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Research Article

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Sport Specific Adaptation in Scapular Upward Rotation in Elite Golfers

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Abstract

Objective: Appropriate scapula position is necessary to optimise maximum force generation during the golf swing. Abnormalities in upward scapular rotation have been associated with various shoulder pathologies. Assessment of scapular position is considered an important clinical measure for sports therapists and trainers to prevent injury. This study investigated scapular upward rotation in elite golfers.

Method: Forty five male golfers on European Challenge Tour and thirty six non-sportsman control volunteers met the inclusion criteria for the study. With the participant standing, the Palmmeter was used to measure lateral distances of the scapula from the spine and these measurements were used in the sin rule to calculate scapular rotation in the coronal plane.

Result: The dominant scapula of controls was more upwardly rotated in both neutral (p=0.04, paired t-test) and in 60 degrees of shoulder abduction (p=0.04, paired t-test). The dominant scapula of golfers was significantly more upwardly rotated in neutral (p=0.01, paired t-test) and the lead scapula was significantly more upwardly rotated in 60° of shoulder abduction (p=0.01, paired t-test).

Conclusion: Asymmetry of scapular rotation in the coronal plane in golfers as an indicator of risk in the golfers shoulder is not appropriate during screening. When compared with controls, golfers had a unique pattern of scapular upward rotation during arm abduction to 60°.

Keywords

Scapular upward rotation; Golf; Shoulder; Screening; Rehabilitation

Introduction

Appropriate scapula position is necessary to optimise maximum force generation in athletes [1,2]. If scapular function is compromised, the shoulder is at greater risk of injury [3-9]. It was advocated by Sahrmann [10] that deviation from symmetry between the scapulae was pathological; however, in athletes asymmetry may be normal [11,12] and using the contralateral side as a reference may not be appropriate. Furthermore, asymmetry in one plane may not be a risk factor on its own [12]. Uhl et al., 2009 [13] report asymmetric findings in the non-athletic population due to dominance effect, finding that 51% of population has asymmetric scapular motion in one single plane and 14.3% in several planes. Despite agreement that scapular asymmetry may be normal, actual measures of scapular position vary between studies. Matsuki [14], reported dominant-side scapula to be more downwardly rotated by 10°. The opposite is reported by Morais and Pascoal, who report 15° more upward rotation on the dominant side [15]. Ludewig et al. [4] and Wartson et al. [16], reported that upward rotation of the scapula should be between 5.4° and 3.6°. It can be reasoned from this literature that asymmetry of scapulae should be considered as normal; in fact, it may be an adaptive alteration. It has been noted by various authors that scapular position may be influenced by participation in a specific sport [11,17-20], although differing tools and methodology do not allow exact comparison of results from each study. Level of participation in sport [21] and fatigue [22-24] have also been shown to influence scapular position, leading to adaptive changes in elite athletes who undertake repetitive arm movements.

No previous literature quantifying scapular upward rotation in golfers was found in the literature. During the down phase of the golf swing, the shoulder accelerates quickly following the hips to generate energy and drive the ball; the shoulder generates 20% of the club speed [25]. Since scapular position is necessary to optimise maximum force generation [1,2] a study investigating scapular upward rotation in golfers is warranted. Assessment of scapular position is considered an important clinical measure for sports therapists and trainers. This study investigated scapular upward rotation in elite golfers on the European Challenge Tour. It was hypothesised that the dominant shoulder would be more upwardly rotated in both controls and golfers when the arms were in neutral and also when the arms were abducted to 60 degrees.

Method

Power analysis

Based on a pilot study and using GPower it was calculated that to perform an independent t-test a sample size of at least 25 in arm neutral (21in 60° arm abduction) per group was required to be able to detect a difference with 2.4°(13.68°) means score, with an 80% power and a 5% (0.05) significance level. This is assuming a STD of 4.04°(9.68°) for the measure of scapular rotation in neutral (60° abduction). For a paired t-test a sample size of 24 per group was required to be able to detect an absolute difference of 5.14° in the variable scapular rotation between groups with a 80% power at a 5% (0.05) significance level.

