# SHOULDER BANDAGE WITH DISTAL TRACTION – APPLICATION TO ATHLETES OVERUSING "OVERHEAD" ACTIVITIES

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Sportsmen with overhead activities very frequently have an increased mobility of the shoulder joints. Thus it is often difficult to distinguish between stability, hyperlaxity, and instability of the joint. Repeated extreme movements strain static stabilizers and lead to their lengthening. The principal problem in sporters is to establish a balance between the mobility and stability of the shoulder joint. Clinical examinations and the following treatment should be focused not only on pain but also on the stability of the glenohumeral joint. We can encounter a whole range of possibilities from glenohumeral instability to the impingement syndrome. We often find a narrowing of the subacromial space in so-called tennis shoulder (rotation of the scapula and relative abduction of the humerus). A helpful therapeutic solution of this problem should be provided by a bandage of our own new construction.

The shoulder bandage consists of an upper arm sleeve and an elastic strap leading across the axilla and fixed around the chest. If the upper extremity is free in adduction, there is no tension to the sleeve but in the moment of abduction, the elastic strap is gradually stretched and the sleeve pulls the proximal humerus down. Greater elevation and greater tension can be modified by the tightening or lengthening of the elastic strap. On the one hand the bandage causes broadening of the subacromial space, on the other hand muscle activity is modified and a higher muscle tonus increasingly stabilizes the joint. This paper describes the effect of the bandage from different points of view – orthopedic, biomechanical, and imaging.

A group of 25 patients is evaluated. The feeling of an increased stability of the shoulder is described by 16 sporters and minimizing of pain by using the bandage is reported by 13 sporters. Constraining of locomotion in the edge position is claimed by 18 persons and decreasing of performance resulting from a slowed up lifting of the arm is declared by 16 persons. 9 sporters use the bandage regularly, 8 use it only in case of problems, 6 persons stopped using it after remission of acute complaints, 2 persons claim no effect of the bandage.

The shoulder bandage increases glenohumeral stability, minimizes the risk of injuring the rotator cuff, reduces the risk of impingement syndrome, alleviates or even eliminates the pain in elevation and in extreme positions of the upper arm. It enables sporters to continue sports activities without the risk of worsening a pathological condition.

*Keywords: Overhead activities, painful shoulder, bandage with distal traction.*

## INTRODUCTION

Painful shoulder is a very frequent disorder in practically all sports disciplines. However, incidence of the condition is substantially higher in sports overusing overhead activities. Such sports involve especially ball games including racquet games (tennis, badminton, squash, pelota etc.), throwing events, swimming and artistic gymnastics. In these sports, the subacromial space is considerably overused. As a result, painful disorders are developed. They may be triggered by frequent overhead position of upper extremities and also by hypermobility of the joint, due to the mechanism of frequent swings associated with moving upper extremities to the extremes of motion. These repeated microtraumas develop into a whole range of changes. The articular capsule becomes lax, which gradually leads to development of glenohumeral instability. They may result in subluxating position in the glenohumeral articulation. They may end in impressions of the humeral head having a character of the Hill-Sachs lesion, even if there was no previous history of complete luxation. In the subsequent stage, the impingement syndrome develops. An increased pressure in the subacromial space irritates soft tissues – the amount of fluid between the layers of the subdeltoid fascia is increased, subacromial bursitis is developed, and the next stage is overloading of the rotator cuff, particularly the supraspinatus tendon. What was initially an inflammatory reaction is gradually transformed into degenerative changes that can end in an irreversible damage to the rotator cuff.

