

# Differences in Scapular Upward Rotation Between Baseball Pitchers and Position Players

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**Background:** Baseball pitchers have been reported to have an increased prevalence of shoulder injury compared with position players such as infielders and outfielders. Furthermore, insufficient scapular upward rotation has been empirically linked with several of these shoulder disorders. However, the difference in scapular upward rotation between pitchers and position players is not known.

**Hypothesis:** Pitchers will have decreased scapular upward rotation of their dominant shoulders compared with position players.

**Study Design:** Descriptive laboratory study.

**Methods:** Dominant shoulder scapular upward rotation was measured with the arm at rest and at 60°, 90°, and 120° of humeral elevation among 15 professional baseball pitchers and 15 position players with no recent history of upper extremity injury.

**Results:** Independent *t* tests showed pitchers have significantly less scapular upward rotation at 60° (3.9°, *P* = .011) and 90° (4.4°, *P* = .009) of humeral elevation compared with position players.

**Conclusion:** Baseball pitchers have less scapular upward rotation than do position players, specifically at humeral elevation angles of 60° and 90°.

**Clinical Relevance:** This decrease in scapular upward rotation may compromise the integrity of the glenohumeral joint and place pitchers at an increased risk of developing shoulder injuries compared with position players. As such, pitchers may benefit from periscapular stretching and strengthening exercises to assist with increasing scapular upward rotation.

**Keywords:** scapula; kinematics; throwing athletes; digital inclinometer

Despite advances in diagnostic and treatment interventions, shoulder injuries continue to plague throwing athletes.<sup>9</sup> McFarland and Wasik<sup>27</sup> reported that 58% of all injuries reported by Division I collegiate baseball players involved the upper extremity. Furthermore, 75% of the total time lost among these athletes was attributed to upper extremity injuries.<sup>27</sup> Among professional baseball players, shoulder injury has accounted for 29% of the days on the disabled list, with pitchers accounting for approximately 48% of all injuries, whereas outfielders had the next highest prevalence with only 20%.<sup>9</sup> These previous reports demonstrate not only the high prevalence of shoulder injuries

among baseball players but also the increased prevalence specifically among pitchers as compared with any other position.

Proper scapular kinematics is vital to the overall function of the shoulder, especially in sports requiring repetitive overhead motions such as baseball. Optimal positioning of the scapula promotes maximum function of the bony constraints to shoulder movement, as well as the most efficient position for the rotator cuff muscles to produce maximum force generation<sup>19,38</sup> and glenohumeral compression.<sup>18</sup> As such, if the scapula is not functioning in a fluid and coordinated movement pattern with the humerus, the integrity of the glenohumeral joint may be compromised, and risk of injury is increased.<sup>8</sup> More specifically, past investigations and clinical observations have noted decreased scapular upward rotation, as well as several other discrepancies in the sagittal and transverse planes of motion, among individuals with various shoulder problems, such as subacromial impingement<sup>13,18,23</sup> and instability.<sup>33</sup>

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Despite the higher prevalence of shoulder injuries among baseball pitchers compared with position players<sup>9</sup> and the importance of good scapular upward rotation in preventing injury,<sup>7,18,23,33</sup> no data are currently available that quantitatively detail the scapular upward rotation of baseball pitchers compared with position players. Therefore, the purpose of this study was to determine if differences exist in the scapular upward rotation of baseball pitchers compared with position players. The authors of this study hypothesized that pitchers have decreased scapular upward rotation during humeral elevation compared with position players. Identification of such scapular differences may help explain the increased prevalence of shoulder injuries among pitchers.

## MATERIALS AND METHODS

### Subjects

Fifteen professional baseball pitchers ( $22.3 \pm 2.0$  years;  $189.6 \pm 4.4$  cm;  $86.6 \pm 8.0$  kg) and 15 position players ( $23 \pm 1.6$  years;  $186.0 \pm 5.4$  cm;  $94.0 \pm 8.9$  kg), consisting of infielders and outfielders, participated in this study. Each subject had the scapular upward rotation of their dominant arm measured. No participants had any recent history (past 2 years) of shoulder abnormalities or any previous shoulder surgery.

