The Effect of Tape on Glenohumeral Rotation Range of Motion in Elite Junior Tennis Players

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ABSTRACT

Objective: Internal rotation deficits have been noted in the dominant arm of tennis players, and may predispose the athlete to shoulder dysfunction and pain. The purpose of this study was to examine the effect of tape on glenohumeral internal, external and total rotation range of motion. Design: Randomized, controlled, double-blind trial. Setting: Private physical therapy practice. Participants: Eleven asymptomatic male subjects (16.8±1.3 years) and ten asymptomatic female subjects (14.9±0.8 years) from an elite junior tennis squad participated. Interventions: Measurement of passive glenohumeral rotational range of motion was performed for the un-taped, sham-taped and taped conditions in random order. A standardized protocol was used with the participants positioned in supine and the humerus abducted to 90 degrees. All measurements were conducted using a goniometer, by one examiner who was blinded to the taping condition and arm dominance of the athlete. Main Outcome Measures: Internal, external, and total rotation range of motion was examined for each of the three taping conditions. Results: There was significantly less internal rotation range of motion in the dominant arm of both the male and female groups when compared to the non-dominant side. Additionally, there was a statistically significant difference between the taped and un-taped conditions for internal, external, and total rotation range of motion for both the male and female groups. A similar difference was found between the taped and sham-taped conditions for each of the rotational measurements. Conclusions: The specific application of tape to the glenohumeral joint can immediately increase rotational range of motion in the dominant arm of elite tennis players. Further study is required to determine the mechanism responsible for this increase.

INTRODUCTION

A number of studies have documented significant glenohumeral internal rotation deficits (GIRD) in the dominant arm of overhead athletes, including tennis players.\textsuperscript{1-5} In contrast to baseball pitchers, tennis players have also demonstrated a reduction in total rotation range of motion (ROM) in the dominant shoulder.\textsuperscript{5} While the exact cause of this ROM deficit is unknown, it has been proposed that this limitation of movement may lead to shoulder dysfunction and pain.\textsuperscript{2,6,7}

Many hypotheses exist to explain the reduction in dominant arm internal rotation. Tightness of the postero-inferior capsule and inflexibility of the posterior rotator cuff musculature have both been suggested as causative factors.\textsuperscript{6,8} Additionally, altered humeral retroversion has been identified in the dominant arm of baseball pitchers and was found to correspond closely to the measured GIRD across multiple studies.\textsuperscript{9-11}

Recent \textit{in vivo} studies using open magnetic resonance imaging (MRI) have demonstrated poor centring of the humeral head on the glenoid in patients with shoulder instability.\textsuperscript{12,13} It is possible that this alteration in arthrokinematics would translate to changes in osteokinematics, and may be another consideration in understanding GIRD. That is, the inability to control the humeral head on the glenoid may lead to deficits in available ROM. From a clinical standpoint it is vitally important that the reasons for the restriction in internal rotation are identified, as inappropriately directed treatment could be harmful.

It has recently been reported that taping can influence joint kinematics in the knee.\textsuperscript{14} Given the relatively limited osseous stability of the glenohumeral joint, it is possible that tape may have a similar impact on shoulder kinematics. There has, however, been little work published on shoulder taping, despite its frequent clinical use. Most of the research to date has concentrated on the effect of tape on scapular mechanics and the only glenohumeral taping studies identified involved neurologically
impaired individuals. No studies were identified that examined the effect of glenohumeral taping in overhead athletes at the time of writing this paper.

The objective of this study was to investigate the effect of a specific glenohumeral taping technique on rotational ROM in the dominant arm of asymptomatic, elite tennis players.

METHODS

Subjects
Eleven male and 10 female tennis players were recruited from an elite junior training squad. Consent was obtained from both the subjects and their parents/guardians and a short performance and injury questionnaire was completed. Subjects were excluded if they had a history of shoulder surgery, a previous shoulder injury that was not fully rehabilitated, or if they had experienced shoulder pain in the preceding 6 months that held them out of training or competition.

Procedure
Passive glenohumeral joint rotation was measured using a universal goniometer with a spirit-level attached to ensure the static arm remained vertical (Figure 1). Subjects were positioned in supine with the arm abducted to 90° and the shoulder joint in neutral rotation. A towel was placed under the humerus to keep the glenohumeral joint in a neutral position, and this was confirmed by visual inspection. The axis of the goniometer was aligned with the distal tip of the olecranon, while the moving arm was aligned with the lateral aspect of the ulna.

Three measurements of external rotation, followed by internal rotation, were then made, with the average of these measurements being used for analysis. The glenohumeral joint was passively rotated until scapulothoracic movement began to occur, as determined by visual inspection.

