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ORIGINAL RESEARCH

SHOULDER RANGE OF MOTION CHARACTERISTICS IN DIVISION III COLLEGIATE SOFTBALL AND BASEBALL PLAYERS

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ABSTRACT

Background: Adaptive changes may occur to the throwing shoulder of overhead athletes that can influence range-of-motion (ROM). Shoulder ROM characteristics of Division III softball (SB) and baseball (BB) players are unique.

Hypothesis/Purpose: To report the passive ROM characteristics of Division III SB and BB players and identify similarities and differences between these two populations.

Study Design: Descriptive, observational research on measurement

Methods: Participants included healthy Division III BB (n = 50) and SB (n = 24) players. Passive shoulder internal rotation (IR) and external rotation (ER) ROM were measured in the supine position with the arm in 90° of abduction and the scapula stabilized. Descriptive statistics and frequency distributions were used to describe ROM. Paired and independent t-tests were also used to compare throwing and non-throwing shoulder ROM for athletes of each sport and to compare the shoulder ROM of SB and BB players, respectively.

Results: The IR and ER ROM for BB players throwing shoulders (IR 54.1 ± 10.9°; ER 94.1 ± 9.1°) were significantly different ($p < 0.001$) from their non-throwing shoulders (IR 63.3 ± 11.1°; ER 87.6 ± 9.2°) while SB players were not ($p = .06$ & $.08$, respectively). Compared to the BB players, the throwing shoulder of SB players demonstrated statistically significantly higher IR ROM ($p < .001$, mean difference = 11.8°, 95% CI: 6.4-17.2°) as well as higher total range of motion (TRM) ($p < .001$, mean difference = 14.4°, 95% CI: 8.6-20.2°) when compared to BB players. Glenohumeral internal rotation deficit (GIRD) was significantly higher in BB players when compared to SB players ($p = .042$, 95% CI: .2-10.8°). There were no significant differences in IR, ER, TRM, GIRD and ER gain between SB or BB pitchers and all other field positions ($p > .05$).

Conclusions: SB players have more ROM and bilateral symmetry when compared to BB players. TRMD occurred more often than GIRD in BB players, indicating that they did not adaptively gain the same amount of ER while losing IR. The throwing shoulder ROM characteristics of both SB and BB players in this study were not influenced by the player's position (pitcher vs. field player).

Level of Evidence: Level III

Keywords: Baseball, college, movement system, range of motion, shoulder, softball.

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Conflict of Interest: All authors have no conflict of interest related to this manuscript.

INTRODUCTION

Adaptive changes may occur to the throwing shoulder of overhead athletes that can influence range-of-motion (ROM). Shoulder ROM characteristics of Division III softball (SB) and baseball (BB) players are unique. The stress placed on the shoulder structures and the associated adaptive changes in range-of-motion (ROM) that can occur when participating in SB or BB may leave athletes susceptible to injury.[1-3] There is evidence that suggests these adaptive changes have consistently been found to cause glenohumeral internal rotation deficit (GIRD) and an associated increase in external rotation (ER gain) at the shoulder joint.[4-9]

A comprehensive review of the literature revealed 30 studies that provided a description of shoulder ROM characteristics of SB and/or BB players (see Appendix A). A majority of the studies examined BB players and approximately a third examined collegiate athletes (Table 1). The limited normative values reported for all player positions and levels of collegiate competition in which athletes participate represents a gap in the literature.

It has been hypothesized that the different levels of training and competition may affect throwing arm ROM characteristics in high school, collegiate and professional BB players. A review of ROM values from previous studies (Appendix A) indicates that professional BB players had higher ER ROM values than collegiate and high school players. A review of the literature revealed that collegiate and professional BB players have similar levels of GIRD that range from 9.7°-12.1° [2,3,10-12] while high school players have a slightly lower value (6.0°-7.4°).[1,13] It should be noted, however, that the majority of studies that examined professional BB players (9 out of 10) included pitchers only.

There are relatively few studies that have reported on the ROM values of high school and collegiate SB players. When comparing the throwing arm ROM values of high school and collegiate SB players, shoulder IR was lower in the collegiate athletes while ER was higher in high school athletes. There was only one study that reported GIRD in both collegiate SB and BB players.[11]

Previous studies have linked the magnitude of the changes in shoulder ROM to increased risk of pathology. A retrospective study by Burkhart et al.[14] reported athletes who suffered a SLAP lesion were found to have an IR deficit. They utilized the term GIRD when the deficit in the throwing shoulder was 20° or more when compared with the non-throwing shoulder and found this ROM deficit to be associated with shoulder labrum pathologies.[4] Dines et al.[6] and Myers et al.[15] indicated that excessive GIRD (EGIRD) could lead to pathology and was associated with rotator cuff injuries (mean EGIRD = 19.7°) and ulnar collateral ligament injuries (mean EGIRD = 28.5°), respectively. Shanley et al.[1] studied shoulder ROM measures as risk factors for shoulder injuries in high school BB players. They reported that GIRD of ≧ 25° was predictive of shoulder injury in BB players and that GIRD was significantly different between injured and non-injured high school BB players. However, Tyler et al.[16] reported patients with internal impingement had an average GIRD of 35°.