Participants

Participants were volunteers who responded to invitations posted at the Challenge Golf Tournaments and at the host university campus. Forty five of 53 male golfers met the inclusion criteria for the study. Thirty six of 46 non-sportsman control volunteers met the inclusion criteria for inclusion in the study. All golfers were currently playing on the European Challenge tour and evaluated during the 48 hours prior to start of tournament. Participants included in the study were of full musculoskeletal development (over the age of 18 years), and had healthy shoulders (as determined by the exclusion criteria).

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Participants were excluded from the study if they had: cervical, shoulder, or elbow pain within six months before testing; previous shoulder girdle or spinal fractures; shoulder surgery; or dislocation of the upper limb; scoliosis; leg length discrepancy; or a rheumatologic condition.

The University of Salford Ethics Panel approved the study protocol. All participants were provided with a detailed information sheet, comprising details of the study and any associated risks. Participants gave written informed consent to testing and anonymised use of the data collected.

Instrumentation

Previous authors [26,27] have established reliability of the PALM to measure the lateral distance of the scapular to the spine. It was proposed by the present authors that these measures would be more useful if used to calculate the rotation angle of the scapula. In a pilot study, inter-rater reliability of using the PALM (Performance Attainment Associate, St.Paul, MN, USA) to measure lateral distance of the scapula from the spine and use of these measures in the sin rule to calculate scapula rotation was established in 20 shoulders ($ICC_{2.1}$=0.74 to 0.88).

Procedure

Participants stood in a relaxed posture that felt comfortable to them. In order to evaluate normal habitual scapular posture no attempt was made to make the participant conform to a single standardised posture. Measurements of scapular rotation in the coronal plane were taken in 2 arm positions, one, shoulder neutral, and two, 60 degrees of active abduction in the coronal plane. For the 60 degrees of arm abduction position, the arm was abducted to 60 degrees of abduction by the examiner as determined by a goniometer (Baseline plastic 360 ISOM Goniometer 12") and the participant was then asked to maintain this position actively. Once 60 degrees of abduction was determined for each participant, in order to assist the participant in maintaining the correct angle of arm abduction, a marker tape was placed on an adjacent wall at the level of the participant's finger tips. The examiner could then ensure that the correct angle was being maintained by the participant while measuring. Between each measurement the participant rested the arm by the side to avoid the effects of fatigue.

The following anatomical landmarks were repeatedly palpated by the examiner: the inferior angle of the scapula (IAS) (Figure 1), the root of the spine of the scapula (RSS) (Figure 2), and the spinous process of the thoracic spine (Sp) (Figures 1 and 2), before taking of each measurement. The participant's skin was not marked by the examiner ensuring that markings could not introduce bias between during repeated palpation and locating of the anatomical landmarks. The PALM callipers were used to measure the distances and horizontal distance was ensured by the analogue inclinometer on the PALM. Three measurement were taken of the following distances: the distance between the inferior angle of the scapula to the closest horizontal spinous process of the thoracic spine (IAS-Sp) Figure 1; the root of spine of the scapula to the closest horizontal spinous process of the thoracic spine (RSS-Sp) Figure 2; and the distance from the inferior angle of the scapula to the root of the spine of the scapula (RSS-IAS), (Figure 3).

Calculation of scapular rotation

The distances IAS-Sp, RSS-Sp, and IAS-RSS were used to calculate the scapula rotation angle. As shown in Figure 4, if a perpendicular line is dropped down from the root of the spine of the scapula (RSS) to intersect the horizontal line between the inferior angle of the scapula and the closest spinous process of the thoracic spine (IAS-Sp), a right angle triangle is created. The hypotenuse is the distance IAS to RSS. The side opposite the angle θ (θ was defined as the angle between the hypotenuse and the vertical) and the vertical is the distance IAS-Sp minus the distance RSS-Sp. To calculate the angle one can apply

$$\sin\theta = \frac{opposite}{hypotenuse}$$

A positive result indicated the degree of upward scapular rotation and a negative result indicated the degree of downward scapular rotation.

