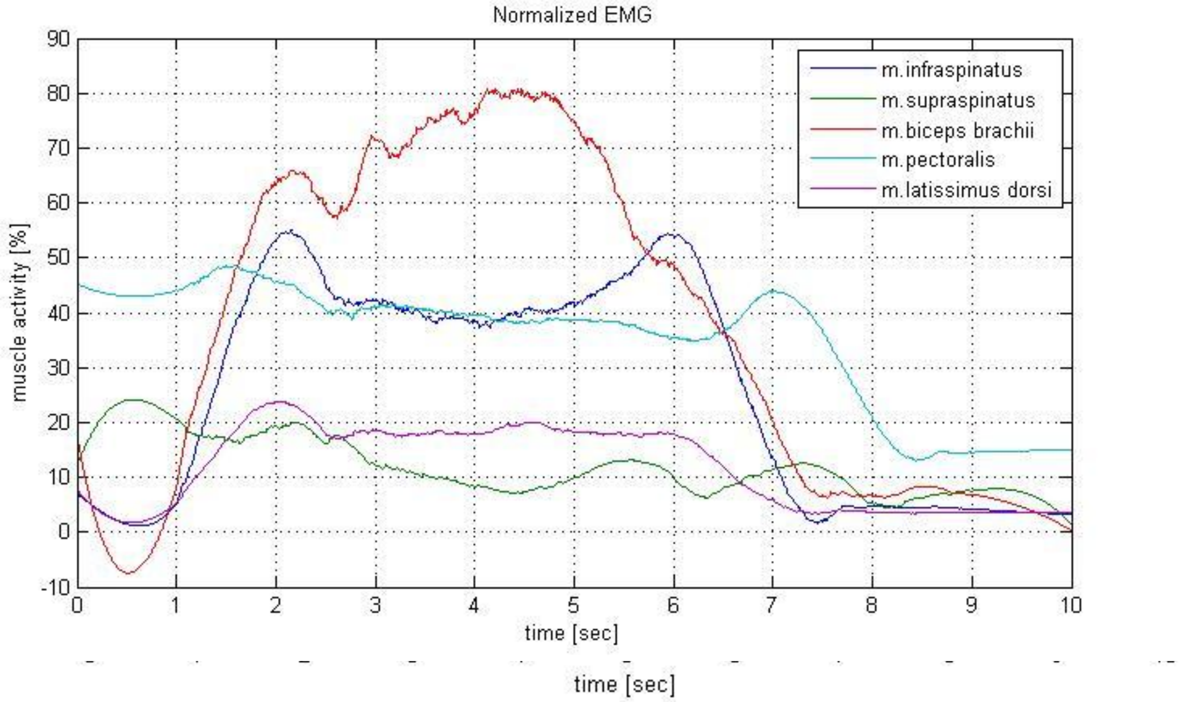


Figure n. 9: Graph of the EMG signal of first participant in brace condition

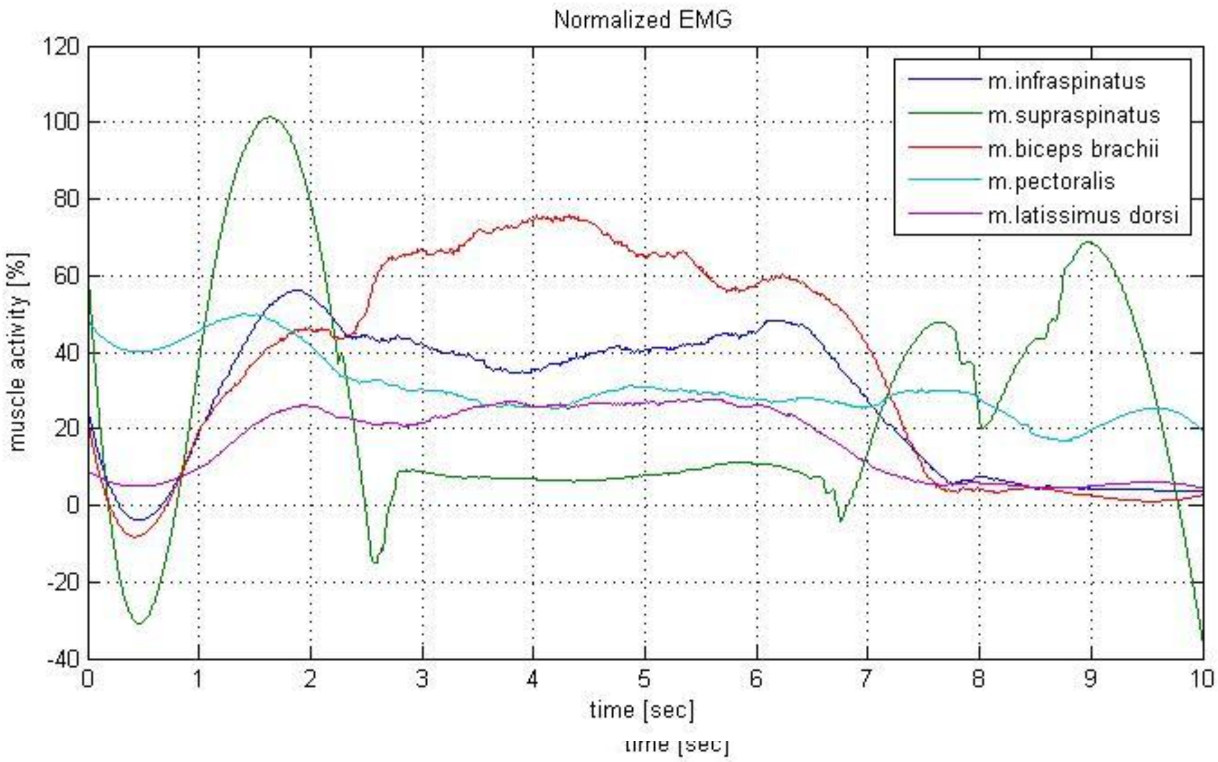


Figure n. 10: Graph of the MG signal of second participant in brace condition.

5.2.3 Kinesiotape Condition

On the figure n. 11 and 12 are the graphs of EMG signals in application of kinesiotape. As on graphs above, the figuren.11 belongs to the participant number one and the figure n. 12 belongs to the participant number two. On the figure n.11 has be presented the error for m. supraspinatus from 7 s. The muscle with the highest amplitude is the m. biceps brachii, second higher amplitude belongs to the m. pectoralis maior, the third higher amplitude is for m. infraspinatus, and the lower activities are for m. latissimus dorsi and m. supraspinatus. The difference in comparing this position with the control position is at the beginning of the exercise, where increase the activity of some muscles increased up to the moderate or high EMG amplitude. This is valid for m. pectoralis maior and m. infraspinatus. Generally, there decrease the m. biceps brachii and m. latissimus dorsi amplitudes, whereas there increase the m. infraspinatus amplitude. The duration of the each selected movements are notice in the table n. 5.