These complaints are very often accompanied by muscular imbalances. Especially shortening of the levator scapulae and the upper portion of the trapezoid muscle leads to rotation of the scapula by ever increasing traction in a proximal direction (in the interior angle of the scapula). The resulting distalisation of the acromium leads to an increase in subacromial hyperpressure. The changed position of the scapula and excessive strain in sports, also lead to overloading of acromioclavicular articulation. Other causes can become a source of complaints less frequently. We should never overlook neurogenic and especially vertebrogenic disorders and the possibility of pain transmission occurring as a result of a cardiac or pulmonary alteration. Therefore, it is necessary to exactly establish causes of complaints. In addition to a very careful clinical examination, focused on evaluating the range of passive and active motions as well as glenohumeral stability, it is vital to examine surrounding muscles to rule out any muscular imbalances. Routinely, the shoulder soft tissues must be examined echographically both in basic views and in stressed positions, in which any glenohumeral instability can be shown with a high accuracy. X-ray or neurological examinations are considered complementary, as are examinations by an internist (cardiologist, chest physician) in high-risk patients. The purpose of this work is to present the first results of impingement syndrome treatment in sporters undergoing conservative therapy using an bandage of their own design with a distal elastic tension.

## AIM OF THE WORK

In 1994 the authors designed a shoulder bandage with a distal traction in reaction to the fact that the market did not offer any other suitable aid, which could improve glenohumeral joint stability and, at the same time, decrease the pressure in the subacromial space when the upper extremity is positioned above the horizontal line. At the beginning only individual aids were made. Since 1999 they have been applied more often thanks to their positive effect. The aim of this work is to analyse the bandage from clinical and biomechanical viewpoints.

## MATERIAL & METHODS

Biomechanical characteristics:

The glenohumeral joint is a shallow ball-and-socket joint. Mechanically it has the character of plane connection. A closed ball-and-socket joint has the character of a spherical connection, but as a result of its shallow socket, the shoulder joint has a flat connection. The position of its individual components in the connection is labile.

No mechanical motion can occur if the resultant force line of action of the shoulder muscular system passes through the potential contact area in a normal direction (it is perpendicular to the joint tangent at the point of contact). Motion equilibrium is then ensured by the contact force in the socket that in magnitude equals the resultant force of the muscular system, but with the opposite orientation and they both lie on the joint line of action.

The action of force in the shoulder joint can be divided into three groups:

a) the action of force in the contact between the humerus and the socket,
b) the action of force associated with usual activities of the muscular system,
c) the action of force associated with excessive activities of the upper arm (sports activities such as hitting a ball in volleyball, strokes with a racquet, shooting baskets in basketball, etc.).

Ad a) First of all we are going to deal with a state in which the shoulder articulation system is in stable equilibrium (mechanical rest) and the action of force associated with the activity of the upper limb is not substantial. The weight of the upper limb is not considered either. Thus the system to be described consists of the force system associated with the activity of the group of muscles and resolved action of force in the contact between the humerus and the socket.

Ad b) The system of muscles represents an adaptive controlled system. Therefore, the action of forces associated with the system of muscles is considered as primary – active, whose action results in the resolved action of force in the contact between the head and socket of the shoulder joint.

A mobile equilibrium between the humerus and the socket will take place, if the resultant of the system of forces from muscles and the resultant of the resolved action of force lie on the same line of action, are of the same magnitude but of opposite orientation, while the line of action of the force is a joint normal at the point of contact (Fig. 1). The normal at the point of contact is perpendicular to the common tangential plane at the point of contact. Thus, the common line of action is determined by geometry of the humerus and the socket at the point of contact. The resultant force of the system of muscles is the action force that need not meet the given condition at a certain moment. Fulfilment of the condition depends on the reaction time of the control system. Its duration is usually very short and thus the position of the socket and humerus is not substantially changed and the contact occurs in a physiologically viable position.

