Scand J Rehab Med 24: 11–15, 1992

THE EFFECT OF SHOULDER MUSCLE TRAINING IN PATIENTS WITH RECURRENT SHOULDER DISLOCATIONS

Lars-Åke Broström, Margareta Kronberg, Gunnar Németh and Ulla Oxelbäck

From the Departments of Orthopedics and Physical Therapy, Karolinska Hospital, S-104 01 Stockholm, Sweden

ABSTRACT. Thirty-three shoulders in 29 patients with recurrent shoulder dislocations, of both traumatic and nontraumatic type, have been studied. The patients suffered from muscle weakness, and had also a hypotrophy of the supra- and infraspinatus muscles. A special training program using an isokinetic pulley-weight apparatus, for muscle strength, coordination and endurance training of the rotator-cuff muscles and the deltoid were given all patients. Shoulder flexors, internal and external rotator muscles were trained three times a week, during a period of 8 weeks. At follow up one year after completion of the specific training program, all shoulders except five were improved. Five shoulders had remaining instability. Four of these patients had generalized joint laxity and a much decreased humeral head retroversion, and were later on stabilized with a rotational osteotomy of the proximal humerus. One of the shoulders with remaining instability was of traumatic type with normal skeletal anatomy. This patient was later on stabilized with a Putti-Platt procedure. We conclude that most of the patients were relieved from pain, and had decrease or cessation of their dislocations. Factors indicating a less good result of training were an abnormal skeletal anatomy, and/or a multidirectional type of instability.

Key words: dislocation, isokinetic, laxity, muscle training, retroversion, shoulder joint.

Surgical treatment of traumatic shoulder dislocations gives generally very satisfactory results, but in patients with generalized joint laxity both the diagnosis and treatment may present a problem (2, 10, 13). Dislocations usually occur after a major trauma, but about four percent of all dislocations occur in subjects with generalized joint laxity without any significant trauma (10, 13, 14). In patients with nontraumatic shoulder dislocations the instability can be multidirectional, although most patients report symptoms of anterior instability, and the most appropriate treatment may be difficult to choose. In previous studies the authors have demonstrated, that many patients with nontraumatic dislocations have a changed muscular activity (7). In the rotator cuff muscles, the activity was increased in the supraspinatus muscle, and decreased in the subscapularis and the infraspinatus muscles (7). EMG recordings in some patients during humeroscapular dislocation showed that in the subscapularis the activity level was low and that there was a delay in the activation when dislocation occurred (2). Furthermore, activity in the anterior and middle parts of the deltoid was decreased (7). Previous studies have also demonstrated that patients with recurrent anterior shoulder dislocations often have an altered skeletal anatomy (6, 12). A decreased humeral head retroversion will make the shoulder joint more vulnerable for anterior dislocations by pulling the humeral head out of the glenoid cavity when the arm is rotated externally, especially in abducted position.

The aims of this study were to analyse the effect of muscle training both in patients with nontraumatic and traumatic recurrent shoulder dislocations and muscle weakness, and to relate the training result to the humeral head retroversion. The training program, for strength, coordination and endurance of the flexor and rotator muscles, was performed using an isokinetic pulley-weight apparatus.

PATIENTS

A consecutive series of 33 shoulders in 29 patients (10 women and 19 men), with a mean age of 27 years (range 19–44 years), with recurrent shoulder dislocations and all planned for surgery, were included in this study. Their mean weight was 69 kg (SD 11.4) and mean height was 172 cm (SD 8.4).

Eleven patients, two women and nine men, had anterior dislocations of traumatic type. All patients with traumatic anterior instability complained of shoulder muscle weakness and in all of them there was visible hypotrophy of the supra- and infraspinatus muscles compared to the contralateral shoulder. None of them had any clinical signs of suprascapularis nerve entrapment.