On figure n. 12 has occurred more errors area, in all duration are valuable only the signals for m. pectoralis maior, m. infraspinatus, m. biceps brachii, m. latissimus dorsi. Regardless to the errors had found, on the graph increasing of the amplitude for m. infraspinatus and m. pectoralis maior in compare with control condition. Further there decreased its amplitude the m. biceps brachii. The muscle with highest activity is the same as on previous conditions; the m. biceps brachii. Second higher amplitude has m. pectoralis maior, at third place is m. infraspinatus and the m. latissimus dorsi and m. supraspinatus are the lowest activated muscles. The result is that the kinesiotape is able within the samples used in this study decrease the activity of the m. biceps brachii, m. latissimus dorsi, and increase the activity of m. pectoralis maior.

5.2.4 The Summary of the results

The results show different amplitudes, shapes and durations of myoelectric signals of m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder in the conditions and participants.

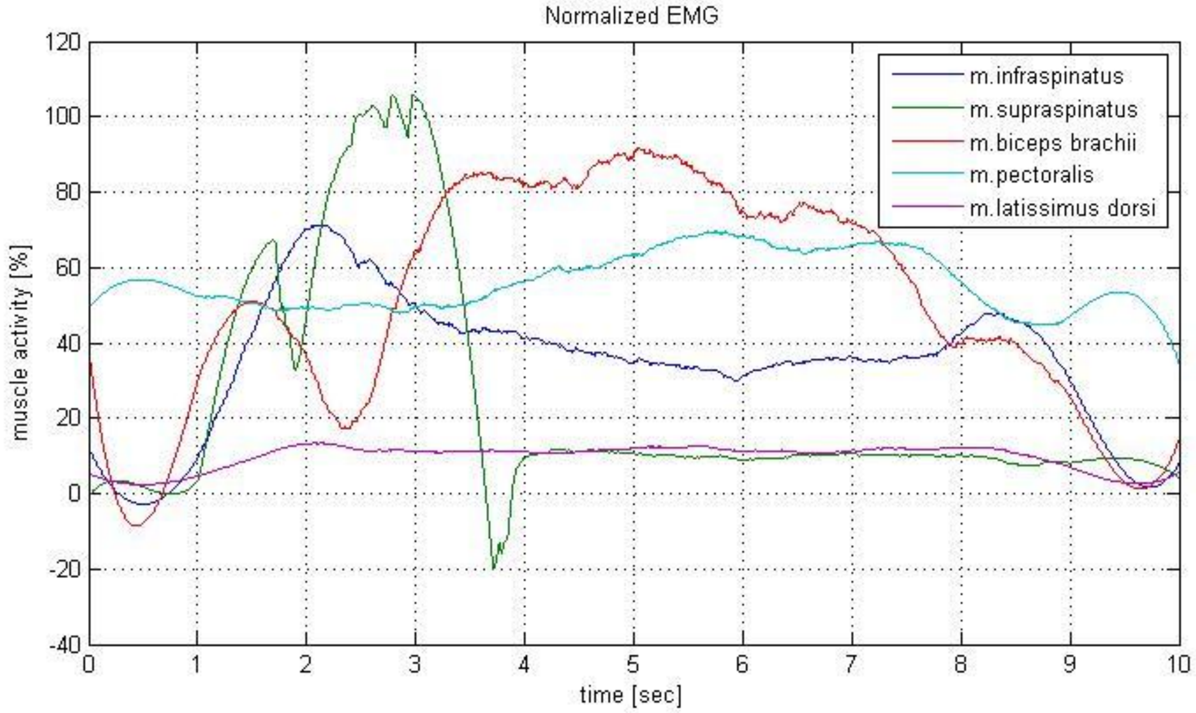


Figure n. 11: Graph of the EMG signal for first participant in kinesiotape condition.

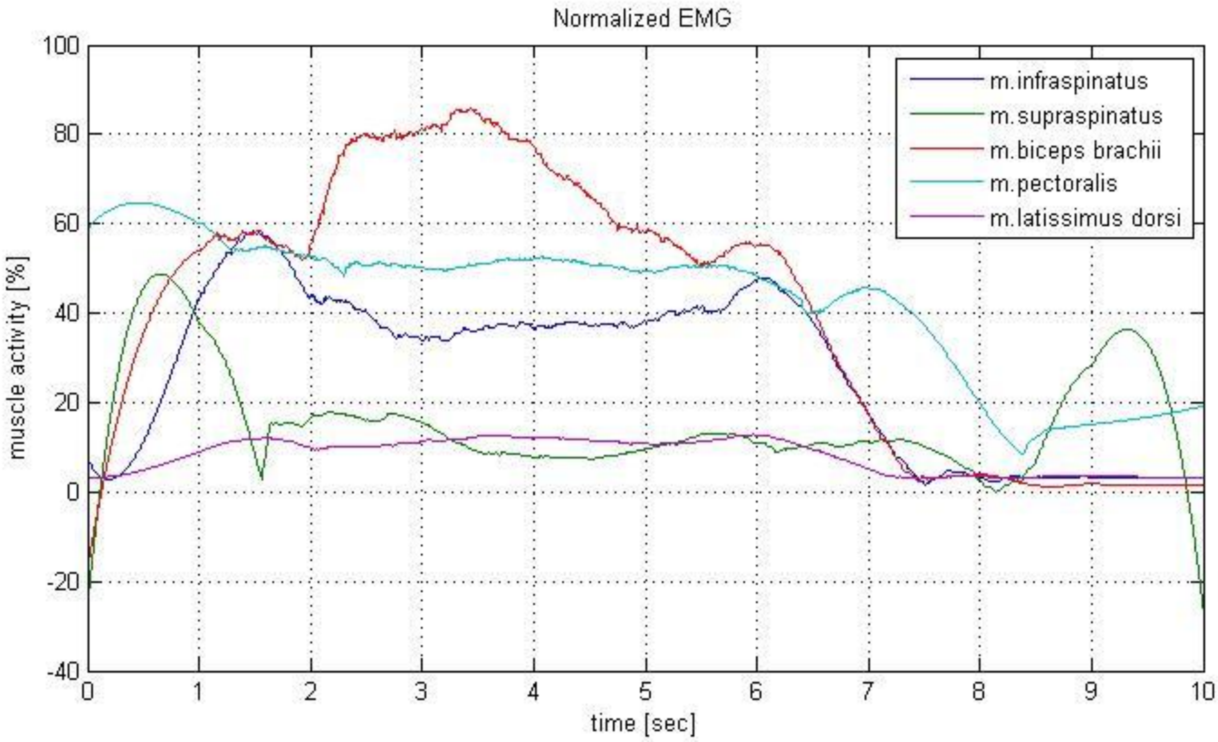


Figure n. 12: Graph of the EMG signal of second participant in kinesiotape condition.

