

Comparison of Range of Motion, Strength and Proprioception of Shoulder Joint in Overhead and Non-overhead Athletes: A Cross-sectional Study

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ABSTRACT

Introduction: The overhead throwing motion is a complex, highly coordinated musculoskeletal sequence that exerts multidirectional and supraphysiological stresses on the shoulders. The repetitive action causes adaptive structural modifications for the athlete to effectively conduct overhead motions. However, the modifications may lead to injuries and pain over time.

Aim: To examine the difference in proprioception, Range Of Motion (ROM), and shoulder strength between overhead and non-overhead athletes.

Materials and Methods: The present cross-sectional study was conducted in Vadodara, Gujarat, India from March 2023 to March 2024. Overhead and non-overhead athletes from various sports complex participated in the study. The players were above 18 years of age, played at least one hr/day, minimum three days/week, since at least a year. Players with acute shoulder pain, shoulder and neck surgeries were excluded from the study. Non-overhead athletes were also included for comparison. Shoulder ROM was assessed passively by using inclinometer, shoulder strength by handheld spring dynamometer and shoulder proprioception by inclinometer. Unpaired t-test was used for comparison between both groups and paired t-test was used for comparison within groups.

Results: Total 160 athletes (80 overhead and 80 non-overhead athletes) participated in the study. Mean age of overhead athletes was 26.90 years and a non-overhead athlete was 26.05 years. Shoulder flexion, extension, External Rotation (ER) ROM was significantly more ($p < 0.001$) and Internal Rotation (IR) was significantly less ($p < 0.001$) in overhead athletes compared to non-overhead athletes. Shoulder Flexion, Extension, ER range was significantly more in dominant hand of overhead athletes ($p < 0.001$). Shoulder strength was significantly more in non-overhead athletes ($p < 0.001$). Shoulder flexors, extensors and internal rotators strength was significantly more in dominant hand of overhead athletes ($p < 0.001$). Proprioception of ER 90° was more significant in non-overhead athletes ($p < 0.001$). There was no significant difference in shoulder proprioception with respect to dominance.

Conclusion: Shoulder flexion, extension, ER ROM was significantly more in overhead athletes and shoulder strength (except external rotator strength) significantly more in dominant hand of overhead athletes compared to non-dominant hand of overhead athletes. However, non-overhead athletes had more IR range compared to overhead athletes. The shoulder strength was significantly more in non-overhead athletes compared to overhead athletes.

Keywords: Joint stability, Physical performance, Sports, Upper extremity

INTRODUCTION

The shoulder's high mobility makes it susceptible to small injuries, especially from repetitive overhead motions in sports like tennis, badminton, basketball, swimming, and volleyball, where serving and smashing place significant stress on the joint [1]. Throwing stresses the shoulder and elbow joints across six different phases. Issues in any phase can increase stress, cause weakness, and lead to overuse injuries in overhead athletes. Understanding these phases is crucial for injury prevention [2]. Athletes playing overhead sports are those who raise their hand up over the head [3]. Similarly, those sports that require the use of the upper limbs but do not require frequent overhead motions are called non-overhead sports [3]. Non-overhead sports are those that require the use of the upper limbs but do not require frequent overhead motions like hockey, football and table tennis [3].

Overhead throwing stresses the shoulders, causing adaptations that improve performance but can disrupt normal movement. Balancing flexibility and stability, the "thrower's paradox" is crucial to avoid subluxation [4]. Basketball requires diverse skills and physical prowess, while volleyball demands strong upper body strength for its actions [5]. Volleyball's overhead actions, while different from

throwing, can cause shoulder instability, often multidirectional. "Swimmer's shoulder" covers various shoulder issues [6]. Tennis serves, like throwing, can cause shoulder instability [6].

Repetitive overhead sports lead to biomechanical overload, causing decreased internal, increased ER Glenohumeral IR Deficit (GIRD) and heightened injury risk. While ROM and strength alone aren't definitive, muscle balance and adequate ROM are vital for shoulder health in these athletes [7]. Repetitive overhead actions make the shoulder vulnerable; even minor ROM changes can cause microtrauma [8]. Rotational strength studies show varied results, with some finding strength imbalances in throwing shoulders [9]. Proprioception in throwers is also debated, with some suggesting improvement and others suggesting impairment due to laxity and excessive ROM [8,9].

