Shoulder Mobility in String Musicians

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ABSTRACT

Background: String musicians partake in repetitive midrange activity of the shoulder on the bowing arm which may put them at risk for shoulder dysfunction. **Objective:** The purpose of this study is to assess the glenohumeral capsular mobility in string musicians and to describe self-mobilization techniques to restore capsular mobility. **Methods:** Thirty one professional string musicians underwent measurement of bilateral shoulder range of motion and neural mobility. Data were analyzed for differences between right and left as well as between musicians with and without prior or current right upper extremity dysfunction. **Results:** A significant decline in combined extension/internal rotation was noted in the bowing arm for all participating musicians. Additionally, an increase in right radial nerve mobility was documented in musicians with right upper extremity dysfunction as compared to the left. **Conclusion:** With 35% of string musicians in this study reporting pain in the bowing arm, further research to investigate the effects of a restorative program for shoulder mobility in this population is warranted.

INTRODUCTION

Shoulder mobility is needed for a variety of daily activities. However, many factors can affect shoulder range of motion and ultimately lead to impairment and disability.

Adhesive capsulitis is a well recognized dysfunction of the shoulder in which loss of glenohumeral motion is notably decreased.[1] A loss of range of motion as a result of adhesive capsulitis has been related to histologic changes in the synovium and joint capsule consisting of perivascular scar formation, fibrosis, and fibroplasia. Clinical examination of a patient with adhesive capsulitis often reveals a predictable pattern of motion loss wherein external rotation (ER) range of motion is most limited, followed by abduction and internal rotation (IR), respectively.[2] Conversely, a recent study notes inconsistency in the capsular pattern suggesting the existence of subgroups of adhesive capsulitis with localized capsular hypomobility.[3]

Selective capsular mobility loss at the shoulder is documented frequently in the throwing literature. A decrease in IR is often noted in baseball pitchers as a result of reactive fibrosis[4] and calcification of the posterior region of the capsule[5] secondary to repetitive microtrauma. Such posterior capsule hypomobility can result in increased superior and anterior translation of the humeral head[6-9] thus compromising the subacromial space.[10] With selective mobility loss of the posterior capsule contributing to impingement syndrome, a posterior capsule stretching program is an important component of the rehabilitation process in overhead athletes.[4,8,9]

In contrast to the abundant literature regarding glenohumeral capsular mobility in throwing athletes, little is written about shoulder injuries in string musicians. Because frequent or sustained use of the arm at or above shoulder level during occupational tasks is a significant risk factor for shoulder dysfunction,[11] the repetitive midrange motion required for playing a stringed instrument may place string musicians at risk for shoulder dysfunction. The prevalence of shoulder pain in the bowing arm of string musicians is 4.6 disorders occurring with 1000 hours of instrumental practice.[12] Furthermore, musicians playing the violin or viola have twice the incidence of shoulder pain compared to those who play the piano.[12] The purpose of this study is to assess the glenohumeral capsular mobility in string musicians, compare range of motion to normative values, and to propose self-mobilization patterns that facilitate the restoration of capsular mobility.

METHODS

Thirty seven string players of the Minnesota Orchestra were involved in this study. Six subjects reporting prior or current left upper extremity dysfunction were excluded from the statistical analysis as their left shoulders would not serve as legitimate controls for comparison. Thus, participants consisted of 15 males and 16 females. The average number of years playing a string instrument professionally was 21.1 (range 2-43), and the age range of participants was 30 to 62 years. Of the 31 participants, 13 were violinists, 9 were cellists, 7 played the viola, and 2 played the bass. No participants reported prior surgical intervention. However, 11 participants indicated experiencing previous right upper extremity injury or existing pain, motion loss weakness, and/or paresthesias. Data were then analyzed using unpaired t-tests to determine whether the shoulder mobility measures were different between the painful and the pain-free musicians groups. Additionally, paired t-tests with significance level set to $p < .05$ were run to analyze right to left differences in both groups.

The clinical examination process focused on the assessment of capsular mobility and represents a portion of the comprehensive examination that the primary author uses for his patients with shoulder dysfunction. Three assessments to evaluate single plane motion were completed. Elevation in the scapular plane was conducted with the subjects standing with their back to the wall and hips and knees slightly bent. Supine ER was measured with the shoulder at 90° abduction and IR with shoulder at 70° to 80° abduction, measured with an inclinometer.