Data analysis

Statistical Package for Student Statistics for Windows version 20.0 (SPSSinc, Chicago,IL), was used for statistical analysis.

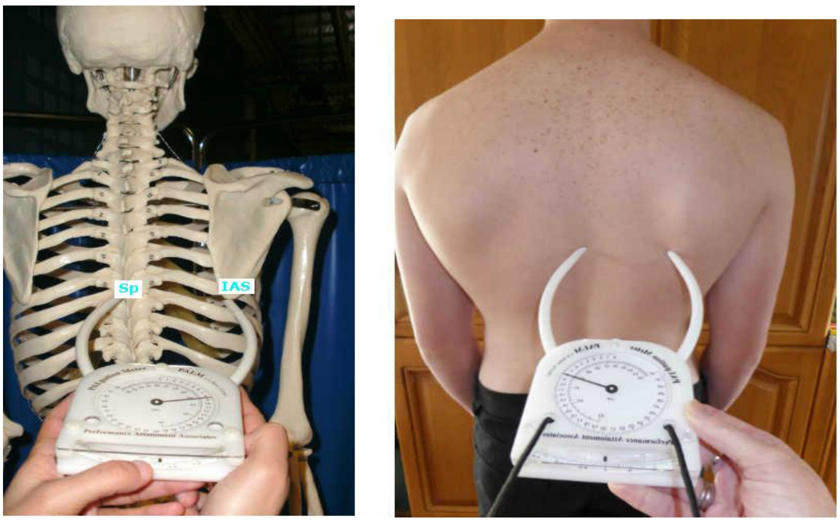


Figure 1: Measurement of the distance between the inferior angle of the scapula (IAS) and the closest horizontal spinous process (Sp) of the thoracic spine (IAS-Sp).

Shoulders included in analysis were sorted according to dominant and non-dominant (lead shoulder in the golfer) sides. The mean of three measures was calculated. Outliers were removed. Normality of distributions was ensured with Shapiro Wilk and Kolmogorov-Smirnow tests. Descriptive analysis was run and paired t-tests used for within group analyse and independent t-tests used for between group analysis (significance level set at 0.05).

Results

Within group analysis

Descriptive statistics and results of t-tests for both groups are reported in Table 1. The dominant scapula of controls was more upwardly rotated in both neutral (dominant side 3.72° STD 4.18° and non-dominant side 2.38° STD 3.41°, p=0.04) and in 60 degrees of shoulder abduction (dominant side 10.17° STD 6.36° and non-dominant side 8.53° STD 3.61°, p=0.04): (Figure 5). The dominant scapula of golfers was significantly more upwardly rotated in neutral (dominant side 5.41° STD 3.22° and lead side 3.17° STD 3.80°, p=0.01) and the lead scapula was significantly more upwardly rotated in 60° of shoulder abduction (dominant side 6.89° STD 3.77° and lead side 8.89° STD 3.36°, p=0.01): (Figure 5).

Between group analysis

There was no significant difference in scapular rotation between golfers and controls in neutral but controls had significantly more upward rotation on the dominant side compared with the dominant side of golfers in 60° of abduction (Δ= 3.24°, p=0.01) (Table 1).

