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Comparing the effectiveness of thrower's specific exercise program with regular warm-up program in recreational cricket bowlers

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ABSTRACT

INTRODUCTION: Thrower's Ten program is a thrower-specific workout program that increases upper-extremity strength, power, and endurance, especially in overhead athletes. The study compares the thrower's ten-exercise program to the regular warm-up program in recreational cricket bowlers' posterior capsule tightness, internal rotator strength, upper extremity stability, and explosive power.

METHODS: Based on inclusion and exclusion criteria, 82 recreational cricket bowlers were divided into experimental (n=41) and control (n=41) groups. The experimental group received Thrower's ten warm-up programs three times a week for six weeks, along with the standard warm-up. Control maintained its warm-up routine. Before and after six weeks, participants were tested for shoulder internal rotator strength, posterior capsule tightness, stability, and explosive power. SPSS software was used to calculate outcome measures mean, standard deviation, independent t-test, and paired t-test.

RESULTS: After six weeks, all outcome measures exhibited a significant difference ($p<0.05$) within the experimental group, whereas none of the outcome measures depicted a significant difference ($p>0.05$) within the control group. A significant difference ($p<0.05$) was seen between the groups for post-test strength and upper extremity stability measures. However, a non-significant difference ($p>0.05$) was noted between groups for posterior capsule tightness and upper extremity explosive power.

CONCLUSION: Compared to the usual warm-up program used by recreational cricket bowlers, the thrower's customized warm-up routine is more successful in improving internal rotator strength and upper extremity stability. Both warm-up programs enhance posterior capsule tightness and upper extremity explosive power.

Keywords: Warm-up, Throwers, Recreational, Cricket bowlers

INTRODUCTION

In the last few decades, a consistently high popularity of cricket in the Asian subcontinent has been witnessed. Irrespective of what level it is being played, cricket's dynamic nature and

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associated uncertainty make it interesting [1]. Bowling is one of the most vital components for the team's success. Cricket bowlers subject their upper extremities to extremes of range of motion (ROM) and repetitive movements, hence, are extremely prone to various injuries (especially of the shoulder) [2]. The British Sports Council recorded 2.6 cricket injuries per 10,000 hours played in a study. A comparable survey conducted by the Australian Cricket Board (ACB) found a result of 24.2 cricket injuries per 10,000 hours played, significantly higher than the data supplied by the British survey. In contrast, upper extremity injuries occur for 25% to 32% of all [3]. Most shoulder injuries comprise the soft tissues (e.g., muscle-tendon unit, cartilage). Shoulder joint conditions can contribute to more than 50% of injuries in throwing sports [2]. Dominant extremity is mainly affected in most athletic shoulder pathologies unless the etiology is a direct trauma. Studies suggest that superior translation of the humerus can result from rotator cuff along with deltoid weakness, resulting in impingement against the subacromial arch that contributes to the deterioration of the rotator cuff, biceps tendinitis, and bursitis [2]. Throwing action moves the body in profuse degrees. It requires the generation of kinetic energy to propel the ball with a velocity produced primarily by the torso and released through the throwing motion. Dissipation of residual energy is vital once the ball is released [2]. Huge distraction forces are produced at the shoulder in the deceleration phase of throwing, which may lead to posterior shoulder tightness [4,5]. The tightness of the posterior capsule of the shoulder and other dynamic restrictions (infraspinatus, posterior deltoid, latissimus dorsi, and teres minor) may result due to the accumulation of such forces, which further results in altered ROM [6,7].

A study done by Keller et al. on overhead athletes reported that, due to repetitive overhead motion with skeletal maturity, force, and torque experienced by the shoulder, changes in ROM, particularly hiked external rotation (ER) and reduced internal rotation (IR), could lead to glenohumeral internal rotation deficit (GIRD) [8]. Wilk et al. defined GIRD as a 20° or more deficit of IR when comparing a throwing shoulder to a non-throwing shoulder. Pitchers having GIRD are nearly twice as likely to be injured as those without GIRD as investigated [9]. The stability of the upper limb is something that should be considered and taken into account. Few studies are available on stability on the upper limb in cricket bowlers. Contemori et al. studied that dynamic and static stability deficits could lead to functional stability alternations and impair the neuromuscular plan that protects the shoulder, predisposing it to overuse or acute injuries [10]. It is vital to have an effective warm-up program for the upper limb as it prepares and helps transition the athlete from resting to a state of exercise, ensuring minimal residual fatigue for the body for the upcoming exercise (sports event) [11], maximizing performance in both training and competition [12]. It is seen that 79% of studies evaluating the effects of warm-up on the subsequent physical execution of tasks found improvements [13]. One guideline for the intensity of warm-up is minor sweating without fatigue. In case of a time delay, positive metabolic effects could be neglected between warm-up and match play during half-time. It is crucial not to warm up too early as the effect of warm-up lasts only for 30 min [12]. Thrower's specific exercise program is a standardized, ordered exercise protocol mapped out to work on the major muscles essential for throwing. The exercises are specific to throwers and are formulated to enhance endurance, power, and strength of shoulder complex musculature [14]. For cricket bowlers, the thrower's specific exercise program can be a quality warm-up program as it incorporates movement patterns, including throwing-directed motions, coordination, high-level dynamic stabilization, neuromuscular control, endurance, and force. EMG findings indicate that this program incorporates exercises that make upper limb muscles and shoulder complex work in the most dynamic way [15].