Internal rotation combined with extension (extension/IR) and a large arm circle motion was used to assess multiplanar motion of the shoulder. Extension/IR required

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participants to slide the thumb up the spine and was quantified using a cloth measuring tape originating at the C7 spinous process to the final location of the thumb along the spine. The large arm circle movement (Figure 3) was used to dynamically assess shoulder and trunk mobility. The motion was completed with participants positioned in side lying with the hips and knees bent to 90°. To assess right shoulder mobility and right trunk rotation, the participant was positioned in left side lying. The trunk was then rotated back as the dorsum of the hand was slid along the floor in a circumducting fashion. Movement of the hand away from the floor indicated a mobility loss and the angle of shoulder abduction at which this occurs was documented.

In addition to the assessment of capsular mobility, bilateral upper limb tension tests were conducted with median and radial nerve biases. Median nerve mobility was assessed in supine by externally rotating the arm at 0° abduction then introducing wrist and finger extension. Prior to performing external rotation the cervical spine was placed in contralateral rotation. The arm was abducted until a mild discomfort was reported by the subject in the shoulder, arm, or hand. Radial nerve mobility was assessed in a similar fashion, however, internal rotation of the humerus accompanied by wrist and finger flexion was established prior to abduction. The degree of shoulder abduction at the point of discomfort for both tests was recorded.

RESULTS

Unpaired t-tests reveal no statistical differences in bowing arm shoulder mobility between the painful and pain free musician groups for any measures recorded (Table 1). However, paired t-tests for right-to-left comparisons indicated 2 mobility patterns with statistically significant differences. In the musician group with prior or existing pain, mean extension/IR was decreased (p=0.13) on the right (mean 7.4cm, range 5.5-12cm) compared to the left (mean 6.1cm, range 4-9cm). Extension/IR was also decreased (p=0.018) in the group with no bowing arm pain to 6.6 cm (range 4-9.5cm) on the right versus 5.6 cm (range 3-9.5) on the left. Additionally, the musicians with right upper extremity dysfunction demonstrated a statistically significant increase (p = 0.023) in bowing arm radial nerve mobility. Mean radial nerve mobility during upper limb tension testing was 29.5 ° on the right (range 21.0 -90.0) and 27.6° (range 17.5-90.0) on the left.

No statistical differences were found when comparing right and left scapular elevation. Right shoulder mean elevation in the plane of the scapula for all participants was 163.9 (range 140-180). Seven of 31 (23%) participants presented with less than 160° scapular plane elevation. Mean ER in this study is 105.8 (range 75-120) with 94% (29/31) of subjects exhibiting greater than 90° ER. Mean IR is 63.7 (range 40-90) with 21 of 31 subjects displaying less than 70° IR mobility. Multiplanar motion assessed using the large arm circle motion was, on average, 154.8 abduction (range 90-180). Thirteen of 31 (42%) subjects were limited to less than 160° abduction when performing the large arm circle motion.

DISCUSSION

The single plane motion assessments used in this study are commonly referenced in the literature.[13,14] Although no statistical differences were noted in either group for any of the single plane mobility patterns, comparison to normative values indicates differences in the shoulder mobility of string musicians. In this study, the mean elevation of 163.9 is 16° below the accepted normative value of 180.[13] A trend toward external rotation hypermobility was noted as well. The mean ER of 105.8 is substantially greater than the normative value of 90°[13] implicating hypermobility of the anterior joint capsule. Normal internal rotation range of motion is 70°.[13] Sixty seven percent of participants in our study presented with an excursion of less than 70° indicating a possible decline in the mobility of the posterior capsule.

For multiplanar mobility, both painful and pain-free musicians displayed a decrease in combined shoulder extension/IR mobility of the bowing arm. This finding suggests that limitations in multiplanar motion patterns may be critical in the early detection of shoulder girdle dysfunction in string musicians. The normal value for the large arm circle pattern is 180° elevation. In our study population, the average excursion was 154.8°. Forty two percent of subjects were

Table 1. Mean shoulder and neural mobility for symptomatic and asymptomatic string musicians. Statistically significant right to left differences are noted with asterisks.

