Available Online at http://www.journalajst.com

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 07, Issue, 11, pp.3874-3879, November, 2016

RESEARCH ARTICLE

ANTHROPOMORPHIC ENGINEERED ARM WORK AND CONTROLLED SUSPENSION EXERCISE IN TREATMENT OF SUBACROMIAL IMPINGEMENT SYNDROME IN ATHLETES

[1]Bellomo, R. G., [2]Supplizi, M., [3]Palermo, T., *,[2]Barassi, G., [2]Barbato, C. and [4]Saggini, R.

[1]Department of Medicine and Science of Aging, "Gabriele d'Annunzio" University, Chieti-Italy
[2]Faculty of Physiotherapy "G.d'Annunzio" University, Chieti-Italy
[3]School of Specialties in PRM, "G.d'Annunzio" University, Chieti- Italy
[4]Department of Medical Sciences, Oral and Biotechnology, "G.d'Annunzio" University, Chieti-Italy

ARTICLE INFO

Article History:
Received 27th August, 2016
Received in revised form
14th September, 2016
Accepted 17th October, 2016
Published online 30th November, 2016

Key words:

Subacromial impingement,
Shoulder pain,
Motor patterns,
Unstable setting,
Suspension exercise,
Shoulder rehabilitation.

ABSTRACT

Subacromial impingement syndrome represents one of the most common causes of shoulder pain. The rehabilitation of this problem is focused on reduction of pain and improvement of dysfunctional motor pattern. The main goal of our study was to determine if a rehabilitation method called controlled suspension exercise (CSE) made in an unstable setting could improve the condition of patient with a subacute phase of subacromial impingement. The study was focused on 19 athletic subjects diagnosed with subacromial impingement syndrome. Pre-treatment and post-treatment evaluation (T0 and T1) was performed by measuring pain using the VAS scale, active ROM using Multi Joint System® (MJS) and through execution of clinical-functional tests for shoulder Hawkins test and/or Yocum test and/or Neer test associated with a positive Jobe test and/or Palm-Up test. Treatment protocol provides for 12 total sessions of CSE (three times a week for 4 weeks) lasting about 45-50 minutes each. At the end of the study all the evaluation parameters showed an improvement with a decrease in VAS scale and positivity to functional shoulder's tests and an increase in shoulder joint ROM. These results suggest that a training in an unstable setting can improve the condition of patients suffering from subacromial impingement.

INTRODUCTION

Subacromial impingement syndrome is one of the most common diagnoses as a consequence of shoulder pain: in fact in 74% of cases is described as the main cause of shoulder joint pain (Kachingwe *et al*., 2008). Factors behind impingement syndrome are both anatomical and biomechanical: if it's true that on anatomical factors, such as acromion shape, it is impossible to intervene with non-invasive approaches, it is also true that you can propose a rehabilitation focused on correction of biomechanical factors that can lead to the onset of subacromial impingement or even better on correction of abnormal motor patterns that are created as a result of pain (Ludewig *et al*., 2000) and which then become part of the vicious circle: pain - muscle inhibition - motor compensation - impairment of function - pain. For impingement syndrome the goal of rehabilitation must be to re-educate ideal motor patterns and to improve recruitment of muscles deactivated by the presence of pain. It has been shown that pain relief, although of fundamental importance to describe as successful the rehabilitative intervention, may not be the only parameter to consider; this is because, even after the complete disappearance of pain, altered motor patterns persist if it wasn't performed a correct re-education (Morl *et al*., 2011). Starting from the concept that the main objectives of rehabilitation protocol should be both to reactivate shoulder's stabilizing muscles and humeral head's depressors (with particular attention to the latissimus dorsi, serratus anterior and teres major) (Halder *et al*., 2001) and to recover scapula's stabilization (Baskurt *et al*., 2011), including the demonstrated effectiveness of controlled suspension exercise (CSE) for rehabilitation in the acute phase of impingement syndromes (Kim *et al*., 2015), in this study we have decided we wanted to extend the use of this method also to sub-acute/chronic phase. In addition we decided to perform the reinforcing exercises in an unstable setting such as that obtained by the CSE station because it is demonstrated that exercises carried out in instability, in terms of muscle recruitment, are more efficient than those carried out on a stable surface (Sumiaki *et al*., 2014; Oh *et al*., 2003). It is important to underline that patients worked without feeling pain because, according to the theories of CSE method, is pain itself to disable local muscles (stabilizers) and to alter