Eighteen patients, eight women and ten men, fulfilled at

least four criteria for generalized joint laxity (4) and had nontraumatic type of dislocations. In this group the direction of instability causing symptoms was posterior in three, anterior in thirteen and multidirectional in two patients. Two of the three patients with posterior instability stated symptoms from both shoulders, and two of the other patients with anterior instability stated bilateral symptoms.

All patients in both groups were severely disabled by their shoulder instability and all had symptoms of recurrent dislocations for at least two years. None of them had any history of previous surgery of their shoulder joints, and only patients with subjective shoulder muscle weakness were included in this study.

METHODS

Clinical examination

All patients were clinically examined for generalized joint laxity (4). Only patients fulfilling at least four of the five criteria for generalized joint laxity were included in the nontraumatic group, and in this group no patient reported significant trauma. In the traumatic group all patients had a history of significant trauma at onset for the instability, and none of them fulfilled more than two of the stated criteria for joint laxity. Except information from the case history the direction of instability was tested with the apprehension test (15), and range of motion was measured with a goniometer in standing position. The patients were reviewed using a questionnaire, before and one year after treatment.

The questionnaire included questions, graded with a four grade scale on number of dislocations per year (>10, 5–10, <5, none), instability (during sleep, movements, at work, none), weakness (severe, moderate, mild, none), pain (severe, moderate, mild, none), subjective improvement (yes, unchanged, no).

Radiographical examination

Both shoulders were radiographically examined in AP (anterior-posterior) and axial views, and radiographs in the semiaxial view were taken for determination of the humeral head retroversion (18).

Pilot study

In four patients with nontraumatic instability the muscle strength was measured with a Cybex II isokinetic loading dynamometer before and after training (5, 11, 17). The axis of the device was aligned with the patient's shoulder joint, and the elbow was held in 90° of flexion. Flexion and abduction was tested with the patient in supine position, and rotation in sitting position. Torque was adjusted for the weight of the arm. The torque values were recorded at two different test speeds, angle velocities 30°/sec and 90°/sec. All the torque measurements were made after the patient's muscle had completed its initial build up to full tension.

Results from the tests with the Cybex II dynamometer are presented in Table I. One of these patients had symptoms of posterior instability. In all three patients (cases 1, 2 and 3) with anterior instability the most obvious increase of strength was measured for external rotators. Strength for flexion, abduction and internal rotation was doubled in the two patients (cases 1 and 2) who reported great benefit of the training, but was mainly unchanged in the patient (case 3) who still suffered from instability after training. In the latter patient muscle strength was very good already at start of training although he reported subjective weakness of the shoulder. As expected the patients were strongest in tests with an angle velocity of 30°/sec.

Table I. *Mean torque in Nm at Cybex tests in 90°/30° angle velocities in four patients with nontraumatic type of shoulder instability before and after treatment*

++=much improved, +=improved, 0=unchanged

	Case no.			
	1	2	3	4
Sex	F	F	M	M
Age (years)	30	31	23	26
Direction (ant/post)	ant	ant	ant	post
Subjective score	++	++	0	+
Before training				
Flexion	18/15	24/22	49/63	50/55
Abduction	14/16	15/32	29/28	38/40
Internal rotation	19/21	40/50	31/30	48/50
External rotation	13/17	20/20	22/24	22/25
After training				
Flexion	27/30	34/36	50/62	55/51
Abduction	28/31	36/34	29/29	44/47
Internal rotation	40/45	40/50	35/36	57/55
External rotation	39/50	40/50	35/38	20/28

The patient with symptoms of posterior instability had an increased retroversion angle, 44°, and he was also strong before treatment. After training there was no increase of measured strength, not even in the external rotators, but the patient reported benefit of the treatment. He did not suffer from instability during sleep and reported improved use of the arm at work.

After treatment the torque values recorded for the four patients in the Cybex tests were comparable to those previously reported in healthy subjects, and the change of torque after training in the three patients with anterior instability was comparabe to that after repair of a torn rotator cuff (17, 19).

