


## Shoulder internal rotator strengthening vs. muscle energy technique for shoulder external rotators on bowling speed in fast bowlers playing cricket - a quasi-experimental study

### Fortalecimento do rotador interno do ombro versus técnica de energia muscular para rotadores externos do ombro na velocidade de lançamento em jogadores rápidos que jogam críquete - um estudo quase-experimental

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**ABSTRACT | INTRODUCTION:** The shoulder joint is the most complex joint in the human body, the most mobile and least stable in relation to other joints. In bowling, using the upper extremity in the throwing motion is one of the most challenging tasks. In order to generate a precise throw, the numerous anatomical components involved in the overhead throwing motion must be coordinated. Shoulder muscular strength is a key component of excellent bowling, and the strength of various shoulder muscle groups influences bowling speed. Therefore, bowling players must exert strength in their performance. This lacks bone stability and sacrifices stability to increase mobility. **OBJECTIVES:** To analyse the effects of strengthening the shoulder internal rotators and the muscular energy technique of the shoulder external rotators on bowling speed in fast cricket players. **METHODS AND MATERIALS:** Participating rapid cricket players from the sports field, aged 18-30 years, were recruited and then randomly allocated into two groups: the strengthening group and the MET group. The strengthening group received muscle strengthening for the shoulder's internal rotators, and the MET group received the muscle energy technique for the external rotators. All the exercise interventions were involved physiotherapist supervision sessions with 12 repetitions and 3 sets 5 days per week up to eight weeks. Range of motion was measured by goniometer instrument, and bowling speed was assessed by speed gun. All outcomes were assessed at baseline, 2nd week, 4th week, and 8th week after the intervention with repeated measures ANOVA. **RESULTS:** Of the 30 participants evaluated, the mean age, height, weight, and BMI were, respectively, 21.40±2.36 years old, 1.74±0.09m, 71.80±16.77kg, and 23.57±4.20Kg/m<sup>2</sup> for the strengthening group and 22.53±1.55 years old, 1.70±0.04m, 62.47±8.02kg, 21.49±2.63Kg/m<sup>2</sup> for the MET group. There was a statistically significant difference for all outcomes regarding the measured times between the two intervention groups. However, there was a greater effect size for internal rotation ROM (1.99 in the strengthening group versus 1.42 in the MET group) and bowling speed (1.52 versus 1.39) in the strengthening group. External rotation ROM had a greater effect size in the MET group (1.66 for the MET group and 1.16 for the strengthening group). **CONCLUSIONS:** The study concludes that a significant improvement in shoulder internal rotators and external rotators' strength leads to improved bowling speed, so the shoulder strength training protocol and muscle energy training can be incorporated for increasing the bowler's speed.

**KEYWORDS:** Bowling. Cricket. Shoulder Internal Rotators. ShoulderExternalRotators.

**RESUMO | INTRODUÇÃO:** A articulação do ombro é a articulação mais complexa do corpo humano, a mais móvel e menos estável em relação às outras articulações. No lançamento, usar a extremidade superior no movimento de arremesso é uma das tarefas mais desafiadoras. Para gerar um arremesso preciso, os numerosos componentes anatômicos envolvidos no movimento de arremesso acima da cabeça devem ser coordenados. A força muscular do ombro é um componente-chave para excelência no lançamento, e a força de vários grupos musculares do ombro influencia a velocidade do lançamento. Por isso, é fundamental que os jogadores de lançamento exerçam força em seu desempenho. Isso carece de estabilidade óssea e sacrifica a estabilidade para aumentar a mobilidade. **OBJETIVOS:** Analisar os efeitos do fortalecimento dos rotadores internos do ombro e da técnica de energia muscular (TEM) dos rotadores externos do ombro na velocidade de arremesso em jogadores rápidos de críquete. **MATERIAIS E MÉTODOS:** Jogadores de críquete rápido participantes de campo esportivo, com idade entre 18 e 30 anos, foram recrutados e então alocados aleatoriamente em dois grupos: grupo fortalecimento e grupo TEM. O grupo fortalecimento recebeu fortalecimento muscular para os rotadores internos do ombro e o grupo TEM recebeu a técnica de energia muscular para os rotadores externos. Todas as intervenções de exercícios envolveram sessão de supervisão do fisioterapeuta com 12 repetições e 3 séries 5 dias por semana até oito semanas. A amplitude de movimento foi medida pelo goniômetro e a velocidade do arremesso foi avaliada pela pistola de velocidade. Todos os resultados foram avaliados na linha de base, 2ª semana, 4ª semana e 8ª semana após a intervenção com a ANOVA de medidas repetidas. **RESULTADOS:** Dos 30 participantes avaliados, a média de idade, altura, peso e IMC foi, respectivamente, 21.40±2.36 anos de idade, 1.74±0.09m, 71.80±16.77kg e 23.57±4.20Kg/m<sup>2</sup> para o grupo fortalecimento e 22.53±1.55 anos, 1.70±0.04m, 62.47±8.02kg, 21.49±2.63 Kg/m<sup>2</sup> para o grupo TEM. Houve diferença estatisticamente significativa para todos os desfechos em relação aos tempos medidos entre os dois grupos de intervenção. Porém, no grupo fortalecimento, houve maior tamanho de efeito para ADM de Rotação Interna (1.99 no grupo fortalecimento versus 1.42 no grupo TEM) e para velocidade do arremesso (1.52 versus 1.39). A ADM de rotação externa obteve maior tamanho de efeito no grupo TEM (1.66 para o grupo TEM e 1.16 para o grupo fortalecimento). **CONCLUSÕES:** O resultado do estudo conclui que uma melhora significativa na força dos rotadores internos e externos do ombro leva a uma melhora na velocidade do lançamento, de modo que o protocolo de treinamento de força do ombro e o treinamento de energia muscular podem ser incorporados para aumentar a velocidade do jogador.