***Corresponding author: Barassi, G.**
Faculty of Physiotherapy "G.d'Annunzio" University, Chieti-Italy.

functional motor patterns (Hodges *et al*., 1996; Falla *et al*., 2004; Moseley *et al*., 2006). Pain may in fact lead to a reduction of movement quality, to a decrease in muscle strength and to a reduction of neuromuscular control; furthermore it is also one of the causes of endurance loss in repeated gestures and thus may lead to an impairment of overall quality of life. Therefore the basic principles of our rehabilitation protocol for subacromial impingement syndrome were: unstable setting and execution of muscle strengthening exercises in total absence of pain.

MATERIALS AND METHODS

Purpose of the study was to verify the effectiveness of controlled suspension exercise (CSE) in reducing pain and functional disability and to optimize shoulder's biomechanics in patients with subacromial impingement syndrome. The study was focused on 19 subjects, 11 men and 8 women, treated between March 2012 and October 2015 at CUMFER (Center Of Physical Medicine And Rehabilitation) of Chieti-Pescara University "G. D'Annunzio". Patients (mean age 35,29 years old), with diagnosis of subacromial impingement syndrome and eligible to the requirements have joined treatment protocol with CSE method on a specific station. All patients practice an amateur or competitive sport which requires the involvement of upper limb muscles (volleyball, basketball, handball, etc.) with a focus on the shoulder girdle. We've excluded patients with previous surgery on glenohumeral joint. Pre-treatment evaluation (T0) was performed by measuring active ROM using Multi Joint System® (MJS) and through execution of clinical-functional tests for shoulder. We've included those patients with a reduction of physiological ROM in flexion and/or abduction and with a positive Hawkins test and/or Yocum test and/or Neer test (which evaluate subacromial impingement) associated with a positive Jobe test and/or Palm Up test. We have also performed other functional tests for rotator cuff and other anatomical structures of shoulder, in order to monitor the pathological state of these anatomical structures and the possible effectiveness of our protocol. To treat our patients, we have used reinforcing exercises in an unstable setting in accordance with CSE performed on a specific station (Kirkesola, 2000; Kirkesola, 2009). After warming up, carried out by scapula depression exercices, patients performed, following Type 1 approach, exercises of "dips", "pull up" from supine position, "shoulder abduction" from supine position and "shoulder extension" from kneeling position. Treatment protocol provides for 12 total sessions (three times a week for 4 weeks) lasting about 45-50 minutes each. Patients were then re-evaluated at the end of therapeutic cycle (T1) by means of MJS system, VAS scale and all functional tests for shoulder used in pre-evaluation. VAS scale were also evaluated at the end of third, sixth and ninth session.

Assessment tools

1) ***Multi Joint System® - MJS*** **(*Fig.1*):** is an evaluative/rehabilitative system which is grew out of need to achieve a global rehabilitative approach for upper limb, especially for shoulder joint (Saggini *et al*., 2009). *Global* shall means the possibility to treat both purely mechanical aspects of rehabilitation and those related to neuro-proprioception.

The main technological feature of MJS is to consists of a multi-joint anthropomorphic arm, placed in parallel to patient's upper limb and adjustable in length and height; this anthropomorphic arm is driven directly by the patient, thus allowing an experience of three-dimensional movement. All shoulder movements are detected by the system thanks to a large number of sensors and are then reported in 2D on a computer screen connected to the device, thus realizing an important visual feedback; this allows to compare in real time the path realized by the shoulder in space with that reported by the system on the screen. The function of MJS that we used in our study was shoulder active ROM measurement. In this way it was possible an active ROM evaluation pre- and post-treatment highly objective, free of any operator-dependent measurement errors.

