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Difference in Transverse Plane Scapular Position of Professional Baseball Players Relative to Baseball Field Position

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DIFFERENCE IN TRANSVERSE PLANE SCAPULAR POSITION OF PROFESSIONAL BASEBALL PLAYERS RELATIVE TO BASEBALL FIELD POSITION

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TABLE OF CONTENTS

LIST OF TABLES

Table

ABSTRACT

DIFFERENCE IN TRANSVERSE PLANE SCAPULAR POSITION OF PROFESSIONAL BASEBALL PLAYERS RELATIVE TO BASEBALL FIELD POSITION

James M. Syms

The objective of this study was to identify the variation of the scaption angle of professional baseball players among field position played. Subjects consisted of 109 minor league professional baseball players reporting for the 2002 spring training season, who were under contract with the Anaheim Angels professional baseball organization. Subjects reported to a sports medicine/physical therapy clinic for their 2002 spring training pre-participation physical examination. The scaption measurements were taken as a component of the examination.

Goniometric measurements were taken with the players in a relaxed standing position. Players were instructed to remain looking forward, roll their shoulders forward three times and then backward three times, and then hold that position for the measurement. A one-time goniometric measure of the player's scaption angle for their dominant and non-dominant arms was recorded. Specific bony landmarks were used to establish the goniometric vector assignment. The spinous process of the T-4 vertebrae and the sternal notch were used to establish the sagittal vector. The triangle at the base of the spine of the scapula, and the posterio-lateral tip of the acromion were used to establish the transverse vector.

The mean scaption angles for the dominant and non-dominant arms were 39.1° and 36.3°, respectively. Significant differences in the mean scaption angle of the player's dominant arm existed between the shortstop position and the positions of center field, second base, and first base; and in the player's non-dominant arm between the shortstop position and the positions of pitcher, second base, and center field. The 40.3° angle for the first baseman position was the greatest scaption angle, the mean angle for the shortstop position was the lowest at 34.3°.

Statistical differences in the scaption angle of dominant arms of baseball players exists between the shortstop field position and the positions of center field, second base, and first base. For the non-dominant arm, statistical differences exist between the shortstop position and the positions of pitcher, second base, and center field.

Key Words: Scaption, Shoulder, Shoulder-girdle, Scapula

There can be significant variation in physical attributes among athletes. Often the physique variation is dictated by the requirements of their athletic activity. Certain physical attributes may afford the athlete a biomechanical advantage that allows him greater performance in his athletic contest or may diminish his risk of injury.

Within a particular team sport, the observed physique variation can be related to position on the field of play. In American football, the 350 pound offensive lineman resides on the same sideline as the 180 pound wide receiver. In baseball, physique variations by their field position are subtle, yet equally significant. The position that the baseball player plays on the field may be related to specific anatomical attributes that enable him to be successful at that field position. Carda[1] performed a study on Division II collegiate baseball players, and reports a difference in physical profile characteristics by position. For the baseball population, the physique variation of the upper body is especially important, because of the overhead throwing activity predominant in the sport. Because of the extreme stresses placed on the shoulder joint of the professional baseball player, they have unique anatomical characteristics and uniformly demonstrate adaptive changes in their upper quarter.[2-4] Increases in humeral external rotation, as well as concomitant decreases in shoulder internal rotation, have been observed in the throwing arm of pitchers.[3]

The shoulder girdle, through its complex anatomy and delicate balance of mobility and stability, is the functional unit that is responsible for movement of the arm with respect to the torso.[5, 6] Coordinated movements of the shoulder girdle are very important for the athlete who participates in overhead throwing activities.[8, 9] The overhead throwing action in baseball is a complex sequence of body movements, that results in the rapid propulsion of the baseball at speeds exceeding 100 mph.[9] The high-energy repetitive forces required of the arm in professional baseball create glenohumeral angular velocities in excess of 6100° to 7000°/second [10, 11] and produce rotational torques exceeding 14,000 inch-pounds.[12]