Discussion

It was hypothesised that the dominant shoulder would be more upwardly rotated in both controls and golfers when the arms were in neutral and when the arms were abducted to 60 degrees. In neutral, the hypothesis was upheld, both golfers and controls had significantly greater upwardly rotated dominant scapulae when compared with the contralateral side. The hypothesis was further upheld in controls where the dominant scapula was more upwardly rotated compared with the non-dominant scapula in 60° arm abduction. However, the hypothesis was not supported in golfers in 60° arm abduction when the golfers' lead scapula was significantly more upwardly rotated in

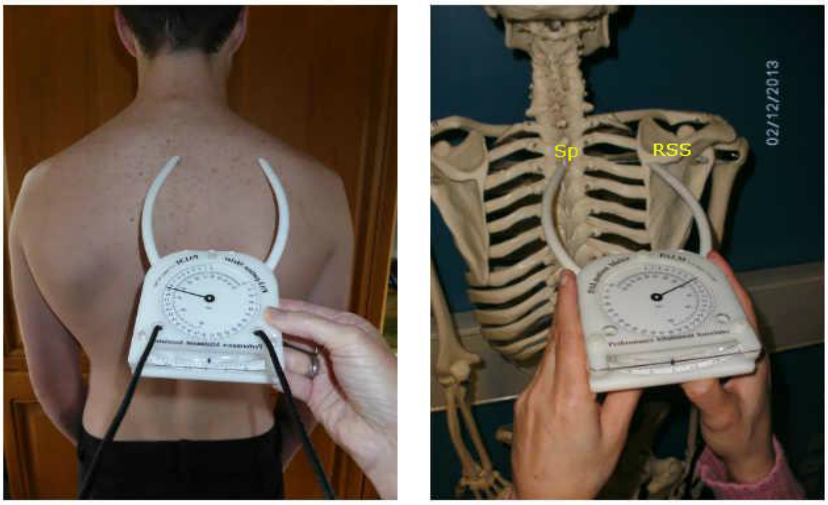


Figure 2: Measurement of the distance between the root of the spine of the scapula (RSS) and the closest horizontal spinous process (Sp) of the thoracic spine (RSS-Sp).

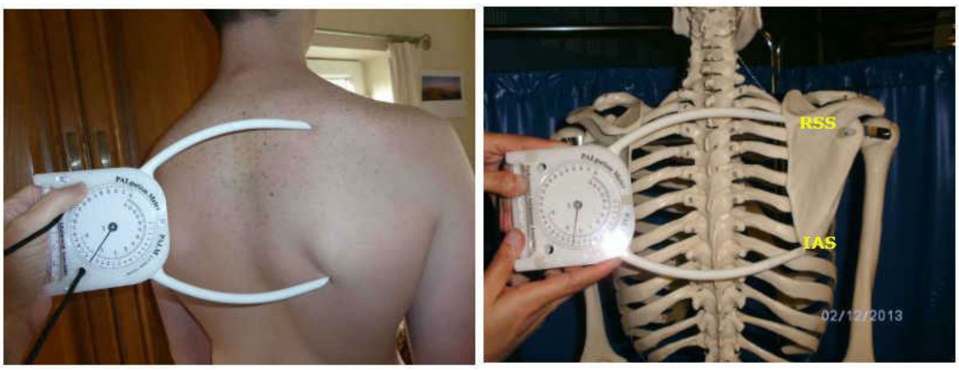


Figure 3: Measurement of the distance from the inferior angle of the scapula (IAS) to the root of the spine of the scapula (RSS-IAS).