		Flexion (degrees)	ER (degrees)	IR (degrees)	Ext/IR (cm)	Arm Circle (degrees)	Median nerve mobility (degrees)	Radial nerve mobility (degrees)
Symptomatic n = 11	R mean	159.1	108.2	64.1	7.4*	146.4	30.8	29.5***
	SD	13.2	8.7	7.3	1.8	31.7	30.8	29.5
	range	140-180	95-120	55-80	5.5-12.0	90-180	20.0-90.0	21.0-90.0
	L mean	161.4	110.9	64.1	6.1*	146.8	36.1	27.6***
	SD	16.1	10	8.6	1.6	42	36.1	27.6
	range	135-180	95-120	50-80	4.0-9.0	70-180	19.0-90.0	17.5-90.0
Asymptomatic n = 20	R mean	166.5	104.5	63.5	6.6**	159.6	25.4	23.0
	SD	10.5	9.6	12.6	1.9	27.1	2.9	2.2
	range	140-180	75-120	40-90	4.0-12.0	110-180	20.0-30.0	18.5-26.5
	L mean	164.8	106.3	66.7	5.6**	163.3	24.1	21.6
	SD	10.9	13.6	13.5	1.7	25.8	2.2	3.6
	range	140-180	70-130	45-95	3.0-9.5	90-180	21.0-29.5	16.0-26.0

limited to less than 160°. Although no significant differences in the arm circle range of motion existed in this study between subjects, this technique allowed for assessment of the ability of the humeral head to glide inferiorly and theoretically clearing the greater tubercle below the acromion and reducing mechanical impingement. Furthermore, the large arm circle acts as a screening tool for thoracic mobility, noting that trunk rotation and extension are required for end range of motion shoulder mobility.

Interestingly, a significant increase in radial nerve mobility was noted in the bowing arm of the group with current or prior pain. This may be due to the nature of the bowing pattern. With the arm in a relatively internally rotated position and undergoing repetitive elbow flexion and extension, a midrange neural glide of the radial nerve is being conducted. Thus, it is possible that that the mobility of the radial nerve within the connective tissue interface is increasing.

A limitation to this study is that the left upper extremity was used for comparison as a control for a portion of the analyses. While the right upper extremity is the bowing arm undergoing repetitive midrange motion, the left upper extremity is typically involved in prolonged outstretched reaching. This range of motion requirement may predispose these individuals for possible left shoulder dysfunction as well. As a result, this study may have underestimated the bowing arm motion patterns secondary to playing a stringed instrument.

Interestingly, the cello is played "upside down" compared with the violin and viola. On the cello, elevation and flexion of the shoulder increase toward the upper register, while shoulder elevation is less for the upper registers on the violin and viola.[15] Overall, playing the cello requires 38° to 81° of shoulder elevation while playing the violin and viola requires 27° to 67°.[15] A larger study population in which the data can be analyzed for variation in mobility patterns between musicians playing each instrument is warranted.

From a clinical perspective, when capsular imbalances in shoulder mobility are noted, the focus of intervention is to restore the balance of capsular mobility. The clinical experience of the senior author indicates that restoring capsular balance beginning with the plane of motion that is least impaired and progressing to the plane of motion that is most impaired will allow for more aggressive intervention without exacerbation. Of additional note, the restoration of internal rotation is challenging due to the excessive lateral scapular migration that occurs with self-applied mobilization patterns. For self–mobilization patterns, the promotion of scapular neutrality is critical in restoring internal rotation. Active scapular retraction with depression is the means by which neutral positioning of the scapula is attained (Figure 1 & 2). Capsular mobilization patterns are followed by the implementation of rotator cuff and scapular stabilization exercises. Only exercises that allow for proper mechanical motion patterns are prescribed. Under the clinical guidance of the senior author, most patients are instructed in 3 mobility patterns and 3 to 4 strengthening exercises which they will use in an ongoing exercise program. The mobility patterns are implemented only if they can be performed without significant pain exacerbation, for example a maximum of 3 to 4 discomfort on a 10-point pain scale. Typical advanced self mobilization patterns used in clinical practice are as follows.