The biomechanics of the upper quarter region involved in the sport of baseball adds to the complexity and importance of the interaction between the anatomical components. One component is the position of the scapula, as it lies on the thorax. This commonly identified component is termed the "scaption angle", with the subsequent plane it creates titled the "scapular plane". The scapular plane is the plane created by the position of the scapula in the transverse plane anterior to the frontal or coronal plane of the body.[13, 14] The position of the scapula on the thorax is most often described as being 30° anterior to the frontal plane.[15] The scapular plane position is often advocated as the position of the shoulder during rehabilitation and performance enhancement training exercises for the upper quarter.[14, 16, 17] This position places the glenohumeral joint in an optimal position with respect to osseous congruency between the humeral head and glenoid,[14] and optimizes the length tension relationship of the deltoid and rotator cuff muscles.[16]

Evaluation of scapula position is vital for the sports medicine practioner's management of upper extremity function in the athlete.[18] Unfortunately, in the clinical setting, the specific assessment procedures used during the clinical examination of the shoulder-shoulder girdle complex can vary greatly among practioners and most often do not include specific evaluation of scapular position.[19] Prescriptions for therapeutic exercises and other preventive intervention strategies are currently unable to consider these factors, as the body of knowledge in this area is lacking.

Static positional biomechanical assessment of the scapula in the transverse plane specific to baseball players has not been thoroughly investigated. The purpose of this study was to assess the difference in transverse plane static scapular position in professional baseball players relative to his position on the field of play.

Methods

Subjects

One hundred nine subjects, currently under contract to play professional baseball, participated in the study. The subjects were professional baseball players from the Anaheim Angels baseball organization, reporting to spring training in Tempe, Arizona for the 2002 baseball season.

Instruments

I used a standard eight-inch universal goniometer to measure the player's scaption angle. Goniometric measurements are used to quantify motion available in a joint or series of joints and also to determine spatial relationships between selected body parts. The goniometric measure is essentially a value assigned to the relationship between two identified bony segments of the body. Goniometric measurement techniques for the upper quarter are well outlined in physical therapy education texts.[20-22] Standard goniometric procedures will identify three specific landmarks for correct application of the goniometer; the axis of rotation of the goniometer, and the location of the proximal and distal arms of the goniometer.

Most support for the validity of goniometry is in the form of face, content, and criterion-related validity.[21] Face validity indicates that the instrument generally appears to measure what it proposes to measure–that it is plausible.[23-25] Content validity is determined by judging whether or not an instrument adequately measures and represents the domain of content of the variable of interest.[23-25] Content and face validity are both based on subjective opinion.

Much of the literature on goniometric measurement does not specifically address the issue of validity. Rather it assumes the angle created by alignment of the arms of a universal goniometer, using the correct bony landmark references, truly represents the angle created by the proximal and distal bones composing the joint.[21] Portney and Watkins[24] report that face validity is easily established for some tests such as the measurement of range of motion, because the instrument measures the variable of interest through direct observation. Gajdosik and Bohannon[25] state, "Physical therapists judge the validity of most range of motion measurements based on their anatomical knowledge and their applied skills of visual inspection, palpation of bony landmarks, and accurate alignment of the goniometer. Generally, the accurate application of knowledge and skills, combined with interpreting the results as measurement of range of motion only, provide sufficient evidence to ensure content validity." An Intraclass Correlation Coefficient of .92 established good reliability for the measurement technique utilized in this study.

Procedures

The subjects completed a short questionnaire regarding arm dominance, total years played as a professional baseball player, the combined total of years played in college and as a professional baseball player, and the position in the field of play that they played most often in the past 12 months. The players were assigned their field position from this self-reported position on the field of play. The dominant arm was also self-reported by the athlete, and was identified as the arm they use to throw a baseball.

