

5-2008

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Recommended Citation

Published in *North American Journal of Sports Physical Therapy*, 2008; 3(2): 83-88 <http://www.ncbi.nlm.nih.gov/pmc/journals/1328/>

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ORIGINAL RESEARCH

GLENOHUMERAL JOINT RANGE OF MOTION IN ELITE MALE GOLFERS: A PILOT STUDY

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ABSTRACT

Background. Shoulder injuries account for up to 17% of all golf related musculoskeletal injuries. One cause may be the repetitive stresses applied to the lead shoulder during the backswing and follow-through phases, which may contribute to the frequency of these injuries. The “elite” golfer may be predisposed to developing a shoulder injury based upon the reported adaptations to the glenohumeral joint.

Objective. To examine and compare bilateral glenohumeral joint rotational range of motion in elite golfers using standard goniometric procedures.

Methods. Twenty-four “elite” male golfers were recruited for this study. Glenohumeral internal (IR) and external rotation (ER) passive range of motion was measured bilaterally at 90° of abduction using a standard universal goniometer. Paired t-tests were utilized to statistically compare the rotational range of motion patterns between the lead and the trailing shoulder.

Results. No statistical differences existed between each shoulder for mean IR or mean ER measures. This finding was consistent throughout different age groups. External rotation measurements were greater than IR measurements in both extremities.

Discussion and Conclusion. Unlike other sports requiring repetitive shoulder function, the “elite” golfers sampled in this pilot investigation did not demonstrate a unique passive range of motion pattern between the lead and trailing shoulders. Factors, including subjects' age, may have confounded the findings. Further studies are warranted utilizing cohorts of golfers with matching age and skill levels. Additional shoulder range of motion measures should be evaluated.

Key Words: golf, passive shoulder range of motion, glenohumeral joint, shoulder injuries

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INTRODUCTION

People of all ages and skill levels play golf worldwide.¹⁻³ For a golfer to improve to the level of an elite player, a combination of natural athletic ability and dedicated practice is required.⁴ To stay at the top of one's game, an elite golfer will routinely practice daily for hours on end.⁴ Competitive golfers may perform up to 2000 swings each week.⁵ Due to the high volume of swings performed during practice and in competition golfers are at risk of developing overuse injuries.⁵⁻¹⁸

Shoulder injuries have been shown to account for 8% to 17.6% of all golf injuries.^{6,12-15} Injuries to the shoulder rank 3rd behind injuries to the low back and the left wrist in professional male golfers.^{6,13} For male amateur golfers shoulder injuries rank 4th following injuries to the low back, the elbow, and the hand and wrist.^{4,16}

The modern golf swing consists of five phases: the takeaway, the backswing, the downswing, acceleration, and follow-through.⁸ It has been proposed that the repetitive stresses applied during the backswing and follow-through phases contribute to the development of golf related overuse injuries.¹⁷ The lead shoulder (the left shoulder for the right hand dominant golfer) tends to experience more injuries than the trailing shoulder.^{7-9,11} Impingement, rotator cuff disease, acromioclavicular joint pain, acromioclavicular osteoarthritis, and distal clavicular osteolysis have been reported in the golfer's lead shoulder.^{4,8,18} Golfers may also be at risk for developing posterior glenohumeral instability.^{7,9}

Posterior Glenohumeral Instability in Golfers

Posterior shoulder instability occurs less frequently than anterior shoulder instability accounting for only 2% to 12% of all glenohumeral instability cases.¹⁹⁻²¹ Traumatic and repetitive overuse mechanisms for the development of posterior shoulder instability have been reported in the literature.^{19,20,22,23} In contact sports, the mechanism for traumatic posterior shoulder instability is the result of a force directed toward the flexed, adducted, and internally rotated arm.^{20,24} Posterior shoulder instability may also be the result of attenuation of the posterior shoulder structures through repetitive mechanisms.^{19,25}

Two investigations have reported the presence of posterior shoulder instability in "elite" golfers.^{7,9} Hovis et al⁷ retrospectively reviewed eight cases of golfers who were experiencing pain in the lead shoulder. Each "elite" golfer (handicap of 5 or less) reported experiencing pain and "a sense of instability at the top of the backswing (*Figure 1*) when their lead arm was fully adducted across the body."⁷ A diagnosis of posterior glenohumeral instability was established in each golfer's lead shoulder with six of the eight also receiving a secondary diagnosis of subacromial impingement.⁷ Mallon and Colosimo⁹ published a retrospective review of 35 cases of shoulder injury in "elite" golfers. Each golfer was defined as either being a professional or a competitive golfer with a handicap of 3 or less.⁹ The lead shoulder was involved in 34 of the 35 cases with 12% of the patients experiencing posterior glenohumeral subluxation.⁹