Escamilla et al. implied that all the 3 training programs (Throwers Ten, Plyometric, and Keiser Pneumatic- 6 weeks) enhanced the throwing velocity in high school baseball players [15]. Gokalp et al. reported that the thrower's ten exercises are a productive way to upgrade the explosive power, isokinetic strength, and balance of the upper limb in sedentary individuals [16]. Kevin et al. reported using a thrower's exercise program in the intermediate, advanced, and return to throwing phase in the post-operative rehabilitation of thermal-assisted capsular shrinkage of the glenohumeral joint [17]. The studies on the thrower's exercise program demonstrated its use in rehabilitation post-injury or post-surgery, improving throwing velocity,

accuracy, and strengthening. Studies are mostly done on baseball players, tennis players, and badminton players. Hence, few types of research implicate the effectiveness of throwers' specific exercise programs in cricket bowlers. Therefore, our study aimed to compare the effectiveness of the thrower's specific exercise program with the regular warm-up program in improving strength, posterior capsule tightness, upper extremity stability, and explosive power in recreational cricket bowlers. We hypothesized that there would be a significant difference in strength, posterior capsule tightness, stability, and explosive power compared to regular warm-ups in recreational cricket bowlers.

METHODS

A Quasi-experimental study was conducted on 82 recreational cricket bowlers recruited as participants from cricket academies around Bangalore. With the help of a simple random sampling technique, participants were randomly divided into Group A (experimental group; n= 41) and Group B (control group; n= 41). The experimental group underwent the thrower's ten protocol thrice a week till 6 weeks, along with a regular warm-up program. In contrast, the control group was asked to continue their regular warm-up exercises. Data for outcome measures were collected twice, i.e., pre-test before starting the intervention and post-test after 6 weeks. The inclusion criteria consist of recreational male cricket bowlers in the age range of 18 to 25 years [18,19], athletes involved in playing cricket for more than a year [20], having no history of injury or surgery related to the upper body, shoulders or arms [20] and athletes in regular practice, conditioning, and skill related cricket training. Athletes with any history of upper extremity trauma in the past year, history of shoulder surgery, or any known systemic, neurological, or rheumatological disorders were excluded from the study [20,4]. Figure 1 gives the flowchart of the experiment. The participants were assessed for strength of internal rotators of the shoulder (subscapularis, latissimus dorsi, teres major, and pectoralis [21] using a Lafayette muscle tester (ICCs= 0.77 to 0.99) [22]. Participants were sitting, and their shoulder was abducted to 90° in the ER. The muscle tester was placed on the volar aspect of the wrist. The participant was instructed to