The subjects completed their pre-participation physical examination by randomly progressing through various stations staffed by either administrative personnel or a medical team consisting of physicians, physical therapists, and athletic trainers of the Anaheim Angels baseball organization, and invited expert clinicians from the at-large medical community. The physical examination consisted of several medical and orthopaedic assessment stations. Each orthopaedic station specifically evaluated the athlete's musculoskeletal health status as it pertains to the ability to safely participate in professional baseball activities. The standard shoulder examination consisted of strength assessment of the shoulder and shoulder girdle musculature; a dynamic neuromuscular coordination assessment of the shoulder-shoulder girdle complex, while performing active elevation in the frontal and sagittal planes; gross range of motion measurements of the glenohumeral articulation in all three planes; joint mobility assessment of the glenohumeral, acromioclavicular, and scapulothoracic joints; and goniometric measurement of the transverse plane scapular static position relative to the body.

A single researcher, who is a Board Certified Specialist in Sports Physical Therapy with 15 years experience as a physical therapist and athletic trainer, performed all of the goniometric measurements. A one-time goniometric measure of the player's scaption angle for his dominant and non-dominant arms was recorded using sagittal and transverse vectors. The measurement of the static scapular position in the transverse plane was taken with the athlete standing in their naturally occurring upright position. Subjects were initially given no verbal, tactile, or visual cueing. Subjects were then instructed to remain looking forward, roll their shoulders forward three times and then backward three times, inhale and exhale deeply, then hold that position for the measurement. This procedure is consistent with previous studies that have shown that these maneuvers produce a natural and reproducible standing posture.[26] While standing in a slightly elevated position relative to the athlete, four discrete bony landmarks were identified through visual and palpatory inspection to establish the sagittal and transverse plane references. The sagittal plane reference was established by creating a vector connecting the bony landmarks of the bisected location of the sternal notch with the spinous process of the fourth thoracic vertebral segment. For the transverse plane reference, the researcher used the triangle at the base of the spine of the scapula, and the posterior-lateral tip projection of the acromion process. The transverse plane reference was then established by creating a vector connecting these two bony landmarks. The bony landmarks used to establish the transverse plane reference have been used in previous studies for the assignment of the scaption angle.[26] The angle formed by the intersection of theses two identified vectors was measure with a standard eight-inch universal goniometer and recorded as the player's scaption angle. The scapular position measurement was performed bilaterally.

Data Analysis

Means and standard deviations were calculated for the dominant and non-dominant arm by individual field position and also stratified as infielder, outfielder, pitcher, and catcher. A one-way analysis of variance (ANOVA) with Duncan Post Hoc Test was used to compare the mean scaption angle among the field positions.

Results

The age of the subjects ranged from 18 to 31 years, with a mean of 23.1 years (SD = 2.3 years). The mean number of years that the subjects have been in professional baseball was 3.3 years (SD = 1.9 years). The mean number of years participating in professional and collegiate baseball combined was 5.1 years (SD = 2.4 years).

The mean scaption angle for the dominant and non-dominant arms was 39.1° and 36.3°, respectively. Significant differences in the mean scaption angle of the player's dominant arm existed between the shortstop position and the positions of center field, second base, and first base; and in the player's non-dominant arm between the mean angle for the shortstop position and the positions of pitcher, second base, and center field. The 40.3° angle for the first baseman position was the greatest scaption angle, the shortstop position was the lowest at 34.3° (See Table 1).

Table 1. Scaption Angle (Degrees) by Position in Field of Play (Mean ± SD)

Position	n	Dominant Arm	Non-Dominant Arm
Pitcher	56	39.6 ± 4.6	37.1 ± 4.1
Catcher	7	38.0 ± 1.6	35.7 ± 2.9
First Base	7	40.3 ± 5.1	35.6 ± 3.8
Second Base	4	40.0 ± 7.3	37.5 ± 3.4
Third Base	9	38.1 ± 4.4	34.4 ± 3.8
Shortstop	6	34.3 ± 2.3	32.2 ± 2.6
Left Field	8	39.4 ± 3.4	35.6 ± 3.4
Center Field	7	39.7 ± 3.3	37.9 ± 4.2
Right Field	5	38.4 ± 4.9	36.2 ± 2.9
Total	109	39.1 ±4.4	36.3 ± 3.9

The sample was then stratified as infielders, outfielders, pitchers, and catchers. For the dominant arm, pitchers as a group demonstrated the greatest mean scaption angle at 39.6°, with the outfielder position players second greatest at 39.3°. The infield position players were third at 38.1°, and the catchers had the lowest mean scaption angle value of 38.0° (See Table 2).

