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Shoulder Strength and Range of Motion in Healthy Collegiate Softball Players

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Context: Shoulder range of motion (ROM) and strength are key injury evaluation components for overhead athletes. Most normative values are derived from male baseball players, with limited information specific to female softball players.

Objective: To determine between-limbs differences in shoulder ROM and strength in healthy collegiate softball players.

Design: Descriptive laboratory study.

Setting: University research laboratory and collegiate athletic training room.

Patients or Other Participants: Twenty-three healthy collegiate softball players (age = 19.9 ± 1.2 years, height = 170.5 ± 4.3 cm, mass = 78.4 ± 11.3 kg).

Main Outcome Measure(s): Shoulder ROM (internal rotation [IR] and external rotation [ER]), isometric strength (IR, ER, flexion, abduction [135°], and horizontal abduction), and a measure of dynamic strength (Upper Quarter Y-Balance Test) were obtained. Paired-samples *t* tests were used to determine between-limbs differences for each outcome measure.

Results: Participants had more ER ROM (12° more) and less IR ROM (12° less) in the dominant arm, relative to the nondominant arm. No differences were present between limbs for any of the isometric strength measures or the Upper Quarter Y-Balance Test reach directions.

Conclusions: Female collegiate softball players demonstrated typical changes in ER and IR ROM in the dominant arm and relatively symmetric performance across strength measures, which contrasts with previous findings in male baseball players.

Key Words: isometric strength, modified Athletic Shoulder Test, Y-Balance test

Key Points

- Female collegiate softball players displayed the typical changes in shoulder range of motion (ROM) that occur with repetitive overhead sports: increased external-rotation ROM and decreased internal-rotation ROM on the dominant side relative to the nondominant side.
- Despite differences in ROM between limbs, isometric and dynamic strength measures were relatively symmetric between limbs. This contrasts with the usual findings in collegiate and professional male baseball players.
- With the establishment of normative shoulder strength and ROM data for softball players in the absence of preinjury measures, clinicians can have some confidence that the uninvolved limb is an adequate benchmark for strength measures, which may be used to inform return-to-play decisions.

The upper extremity is one of the most common regions of injury in overhead athletes such as baseball and softball players.[1] High stresses associated with the throwing motion and resultant repetitive microtrauma to the surrounding contractile and noncontractile tissues contribute to injuries.[2,3] Chronic adaptations in glenohumeral joint range of motion (ROM) are known to occur in the throwing arm relative to the contralateral limb and include increased external-rotation (ER) ROM, decreased internal-rotation (IR) ROM, decreased horizontal-adduction ROM, and decreased total arc of rotation ROM.[4,5] An increase in ER ROM with a decrease in IR ROM in the dominant arm has been classified as *glenohumeral internal-rotation deficit* (GIRD).[3,6] Although these adaptations in ROM may occur naturally due to sport demands, asymmetric shoulder ROM may contribute to pain, decreased sport performance, or shoulder injury.[3,6] As a result of these reported differences and possible adverse effects from common adaptation patterns in throwing athletes, glenohumeral ROM, and especially rotation, is a key factor to evaluate in an overhead athlete.

Consistent with ROM, changes in strength are also known to occur with throwing athletes.[7,8] Overhead athletes often demonstrate greater IR strength in the dominant limb compared with the nondominant limb, with mixed results for changes in ER strength in the dominant limb.[7,8] The resulting increase in IR strength compared with ER strength has been attributed to the overload of eccentric contraction of the humeral external rotators during the deceleration phase of throwing.[2] An adequate balance between ER and IR strength, often expressed as a ratio or percentage, helps to maintain dynamic stabilization of the shoulder. Due to the greater IR strength in the dominant arm, the ER:IR ratio is usually lower in the dominant arm relative to the nondominant arm.[7,8] Injured individuals typically have lower ER:IR ratios,[9] but a specific threshold that identifies a risk for shoulder injury has not yet been determined.[10] Dynamic strength, in a closed kinetic chain position, can be

Table 1. Participants' Demographics

Characteristic (n = 23)	Value[a]
Age, y	19.9 ± 1.2
Height, cm	170.5 ± 4.3
Mass, kg	78.4 ± 11.3
Arm length, cm	82.2 ± 18.1
Dominant arm	20 right, 3 left
Position (primary)	Catcher = 4, infield = 5, outfield = 7, pitcher = 4, utility = 3

[a] Mean ± SD unless otherwise stated.

assessed using the Upper Quarter Y-Balance Test (UQYBT).[11,12] Collegiate overhead athletes with a history of shoulder injury displayed shorter UQYBT reach distances compared with uninjured athletes,[9] and these shorter reach distances demonstrate the clinical utility of a dynamic strength test.