Figure 1: Backswing Phase of the Golf Swing

Glenohumeral Joint Range of Motion Patterns in Overhead Athletes

Overhead athletes present with unique rotational range of motion (ROM) patterns.²⁶⁻³² For example, javelin throwers and collegiate water-polo players tend to have significantly greater external rotation (ER) motion in their dominant (throwing) arm than their nondominant arm.^{28,29} Ellenbecker et al²⁶ found elite junior tennis players demonstrate significantly less internal rotation (IR) motion with the dominant extremity. Range of motion patterns of the glenohumeral joint have been extensively researched in baseball pitchers.^{27,30,32-41} Baseball pitchers typically demonstrate increased passive ER range of motion that is significantly greater in the dominant throwing arm and significantly less passive IR range of motion in the throwing shoulder as compared with the contralateral side.^{27,30,32,36,38,39} It has been proposed that the repetitive stresses to the shoulder experienced by the overhead athlete may lead to attenuation of the anterior shoulder capsule and ligaments.^{39,40} While this may be the case in many of the aforementioned sports, recent published reports suggest that osseous adaptations may play a significant role in the ROM presentations in the baseball pitcher.^{32,33,34,37,41}

For some overhead athletes the extremes of glenohumeral joint motion that occur during overhead sports activities increase their risk of injury to the shoulder.^{40,42} Appreciating the unique ROM patterns in competitive athletes may assist sports medicine professionals when developing injury prevention strength training programs and rehabilitation strategies for the injured athlete.⁴³ While golf specific rehabilitation programs have been published in the literature, a paucity of injury prevention programs exist.^{42,44} Unfortunately, published reports of conservative treatment programs for golfer's with a diagnosis of posterior shoulder instability has only helped to return a minority of athletes successfully back to sport.^{7,9} In response to failed conservative treatments physicians have prescribed nonsteroidal medication, injected the shoulder with steroids, and performed surgery to help return golfers back to sport.^{7,9}

Pathomechanics of the Golf Swing

Previous reports have suggested that the biomechanics of the golf swing may contribute to the development of posterior shoulder instability.^{7,9} During the backswing phase, the golfer's lead shoulder elevates and horizontally adducts (*Figure 1*). Mitchell et al⁴⁵ found that the lead shoulder horizontally adducts during the golf swing upwards of $126^{\circ} \pm 7^{\circ}$.⁴⁵ It is plausible that attenuation of the posterior structures of the lead shoulder may occur in response to performing a high volume of golf swings.

Hovis et al⁷ proposed that the development of posterior instability in elite golfers is a result of two factors: serratus anterior muscle fatigue and repetitive internal shoulder rotational forces created by subscapularis muscle activity.⁷ Kao et al⁴⁶ utilizing dynamic electromyography and cinematography found that the serratus anterior muscle on the lead arm side is active during the entire swing.^{8,46} Due to this fact, the serratus anterior muscle on the lead arm side is believed to be at risk of muscular fatigue during practice or competition.^{7,8,46} Muscular fatigue of the serratus anterior (or other scapular muscles) will affect the normal biomechanical relationship between the scapula and the humerus.^{7,46-48} Alterations to scapular position may impair the ability of the external rotators of the shoulder to provide stability at the glenohumeral joint.⁴⁸

Hovis et al⁷ propose that continuing to play golf, in the presence of scapular muscular fatigue, will allow the subscapularis muscle to impart an internal rotation stress to the shoulder contributing to the attenuation of the posterior shoulder.

The purpose of this pilot study was to compare the passive rotational ROM patterns of the glenohumeral joint in the trailing (dominant) and lead (nondominant) shoulders in a group of elite golfers. To the date, the rotational range of motion patterns of the glenohumeral joint have not been studied in the elite golfer.