2) ***Functional shoulder tests*:** functional tests used in this study were numerous, in order to evaluate shoulder in detail. We have performed both tests for subacromial impingement and tests for the evaluation of rotator cuff and biceps long head tendon state. For each test it has been assigned a "-" if negative, "+/- -" if weak positive, "++ / -" if positive and "+++" if highly positive. Tests used were the following: Neer test, Hawkins test, Yocum test, acromioclavicular joint palpation, Cross Arm test, Jobe test, Lift off (Gerber test), Napoleon test, Patte test, Patte 90° test, Palm up test, biceps long head palpation.
3) ***VAS Scale*:** It is the Visual Analog Scale of pain. It's a measuring instrument of subjective characteristics of pain felt by the patient.

Fig. 1. The Multi Joint System® equipment

Treatment protocol:

Treatment protocol includes:

- Program of exercises performed using CSE working station
- Number of sessions: 12 (3 times a week for 4 weeks)
- Duration of each session: 45-50 minutes

There are two approaches in CSE method: type 1 and type 2. These show substantial differences and lend themselves to different types of physiotherapy intervention. In type 1 approach a low number of repetitions are performed (4-5) in each set, and these are separated by a rest period of 30 seconds. Load is increased at each series, if possible, and if the performance doesn't evoke pain and/or muscular compensation. At each session Weak Link Test was performed to test progress and patient's physical condition. This approach is the one used in this study for subacromial impingement rehabilitation. The rehabilitation protocol we proposed to our patients includes 5 exercises that focus on recruiting and strengthening humeral head depressors and scapula adductors, with particular emphasis to latissimus dorsi muscle and rhomboid muscles. The running time was: 3 seconds in concentric contraction, 1 second in isometric contraction at the end of ROM and 3 seconds of eccentric contraction. Exercises have always been monitored by operator and movements were always carried out in a controlled way. Vocal inputs were performed by the physical therapist to improve selective recruitment of certain muscle groups rather than others. This was very important during the therapeutic process; in fact, since all patients were sportsmen with a good muscle strength, they tended to bypass the use of some deficient muscles (such as latissimus dorsi or humeral head stabilizers) recruiting those strongest (as deltoid and pectoralis major). Our attention was therefore focused not on *quantity* of muscle strength produced, but on *quality*. Exercises execution order didnot change during several sessions, while intensity of any single exercise (thus choosing the difficulty level of the latter) was settled every time thanks to Weak Link Test.

Since third session, if it was possible and in case of strength difference between right and left side, we have introduced monolateral work with the goal to reduce this difference. It is important to underline that not always the weakest emisoma was that one with subacromial impingement.

Treatment protocol contain five kind of exercises

1. Scapula depression from seated position;
2. Shoulders extension with flexed elbow (dips);
3. Body traction from lying down position;
4. Shoulders abduction from lying down position;
5. Shoulders flexion from kneeing position.

RESULTS

In this study we recruited 19 patients (11 M, 8 F), with a mean age of 35,29 (± 9,03) years old, sportsmen and diagnosed with subacromial impingement syndrome. Treatment was performed on a working station in accordance with CSE method (12 sessions, 45-50 minutes each, three times a week). Patients were evaluated at the beginning (T0) and at the end (T1) of treatment protocol with: *VAS Scale* (also at the end of third, sixth and ninth session), *Functional shoulder tests and active joint ROM evaluation with MJS.* VAS scale (*Tab. 1*) decreased by 64.08%, from an average of 5.79 (± 0.98) at T0 to an average of 2.08 (± 0.80) at the end of treatment; this reduction was found to be statistically significant ($p < 0.01$). In addition it should be pointed out that the assessment of VAS scale was also carried out in course of therapeutic program (at III, VI and IX session) and it was possible to highlight a steady decline in mean value (*Fig.2*). Even positive findings to various shoulder functional tests decreased remarkably (*Fig. 3*). Depending on positivity degree, for each test it has been associated a numeric value: 0 to the absence of pain and/or lack of strength (negative test), 1 to mild positive test (+/--, pain or strength loss), 2 was assigned to moderate positive test (++/-, pain and strength loss) and 3 to marked positive test (+++), with acute pain and total strength loss. In the assessment carried out after 12 sessions, we have noticed an improvement in 89% of tests and a total cancellation of positive value in 67% of cases. In only 2% of cases there was a worsening in functional assessment; however this was limited to just two patients. Tests performed before starting treatment, used as inclusion criteria, were positive: Hawkins test in 94.2% of patients, Yocum test in 84,3% of cases and Neer test in 100%; at the end of sessions they were positive, respectively, in 26.3% of cases, in 21% and 31.6%.