Examination of glenohumeral rotation ROM and static and dynamic shoulder strength can discriminate between dominant and nondominant arms[2,13] and injured and uninjured groups[9,14] in the overhead athlete population. The vast majority of research regarding normative values for shoulder ROM and strength in overhead throwing athletes has addressed male baseball players at various levels of play.[7,8,15] Limited information is specific to female softball players, especially at the collegiate level. Previous authors[5,13] showed that female collegiate softball players, when compared with male collegiate baseball players, had decreased GIRD (3° to 4° versus baseball 9° to 10°), greater IR ROM (66° versus baseball 54°), and greater total ROM in the throwing arm (163° versus baseball 148°). Female softball players exhibit greater IR ROM values when compared with male baseball players, which may contribute to the relative decrease in GIRD. Although these studies highlight ROM differences between baseball and softball players, less is known regarding strength measures (eg, isometric, dynamic). Differences between sexes and sports suggest the need for normative baseline data to further evaluate injury prevention and performance enhancement in female athletes.[16] Therefore, the purpose of our study was to determine between-limbs differences in shoulder ROM and strength in healthy collegiate softball players.

METHODS

Participants

Twenty-three healthy collegiate softball players from a National Collegiate Athletic Association (NCAA) Division I team participated in the study and were selected from a sample of convenience. All data-collection sessions occurred during the preseason (November to January), before competitive play. Athletes were excluded if they had a current upper extremity injury and were not cleared for testing by a medical provider (eg, athletic trainer, team physician, physical therapist). First, body anthropometrics and demographic outcomes were obtained: height (cm), body mass (kg), age, arm length (distance from C7 to the tip of the third digit), and dominant arm (Table 1). The *dominant arm* was classified as the limb the athlete used to throw a ball. The study was approved by the Institutional Review Board at Creighton University (IRB 1121863), and all participants signed an approved informed consent form before the study began.

Experimental Setup and Testing Procedures

Range of Motion. Range-of-motion measures were obtained with the participant in supine position with the humerus abducted to 90° and the elbow flexed to 90°.[13,17] The humerus was supported with a towel placed underneath the midshaft to maintain proper horizontal alignment at the glenohumeral joint. A digital inclinometer was positioned proximal to the proximal wrist crease on the volar aspect of the forearm for ER (Figure 1A) and the dorsal aspect for IR (Figure 1B). Test order sequence and initial testing arm were randomized. The tester provided stabilization at the scapula to prevent scapular tilting in the anterior direction for IR and posterior direction for ER. The tester passively took the participant through the motion until a firm end feel was noted. Three repetitions were performed and recorded in each direction and then the measures were conducted on the opposite arm. Both measures have demonstrated excellent within-session intrarater reliability (intraclass correlation coefficient [ICC] = 0.98).[17]

Isometric Strength. Strength measures for shoulder ER and IR were obtained in a similar position as for the ROM

Figure 1. Shoulder range-of-motion measures: A, external rotation; B, internal rotation.