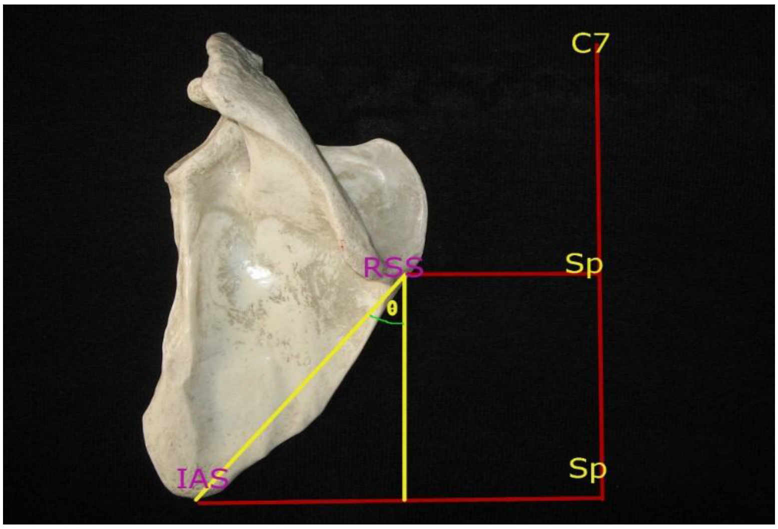
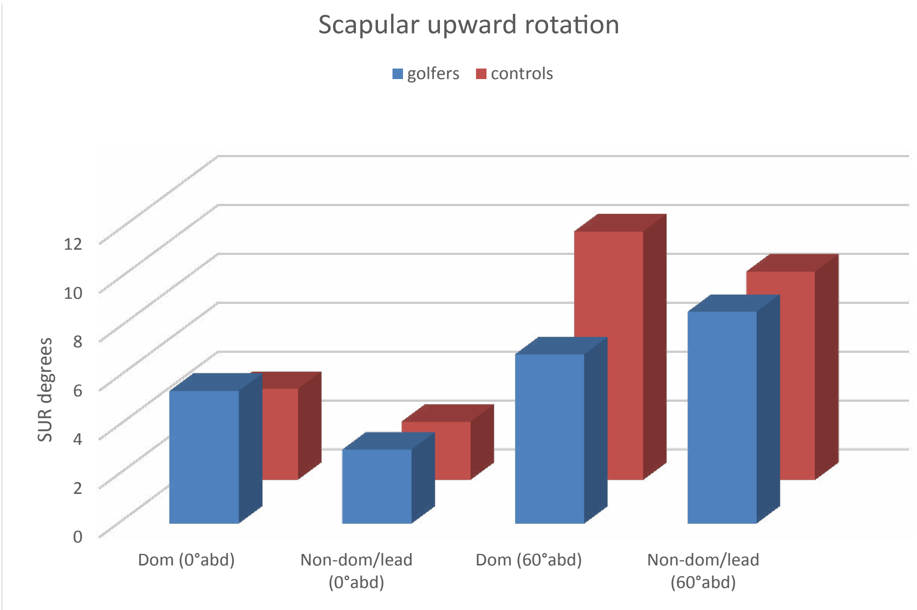


Figure 4: Calculation of the scapular rotation angle. Abbreviations: RSS=Root of Spine of Scapula; IAS Inferior Angle of Scapula; C7=Cervical vertebra 7; Sp=Spine of Scapula.



Abbreviations: SUR=Scapular Upward Rotation, Dom=Dominant, Non-dom=Non-Dominant, °=degrees, abd=Abduction

Figure 5: Scapular rotation in golfers and controls.

Abbreviations: STD=Standard Deviation; abd=Abduction; SUR=Scapular Upward Rotation

Table 1: Descriptive statistics and results of t-tests for scapular upward rotation.

	Golfers Mean (STD) degrees	Paired t-test golfers p value	Controls Mean (STD) degrees	Paired t-test controls p value	Mean difference degrees	Independent t- test p value
Dominant SUR 0° abd	5.43(3.18)	0.01	3.72(4.18)	0.04	-1.71	0.05
Non-dominant/lead SUR 0° abd	3.03(3.72)		2.38(3.41)		0.65	0.40
Dominant SUR 60° abd	6.93(3.78)	0.01	10.17(6.36)	0.04	3.24	0.01
Non-dominant/lead SUR 60° abd	8.67(3.52)		8.53(3.61)		-0.14	0.86

comparison to the dominant scapula. On between-group comparison there was no significant difference in scapula rotation between golfers and controls in neutral but controls did have significantly more upward rotation on the dominant side compared with the dominant side of golfers in 60° of abduction. Asymmetry of scapular upward rotation is noted in both male controls and golfers in neutral and in the early ranges of shoulder abduction. Actual measures of scapular upward rotation are within the ranges previously reported in the literature [28-33]. Asymmetry of scapular position in the coronal plane in golfers is also in keeping with previous authors' findings relating to sportsmen [28-31,33].