Muscle strength

Muscle strength was assessed approximately by the load that was used before and after training of coordination and endurance with the isokinetic pulley-weight apparatus (1). Repetition maximum (RM) is the maximum load in Newton that can be lifted in the apparatus once, and change in RM was used to assess change of strength after treatment. There was high accordance between the results from the Cybex II pilot study and those calculated from the used load in the pulley-weight apparatus.

Treatment

An isokinetic pulley-weight apparatus (1) was used for training of internal and external rotator muscles and flexor mus-

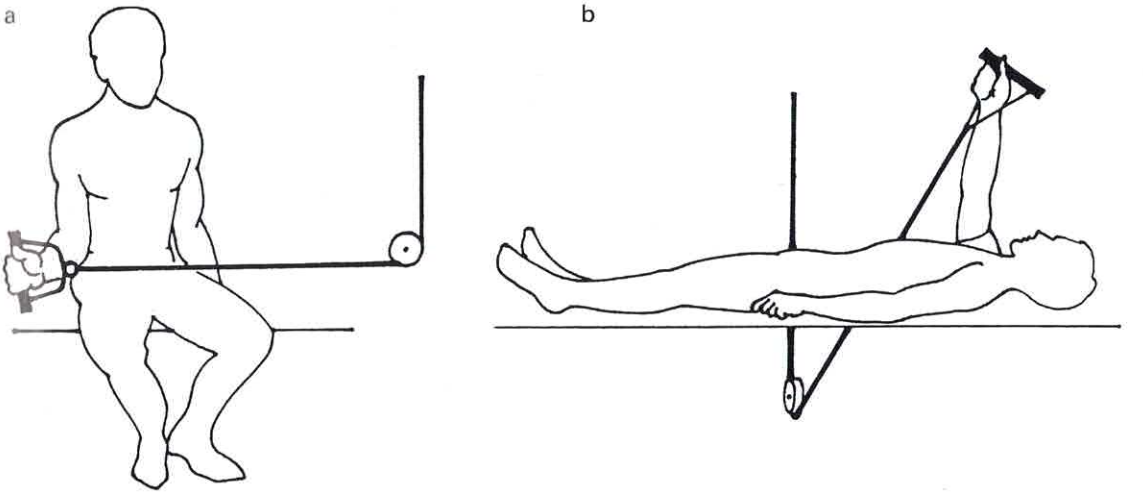

Fig. 1. Isokinetic pulley-weight-apparatus used for training of (*a*) external rotation sitting with the arm in neutral position, (*b*) flexion in supine position.

cles. External and internal rotation training was performed in neutral position and in 45° of abduction with the rod from the pulley apparatus perpendicular to the upper arm (Fig. 1 *a*). Flexion was trained in supine position with the elbow straight (Fig. 1 *b*). Strength exercises were performed with a load of 80% of RM. Each exercise consists of 10 bouts and was performed three times with a one minute rest in between. Training of coordination and endurance was performed in a similar way but with a load of 60% of RM, and each exercise consists of 25 bouts and was performed three times.

The patients followed this training program three times a week during 8 weeks, for a total of 24 times, and in addition they were recommended to practice a similar exercise program at home every day with a Theraband (six inches wide and 18 feet long), a latex resistive exerciser of medium resistance (Hygienic Co/Akron, Ohio, USA).

RESULTS

Radiographical examination

Osteoarthrosis of the humeroscapular joint was not observed in any of our patients. Hill Sach's lesions were only observed in four shoulders with traumatic type of instability. The mean humeral head retroversion was 43.2° (SD 5.3°) for the five shoulders with posterior dislocations, and 23.4° (SD 8.0°) for the shoulders with anterior instability and improved stability after training. Shoulders that were later operated on with a rotation osteotomy of the proximal humerus had a preoperative mean retroversion angle of 9.4° (SD 6.6°). The 95% two tail interval for normal retroversion angle is reported to be 30–35° on the dominant side and 26–31° on the nondominant side (8).