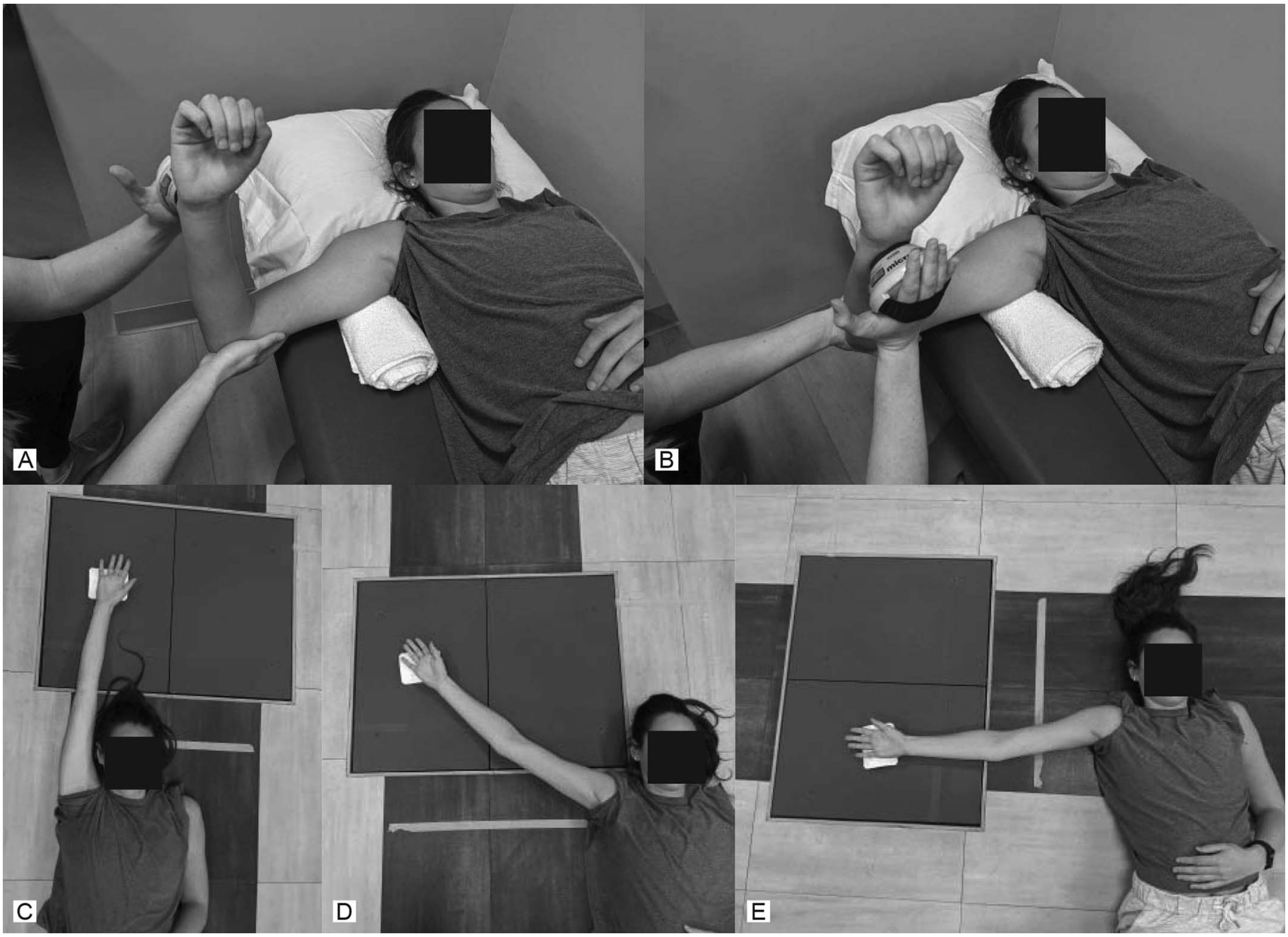

Figure 2. Shoulder strength measures: A, external rotation; B, internal rotation; C, full shoulder abduction (I-position); D, 135° of shoulder abduction (Y-position); E, horizontal abduction (T-position).

measures.[17] A digital hand-held dynamometer (HHD) was placed proximal to the proximal wrist crease on the dorsal aspect of the forearm for ER strength measures (Figure 2A) and on the volar aspect of the forearm for IR strength measures (Figure 2B). Test order sequence was randomized, but the arm tested first was the same as for the ROM measures. Participants were passively placed in the correct position and instructed to push as hard as they could into the HHD for 3 seconds. The test was then repeated for the other rotational direction. Three repetitions were performed and recorded in each direction, with the average of the 3 values used for data analysis. After measures were obtained for the initial arm, the measures were obtained for the opposite arm. Participants were allowed 1 practice trial for each arm to familiarize themselves with each test. Both measures have displayed excellent within-session intrarater reliability (ICC = 0.95 to 0.99).[17]