Ad c) So far we have dealt with the case in which upper limb activity is not decisive. Now the focus will be on

the action of force in the shoulder joint with significant activity of the upper arm in sports, where the upper limb is active in overhead positions. This activity involves, in addition to the above mentioned action of forces, inertial forces and also the action of forces involved in the sports performance itself, i. e. the one associated with strokes of a different character, such as direct hand strokes in volleyball, strokes with racquets in tennis or squash or ball shooting in basketball or handball. In all these activities the impact forces have, in comparison with the above mentioned forces, a several times greater magnitude with a short duration. Both facts act adversely on the shoulder joint function. If the action of impact forces is shorter or equals the reaction times of the muscle system, then its reaction lacks the time to provide such a ratio of forces as could ensure dynamic conditions of balance. It means that the resultant's line of the action of force associated with the sporting activity and muscle group does not have its normal direction at the points of contact. Besides a normal component it has a tangential component as well. In this instance the character of the system of forces is beyond control, and the resultant's line of action passes beyond the area of possible contact of the socket with the humerus. The humerus is translated into a non-functioning position. However, it must be said that during this activity the tangential component is heading upwards and thus the humerus head is translated upwards and thus subacromial hyper pressure may occur (Fig. 2, the outline).

In thid analysis we are going to consider arbitrary motion of the upper limb, including the motion in which overloading by activities occurs. It is a case of a concrete state of motion determined by the position, speed and acceleration of the upper limb. In the given state, the forces involved in all elements affecting the motion of the upper limb and the force associated with its activity will assume a certain, entirely concrete value. A dynamic task, which is defined in such a way, will be formally transformed into a static one by introducing inertial forces and moments on the basis of d'Alembert principle.

Due to the fact that any entirely determined force system from the point of view of static equivalence can be replaced by a force and a force couple, determined at the moment, it is possible, using a gradual statically equivalent substitution, to express actions of other elements of the upper limb at an arbitrary point of the elbow joint via a force and moment resultant, determined at the moment.

Now, the arm can relax. Force elements acting on a relaxed arm can be formally divided into:

- forces and force moments in muscles and other tissues ($\mathbf{F}_{VO}$, $\mathbf{M}_{VO}$),
- inertial forces and moments ($\mathbf{F}_{A}$, $\mathbf{M}_{A}$),
- force and moment resultants of the relaxed parts of the upper limb acting in the elbow joint ($\mathbf{F}_{VL}$, $\mathbf{M}_{VL}$),
- force and moment resultants in the shoulder joint ($\mathbf{F}_{VR}$, $\mathbf{M}_{VR)}$.

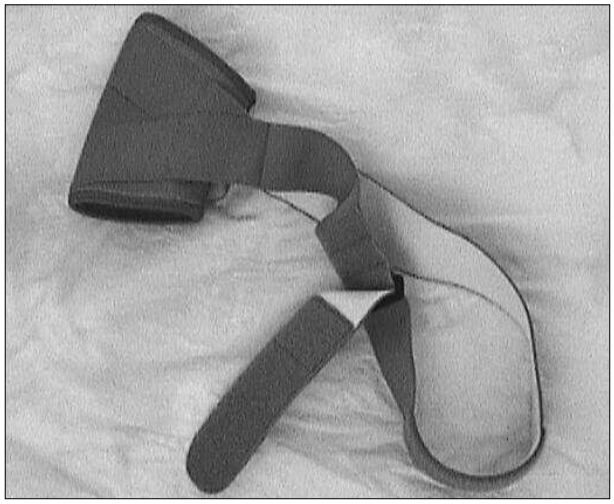
Then the equilibrium equation can be expressed in the form:

$$\mathbf{F}_{VO} + \mathbf{F}_{A} + \mathbf{F}_{VL} + \mathbf{F}_{VR} = \mathbf{0}$$
$$\mathbf{M}_{VO} + \mathbf{M}_{A} + \mathbf{M}_{VL} + \mathbf{M}_{VR} = \mathbf{0}$$

Now a mechanical analysis of the shoulder joint will be made. The shoulder joint is an open ball-and-socket joint. From the mechanical point of view it has the character of a flat, conditionally functional coupling. (The joint is functional if the resultant contact force is directed into the joint.) In a physiologically developed joint, the passive constraints (friction) are not substantial, which is manifested by a zero moment resultant ($M_{VR} = 0$) and perpendicularity of the carrier of the force resultant $F_{VR}$ to the common tangent plane in the point of contact.