![Figure 1. Measurement technique for assessing glenohumeral joint range of motion.](image)

Other studies examining shoulder ROM in this population have utilized similar methods with the addition of manual scapular stabilization by the examiner. However, due to the potential impact of the stabilizing hand on shoulder joint proprioception, we elected instead to use visual inspection of scapular movement to determine the test end-point. For the internal rotation movement, the test was stopped at the point the posterolateral acromion began to lift off the table. For the external rotation measurement, the end-point was determined by visualizing a lifting of the inferior angle of the scapula off the table, or a lumbar extension movement. Reliability of this technique has been previously established.

Randomization was used to determine which arm would be measured first, with the assessor being blinded to the athlete’s arm dominance. The order of the three conditions, control (no tape), sham-tape and therapeutic tape was also randomized to control for the possibility of a “warming-up” effect.
To maintain examiner blinding, the sham tape and therapeutic tape were placed in identical positions, with no tension applied to the sham tape.

The taping technique involved the application of hypoallergenic tape from the anterior aspect of the humeral head. The tape was passed over and just lateral to the acromion process to finish at the inferior angle of the scapula (Figure 2). Two pieces of non-stretch sports tape were then applied using the same landmarks, while one hand provided a maximal posterior force to the humeral head.

All measurements were made by one experienced examiner (BM) so as to reduce the problem of interrater error. The intrarater reliability of this technique of ROM measurement has been reported as between 0.63 and 0.71, which is considered to be fair to good as a clinical measure. A second investigator (JM) completed the randomization, data recording and taping. Both the examiner and the participants were aware of the goniometer readings, which were verbally reported.

**Data Analysis**

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS, Chicago, Ill). Dependent t-tests were used to analyze the difference between the dominant and non-dominant arms for internal, external, and total rotation ROM for the boys’ and girls’ groups separately. External rotation, internal rotation, and total rotation ROM data for each of the three experimental groups were then submitted to a one-way ANOVA, and where main effect differences were found, post-hoc testing was carried out using Tukey’s HSD test. The alpha level for statistical significance was set at 0.05.

**RESULTS**

The 11 male athletes ranged in age from 13 to 18 years (mean ± SD, 16.8±1.3), and the 10 female athletes ranged in age from 13 to 16 years (mean ± SD, 14.9 ± 0.8).

**Dominant Versus Non-dominant Arm**

Results for the control condition are presented in Table 1, and demonstrated significantly less internal rotation in the dominant arms of both the boys’ (p=0.001) and girls’ groups (p=0.001). There was a significant increase in external rotation in the dominant arm of the girls’ group (p=0.007), but no difference was found for the boys (p=0.22). When considering total rotation, there was significantly less ROM in the dominant arms of the boys, but only a trend was noted in the girls’ group (p=0.068).
Table 1. Group summary data for dominant and non-dominant arm comparison of external, internal, and total rotation range of motion.

<table>
<thead>
<tr>
<th></th>
<th>BOYS</th>
<th>GIRLS</th>
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<tbody>
<tr>
<td></td>
<td>ER</td>
<td>IR*</td>
</tr>
<tr>
<td>Dominant Arm</td>
<td>93.7 (10.0)</td>
<td>41.9 (7.7)</td>
</tr>
<tr>
<td>Non-dominant Arm</td>
<td>90.7 (10.2)</td>
<td>55.0 (7.4)</td>
</tr>
</tbody>
</table>

NOTE: Data are presented as Mean (SD)
ER, External Rotation; IR, Internal Rotation; TR, Total Rotation
* denotes significant difference between the dominant and non-dominant arms, p<0.05

Experimental Conditions
When compared to both the control and sham taped conditions, therapeutic tape resulted in a significant increase in external rotation, internal rotation and total rotation ROM for both the male and female groups. There was no difference between the sham tape and control conditions for any of the ROM measurements examined (Figure 3).

Figure 3. Internal, external, and total rotation range of motion means for each of the experimental conditions.

NOTE: * denotes significant difference between experimental conditions, p<0.05
DISCUSSION

The data presented in this study support the existence of a significant difference in rotational ROM between the dominant and non-dominant arms of elite junior tennis players. When considered more closely, and in agreement with the study by Ellenbecker et al., there was less internal rotation and total rotation ROM in the dominant arm of subjects in the male group. In contrast, the female group demonstrated less internal and more external rotation in the dominant arm, with no overall difference in total rotation ROM.

Whilst these movement deficits appear reasonably clear and consistent across multiple studies, it remains unclear what factor or factors are responsible. Many hypotheses have been put forward to explain the presence of the GIRD and treatments have therefore been widely varied, ranging from surgical release of the posterior capsule to conservative stretching and neuromuscular stabilization protocols. It is imperative that the reasons for this movement deficit are established, as it is possible that some of these treatments may do more harm than good.