Fig. 2. The five specific exercises used in the study according to the CSE method

Positive value decreased in all 3 tests: Hawkins test rose from an average of 1.67 at T0 to 0.28 to T1; Yocum test mean value has decreased from 2.00 at T0 to 0.38 after treatment; finally Neer test, from an average value of 1.89 at T0, has reached a mean value of 0.37 at T1.

in regards to Palm Up test. Also these results were found to be statistically significant ($p<0.01$). Mean values of joint ROM investigated have increased (*Tab. 2, Fig.4*). Flexion increased of about 20%, from a mean value of 139.58° (±26.94°) at T0 to a final mean value of 167.45° (±15.67°), with a $p <0.01$.

Table 1. VAS scale evaluation from time T0 to time T1

	VAS Scale				
	T0	III session	VI session	IX session	T1
Patient n° 1	7,5	7	5,5	4	3
Patient n° 2	5,5	4,5	3,5	2	1
Patient n° 3	7	5,5	4	4	2,5
Patient n° 4	5,5	4	3,5	3	3
Patient n° 5	4,5	3,5	2	2	1
Patient n° 6	5,5	4	2	2	1
Patient n° 7	5	4	3,5	3	3
Patient n° 8	4	3	2,5	2	1
Patient n° 9	7	6	4	3,5	3
Patient n° 10	5	4	3	2.5	2
Patient n° 11	5,5	4	2	1,5	1,5
Patient n° 12	5	4	3,5	3	2
Patient n° 13	6	6	3,5	2,5	2,5
Patient n° 14	5	4	3	2	2
Patient n° 15	6,5	4,5	3,5	3	2
Patient n° 16	7,5	6	5	5	3
Patient n° 17	6	5	3,5	3	2
Patient n° 18	6	5	4,5	4,5	3
Patient n° 19	6	4	3	2	1
Mean value	5,79	4,63	3,42	2,87	2,08
Standard Deviation	0,98	1,04	0,95	0,97	0,80
Decrease % compared to T0	--	-20,03	-40,93	-50,43	64,08

Table 2. Joint ROM evaluation from T0 to T1

	Joint ROM					
	Flexion		Abduction		External Rotation	
	T0	T1	T0	T1	T0	T1
Patient n° 1	120,5	168,9	115,4	167	35,6	51,7
Patient n° 2	130,6	175	120,5	150	35,3	63,1
Patient n° 3	108,4	155,1	96,8	150,8	34,6	41,4
Patient n° 4	85,9	116,1	64,1	102,4	35	41,5
Patient n° 5	118,2	174,6	98,7	164,8	34,1	63,1
Patient n° 6	134,3	180	70,1	180	27,6	45,6
Patient n° 7	99,8	180	63,5	104,4	35,6	57,7
Patient n° 8	111	160,7	90,7	150,6	42,1	83,3
Patient n° 9	160,1	180	139,8	180	50,2	85,2
Patient n° 10	159,9	180	140,2	180	67,3	74,8
Patient n° 11	150,5	161	119,4	135,3	69,8	85
Patient n° 12	180	180	139,1	157,7	70,2	82,3
Patient n° 13	142,4	180	134,4	163,9	43,7	82,6
Patient n° 14	159,6	172,1	130,1	168,8	50,4	84,6
Patient n° 15	156,2	160,2	161,5	172,1	68	74,4
Patient n° 16	129,4	147,9	114,8	139,2	58,7	63,8
Patient n° 17	168,3	170,4	152	157,9	70,4	70,7
Patient n° 18	166,2	167,6	161,3	163,1	68,2	69,8
Patient n° 19	170,8	172	167,4	167,6	55,6	65,2
Standard Deviation	26,94		32,39		15,32	
Mean value T0	139,59		119,99		50,13	
Mean value T1	167,45		155,56		67,67	
Standard Deviation	15,67		22,28		14,84	
T. Student	0,0004		0,0004		0,001	
Increase %	19,99		29,65		35,13	