Next, isometric shoulder-flexion, -abduction, and horizontal-abduction strength were measured (Figure 2C, D, and E). A modified Athletic Shoulder (ASH) test was used, but instead of having participants perform the test in a prone position for the anterior shoulder musculature,[18] they performed the test in a supine position for the posterior shoulder musculature. Participants were positioned supine, with full elbow extension, and the dorsal aspect of the testing hand was placed directly on a closed-cell foam pad, which was in the middle of a force plate (Bertec Corp). The individual was first positioned with the testing arm in full shoulder abduction (I-position), then in 135° of abduction (Y-position), and finished with the arm in 90° of abduction (T-position). To prevent trunk rotation and minimize compensatory strategies, the nontested hand was kept on the abdomen during the 135° and 90° of abduction positions. Participants were instructed to push the back of their hand into the foam pad as hard and quickly as they could and hold the contraction for 3 seconds. Three trials were performed in each position with a 20-second break between contractions. Trials were excluded if the hand moved between trials, noticeable compensatory strategies were used, or the individual did not perform the test correctly. Participants were allowed 2 submaximal (80% to 90% of maximum effort) contractions in each position to familiarize themselves with the test. The force plate was interfaced with commercially available data-collection software (ForceDecks, VALD Performance), and the average force from the 3 trials for each position was used for data analysis. Measures of anterior shoulder strength in each of the 3 positions demonstrated excellent reliability (ICC = 0.87 to 0.99, SEM = 6.3 to 10.8, minimal detectable change = 10.7% to 20.1%).[18]

Figure 3. Upper Quarter Y-Balance Test testing positions: A, medial; B, inferolateral; C, superolateral.

Dynamic Strength. The UQYBT was conducted to evaluate upper extremity performance.[9,11,12] Participants started in a plank position with the feet shoulder-width apart and the index finger of the testing shoulder on the zero-centimeter mark of the tape measure (Figure 3). They were instructed to maintain a 3-point position (1 arm and both legs in contact with the ground) to use the testing arm to slide a foam pad, with their fingertips, as far as possible systematically in the medial, inferolateral, and superolateral directions along a tape measure on the floor (Figure 3). Participants were provided a visual demonstration of the exercise by the examiner and were allowed up to 2 practice trials as needed. Three trials were performed in each direction with a 30-second rest break between sets. Test order sequence was randomized, but the arm tested first was consistent with the ROM measures. After measures were obtained for the initial arm, they were repeated for the opposite arm. A trial was repeated if the testing hand or either knee came in contact with the ground, if the individual forcefully pushed the foam pad across the floor, or if she did not maintain contact with the foam pad at all times. Results were normalized to participant arm length (distance from C7 to the tip of the third digit) for descriptive purposes. Excellent reliability measurements for the UQYBT were reported for intersession (ICC = 0.92 to 0.95) and interrater (ICC = 0.99 to 1.00) testing.[11,12]

Data Analysis

Statistical analyses were performed with SPSS (version 24.0; IBM Corp). Significance for all statistical analyses was established a priori as $P < .05$. Primary outcome measures were ER, IR, and total arc ROM (degrees); isometric strength (ER, IR, shoulder flexion, abduction, and horizontal abduction); ER:IR isometric strength expressed as a percentage; and UQYBT reach distances normalized to arm length. For descriptive purposes and to allow comparison with other studies, the strength data were normalized to body mass (kg) and reach distances were normalized to upper extremity length (cm). Paired-samples *t* tests were used to determine between-limbs differences for each outcome measure.

RESULTS

Participants demonstrated greater ER ROM (12.0°, 95% CI = 5.0°, 19.0°; $P = .02$) in the dominant arm relative to the nondominant arm and less IR ROM (–12.2°, 95% CI = –18.0°, –6.5°; $P < .001$) in the dominant arm relative to the nondominant arm (Table 2). Total arc of motion between sides did not differ (0.2°, 95% CI = –3.9°, 4.3°; $P = .91$). No differences were present between limbs for any of the shoulder strength measures: ER (–2.9 N, 95% CI = –10.3 N, 4.5 N; $P = .43$), IR (–0.9 N, 95% CI = –9.2 N, 7.3 N; $P = .82$), flexion (–1.5 N, 95% CI = –4.4 N, 1.2 N; $P = .25$), abduction (–1.3 N, 95% CI = –4.5 N, 1.9 N; $P = .40$), horizontal abduction (–1.3 N, 95% CI = –4.4 N, 1.7 N; $P = .37$), or the ratio for ER:IR (–1.4%, 95% CI = –7.0%, 4.4%; $P = .63$; Table 3). Additionally, normalized UQYBT reach distances did not display differences between limbs in the superolateral (–1.1%, 95% CI = –3.2%, 1.1%; $P = .37$), inferolateral (–1.3%, 95% CI = –4.0%, 1.5%; $P = .06$), or medial (–4.0%, 95% CI = –8.2%, 0.1%; $P = .34$) reach directions (Table 4).