For the purpose of this study if the athlete had any loss of IR in the throwing arm compared to their non-throwing arm they were described as having GIRD. If the magnitude of GIRD was equal to or greater than 20° the athlete was considered to have EGIRD. Several authors have indicated that EGIRD may predispose athletes to a variety of elbow and shoulder pathologies.[4,6,15,16] Additionally, any athlete who had a total range of motion (TROM or IR + ER) deficit ≥ 5° between their throwing shoulder and non-throwing shoulder was considered to have TROM deficit (TRMD).[17] For the purpose of this study any athlete who had a TROM deficit of more than or equal to 5° between their throwing shoulder and non-throwing shoulder was considered to have TRMD.[17]

Although Division III BB and SB has the largest number of participating players,[18] a review of the current literature showed that there are no studies that describe the shoulder ROM of these athletes (Appendix A). The NCAA reports that in the 2015-16 season Division III BB had a greater number of participants (13,465) as compared to Division I (10,429) and Division II (10,660). Similarly, there were more SB players participating in Division III (7,646) compared to Division I (6,042) and Division II (5,992).[18] Clinicians need to be able to identify normal and atypical ROM measurements

Table 1. *Literature Review of Normative Shoulder ROM Values for Collegiate Baseball and Softball Players.*

Author	Population	Collegiate Division	Measurement Tool	IR ROM Dominant Shoulder	ER ROM Dominant Shoulder	TRM Dominant Shoulder	IR ROM Nondominant Shoulder	ER ROM Nondominant Shoulder	TRM Nondominant Shoulder	TRMD or TRMG	GIRD
Anloague et al.[25]	42 Collegiate BB Pitchers	D1	Standard Goniometer	47.98° ± 9.88°	98.92° ± 17.68°	146.9°	60.69° ± 8.27°	84.94° ± 10.79°	145.6° No SD reported	No value	No value
Baltaci et al.[22]	38 Collegiate BB Players: 15 pitchers, 23 Position Players	Not Reported	Standard Goniometer	Pitcher 55.8° ± 7.1° Position Players 58.2° ± 7.1°	Pitchers 131.5° ±11.5° Position Players 122.4° ± 10.9°	Pitchers 187.4° ± 15.8° Position Players 180.6° ±12.5°	No Value	No Value	No Value	No Value	No Value
Hibberd et al.[11]	53 Collegiate BB Players and 35 Collegiate SB Players	Not Reported	Digital Inclinometer	No Value	No Value	No Value	No Value	No Value	No Value	TRMG BB 6.9 ° ± 10.8° SB 1.5° ± 7.0°	BB 9.9° ± 9.5° SB 2.5° ± 6.4°
Laudner et al.[27]	18 Collegiate BB Players	DI	Digital Inclinometer	41.6 ° ± 8.0°	No Value	No Value	No Value	No Value	No Value	No Value	No Value
Oliver et al.[8]	49 Collegiate SB Players: 10 Pitchers and 39 Position Players	DI	Digital Inclinometer	Pitchers: 39.3° ± 9.0° Position Players: 33.9° ± 9.6°	Pitchers: 100.7° ± 8.9° Position Players: 98.9° ± 12.6°	Pitchers: 140.0° ± 9.7° Position Players: 132.9° ± 15.4°	Pitchers: 38.3° ± 11.2° Position Players: 36.7° ± 8.2°	Pitchers: 100.0° ± 10.3° Position Players: 97.5° ± 8.6°	Pitchers: 138.2° ± 9.8° Position Players: 134.3° ± 14.6°	No Value	No Value
Osbahr et al.[10]	19 Collegiate BB Pitchers	Not Reported	Standard Goniometer	79.3° ± 13.3°	126.8° ± 12.0°	No Value	91.4° ± 13.6°	114.5° ± 9.1°	No Value	No Value	-12.1° ± 8.6°
Oyama et al.[26]	15 Collegiate BB Pitchers	Not Reported	Digital Inclinometer	Pre-stretch 36.9° ± 10.9° Post Stretch 41.2° ± 10.1°	Pre-stretch 118.7°± 10.4° Post Stretch 118.7° ±11.0°	No Value	No Value	No Value	No Value	TRMD 9.5° ± 11.8°	No Value
Reagan et al.[23]	54 Collegiate BB Players: 25 Pitchers and 29 Position Players	Not Reported	Standard Goniometer	43.0° ± 7.4°	116.3° ± 11.4°	159.5° ± 12.4°	51.2° ± 7.3°	106.6° ± 11.2°	157.8° ± 11.5°	No Value	No Value
Rutolo et al.[24]	67 Collegiate BB Players: 26 Pitchers and 41 Position Players	Not Reported	Standard Goniometer	23.7° No SD reported	117.6° No SD reported	140.7° No SD reported	32.6° No SD reported	108.8° No SD reported	141.6° No SD reported	No Value	No Value

ROM= Range of Motion, IR=Internal Rotation, ER=External Rotation, TRM=Total Range of Motion, TRM=Total Range of Motion, TRMD=Total Range of Motion Deficit, TRMG=Total Range of Motion Gain, GIRD=Glenohumeral Internal Range of Motion Deficit, DI=Division I, SD=Standard Deviation.

when examining SB and BB players. The purpose of this study was to report the passive ROM characteristics of Division III SB and BB players and identify similarities and differences between these two populations.

METHODS

Participants

Seventy-four Division III collegiate athletes (SB n = 24, BB n = 50) with an age range of 18-21 years old

(Table 2) agreed to participate and offered informed consent. The inclusion criteria for this study were: 1) healthy SB or BB collegiate athletes, 2) over the age of 18 years 3) no self-reported current shoulder injury or medical condition that would preclude participation in sports. Those athletes who reported a history of shoulder injury (22% BB and 17% of SB players) were allowed to participate. The Utica College Institutional Review Board approved this study and athletes were recruited during their preseason from a local Division III college.

Data Collection

Participants provided demographic and history information including: age, years of participation, primary position on the team, and history of shoulder injury. Data collection occurred during the preseason, and was scheduled in advance of any training activity. The order of which measurement (IR or ER ROM) and arm (left or right) were randomized.

