Do changes in hand grip strength correlate with shoulder rotator cuff function?

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Abstract

Background: Shoulder pain as a result of rotator cuff pathology is one of the most common musculoskeletal complaints presenting within primary care. Assessment of hand grip strength has been proposed as an indicator of rotator cuff function. This experimental study assessed the relationship between grip strength and shoulder lateral rotator muscle strength in a number of different shoulder positions, aiming to investigate whether such a relationship existed and whether grip strength could be used as a functional assessment tool for the posterior cuff.

Methods: Twenty-seven healthy, physically active, volunteers (19 males, eight females) with no history of shoulder, upper limb or neck injury comprised the study group. The mean (SD) age was 19.8 (5.7) years (range 18 years to 23 years). Grip strength (measured with hand grip dynamometer) and lateral rotator strength (measured with a hand held dynamometer) was measured at neutral, 90° abduction, and 90° abduction with 90° external rotation.

Results: The correlation between grip strength and shoulder lateral rotation strength ranged between $r=0.91$ ($r^2=0.84$) and $r=0.72$ ($r^2=0.52$) across all positions.

Conclusions: A strong correlation between grip strength and lateral rotator strength was shown at all positions for both left and right hands, suggesting that assessment of grip strength could be used as a rotator cuff monitor of recruitment function.

Keywords

hand grip, lateral rotator strength, rotator cuff, shoulder

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Introduction

The overall prevalence of shoulder pain in the UK population is estimated to be around 7%,¹ with shoulder impingement syndrome (SIS) being the most commonly diagnosed shoulder disorder in the primary care.^{2,3} In 1972, Neer⁴ coined the term sub-acromial impingement and proposed a pathomechanical model in which mechanical compression of the soft tissues within the sub-acromial space occurred as a consequence of narrowing of the sub-acromial dimensions.⁵ During active elevation, the humeral head superiorly migrates 1 mm to 3 mm over the initial 30° to 60°⁶ before stabilizing in the centre of the glenoid, although rotator cuff weakness can lead to excessive superior translation of the humeral head leading to a further

decrease in the sub-acromial space during elevation, thus causing mechanical compression of the sub-acromial structures.⁷ Repetitive micro-trauma to the articular side of the rotator cuff can cause the tendon to become compressed between the superior posterior glenoid rim and the humeral head.⁸ This impingement typically occurs in the presence of increased capsular laxity or instability of the glenohumeral joint.⁹

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Improvement in strength of the shoulder muscles is generally required during the rehabilitation process following shoulder injury,¹⁰ and several studies report the presence of weakness or sub-optimal recruitment of the rotator cuff in patients presenting with sub-acromial impingement.^{11,12} In addition, the existence of an imbalance between the agonist and antagonist muscle groups has been shown to be one of the major risk factors for developing shoulder injuries,¹³ with a reduction in the external rotator strength conceivably causing in injury.¹⁴ As a result, improvements in strength of the shoulder muscles are generally required during the rehabilitation process following shoulder injury.¹⁰ One recent study¹⁵ examined the reliability of using a hand held dynamometer, which is a more objective measure of assessing strength than manual muscle testing, aiming to measure glenohumeral rotation strength in different patients and different shoulder positions, and reported good to excellent reliability regardless of patient or shoulder position.

Measurement of grip strength is commonly used within rehabilitation to compare against normative values, or to compare strength between dominant and nondominant limbs. Alizadehkhayat et al.¹⁶ found that a standardized hand grip task in a neutral position activated supraspinatus and infraspinatus. Grip strength has been shown to be correlated with the strength of the upper extremity, general strength of the body¹⁷ and as an objective measure of upper extremity function.¹⁸ Nascimento et al.¹⁹ and Manadlidis and O'Brien¹⁰ found a statistically significant and positive relationship between isometric hand grip strength and isokinetic peak torque and work measures of the shoulder stabilizing muscles. The relationship has been proposed as a result of the requirement of a stable proximal shoulder girdle to enable optimal recruitment of the distal muscles, and the force transmitted along the myofascial pathways.²⁰

Hand grip dynamometers have been shown to be accurate and reliable for measuring grip strength,^{21,22} and easy to use. Nascimento et al.¹⁹ and Manadlidis and O'Brien¹⁰ found a statistically significant and positive relationship between isometric hand grip strength and isokinetic peak torque and work measures of the shoulder stabilizing muscles.