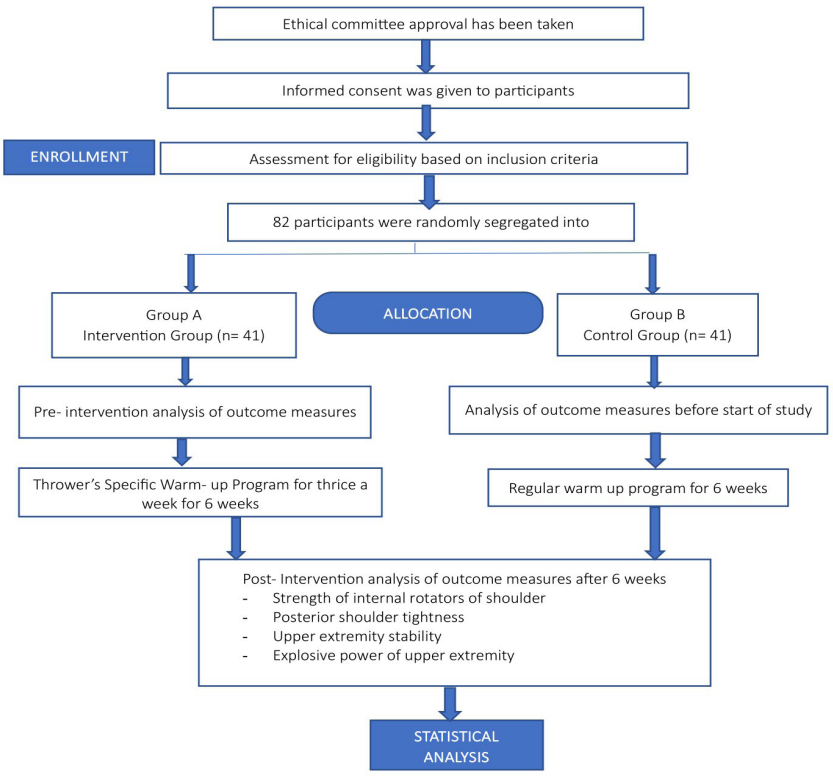

Figure 1. The flowchart of the experiment

Table 1: Progression of Thrower's specific exercise program for the experimental group

Weeks	Resistance band colors (34-36) (Theraband)	No. of repetitions	No. of sets	Rest time (between each set-in minutes)
Weeks 1 to 2	Green	10	2	3
Weeks 3 to 4	Green	10	3	3
Weeks 5 to 6	Blue	15	3	3

perform IR resisting with maximal force, whereas the tester performed a break test simultaneously. A mean of 2 trials was used as a result [22-24].

Tightness of the posterior capsule and other dynamic constraints (teres minor, posterior deltoid, latissimus dorsi, and infraspinatus) may result due to the accumulation of forces in the follow-through phase of throwing, which further results in altered ROM, especially reduced glenohumeral internal rotation in throwing arm. [4]. In this study, a universal goniometer (ICC=0.53–0.97) [5] is used to measure the internal glenohumeral rotation [25]. During the measurement, the participant was lying supine with the shoulder in 90° abduction and the elbow in 90° flexion [4,5,9,26]. The fulcrum of the goniometer was placed on the olecranon process, and the stationary arm was parallel to the floor. The movable arc is along the forearm's ulnar border, and the participant was asked to perform internal rotation of the glenohumeral joint, and range was noted [4,5,9,26].

Institutional ethical clearance (Ref. No.: EC-MPT/21/PHY/006) was obtained for the study. Recreational cricket bowlers were given the consent form, and the procedure was described.

The stability of the upper extremity in participants in this study is tested using the Closed kinetic chain upper extremity stability test (CKCUEST) (ICC > 0.75) (CKCUES Test, Lee and Kim 2015; Roush et al., 2007) [27,28]. The participant maintains a push-up position during the test. As measured by a standard tape, two strips of athletic tape 1.5 inches wide were put parallel on the floor, 36 inches apart. From the beginning posture, the participants were asked to use one hand to stretch across their body to touch the tape lying under the opposite hand. The hand was restored to the starting position after contacting the tape line. The participant then repeated the maneuver with the opposite hand. Touches were recorded every time the participant's hand reached across their body, contacting the tape. In total, the trial lasted for 15 seconds. Each participant completed a warm-up trial, three test trials, and a 45-second rest interval between trials. An average of 3 trials was utilized. Participants in the test were asked to maintain a straight, flat back, keeping their hands and shoulders perpendicular to have the weight of the body evenly distributed on the upper limbs and never let their knees touch the ground [28-30].

For explosive power, the seated overhead medicine-ball throw (ICC= 0.94 to 0.98) [31] performance was evaluated using a 2-kg rubber medicine ball after a standard familiarization session [32] —participant sitting on the floor with head, shoulder, and back against the wall. A Medicine ball of 2 kg was held in both arms with elbows flexed, shoulders abducted to 90°, and legs extended. A measuring tape of 10 m was put on the floor. Participants had to throw the medicine ball forward as fast as possible in a straight line with their heads, shoulders, and back in full contact with the wall. After 3 practice trials, 4 test trials were completed with 1 minute of rest time between each. With outstretched arms in front of the body, the medicine ball was dropped to account for variable arm lengths. The interval between the wall and the ball drop mark's most proximal end was deducted from the total throwing distance. Four throwing trials were carried out, and their mean distance was noted for further analysis [20,32,33].