**PALAVRAS-CHAVE:** Lançamento. Críquete. Rotadores internos do ombro. Rotadores externos do ombro.

## Introduction

Cricket is one of the most popular games in the world. This sport has received considerable research attention, which appears to have coincided with an increase in cricket's global audience. As a result, research into the determinants of speed bowling has also become prominent.<sup>1</sup> A combination of many factors determines success in medium-fast bowling (Medium Pacers). In highlighting the speed of the ball as it is thrown, a fastball toss reduces the time available for a batsman to detect and use the toss information and execute an appropriate motor response. To achieve high ball-throwing speeds: the player's torso must flex, extend, lateralize, and rotate the body in a short period. The body must absorb ground reaction forces of up to six times the body weight.<sup>2</sup>

The speed at which the ball is thrown contributes to rapid bowling success by reducing the time the batter must assess the ball's trajectory and decide which shot to play. The recent surge in interest in this sport has led to greater professionalism for elite or first-class players who can play a large volume of matches in a calendar year with three formats: T-Twenty (T20) being a 3-hour match, one-day (OD) lasting 6-7 hours and multi-day (MD) played between 3 and 5 days, different physical qualities are required for cricket players. These players have distinct roles while playing as a team, bowling, or field hitting (i.e., fast, medium, or slow speed), so they require specific fitness qualities for strength and conditioning based on their roles.<sup>2</sup>

In cricket, during fast bowling, the pitcher's throwing speed has a strong influence on the throw.<sup>3</sup> Underweight and overweight implement training, known as Modified Implement Training (MIT), is a recognized method of increasing pitch speed. When throwing a ball, the shoulder joint maintains the force generated by the torso and legs. This pitch release puts heavy pressure on the surrounding muscles, ligaments, bones, and soft tissue. This joint regulates the maximum throwing movement, generating high-speed force and torque, causing severe stresses.<sup>4,5</sup> These stresses are highly related to pathologies of the glenohumeral joint.

Fast bowling requires a basic sequence to achieve biomechanically correct bowling technique and posture. This sequence can be divided into five main steps: running, pre-delivery stride, delivery stride (back foot and front foot contact), ball release (in/out), and then forward.<sup>2,6</sup> Several categories of research have documented that the internal rotation range is smaller than the external rotation in maximal players is called the Glenohumeral Internal Rotation Deficit (GIRD).<sup>3</sup> Literature says that the strength of the outer rotators is about 65% greater than the strength of the inner rotators. During bowling, the shoulder internal rotators are more involved in the thrust phase of the arm using concentric contractions of these muscles; on the other hand, the external rotators are usually involved during the decay phase.