5.3 Results of second research question

The summary of the results are in research question number two

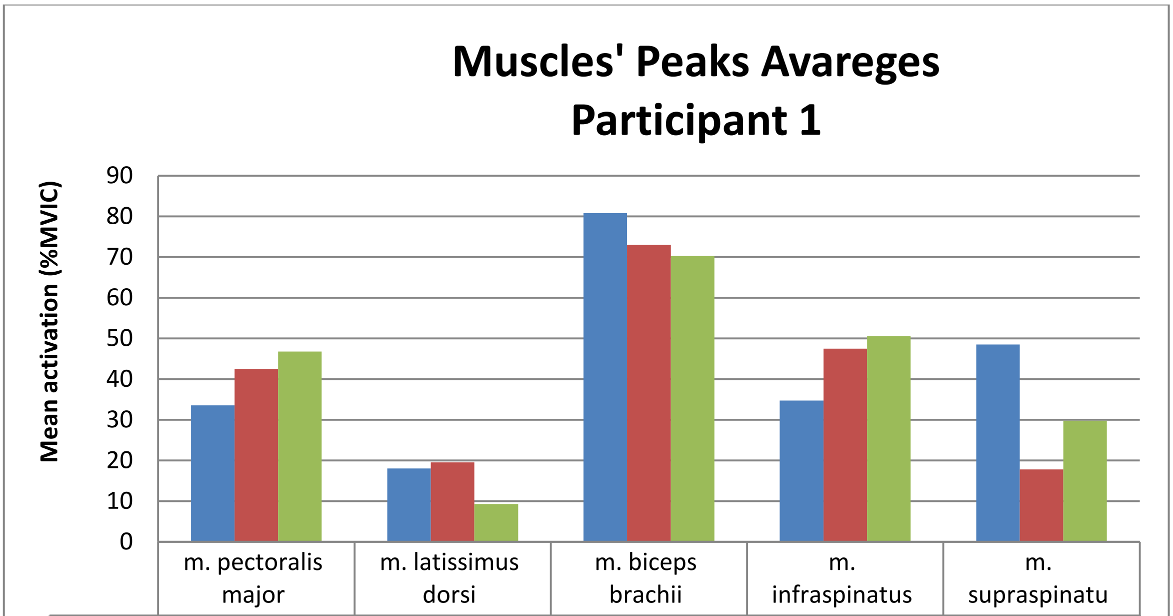
The second research question was: " How will significantly change the amplitudes and peaks of the myoelectric signals of m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder inside two conditions i.e. kinesiotape for shoulder and tennis brace with the control condition?"

This question has been solved within the hypothesis Ho1, Ho2, Ho3, Ho4, and Ho5.

The results of the Ho1

The first hypothesis says; "At least one of the selected muscles i.e. m. pectoralis maior, m. biceps brachii, m. latissimus dorsi, m. supraspinatus, or m. infraspinatus has the highest peaks averages within all conditions," the following results are found.

To confirm the hypothesis the total average of the highest peaks activations (% MVIC) for each muscle are needed. There are taken four highest peaks values of each muscles and calculated from them so call the total averages (μ); the higher average value the higher muscle activity. Each muscle average values are compared and the results are seen in the bar charts of figure n. 13 and 14. On both figures are visible the highest column in each conditions for m. biceps brachii its average activity is in control condition -μ=80, 75%; tape condition- μ= 70, 25%; and brace condition - μ= 73% for first participant and μ= 56, 75%; μ= 75%; and 61, 25% for second participant in same ranking of the conditions as above.



	m. pectoralis major	m. latissimus dorsi	m. biceps brachii	m. infraspinatus	m. supraspinatu
Contol	33,5	18	80,75	34,75	48,5
Brace	42,5	19,5	73	47,5	17,75
Tape	46,75	9,25	70,25	50,5	29,75

Figure n. 13: Bar chart of the muscles peak averages of first participant.

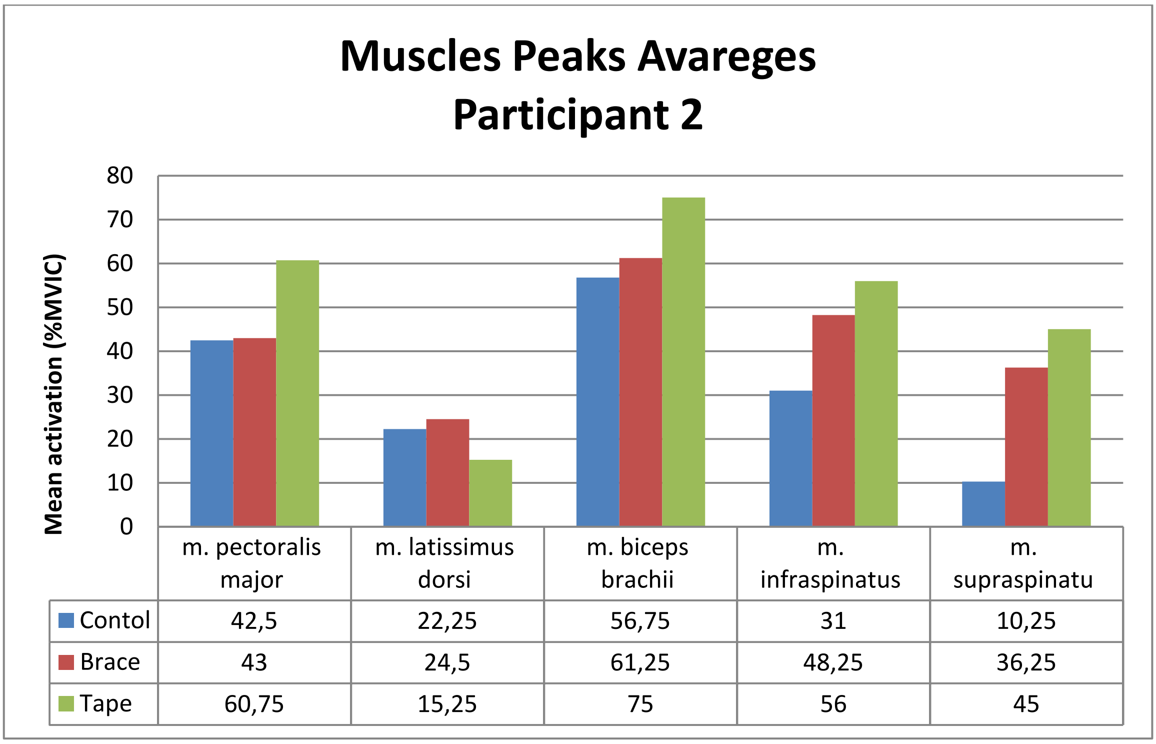


Figure n.14: Bar chart of the muscles peak averages of second participant.

