Clinical note

Specific evaluation of the function of force couples relevant for stabilization of the glenohumeral joint

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SUMMARY. Two clinical evaluation procedures for assessment of dynamic stability of the glenohumeral joint are presented in this paper, together with the biomedical evidence on which they are based. They are the Dynamic Rotary Stability Test (DRST) and the Dynamic Relocation Test (DRT). The purpose of the tests is presented and the technique required to perform the tests are described in detail.

INTRODUCTION

The glenohumeral joint is highly mobile, with little bony or ligamentous stability provided in mid-range. Mid-range stability is provided by the rotator cuff in a function termed ‘concavity compression’ (Lippitt et al. 1993; Lippitt & Matsen 1993), where the stabilizing force of the rotator cuff contraction compresses the convex humeral head into the concavity of the glenoid. The rotator cuff can also be considered the ‘fine tuner’ of the glenohumeral joint (Wilk 1994). The force couples associated with elevation of the arm have two components – a coronal plane force couple between deltoid and supraspinatus superiorly and the lower elements of the rotator cuff inferiorly, and a transverse force couple between subscapularis anteriorly and infraspinatus/teres minor posteriorly (Saha 1971; Poppen & Walker 1978; Kapandji 1982; Soderberg 1986; Schenkman & Rugo de Cartaya 1987, 1994; Norkin & Levangie 1988; Wilk 1994; Burkhart 1994, 1996).

The transverse force couple is responsible for maintaining the humeral head centred in the glenoid during dynamic activity. A relative balance must be maintained between the activity in subscapularis and that in infraspinatus and/or teres minor for the centring function to be achieved. In relation to elevation, failure within the transverse force couple will lead to failure of the coronal plane force couple, as the compression component of the function will be missing, allowing the pull of deltoid to translate the humeral head superiorly under the acromion (Saha 1971; Poppen & Walker 1978; Kapandji 1982; Soderberg 1986; Schenkman & Rugo de Cartaya 1987, 1994; Norkin & Levangie 1988; Wilk 1994; Burkhart 1994, 1996).

On the basis of this understanding of the force couples, the authors have developed two tests to evaluate the dynamic stability of the glenohumeral joint. We have used these tests in the clinic over a number of years, both as evaluation tools and as the basis for dynamic rehabilitation of the glenohumeral joint.

THE DYNAMIC ROTARY STABILITY TEST

The Dynamic Rotary Stability Test (DRST) is used to evaluate the ability of the rotator cuff to maintain the humeral head centred in the glenoid when the arm is loaded through rotation. It is predicated on the
knowledge that the head of humerus should remain centred in the glenoid throughout the range of rotation in any position of abduction or flexion (Howell & Galinat 1987; Howell et al. 1988), except at the limits of range, where ligamentous tightening forces the humeral head to translate (Harryman et al. 1990, 1992). In an unstable shoulder, or one in which dynamic control by the rotator cuff is lacking, the humeral head can be felt to translate when the rotator cuff is loaded, usually anteriorly during resisted lateral rotation and posteriorly with resisted medial rotation. These directions are opposite to those associated with ligamentous tightening at end range (Harryman et al. 1990, 1992). In more subtle situations or where the instability is more functional than structural, provocation of symptoms or alteration in the quality of contraction will alert the examiner to dysfunction without the sensation of humeral head translation. In patients with subacromial impingement, for example, the humeral head may be felt to translate superiorly rather than anteriorly or posteriorly.

The DRST is undertaken in different parts of the range of glenohumeral flexion and abduction from neutral towards the functional position(s) in which the patient has symptoms, whether pain, weakness, apprehension or instability. The number of positions in which the test is performed depends on the irritability of the condition, the general physical status of the patient, the clarity with which the patient can identify the position(s) in which symptoms are provoked and the demands placed on the shoulder by the patient. The aim is to find the position(s) in range where the patient has control of the head of humerus as close to the position in which control is lost as possible. The test is performed isometrically, isotonically, concentrically and eccentrically at different speeds and under different loads, depending on the demands placed on the shoulder by the patient. The amount of resistance added is usually light to moderate, as the assessment is one of the ability of the rotator cuff to stabilize, rather than one of strength of rotation.

Technique

The test is best performed in sitting. The therapist holds around the head of the humerus such that the middle finger is positioned longitudinally along the anterior joint line, adjacent to the coracoid process, the palm of the hand is over the top of the shoulder, adjacent to the acromioclavicular joint and the thumb is positioned longitudinally along the posterior joint line. There should be complete contact with the shoulder from anterior to posterior. The hand should be placed medial to the deltoid, if possible, to avoid contraction of deltoid masking the ability to feel humeral head movement. To examine the right shoulder, the left hand is used to palpate the head of humerus.