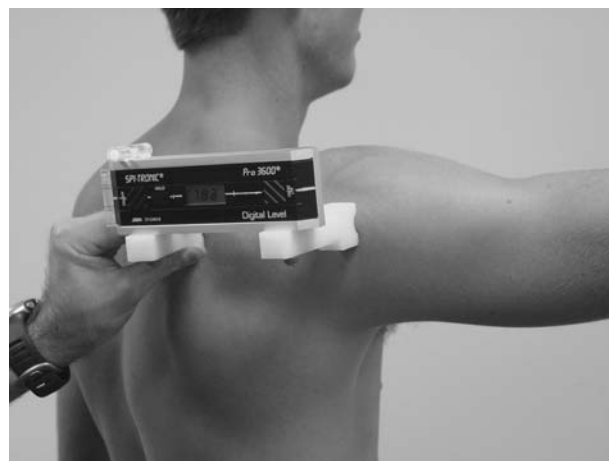
### Instrumentation

Scapular upward rotation was measured using the Pro 3600 Digital Inclinometer (SPI-Tronic, Garden Grove, Calif). This device provides a real-time digital reading of angles with respect to either a horizontal or vertical reference and is accurate up to  $0.1^\circ$  as reported by the manufacturer. Two adjustable plastic locator rods, approximately 10 cm in length (Figure 1), were attached to the inclinometer for scapular upward rotation measurements. These locator rods are Y-shaped and designed to rest comfortably over the bony contours of the scapula.<sup>16</sup> A bubble level was secured to the inclinometer to ensure minimal anterior/posterior tilt of the device about an axis parallel to the scapular spine (Figure 1).<sup>16</sup>

### Procedures

Each subject attended 1 testing session in the athletic training room of a professional baseball organization's training facility and provided informed consent as mandated by the university's institutional review board before participation.

The investigators assessed scapular upward rotation in a resting position and in the scapular plane ( $45^\circ$  angle from sagittal plane as determined by goniometric measurement) at humeral elevation angles of  $60^\circ$ ,  $90^\circ$ , and  $120^\circ$ . Subjects elevated the arm in the scapular plane with the thumb positioned toward the ceiling throughout the testing procedure. Scapular position in the resting position was measured with the subject's arm in a relaxed position at the side of the body. Subjects then elevated their arms



**Figure 1.** Scapular upward rotation is measured with a digital inclinometer and plastic locator rods.

until reaching the specific humeral angles ( $60^\circ$ ,  $90^\circ$ , or  $120^\circ$ ). These angles were determined by aligning the digital inclinometer along the shaft of the humerus, creating an angle between the humerus and a vertical reference. At each angle, the subject was instructed to hold that position, while the digital inclinometer was positioned over the scapula and the amount of scapular upward rotation was measured. The locator rods were positioned over the posterolateral acromion and the root of the scapular spine (Figure 1). The process of aligning the inclinometer over the scapula and determining the amount of upward rotation took approximately 5 to 8 seconds per arm position. After each angle of arm elevation, the subject returned to the resting position, and an ample rest period was provided before initiation of the next arm position to minimize fatigue.

A priori intratester reliability of the scapular upward rotation measurements was assessed by the investigators of this study. Twenty shoulders, without any previous injury or surgery, were measured using an ICC<sub>(2,k)</sub> formula.<sup>45</sup> Each subject's scapular motion was measured and then reassessed a minimum of 24 hours later. The ICC and standard error of measurement values for scapular upward rotation were 0.95 ( $0.5^\circ$ ), 0.93 ( $0.8^\circ$ ), 0.95 ( $1^\circ$ ), and 0.92 ( $1.1^\circ$ ) at rest,  $60^\circ$ ,  $90^\circ$ , and  $120^\circ$  of humeral elevation, respectively. Johnson et al<sup>16</sup> reported good to excellent validity of this measurement by comparing the method to both static ( $r = 0.74$ - $0.92$ ) and dynamic ( $r = 0.59$ - $0.73$ ) humeral positions using an electromagnetic spatial tracking device.

### Data Analysis

Independent *t* tests (SPSS version 11.5, SPSS Inc, Chicago, Ill) were used to determine statistically significant differences in scapular upward rotation at each angle of humeral elevation. Because multiple tests were calculated by the investigators,  $\alpha_1$  was adjusted using a standard version Bonferroni correction ( $P = .05/4$ , or  $P = .013$ ) to protect against type I error.