These results were found to be statistically significant ($p <0.01$). Tests for supraspinatus and biceps long head evaluation, Jobe and Palm Up tests, were found to be positive at T0 respectively in 94.2% and in 84,3% of patients, while at T1 in 15.7% (Jobe test) and in 36.8% (Palm Up test); these tests have undergone a decrease in positive value: from 1.72 (T0) to 0.17 (T1) considering Jobe test and from 1.69 to 0.56

Before treatment abduction had a mean value of 119.99° (±32.38°) compared to 155.56° (±22,28°) at the end of rehabilitation protocol ($p<0.01$), with an improvement of 29.65%. The highest increase took place in external rotation movement, which has had an improvement of 35.13%: in fact it rose from an initial mean value of 50.13° (±15.32°) to the value of 67.67° (±14,84°) at T1 ($p <0.01$).

DISCUSSION

The purpose of the study was to demonstrate the effectiveness of a protocol of exercises in unstable setting with CSE method for subacromial impingement syndrome in sportsmen. Experienced musculoskeletal physical therapists believe that exercise is central in treating patients with this syndrome and that gaining patient buy-in to its importance, patient education, promoting self-management, and postural advice are central to the successful treatment (Hanratty *et al*., 2016). Baskurt's study[5] showed the effectiveness of stretching, strengthening exercises, and scapular stabilization exercises on pain, shoulder range of motion, muscle strength, scapular dyskinesia and quality of life in patients with subacromial impingement syndrome. Dysfunction in the kinetic chain caused by poor scapula stabilization can contribute to shoulder injuries and shoulder impingement syndrome; It has been verified (Moezy *et al*., 2014) that the scapular stabilization based exercise intervention was successful in increasing shoulder range, decreasing forward head and shoulder postures and pectoralis minor flexibility. It has also been demonstrated the effectiveness of CSE method for rehabilitation in the acute phase of impingement syndromes (Kim *et al*., 2015).

In this study, patient's pain decreased significantly after application of this technique; the authors argue that the improvement in pain may have been more closely related to an increase in the scapulohumeral stability and subacromial space. According to VAS scale scores it is possible to affirm that pain is significantly decreased; this may be due to the improvement in joint stability following motor rehabilitation (through the use of muscle-strengthening exercises in unstable setting), but also to inflammatory processes decrease of rotator cuff tendons, as a result of physiological subacromial space recovery. This analysis is supported by the improvement of all functional tests, which investigate rotator cuff status (Jobe, Lift-off, Patte and Patte at 90°), and by the improvement of three tests for subacromial impingement (Hawkins, Neer and Yocum). These results are due to shoulder biomechanics perfection: focused strengthening and physical rehabilitation of latissimus dorsi and serratus, combined with the recovery of rhomboid muscles and humeral head stabilizers, led to the loss of pathological motor patterns related to pain and also led to an overall improvement in shoulder kinematics. This allowed the interruption of that vicious circle which leads rotator cuff tendon to a continuous functional overload and a consequent painful symptomatology.

Joint ROM recovery is another evidence supporting the improvement about inflammatory general state of rotator cuff and about recovery of functional motor patterns. All three evaluated movements have significantly improved at the end of 12 therapy sessions (4 weeks) and all patients reported an overall improvement in quality of life. The most significant increase in percentage with regard to ROM was that relating to external rotation (equal to 35.13%), but also flexion and abduction movements enhancement were statistically significant. This highlights the relevance of therapeutic protocol proposed for shoulder impingement syndrome rehabilitation since in patients treated both the quality of life and sporting gesture has improved considerably. It is worth dwelling on pain monitoring: according to our results after six sessions (2 weeks) VAS mean value has already decreased by 40.93% in a statistically significant way ($p < 0.01$) compared to the initial value (from 5.79 ± 0.98 at T0 to 3.42 ± 0.95 after sixth session). This shows the opportunity to use exercises in unstable setting also to act on pain.

Conclusion

In conclusion we can affirm that strengthening exercise in unstable setting with CSE method significantly reduced pain in patients with shoulder impingement syndrome, improved the overall inflammatory condition of structures associated with glenohumeral joint and as a result significantly increased shoulder joint ROM. Such a marked decrease of pain without any use of pharmacological or physical therapy might suggest an integration of exercises in unstable setting inside primary prevention protocols for shoulder subacromial impingement syndrome. All patients were satisfied with treatment protocol proposed and have resumed their sports activities, with particular attention to glenohumeral joint overload; furthermore they reported a greater awareness about sporting gestures performed during training. Study limitations, in addition to the numerically small sample, was the absence of a follow-up. However this could be a starting point for future studies considering the possibility to integrate exercises in unstable setting within athletes training programs in order to prevent upper limbs pathologies, especially in sports that require high stress of glenohumeral joint.