Figure 1. Lift off. For the lift off, the patient slides palms up the wall to a point of mild tightness in the shoulders. One thumb is turned to point posteriorly and the arm and hand is lifted 2 to 3 inches off the wall. Alternating lifts are completed.

Figure 2. Grasp. In the grasp pattern, the patient is instructed to stand with erect posture bringing the hands behind the back to grasp the opposing forearm. Then, with a deep inhalation the scapulae are drawn down and back to reproduce mild tightness, but not pain, in the anterior shoulder.

The lift off (Figure 1) is an overhead mobility pattern targeted to mobilize the inferior capsule, thus allowing for the accessory inferior glide of the humeral head on the glenoid. Patients are instructed to stand with one in front of the other, with one toe flush to the wall while sliding both palms up the wall to a point of mild tightness in the shoulders. Subsequently, one thumb is turned to point posteriorly and the arm and hand is lifted 3 inches off the wall. The stretch is held for 2 to 3 seconds alternating between right and left. Four to 5 repetitions are completed bilaterally before lowering the arms along the wall to shoulder height. Two to 3 sets are repeated.

Both the grasp (Figure 2) and large arm circle (Figure 3) patterns work to restore multiplanar shoulder mobility while incorporating thoracic cage excursion. In the grasp pattern, the patient is instructed to stand with erect posture bringing the hands

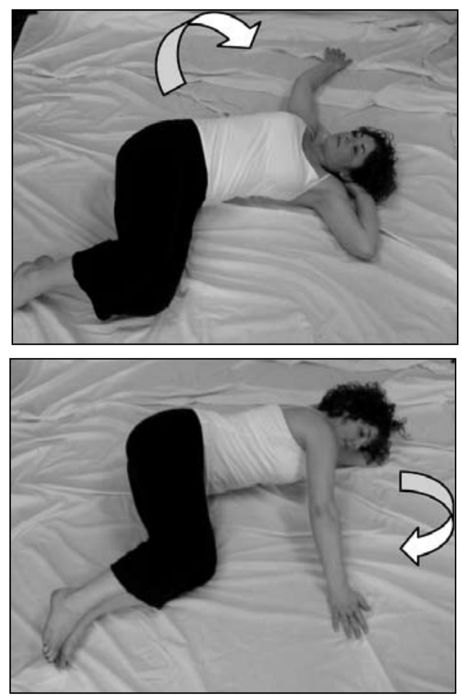

Figure 3. The large arm circle is completed in side lying on the unaffected extremity with the knees and hips bent to 90°. Keeping knees aligned, one on top of the other, the trunk is rotated back to allow both scapulae to articulate with the supporting surface. Concurrently, the affected hand is positioned palm up and maintains contact with the floor as it slides up overhead into abduction. The palm then flips down and the patient extends the shoulder, bringing the arm to the hip to complete the circle.

behind the back to grasp the opposing forearm. Then, with a deep inhalation the scapulae are drawn down and back to reproduce mild tightness, but not pain, in the anterior shoulder. Ten repetitions are completed 2 to 3 times daily. For most, the goal is to grasp the opposite elbow.

Finally, the large arm circle pattern (Figure 3) is completed in side lying on the unaffected extremity with the knees and hips bent to 90°. Keeping knees aligned, one on top of the other, the trunk is rotated back to allow both scapulae to articulate with the supporting surface. Concurrently, the affected hand is positioned palm up and maintains contact with the floor as it slides up overhead into abduction. The palm then flips down and the patient extends the shoulder, bringing the arm to the hip to complete the circle. Ten revolutions in both clockwise and counterclockwise directions are recommended.

CONCLUSION

In this study of shoulder mobility in string musicians, a statistically significant limitation for Ext/IR of the bowing arm was documented. Additionally, excursion of the radial nerve in the bowing arm with upper limb tension testing is increased in musicians with prior or current right upper extremity dysfunction. Compared to normative values, greater than 90% of musicians were found to have excessive shoulder external rotation. However, nearly two thirds of the participants present with deficits in single plane IR excursion. It is possible that a selective independent home-based stretching program may serve to restore the selective decline in capsular mobility. With 35% of string musicians in this study reporting pain in the bowing arm, further research to provide clinical evidence for a restorative program for shoulder mobility is warranted.

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