Grip strength can be measured quantitatively using a hand dynamometer and has been shown to provide an objective index of the functional integrity of the upper extremity. Hand grip dynamometry is comparatively inexpensive, compared to conventional isokinetic dynamometers, and correlation between the two has been reported as being moderate.¹⁰

Shoulder injuries are prevalent in sport^{23–25} and are multifactorial. One of the proposed mechanisms for shoulder injury is a result of rotator cuff fatigue,

which contributes to superior humeral head migration during arm elevation and causes impingement of the soft tissues in the sub acromial space during training activity. The present study aimed to assess the relationship between grip strength and shoulder lateral rotator muscle strength in a number of different shoulder positions. If an association was found then grip strength measurements could be utilized within a rehabilitation and training session to monitor rotator cuff function with the possibility of reducing shoulder injury.

Materials and methods

Participants

Twenty-seven subjects volunteered to participate in the study (19 males and eight females). All were healthy and physically active, with no history of shoulder, upper limb or neck injury. The mean (SD) age was 19.8 (5.7) years (range 18 years to 23 years). All subjects were right-hand dominant as defined by the hand that they wrote with. All participants gave informed written consent and the study was approved by the University research ethics governance committee.

Protocol

Assessment of grip strength. Grip strength was measured using a handheld dynamometer (Takei Physical Fitness test Grip-A; Grip Strength Dynamometer TKK Grip-A; Cranlea & Company, Birmingham, UK). Participants completed 5-second maximal contractions with the arm in three different positions: neutral (Figure 1), 90° abduction (Figure 2), and 90° abduction with 90° external rotation (Figure 3). The wrist was kept in neutral and the elbow at 90° flexion in all positions. Participants were standing with their feet approximately shoulder width apart, with a wall behind them to add stability, prevent trunk rotation and help maintain arm position. Both hands were

Figure 1. Grip strength measurement in neutral.

Figure 2. Grip strength measurement at 90°.

Figure 4. Lateral rotation strength measurement in neutral.

Figure 3. Grip strength measurement at 90° abduction and 90° external rotation.

Figure 5. Lateral rotation strength measurement at 90° abduction.

tested three times in each arm position and verbal encouragement was used to ensure maximal contractions. An average was then taken of these three scores. There was a rest time of 1 minute to ensure sufficient recovery inbetween each contraction. Block order was used to determine the order of positions tested to prevent any learning effect occurring and arms were tested alternately. The tester remained the same during all data collection. The same method was implemented in testing rotator cuff strength.

Assessment of shoulder lateral rotator muscle strength. Lateral rotator muscle strength was measured using a handheld dynamometer (Hoggan MicroFET2; Scientific LLC, Salt Lake City, UT, USA) in the same three arm positions as those used for grip testing (Figures 4–6) when standing. In the neutral and 90° abduction with 90° external rotation positions, the dynamometer was placed against a wall for stability and to give resistance to counter the maximal contraction. In the 90° abduction position, a strap was adjusted to participants' shoulder height and used as an aid to the examiner to place the dynamometer inside and resist the maximal contraction that was in an upward direction. Both shoulders were tested three

Figure 6. Lateral rotation measurement at 90° abduction and 90° external rotation.

times in each position and verbal encouragement was used to ensure maximal contractions before an average was taken. A rest time of 1 minute inbetween each contraction ensured sufficient recovery.

Statistical analysis

The relationship between grip strength and shoulder lateral rotator strength for each position was assessed using Pearson's product moment correlation.

Figure 7. Mean (SD) grip strength across the three testing positions.

Figure 8. Mean (SD) shoulder lateral rotation strength across the three testing positions.

Results

Figure 7 shows the average grip strength for participants across the three positions. Figure 8 shows the average shoulder lateral rotator muscle strength for participants across the three positions. The correlation between grip strength and shoulder lateral rotation strength in the neutral position was $r = 0.91$ ($r^2 = 0.84$) for the left and $r = 0.86$ ($r^2 = 0.66$) for the right. The correlation between grip strength and shoulder lateral rotation strength in the 90° shoulder abducted position was $r = 0.82$ ($r^2 = 0.67$) for the left and $r = 0.72$ ($r^2 = 0.52$) for the right. The correlation between grip strength and shoulder lateral rotation strength in the shoulder 90° abducted externally rotated position was $r = 0.78$ ($r^2 = 0.61$) for the left and $r = 0.75$ ($r^2 = 0.57$) for the right (Table 1).

Discussion

The present study, in line with previous studies, shows that hand grip strength is most reliably assessed when standardized methods and calibrated equipment are utilized, even when different examiners and equipment are used.^{26,27} Previous studies²⁶ found that the mean of three grip strength trials is a more accurate measure than one trial of the best of three trials. Published

Table 1. Correlation between lateral rotator muscle strength and grip strength at different shoulder positions.