Stability

Before treatment there were more than 10 dislocations per year reported for 28 shoulders and more than five dislocations for five shoulders. After treatment seven shoulders became stable, 21 shoulders were improved, and five not improved. In the five shoulders with remaining instability the patients had instability problems during sleep. All five shoulders became stable after surgery, in four shoulders with generalized joint laxity and much decreased humeral head retroversion after correction of the anatomy with a proximal humerus osteotomy, and in one shoulder with traumatic type of instability and normal skeletal anatomy after a Putti-Platt procedure. In the two patients with multidirectional instability improvement of stability after training was slight and of short duration. One of these patients' shoulder became stable after surgical correction of the humeral head retroversion and the other patient with a normal humeral head retroversion is planned for a capsular shift operation (10).

Pain

Before treatment 11 patients stated moderate and 12 mild pain. After training all except four patients were improved. All these four patients were unchanged concerning pain, two had still after training moderate

pain, and two had mild pain. At one year follow up two patients stated moderate, eight patients mild pain, and the rest no pain at all.

Muscle strength

At tests before treatment nine patients, of which six had generalized joint laxity, could not manage to perform the scheduled training program for external rotators with load in the pulley apparatus (just the weight of the apparatus was managed). Three patients, all with generalized joint laxity, were unabled to perform the program for internal rotators. After treatment, there was an overall increase in strength except in four patients with generalized joint laxity and a decreased humeral head retroversion. Mean increase of maximum strength for external rotator muscles was 11.8 N (SD 10.1) and for internal rotator muscles 13.7 N (SD 13.2). In five shoulders, four of traumatic type, muscle strength increased with more than 30 N after treatment.

DISCUSSION

The results of this study showed that in patients with recurrent shoulder dislocations training of muscle strength, coordination and endurance should be considered, both in patients with nontraumatic and traumatic type of instability. Most of the patients developed relief from pain, and decrease or cessation of their dislocations. Although there was an overall positive effect of the treatment reported by the patients it seems as if the patients have to be encouraged to continue muscle training with a home-program and in particular the patients with joint laxity and multidirectional instability.

The discrepancy in occurrence of anterior and posterior instability, despite joint laxity, can be explained by the shoulder anatomy. The shallowness of the glenoid cavity facing downward laterally and forward, and the advantage of the muscle activity in the external rotators over the subscapularis muscle during external rotation (9) will make the shoulder joints more susceptible to anterior dislocation. An adequate strength and coordination of the shoulder muscles is then a prerequisite to maintain stability. A decreased humeral head retroversion, as previously found in many patients with recurrent anterior shoulder dislocations, will further enhance the need for adequate muscle function in the rotator cuff, since during external rotation when the humeral head tends to move out of the glenoid cavity there will be increased stress on the anterior structures (6, 8). Correction of a decreased humeral head retroversion can be made by a rotation osteotomy of proximal humerus (3), but in these patients preoperative training of shoulder muscles might still be very beneficial for the postoperative rehabilitation. However, in shoulders with an abnormal skeletal anatomy, a humeral head retroversion angle less than 10°, only training of the rotator-cuff muscles seems to be insufficient to make the shoulder joint stable. In these patients surgical correction of the anatomy is probably a requisite to achieve stability.

The treatment program used in this study was made up with regard to findings in previous studies with EMG recordings in patients with generalized joint laxity and symptoms from shoulder instability (2, 7, 9). In these studies a changed muscular activity, especially in the rotator-cuff muscles, was found in patients with generalized joint laxity compared to normals. Thus, muscle training was focused on the rotator cuff muscles and the deltoid, with training of strength, coordination and endurance in neutral and in 45° of abduction.

Previously, a positive effect of training has been reported for patients with voluntary type of dislocations (16), but in the present series of patients, stability was also improved in shoulders with traumatic type of instability. However, in the present study only patients with subjective shoulder muscle weakness and hypotrophy of the supra- and infraspinatus muscles were included.