Shoulder Passive Range-of-Motion

To assess passive shoulder IR and ER ROM a single Baseline™ bubble inclinometer (Model number 12-1056, White Plains, NY) was used. Measurements were taken with the participant in the supine position, with the shoulder abducted to 90°, the elbow flexed to 90° and the forearm in neutral rotation with the elbow supported on a folded towel to align the humerus with the glenoid fossa. The tester manually stabilized the shoulder girdle at the level of the spine of scapula and clavicle (Figure 1). The inclinometer was aligned over the ulnar border, just proximal to the ulnar styloid process. The GH joint was passively moved to maximum available ROM for rotation without overpressure or scapular movement.[19] Two trials were taken for each ROM measure and the average of the two measures was calculated and used for analysis.

Figure 1. *Measurement of Shoulder Internal Rotation Range of Motion.*

The methods for measuring passive ROM used in this study have been found to have good to excellent reliability.[19-21] To ensure accurate reliability and validity of all included measurements used in this study, a pilot study was performed utilizing 20 collegiate athletes. There was high agreement between GH measurements of IR and ER ROM obtained by the goniometer and a single Baseline™ bubble inclinometer with high concurrent validity (ICC = .95). Moreover, the inclinometer measurements of both IR and ER had good test-retest reliability (ICC = .74 & .87, respectively) and inter-tester reliability (ICC = .85 & .79, respectively).

Data Analysis

SPSS (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.) was used to perform: 1) frequency distribution, descriptive statistic and cross tabulation for the shoulder ROM; and 2) paired t-tests to compare throwing and non-throwing arms for each sport and independent t-tests to compare the shoulder ROM of SB and BB players. To determine the relationship between the player's position on the field, GIRD and TRMD, cross tabulation was performed. It was estimated that 45 participants would be sufficient to provide a good point estimate of passive ROM, with 80% power, using a standard deviation of 11° and a 7° margin of error for the 95% confidence interval.

RESULTS

A total of 74 Division III athletes (SB = 24 & BB = 50) participated in this study (Table 2). The majority of athletes (82% of the SB and 88% of the BB players) participated in more than one SB or BB season per year, while only 12% reported participating in more than one sport. There was a higher proportion of pitchers in the BB participants (28%) compared to SB participants (17%). Since there were no significant PROM differences between pitchers and field

Table 2. *Participant Characteristics.*

Participant Characteristics	Baseball (SD)	Softball (SD)
Age (years)	19.3 (1.0)	19.2 (1.0)
Injury History (%)	11.0 (22%)	4.0 (16.6%)
Years Competing (years)	13.8 (2.8)	13.6 (2.2)
Sports Position (n)		
Pitcher	14	4
Catcher	8	4
Infield	18	9
Outfield	10	7

SD: Standard Deviation

Table 3. *ParticipantDescriptive Statistics and 95% Confidence Intervals for Shoulder Range of Motion of Baseball Players (n = 50).*

	Throwing Arm			Non-Throwing Arm			
	Mean (SD)	95% CI		Mean (SD)	95% CI		*p*-value
		Lower limit	Upper limit		Lower limit	Upper limit	
IR	54.1° (10.9)	51.1	57.2	63.3° (11.1)	60.2	66.4	< .001
ER	94.1° (9.1)	91.6	96.7	87.6° (9.2)	85.0	90.2	< .001
TRM	148.2° (11.6)	145.0	151.5	150.9° (13.3)	147.2	154.6	.032

SD=Standard Deviation, CI=Confidence Interval, IR=Internal Rotation Range of Motion, ER=External Rotation Range of Motion, TRM=Total Range of Motion.

Table 4. *Descriptive Statistics and 95% Confidence Intervals for Shoulder Range of Motion of Softball Players (n = 24).*

	Throwing Arm			Non-Throwing Arm			
	Mean (SD)	95% CI		Mean (SD)	95% CI		*p*-value
		Lower limit	Upper limit		Lower limit	Upper limit	
IR	65.9° (10.9)	61.6	70.3	69.6° (9.7)	65.8	73.5	.061
ER	96.7° (8.8)	93.2	100.2	93.°7 (10.0)	89.6	97.7	.078
TRM	162.6° (11.9)	157.9	167.3	163.3° (12.3)	158.4	168.2	.69

CI=Confidence Interval, SD=Standard Deviation, IR=Internal Rotation Range of Motion, ER=External Rotation Range of Motion, TRM=Total Range of Motion.

players, the results presented for BB players (Table 3) and SB players (Table 4) represent combined averages and variability estimates for ROM for all playing positions.

Baseball

Table 3 provides all data on BB player's shoulder PROM characteristics. The shoulder PROM of the BB players demonstrated statistically significant differences between their throwing and non-throwing shoulders. BB players had significantly less IR ($p < 0.001$), and TRM ($p < 0.032$) while they had more ER ($p < 0.001$) in the throwing shoulder. On average, BB players demonstrated a GIRD of 9.2 $\pm$ 11.3° (95% CI: 6.1-12.3). Although 62% (n = 31) of BB players demonstrated 5° or more of GIRD, only 18% had EGIRD (range 20-45°**)**. On the contrary, 16 BB players (32%) had a minimal (< 5° of deficit or gain) difference in IR rotation (Figure 2a). BB players throwing shoulders demonstrated an average ER