DISCUSSION

The primary purpose of our study was to characterize differences in shoulder ROM and strength between the dominant and nondominant arms of healthy collegiate softball players. The main findings indicated that female softball players demonstrated greater ER ROM and less IR ROM in the dominant arm relative to the nondominant arm, while isometric and dynamic strength was relatively symmetric between arms. Chronic adaptations in glenohumeral joint ROM[4,5] and strength[7,8] are known to occur in the dominant arm relative to the nondominant arm in overhead athletes, but these results suggest that performance differences between limbs for throwing athletes may be sex or sport specific.

Table 2. Shoulder Range-of-Motion Measures

Motion, °	Arm, Mean ± SD		Mean Difference Scores (95% CI)	*P* Value
	Dominant	Nondominant		
Internal rotation	65.1 ± 10.6	77.3 ± 11.1	−12.2 (−18.0, −6.5)	<.001
External rotation	96.7 ± 12.7	84.6 ± 9.1	12.0 (5.0, 19.0)	.02
Total arc	161.7 ± 12.8	161.9 ± 13.4	0.2 (−3.9, 4.3)	.91

Table 3. Shoulder Strength Measures

Measure[a]	Arm, Mean ± SD		Mean Difference Scores (95% CI)	*P* Value
	Dominant	Nondominant		
External rotation	137.2 ± 25.4	140.5 ± 23.7	−2.9 (−10.3, 4.5)	.43
Normalized	17.2 ± 4.0	17.6 ± 3.8	−0.4 (−1.4, 0.6)	
Internal rotation	149.1 ± 25.9	151.7 ± 27.0	−0.9 (−9.2, 7.3)	.82
Normalized	18.7 ± 4.1	18.9 ± 4.5	−0.2 (−1.3, 1.0)	
External : internal rotation	92.3 ± 12.6	93.6 ± 8.7	−1.4 (−7.0, 4.4)	.63
Flexion	31.4 ± 10.0	33.0 ± 9.8	−1.5 (−4.4, 1.2)	.25
Normalized	4.1 ± 1.1	4.3 ± 1.2	−0.2 (−0.6, 0.2)	
Abduction, 135°	39.9 ± 9.3	41.2 ± 10.0	−1.3 (−4.5, 1.9)	.40
Normalized	5.2 ± 1.1	5.3 ± 1.1	−0.1 (−0.6, 0.3)	
Horizontal abduction, 90°	44.1 ± 9.0	45.5 ± 11.1	−1.3 (−4.4, 1.7)	.37
Normalized	5.7 ± 1.0	5.9 ± 1.4	−0.2 (−0.6, 0.2)	

[a] Values expressed as N except for normalized values.

Range of Motion

Both ER and IR ROM differed between limbs. This finding supports the general ROM adaptation pattern in both softball and baseball players.[1,4,5] Our participants had 12.0° more (95% CI = 5.0°, 19.0°) ER ROM in the dominant arm relative to the nondominant arm and 12.2° less (95% CI = –18.0°, –6.5°) IR ROM in the dominant arm relative to the nondominant arm. Despite these differences between limbs for ER and IR ROM, the total ROM between limbs was relatively similar (mean difference = 0.2°, 95% CI = –3.9°, 4.3°). Female softball players are known to demonstrate adaptive changes in the dominant arm relative to the nondominant arm, which include a loss of IR ROM and an increase in ER ROM but preservation of a consistent total arc of motion between sides.[5,13,19] Differences of approximately 12° for ER and IR ROM are of greater magnitude than in previous studies whose authors reported <5° difference in both ER and IR ROM between the dominant and nondominant arms in high school and collegiate softball players.[13,16,19] Although changes in ER and IR ROM occur during the season (increased ER, decreased IR),[3,20] we could not definitively determine if seasonal timing might explain the greater magnitude of differences we found. Data collection occurred in the preseason (November to January, before competitive play) which was relatively consistent with other researchers who did not include late-season measures.[13,16,19] The differences between sides that we noted were of greater magnitude than in earlier investigations, yet the total arc of motion (162°) fell within the ranges reported previously for collegiate-level softball players (134° to 162°),[13,19] uninjured overhead collegiate athletes (153°),[9] and first-year students at a military academy (163° to 164°).[21] Variance in point estimates may be due to subtle differences in the methods used to obtain ROM measures. Although the authors of comparative studies and we all described methods to minimize ROM from contributing sources (eg, adjacent joints, compensatory strategies),[9,13,19,21] those with the lowest ROM values relied on visual inspection of compensatory strategies and the examiners did not perform scapular stabilization while obtaining ROM measures.[19] In our work, a single examiner obtained ROM, which is common in clinical practice but requires the examiner to both measure and be aware of compensatory strategies. Future investigators may consider having 2 examiners assess ROM, 1 to record the measurement while the other stabilizes the glenohumeral joint and monitors for compensatory movement.