	Correlation left hand	Correlation right hand
Neutral shoulder rotation	0.91 ($r^2 = 0.84$)	0.86 ($r^2 = 0.66$)
90° shoulder abduction	0.82 ($r^2 = 0.67$)	0.72 ($r^2 = 0.52$)
90° shoulder abduction & external rotation	0.78 ($r^2 = 0.61$)	0.75 ($r^2 = 0.57$)

data of grip strength values between the sexes show that males have higher peak strength. The peak strength occurs in the fourth decade in both sexes and undergoes a similar gradual decline.²⁸

Several studies have shown a positive correlation between hand gripping activity and rotator cuff muscle activity in line with the findings of the present study.^{29–31} Kwasniewski³² compared bilateral rotator cuff strength in patients with a unilateral hand or wrist disorder using a hand held dynamometer and reported a statistically significant decrease in elevated external rotation strength. Kwasniewski³² stated that it was unclear whether there is a causal relationship. Similarly, Budoff³³ found an increased prevalence of rotator cuff weakness of the limb with an associated hand or wrist disorder.

Alterations in muscle activity patterns have been documented in the presence of shoulder dysfunction^{34–36} with the activity of some shoulder muscles increasing, whereas others decrease when gripping is added to shoulder movements.^{30,37} Alterations in muscle activity where there is pain is considered to reduce load within the painful region to protect from further pain and/or injury³⁸ and gripping may result in a redistribution of force in the rotator cuff muscles.³⁷ Because co-activation of the proximal and distal arm muscles has been shown to occur during gripping (possibly as a result of the grip motor control command eliciting activity in the proximal shoulder muscles),³⁹ it is feasible that assessment of grip will give an indication of the activity of the rotator cuff. This is especially likely in the light of the findings of Antony and Keir³⁷ who noted that infraspinatus activity increased when gripping was added to shoulder motion.

The strong positive correlation found between the two variables in the present study in both hands is in agreement with the findings of Mandalidis and O'Brien¹⁰ who investigated the relationship between isometric grip strength and isokinetic strength of the shoulder stabilizers. This concurs with the concept of

shoulder stabilizer activity increasing during handgrip actions shown in previous studies.^{30,37} Sporrang et al.³⁰ found that the electromyographic activity of rotator cuff musculature (most significantly the supraspinatus) increased significantly during isometric handgrip tasks, particularly in positions of shoulder flexion/abduction, and that biceps brachii activity also increased during handgrip. It has been suggested that this may cause changes in activity of the shoulder muscles and potentially changes in 'internal loading' of the shoulder.³⁷ In addition, Walaa and Walaa⁴⁰ also found that hand grip strength correlated with body position. They compared hand grip strength in several positions and found that hand grip strength decreased in the order: standing, sitting, supine, side lying and prone. They proposed that rehabilitation of the shoulder musculature should be started from the prone position, followed by the sitting or standing position after gaining more strength in hand grip and from side-lying, sitting or standing for shoulder abductors.⁴⁰

Previous studies have shown males to have a significantly stronger grip,^{41,42} although the present study does not take sex differences into account and it may be the case that sex has a specific effect on the relationship found.

The present study has a significant limitation in that the investigations were conducted on healthy asymptomatic shoulders; it remains to be confirmed whether a similar relationship exists in pathological shoulders.

Conclusions

Hand grip strength can be quantified by measuring the amount of static force that the hand can squeeze around a dynamometer⁴³ and provides an objective index of the functional integrity of the upper extremity.⁴⁴ The results of the present study show that grip strength can be reliably used to assess the function of the lateral rotators of the shoulder in normal individuals. We propose that this could be useful as a monitoring tool for assessing readiness to perform a sporting activity and for assessment of fatigue during training. It may also prove a useful tool when contraction of the rotator cuff is restricted as a result of surgery and in the monitoring of muscle atrophy.

These results show a strong correlation between grip strength and lateral rotator strength at all positions for both left and right hands, which suggests that assessment of grip strength could be used to monitor the function of the posterior cuff, once baseline readings have been attained during training and rehabilitation. With the arm in a neutral position, grip strength could be used to monitor the stages of the rehabilitation process, especially in patients who have a limited range of motion and/or pain.

Declaration of conflicting interests

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Ethical review and patient consent

All participants gave informed written consent and the study was approved by the University research ethics governance committee.

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