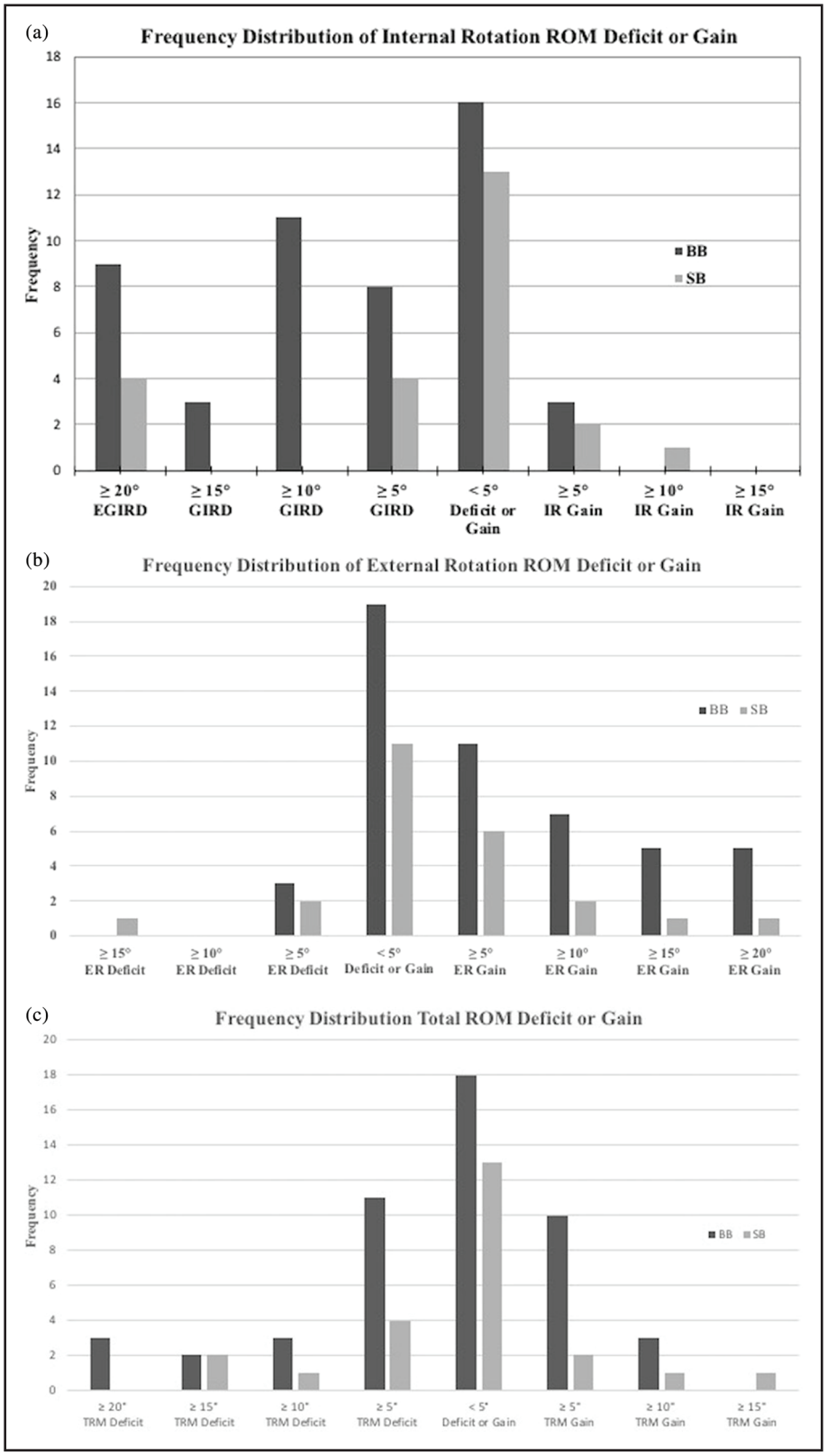

Figure 2. *a) Number of softball (SB) (n = 24) and baseball (BB) (n = 50) players with differences in the throwing arm internal rotation (IR) compared to the non-throwing arm. b) Number of softball (SB) (n = 24) and baseball (BB) (n = 50) players with differences in the throwing arm external rotation (ER) compared to the non-throwing arm. c) Number of softball (SB) (n = 24) and baseball (BB) (n = 50) players with differences in the throwing arm total range of motion (TRM) compared to the non-throwing arm.*

gain of 6.5 ± 8.0° (95% CI: 4.3-8.8) but only 56% (n = 28) gained 5° or more. Additionally, 38% (n = 19) had a minimal difference (< 5° of deficit or gain) in ER rotation (Figure 2b). The combination of average GIRD and ER gain led to an overall average TRMD of 2.7 ± 8.6° (95% CI: 0.3-5.1). While 38% (n = 19) of the BB players had a TRMD of 5° or more, an equal amount of BB players (36%) had minimal difference in TRM (< 5° of deficit or gain) and 26% (n = 13) gained 5° or more (Figure 2c).

Although there were no significant differences in IR, ER, TRM, EGIRD and ER gain between BB pitchers and all other positions (p > .05), cross tabulation of player's position on the field with EGIRD, TRMD revealed the following observations: 1) of the 9 BB players that had EGIRD, five of them were pitchers (36% of the pitchers) and the remaining four were field players (11% of field players); 2) a Chi-squared test indicated that BB pitchers have a significantly higher incidence of EGIRD (X^2 = 4.1, P = .042); 3) of the 14 pitchers in this study, five of them had both a TRMD and EGIRD, three had TRMD but no EGIRD and none had EGIRD only; 4) of the 36 field players, three had both TRMD and EGIRD, eight had only TRMD, and four had EGIRD only.