TABLE 1  
Descriptive Statistics for Scapular Upward Rotation<sup>a</sup>

Angle of Humeral Elevation, deg	Pitchers	Position Players	<i>P</i>
Rest	4.0 ± 3.2	6.0 ± 3.5	.058
60 <sup>b</sup>	6.4 ± 4.9	10.3 ± 3.9	.011
90 <sup>b</sup>	11.5 ± 4.9	15.9 ± 4.6	.008
120	16.9 ± 2.1	20.1 ± 4.4	.037

<sup>a</sup>Values are mean ± SD in degrees.

<sup>b</sup>Indicates statistically significant difference ( $P < .013$ ) between groups.

## RESULTS

The descriptive statistics for scapular upward rotation among the pitcher and position player groups are shown in Table 1. These data yielded statistically significant differences at 60° ( $P = .011$ ) and 90° ( $P = .008$ ) of humeral elevation between the 2 groups (Figure 2). No other statistically significant differences were noted.

## DISCUSSION

Discrepancies in scapular upward rotation may result in lost center of rotation,<sup>18</sup> diminished function of the kinetic chain between the upper and lower extremity,<sup>18,34</sup> and decreased muscular function,<sup>7,18</sup> thereby increasing the risk of shoulder injury.<sup>7,18,35,44</sup> Therefore, proper scapular kinematics is essential for throwing athletes, such as baseball players, who routinely throw hundreds of balls every day over the course of a 165-game season. The results of this study emphasize the decreased scapular upward rotation among baseball pitchers when compared with position players.

One possible explanation for the differences in scapular upward rotation among the 2 groups could be the amount of glenohumeral joint laxity. Pitchers have been shown to have significantly more passive external shoulder rotation at 90° of abduction compared with position players.<sup>5</sup> The primary static restraint against this motion is the inferior glenohumeral ligament,<sup>6,32,42</sup> which may be subjected to microtrauma during the late cocking phase of the throwing motion.<sup>14,20,36,37</sup> As the humerus elevates, tension is placed on the inferior glenohumeral ligament, which is hypothesized to aid in passively upwardly rotating the scapula.<sup>11,22</sup> However, if this ligament is lax, tension is decreased, and there is a reduction in assistance of scapular upward rotation. As such, increased laxity of the inferior glenohumeral ligament in pitchers may offer an explanation for the decreased scapular upward rotation when compared with position players.

Another possible explanation for the differences in scapular upward rotation between pitchers and position players may be attributed to muscle fatigue. Previous investigations have noted the relationship between increased shoulder fatigue and alterations in scapular upward rotation.<sup>28,39-41</sup> Although fatigue was not measured in the current study, it is hypothesized that pitchers may experience higher levels

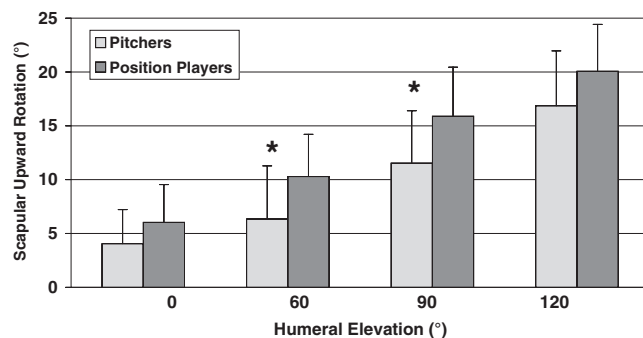


Figure 2. Scapular upward rotation among the pitcher and position player groups. \*Significantly less scapular upward rotation was seen among pitchers compared with position players.

of muscular fatigue than do position players because of the numerous throws and subsequent strain placed on the shoulder during a standard game. As such, decreased activation and strength of the lower, middle, and upper trapezius as well as the serratus anterior have been shown to significantly limit the amount of upward scapular rotation available.<sup>1,11</sup> Therefore, increased muscular fatigue and the ensuing weakness experienced by pitchers may be a common factor resulting in decreased scapular upward rotation compared with that of position players.

Last, increased contracture of the periscapular muscles may significantly affect the amount of motion available in 1 or more of the planes of scapular motion. As such, tightness of the downward rotators of the scapula, such as the rhomboids, levator scapula, and pectoralis minor, may limit how much upward rotation is available. Borstad<sup>3</sup> suggested stretching the pectoralis minor to increase scapular upward rotation and has also reported on the efficiency of several techniques for stretching this muscle.<sup>4</sup> Furthermore, Burkhart et al<sup>7</sup> clinically noted increased pectoralis minor tightness among throwing athletes with scapula dyskinesia. Therefore, tightness of these and other periscapular muscles should not be neglected during the evaluation and treatment of such athletes.