Female softball players are thought to have less IR ROM deficit than baseball players.[1] Research[22–24] on male baseball players has yielded IR ROM deficits ranging from 10° to 17°. An IR ROM difference between limbs >25° is a risk factor for injury (4 to 5 times greater risk) in high school baseball and softball players.[1] Earlier authors[1] found that softball players had a greater total arc of motion and horizontal-adduction ROM in the dominant arm compared with the dominant arm of baseball players. Female softball players are believed to demonstrate smaller changes in glenohumeral joint ROM in the dominant arm relative to the nondominant arm because the softball field has smaller dimensions than the baseball field and because a softball weighs 20% more than a baseball, which may influence joint torques and muscle contributions during throwing.[5] The concomitant increase in ER and decrease in IR ROM are frequently observed in throwing athletes in the dominant arm, yet the reason for this adaptation has not been determined.[1,2] Previous investigators[4–6,25] suggested it could be due to contracture of the posterior capsule, tightness of the inferior glenohumeral ligament or musculotendinous structures, or osseous changes, specifically humeral retroversion. Hibberd et al[5] reported an increase in

Table 4. Upper Quarter Y-Balance Test Reach Distances

Reach Direction[a]	Arm, Mean ± SD		Mean Difference Scores (95% CI)	*P* Value
	Dominant	Nondominant		
Medial	73.5 ± 8.1	74.3 ± 8.5	−0.83 (−2.7, 1.1)	.34
Normalized	85.5 ± 9.0	86.6 ± 10.1	−1.1 (−3.2, 1.1)	
Inferolateral	58.3 ± 10.2	61.7 ± 11.3	−1.1 (−3.5, 1.3)	.06
Normalized	48.8 ± 8.9	49.8 ± 9.2	−1.3 (−4.0, 1.5)	
Superolateral	41.6 ± 7.4	42.7 ± 7.8	−3.4 (−6.9, 0.1)	.37
Normalized	67.7 ± 10.9	71.7 ± 12.8	−4.0 (−8.2, 0.1)	

[a] Reach distance values expressed as cm except for normalized values.

the frequency of GIRD and humeral retroversion leading to total ROM differences in baseball players. Humeral retroversion has been suggested to have a direct correlation with a change in ROM, specifically an increase in ER ROM, in the dominant arm.[5,24] Because of this finding, physical adaptations and injuries may differ in the collegiate softball population. A limitation of our study was that position-specific (eg, pitcher, catcher, infield, outfield, utility) ROM measures were not examined due to the limited sample size (Table 1). When ROM differences between position players were compared, softball windmill pitchers showed no increase in ER ROM,[20] which may reflect differences in throwing mechanics. Future authors should better examine position-specific differences in ROM and more directly compare male and female athletes.