Thrower's ten protocol includes 17 exercises that specifically focus on training the upper limb in throwers [11,13-16,22]. The 17 exercises are: 1a-diagonal pattern D2 flexion, 1b- diagonal pattern D2 extension, 2a- ER at 0° abduction, 2b- IR at 0° abduction, 2c- ER at 90° abduction, 2d- IR at 90° abduction, 3- shoulder at 90° abduction, 4- scaption IR, 5a- prone horizontal abduction (neutral), 5b-prone horizontal abduction (full ER), 6- seated press-ups, 7- prone rowing, 8- push-ups, 9a- elbow flexion, 9b- elbow extension, 10a- wrist flexion, 10b- wrist extension, 10c- supination, 10d-pronation [25,37-39] (Table 1).

The regular warm-up program by the participants

Table 2: Mean and standard deviations for baseline characteristics

Variables	Experimental-Group		Control Group	
	Mean	Std. Deviation	Mean	Std. Deviation
Age in years	23.93	1.081	23.73	1.184
Weight (Kg)	66.54	7.270	67.59	5.030
Height (m)	1.6878	0.06199	1.6832	0.06389
BMI	22.7427	3.74649	23.9683	1.45145

Std. Deviation: Standard deviation

included shoulder ROM exercises, lunges, and squats with 2 sets of 15 repetitions. They also included forward running, sideways running, and stretching of the hamstring, quadriceps, and calf (15 seconds of stretch, 3 repetitions).

SPSS (version 29.0) for Windows developed by IBM inc., NY, USA, was utilized to analyze the data. A descriptive statistics test was done to find the mean and standard deviation (SD) of baseline characteristics and outcome measures. A paired t-test was employed to assess statistically significant differences between the experimental and control groups in recreational cricket bowlers. Between the experimental and control groups, a statistically significant difference was observed using an independent t-test. To find the significance level, the p-value for the outcome measures should be less than 0.05.

RESULTS

The mean and standard deviation for the baseline characteristics is mentioned in Table 2. It is inferred from Table 2 that mean age, weight, height, and BMI are nearly the same for the recreational cricket bowlers in both the experimental and

Table 3: Paired t-test for experimental group and control group

Tests	Experimental group				Control group			
	Mean	Std. Deviation	T	P	Mean	Std. Deviation	T	P
Strength of Shoulder Internal Rotators - Pre-Test (Kg)- Post-Test (Kg)	-0.56951	0.5251	-6.945	0.000**	0.00	0.19685	0.00	1.000*
Shoulder Posterior Capsule Tightness - Pre-Test (Degrees)- Post-Test (Degrees)	-1.829	4.577	-2.559	0.014**	-0.122	1.763	-0.443	0.660*
Upper Extremity Stability- Pre-Test (Repetitions)- Post-Test (Repetitions)	-1.927	1.292	-9.549	0.000**	0.073	0.787	0.595	0.555*
Upper Extremity Explosive Power - Pre-Test (Meter)- Post-Test (Meter)	-0.14073	0.14146	-6.37	0.000**	-0.00463	0.02158	-1.375	0.177*

*** Statistically significant, * Statistically non-significant*

Table 4: Independent t-Test – Experimental and Control Group

Variables	Groups	Mean	Std. Deviation	T	p
Strength of Shoulder Internal Rotators- Pre-Test (Kg)	Group A (Experimental)	6.2134	0.75100	-0.977	0.332*
	Group B (Control)	6.3659	0.65940	-0.977	0.332*
Strength of Shoulder Internal Rotators- Post Test (Kg)	Group A (Experimental)	6.7829	0.53240	3.170	0.002**
	Group B (Control)	6.3659	0.65302	3.170	0.002**
Shoulder Posterior Capsule Tightness- Pre-Test (Degrees)	Group A (Experimental)	72.1951	5.48279	-1.346	0.182*
	Group B (Control)	74.1463	7.49187	-1.346	0.183*
Shoulder Posterior Capsule Tightness- Post-Test (Degrees)	Group A (Experimental)	74.0244	5.72489	-0.166	0.869*
	Group B (Control)	74.2683	7.46332	-0.166	0.869*
Upper Extremity Stability- Pre-Test (Repetitions)	Group A (Experimental)	18.9268	3.01985	0.989	0.325*
	Group B (Control)	18.3415	2.28703	0.989	0.326*
Upper Extremity Stability- Post-Test (Repetitions)	Group A (Experimental)	20.8537	2.42447	5.280	0.000**
	Group B (Control)	18.2683	1.98777	5.280	0.000**
Upper Extremity Explosive Power- Pre-Test (Meter)	Group A (Experimental)	4.1741	0.49887	-0.420	0.675*
	Group B (Control)	4.2154	0.38108	-0.420	0.675*
Upper Extremity Explosive Power- Post Test (Meter)	Group A (Experimental)	4.3149	0.44287	1.039	0.302*
	Group B (Control)	4.2200	0.38154	1.039	0.302*

*** Statistically significant, * Statistically non-significant*

control groups.