**Thus** $M_{VO} + M_{A} + M_{VL} = 0$
**and if we denote** $F_{VO} + F_{A} + F_{VL} = F_{V}$,
**then** $F_{V} = F_{VR}$

**Fig. 1**
The muscular system represents a controlled system, therefore if it is not overloaded, it ensures that the above conditions can be satisfied without any problems



In case of overloading, the force resultant is directed against the upper edge of the glenoid fossa and the humerus head is translated in the same direction until it is subluxated and strikes the soft tissues, which causes pain and a gradual development of pathological changes. The change in the direction of force resultant $\mathbf{F}_{V}$ can be achieved by adding force $\mathbf{F}_{p}$ (Fig. 2) that is, in our case, exerted by the shoulder orthosis. As seen in the figure, force $\mathbf{F}_{p,}$ must have a direction and magnitude within

a certain range, which provides variability of the shoulder orthosis. Using appropriate parameters of force $\mathbf{F}_p$, the altered resultant $\mathbf{F}_{Vp}$ will have the same direction as if it were not overloaded and so no displacement of the humerus head occurs.

**Fig. 2**

## DESCRIPTION OF THE BANDAGE

The new type of bandage is based on an innovative design concept. It consists of an atypical design and overall construction as well as a new combination of materials. The sleeve, extended over the proximal arm, is made of a special breathable material, Syncrolast, which does not cause any sores after round-the-clock wearing (Fig. 3). It is fixed to the thoracic wall by means of a stretchable, rubber traction over the axilla. If the arm hangs freely, there is no traction exerted on the fixed arm sleeve and the orthosis does not have any effect (Fig. 4). When the arm is elevated, the elastic traction is gradually stretched and the sleeve pulls the proximal arm in a distal direction towards the chest (Fig. 5). The greater the elevation of the arm, the greater is the distal pull and hence the greater unloading of the subacromial space. The traction can be adjusted by tightening or loosening of the fixation to the chest wall by sliding velcro fastening.

**Fig. 3**

**Fig. 4**

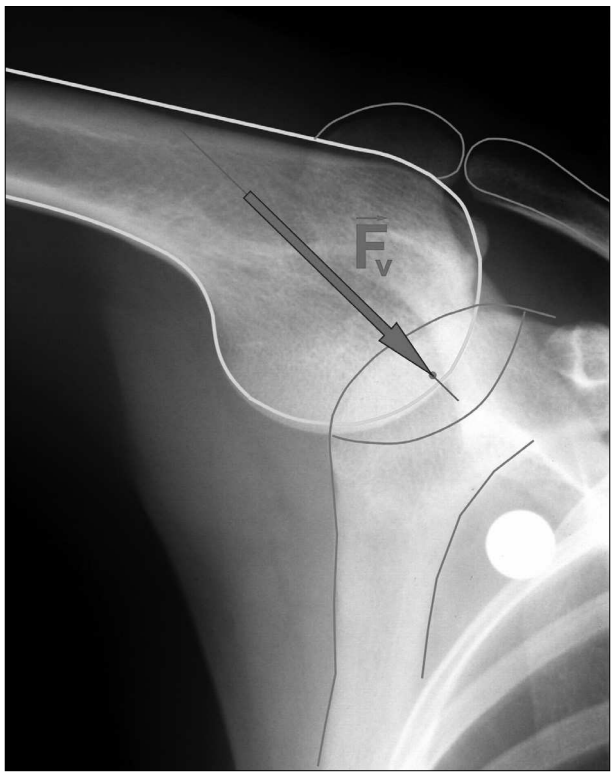
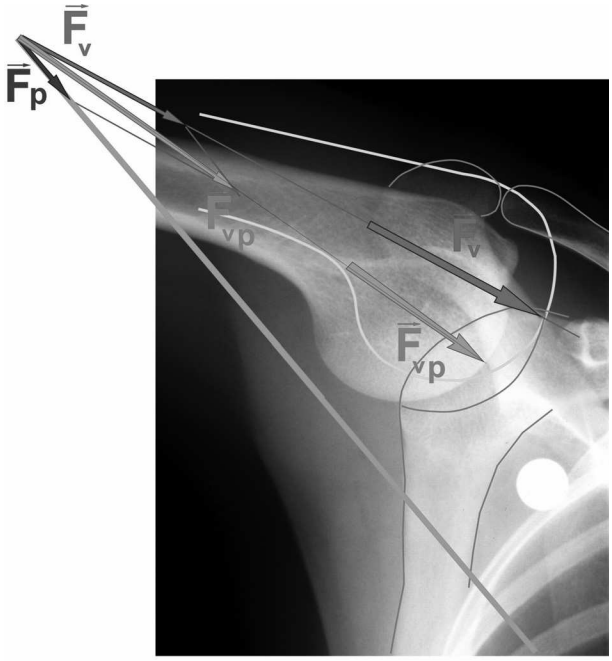