Isometric Strength

Across all strength measures, female collegiate softball players demonstrated no significant difference between sides. These results contrast with the findings for male baseball players, who displayed greater IR strength, with similar or less ER strength in the dominant relative to the nondominant arm.[26,27] High school and collegiate softball players exhibited increased IR strength in the dominant arm relative to the nondominant arm.[25] The windmill pitch requires rapid IR with delivery of the softball; constant motion repetition is thought to contribute to the increase in IR strength. The ER:IR strength ratio has clinical relevance for overhead athletes as these are common measures associated with injury.[9,14] Our findings indicated that ER and IR isometric strength was about 17% to 19% of body mass and ER:IR was 92% for both the dominant and nondominant arms. Isometric strength values were slightly lower than previously published values for both ER (21% body mass) and IR (19% to 21% body mass) isometric strength in female softball pitchers.[28] The ER:IR ratios from our research are much higher than reported dominant-arm ratios in collegiate and professional male baseball players (63% to 78%)[2,22,26,27] but are consistent with normative data from female softball players (100%)[14] and overhead collegiate-age female athletes (96% to 102%).[9] Lower ER:IR ratios are thought to be related to shoulder injuries,[9] and female collegiate softball pitchers with current upper extremity pain demonstrated lower ER:IR ratios (87% versus 100%) compared with uninjured pitchers.[14] Although isokinetic testing may be more functional than isometric testing, access to an isokinetic dynamometer may be limited. Thus, isometric tests may be a more clinically feasible option that can be performed using an HHD[8] or force plates.[18] A limitation of our work was that measures of ER and IR strength were obtained using an HHD held by the examiner versus a fixed stabilization method.[9,29,30] Fixed stabilization methods are more reliable than having the examiner hold the HHD, especially when the patient or participant is stronger than the examiner.[29] Because most forces obtained using the HHD were relatively low (average = 152 N) and were relatively consistent with results specific to female collegiate softball pitchers,[14] this may not have negatively affected our findings. Future authors should consider using a fixed stabilization method (eg, table leg) when testing athletic populations.[9]

In addition to the more common ER and IR isometric strength measurements, isometric shoulder strength was also tested in flexion, horizontal abduction, and 135° of abduction utilizing force plates (modified ASH test) to provide a global assessment of posterior shoulder strength. No differences were present between limbs. These results contrast with those from male baseball players (professional pitchers), in whom the dominant arm had stronger middle and lower trapezius muscles than the nondominant arm.[2] Strength differences between arms may be common in male baseball players,[2,8,22,26,27] yet our outcomes suggested that female softball players have relatively symmetric strength. We did not study male baseball players, so future researchers should better determine strength differences between limbs and sexes. A limitation of the isometric strength measure was that testing for flexion, abduction, and horizontal abduction constituted a modified version of the ASH test.[18] The ASH test was originally described as being performed in a prone position, targeting the anterior musculature of the shoulder. Our participants performed a modified version of the ASH test, which focused on the posterior musculature of the shoulder. The original version of the ASH test yielded excellent reliability (ICC = 0.87 to 0.99, SEM = 6.3 to 10.8, MDC = 10.7% to 20.1%) for evaluating the isometric strength of the anterior shoulder musculature, but normative values and reliability for measures of posterior shoulder muscle strength are not known. Future investigators should assess the reliability and validity of the ASH test for evaluating posterior shoulder musculature strength in the supine position across a variety of sport populations.

Dynamic Strength

The UQYBT is a reliable screening tool used to assess unilateral upper extremity stability and trunk mobility in a closed kinetic chain position.[11] Our results showed no difference between limbs for any of the UQYBT reach directions. Although a difference was evident between sides in glenohumeral joint ROM, this did not appear to negatively affect UQYBT reach distances. As previously suggested,[11] the UQYBT does not require the shoulder to reach near end ranges of motion and supports the idea that available motion may not specifically influence UQYBT performance. Limited sport-specific data exist for female softball players, especially at the collegiate level. Earlier authors focused on female softball players at the high school[11] or collegiate level[31] or on collegiate softball players as a component of a larger overhead collegiate athlete population.[9] Several researchers[12,32] discussed the need for normative data for overhead athletes at various levels of play to predict injuries. Normalized UQYBT reach distances for collegiate softball players in our study were substantially lower than those for high school softball players[11] and collegiate athletes.[9,31,33] Differences in study methods, specifically the device used for the UQYBT, may have contributed to different findings. We placed a tape measure on the floor and participants slid a foam pad along it, which contrasts with using athletic tape on the floor[9] or a commercially available device.[11,31,33] Another factor that may have contributed to shorter reach distances was that our participants were not provided a structured warm-up for the UQYBT. They were given a visual demonstration of the exercise by the examiner and were allowed up to 2 familiarization trials, but anecdotally, most individuals elected to not perform warm-up repetitions. Previous authors have used 2 to 3 repetitions in each direction as a warm-up before the 3 repetitions that were recorded for data analysis.[9,11,33] Testing was conducted in large groups with efforts to best minimize student-athlete time burden, and a limitation was that adequate warm-up was not provided on a relatively novel test. Future investigators should include adequate warm-ups for test procedures. Despite the shorter reach distances we noted, the overall performance between sides was not different.