The results of the Ho2

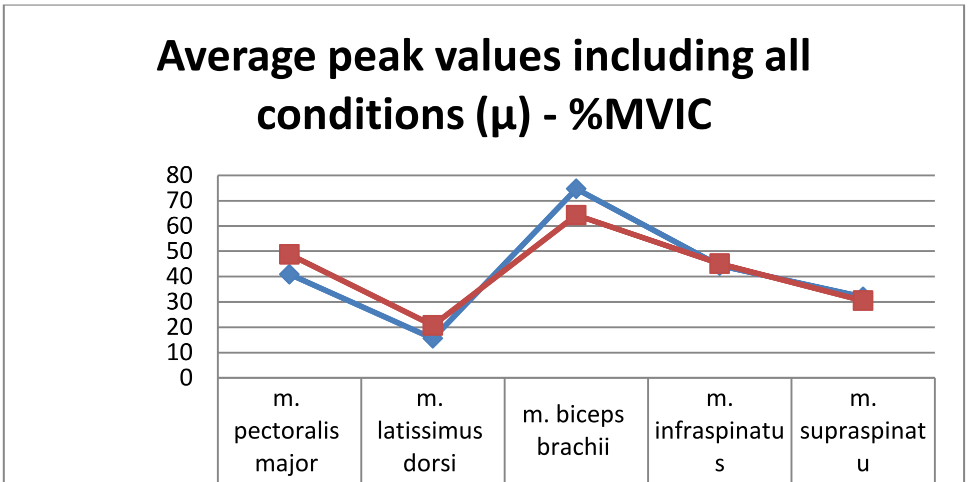
The second hypothesis says; "At least one of the selected muscles i.e. m. pectoralis maior, m. biceps brachii, m. latissimus dorsi, m. supraspinatus, or m. infraspinatus has the lowest amplitude average within all conditions," the following results are found.

To confirm the hypothesis the above technique for the measuring of the peaks averages are used, but in this case are take the lowest peaks (μ) of the activations (%MVIC) for every of muscle; the lower peak average the lower muscle activation. Figure number 13for first participant shows the lowest peak average activity in control condition for m. latissimus dorsi - μ= 18%; in tape condition for m. latissimus dorsi as well μ= 9, 25%; but then the is result for brace condition distinguishes in this condition has the lowest peaks average m. supraspinatus - μ= 17, 75%. On figure n. 14, is then seen again the lowest average peaks for m. latissimus dorsi μ= 24, 5% at brace condition; μ= 15, 25% at tape condition; but then is the differentiation again but now it is in control condition where is the least activated muscle the m. supraspinatus - μ=10, 25%.

The results of the Ho3

Third hypothesis thinks; " If there are differences in average peaks including all conditions of same muscles within the participants there might be different standard value deviations for every muscle so that, the mean value of the standard deviation would have significance level," the following results are obtained.

At first, are calculated the total peaks averages (µ) including all conditions together for every muscle separately and the results are seen in figure number ten. The figure also shows the curve of the total value averages of each participant. The curves have similar shapes but the different course of the values from that it follows that the present variations in values, which prove the numbers in the table below the graph. According to the graph is clear that there is not identical muscles activities are present and the standard deviation might occur.



	m. pectoralis major	m. latissimus dorsi	m. biceps brachii	m. infraspinatu s	m. supraspinat u
Particp.1	40,9	15,6	74,7	44,3	32
Part2	48,8	20,7	64,3	45,1	30,5

Chyba! Nenalezen zdroj odkazů.

The highest total peak average for first participant has m. biceps brachii µ= 74, 7%, then m. infraspinatus µ= 44, 3%, m. pectoralis maior µ= 40, 9%, m. supraspinatus µ= 32% and the lowest has m. latissimus dorsi µ= 15, 6%. The highest total average for second participant has again the m. biceps brachii µ= 64, 3%, then m. pectoralis maior µ= 48, 8%, m. infraspinatus µ=45 1%, m. supraspinatus µ= 30, 5% and the same as on first participant has the lowest activity m. latissimus dorsi µ=20, 7%.

Muscles		SD1	SD2
m. pectoralis major		4,94	8,00
m. latissimus dorsi		4,22	3,61
m. biceps brachii		4,06	7,11
m. infraspinatus		6,33	9,39
m. supraspinatus		11,00	13,50
P - value		0,016	0,033

Table n. 5: Standard deviation of the peaks averages of the selected muscles including all condition and, p-value of standard deviation of every muscle including all conditions. SD1- first participant, SD 2- second participant, P- value <0, 05.

Then are the standard deviations of the conditions measured by calculating the peaks value of each muscle in every condition and the result informs about the standard deviation within the conditions for each muscle. The results are seen in the table number six says that the biggest deviation within the condition is for m. supraspinatus. The standard deviation of this muscle for first participant (SD1) is 11, for second participant (SD2) is 13, 50. The least deviates muscle between the conditions by first participant is m. biceps brachii - SD= 4, 06 and by second participant is m. latissimus dorsi - SD=3, 61. Further to find the mean value of the standard deviation within the participant the two sample pair T-test are measured. The results are seen in the table number six for first participant is p-value equal 0,016, and for second participant is p-value equal 0,033 therefore indicates the significant importance for both values, but more valuable is for first participant.

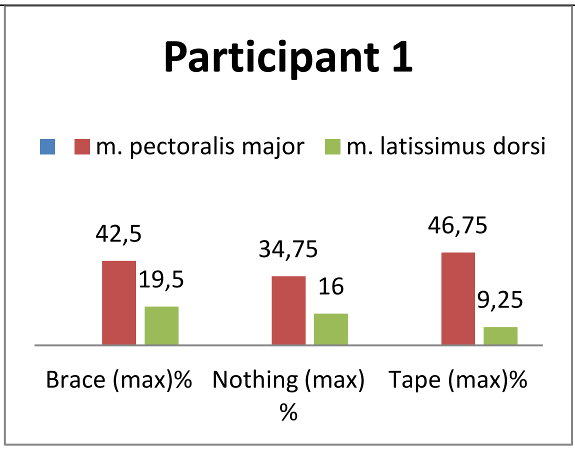
The results of the Ho4

With the relation to the Ho4 what says;" There occurs decrease of the average of the peaks values for m. latissimus dorsi and m. pectoralis maior, if there is kinesiotape application," are obtained the following results.