**Fig. 5**




**X-ray and USG examinations**

To verify the effect of the orthosis, X-ray examination was performed by means of skiagraphic device Argostat plus HF50R and ultrasound examination by means of Medison Sono ACE.

Images were realized both without and with the bandage.

X-ray examination: To evaluate the skiagrams objectively, a calibration pellet was attached to the patient's body. The skiagrams were taken at a standard distance and position to rule out any distortion. Subsequently the subacromial space, imaged on the skiagrams, was compared.

In the skiagram with a fitted orthosis, the width of the subacromial space increased by 20% (Fig. 6). Comparative images are performed routinely, that is why the ethical committee's consent was not required.

USG examination: The distance between the outline of the humerus head and the acromial border was compared in the standard position of the upper extremity and echographic probe (lateral longitudinal view) (Fig. 7). The results of measurement corresponded with the X-ray findings.

**Fig. 6**

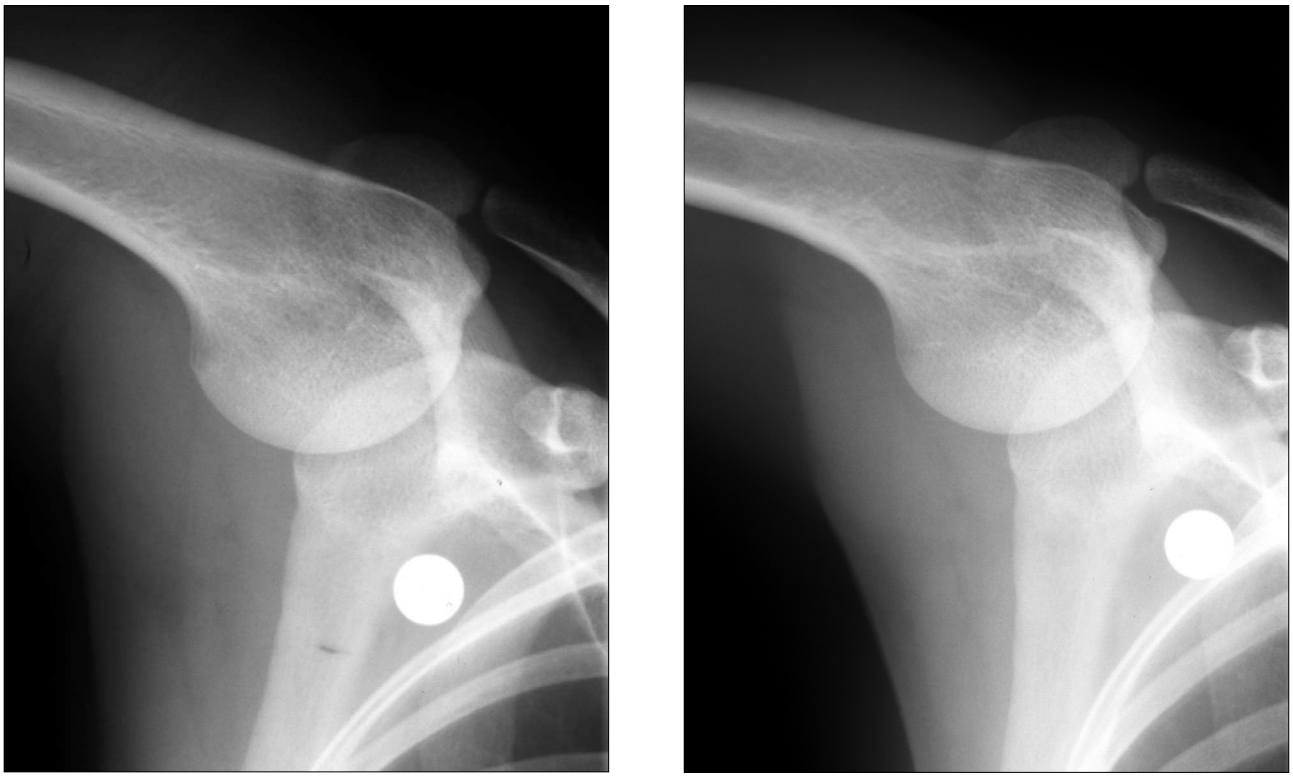
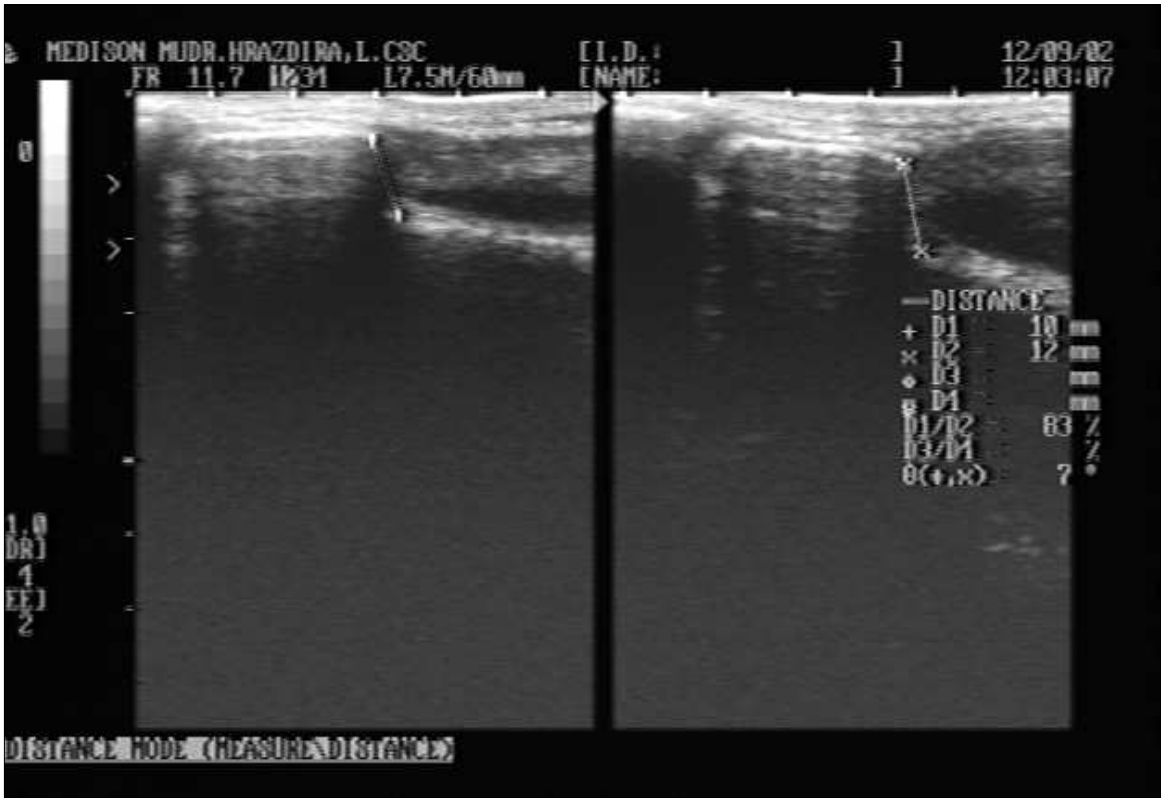