A paired t-test revealed that, within the experimental group, for pre and post-test, the thrower's specific exercise program resulted in a significant difference ($p<0.05$) in the strength of internal rotators of the shoulder, shoulder posterior capsule tightness (IR ROM), upper extremity stability (CKCUEST) and upper extremity explosive power (SMBT) in recreational cricket bowlers as mentioned in table 3 hence alternate hypothesis was accepted.

Meanwhile, the paired t-test depicted a non-significant difference ($p>0.05$) for pre- and post-test outcome measures within the control group, as illustrated in Table 3; hence, the null hypothesis was accepted.

An independent t-test revealed that between the groups, the non-significant difference ($p>0.05$) for pre-test values for the outcome measures was seen, as mentioned in Table 4; therefore, the null hypothesis was accepted. Whereas a significant difference($p<0.05$) was seen in the post-test values for the strength of shoulder internal rotators and upper extremity stability (CKCUEST) between the experimental and control groups, as mentioned in Table 4. However, a non-significant difference ($p>0.05$) was noted for the post-test values of shoulder posterior capsule tightness (IR ROM) and upper limb explosive power (SMBT) between the experimental and control groups, as given in Table 4.

DISCUSSION

This research examined the outcome of a thrower's ten-exercise program in improving posterior capsule tightness of the shoulder, the strength of internal rotators, upper limb stability, and upper extremity explosive power compared to regular warm-up programs in recreational cricket bowlers. It was seen that the thrower's ten exercise program had a significant, positive effect in improving the strength of internal rotators and upper limb stability. However, both warm-up programs are useful in improving posterior capsule tightness of the shoulder and upper limb explosive power.

It is paramount to have an efficient warm-up program to prepare/ condition the body for the upcoming high-intensity activity. As depicted in some studies [40,41], thrower's specific exercises focus on activating rotator cuff muscles and stabilizing the shoulder by other muscles, resulting in an enhancement of muscular strength

due to activation of the rotator cuff muscles of the shoulder girdle. Thus, the thrower's specific warm-up program effectively improves muscular strength. Myers et al., in 2005, implicated that thrower's specific program exercises are efficacious in activating muscles important to throwing motion to a great extent, hence being a boon for warm-up routines in throwers. The effectiveness of the thrower's specific warm-up program on the internal rotators has never been studied before. In this article, the strength of internal rotators was assessed using the Lafayette manual muscle tester, as they play a vital role in the deceleration phase of throwing, ultimately leading to the ball's release, and a significant improvement was seen in the experimental group. EMG studies establish that this program incorporates exercises that make complex shoulder muscles work in the most active way [14, 15]. An increase in neural response, recruitment of the motor unit, and synchronous firing of the motor unit could be the reason for the increase in strength after 6 weeks of training. Previous studies evaluated the effect of the thrower's ten-exercise program in improving the scapular dyskinesis and accuracy of throwing, wherein they reported favorable results of this program in improving the same [42]. The improved strength of scapular stabilizing muscles was thought to form a firm scapular base to systematically transfer kinetic energy by rotator cuff muscles to distal segments, enhancing throwing accuracy42. Scapular motion asynchrony or inadequate strength are predisposing factors for the risk of injury in the overhead athletic population. A study reported that the thrower's ten program and scapular retractor strengthening had similar benefits in improving performance [21]. In the deceleration phase of throwing, enormous distraction forces are generated at the shoulder, which may contribute to posterior shoulder tightness [4,5]. As the humerus rotates internally during the follow-through phase, the inferior posterior capsule may be put in a primary location to resist the deceleration pressures, creating a direct constraint against these loads [4]. The accumulation of such stresses contributes to posterior capsule tightness and other dynamic constraints (teres minor, infraspinatus, posterior deltoid, and latissimus dorsi), resulting in altered ROM [4]. The effect of the thrower's specific program in reducing the shoulder posterior capsule tightness has never been assessed before. Hence, this study is the first to find the same. The reduced shoulder internal rotation ROM indicates posterior capsule tightness. Reduced internal ROM of the shoulder joint indicates posterior capsule tightness. A statistically significant difference was not seen in the IR ROM between the control and experimental groups in this study, although some improvement occurred after 6 weeks. However, a statistically significant difference was seen within the experimental group after 6 weeks of thrower's specific exercises for the same. Therefore, it was inferred that the thrower's ten program helps reduce posterior capsule tightness in recreational cricket bowlers.