The average of four highest peaks activation (μ= % MVIC) in each conditions were taken from EMG signals of the m. latissimus dorsi and m. pectoralis maior (figure n. 16). Moreover, calculated from them the quantity of the divergent for total averages peaks activation for m. pectoralis maior and m. latissimus dorsi in kinesiotape condition compared with control and brace conditions. The results are positive or negative, positive for increasing of muscles activity toward the kinesiotape and negative result for decreasing the muscle activity toward the kinesiotape condition.

Tape vs. Nothing

The activity of m. pectoralis maior as was expected did not decrease for both participants, as is seen in table n. 6 the activity of this muscle increased on first participant about 18,25% and for second participant about 12%. Nevertheless, the activity of m. latissimus dorsi decrease about -7% for first participant and -25, 25% for second participant.



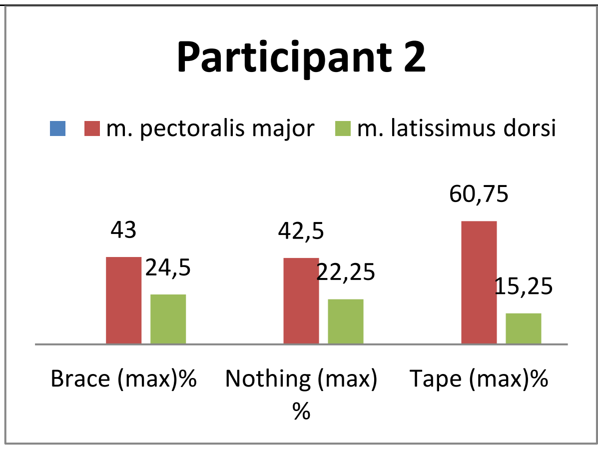


Figure n. 15: Bar charts of total peaks averages (μ) for m. pectoralis maior and m. latissimus dorsi (MVIC %).

Tape vs. Brace

In these circumstances are the kinesiotapes the one that increase the activity of m. pectoralis maior for first participant about 17, 75% and second participant about 4, 25%. Whereas, it the case of m. latissimus dorsi for both participants reduce the amplitude about -9, 25% for first participant and -10% for second participant.

Differences		
Muscle	**Tape vs. Control**	**Tape vs. Brace**
P1	18,25	17,75
LD1	-7	-9,25
P2	12	4,25
LD2	-25,25	-10

Table n. 6: The quantity of the divergent for total averages peaks values in compared the kinesiotape with other conditions (P1- pectoral muscle of first participant, LD1- latissimus dorsi muscle of first participant, P2- pectoral muscle of second participant, LD2- latissimus dorsi of second participant).

The results of the Ho 5

The hypothesis number five says; " Minimal one of the selected muscles i.e.; m. pectoralis maior, m. biceps brachii, m. latissimus dorsi, m. supraspinatus, or m. infraspinatus would have similar peak average value within participants in brace condition," the following results were found.

The results that found on figure n. 17 graphically demonstrated the peaks average values for each muscle for both participants as well as the numerical values in the table below the graph. At the first view, is assumable the similar activities for m. pectoralis maior, m. latissimus dorsi and m. infraspinatus because these muscles have their peaks closed to each other. The table below then confirms the fact that is readable also on the graph.

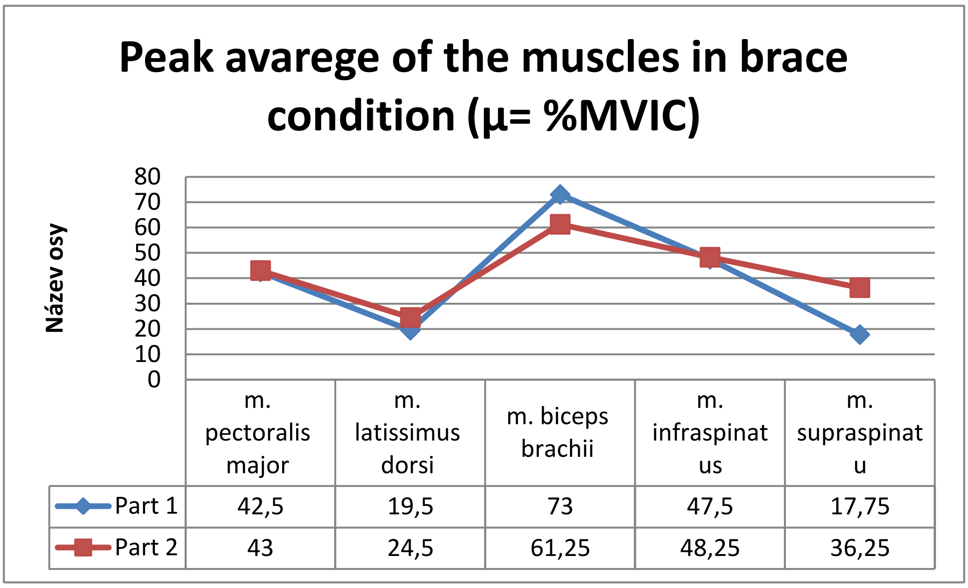


Figure n. 16:5 Peak average values of the muscles EMG signals in brace condition for each muscles (μ=% MVIC).

The results of the m. pectoralis is for first participant equal 42,5% and second equal 43% whereas significant similar activation. Further, there are similar activity of the latissimus dorsi as well for first participant is equal 19,5% and second participant equal 24,5%, last muscles that similar activated in same level are m. infraspinatus. For first participant it was equal 47,7% and second participant 48.25%. The other muscles had big differences in their activity for m. biceps brachii of first participant it was 73% and for second participant it equal 61,25% that means about 11,75% different and for m. supraspinatus for first participant 17,75% and second 36,25% so that means 18,5 % different in the peaks values.

6 Discussion

This work was inspirited by study investigated the effects of scapular bracing and alteration of posture and muscle activity in overhead athletes with poor posture. The study examine whether a scapular stabilization brace acutely alters posture and scapular muscle activity in healthy overhead athletes with forward-head, rounded shoulder posture. The design of the study was the randomized clinical trial randomized the participants into two groups: compression shirt with no strap tension (S) and compression shirt with the straps fully tensioned (S+T). The results confirm the application of the brace cause a small increase in lower trapeze EMG during forward flexion and decrease upper trapeze EMG during some exercises in the S+T group. The conclusion is that the application of the scapular brace improved shoulder posture and scapular muscle activity, use of scapular brace might improve the shoulder posture in overhead athletes.

The aim of this diploma study was to compare the amplitude, shape and duration of the myoelectric signals of m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder in kinesiotape, tennis elbow, and control conditions. As can seen in the chapter summarizing the results, the obtained results are very inconsistent, although, this could have been expect from the pilot study with two participants. Therefore cannot be the summary result values accepted as significant because there were low numbers of participants, although a higher number of participants are need in further studies to obtain results that are more significant. Two healthy women participants were chose according to their skills on vertical pole.