Softball

When comparing SB players throwing and non-throwing shoulders (Table 4) there were no statistically significant differences in IR, ER or TRM (p > .05). Additionally, there were no significant differences in IR, ER, TRM, GIRD and ER gain between SB pitchers and all other field positions (p > .05). Of the SB players 83% (n = 13) had a minimal difference in IR rotation between the throwing and non-throwing shoulders (< 5° of deficit or gain) while only 17% (n = 4) had EGIRD (Figure 2a). The percentage of SB players that exhibited ER gains of ≥ 5° was 42% (n = 10) (Figure 2b). SB players with a TRM gain ≥ 5° was 17% (n = 4) while 29% (n = 7) had a TRMD ≥ 5° (Figure 2c).

Cross tabulation of EGIRD and the player's position on the field was calculated to determine the relationship between these variables for the SB players. Seven SB players had TRMD ≥ 5°, of which three of them had both TRMD and EGIRD. Of those three players with both TRMD and EGIRD, only one was a pitcher. The incidences of EGIRD and TRMD in SB pitchers could not be calculated due to the low number of pitchers.

Comparison of SB and BB Players

Although this study included an unequal number of BB (n = 50) and SB players (n = 24), Levene's Test of homogeneity of variance indicated no significant difference between their group variances. SB players non-throwing shoulder demonstrated a significantly higher IR, ER and TRM when compared to the BB players' non-throwing shoulder (Table 5). However, compared to the BB players, the throwing shoulder of SB players demonstrated statistically significantly higher IR and TRM as well as significantly lower GIRD (Table 5). Of the players that had EGIRD (nine BB and four SB) only one BB player and none of the SB players reported a history of shoulder injury. There was no statistically significant difference between SB and BB for ER gain.

DISCUSSION

Baseball Players

The dual aim of this study was to describe values for shoulder ROM for Division III collegiate SB and BB players as well as provide a comparative analysis of these two populations.

The SB and BB players in this study reported playing multiple seasons per year with an average of 13 years playing their sport. This frequency of play and number of years participating may explain the statistically and clinically significant differences in ROM between BB players throwing and non-throwing shoulders. Collegiate athletes appear to be unique when compared to high school and professional players but there is variability within each group according to multiple authors (Appendix A). The throwing shoulder ER values of Division III BB players in this study were lower than those reported by other studies that examined Division I (most did not report division) BB players, while IR values were higher (Table 1). Collegiate BB players throwing shoulder ER, in the literature, ranged from 98.9°-131.5° (Table 1). In previous research, the throwing shoulder IR ROM values for collegiate BB players had high variability and ranged from 23.7°-79.3° (Table 1), compared to the average of 54.1° (Table 2). These

Table 5. *Differences Between Baseball and Softball Players Non-Throwing & Throwing Shoulders.*

	Shoulder Side	SB Mean (SD)	BB Mean (SD)	Mean Difference	Sig. (*p*)	95% CI of the Difference	
						Lower	Upper
IR ROM	Non-Throwing	69.6 (9.7)	63.3 (11.1)	6.3	0.020*	1.0	11.6
	Throwing	65.9 (10.9)	54.1 (10.9)	11.8	< .001*	6.4	17.2
ER ROM	Non-Throwing	93.7 (10.0)	87.6 (9.2)	6.0	0.012*	1.4	10.7
	Throwing	96.7 (8.8)	94.1 (9.1)	2.6	0.255	-1.9	7.0
TRM	Non-Throwing	163.3 (12.3)	150.9 (13.3)	12.4	< .001*	5.9	18.8
	Throwing	162.6 (11.9)	148.2 (11.6)	14.4	< .001*	8.6	20.2
GIRD		3.7 (9.2)	9.2 (11.3)	5.5	0.042*	0.2	10.8
ER Gain		3.0 (8.1)	6.5 (8.0)	3.5	0.084	-0.5	7.5

SD=Standard Deviation, CI= Confidence Interval, ROM= Range of Motion, IR=Internal Rotation, ER=External Rotation, TRM=Total Range of Motion.
*Statistically significant difference $p < .05$

differences and the variability in the literature may be related to the stabilization methods used to measure ROM, level of play and/or the field position(s).

A review of the methodology used to measure shoulder IR and ER of collegiate SB and BB players revealed some variability in the overpressure given at end range, hand position and the measurement tool used. This study utilized the same direct scapular stabilization described by Wilk et al.,[20] that demonstrated higher intrarater reliability than other methods. The use of overpressure may significantly alter the value of shoulder ROM obtained. The most common method of determining the end-range of motion is using the presence of a capsular end-feel or detecting scapular movement.[8,11,22-24] Osbahr et al.[10] attempted to standardize overpressure using a handheld dynamometer, which resulted in higher ROM values when compared to other results seen in the literature. Direct scapular stabilization is more consistently used in the literature and the majority of articles reviewed utilized stabilization in order to prevent scapular tilting.[11,22-27] There was, however, variability in hand positions/contact points on the scapula and various directions of stabilization force.

The instrumentation used in the literature to measure IR and ER was consistently a standard goniometer[10,22-25] or a digital inclinometer.[11,26,27] ROM measurements of IR and ER using a bubble inclinometer correlated highly with goniometry in the pilot study. The high correlation of these two devices and the ease of use of a bubble inclinometer should be considered when performing this measurement.

Although a large proportion of the BB players demonstrated some degree of IR deficit, only 18% (n = 9) of them demonstrated EGIRD. EGIRD has been linked to the development of adaptive changes in the shoulder, which include humeral retroversion and posterior shoulder stiffness.[28,29] These adaptive changes have been found in BB players as young as 8-10.5 years old and were hypothesized to be a contributing factor to the development of EGIRD over the course of an athlete's career.[13] EGIRD has also been linked to increased risk of shoulder injury.[1,4,6,14,16] In this study pitchers developed EGIRD more often than field position players. EGIRD may be an important variable to consider when evaluating pitchers.