Fast bowling requires the arm to be rotated around 60000.s-1, which requires shoulder integrity. Cricket players are susceptible to injuries from the overuse of repetitive training. This results in a decrease in shoulder joint ROM leads to joint pain, which decreases the performance rate of these players.<sup>3</sup> Therefore, in addition to the technical skills required for performance, they also need a high level of aptitude.<sup>7</sup>

Also, these injuries are common in athletes who shoot overhead. This repetitive overhead movement causes bone adaptations in athletes with immature skeletons. With training, torque and force cause changes in the range of motion specifically increased external rotation and decreased internal rotation, resulting in GIRD.<sup>8,9</sup> In fact, athletes who perform these movements develop adaptations in the dominant shoulder that alter their passive range of motion (ROM).<sup>4</sup> During their sporting careers in cricket, baseball, volleyball, and basketball, 30% of athletes have suffered injuries in the shoulder. The most common injuries were subacromial impingement syndrome, rotator cuff tendinitis, glenohumeral ligament injury, and other muscle or ligament injuries, representing 27% and 24% of the total of these injuries. Thus, shoulder injuries continue to affect cricket athletes, despite progress in diagnostic and therapeutic measures.<sup>10</sup> However, there is little data on the occurrence of specific shoulder injuries in these athletes.<sup>5</sup>

Studies have not shown the negative effects of undershooting and overweight implements on throwing control or risk of injury.<sup>11-13</sup> A recent biomechanical study shows that these throws can produce variations in kinematics (specifically in arm, trunk, pelvis, and shoulder speeds). No increase in arm kinetics and maximal crow-hop throwing effort with the same implements can increase shoulder angular velocity IR and elbow varus torque.<sup>2,7</sup> Considering the primordial levels of maximum arm speeds and distances that persist due to the long duration of the throwing movements, the shoulder joint experiences an excess of force.

As an effect of repetitive exposure and high loads, specific maladjustments occur, usually in the shoulder joint's bone and soft tissue structures. It often has a variation in shoulder ROM on the throw, a more lateral rotation, and a decreased medial rotation ROM.<sup>11</sup> An instigated humeral retroversion that basically causes a uniform change in motion, the extended limb, the externally rotating joint, causes reduction of internal rotation. However, a subsequent contraction of the shoulder capsule can result in a shortened glenohumeral IR without a marked enhancement in the ER; attenuated horizontal adduction makes the joint highly subject to injury.<sup>12,13</sup>

Traditionally, the treatments applied in this clinical condition to avoid tissue damage are protection, rest, ice, compression, and elevation (PRICE).<sup>14</sup> Although this is the effective protocol, low-intensity pulsed ultrasound, and electrical stimulation are also used in neuromuscular disorders in injured cricketers, especially bowling players.<sup>14</sup> Other applied techniques are isometric exercises, and muscle energy technique is also used for therapeutic benefits. The study indicated that strengthening the shoulder internal rotators and shoulder external rotator MET helped increase bowling speed in healthy individuals, but their individual effects have not yet been proven.<sup>15</sup>

The study's main objective compared the effects of strengthening the shoulder internal rotators and external rotator muscle energy technique on bowling speed in fast cricket players. The null hypothesis states that strengthening the internal rotator muscles of the shoulder influences bowling speed and ROM in fast players. On the other hand, the use of a muscle energy strategy for the external

rotator muscles of the shoulder has a significant impact on the bowling pace of fast players. As a result of this study, it will be demonstrated whether strengthening the internal rotator muscles of the shoulder and employing a muscular energy approach to the external rotators can help fast bowlers increase their bowling speed.<sup>15</sup>

## Methods and materials

This quasi-experimental study design was used in this study. The study was conducted at the Department of Physiotherapy, Sports Physiotherapy Laboratory, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India.. Study was approved by the Institutional Ethical and Research Committee of Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India, reference number MMDU\IEC\1531 on 10/12/2019. It was registered in the Clinical Trials Registry - India (CTRI/2020/06/026046) on 06/23/2020). Inclusion criteria are male rapid launchers, age 18-30 years, launchers without injury to the anterior and ligamentous muscles of the shoulder. Exclusion criteria include the history of fractured shoulder, open wound in the upper limb, previous shoulder surgery between 6 months to 1 year. Participants were recruited from Maharishi Markandeshwar (Deemed to be University), Mullana, Sports Field.