Control condition, was chosen as a basement for the other conditions with which were comparing with. The elbow condition was in interest to find out if there would be by muscles chaining the changes not only for the forearm muscles but also for the shoulder muscles. For this reason was used the tennis elbow brace which normally influent the extensors of the forearms as proved in many studies before, but as is known from the literatures there are muscles chaining in musculoskeletal system occur. Many authors such as Lewit (2003), Travell and Simons(1999) etc. refer to that fact in the treatment of pathologies. The kinesiotape condition was chose because in contrast to many of the rigid tapes is highly elastic and has been designed specifically for, among other things: facilitation or inhibition of muscle. There are many studies proved the positive influence of kinesiotapes on the muscles activations. Some studies have focused on the use of kinesiotape for specific injuries for example, the study done by Selkowitz et al. (2007) was completed on twenty-one volunteers with suspected shoulder impingement syndrome performed shoulder abduction in the scapular plane and a functional overhead-reaching (“shelf”) task, both with and without tape. Other study for example estimated the effect of kinesiotaping on seventeen baseball players with shoulder impingement (Hsu et al, 2008) in contrast to those studies, this diploma work recruited healthy volunteers. Some studies focused of the healthy participants as well; Cools et al. (2002), (Lin et al., 2011) and others.

6.1 Discussion to the first research question

"Will be the amplitudes, durations, and shapes of the myoelectric signals of the m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder the same or at least similar for both participants within conditions?"

The hypothesis says there are different in EMG amplitudes, shapes and durations of the myoelectric signals of the m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder within the conditions and participant.

This hypothesis anticipating the different EMG amplitude was definitely confirmed, but it is important to notice that there are small samples comparing these facts on. The differences were between two participants only; regardless to this fact is the hypothesis valid. In control condition there was for both participants the most activated muscle the m. biceps brachii this were familiar for both participants, but then there is different activation for m. pectoralis maior and m. infraspinatus. By first participant as the higher most activated muscle was the m. pectoralis whereas by the second participant it was the m. infraspinatus. Then there were seen the same ranking of the muscle activity for m. latissimus dorsi and m. supraspinatus. For what could not the hypothesis confirmed was for the shape of the curves. Although, the every EMG signal had different shapes there were seen the similarity in the character of the activities. At the beginning, there was always significant changing of the activation peak (% MVIC) then at the horizontal position unchanged and changing again when reaching the ending positions (F- H). There proved the differences in the amplitudes in compare with control condition of both participants. As the highest activated muscle was again the m. biceps brachii, but then there are especially in horizontal position the changing of peak value (% MVIC) for m. pectoralis maior and m. infraspinatus of first participant and vice versa for second participant. There were decrease amplitudes for m. pectoralis maior for both participants in elbow brace condition. The less amplitude deviations were for m. latissimus dorsi and m. supraspinatus. Kinesiotape decreased the amplitudes of the m. latissimus dorsi because the application of the kinesiotape was to support shoulder internal rotation by facilitation of m. latissimus dorsi and helps it in its function. The kinesiotape was stretched on 75% of its length applied as was described in methodology of the work.

In this type of experiment with only two samples included, it is obvious that there will not be finding the same or even similarity of the amplitudes, shapes and durations of myoelectric signals within the conditions and participant, because according Véle (2006) there is no possibility to do the repetition of the movement pattern with exact consensus. Every movement adapts incrementally to external and internal environments but also on mental state. Based on this information, I have tried to achieve the exact instructions before each measurement and ensuring constant external environment such as temperature in the room, the silence, to realize the most stable environment.

The deficiency of this experiment was the fact that the results could not be compared in greater amount of the variances because there were only data from two participants, which were possible to be comparing only with each other, hereby reducing the credibility of the comparison. It should be reveal, that the shapes of the EMG signals are strongly affected by the errors in the measurement. At the areas of the errors occur the pathological shapes of the curves so that, they do not give any valid information and on the contrary distort the veracity of the curves.

6.2 Discussion to the second research question

"***How will significantly change the amplitudes, and peaks of the myoelectric signals of m. infraspinatus, m. supraspinatus, m. pectoralis maior, m. biceps brachii and m. latissimus dorsi on dominant shoulder inside two conditions i.e. kinesiotape for shoulder and tennis brace with the control condition?"***

<u>The first hypothesis said at least one of the selected muscles i.e. m. pectoralis maior, m. biceps brachii or m. latissimus dorsi, m. supraspinatus, and m. infraspinatus has the highest activation average within all conditions.</u>

The result of this statement was within two participants of this study case. The figure n. 13 and 14 represents the bar charts of the muscles peaks averages. The average had been calculated by taking the four highest peaks for every muscle in each condition. The muscle fulfilled the hypothesis statement was only m. biceps brachii which had the highest peaks averages in all condition for both participants. Control condition -μ=80, 75%; tape condition-μ= 70, 25%; brace condition - μ= 73% for first participant and μ= 56, 75%; μ= 75%; and 61, 25% for second participant in same ranking of the conditions as for first participant. The hypothesis was not rejecting in the reason that said at least one muscle had highest average activity within conditions. In addition, this was proved for m. biceps brachii.

On similar task was based the article review concluded by Escamilla and Andrews (2009), the review focuses on shoulder muscle activity (rotator cuff, deltoids, pectoralis major, latissimus dorsi, triceps and biceps brachii, and scapular muscles) measured by EMG during the overhead throwing motion to understand why certain muscles are active during different phases of an activity. However, the differences of that review to this study are that, they were interested of the muscles highest peaks in different conditions formed by different sports activities. The highest peak in all overhead sport activities such as softball pitch, baseball pitch, volleyball serve etc were for rotator cuff muscles, as well as for m. serratus anterior, lower, middle and upper m. trapezius or m. levator scapulae. For example, there occurred similar peak activation for peak activation for rhomboids and levator scapulae approximately 60% MVIC during the golf swing.

<u>Second hypothesis said that at least at least one of the selected muscles i.e. m. pectoralis maior, m. biceps brachii or m. latissimus dorsi, m. supraspinatus, and m. infraspinatus has the lowest average of the peak activations with the conditions.</u>

The figure n. 13 and 14 showed the variability in the average of the lowest peak activation dependent on the condition and participant, it is again notice that the results are within two samples only. The value of the lowest averages activation was for first participant the m. latissimus dorsi μ=18% in control condition, μ= 9, 25% in tape condition and μ= 17, 75% for m. supraspinatus in brace condition. Heterogeneous were the results also for first participant, there were again for the m. latissimus dorsi but μ=24, 5% in brace condition, μ=15, 25% in tape condition, and μ=10, 25% in control condition.