Researchers hypothesised that throwers undergo certain adaptations over time [10]. Clinical observations indicate that hand dominance causes some variations between the dominant and non-dominant shoulders, bilateral comparisons may be deceptive [10]. Many studies have looked at shoulder ROM, strength, and proprioception in athletic populations like lawn tennis, baseball and volleyball players [1,4,5]. Only one study compared overhead

athletes to non-overhead athletes [3]. Thus, the aim of the present study was to assess and compare the proprioception, range, and shoulder strength in overhead and non-overhead athletes.

MATERIALS AND METHODS

The present cross-sectional study carried out on overhead and non-overhead athletes recruited from the sports complexes of Vadodara, Gujarat, India from March 2023 to March 2024. The study was approved by Sumandeep Vidyapeeth Institutional Ethics Committee (SVIEC) (SVIEC no- SVIEC/ON/PHYS/BNMPT/22APRIL/23/7) and registered with Clinical Trial Registry India (CTRI) with approval number (CTRI registration no. -CTRI/2023/05/053208). Permission from various sports complexes of Vadodara was taken.

Inclusion and Exclusion criteria: The study included athletes playing overhead and non-overhead sports. Athletes playing overhead sports (who raise the hand up over the head) [3], from 18 to 40 years of age, playing since at least a year for minimum one hour/day, three days a week, were included in the study. This included cricket bowlers, basketball players, volleyball players, swimmers, tennis players and badminton players. Players playing hockey, football, and kabaddi were included in the non-overhead category. Those sports that require the use of the upper limbs but do not require frequent overhead motions [3] like hockey, football and batsmen, were considered as non-overhead sports. Those athletes who had undergone shoulder surgery or having acute shoulder pain were excluded from the study. Those who were willing to participate gave a written informed consent form. A participant information sheet was given to them explaining the details of the study. The dominant limb was identified as the arm that would be used to throw a ball or start a movement (in case of swimming) for both overhead and non-overhead athletes.

Sample size calculation: Sample size was calculated using the following formula:

$$N=4pq/L^2$$

p= prevalence of various shoulder injuries in the overhead athletes=30% [11]

$$q=1-p=70\%$$

$$L=\text{allowable error}=10$$

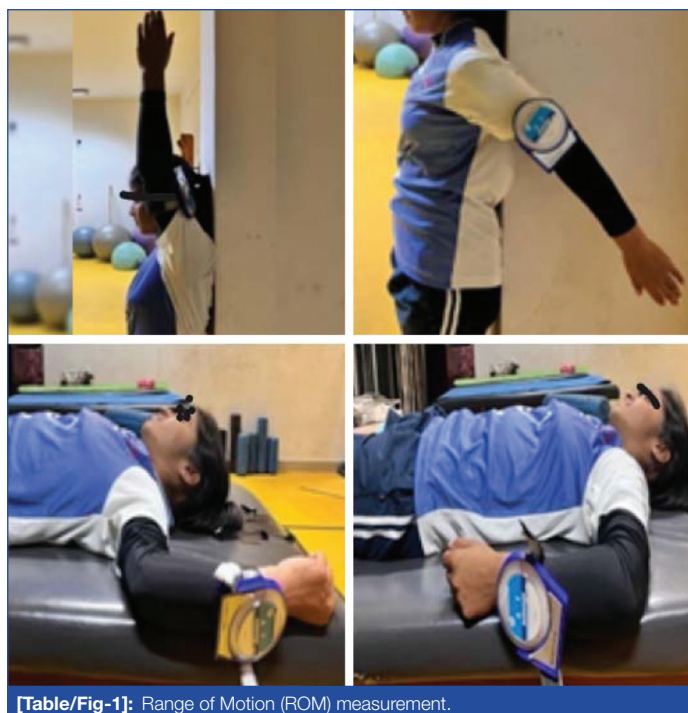
$$N=84$$

As non-overhead athletes were also taken in the study, the total sample size was taken as 80+80=160.