The test is first performed isometrically, with all movements into medial rotation undertaken together, followed by all movements into lateral rotation (or vice versa). With the patient’s arm by the side, elbow flexed to a right angle and in neutral pro- and supination, the therapist slowly applies manual resistance at the distal forearm to an isometric contraction up to moderate resistance into one or other rotation (with the right hand for a right shoulder). At the same time, the therapist feels for movement of the head of humerus or alteration in the quality of contraction, watches for altered scapular and trunk movement and enquires about provocation of symptoms.

The arm is then moved some way into elevation, usually initially in the plane of the scapula, with the test position chosen on the basis of the principles outlined above. The isometric contraction is repeated, with the same assessment. The contraction is repeated in different positions in range until one is found in which any of the abnormal features outlined above is identified, or to full range in the symptom provoking direction (Fig. 1A and B). The test is then repeated isometrically through the same positions with the resistance towards the opposite rotation. If a thrower indicates pain in the late cocking position of a throw, for example, the final position examined would be one of abduction/ horizontal extension and lateral rotation, whereas for a swimmer with pain at catch in the freestyle stroke, the end position would be flexion combined with medial rotation. For an elderly sedentary person with a painful arc during elevation, testing may be performed below and above the range of the painful arc initially, with the final positions approximating that found to be painful on active movement assessment.

The test is then repeated isotonically through the same test positions. Initially, the patient’s arm is taken through full rotation passively, to teach the required movement, with the task then made assisted active, gradually adding resistance to the movement. The resistance added is never more than light to moderate, as the patient must be able to readily achieve the movement for the therapist to detect any abnormality. The isotonic resistance is applied slowly. As with the isometric contractions, all tests into one rotation are usually done together, followed by those in the opposite direction, as patients find this procedure easier to master than doing both rotations in the same position before moving on to the next position. The test is then repeated in the opposite direction.

Care must be taken to ensure that the movement remains one of rotation, as the patient will tend to push out into abduction with resited lateral rotation.
or into adduction with medial rotation, leading to a different feel of humeral head movement. This tendency becomes more obvious as the test is undertaken further into abduction range. To facilitate maintenance of a rotary movement, the therapist can ask the patient to point the tip of the elbow towards an appropriate imaginary spot on the wall in line with the upper arm and to keep it still, spinning the forearm around that point. Inappropriate resistance by the therapist, such that the patient is unable to achieve pure rotation is another cause of incorrect movement during the test. The therapist must be aware of and adjust to the normal change in strength, particularly in lateral rotation, with the arm higher in range. The therapist must also ensure that the resistance is always provided at right angles to the direction of movement, to facilitate pure rotation.

The test is then progressed further, with increased speed, eccentric movement, quick changeovers from medial to lateral rotation and vice versa, concentric to eccentric changeovers, as indicated by the patient’s presentation and lifestyle/sport requirements. Sometimes, asking the patient to perform quick reversals of the movement while holding a small weight in the hand, will demonstrate the abnormal translation more effectively than against manual resistance. Commonly the patient can detect their own lack of control or stability in different positions and therefore should always be asked how it compares to testing the other shoulder at the same angle.

With each stage of the test, the aim is to find the position where control is lost, with control identified as a smooth, controlled contraction, with no abnormal translation, pain or apprehension. Having found this position, the arm should be moved away from that position in small increments, and re-tested each time, until a position is reached where control is re-established. Positions of control are usually found with the arm closer to the body, but this may not be the case, depending on the patient’s functional activities. Therefore, the process should be undertaken in both directions – that is, into more and less abduction/flexion. Working on the principle of training overload (Kibler & Chandler 1994), the closer to the point of loss of control that can be identified for future re-training, the more quickly control is likely to be regained. Often patients have isometric control further into range than isotonic control and control at speed at a lower range than at higher ranges. If a lack of control is identified through this test, rehabilitation of the control can be
undertaken, making use of the positions of control to facilitate stabilizing activation of the rotator cuff in positions where the control is lacking. If necessary the patient’s upper arm can be supported during the testing and initial re-training, although ultimately such support must be withdrawn as the training progresses.

Throughout the test, the therapist must also observe the scapula and trunk. There should be no compensation (e.g. shoulder shrug) or loss of control (e.g. altered scapular or trunk stability) elsewhere during the test. While the loss of control identified is not that of the glenohumeral joint, an inability to maintain the scapula on the chest wall or the trunk in a stable position indicates that the overall neuromuscular control at that particular point in range is lacking. Therefore, the test should be repeated in a slightly lower range until the point is found where the scapula or trunk can be maintained in position while the rotator cuff is loaded. This becomes important in management, as if the shoulder is allowed to work when either the scapula or trunk is not stable, abnormal motor programmes are encouraged and the risk of symptom aggravation is increased.