The results did not follow the hypothesis statement that at least one of the selected muscles have to had the lowest peaks averages within all conditions, accordingly is the hypothesis rejected. The same article review concluded by Escamilla and Andrews (2009) also notes the lowest shoulder muscle activity in different overhead sports that were mentioned above. Their resulted the similar lowest activity in baseball hitting is for m. serratus anterior (30-40% MVIC) and for muscles (28-39% MVIC).

<u>Third hypothesis thought if there were differences in average peaks including all</u>

conditions of same muscles within the participants there might was be different standard value deviations for every muscle so that, the mean value of standard deviation would had significance level.

By the results were established that there occurred the differences in the averages including all conditions total peaks for same muscles of both participants. The different peak average values were for m. biceps brachii, m. infraspinatus, m. latissimus dorsi, m. supraspinatus and m. pectoralis of each participant. The result of measuring the standard deviations settled the most deviated muscles within the conditions for both participants as the m. supraspinatus (SD1=11, SD2=13,50) and least deviated muscle differed for first participant and second participant. The least deviated muscle of first participant was the m. biceps brachii (SD= 4, 06) and for second participant it was the m. latissimus dorsi (SD=3, 61). The significance levels of the each standard deviation mean value within the participants resulted positively for both of them that, level that is more significant belonged to first participant (0,016) and for second was less significant (0,033). It is important to notice that these values are not statistically significant, because the analysis contained low samples amount. Within the facts that were solved was third hypothesis strongly valid.

The fourth hypothesis said that there would be decrease average of the peaks values for m. latissimus dorsi and m. pectoralis maior, if there was applied the kinesiotape.

This hypothesis was rejecting for m. pectoralis maior of both participants because the kinesiotape did not decrease their activities as it said, but on the contrary did increase their activity as was seen in table n.6; kinesiotape vs. control condition P1: +18, 25; P2: +12. Kinesiotape vs. brace condition P1:+17, 75; P2: + 4, 25. Nevertheless, this hypothesis could not be rejected for the influence of the kinesiotape on activities of m. latissimus of both participants, because there were occurred the decreasing of the total peak averages as was said. Kinesiotape vs. nothing condition LD1: -7; LD2: -25, 25 and kinesiotape vs. brace conditions LD1:-9, 25; LD2: -10.

The last settled hypothesis said that minimal one of the selected muscles i.e.; m. pectoralis maior, m. biceps brachii, m. latissimus dorsi, m. supraspinatus, or m. infraspinatus would had similar peak average value within participants in brace condition.

The activity of m. pectoralis and m infraspinatus had similarity. The m. pectoralis is for first participant =42,5% and second = 43%, m. infraspinatus for first participant = 47,7% and second participant= 48.25%.

7 Conclusion

In this pilot study had been using surface electromyography for examining two different conditions at Shoulder Mount pole acrobatic exercise on the activity of m. pectoralis maior, m. biceps brachii, m. infraspinatus, m. supraspinatus and m latissimus dorsi. It was curious on the myoelectric amplitudes, shapes, and duration of the muscles if there applied two different conditions (kinesiotape and elbow brace) and compared with control condition what was done without them.

Participant found the kinesiotape application subjectively beneficial, both described improvement of the movement quality performance. They described better posture and helpfully limitation of the arm ROM overhead. Objectively as the results showed has the kinesiotape the most impact on m. latissimus dorsi and m. infraspinatus. The application of the kinesiotape that was used in the experiment did not bring any positive outcomes. For further researches will be important to focus on those application techniques which will stabilized the scapular and rotator cuff muscles. The reasons of the application of the kinesiotape condition as how was used in the experiment estimated on my assumption that the highest activity would belongs to m. latissimus dorsi so that I support it in its action. Another question arises in the term of the significance of the findings results. Cause is the study only of two samples, there is no possible to speak about the significance the results.

My interest of find out the impact of elbow bracing on activities of the shoulder muscles differ within the participants, but on graphs are seen in comparing the amplitudes in control conditions, the positive outcomes in decreasing for m. biceps brachii. According to the amplitudes is the most important muscle for Shoulder Mount, its amplitude stayed high in every condition for both participants. It should be notice, although the overall results for the brace condition of the m. biceps brachii are positive, the participants felt uncomfortable with the brace, which restricted them fully bent their elbow.

To determine a definite conclusion would be needed to expand the number of people tested. It would also be appropriate to carry out a similar research on patients with a certain type of pathological changes in the shoulder area.

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Enclosure n. 2: An informed content of the participant, example.

Enclosure n. 3: The table of peak values of the EMG signals for further analyzes for first participant.

Enclosure n. 4: The table of peak values of the EMG signals for further analyzes for second participant.

Enclosure n. 5: Video of Shoulder Mount motion analysis in Qualisys Track Manager.

Enclosure n. 6: Video record of the Shoulder Mount exercise (attachment to the methodology of the work).

Enclosure n. 7: ROM in shoulder joint

Enclosure n. 1

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Application for Ethics Board Review

of the research project, doctoral research, master degree research, undergraduate research, involving human subjects

Project title: Muscles activation during „SHOULDER MOUNT“ pole acrobatic exercise

Nature of the research project: master degree research

Author: Modinat Sanni, Bc.
Supervisor: Ing. Miroslav Vilímek

Research project description: This study is an empirical - theoretical study presents the literature review regarding to the topic of the shoulder function anatomy, kinesiology, biomechanics, non traumatic injuries of the shoulder and their prevention by using the available literatures. Further, the study also compares by surface electromyography the amplitudes, shapes and durations of myoelectric signals of m. latissimus dorsi, m. pectoralis maior, m. biceps brachii, m. infraspinatus and m. supraspinatus on dominant shoulder in two healthy individuals during acrobatic exercise on vertical pole known as "Shoulder Mount". The purpose is monitor the changes in two different conditions; i.e. kinesiotape and elbow brace in compare with the control condition and find out their ability to affect the myoelectric activity of selected muscles. Further, the Shoulder Mount exercise is recorded by six Qualisys camera for motion analyses.
Guaranteed safety to be judged by experts: Subjects will be protecting from the risk of fall by using the divine grip from non name company, to eliminate an accidental slip of the hands.
Ethical aspects of the research: No
Informed consent (attached): Yes

Date: 10 March 2015 Author's signature:

Faculty of Physical Education and Sport, Charles University in Prague
ETHICS BOARD REVIEW

Ethics Board members: Prof. Ing. Václav Bunc, CSc.
Prof. PhDr. Pavel Slepička, DrSc.
Doc. MUDr. Jan Heller, CSc.