Table 2. Scaption Angle (Degrees) by Stratified Position in Field of Play (Mean ± SD)

Position	n	Dominant Arm	Non-Dominant Arm
Infielders	26	38.1 ± 5.0	34.7 ± 3.7
Outfielders	20	39.3 ± 3.6	36.6 ± 3.5
Pitchers	56	39.6 ± 4.6	37.1 ± 4.1
Catchers	7	38.0 ± 1.6	35.7 ± 2.9
Total	109	39.1 ± 4.4	36.3 ± 3.9

Discussion

I found a difference in the scapular plane position of the baseball player population among certain field positions. I also found that the scaption plane in the baseball player population was different than the accepted default 30° position of the scapula typically utilized in clinical practice. It is theorized that greater specificity of scapular plane assignment is necessary to more accurately describe and understand movement behavior of the upper quarter, to provide more precise exercise prescriptions, and to avoid iatrogenically traumatizing the surrounding soft tissues of the glenohumeral articulation. This variation of the position of the scapula in baseball players from the general population, and the variation between baseball players relative to position in the field of play, now requires the rehabilitation profession to re-inspect the constructs utilized in sports medicine. Muscle length tension relationships, arthrokinematic relationships, and joint soft tissue compressive and tension effects about the glenohumeral joint will need to be re-evaluated. Unfortunately, evaluative procedures are not consistent in different clinical settings. Scaption assessment in the baseball population should become a routine evaluative procedure in the medical assessment of that athlete.

One complication in dealing with this body region is the degrees of freedom available in the region and subsequent intimate interaction and interrelationship of one structure to another. The scapulothoracic joint is not a true anatomical joint, but rather is considered to be a physiological joint that relies on soft tissue to maintain its relationship to the thorax. This allows a great deal of mobility throughout the entire complex. Because of this, quantification of specific static positional and dynamic movement behavior can be difficult to achieve. During movement analysis of an athlete in the athletic training and physical therapy clinical practice settings, the clinician typically assumes that the proximal segment is static and that any movement and subsequent positioning of a body segment is due solely to the dynamics of the distal segment. When both bony partners have a degree of mobility, however, the relative position of the two bony segments is actually a result of the dynamic mobility interaction between the segments. This is especially true for the shoulder-shoulder girdle complex, as it has limited bony attachment to the more stable proximal axial skeleton.

Goniometric measurements used in describing the upper quarter's spatial orientation and functional significance are somewhat controversial. The controversy stems from a less than uniform application of the scapula's spatial measurement procedure to the functional explanation of the consequences of the measurement. Oatis[6] describes this difference in references as a "scapula-fixed" reference and a "body-fixed" reference. Whereas the scapula-fixed reference uses the scapula as the point of reference, the body-fixed reference uses traditional cardinal plane references for assignment of the spatial measurements of the scapula and other upper quarter positions. As previously stated, goniometric measurements assume the angle created by alignment of the arms of the goniometer are from the vectors created by the proximal and distal bones composing the joint.[37-39] In the standard practice for measuring range of motion of the shoulder, however, the proximal bony partner, the scapula, is not used. Standard practice is to align the stationary arm of the goniometer with the sagittal plane to establish the proximal vector, regardless of the position of the scapula on the thorax. Because of the variation in scapular positioning found in this study, identical measurements for shoulder range of motion can actually present with different arthrokinematic relationships between the scapula and the humerus and afford different amounts of tension across the soft tissues components that cross the joint. Unfortunately, most statements in current research utilize the "body-fixed" reference for shoulder range of motion and it now appears that they would likely under predict the true amount of external rotation and exaggerate the true amount of internal rotation.