THE DYNAMIC RELOCATION TEST

The Dynamic Relocation Test (DRT), initially developed by Guy David (see acknowledgement), is a test of the ability of the rotator cuff, and in particular the lower elements of the rotator cuff, to stabilize the head of humerus in the glenoid by means of co-contraction against a de-stabilizing load. It is predicated on the knowledge that, in normal situations, the rotator cuff functions in co-contraction to stabilize during dynamic activity of the more superficial torque producing muscles (Kibler & Chandler 1994; Wilk 1994; Kibler 1998; David et al. 2000). In shoulders with pain, the co-contraction appears to be lost, although this has not yet been demonstrated under research conditions (David et al. 1997). The test is also based on the knowledge that activity in the normal rotator cuff precedes the onset of movement, whereas in the painful shoulder, this pre-activation appears to be disturbed and often delayed. Such muscle activity draws the humeral head into the glenoid, stiffening the joint and minimizing the amount of translation available (Wilk 1994; Kibler 1998).

The best position in which to evaluate rotator cuff co-contraction is that where the fibres of the relevant muscles are optimally aligned to achieve relocation of the humeral head – 60–80° of abduction in the scapular plane (Wilk 1994). Once the ability to isolate the co-contraction has been determined in this position, the ability to create the dynamic relocation can be evaluated in different positions, as indicated above for the DRST, and during different tasks.

Technique

The starting position for the test is with the patient either sitting or supine and the arm supported in approximately 60–80° of elevation in the scapular plane, neutral rotation and 90° elbow flexion. During the test, the therapist asks the patient to draw the humeral head into the glenoid by means of co-contraction of the transverse force couple (Burkhart 1994, 1996) – subscapularis anteriorly and infraspinatus/teres minor posteriorly. To evaluate this contraction, it is best if the therapist can palpate at least one component of the force couple. Palpation of a contraction of infraspinatus is difficult, because overlapping muscles can cloud the assessment, but subscapularis can be palpated in isolation in the floor of the axilla. Therefore, before evaluating the relocation manoeuvre, the therapist must find subscapularis and place the flat surface of three fingers over this muscle belly. The axilla can be reached from either anterior or posterior, with this handling varying between patients.

To ensure that the fingers are correctly placed, resist a gentle medial rotation contraction, at which time the subscapularis can be felt to tighten under the fingers. If the hand is placed anteriorly, pectoralis major can also be felt to contract and the therapist must ensure that distinction can be made between the contraction of these two muscles. If the hand is placed posteriorly, distinction between contraction of latissimus dorsi and subscapularis must also be made. The remainder of the therapist’s hand is placed over the shoulder, so that the proximal phalanges are over either pectoralis major anteriorly or latissimus dorsi posteriorly. These fingers can then palpate and monitor for activity in the superficial muscles during the test. The therapist’s left hand is used when evaluating the patient’s right shoulder.

Once the therapist is confident of hand placement over the belly of subscapularis, the patient is specifically asked to relax, as they will often develop a level of static muscle tension in anticipation of the test procedure. A description is provided to the patient of the manoeuvre, making use of visual images such as ‘draw your arm bone up into its socket’ or ‘suck the arm into its socket’.

Extremely gentle resistance is applied longitudinally along the shaft of the humerus with the right hand and the patient asked to pull the humeral head back into the glenoid, as has just been explained (Fig. 2). Initially, most patients will pull in strongly with all superficial muscles, with or without any contribution from the rotator cuff. Localized contraction can be facilitated by instructing the patient to reduce the effort used to produce the movement,
reducing the strength of the contraction gradually more and more until it can be isolated to the rotator cuff. The patient must be encouraged to relax all superficial muscles, in particular, latissimus dorsi, posterior deltoid, pectoralis major and upper trapezius, which tend to be overactive when the movement is first attempted. Such relaxation assists the patient in relative isolation of the contraction to the rotator cuff. Light manual contact over these muscles to help the patient recognize when they are contracted can sometimes also help with relaxation. Similarly, deliberately providing some pressure on the belly of subscapularis, so that the contraction can be felt by the patient as increased pressure against the fingers can stimulate a more isolated contraction.

If the patient has difficulty mastering the task or, if the attempt involves a considerable amount of superior translation of the humeral head and overactivity of upper trapezius, relocation can be facilitated by encouraging a gentle depressive component to the drawing in movement, with the depression only of the head of humerus onto the fingers in the axilla. This facilitatory technique is particularly useful for the patient whose humeral head translates superiorly during active abduction – for example, the patient with a subacromial impingement.