Study Procedure

STEP 1: To measure Range Of Motion (ROM): At the beginning of the test, the active shoulder movement of each athlete was determined for internal and ER, flexion and extension. An inclinometer was attached with a velcro strap to the lateral aspect of the subject's wrist proximal to the ulnar styloid process to test IR and ER. It was attached proximal to the elbow to measure flexion and extension. During active movement, the subject was instructed to make a fist to reduce additional hand and wrist movements. The active ROM of internal and ER was measured with the subject in a supine position, with the shoulder abducted and the elbow flexed at 90°. The internal and ER test was performed with the subject lying on his back so that the table stabilises the scapula, to reduce scapular rotation. Flexion and extension movements were measured while the subject was standing with the back touching the column. In this position, the subject was instructed to stand straight with the scapula already stabilised by the pillar. If the subject moved his body during any of the movement measurements, the experiment was repeated. The subjects had to keep the forearm in the same plane throughout the entire ROM [Table/Fig-1] [1].

STEP 2: To measure strength: At the beginning of the test, the isometric strength of each athlete's shoulder was determined for internal and ER, flexion and extension. A handheld spring



[Table/Fig-1]: Range of Motion (ROM) measurement.

dynamometer was attached to the lateral side of the subject's wrist with a strap for internal, external, flexion, and extension forces. During the strength test, the subject was instructed to make a fist to reduce possible external movements. The internal and external strength test was performed with the subject in the supine position, shoulder abducted and elbow flexed at 90°, with the scapula stabilised on a table. The rater provided stabilisation to the distal end of the humerus to prevent unwanted humeral movement. Flexion and extension strength were measured while the subject was standing with the back touching the column. In this position, the subject was instructed to stand straight, and the scapula was already stabilised by the pillar. If the subject moved the body during any of the force measurements, the test was repeated. The subjects had to keep the forearm in the same plane throughout the entire ROM [Table/Fig-2] [1].



[Table/Fig-2]: Muscle strength measurement.

STEP 3: Measurement of proprioception: Active joint position detection for internal and ER, flexion and extension of each athlete was determined at the beginning of the test. The inclinometer was attached with Velcro to the lateral side of the subject's wrist, just close

to the ulnar styloid process to test joint position detection of internal and ER. It was close to the elbow joint to detect flexion and extension movement. Target angles were calculated for all four movements on both the sides. These target angles were then used when the subject attempted to align the joint position with the sensory test during the required repositioning. Specifically, the investigators moved the subject's limb to the target corner and held it there for three seconds. The rest given between two trials was three to five seconds. The subject was then instructed to relax and actively return the hand to the neutral starting position. During the IR/ER test, a neutral position was achieved when the arm was perpendicular to the table (0° shoulder rotation). During the flexion/extension test, a neutral position was achieved with the subject's arm relaxed at the side. Each subject was then allowed to actively move their hand back to the target and let the experimenter know when they felt they had reproduced the original target perspective. The hand was kept still while the angle measurement was recorded. The transfer was repeated three times for each of the four movements. Both the sides were tested. The subject was instructed to make a fist with the accompanying hand, thus reducing the additional movements of the hand and wrist. Active joint position sensing for IR and ER was measured with the subject supine, shoulder abducted, and elbow flexed 90°. The internal and ER test was performed with the subject in a supine position so that the scapula stabilised the table, which reduced scapular motion. Flexion and extension movements were measured while the subject was standing with the back touching the column. In this position, the subject was instructed to maintain a vertical position and the scapula were already stabilised by the pillar. If the subject moved his body during any of the measurements, the experiment was repeated. The subjects had to keep the forearm in the same plane throughout the entire ROM [1]. Proprioception for flexion movement was measured at 60,90 and 120 degrees. Proprioception for extension movement was measured at 20,40 and 60 degrees. Proprioception for IR movement was measured at 20,40 and 60 degrees. Proprioception for ER movement was measured at 20,40 and 60 degrees [Table/ Fig-3] [12].



[Table/Fig-3]: Proprioception measurement.

STATISTICAL ANALYSIS

All statistical analysis was done using Statistical Package for Social Sciences (SPSS) 25 software for windows. Descriptive analysis was obtained by mean and standard deviation. The data was found to be normally distributed. Independent t-test was performed to compare shoulder strength, ROM and proprioception between overhead and non-overhead athletes. Paired t-test was used to compare

the shoulder strength, ROM and proprioception of dominant and non-dominant hand in each group. Significance level was kept at $p < 0.05$.