The stability of the shoulder joint depends on the amalgamation of interaction between shoulder complex and static-dynamic balance. The activation of the agonist and the antagonist also contribute to shoulder joint stabilization. The thrower's ten programs comprise different scapular stabilization exercises and proprioceptive neuromuscular facilitation (PNF) patterns mimicking the acceleration and deceleration throwing phase. PNF pattern enhances motor learning and improves dynamic stability along with neuromuscular control [42]. In this research, the upper limb stability was examined using the CKCUEST. It was inferred that the thrower's specific warm-up program improved the stability of the upper limb. An RCT done by Gokalp in 2020 concluded that 8 weeks of thrower's ten exercises improves upper limb balance (assessed using the Upper Limb Y-balance test) in healthy people with a sedentary lifestyle [16]. This program includes movement patterns, including throwing-specific motions, high-level neuromuscular control, endurance, dynamic stabilization, coordination, and force [14,15]. "Thrower's paradox," a concept introduced by Kevin et al. (2002), implies that the throwing shoulder should be adequately slack enough to throw but firm enough to avoid injuries [17]. Throwing distance depends on the explosive power of the upper limb, wherein good muscular strength is supposed to be effective in increasing throwing distance. This study examined explosive power using SMBT, a type of functional test that is inexpensive, easy, and quick to administer or interpret [30]. This article showed a significant difference within the experimental group post-test (after 6 weeks). In contrast, non-significant improvement was observed in explosive power between the control and experimental groups

(after 6 weeks). Even though the thrower's ten exercise program contributes to the strengthening of scapular retractor muscles along with improved stabilization and balance, in this article, non-significant improvement was observed in explosive power between groups despite a bit of improvement. This implies that both the warm-up protocols, i.e., the thrower's ten warm-up program and the regular warm-up program, are effective in enhancing the explosive power.

Limitations: Female participants were excluded from this study. The small sample size was another limitation. A larger age group, like 18- 30 years, could have been included. The strength of the shoulder's external rotators should also be assessed along with the internal rotators. The study duration of more than 6 weeks may have given better results. Since the participants were asked to do the thrower's ten exercises thrice a week for 6 weeks, regular monitoring was not done. Follow-up was also not done. Lastly, participants from other overhead sports should also be included.

CONCLUSION

Compared to the usual warm-up program used by recreational cricket bowlers, the thrower's customized warm-up routine is more successful in improving internal rotator strength and upper extremity stability. Both warm-up programs reduced posterior capsule tightness of the shoulder and enhanced upper extremity explosive power.

REFERENCES

1. Bambal P. A Comparative Study of the Physical Fitness of Fast Bowlers of Various States of India. Research Chronicler. 2019, 7(8), 1-5

2. Richard B. B.; and Francis G. O'Connor. Sports medicine for the primary care physician. Third edition. CRC press; 2004.

3. Dhillon M.S.; Garg B.; Soni R.K.; Dhillon H.; Prabhakar S. Nature and incidence of upper limb injuries in professional cricket players a prospective observation. Sports Medicine, Arthroscopy, Rehabilitation, Therapy & Technology. 2012, 4(1), 1-4.

4. Johansen R.L.; Callis M.; Potts J.; Shall L.M. A modified internal rotation stretching technique for overhand and throwing athletes. Journal of Orthopaedic & Sports Physical Therapy. 1995, 21(4), 216-9.

5. van Rijn S.F.; Zwerus E.L.; Koenraadt K.L.; Jacobs W.C.; van den Bekerom M.P.; Eygendaal D. The reliability and validity of goniometric elbow measurements in adults: a systematic review of the literature. Shoulder & Elbow. 2018, 10(4), 274-84.

6. Berckmans K.; Maenhout A.G.; Matthijs L.; Castelein B.; Cools A.M. The isokinetic assessment of rotator cuff strength ratios and the effect of an exercise program on these ratios in overhead athletes: A systematic literature review. Phys Ther Sport. 2017, 27, 65-75.