The mean TRM for the BB players was lower than what has been reported in other studies (Table 1). It has been reported in the literature[11,26] that BB players frequently have a TRMD of ≥ 5°, which was true for 28% (n = 14) of the BB players in this study, however, 26% (n = 13) of them had a TRM gain. This TRM gain was either the result of BB players gaining more ER than GIRD or gaining both ER and IR. In this study, TRMD occurred more often in BB players who have EGIRD. TRMD may be a more important clinical measure than EGIRD, as it represents a loss of IR and an inadequate gain of ER. Currently, there is not sufficient evidence that identifies the degree to which TRMD or TRM gain are associated with increased risk of injury in the collegiate BB or SB players.

Softball Players

In contrast to the BB players, the mean PROM of the SB players throwing shoulder (Table 4) was not significantly different from the non-throwing shoulder. Most SB players in this study either had an IR gain or minimal to no GIRD (Figure 2a) which was similar to results reported by Hibberd et al.[11] Oliver et al.,[8] reported lower IR and TRM, and higher ER values (Table 1) for Division I SB players when compared to results of this study. The relative symmetry of SB players ROM values makes them unique when compared to BB players.

Comparison of SB and BB Players

The results of this study indicate that Division III SB players had more shoulder IR and TRM than BB players for both the throwing and non-throwing shoulders, while demonstrating similar throwing shoulder ER (Table 3 and 4). The playing position (pitcher vs. field player) did not seem to influence the throwing arm ROM characteristics of either SB or BB players. There are only two studies that examined the ROM characteristics of collegiate SB and BB players.[11,30] Dwelly et al.[30] combined the ROM data for the SB and BB players so these groups could not be compared. The ROM findings of this study were consistent with Hibberd et al.[11] who described the ROM characteristics of Division I collegiate SB and BB players (excluding pitchers) and a control group of non-throwing participants. This study found similar GIRD averages for SB and BB players as Hibberd et al.[11] who found that average GIRD for BB players was higher than SB players and that the average TRMD for BB players was higher than SB players. Hibberd et al.[11] did not report the percentage of players with GIRD to make a comparison to the results of this study.

SB and BB players place unique demands on their shoulders and this could explain the differing ROM characteristics of their throwing shoulders. The unique demands may be related to the equipment and environmental differences such as the SB weighing approximately 20% more than a BB and that the SB bases are a shorter distance apart than BB.[31,32] The greater forces produced by the BB players' shoulders may affect physical adaptations of the shoulder-stabilizing musculature and posterior capsule which may be linked to greater amounts of GIRD when compared with SB players.[33] Moreover, recent research has noted that these adaptive changes of SB and BB players are not purely related to soft tissue changes, but may involve the development of humeral retrotorsion.[28,29,34]

Division III collegiate SB and BB athletes appear to engage in these sports at a very early age and continued with their participation in multiple seasons annually as collegiate athletes. Early participation and multi-season participation may lead to adaptive changes in shoulder structures that could influence their ROM characteristics.[13] However, an important finding of this study was related to the subgroup analysis of the degree of GIRD, TRMD and their association with the player's field position. The results indicated that the changes in IR, ER or TROM had a wide range of presentations of deficits or gains (Figures 2a-c). These normal adaptations or pathological variations may lose their clinical significance when only examining point estimate (such as means and standard deviations) or between group differences in hypothesis testing. The variations of ROM deficits or gains need to be taken into consideration when examining the characteristics of each individual player and not just the group means.

Limitations and Future Research Recommendations

One limitation of this study is that humeral retrotorsion was not examined secondary to the lack of

necessary equipment and the contribution of osseous changes cannot be determined for the sample that was studied. The single site for data collection and the use of sample of convenience may limit the ability to generalize the results of this study. Additionally, the sample size of SB players was smaller than the BB group. Dwelly et al.[30] reported that, as the competitive season progressed, Division I and II SB and BB players gained ER but did not lose an equivalent amount of IR. The participants of this study were measured in the preseason. There is a potential for ER ROM gain throughout the season and should be considered when comparing normative preseason ROM values to those measured during or after the season.

Differences in methodology, described in the literature reviewed, may explain the variability in the measures reported (Table 1) and could be due to factors such as stabilization, overpressure, and/or the instrumentation that was utilized. The methodology used in this study should be considered for future shoulder ROM studies as it addressed key factors including scapular stabilization, overpressure and instrumentation that demonstrated excellent reliability.[20] Future research should also focus on the shoulder performance characteristics and biomechanical analysis of the throwing motion of all SB and BB field positions to determine the unique characteristics of these groups. Prospective studies are needed for Division III SB and BB players to identify the unique characteristics of pitchers and field players that may affect performance and possibly increase the risk for injury. The degree of TRMD should be one of the unique ROM characteristics focused on in future studies.

CONCLUSION

The ROM characteristics of Division III SB and BB players have not been adequately documented in the current literature. The findings of the current study indicated that Division III collegiate BB players presented with statistically significant IR and ER differences in their throwing shoulder when compared to the non-throwing shoulder, specifically an IR deficit and an ER gain. Conversely, the differences in ROM of the throwing and non-throwing shoulders in SB players were not statistically significant. In this group of Division III SB and BB players, there was no statistically significant differences in IR, ER, TRM, GIRD and ER gain between pitchers and all other positions. BB players in this study had a higher frequency of EGIRD and also have a statistically significant higher level of GIRD when compared to SB players. Although the overhead throwing motions are similar between BB and SB players, the average ROM values in this study indicate that the athletes adapt to the demands of the sport differently. Clinicians should consider this study's subgroup analysis of SB and BB players, which demonstrated a large percentage of athletes that had relative symmetry in their ROM ($< 5^\circ$ of IR or ER ROM difference between shoulders). The identification of normative shoulder ROM values and the understanding that Division III SB and BB players have unique ROM characteristics is critically important for the examination and evaluation of these athletes.