RESULTS

Total 160 participants were included in the study among them 80 were overhead athletes and 80 non-overhead athletes. Baseline characteristics of participants in both the groups have been shown in [Table/Fig-4]. This includes age, Body Mass Index (BMI) and training hours in both overhead and non-overhead group. The mean years of experience for overhead group was 6.34 ± 3.18 years and for non-overhead group was 5.33 ± 2.68 years.

Variables	Overhead athletes Mean SD	Non-overhead athletes Mean SD	p-value
Age (years)	26.90±5.267	26.05±3.445	0.607
BMI (Kg/m ²)	24.14±3.95	24.17±2.40	0.182
Training hours (hours)	2.138±0.7671	1.925±0.4577	0.665

[Table/Fig-4]: Baseline characteristics in both the groups. *independent t test, $p < 0.05$; significant

As seen in [Table/Fig-5], badminton players were the most in number in overhead athletes, followed by lawn tennis, basketball and swimming. Bowlers were the least in number. Football, kabaddi, hockey players and runners were equally distributed, with batsmen being the highest in numbers [Table/Fig-6].

Shoulder flexion, extension and ER ranges were significantly more and shoulder IR range was significantly less in overhead athletes compared to non-overhead athletes ($p < 0.05$) [Table/Fig-7].

Overhead sports	No. of participants (n=80)	Percentage (%)
Volleyball	12	15
Cricket (bowler)	2	2.5
Lawn tennis	18	22.5
Basketball	16	20
Swimming	12	15
Badminton	20	25

[Table/Fig-5]: Distribution of overhead athletes in various sports.

Non-overhead sports	No. of participants (n=80)	Percentage (%)
Cricket (batsmen)	20	25
Football	15	18.75
Kabaddi	15	18.75
Hockey	15	18.75
Runners	15	18.75

[Table/Fig-6]: Distribution of non-overhead athletes in various sports.

Variable (degrees)		Mean (SD)	SEM	T	p-value
Flexion	OH	178.13±5.91	0.66	1.987	0.048
	NOH	176.50±4.31	0.48		
Extension	OH	62.98±7.18	0.80	6.816	<0.001
	NOH	56.38±4.84	0.54		
Internal Rotation (IR)	OH	66.28±5.36	0.60	10.925	<0.001
	NOH	76.55±6.49	0.73		
External Rotation (ER)	OH	92.14±3.54	0.40	6.209	<0.001
	NOH	88.89±3.07	0.34		

[Table/Fig-7]: Difference in shoulder ranges of dominant hand between overhead and non-overhead athletes. Independent t-test, $p < 0.05$; significant SD: Standard deviation, SEM: Standard error mean, OH: overhead, NOH: Non-overhead

Shoulder flexor, extensor, external rotators, internal rotators were significantly more in non-overhead athletes ($p < 0.05$). The strength

in shoulder flexors, extensors, internal and external rotators was significantly more in non-overhead athletes compared to overhead athletes ($p < 0.05$) [Table/Fig-8].

Variables (kg)		Mean (SD)	SEM	T	p-value
Flexors	OH	9.754±2.77	0.31	3.507	<0.001
	NOH	11.07±1.92	0.21		
Extensors	OH	7.330±1.55	0.17	12.557	<0.001
	NOH	10.504±1.64	0.18		
Internal rotators	OH	5.994±1.43	0.16	22.217	<0.001
	NOH	10.836±1.32	0.14		
External rotators	OH	4.966±1.27	0.14	32.400	<0.001
	NOH	11.49±1.27	0.14		

[Table/Fig-8]: Difference in shoulder strength of dominant hand between overhead and non-overhead athletes. Independent t-test, $p < 0.05$: significant SD: Standard deviation; SEM: Standard error mean; OH: overhead; NOH: Non-overhead

Shoulder ER proprioception at 90° was significantly more in non-overhead athletes ($p < 0.05$). Proprioception for all other movements was not different in both the groups [Table/Fig-9].