The Ethics Board at the Faculty of Physical Education and Sport, Charles University, approved the research project.

Approval number: 68/2015

Date: 12. 3. 2015

The Ethics Board at the Faculty of Physical Education and Sport, Charles University, reviewed the submitted research project and **found no contradictions with valid principles**, regulations and international guidelines for biomedical research involving human subjects.

The chief investigator of the project met the necessary requirements for receiving the Ethics Board approval.

Official school stamp
UNIVERZITA KARLOVA v Praze
Fakulta tělesné výchovy a sportu
José Martího 31, 162 52, Praha 6
1

Signature, REB Chairman

Enclosure n. 2

INFORMOVANÝ SOUHLAS

Muscles activation during "Shoulder Mount" pole acrobatic exercise.

Jméno:

Datum narození:

Účastník byl do studie zařazen pod číslem:

1. Já níže podepsaný (á) souhlasím s mou účastí ve studii. Je mi více než 18 let.

2. Byl (a) jsem podrobně informován (a) o cílu studie, o jejích postupech, a o tom, co se ode mě očekává. Beru na vědomí, že prováděná studie je výzkumnou činností. Porozuměl (a) jsem tomu, že svou účastí ve studii mohu kdykoliv přerušit či odstoupit. Moje účast ve studiu je dobrovolná.

3. Při zařazení do studie budou moje osobní data uchována s plnou ochranou s důvěrnosti dle platných zákonů ČR. Je zrušena ochrana důvěrnosti mých osobních dat. Pro výzkumné a vědecké účely mohou být moje osobní údaje poskytnuty pouze bez identifikačních údajů (anonymní data) nebo s mým výslovným souhlasem.

4. S mojí účastí ve studiu není spojeno poskytnutí žádné odměny.

5. Porozuměl (a) jsem tomu, že mé jméno se nebude nikdy vyskytovat v referátech o této studii. Já naopak nebudu proti použití výsledků z této studie.

Podpis účastníka:

Datum:

Podpis řešitele studia:

Datum:

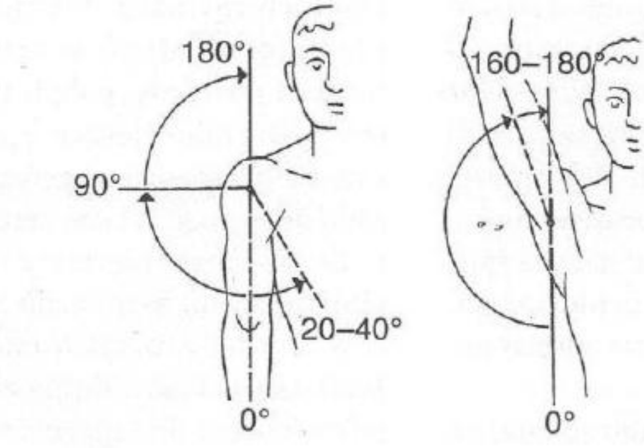
Enclosure n. 3

Participant Number 1				
Brace Condition				
Muscle	**Peak 1**	**Peak 2**	**Peak 3**	**Peak 4**
m. pectoralis major	48	43	40	39
m. latissimus dorsi	22	18	20	18
m. biceps brachii	63	71	78	80
m. infraspinatus	53	54	41	42
m. supraspinatu	24	13	20	14
Control Condition				
Muscle	**Peak 1**	**Peak 2**	**Peak 3**	**Peak 4**
m. pectoralis major	42	32	22	38
m. latissimus dorsi	25	23	15	9
m. biceps brachii	78	90	85	70
m. infraspinatus	42	39	48	10
m. supraspinatu	35	18	51	90
Kinesiotape Condition				
Muscle	**Peak 1**	**Peak 2**	**Peak 3**	**Peak 4**
m. pectoralis major	62	55	50	20
m. latissimus dorsi	15	10	12	0
m. biceps brachii	59	80	85	57
m. infraspinatus	60	45	47	50
m. supraspinatu	43	19	19	38

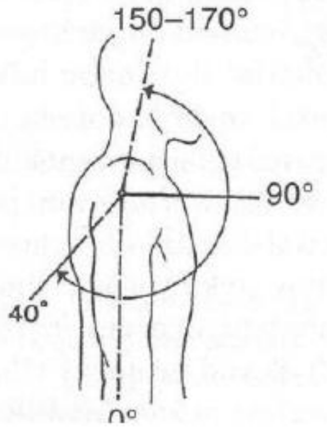
Enclosure n. 4

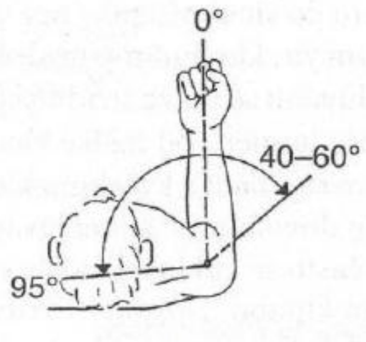
Participant Number 2				
Brace Condition				
Muscle	**Peak 1**	**Peak 2**	**Peak 3**	**Peak 4**
m. pectoralis major	50	52	32	38
m. latissimus dorsi	10	25	30	33
m. biceps brachii	45	65	75	60
m. infraspinatus	58	45	50	40
m. supraspinatus	70	10	15	50
Control Condition				
Muscle	**Peak 1**	**Peak 2**	**Peak 3**	**Peak 4**
m. pectoralis major	41	42	48	39
m. latissimus dorsi	18	25	27	19
m. biceps brachii	8	63	80	76
m. infraspinatus	5	40	38	41
m. supraspinatus	10	14	8	9
Kinesiotape Condition				
Muscle	**Peak 1**	**Peak 2**	**Peak 3**	**Peak 4**
m. pectoralis major	58	60	70	55
m. latissimus dorsi	17	17	17	10
m. biceps brachii	78	50	82	90
m. infraspinatus	40	74	60	50
m. supraspinatus	62	98	10	10

Enclosure n. 7



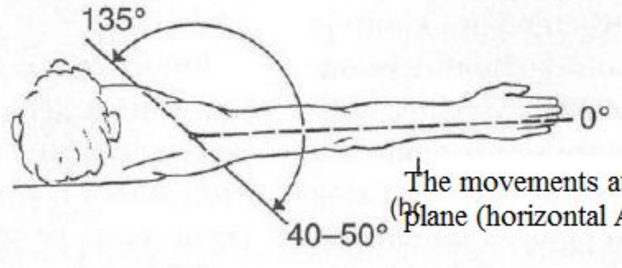
Movements at frontal plane (abduction, adduction)





Rotational movements

Movements at sagital plane (flexion, extension



The movements at the horizontal plane (horizontal ADB and ADD)

(Kapandji, 2006)