Biomechanical models and clinical observations have lead to the theory of adaptive change in the capsule of overhead throwing athletes, including tennis players. According to this theory, tightness of the posterior capsule and increased anterior capsular laxity will lead to excessive anterior translation of the humeral head during shoulder movements. It is suggested that these changes in arthrokinematics may lead to alterations in osteokinematics, including the GIRD. Providing some support for this theory, a recent open magnetic resonance imaging (MRI) study of shoulders with anterior instability demonstrated a significant anteroinferior shift of the humeral head in the abducted and externally rotated position compared to the asymptomatic shoulder. Only a trend was noted, however, for changes in the humeral head position during internal rotation movements.

Other authors have suggested that adaptive tightness of the posterior capsular structures in overhead athletes may be responsible for a posterosuperior shift of the humeral head during overhead activities. This superior translation is proposed to lead to internal impingement and anatomical changes such as rotator cuff tears and superior labral tears. The biomechanical evidence for this theory is limited, and primarily draws on imaging studies and intraoperative descriptive data.

Increased humeral retroversion has also been demonstrated to closely correlate with changes in rotational ROM in baseball players. Humeral retroversion is defined as the angle between the axis of the proximal articular surface and the axis of the distal articular surface or interepicondylar line. These studies suggest that tightness of the posterior capsular structures and soft-tissues may not be as significant as changes in the proximal humeral bony anatomy.

Finally, it has been hypothesized that the humeral head may be positioned too far anteriorly on the glenoid in overhead athletes. Trends demonstrated in recent arthrokinematic studies using open MRI provide some support for this hypothesis, however the reasons for this altered resting position remain unclear.

It is apparent from these biomechanical studies that arthrokinematics can—and do—vary widely in the glenohumeral joint, and it is likely that any movement patterns noted, such as the GIRD, will have a multifactorial etiology.

In our study, the specific application of tape to the shoulder joint of elite junior tennis players resulted in a significant increase in internal rotation ROM, however the reason for this change is unclear. While it is possible that providing a posterior force to the humeral head resulted in the stretching of tight posterior capsular structures, it is difficult to imagine that surface tape could overcome the large forces applied to the joint by capsuloligamentous structures and the rotator cuff musculature. Even the ability of tape to maintain a medial glide on the patella, a far more mobile structure, has been questioned and mechanisms other than patellar alignment are suspected for the change in patellofemoral symptoms with tape. Given the significance of the change in internal rotation ROM with this specific taping technique, it is hypothesized that a tight posterior capsule was not the reason for the exhibited GIRD in this group of tennis players.
Equally, it appears unlikely that a simple proprioceptive change from skin receptors is responsible for this altered ROM, as sham taping did not significantly affect the internal rotation ROM. Given the fact that humeral head translation and shoulder ROM are dictated by a complex interplay between passive and active stabilizers,\textsuperscript{35} it is proposed that facilitation of capsuloligamentous mechanoreceptors may have improved the active stabilization of the humeral head and therefore allowed more normal ROM to occur. This hypothesis is partly supported by the findings of Hodge et al.\textsuperscript{13} who demonstrated with dynamic MRI that during active movement in asymptomatic shoulders the humeral head remains exactly centred on the glenoid.

During functional movements, it is likely that the scapular position may have an impact on available glenohumeral joint rotation. For example, adaptive increases in anterior tilting of the scapular have been demonstrated during internal rotation in patients with GIRD.\textsuperscript{36} In this study, we attempted to minimize the impact of scapular movement and position by conducting all measurements in supine and carefully ensuring that there was no scapular motion during measurement. Additionally, the tape was stopped at the inferior angle of the scapula to minimize the involvement of the scapulothoracic articulation.

It is probable that glenohumeral arthrokinematics will vary significantly between individuals.\textsuperscript{30,35} Some overhead athletes will enter their sport with an already unstable shoulder, while others may develop the hypothesised tight posterior/loose anterior capsular arrangement. Much work needs to be done to identify ways of assessing humeral head mechanics and correlating this information with pathologies such as posterosuperior impingement, labral tears, and rotator cuff tendinopathies. With this information, it is possible that incorrect and potentially harmful treatments may be avoided, and athletes or patients with GIRD may receive targeted and effective management.

**CONCLUSION**

Internal rotation deficits may result from a number of factors and identifying the specific problem is important so appropriate treatment may be implemented. Simply identifying a reduction in internal rotation ROM may not be enough to assume a tight posterior capsule that requires stretching or surgical release. Clinically, tape may be applied to the shoulder of overhead athletes to increase internal rotation ROM, however further research is required to determine the mechanism for this change.

**REFERENCES**