Variation in three-dimensional scapular motion has been reported between baseball players with impingement and those without. Likewise, differences have been noted between healthy baseball players and non-sportsmen [31]. This variation between sportsmen and non-sportsmen in scapular kinematics has been interpreted as a response to the demands of repetitive sport on the shoulder [31]. Further research has highlighted that scapular asymmetry exists between shoulders in overhead sportsmen [28,30,31]. The present study adds to this body of knowledge by supporting the finding of scapular asymmetry in golfers. Previously investigated sports include baseball pitchers [31], baseball position players [28], overhead athletes [30]. The results of the present study are unique because symmetry of scapular position has not previously been investigated in golfers. In the previously-investigated sports, the upper limb movements are noticeably asymmetrical and hence asymmetry in scapular position can be supposed. The golf swing, on the other hand, has a through swing that mirrors the back swing. But the golf swing is complex and despite symmetry of swing motion, the demands placed on each shoulder vary greatly [34]. The adaptation in scapular position in golfers playing at the highest levels may illustrate chronic adaptation to the golf swing and may not be detrimental or indicative of pathology.

Abnormalities in scapular kinematics, particularly decreased upward scapular rotation, have been associated with various shoulder pathologies in studies comparing healthy shoulders with those of patients with impingement syndrome and rotator cuff tendinopathy [6,7,35-38]. Underlying some of the fundamental principles in shoulder girdle rehabilitation are the following concepts: that upward rotation of the scapula is clinically important to prevent the humeral head from compressing and shearing against the under-surface of the acromion process during humeral elevation [6,39]; that congruity of the glenoid and head of humerus, and centring of the axis of rotation and stability of the glenohumeral joint, are dependent on scapular position [40]; that control of length/tension relationships between the scapular and glenohumeral muscles is affected by scapular position [39,41]; that abnormal scapular movement is associated with glenohumeral instability and subacromial impingement syndrome [39]. Consequently, conventional wisdom has been that observation and measurement of the static scapular position is essential in the clinical examination when investigating shoulder pathology, the asymptomatic side being used as a baseline reference and asymmetry assumed to be pathological [15]. However, this study confirms in elite golfers what previous authors have demonstrated [5,13-15,30], namely, that asymmetry of scapular position in the coronal plane is not an indication of risk of injury. The authors Morais and Pascoal [15], found that the magnitude of movement between sides was similar, despite scapular asymmetry in static arm positions. From this it could be concluded that the magnitude of scapular upward rotation during motion may be more important to evaluate than resting scapular position. Side to side differences in scapular positon may be due to optimal adaptation for function. Asymmetry that is continuous throughout arm motion may not be an indication of pathology [31]. Asymmetry of scapular position in the coronal plane in golfers as an indicator of risk in the golfers shoulder is not appropriate during screening.

Limitations

Although the results of this study are useful, the current study has limitations that should be borne in mind when interpreting the results and addressed in future studies. Firstly, measurement sequence on the participants was not randomised when using the PALM. Secondly, in this study only one component of the five possible degrees of freedom of scapular motion was examined. Upward rotation occurs not in isolation but in combination with these other scapular motions. Thirdly, upward scapular rotation was evaluated at rest and during an isotonic hold of the arm; this may not represent the true influence of load on scapular position and does not represent scapular kinematics during dynamic movement. Previous authors report differences in scapular rotation under static and dynamic conditions [42] and under loaded and unloaded conditions [43]. Fourthly, blinding the researcher to the participant's group identity during collection of data was not possible. Finally, the small group sizes in this study make it difficult to yield normative data; data on scapular positon in a larger number of golfers is warranted.

Conclusion

Asymmetry of scapular rotation in the coronal plane in golfers as an indicator of risk in the golfers shoulder is not appropriate during screening. Magnitude of scapular upward rotation may be a better indicator of risk to injury.

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