**Fig. 7**




**Group of patients**

The shoulder orthosis was fitted in 25 athletes clinically diagnosed with impingement syndrome. We monitored its effect on soreness, seriously restricted range of motion and change of biomechanics in the shoulder girdle, ability to improve stability of the glenohumeral joint and patients' subjective feelings with or without a bandage.

## RESULTS

All 23 subjects reported subjective alleviation of pain and 2 persons reported no effect of the bandage. A subjective feeling of shoulder strengthening and an increase in stability was confirmed in 16 subjects. The sensation of restricting motion in extreme positions was stated by 18 subjects. A feeling of limitation in performance as a result of slowing during wind up and cocking is claimed by 16 athletes.

In 16 athletes, the bandage must be worn for sport, 9 wear it intermittently, 8 stopped wearing it when their acute complaints subsided, 2 athletes do not use it due to allegedly zero effect.

## DISCUSSION

As the bandage is of a completely new design, it cannot be compared with other cases known in literature. The bandage distalises the humerus head. It reduces the risk of increase in pressure in the subacromium when the arm is lifted above the horizontal line and thus reduces the possibility of the development of (primary) impingement syndrome. It acts as an antagonist to the supraspinatus, which is the primary depressor of the humerus. At the same time it reduces demand on the long head ligament of the biceps and decreases the strain of the lower glenohumeral ligament. By its pull, the orthosis reduces the risk of rotator cuff injuries against the distal side of the coracoacromial arch and the risk of secondary impingement syndrome development. It also acts against the development of secondary impingement syndrome by translating pressure over the humerus into the socket of the glenohumeral articulation. It lends higher stability to the joint and reduces the risk of translating positions of the humerus head. Simultaneously, tonus of the muscles is raised in the shoulder girdle by a double mechanism. On the one hand, muscles are stimulated to develop a higher activity to actively overcome the resistance in elevating the arm above the horizontal line. On the other hand, the bandage fitting in itself modifies proprioceptive innervation. The continuous stimulation of exteroceptors by the bandage produces

sensoric impulses in afferent neurons travelling to the posterior spinal-chord, interneurons excite impulses in motoneurons of one or more segments, which results in a certain reflexive response. Weak stimulation and repeated stimuli then lead to an increased muscular tonus or to a tonic reflexive response (reflexive activity on the spinal cord level). Simultaneously, the increased tonus of periscapular muscles and the increased pressure of the humerus head against the scapula will reduce the risk of developing scapulothoracic instability.

## CONCLUSION

A shoulder bandage with distal traction enables sporters to continue sports activities without the risk of worsening the impingement syndrome. It improves stability of the glenohumeral articulation, alleviates or even eliminates pain during arm elevation by reducing the pressure in the subacromial space.

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## RAMENNÍ ORTÉZA S DISTÁLNÍM TAHEM – POUŽITÍ VE SPORTOVNÍ MEDICÍNĚ U PŘETÍŽENÍ „OVERHEAD" AKTIVITAMI

(Souhrn anglického textu)

Autoři předkládají první výsledky léčby impingement syndromu u sportovců léčených konzervativně pomocí ortézy vlastní konstrukce, s distálním elastickým tahem.