Variables (degrees)		Mean (SD)	SEM	T	p-value
Proprioception Flexion 60°	OH	60.909±1.79	0.200	2.357	0.019
	NOH	60.219±1.90	0.213		
Proprioception Flexion 90°	OH	90.216±1.90	0.212	1.274	0.204
	NOH	89.822±2.013	0.225		
Proprioception Flexion 120°	OH	120.56±1.77	0.197	0.538	0.591
	NOH	120.40±2.12	0.237		
Proprioception Extension 20°	OH	21.10±1.96	0.219	2.062	0.040
	NOH	20.41±2.270	0.253		
Proprioception Extension 40°	OH	40.45±2.09	0.234	0.294	0.769
	NOH	40.54±2.03	0.227		
Proprioception Extension 60°	OH	60.46±1.59	0.178	0.843	0.400
	NOH	60.21±2.12	0.237		
Proprioception Internal Rotation (IR) 20°	OH	20.88±1.79	0.200	0.091	0.927
	NOH	20.85±2.27	0.254		
Proprioception Internal Rotation (IR) 40°	OH	40.13±2.12	0.238	1.222	0.223
	NOH	40.58±2.42	0.271		
Proprioception Internal Rotation (IR) 60°	OH	60.51±1.77	0.198	0.396	0.692
	NOH	60.38±2.30	0.258		
Proprioception External Rotation (ER) 30°	OH	30.86±2.67	0.299	0.157	0.874
	NOH	30.92±2.55	0.285		
Proprioception External Rotation (ER) 60°	OH	60.24±2.40	0.269	0.864	0.388
	NOH	60.56±2.14	0.240		
Proprioception External Rotation (ER) 90°	OH	89.47±2.38	0.267	3.375	<0.001
	NOH	90.71±2.26	0.253		

[Table/Fig-9]: Difference in shoulder proprioception of dominant hand between overhead and non-overhead athletes. Independent t-test, $p < 0.05$: significant SD: Standard deviation; SEM: Standard error mean; OH: Overhead; NOH: Non-overhead

As seen in [Table/Fig-10], shoulder flexion, extension, and ER were significantly more in dominant hand and IR was significantly less in the dominant hand compared to non-dominant hand ($p < 0.05$).

The strength in shoulder flexors, extensors and internal rotators was significantly more in dominant hand and strength in external rotators was significantly less in the dominant hand compared to non-dominant hand ($p < 0.05$) [Table/Fig-11]. There was no statistically significant difference in shoulder proprioception for any of the movements with respect to dominance in overhead athletes as seen in [Table/Fig-12].

Variables (degrees)		Mean (SD)	SEM	T	p-value
Flexion	D	178.13±5.91	0.66	6.04	<0.001
	ND	175.76±4.98	0.56		
Extension	D	62.98±7.18	0.80	3.69	<0.001
	ND	61.59±7.69	0.86		
Internal Rotation (IR)	D	66.28±5.36	0.60	7.96	<0.001
	ND	69.43±4.84	0.54		
External Rotation (ER)	D	92.14±3.54	0.40	5.60	<0.001
	ND	90.25±2.86	0.32		

[Table/Fig-10]: Difference in shoulder ranges in overhead athletes with respect to dominance. Paired t-test, $p < 0.05$: significant SD: Standard deviation; SEM: Standard error mean; D: Dominant side; ND: Non dominant side

Variables (kg)		Mean (SD)	SEM	T	p-value
Flexors	D	9.75±2.77	0.31	3.56	<0.001
	ND	9.61±2.78	0.31		
Extensors	D	7.33±1.55	0.17	4.17	<0.001
	ND	7.19±1.62	0.18		
Internal rotators	D	5.99±1.43	0.16	3.59	<0.001
	ND	5.82±1.47	0.16		
External rotators	D	4.96±1.27	0.14	6.58	<0.001
	ND	5.30±1.38	0.15		

[Table/Fig-11]: Difference in shoulder strength in overhead athletes with respect to dominance. Paired t-test, $p < 0.05$: significant SD: Standard deviation; SEM: Standard error mean; D: Dominant side; ND: Non dominant side

