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Quantitative analysis of peak torque and power–velocity characteristics of shoulder rotator muscles after arthroscopic labral repair

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ABSTRACT

Objectives: We aimed to use biomechanical testing to assess differences in the power and strength of patients who participated in a short-term, home-based rehabilitation program following arthroscopic labral repair compared with a healthy control group.
Design: The functional outcomes of patients who underwent arthroscopic labral repair followed by self-directed short-term rehabilitation at home were compared with age- and body mass index (BMI)-matched healthy controls.
Methods: Group I included 20 male patients who had undergone arthroscopic labral repair after being diagnosed with recurrent anterior glenohumeral joint instability without bony lesions of the humeral head or glenoid. Postoperatively, they participated in physical therapy for 17 ± 4 appointments, followed by self-guided home-based exercises. Group II included 25 males without injuries. The two groups were matched for age and BMI. The orthopaedic examination, functional tests, and biomechanical measurements were performed under isokinetic conditions at an average of 16 ± 3 months postoperatively.
Results: Significant differences were observed in range of shoulder rotation on the operative shoulder compared with the unaffected side and in the dominant arms of the control group. The patients were also found to have significant deficits in biomechanical parameters such as power and peak torque angle.
Conclusions: Significant deficits in peak torque, power, and peak torque angle during external and internal shoulder rotation remained up to 16 months after arthroscopic labral repair. Further research is needed to understand the changes in shoulder power assessment after labral repair.

1. Introduction

Tissue damage with associated glenohumeral joint instability often requires surgical treatment.[1,2] The treatment type and method depends on the results of orthopaedic and other examinations such as ultrasound assessment or MRI.[2,3] The recommendation for surgery depends on multiple factors, such as the type and degree of soft tissue damage, bony lesions (e.g. Hill-Sachs, Bankart), the clinical condition of the patient, his or her age, and concomitant injuries and diseases.[4,5]

Multistage physical therapy comprising comprehensive therapeutic procedures is often employed on patients with injuries to the glenohumeral joint.[6,7] The primary goal of this treatment is to reduce inflammation and pain. Other aims include restoring the range of motion of the joint and improving proprioception.[6] Successful therapy may result in improved function of the joint and the entire upper limb, allowing the patient to return to work.[6,7] If possible, the overhead dynamic movements of the upper limb are also restored.[8] The assessment of treatment efficacy following glenohumeral joint injuries may require measurement of the isokinetic dynamometry of the muscles that allow for external and internal glenohumeral joint rotation.[9] Most often, the peak torque between the operative and non-operative shoulders has good to very good reliability in the progress assessment of physiotherapy.[10] The ratio of internal to external peak torque (IR/ER ratio) is also commonly normalized following glenohumeral joint arthroscopy, although the reliability of the strength ratio is low for repeated measures.[11] Decreased peak torque and IR/ER ratio have been noted in athletes with unstable shoulders and in patients with massive rotator cuff tears.[8,12] A reduced throwing velocity is also noted, often accompanied by subjective apprehension to dynamic overhead movement or a reduced range of motion arc.[13] This may be associated with

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the ability for muscles to generate fast contractions in response to external agitation.[14] Lower strength and apprehension related to high velocity rotational movement may result in a poor time-to-peak torque (TPT) and the patient's inability to generate a high power output.[15]

Several prior studies have analyzed the power output estimated by isokinetic dynamometry,[12,15,16] and rehabilitation programs and guidelines for postsurgical treatment have been proposed [6,7,17] to evaluate peak torque and the IR/ER ratio.[18] However, the analysis of other isokinetic test parameters, such as the peak torque angle or power, are inconsistently performed or are measured only during treatment following a rotator cuff tear.[12] The level of power generated, changes in the peak torque angle, or the TPT following glenohumeral joint instability treated arthroscopically are unknown. Specific positions for isokinetic shoulder assessment may be more useful for examining overhead internal and external rotation. These types of movement at high speed are strongly associated with shoulder dislocation or superior labrum anterior posterior lesions.[9] Deficiencies in prior work highlight the need for the evaluation of the power output of the internal and external shoulder rotators, peak torque, peak torque angle, and TPT. Patient-reported functional scales are commonly used for postoperative evaluation following labral repair.[19]

The aim of this study was to assess a number of isokinetic tests on the internal and external rotators of the shoulder in male patients following 16 months of arthroscopic labral stabilization as a consequence of anterior glenohumeral joint dislocation. Short-term, primarily home-based physical rehabilitation was conducted after arthroscopy.

2. Material and methods

This study was approved by the College of Physiotherapy ethics committee, and written informed consent was obtained from all of subjects prior to participation in the study. The study was conducted according to the ethical guidelines and principles of the Declaration of Helsinki.