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Appendix A. *Literature Review of Normative Shoulder ROM Values for Baseball and Softball.*

Author	Population	Measurement Tool	IR Dominate Shoulder	ER Dominate Shoulder	TRM Dominate Shoulder	IR Non-dominant shoulder	ER Non-dominant shoulder	TRM Non-dominant shoulder	TRMD or TRMG	GIRD
Professional Players										
Borsa, et al.[35]	43 Professional BB Pitchers	Standard Goniometer	68.6° ± 9.2°	134.8° ± 10.2°	203.4° ± 9.7°	78.3° ± 10.6°	125.8° ± 8.7°	204.1° ± 9.7°	TRMD -0.7° ± 9.2°	-9.7° ± 7.6°
Borsa et al.[12]	34 Professional BB Pitchers	Standard Goniometer	59.7° ± 7.0°	135.5° ± 9.5°	195.2° ± 12.1°	68.2° ± 8.6°	130.4° ± 10.7°	198.6° ± 26.6°	No value	No value
Crocket et al.[28]	25 Professional BB Pitchers	Standard Goniometer	62° ± 7.4°	128° ± 9.2°	189° ± 12.6°	71° ± 9.3°	119° ± 7.2°	189°± 12.7°	No value	No value
Ellenbecker et al.[7]	46 Professional BB Pitchers	Standard Goniometer	42.2° ± 15.8°	103.2° ± 9.1°	145.7° ± 18.0°	52.4° ± 16.4°	94.5° ± 8.1°	146.9° ± 17.5°	No value	No value
Freehill et al.[36]	21 Professional BB Pitchers	Standard Goniometer	Start of season: 70.9° ± 11.8° End of season: 73.6° ± 13.2°	Start of season: 124.8 ° ± 19.5° End of season: 126.3° ± 21.6°	Start of season: 196.5° ± 22.1° End of season: 199.9° ± 26.0°	Start of season: 76.3° ± 12.4° End of season: 81.4° ± 10.4°	Start of season: 116.3° ± 12.7° End of season: 119.0° ± 16.4°	Start of season: 193.6° ± 19.9° End of season: 200.4° ± 22.0°	No value	No value
Laudner et al.[37]	20 Professional BB Pitchers 20 Professional BB position players	Digital Inclinometer	Pitchers 44.7° ± 6.3° Position Players 44.1° ± 8.6°	Pitchers 115.5° ± 7.8° Position Players 109.5° ± 9.7°	No value	Pitchers 58.0° ± 9.8° Position Players 52.0° ± 8.0°	Pitchers 107.0° ± 7.8° Position Players 109.5° ± 9.7°	No value	No value	No value
Lintner, et al.[38]	85 Professional BB Pitchers	Standard Goniometer	Stretching group: 74.3° Non-stretching group: 55.2°	Stretching group: 142.7° Non-stretching group: 138.9°	Stretching group: 216.98° Non-Stretching group: 194.2°	No value	No value	No value	No value	No value
Wilk et al.[2]	122 Professional BB pitchers	Standard Goniometer	47.5° ± 10.6°	136.1° ± 11.2°	183.7° ± 14.5°	59.1° ± 11.0°	128.6° ± 11.0°	187.7° ± 14.5°	No value	-11.3° ± 11.3°
Wilk et al.[19]	369 Professional BB Pitchers	Standard Goniometer	52° ± 12°	132 ° ± 11°	184° No SD reported	63° ± 12°	127° ± 11°	190° No SD reported	No value	No value
Wilk et al.[3]	296 Professional BB Pitchers	Standard Goniometer	52.3° (No SD)	131.2°	183.4°	62.8°	124.9°	187.7°	TRMD of -4.2° ± 0.7°	-10.5° ± 0.7°
Collegiate Players										
Anloague et al.[25]	42 DI Collegiate BB Pitchers	Standard Goniometer	47.98° ± 9.88°	98.92° ± 17.68°	146.9°	60.69° ± 8.27°	84.94° ± 10.79°	145.6° No SD reported	No value	No value
Baltaci et al.[22]	38 Collegiate BB Players: 15 pitchers, 23 Position Players	Standard Goniometer	Pitchers 55.8°± 7.1° Position Players 58.2° ± 7.1°	Pitchers 131.5° ± 11.5° Position Players 122.4° ± 10.9°	Pitchers 187.4° ± 15.8° Position Players 180.6° ± 12.5°	No value	No value	No value	No value	No value

Appendix A. *Literature Review of Normative Shoulder ROM Values for Baseball and Softball. (continued)*