Our participants had relatively symmetric reach distances, yet collegiate athletes with a history of upper extremity injury have demonstrated deficits in UQYBT reach distances, specifically in the superolateral reach direction.[9] Because data for the contralateral limb were not provided by Kim et al,[9] it is unclear whether the injured group had substantial asymmetry in reach distances or simply had decreased reach distances for both arms. Future researchers should determine whether achieving greater reach distances or more symmetric reach distances improves patient outcomes after upper extremity injury. Few tests have been established to determine readiness to return to play for athletes with an upper extremity injury. Our work advances knowledge of normative performance values for the UQYBT in a collegiate softball population and suggests that female collegiate softball players without a history of injury have relatively symmetric performance between sides.

Limitations

Despite the valuable normative data we provide, several limitations exist. The sample was limited to 1 women's NCAA Division I collegiate softball team. Thus, the findings cannot be extrapolated to other teams or levels of play. Additionally, given the limited sample size, it was not possible to determine position-specific normative values or compare positions (eg, pitcher, catcher, infield, outfield). Although individuals with a current upper extremity injury were excluded, it is possible that permanent impairments were present in those with a history of injury. Another limitation was that participants may have had a history of upper extremity injury that resulted in persistent impairments but were not excluded from the research because they did not report a current injury that restricted participation. It would be difficult to find a large group of athletes at this level who have not experienced at least 1 upper extremity injury during their careers. Furthermore, we did not conduct longitudinal follow-up over the course of the season to see if injuries developed. Future investigators should consider larger datasets with longitudinal tracking of injury rates. Also, it was not clear if outcomes would have differed from those of a comparison group (eg, athletes in a lower-extremity–specific sport or the general population). We did not include a control group or reference population given that our focus was on normative metrics for a population of healthy collegiate softball players. Future authors should continue to establish normative shoulder ROM and strength values for the collegiate softball population, with reference to other relevant comparison groups. Baseline data will allow us to further analyze and possibly predict shoulder injuries in this population.

Clinical Application

Range-of-motion and strength measures for throwing athletes are most often derived from male baseball players with the findings extrapolated to female softball players due to the commonalities in the throwing motions. Our collegiate softball players displayed increased ER ROM and decreased IR ROM in the dominant arm similar to baseball players in previous studies, yet shoulder strength did not differ. These results are essential for establishing normative ROM and strength benchmarks for collegiate softball players. Normative data allow clinicians to gain insight into possible injury prevention, guide rehabilitation interventions, and make better informed return-to-sport decisions after injury or surgery. Baseball and softball athletes are usually prescribed similar injury-prevention programs due to the similarities between the throwing motions and increased risk of injury due to common shoulder ROM conditions.[5] The collegiate softball population should continue to be evaluated to enable us to further understand sex- and sport-specific differences compared with male baseball players.

CONCLUSIONS

These findings provide potential normative data regarding shoulder ROM and strength for female collegiate softball players. Female collegiate softball players demonstrated greater ER ROM and less IR ROM in the dominant arm relative to the nondominant arm, which is consistent with softball and baseball participants in previous research. Although this specific finding was not unique, it highlights the potential for female collegiate softball players to develop ROM adaptations in the dominant arm. In contrast to male baseball players, our collegiate softball players showed relatively symmetric isometric and dynamic strength measures. Clinically, this offers preliminary evidence that uninjured female collegiate softball players have relatively symmetric isometric and dynamic strength. This suggests that after shoulder injury, in the absence of preinjury measures, clinicians can have some confidence in using the uninvolved limb as an adequate benchmark for strength measures. Additionally, strengthening interventions for the shoulder should continue to focus on symmetric strength, scapular and rotator cuff endurance, and neuromuscular control, especially in female overhead athletes. Performance differences between limbs may be sex or sport specific.

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