Ramenní ortéza byla naložena u 25 pacientů – sportovců s diagnózou impingement syndromu. Byl sledován vliv na bolestivost, závažnost omezení rozsahu pohybu a změnu biomechaniky pletence ramenního. Dále schopnost zvýšit stabilitu glenohumerálního skloubení a subjektivní pocit sportujícího pacienta.

Nový typ ortézy spočívá v netradičním pojetí konstrukce. Krátký rukáv, který je z elastického materiálu, je natažen na proximální paži. Pomocí pružného gumového tahu je fixován k hrudní stěně. Pokud horní končetina volně visí, není žádný tah za fixovanou pažní manžetu. V okamžiku elevace končetiny dochází k postupnému napínání gumového tahu a manžeta stahuje proximální paži směrem distálním. Čím větší je elevace končetiny, tím větší je tah distálním směrem a odlehčení subacromiálního prostoru. Tah je možno modifikovat přitažením nebo uvolněním upnutí fixace na hrudní stěnu.

Subjektivně udávané zlepšení bolestivosti při sportu je u 23 pacientů, ve dvou případech nemá ortéza žádný efekt. Subjektivní pocit zpevnění ramene a zvýšení stability prokazujeme u 16 sportovců. Pocit omezení hybnosti v krajní poloze udává 18 jedinců. Pocit snížení výkonnosti v důsledku zpomaleného nápřahu je u 16 jedinců.

Potřeba nezbytnosti užití ortézy na sport je u 6 jedinců, 9 používá ortézu intermitentně, 8 po odeznění akutních potíží ortézu odložilo, 2 pro nulový efekt nepoužívají.

Vzhledem k tomu, že se jedná o zcela nový charakter bandáže, nelze komparovat se zkušenostmi v literatuře. Ortéza distalizuje hlavici humeru. Snižuje riziko vzniku zvýšeného tlaku subakromiálně při elevaci paže nad horizontálu a tím rozvoje (primárního) impingement syndromu. Působí jako agonista m. supraspinatus, který je primárním depresorem hlavice pažní kosti. Současně snižuje nároky na šlachu dlouhé hlavy bicepsu a snižuje napětí dolního glenohumerálního vazu. Ortéza svým tahem snižuje riziko poranění manžety rotátorů o distální stranu korakoakromiálního oblouku a snižuje riziko vzniku sekundárního impingement syndromu. Proti vzniku sekundárního impingement syndromu působí i tlakem přenášejícím se přes pažní kost do jamky glenohumerálního skloubení. Zvyšuje se stabilita kloubu a snižuje riziko translačních poloh hlavice humeru. Současně dvojím mechanismem dochází ke zvýšení svalového tonu v oblasti pletence pažního. Jednak aktivním

překonáváním odporu při elevaci paže nad horizontálu jsou svaly nuceny ke zvýšené aktivitě, dále již samotné naložení bandáže mechanismem modifikace proprioceptivní inervace – trvalé dráždění exteroreceptorů bandáží vyvolá senzorické vzruchy v aferentních neuronech jdoucích do zadních provazců míšních, interneurony vybaví vzruchy v motoneuronech jednoho či více segmentů a dojde k reflexní odpovědi, slabé dráždění a opakované podněty pak vedou ke zvýšení svalového tonu resp. k tonické reflexní odpovědi (reflexní činnost na úrovni míchy). Zvýšený tonus periskapulárních svalů i zvýšený tlak hlavice humeru proti lopatce současně snižuje riziko rozvoje skapulotorakální instability.

Bandáž ramena s distálním tahem umožní pokračovat ve sportovní aktivitě bez rizika prohlubování impingement syndromu, zvýší stabilitu glenohumerálního skloubení, zmírní až odstraní algie v elevaci paže snížením tlaku v subacromiálním prostoru.

*Klíčová slova: overhead sportovní aktivity, bolestivé rameno, ortéza s ditálním tahem.*

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