Variable (degrees)		Mean (SD)	SEM	T	p-value
Proprioception Flexion 60°	D	60.90±1.79	0.20	0.725	0.470
	ND	60.69±2.03	0.22		
Proprioception Flexion 90°	D	90.21±1.90	0.21	0.286	0.775
	ND	90.30±2.15	0.24		
Proprioception Flexion 120°	D	120.56±1.77	0.19	0.354	0.724
	ND	120.47±1.90	0.21		
Proprioception Extension 20°	D	21.10±1.96	0.21	0.636	0.526
	ND	20.90±2.13	0.23		
Proprioception Extension 40°	D	40.45±2.09	0.23	0.503	0.616
	ND	40.24±2.77	0.30		
Proprioception Extension 60°	D	60.46±1.59	0.17	0.526	0.600
	ND	60.63±2.45	0.27		
Proprioception Internal Rotation (IR) 20°	D	20.88±1.79	0.20	0.077	0.938
	ND	20.91±0.41	0.26		
Proprioception Internal Rotation (IR) 40°	D	40.13±2.12	0.23	1.096	0.276
	ND	40.55±2.45	0.27		
Proprioception Internal Rotation (IR) 60°	D	60.51±1.77	0.19	0.365	0.715
	ND	60.40±2.18	0.24		
Proprioception External Rotation (ER) 30°	D	30.86±2.67	0.29	1.081	0.282
	ND	30.47±2.02	0.22		
Proprioception External Rotation (ER) 60°	D	60.24±2.40	0.26	0.511	0.610
	ND	60.40±1.63	0.18		
Proprioception External Rotation (ER) 90°	D	89.47±2.38	0.26	1.311	0.193
	ND	89.00±2.11	0.23		

[Table/Fig-12]: Difference in shoulder proprioception with respect to dominance in overhead athletes. Paired t-test, $p < 0.05$: significant SD: Standard deviation; SEM: Standard error mean; D: Dominant side; ND: Non dominant side

DISCUSSION

In this study, overhead athletes had significantly greater ranges of shoulder flexion, extension, and ER, and reduced ranges of IR

compared to non-overhead athletes, which is in line with the results of Nodehi-Moghadam A et al., [13]. According to these authors, the demands of throwing may lead to an increase in shoulder ER range, which may or may not result in a decrease in shoulder IR. The posterior soft tissue structures' tightness results in an IR deficit. The resultant loss of IR and an increase in ER, has been ascribed to either the advancement of glenohumeral laxity that was already present or to recurrent micro traumatic stressors that cause the posterior shoulder capsule to become taut [3,13,14]. According to Wilk KE et al., majority of throwers have their shoulders rotating more externally and less internally [14]. GIRD is the term used to describe this lack of IR in the throwing shoulder [14-17]. There is higher humeral retro torsion on throwing side than the non-throwing side, which causes an increase in shoulder ER and a decrease in IR ROM without changing the total amount of shoulder ROM [18-20]. As reported by Dwelly PM et al., over the course of one athletic season, rise in glenohumeral ER ROM was observed in the dominant shoulders, but not in IR range. This increase was secondary to the demands of throwing. Maximal ER is needed in the later phase of cocking to attain the ideal internal rotation velocity [17,18].

The athletes included in the non-overhead category, in the present study were runners, football, kabaddi, cricket (batsmen), and hockey players. Non-overhead athletes possessed much greater strength in all shoulder muscles compared to their overhead counterparts which is in contrast to the findings of Nodehi-Moghadam A et al., [13]. They found overhead athletes to have more strength in their rotators compared to non-athletic athletes. In the present study, all the athletes participating in non-overhead sports trained in strength and resistance before competition, while players participating in overhead sports only trained in flexibility and stretching. It is possible that this made non-overhead athletes stronger. However, the training methods used by both the groups were not measured systematically, in the present study. According to Vanderstukken F et al., all hockey players hold the stick in the same manner, regardless of hand dominance, which causes each shoulder to load differently during play. Also, hockey players utilise their upper limbs a lot; both in closed and open chains [21,22]. This fact could also be responsible for more strength in non-overhead athletes, especially hockey players. Pramanick S et al., reported that the most important factors in Kabaddi are explosive strength in the shoulders and legs. It needs strength in the shoulders and legs to jump and kick or move quickly. Therefore, a major focus of kabaddi players' physical training is typically on strengthening their thigh, leg, and shoulder muscles [23]. Increased upper body strength is especially crucial for hitting forceful cricket strokes. According to Taliep MS et al., an essential component of a cricket batsman's success is having strong upper body muscles [24]. Strengthening is therefore stressed in all non-overhead sports, which may have contributed to non-overhead athletes' comparatively higher strength. In contrast to the results of the present study, a study by Nodehi-Moghadam A et al., demonstrated that the shoulder rotator muscles of throwing athletes were noticeably stronger than those of non-athletic subjects [13]. In comparison to the throwing group, research revealed that the non-throwing subjects had more trouble identifying motion. The explanation might be that throwing athletes produce more laxity since they have more years of expertise in unilateral overhead sports. Findings contradict those of research by Dover GC et al., which indicate that overhead throwers have a proprioception deficit in comparison to controls [25]. The authors attributed the discrepancy in the results to the sports involved and the duration of the overhead throwing athletes. Longer years of expertise in unilateral overhead sports may cause throwing athletes to become slacker and show a tendency towards proprioceptive reduction [13,25]. Similarly, in this study also, shoulder ER proprioception at 90° was significantly more in non-overhead athletes ($p < 0.05$). Proprioception for all other movements was not different in both the groups.