7. Laudner K.G.; Sipes R.C.; Wilson J.T. The acute effects of sleeper stretches on shoulder range of motion. Journal of Athletic Training. 2008, 43(4), 359-63.

8. Keller R.A.,; De Giacomo A.F.; Neumann J.A.; Limpisvasti O.; Tibone J.E. Glenohumeral internal rotation deficit and risk of upper extremity injury in overhead athletes: a meta-analysis and systematic review. Sports health. 2018, 10(2), 125-32.

9. Wilk K.E.; Macrina L.C.; Fleisig G.S.; Porterfield R.; Simpson C.D.; Harker P.; Paparesta N.; Andrews J.R. Correlation of glenohumeral internal rotation deficit and total rotational motion to shoulder injuries in professional baseball pitchers. The American Journal of Sports Medicine. 2011, 39(2), 329-35.

10. Contemori S.; and Biscarini A. Isolated infraspinatus atrophy secondary to suprascapular nerve neuropathy results in altered shoulder muscles activity. Journal of Sport Rehabilitation. 2019, 28(3), 219-28.

11. Brukner P.; and Khan K. Clinical sports medicine, Third edition. TATA McGRAW HILL; 2008.

12. Silva L.M.; Neiva H.P.; Marques M.C.; Izquierdo M.; Marinho D.A. Effects of warm-up, post-warm-up, and re-warm-up strategies on explosive efforts in team sports: A systematic review. Sports Medicine. 2018, 48(10), 2285-99.

13. Hammami A.; Zois J.; Slimani M.; Russell M.; Bouhel E. The efficacy, and characteristics of, warm-up and re-warm-up practices in soccer players: a systematic review. The Journal of Sports Medicine and Physical Fitness. 2016, 58(1-2), 135-49.

14. James R. A.; Gary L. H.; and Kevin E. W. Physical rehabilitation of the injured athlete. 4th edition. ELSEVIER; 2012.

15. Escamilla R.F.; Ionno M.; deMahy M.S.; Fleisig G.S.; Wilk K.E.; Yamashiro K.; Mikla T.; Paulos L.; Andrews J.R. Comparison of three baseball-specific