METHODS

Subjects

Twenty-four right hand dominant male golfers with a handicap of 5 or less (mean = 2.13; SD = 1.43) volunteered to participate in the study. The golfers, ranging in age from 24 to 57 years (mean = 39.67; SD = 9.78), were recruited at the Oregon Golf Association course in Woodburn, Oregon on June 3rd, 2006. A golfer was excluded from participation in the study if he had a handicap greater than 5, if he was experiencing a current episode of shoulder pain, or had a previous history of a traumatic shoulder injury or a surgical procedure to either shoulder. None of the subjects who volunteered were excluded. The Institutional Review Board of Pacific University approved this study prior to data collection; informed consent was obtained from each subject.

Procedure

The lead examiner, blinded to the lead shoulder of each golfer, performed all measurements. Range of motion testing was performed in a manner similar to other studies investigating range of motion patterns in athletic populations.^{27,30} Subjects were asked to lie in a supine position on a portable physical therapy treatment table. The shoulder was positioned in 90° of shoulder abduction with the elbow flexed to 90° and the forearm in a neutral position. Range of motion measurements were recorded using a standard universal goniometer. The axis of the goniometer was placed at the olecranon process with the stationary arm directed vertically and the moving arm aligned with the ulna.

Starting from a position of neutral shoulder rotation, the subject's extremity was passively externally rotated with slight overpressure added at the end range to appreciate the end feel.⁴⁹ The end feel, as defined by Cyriax,⁵⁰ is the sensation experienced by the examiner at the terminal ROM during passive motion testing.^{49,50} Scapula stabilization was maintained through manual contacts on the anterior shoulder and from the weight of the subject's body against the table. Once the limit of ER motion was achieved, the angle was measured. Passive internal rotation was performed in a similar manner with the tester internally rotating the extremity with a stabilizing force manually applied to the coracoid and anterior shoulder in order to prevent scapular movement. Three measurements were recorded for both IR and ER with means calculated for each.

Intrarater reliability was established prior to data collection. Passive shoulder external and internal rotation ROM was measured bilaterally in five elite-

dividing the golfers into two groups by age: group 1 (24-39 years) and group 2 (40+ years).⁴⁵ Paired t-tests were used to analyze the passive range of motion for lead and trailing shoulders and total rotation range of motion. The alpha level was set at 0.05.

RESULTS

Tables 1-3 present the passive range of motion measures for the entire group of elite golfers and by each age category. No significant differences existed between the lead and the trailing shoulders for either IR or ER passive ROM for the entire cohort or within each individual group. In addition, no significant difference for total rotation ROM existed between extremities for the entire group or within each individual group.

In general, ER passive ROM measurements were greater than internal rotation measurements in both extremities (*Table 1*). This relationship (ER > IR) was consistent throughout each age group (*Table 2-3*).

Table 1. *Shoulder Passive Range of Motion Measurements for the 24 Male Elite Golfers. The right arm was the dominant (trailing) arm in all of the golfers. All PROM measurements recorded in degrees. NS = not significant.*

	Mean	SD	p Value	t value	Significance
External Rotation					
Trailing Arm	91.04°	7.85°	<i>p</i> = .466	<i>t</i> = .74	NS
Lead Arm	90.32°	6.54°			
Internal Rotation					
Trailing Arm	50.11°	9.34°	<i>p</i> = .334	<i>t</i> = -0.99	NS
Lead Arm	51.76°	10.40°			
Total Rotation Range of Motion					
Trailing Arm	141.15°	10.87°	<i>p</i> = .61	<i>t</i> = -0.53	NS
Lead Arm	142.08°	13.67°			

level golfers with 48 hours between the two tests. An intraclass correlation coefficient (ICC 3,3) and standard error of measurement (SEM) were used to quantify the test-retest reliability of both measurement procedures. Intrarater reliability was found to be very good; the ICC for measuring ER was .99 with a SEM of .28° and .99 for IR with a SEM of .53°.

Data Analysis

Data was analyzed comparing the golfer's lead and trailing shoulders as well as the total rotation range of motion. Additional analysis was performed by

DISCUSSION

If "elite" level golfers had an increased risk of posterior glenohumeral instability, it was thought that a statistically significant difference in either ER or IR motion between the lead and the trailing shoulder would be found. The results of this study demonstrate that within this sample of "elite" golfers, no significant difference existed between the lead and the trailing shoulder for either glenohumeral ER or IR passive ROM.