The strength and endurance of the shoulder and shoulder girdle musculature is cited as an important factor in the rehabilitation of the shoulder following a rotator cuff injury or surgery.[27] Brewster[27] states, "The most important caveat to any rotator cuff rehabilitation program is avoiding excessive anterior translation of the humeral head as dynamic stability is restored" The optimal length tension relation of the rotator cuff musculature is intimately affected by the position of the scapula. In Brewster's rotator cuff program, however, exercises are described as being performed in the scapular plane of 20°-30°. He does not consider the differences of body type. This study has shown that there is a difference in the scapular angle in the sport participants of baseball. If an athlete has a scapular plane of greater than 30°, exercises performed at the "default" 30° scaption position places the posterior elements on slack allowing them to exhibit a shorten-weakened behavior and places excessive tension upon the anterior joint structures thereby potentially contributing to anterior joint laxity.

Summary

There exists a difference in the position of the scaption angle in professional baseball players specific to position of field of play. The scaption angles found in the various positions of play for the baseball player are also different from the accepted default position of the scapula used in establishing exercise prescriptions for the general public. Rehabilitation professionals must now account for the variation in scaption angles, when prescribing exercise programs for their athletes and patients.

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APPENDIX

Literature Review

As early as 1937, an accepted normal value for the scaption angle in the general population had been identified.[1] Often citing the work of Steindler,[2] this angle is reported to be the hallmark position of 30° anterior to the frontal plane.[3 - 8] The value assigned to the scaption angle has also been reported to be as large as 45° and as small as 20°.[3, 9, 10] The large variation in the normal values for this measurement is problematic for the clinician and researcher. In clinical practice and in research studies, the accepted 30°scaption position of the shoulder-shoulder girdle is often indiscriminately applied to all patients and research subjects, regardless of physique presentation. The analogous transverse plane biomechanical arrangement in the lower quarter is the amount of anteversion present in the femoral component of the enarthrodial femur-acetabular articulation. The normal range of version angulation in the femoral component is anterior by 8° to 15°, a range of only 7°.[8] The range of the accepted values of the similar transverse plane phenomena in the upper quarter is 25°, which is over three times greater than for the lower quarter.

Assessment of the shoulder–shoulder girdle has been thoroughly investigated by many individuals.[1, 11-16] Specifically, studies of the shoulder-shoulder girdle have included investigation of the region's muscle EMG activity,[17-26] strength,[7, 27-29] static posture[30], dynamic behavior,[21, 31-36] and postural-biomechanical relationships.[1, 33, 35-42] The studies of the postural-biomechanical relationships in the shoulder-girdle complex have been biased toward static postural[1, 36, 37, 39-42] and dynamic translatoric movement assessment[36-38, 43] of the scapula occurring in the sagittal and frontal planes; and the rotary motions occurring around the horizontal and sagittal axis.[44] Studies have also concentrated on the static and dynamic function of the glenohumeral, acrmioclavicular, and sternoclavicular joint but not the scapulothoracic joint.[4, 45] Unfortunately, these studies have not taken into account or appreciated the anatomical variation that may exist within the populations that have been investigated, specifically the variation in the position of the scapular plane. During the studies, the researchers have either utilized an accepted biomechanical declaration regarding the scapular position on the thorax,[10, 46-50] or did not account for the potential variation.[28, 45, 49-51] Other studies do not report the specific scaption plane position assignment in their research protocol.[52-55] Hartsell[56] performed a study assessing the postoperative eccentric and concentric isokinetic strength of the shoulder rotators in the scapular and neutral planes. In this study, the scapular plane was assigned as being 30° anterior to the frontal plane. It appears that the assignment of the scapular plane is from acceptance of a "default' assignment, rather than specific consideration of the individual's upper quarter physique. This apparent arbitrary assignment or acceptance of scapular position may be due in part because there is not agreement in the literature for the value or range describing the scaption angle.[40, 45]

Potential variations in physical attributes between different populations was investigated and found to be significant.[29] Codine[29] investigated the influence of sport discipline on rotator cuff muscle strength balance in various athletic populations and the non-athletic population. He found that a difference existed between the non-athlete, the tennis player and the baseball player populations. He concludes that this study raises questions about the influence of sport discipline on the muscle balance for these specific populations and indicates the need to establish normative values based on the characteristics of the population under study.