The present study indicated that in overhead athletes, the dominant hand had more strength in shoulder flexors, extensors and internal rotators and lower strength in external rotators which is in line with the findings of a study by Nodehi-Moghadam A et al., [13]. These authors reported that the shoulder rotator muscles in throwing athletes provided critical stability and mobility to the glenohumeral joint. Also, the average eccentric external rotator strength was weaker in the dominant arm, compared to the concentric internal rotator strength. To provide proper dynamic stabilisation, the external to internal muscles strength ratio should be 66% to 75% [13]. This in the present study was found to be 78%. In contrast to previous research on young, male, elite tennis players, Stanley A et al., found no impact of dominance in the strength ratios of amateur female tennis players, but larger IR/ER ratios in the dominant arm. They believed that because amateur athletes compete and train at different frequencies and intensities, and because these variations may potentially be due to variations in technique, the muscle adaptations that amateur athletes experience are far smaller than those of elite athletes [26].

Limitation(s)

The distribution of different sports in the overhead and non-overhead category was not equal.

CONCLUSION(S)

Overhead athletes exhibit greater shoulder flexibility in flexion, extension, and ER, but less strength and internal rotation compared to non-overhead athletes. Dominant hands in overhead athletes show further ROM and strength gains, except for ER. Proprioception varies based on activity and range. Longitudinal studies incorporating management of strength and ROM deficits may be undertaken.