A group of 23 male patients who had undergone arthroscopic treatment of unidirectional anterior instability of the shoulder without glenoid bone loss, rotator cuff tears, or injuries to the long head of the biceps tendon (LHBT) responded to a written invitation to participate in the study. Three participants had a postoperative shoulder dislocation (at 4, 11, and 21 months following surgery, respectively), so were excluded from further analysis. The included 20 male patients had all undergone an arthroscopic anchor stabilization of the glenoid labrum with a single suture anchor performed by one surgeon (H.N.), with an average of 16 ± 3 months of postoperative follow-up. There had been no preoperative physical therapy. Surgery was performed on 9 left shoulders and 11 right shoulders. Postoperative treatment included sling immobilization for 2 weeks, followed by 6 weeks of physical therapy with 17 ± 4 appointments between 45 min and 1 h in length. Limited isometric exercises of the elbow and joint area began on the fifth postoperative day. The shoulder remained immobilized, although brace removal was permitted for pendulum exercises. The following exercises and procedures were sequentially introduced: cold packs, exercises stabilizing and mobilizing the shoulder blades, massage of the shoulder blade area and the cervical spine, active exercises of the elbow and wrist, and isometric exercises of the muscles in the glenohumeral joint area along the sagittal plane. Between the third and the fifth postoperative week the program transitioned to self-assisted exercises without weight-bearing with painless range of motion, pendulum exercises, attempts at active shoulder flexion to 60–90°, shoulder blade activation exercises, mobilization of the glenohumeral track and rhythm, and closed-chain proprioceptive exercises. Patients participated in a total of 6 weeks of postoperative rehabilitation in a physical therapy clinic, and after that time exercised at home according to instructions which included full active range of motion exercises and flexion, shoulder W,T,L routines 3 times per week.

From the start of our study, we found that the patients achieved good results from the orthopaedic assessment. Patients were evaluated clinically in an examination that included specific clinical tests to assess for glenohumeral joint stability and rotator cuff integrity. These included the Apprehension test, Jobe's test, Speed's test, Hawkin's test, and Neer's test.[1,2] Ultrasonography was conducted to exclude a rotator cuff tear or LHBT tendinopathy. The combined physical and imaging findings confirmed glenohumeral joint stability and rotator cuff tendon integrity. Other inclusion criteria were a lack of pain during the week preceding the study and during all of the examinations.

The inclusion criteria for the control group was the following: no injuries of the upper limb, no pain or range of movement deficits from one side to the other, and a signed informed consent to participate in the experiment.

Group I was comprised of 20 male patients following arthroscopic labral repair, and group II included 25 healthy male volunteers (physical therapy students and graduates) with no upper limb injuries, who served as controls. The controls were age- and body mass index (BMI)-matched with the group I patients, with no statistically significant differences in these values. Neither the patients nor the controls participated occupationally or recreationally in activities that required dynamic overhead movements. The somatic characteristics of these two groups are shown in Table 1.

Active range of uniplanar movements for the glenohumeral joint were measured in the sagittal, frontal, and transverse planes according to the methodology described by Ellenbecker et al.[1] using a goniometer. The measurements started along the sagittal and frontal plane, successively, and included adduction, horizontal abduction and rotation of the glenohumeral joint while sitting with the elbow next to the trunk, starting from internal rotation. Range of rotation was measured in the prone position at 90° of arm abduction. Both the operative and non-operative arms were measured using the same techniques. Functional multiplanar shoulder movement tests were consecutively introduced. These included hand-behind-the-back (Test1), bilateral placement of the thumbs at the level of the lower scapular angles (Test2), placing both hands on the nape of the neck (Test3), and putting both hands into rear pants pockets (Test4). In cases of limited joint mobility during Test1, the distance between the distal thirds of the fingers was measured. In Test2, the distance between the thumbs was measured.

Biomechanical measurements of internal and external rotators were performed under isokinetic conditions following a 10 min warm-up consisting of scaption, YWTL shoulder routines, and rotational movements with an elastic resistance band. The subject then assumed the supine position with his arm abducted 90° on the Humac Norm Testing & Rehabilitation System (CSMi Solutions, Stoughton MA) for the measurement of peak torque (PT), mean power, TPT, and PT angle. Stabilization, adjusting the length of the lever arm, and patient familiarization with isokinetic measurements was performed.[20] Measurements involved alternating movements in internal and external arm rotation with maximum voluntary strength and velocity under isokinetic conditions, and with angular speeds of 180 deg/s and 90 deg/s. These exercises were accomplished with 10 and 6 repetitions in a consecutive series. There was a 2 min break between each series. After isokinetic measurement of the uninvolved limb, the same procedure was performed on the operative limb. In the control group, the measurements started with the dominant arm using an identical measurement approach. In each case, the participants were asked if they felt any pain or instability during each exercise.

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