Anatomical-Biomechanical Considerations in the Upper Quarter

The complexity of correct upper quarter function in baseball is demonstrated in the anatomical components and the biomechanical relationships of the region. Specific anatomical components of this region include the bony, muscular, inert soft tissue, and neural tissues of the region. The proximal bony segments of the upper quarter can be categorized as the "shoulder", consisting of the humerus and its articulation with the glenoid fossa; and the "shoulder girdle", consisting of the scapula and its articulations with the thoracic spine and the clavicle. Functionally, it is of great importance to include the bony constituents of the thoracic spine in this complex as normal function of the region is affected by the architectural arrangement of the thoracic ribs and vertebrae.[58, 59, 60] Normal function of the upper quarter in baseball is especially dependent upon the non-dysfunctional interaction between these shoulder and shoulder-girdle components.

The intimate arrangement of the corresponding articulations of this region, the scapulothoracic, acromioclavicular, steronclavicular and glenohumeral joints, is such that movement of the scapula in any plane always produces concurrent motion in the other three related joints.[59, 61] Collectively, these articulations affect the static positioning and dynamic movement characteristics of the scapula upon the thorax. Therefore, the static and dynamic behavior of the shoulder-shoulder girdle complex is, in part, a function of the interaction of these multiple articulations.

Muscular investment of the upper quarter region is extensive. Muscles of the region are categorized as axioscapular, scapulohumeral, or axiohumeral based on their bony attachments.[4] Musculature of the **axioscapular** category include the levator scapula, rhomboid major, rhomboid minor, serratus anterior, pectoralis minor, and all three portions of the trapezius muscle. **Scapulohumeral** musculature consists of the deltoid, supraspinatus, infraspinatus, subscapularis, teres minor, and teres major. The lone **axiohumeral** muscle is the pectoralis major. The latissimus dorsi muscle is uniquely classified as being part of two categories, placed in the axiohumeral and scapulohumeral categories because of its attachments with the axial skeleton, the scapula, and the humerus. The scapula relies on muscular support to position itself on the thoracic wall.

Inert soft tissues of the region maintain joint integrity and limit the range of motion of the articulations. The glenohumeral joint capsule, the superior, middle and inferior glenohumeral joint ligaments, and glenoid labrum are the major structures performing this role. The joint capsule of the glenohumeral joint provides static stability to the articulation.[62] It is reinforced, however, by the invested glenohumeral ligaments. The anterior band of the inferior glenohumeral complex has been found to be the primary restraint to anterior translation with the arm in 90° of abduction.[63] In lesser degrees of abduction, the superior and middle glenohumeral ligaments reinforce the anterior joint capsule to resist anterior translation.[64] Posterior translation is resisted by the anterior superior joint capsule and the posterior band of the inferior glenohumeral ligament.[65] It is important to note that these static stabilizers are lax during motion in the functional range, and only at extremes of range of motion do the ligament and capsule become taut.[66] The scapula is encapsulated by numerous soft tissue attachments with the sole bony attachment to the axial skeleton occurring at the sternoclavicular joint, via the clavicle. This soft tissue arrangement assists in stabilizing the scapula firmly against the posterior surface of the thorax.[4,5] Any change in the position of the scapula can affect the behavior of the invested soft tissue of the region.

Regional neural tissues are important for the motor control of the upper quarter and include the terminal portions of the brachial plexus, specifically the dorsal scapular, long thoracic, thoracodorsal, suprascapular, axillary, median, ulnar, radial, and musculocutaneous peripheral nerves. Additionally, all muscles and joints of the shoulder and shoulder girdle region are invested with specialized neural structures; muscle spindles, and golgi tendon organs in the muscular tissue, and joint receptors embedded in the articulation's capsule.[5] A thorough understanding of the complex interaction between these bony, muscular, soft tissue, and neural tissues is essential for successful rehabilitation and training of this region for the baseball player.

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