Patients suffering from subacromial impingement have been empirically linked to decreased scapular upward rotation.<sup>7,18,23</sup> During shoulder elevation, an insufficient amount of scapular upward rotation fails to elevate the lateral acromion away from the humeral head, thereby compressing the soft tissue structures. Ludewig and Cook<sup>23</sup> reported subacromial impingement subjects to have diminished scapular upward rotation during a humeral elevation task compared with a control group. Endo et al<sup>13</sup> used radiographs to show subacromial impingement patients to have decreased scapular upward rotation on the involved side compared with the noninvolved side. Furthermore, Cools et al<sup>10</sup> reported a delay in lower trapezius muscle activity among subacromial impingement patients compared with controls during unexpected arm movements.

Kibler<sup>18</sup> hypothesized that decreased scapular upward rotation among throwing athletes may result in detrimental

concavity/compression alterations between the humerus and the glenoid. This alteration in scapular coordination was speculated to result in increased anterior humeral head translation and increased stress on the anterior stabilizing structures, thereby increasing the risk of injury. This hypothesis is supported by the findings of Ozaki,<sup>33</sup> who empirically confirmed patients with diagnosed glenohumeral instability have a decrease in scapular upward rotation when compared with a control group.

Although the results of this study showed statistically significant differences in scapular upward rotation between the groups at 60° and 90° of humeral elevation, the actual differences appear to be relatively minor (3.9° and 4.4°, respectively). However, when these results are compared with those of previous investigations, the magnitude of such differences may be clinically significant as well. Ludewig and Cook<sup>23</sup> reported a 4.1° decrease in scapular upward rotation among subacromial impingement patients compared with control subjects, and Su et al<sup>39</sup> reported a 2.5° to 4° decrease in scapular upward rotation among swimmers with diagnosed subacromial impingement after a regular practice session.<sup>2</sup> Because of the relatively small space between the acromion and the humeral head, even a minor decrease in the subacromial space may result in significant changes in soft tissue compression.<sup>31</sup>

These previous investigations and hypotheses<sup>8,12,13,18,23,25,29</sup> emphasize the importance of early identification of lost scapular upward rotation to limit soft tissue damage. The results of the current study may partially explain the increased prevalence of shoulder injury among pitchers compared with position players. These findings may be of particular importance to the clinician because of the association between decreased scapular upward rotation and pathologic entities such as subacromial impingement<sup>13,23</sup> and glenohumeral instability.<sup>33</sup>

The authors of this study recognize several methodological limitations that must be addressed. Scapular kinematics has been well documented as occurring in 3 dimensions (upward/downward rotation, internal/external rotation, anterior/posterior tilt, elevation/depression, protraction/retraction) in conjunction with humeral movement.<sup>17,21,26,43</sup> Although the methods used for the present investigation simply measured scapular upward rotation, previous literature emphasizes the importance of scapular upward rotation to the overall function of the shoulder.<sup>7,18,23</sup> As such, decreased scapular upward rotation may result in compensatory motions, such as increased scapular elevation, posterior tilt, external rotation, and/or retraction as an adaptation to avoid soft tissue encroachment between the humeral head and acromion.<sup>13,23,25,44</sup> However, it remains unclear how an alteration in 1 plane may directly affect the remaining planes of motion. Regardless, evaluations and prevention and rehabilitative interventions should be designed to target all 3 planes of motion to return the shoulder to a normal pattern of motion.<sup>30</sup>

We also used a static measurement of scapular upward rotation as compared with a more functional dynamic analysis. However, Johnson et al<sup>16</sup> previously compared this type of static measurement to using a 3-dimensional magnetic tracking device during a dynamic movement and found the static measurement to have excellent validity.

Last, this study included baseball players without a history of upper extremity injury or surgery. Individuals with shoulder problems such as subacromial impingement and glenohumeral instability may have different results and should be addressed in future investigations.

## CONCLUSION

The results of this study indicate that baseball pitchers have significantly less scapular upward rotation than do position players at the higher angles of humeral elevation. As such, these athletes may be at an increased risk for developing injuries that have been associated with decreased scapular upward rotation, such as subacromial impingement and glenohumeral instability. This study may provide clinicians with a better understanding of 1 risk factor for shoulder injury among baseball pitchers.

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