Hibberd et al.[11]	53 Collegiate BB Players and 35 Collegiate SB Players	Digital Inclinometer	No value	No value	No value	No value	No value	No value	TRMG of BB: 6.9° ± 10.8 ° SB: 1.5° ± 7.0 °	BB: 9.9° ± 9.5° SB: 2.5° ± 6.4°
Laudner et al.[27]	18 DI Collegiate BB Players	Digital Inclinometer	41.6° ± 8.0°	No value	No value	No value	No value	No value	No value	No value
Oliver et al.[8]	49 DI Collegiate SB Players: 10 Pitchers and 39 Position Players	Digital Inclinometer	Pitchers: 39.3° ± 9.0° Position Players: 33.9° ± 9.6°	Pitchers: 100.7° ± 8.9° Position Players: 98.9° ± 12.6°	Pitchers: 140.0° ± 9.7° Position Players: 132.9° ± 15.4°	Pitchers: 38.3° ± 11.2° Position Players: 36.7° ± 8.2°	Pitchers: 100.0° ± 10.3° Position Players: 97.5° ± 8.6°	Pitchers: 138.2° ± 9.8° Position Players: 134.3° ± 14.6°	No value	No value
Osbahr et al.[10]	19 Collegiate BB Pitchers	Standard Goniometer	79.3° ± 13.3°	126.8° ± 12.0°	No value	91.4°± 13.6°	114.5° ± 9.1°	No value	No value	-12.1° ± 8.6°
Oyama et al.[26]	15 Collegiate BB Pitchers	Digital Inclinometer	Prestretch: 36.9° ± 10.9° Post Stretch: 41.2° ± 10.1°	Prestretch: 118.7° ± 10.4° Post Stretch: 118.7° ± 11.0°	No value	No value	No value	No value	TRMD of 9.5° ± 11.8°	No value
Reagan et al.[23]	54 Collegiate BB Players: 25 Pitchers and 29 Position Players	Standard Goniometer	43.0° ± 7.4 °	116.3° ± 11.4 °	159.5° ± 12.4 °	51.2 ° ± 7.3°	106.6 ° ± 11.2°	157.8 ° ± 11.5°	No value	No value
Rutolo et al.[24]	67 Collegiate BB Players: 26 Pitchers 41 Position Players	Standard Goniometer	23.7 (No SD reported)	117.6 (No SD reported)	140.7 (No SD reported)	32.6 (No SD reported)	108.8 (No SD reported)	141.6 (No SD reported)	No value	No value
Youth/High School Players										
Greenberg et al.[13]	85 Youth (8-14 yo) BB Players	Digital Inclinometer	39.8° ± 0.8°	124.9° ± 1.0°	164.8° ± 1.3°	45.8° ± 0.8°	119.8° ± 0.9°	165.7° ± 1.2°	TRMD -0.8° ± 0.9°	-6.0° ± 0.8°
Hurd et al.[39]	210 High School BB Pitchers (14-18 yo)	Standard Goniometer	60° ± 11°	130 ° ± 11°	190 ° ± 15°	75° ± 11°	120° ± 10°	195° ± 15°	No value	No value
Picha et al.[40]	72 Youth and High School BB players (7-18 y.o).	Standard Goniometer	48.6° ± 1.9°	101.9 ° ± 1.2°	150.5 ° ± 2.1°	57.2° ± 1.5°	97.9° ± 1.1°	154.9° ± 1.8°	No value	No value
Shanley et al.[1]	246 High School Players: 12 SB Pitchers, 91 SB Position Players; 39 BB Pitchers,104 BB Position Players	Standard Goniometer	BB: 53.4° ± 11.4° SB: 60.2° ± 13.6°	BB: 125.6° ± 11.4° SB: 123.8° ± 13.6°	BB: 179.1°± 16.4° SB: 184.1° ± 19.3°	No value	No value	No value	No value	Injured BB: 12.1° ± 11.8° Non-injured BB 7.4° ± 8.6°
Shanley et al.[41]	12 High School SB Pitchers	Standard Goniometer	60.6° ± 8.3°	119.1° ± 12.9°	179.7 ° ± 16.9°	62.9° ± 12.9°	119.5° ± 12.8°	182.3 ° ± 12.5°	No value	No value
Werner et al.[42]	53 High School SB Pitchers	Standard Goniometer	57° ± 13°	129° ± 19°	No value	61° ± 11°	123° ± 19°	No value	No value	No value

Appendix A. *Literature Review of Normative Shoulder ROM Values for Baseball and Softball. (continued)*

Mixed Population/ Unknown Age										
Bogenschutz et al.[34]	15 SB players (over the age of 16)	Standard Goniometer	60.° ± 10.2°	109.9° ± 12.1°	No value	No value	No value	No value	No value	No value
Chant et al.[29]	15 Professional BB Players and 4 Amateur League BB Players	Standard Goniometer	57.1° ± 8.7°	114° ± 9.8°	171.1° ± 12.5°	73.5° ± 9.6°	104.1° ± 7.4°	177.6° ± 11.0°	TRMG 6.5°	No value
Garrison et al.[43]	60 High School and Collegiate BB Players: 44 Pitchers 16 Position Players	Standard Goniometer	20.61° ± 5.97°	121.85° ± 9.46°	No value	34.38° ± 6.52°	106.81° ± 11.23°	No value	TRMG 1.29° ± 8.33°	-13.76° ± 6.41°
Dines et al.[6]	8 High School BB Players, 10 DI Collegiate BB Players, and 11 Professional BB Players.	Standard Goniometer	38.34° ± 11.40°	104.76° (No SD reported)	No value	No value	No value	No value	No value	38.34° ± 11.40°
Myers et al.[15]	11 BB Players (18-30 yo)	Standard Goniometer	51.1° ± 14.4°	116.0 ° ± 10.3°	No value	No value	No value	No value	No value	-11.1° ± 9.4°

IR=Internal Rotation, ER=External Rotation, TRM=Total Range of Motion, TRMD=Total Range of Motion Deficit, GIRD=Glenohumeral Internal Rotation Deficit, D1=Division 1, TRMG=Total Range of Motion Gain, SD=Standard Deviation, yo=years old