Several challenges were faced in attempting to research the "elite" golfer including subject recruit-

Table 2. *Shoulder Passive Range of Motion Measurements for Male Golfers Age Range 24 to 39 Years (n = 13). The right arm was the dominant (trailing) arm in all of the golfers. All PROM measurements recorded in degrees. NS = not significant.*

	Mean	SD	p Value	t ratio	Significance
External Rotation					
Trailing Arm	90.36°	7.84°	p = .575	0.58	NS
Lead Arm	89.69°	5.43°			
Internal Rotation					
Trailing Arm	53.29°	8.73°	p = .362	-0.95	NS
Lead Arm	55.21°	10.97°			
Total Rotational Range of Motion					
Trailing Arm	143.63°	12.00°	p = .60	-0.54	NS
Lead Arm	144.90°	14.53°			

Table 3. *Shoulder Passive Range of Motion Measurements for Male Golfers Age Range 40 Years or Older (n = 11) The right arm was the dominant (trailing) arm in all of the golfers. All PROM measurements recorded in degrees. NS = not significant.*

	Mean	SD	p Value	t ratio	Significance
External Rotation					
Trailing Arm	91.85°	8.17°	p = .653	0.46	NS
Lead Arm	91.06°	7.86°			
Internal Rotation					
Trailing Arm	46.37°	9.00°	p = .654	-0.46	NS
Lead Arm	47.69°	8.42°			
Total Rotational Range of Motion					
Trailing Arm	138.22°	9.01°	p = .853	-0.19	NS
Lead Arm	138.76°	12.40°			

ment and selecting which shoulder motions to measure. The first challenge encountered was recruiting a high number of “elite” golfers with a 5 or lower handicap. Team sports provide researchers a large subject population in a central location to test at one time. Unlike team sports, golf is an individual sport (except at the high school or collegiate level), allowing the golfer to practice and play whenever or wherever one chooses. This obviously increases the challenge of locating the target population.

Several options were discussed for obtaining our target population including recruiting golfers from local colleges, recruiting local golf professionals, and recruiting members from a local course. The greater Portland, Oregon region is devoid of NCAA division I universities, but has numerous smaller division III colleges. While golfers at these schools were readily accessible, their skill level consistently fell short of

the “elite” definition (as defined in literature by Hovis et al⁷ as 5 or below). In addition, many of the division III collegiate golfers were unaware of their handicap level. Measuring the ROM of local golf professionals appeared to be a means to recruit subjects, but this endeavor would have been a too time intensive. Recruitment of golfers during one session at the Oregon Golf Association course was decided. Based upon professional contacts, it was determined that golfers at the Oregon Golf Association course would meet the inclusion criteria. Twenty four golfers participated in this study. Despite the limited time commitment to testing, some golfers declined participation. The subject population, based upon handicap level, is similar to those reported by Mallon et al⁹ and Hovis et al.⁷

The second challenge encountered was in deciding how many passive shoulder motions to measure. The initial goal for this study was to collect passive

ROM measurements bilaterally for shoulder ER, IR, and horizontal adduction. Based upon where and how to conduct the study, it was decided to only measure glenohumeral ER and IR for this pilot investigation. These measurements can be performed quickly with minimal positional changes and minimal equipment requirements. It was believed that conducting the horizontal adduction measures might affect the recruitment potential of volunteers due to the time requirements associated with the positional changes and additional measurements. Adequate testing environment (space, equipment, and staff) to appropriately perform the horizontal adduction measurements would also have been a challenge.⁵¹

Future research is suggested to build upon this investigation by testing bilateral glenohumeral rotation ROM patterns as well as horizontal adduction. Recruiting subjects from the professional ranks, NCAA division I schools, and from the American Junior Golf Association is also suggested. Reported ROM patterns observed in golfers may be the result of age specific changes versus sport related adaptations. Compared to other team and individual sports, golf can be “picked up” with participants achieving success (low handicap) at any age. Range of motion patterns observed in the 30-, 40- or 50-year old “elite” golfer may be due to sport or occupational pursuits from an earlier age. Range of motion patterns should also be investigated in junior and collegiate aged golfers, excluding those who had previous participation in overhead sports. If unique ROM patterns were identified in these populations then subsequent longitudinal testing should be conducted.

CONCLUSION

This study was an initial investigation of the anthropometric characteristics of the shoulders in “elite” golfers. The results demonstrated no statistical difference between extremities for each rotation pattern. Further testing is warranted to measure additional shoulder measures in specific “elite” golfer samples. A comprehensive appreciation of the golfers' shoulder may lead to advances in injury prevention training strategies and rehabilitation programs.

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We apologize for the misspelling of Mr. Brumitt's name in NAJSPT Volume 3, Number 1.