6-week training programs on throwing velocity in high school baseball players. The Journal of Strength & Conditioning Research. 2012, 26(7), 1767-1781
16. Gokalp O.; Kirmizigil B. Effects of Thrower's Ten exercises on upper extremity performance: A randomised controlled study. Medicine. 2020, 10, 99(42), e22837.
17. Wilk KE, Reinold MM, Dugas JR, Andrews JR. Rehabilitation following thermal-assisted capsular shrinkage of the glenohumeral joint: current concepts. Journal of Orthopaedic & Sports Physical Therapy. 2002, 32(6), 268-92.
18. Orchard J.W.; Kountouris A.; Sims K. Incidence and prevalence of elite male cricket injuries using updated consensus definitions. Open Access Journal of Sports Medicine. 2016, 7, 187-194.
19. Ranson C.; Gregory P.L. Shoulder injury in professional cricketers. Physical Therapy in Sport. 2008, 9(1), 34-9.
20. Turgut E.; Cinar-Medeni O.; Colakoglu F.F.; Baltaci G. "Ballistic Six" upper-extremity plyometric training for the pediatric volleyball players. The Journal of Strength & Conditioning Research. 2019, 33(5), 1305-10.
21. Andrews A.W.; Thomas M.W.; Bohannon R.W. Normative values for isometric muscle force measurements obtained with hand-held dynamometers. Physical therapy. 1996, 76(3), 248-59.
22. Patel H.A.; Arunmozhi R.; Arfath U. Efficacy of Scapular Retractor Strength Training Vs Thrower's Ten Programme on Performance in Recreational Overhead Athletes-A Comparative Study. International Journal of Therapies and Rehabilitation Research. 2014, 3(1), 1.
23. Ishøi L.; Hölmich P.; Thorborg K. Measures of hip muscle strength and rate of force development using a fixated handheld dynamometer: intra-tester intra-day reliability of a clinical set-up. International Journal of Sports Physical Therapy. 2019, 14(5), 715-723.
24. Cools A.M.; Palmans T.; Johansson F.R. Age-related, sport-specific adaptions of the shoulder girdle in elite adolescent tennis players. Journal of Athletic Training. 2014, 49(5), 647-53.
25. Wilk K.E.; Arrigo C.A.; Hooks T.R.; Andrews J.R. Rehabilitation of the overhead throwing athlete: there is more to it than just external rotation/ internal rotation strengthening. Pm&r. 2016, 8(3), S78-90.
26. Myers J.B.; Oyama S.; Wassinger C.A.; Ricci R.D.; Abt J.P.; Conley K.M.; Lephart S.M. Reliability, precision, accuracy, and validity of posterior shoulder tightness assessment in overhead athletes. The American Journal of Sports Medicine. 2007, 35(11), 1922-30.
27. Lee D.R.; Kim L.J. Reliability and validity of the closed kinetic chain upper extremity stability test. Journal of Physical Therapy Science. 2015, 27(4), 1071-3.
28. Roush J.R.; Kitamura J.; Waits M.C. Reference values for the closed kinetic chain upper extremity stability test (CKCUEST) for collegiate baseball players. North American journal of sports physical therapy: NAJSPT. 2007, 2(3), 159-163.
29. Silva Y.A.; Novaes W.A.; Dos Passos M.H.; Nascimento V.Y.; Cavalcante B.R.; Pitangui A.C.; De Araújo R.C.; Reliability of the closed kinetic chain upper extremity stability test in young adults. Physical Therapy in Sport. 2019, 38, 17-22.
30. Borms D.; Cools A. Upper-extremity functional performance tests: reference values for overhead athletes. International Journal of Sports Medicine. 2018, 39(06), 433-41.
31. Beckham G.; Lish S.; Disney C.; Keebler L.; DeBeliso M.; Adams K.J. The reliability of the seated medicine ball throw as assessed with accelerometer instrumentation. Journal of Physical Activity Research. 2019, 4(2), 108-113.
32. Borms D.; Maenhout A.; Cools A.M. Upper quadrant field tests and isokinetic upper limb strength in overhead athletes. Journal of Athletic Training. 2016, 51(10), 789-96.
33. Harris C.; Wattles A.P.; DeBeliso M.; Sevene-Adams P.G.; Berning J.M.; Adams K.J. The seated medicine ball throw as a test of upper body power in older adults. The Journal of Strength & Conditioning Research. 2011, 25(8), 2344-8.
34. Aktug Z.B. Do the exercises performed with a theraband have an effect on knee muscle strength balances? Journal of Back and Musculoskeletal Rehabilitation. 2020, 33(1), 65-71
35. Hughes C.J.; Hurd K.; Jones A.; Sprigle S. Resistance properties of Thera-Band® tubing during shoulder abduction exercise. Journal of Orthopaedic & Sports Physical Therapy. 1999, 29(7), 413-20.
36. Andrews A.W.; Thomas M.W.; Bohannon R.W. Normative values for isometric muscle force measurements obtained with hand-held dynamometers. Physical therapy. 1996, 76(3), 248-59
37. Mentiplay B.F.; Perraton L.G.; Bower K.J.; Adair

B.; Pua Y.H.; Williams G.P.; McGaw R.; Clark R.A. Assessment of lower limb muscle strength and power using hand-held and fixed dynamometry: a reliability and validity study. PloS One. 2015, 10(10), e0140822.

38. Cools A.M.; De Wilde L.; Van Tongel A.; Ceyssens C.; Ryckewaert R.; Cambier D.C. Measuring shoulder external and internal rotation strength and range of motion: comprehensive intra-rater and inter-rater reliability study of several testing protocols. Journal of Shoulder and Elbow Surgery. 2014, 23(10), 1454-61.

39. Çelik D.; Dirican A.; Baltaci G. Intrarater reliability of assessing strength of the shoulder and scapular muscles. Journal of Sport Rehabilitation. 2012, 21(1).

40. Alizadehkhaiyat O.; Hawkes D.H.; Kemp G.J.; Frostick S.P. Electromyographic analysis of shoulder girdle muscles during common internal rotation exercises. International Journal of Sports Physical Therapy. 2015, 10(5), 645-654.

41. Reinold M.M.; Wilk K.E.; Fleisig G.S.; Zheng N.; Barrentine S.W.; Chmielewski T.; Cody R.C.; Jameson G.G.; Andrews J.R. Electromyographic analysis of the rotator cuff and deltoid musculature during common shoulder external rotation exercises. Journal of Orthopaedic & Sports Physical Therapy. 2004, 34(7), 385-94.

42. Ponkshe K.P.; Agrawal R.; Rampurwala F.; Tamboli A. Effect of thrower's ten exercise program on scapular dyskinesia and throwing accuracy in cricket bowlers. Int J Physiother Res. 2021, 9(5), 4008-12.