REFERENCES

- Saadatian A, Sahebozamani M, Amiri Khorasani MT, Karimi MT, Sadeghi M. Comparison of shoulder joint functional range of motion in overhead athletes with and without shoulder impingement syndrome: A cross-sectional study. *J Rehabil Sci Res.* 2018;5(2):31-35.
- Mayes M, Salesky M, Lansdown DA. Throwing injury prevention strategies with a whole kinetic chain-focused approach. *Curr Rev Musculoskelet Med.* 2022;15(2):53-64.
- Ohuchi K, Kijima H, Saito H, Sugimura Y, Yoshikawa T, Miyakoshi N. Risk factors for glenohumeral internal rotation deficit in adolescent athletes: A comparison of overhead sports and non-overhead sports. *Cureus.* 2023;15(1):e34045. Doi: 10.7759/cureus.34045.
- Trasolini NA, Nicholson KF, Mylott J, Bullock GS, Hulburt TC, Waterman BR. Biomechanical analysis of the throwing athlete and its impact on return to sport. *Arthrosc Sports Med Rehabil.* 2022;4(1):e83-e91.
- Vurgun N, Cengiz ŞŞ, Örcütas H. Comparison of upper extremity proprioception among team athletes. *Akdeniz Spor Bilim Derg.* 2022;5(Suppl 1):382-90.
- DeFroda SF, Goyal D, Patel N, Gupta N, Mulcahey MK. Shoulder instability in the overhead athlete. *Curr Sports Med Rep.* 2018;17(9):308-14.
- Kibler WB, Sciascia A. The overhead athlete. In: *Shoulder arthroscopy: Principles and practice.* Berlin (DE): Springer; 2023. p. 405-26.
- Edmonds EW, Dengerink DD. Common conditions in the overhead athlete. *Am Fam Physician.* 2014;89(7):537-41.
- Kennedy DJ, Visco CJ, Press J. Current concepts for shoulder training in the overhead athlete. *Curr Sports Med Rep.* 2009;8(3):154-60.
- Bakshi N, Freehill MT. The overhead athlete's shoulder. *Sports Med Arthrosc Rev.* 2018;26(3):88-94.
- Laudner K, Sipes R. The incidence of shoulder injury among collegiate overhead athletes. *J Intercoll Sport.* 2009;2(2):260-68.
- Lubiatowski P, Ogrodowicz P, Wojtaszek M, Kaniewski R, Stefaniak J, Dudziński W, et al. Measurement of active shoulder proprioception: Dedicated system and device. *Eur J Orthop Surg Traumatol.* 2013;23(2):177-83.
- Nodehi-Moghadam A, Nasrin N, Kharazmi A, Eskandari Z. A comparative study on shoulder rotational strength, range of motion and proprioception between throwing athletes and non-athletic persons. *Asian J Sports Med.* 2013;4(1):34.
- Wilk KE, Obma P, Simpson CD, Cain EL, Dugas J, Andrews JR. Shoulder injuries in the overhead athlete. *J Orthop Sports Phys Ther.* 2009;39(2):38-54.
- Holt K, Boettcher C, Halaki M, Ginn KA. Humeral torsion and shoulder rotation range of motion parameters in elite swimmers. *J Sci Med Sport.* 2017;20(5):469-74.
- Vairo GL, Duffey ML, Owens BD, Cameron KL. Clinical descriptive measures of shoulder range of motion for a healthy, young and physically active cohort. *Sports Med Arthrosc Rehabil Ther Technol.* 2012;4(1):1-7.

- [17] Dwelly PM, Tripp BL, Tripp PA, Eberman LE, Gorin S. Glenohumeral rotational range of motion in collegiate overhead-throwing athletes during an athletic season. *J Athl Train.* 2009;44(6):611-16.
- [18] Pereira FR, Gonçalves GG, Reis DR, Rohlfis IC, Mendonça LD, Bittencourt NF. Comparison of glenohumeral joint rotation range of motion in young athletes. *Rev Bras Med Esporte.* 2019;25(1):53-57. Doi: 10.1590/1517-869220192501141465.
- [19] Mizoguchi Y, Suzuki K, Shimada N, Naka H, Kimura F, Akasaka K. Prevalence of glenohumeral internal rotation deficit and sex differences in range of motion of adolescent volleyball players: A case-control study. *Healthcare (Basel).* 2022;10(11):2263.
- [20] Barnes CJ, Van Steyn SJ, Fischer RA. The effects of age, sex, and shoulder dominance on range of motion of the shoulder. *J Shoulder Elbow Surg.* 2001;10(3):242-46.
- [21] Vanderstukken F, Borms D, Berckmans K, Spanhove V, Cools AM. Relative scapular-muscle ratios during maximal isokinetic shoulder-girdle strength performance in elite field hockey players. *J Athl Train.* 2020;55(3):274-81.
- [22] Vanderstukken F, Jansen N, Mertens T, Cools AM. Elite male field hockey players have symmetric isokinetic glenohumeral strength profiles but show asymmetry in scapular muscle strength. *J Sports Sci.* 2019;37(5):484-91.
- [23] Pramanick S, Chowdhuri P, Dutta R, Rahaman A. The strength and power of kabaddi and athletics players. *Int J Physiol Nutr Phys Educ.* 2022;19(1):20-28.
- [24] Taliep MS, Prim SK, Gray J. Upper body muscle strength and batting performance in cricket batsmen. *J Strength Cond Res.* 2010;24(12):3484-87.
- [25] Dover GC, Kaminski TW, Meister K, Powers ME, Horodyski M. Assessment of shoulder proprioception in the female softball athlete. *Am J Sports Med.* 2003;31(3):431-37.
- [26] Stanley A, McGann R, Hall J, McKenna L, Briffa NK. Shoulder strength and range of motion in female amateur-league tennis players. *J Orthop Sports Phys Ther.* 2004;34(7):402-09.

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