Factors indicating a less good result of training were an abnormal skeletal anatomy, and/or a multidirectional instability. The stabilizing effect provided by the training, in patients with multidirectional instability, was of short duration.

REFERENCES

1. Arborelius, U. P. & Ekholm, J.: Mechanics of shoulder locomotor system during exercises resisted by weight-and-pulley-circuit. Scand J Rehab Med *10:* 171–177, 1978.
2. Broström, L.-Å., Kronberg, M. & Németh, G.: Muscle activity during shoulder dislocation. Acta Orthop Scand *60:* 639–641, 1989.
3. Broström, L.-Å., Kronberg, M. & Söderlund, V.: Methodological aspects of proximal humerus osteotomy. Orthop Research (Submitted 1991).
4. Carter, C. & Wilkinson, J.: Persistent joint laxity and congenital dislocation of the hip. J Bone Jt Surg *46 B:* 40–45, 1964.
5. Gransberg, L. & Knutsson, E.: Determination of dynamic muscle strength in man with acceleration controlled

isokinetic movements. Acta Physiol Scand *119:* 317–320, 1983.
6. Kronberg, M. & Broström, L.-Å.: Humeral head retroversion in patients with unstable humeroscapular joints. Clin Orthop *260:* 207–211, 1990.
7. Kronberg, M., Broström, L.-Å. & Németh, G.: Differences in shoulder muscle activity between patients with generalized joint laxity and normal controls. Clin Orthop *269:* 181–192, 1991.
8. Kronberg, M., Broström, L.-Å. & Söderlund, V.: Retroversion of the humeral head in the normal shoulder and its relationship to the normal range of motion. Clin Orthop *253:* 113–117, 1990.
9. Kronberg, M., Németh, G. & Broström, L.-Å.: Muscle activity and coordination in the normal shoulder. An electromyographic study. Clin Orthop *257:* 76–85, 1990.
10. Neer, C. & Foster, C.: Inferior capsular shift for involuntary inferior and multidirectional instability of the shoulder. J Bone Jt Surg *62A:* 897–908, 1980.
11. Perrine, J. & Edgerton, V. R.: Muscle force–velocity and power–velocity relationships under isokinetic loading. Med Sci Sports *10:* 159–166, 1978.
12. Pieper, H.: Shoulder dislocation in skiing. Choice of surgical method depending on the degree of humeral retrotorsion. J Sports Med *6:* 155–160, 1980.
13. Rowe, C. R., Pierce, D. S. & Clark, J. G.: Voluntary dislocation of the shoulder. J Bone Joint Surg *55A:* 445–460, 1973.
14. Rowe, C. R. & Sakellarides, H. T.: Factors related to recurrences of anterior dislocations of the shoulder. Clin Orthop *20:* 40–48, 1961.
15. Rowe, C. R. & Zarins, B.: Recurrent transient subluxation of the shoulder. J Bone Joint Surg *63A:* 863–872, 1981.
16. Rowe, C. R., Zarins, B. & Ciullo, J. V.: Recurrent anterior dislocation of the shoulder after surgical repair, apparent causes of failure and treatment. J Bone Joint Surg *66A:* 159–168, 1984.
17. Soderberg, G. J. & Blaschak, M. J.: Shoulder internal and external rotation peak torque production through a velocity spectrum in differering positions. J Orthop Sport Phys Ther *8:* 518–524, 1987.
18. Söderlund, V., Kronberg, M. & Broström, L.-Å.: Radiologic assessment of humeral head retroversion. Description of a new method. Acta Radiologica *30:* 501–505, 1989.
19. Walker, S. W., Couch, W. H., Boester, G. A. & Sprowl, D. W.: Isokinetic strength of the shoulder after repair of a torn rotator cuff. J Bone Joint Surg *69A:* 1041–1044, 1987.

Address for offprints:

Margareta Kronberg, M.D.
Department of Orthopedics
Karolinska Hospital
S-10401 Stockholm
Sweden