Alternative forms of facilitation can be used, with the therapist experimenting until one is found that is useful with a particular patient. A technique that is often useful with patients with anterior instability is to provide a slight medial rotation bias to the longitudinal movement and ask the patient to draw the arm in and backwards, thus creating a slight external rotation moment in conjunction with the co-contraction. Similarly the simple imagery of ‘widening your shoulders’ or thinking of excessive protraction as a closed book and ‘opening the book’ will be sufficient for some patients. The use of weightbearing can be useful with some patients, rather than the traction movement.

Elastic tape applied to simulate compression of the humeral head into the glenoid can also facilitate the contraction. The tape is applied in gentle weightbearing through the elbow with the arm in slight scapular plane abduction and neutral rotation. The tape is spiralled from the midpoint of the anterior arm in line with the deltoid insertion with one band over the anterior deltoid and acromion and finishing along the spine of the scapula and the other in a similar fashion over posterior deltoid and the acromion, finishing along the clavicle. An initial half circle around the arm at the level of deltoid insertion is often used as an anchor, laid on with no tension, while tension is used in the tape over the anterior and posterior deltoid to draw the humeral head upwards into the glenoid. A final anchor may be needed over the top of the shoulder girdle to fix the proximal ends of the tape. Use of a non-allergenic under-tape is recommended (Fig. 3).

The contraction technique is unfamiliar to most people, so interpretation of the test must be made with care. The therapist must not be too quick to assume that the patient cannot achieve the contraction, as even subjects with a normal shoulder and good kinaesthetic sense may take some time and assistance to master the task, though most can usually achieve an isolated contraction relatively readily. Patients with a dysfunctional shoulder may find isolation of this contraction to the rotator cuff extremely difficult or impossible to achieve without considerable practice and facilitation. If after such facilitation, the patient is still unable to isolate or even initiate a rotator cuff contraction, the conclusion of lack of dynamic control of the humeral head is reasonable.

If the patient is able to achieve the relocation contraction and isolate it in an optimal position against the gentle resistive force, the next step is to ask them to repeat the contraction without the stimulation of the traction. The patient must then be taught to feel the contraction for themselves, with...
correct placement of their fingers in the axilla and the sensation of contraction in subscapularis to ensure correct positioning, if they are to practise the manoeuvre at home. The therapist must then ensure that the patient can recognize the co-contraction without external tactile or resistive facilitation as this is the first step for home training. Once this can be achieved, progression depends on the starting position for the test. If sitting, first wrist extension and then shoulder rotation, both performed with the elbow still supported, tend to be good initial muscular loads to add, as they provide a cognitive distraction without a significant physical challenge. If the test were initially performed in supine, movement of the arm towards lateral rotation, still in the scapular plane, and performing the relocation manoeuvre isometrically would be an appropriate early cognitive progression.

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From this point, progression can be made by maintenance of the co-contraction during any relevant functional movement, with progressively increasing difficulty. The aim is to find the point in range in the specific movement where the patient has control and where such control is lost. If the patient has a positive apprehension/relocation test, progression towards dynamic control of the humeral head in the apprehension position (that is, full lateral rotation in abduction) can be appropriate, in addition to development of control during more functional tasks. If abnormality of control were detected during the DRST, the test position in which loss of control was found can be re-evaluated following facilitation of dynamic relocation, to determine whether control was enhanced with this manoeuvre. If control is improved, the prognosis of benefit from a dynamic rehabilitation program making use of the concepts of relocation and control is good.

The test manoeuvres can be used during management of a dynamic control problem of the shoulder, as described in Magarey and Jones (2003). The authors are still working on ways of measuring the outcome of these tests objectively, so that they can be used as objective clinical and research outcome measures. Similarly, as yet, we have no figures on what could be considered normal, nor any measures of reliability or validity. At this point, manual palpation of humeral head translation or alteration of quality of contraction are the only measures of normality during the DRST, while palpation of rotator cuff contraction is the only clinical measure of normality for the DRT. This test can be measured objectively, with in-dwelling EMG electrodes, not appropriate for a clinical setting and by means of dynamic ultrasound, where the movement of the humeral head into the glenoid can be visualized, a technique also not ideal as yet for most clinicians. Research is continuing to find ways in which more objective measures, similar to those identified for the deep cervical flexors (Jull 2000; Jull et al. 2002) or transversus abdominus (Richardson et al. 1999) can be applied to these test procedures. In the meantime, these tests have been found clinically useful in identification of the patient with poor dynamic control of the glenohumeral joint and in management of these patients.

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