Conflict of interest

All authors declare that there is no personal interest properties, financial, professional or other of any nature or kind in any product, service or company that could be interpreted as influencing the position presented in this manuscript.

REFERENCES

Baskurt, Z., F. Baskurt, N. Glecek, M. H. Özkan 2011. The Effectiveness of Scapular Stabilization Exercise in the Patients with Subacromial Impingement Syndrome, *J Back Musculoskeletal Rehabil*

Falla, D., G. Bilenkij, G. Jull, 2004. Patients With Chronic Neck Pain Demonstrate Altered Patterns of Muscle Activation During Performance of a Functional Upper Limb Task, *Spine*

Halder, A. M., K. D. Zhao, S. W. Odrscoll, B. F. Morrey, K. N. An, 2001. Dynamic Contributions to Superior Shoulder Stability, *J Orthop Res*

Hanratty, E., D. P. Kerr, I. M. Wilson, M. McCracken, J. Sim, J. R. Basford, J. G. McVeigh, 2016. Physical Therapists Perceptions and Use of Exercise in the Management of Subacromial Shoulder Impingement Syndrome: Focus Group Study, *Physical Therapy*

Hodges, P. W. and C. A. Richardson, 1996. Inefficient Muscular Stabilization of the Lumbar Spine Associated with Low Back Pain. A Motor Control Evaluation of Transversus Abdominis, *Spine*

Kachingwe, A. F., B. Phillips, E. Sletten *et al*. 2008. Comparison of Manual Therapy Techniques with Therapeutic Exercise in the Treatment of Shoulder Impingement: a Randomized Controlled Pilot Clinical Trial, *J Manual Manip Ther*.

Kim, S. Y., M. H. Kang, D. K. Lee, J. S. Oh 2015. Effects of the Neurac® Technique in Patients with Acute-phase

Subacromial Impingement Syndrome, *Journal of Physical Therapy Science*

Kirkesola, G. 2000. Sling Exercise Therapys-E-T: a Concept for Exercise and Active Treatment of Musculoskeletal Disorders, *Fysioterapeuten*

Kirkesola, G. 2009. Neurac®: a New Treatment Method for Long-term Musculoskeletal Pain, *Fysioterapeuten*

Ludewig, P. M. and T.M. Cook 2000. Alterations in Shoulder Kinematics and Associated Muscle Activity in People with Symptoms of Shoulder Impingement, *Phys Ther*

Moezy, A., S. Sepehrifar,M. Solaymani Dodaran 2014. The Effects of Scapular Stabilization Based Exercise Therapy on Pain, Posture, Flexibility and Shoulder Mobility in Patients with Shoulder Impingement Syndrome: a Controlled Randomized Clinical Trial, *Medical Journal of the Islamic Republic of Iran.*

Mörl, F., A. Matkey, S. Bretschneider, A. Bernsdorf, I. Bradl 2011. Pain Relief Due to Physiotherapy Doesn't Change the Motor Function of she Shoulder, *J Bodyw Mov Ther*

Moseley, G. L. and P. W. Hodges, 2006. Reduced Variability of Postural Strategy Prevents Normalization of Motor Changes Induced by Back Pain: a Risk Factor for Chronic Trouble?, *Behavioral Neuroscience*

Oh, J. S., J. S. Park, S. Y.Kim 2003. Comparison of Muscle Activity During A Push-Up an a Suspension Sling and Fixed Support, *J Phys Ther*

Saggini, R., R. G. Bellomo, M. C. Zuccaro, S. Tripoli, F. Cancelli, 2009. Confronto tra Diversi Protocolli Terapeutici nella Periartrite Calcifica di Spalla, *Europa Medicophysica*

Sumiaki, M., C. Tatsuya, Y. Masayoshi, K. Hiroaki 2014. Muscular Activities During Sling and Ground Based Push-Up Exercise, *BMC Res Notes*

****