The sample size was calculated using the G\*power tool. Internal rotation ROM values for studies related to healthy fast bowlers were considered. Mean pre- 20.7 and mean post- 32.08, effects size- 1.13. The level of significance was set at 0.05. To obtain a power of 95%, a sample size of n=14 in each group. Moreover, considering a 30% dropout rate, a final sample of n=20 in each group.<sup>15</sup>

### Simple randomization of groups

We got 30 envelopes of the same size, covered with a sheet of carbon paper, to avoid transparency. In 15 envelopes, the Strengthening Group was identified. In the other 15, the MET Group. Subsequently, they were covered with sheets of A4 paper and then sealed.

All envelopes have been mixed and shuffled well. After properly shuffling the envelopes, a number from 1 to 30 was placed in sequential order.<sup>16</sup> Participants were randomly and equally (1: 1) allocated to the Strengthening Group (Internal rotators strengthening) and Strengthening Group (muscle energy technique of external rotators) with the aid of the lottery method. Participants were unaware of the treatment received.

The sealed sequentially numbered and opaque envelopes were kept in a dry and airtight container until the respective groups were assigned to the participants. Each time the participants were enrolled, the envelope was drawn according to the serial number, and the participants were randomly allocated to the Strengthening Group and MET Group.<sup>17</sup>

Before starting any treatment, contraindications related to the shoulder and cervical region were investigated. A baseline measurement was taken; between baseline and week 8, the measurement of week 2 and week 4. After a thorough participant assessment and documentation of outcome variables, the physical therapy intervention was administered. All participants in the Strengthening Group underwent strengthening of the shoulder internal rotators, and in the MET Group the muscle energy technique (MET) of the external rotators. The post-result measurement was performed in the 8th week.

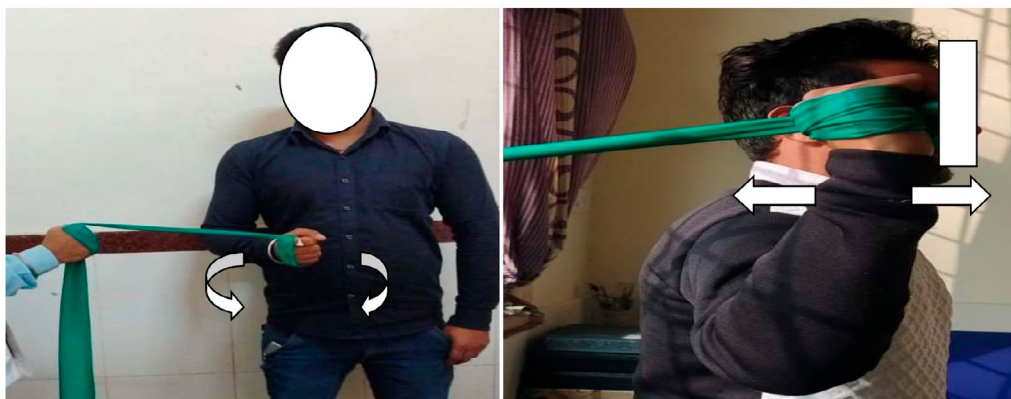
## Procedures

### Internal rotators muscle strengthening Subscapularis and Teres major Strengthening

Diagonal pattern: Subject stood with his back to the wall, knees slightly bent and feet shoulder-width apart in a split stance. The elastic resistance cord (Blue with easy resistance, 5.0 lb, and Green with heavy resistance. 4.5 lb) is seized at shoulder height with the elbow slightly bent, and the humerus in a neutral position abducted to 90°.

The participant flexed horizontally, adducted, and internally rotated the humerus until the hand reached the anterosuperior iliac spine opposite the resistance. The humerus was rotated internally by 90° progressively during the movement, starting at the initial position and ending at the moment of touching the anterosuperior iliac spine. When the participant's hand touched the anterior superior iliac spine, it slowly returned to the starting position by rotating externally, extending horizontally, and abducting the humerus.<sup>18</sup> Strengthening exercises were involved physiotherapist supervision sessions with 12 repetitions and three sets five days per week up to eight weeks.

Figure 1. Strengthening exercise of internal rotators of shoulder joint



## Strengthening of latissimus dorsi

Resistance Band Pulls Back and Down: Begin this exercise by standing or kneeling with the back straight and holding a resistance band in front of the subjects. Slowly pull the arms back, bringing the shoulder blades together and keeping the back and elbows straight. Slowly pull the resistance band up to the hips. Hold for 10 seconds and return to starting position. Strengthening exercises were involved a physiotherapist supervision session with 12 repetitions and 3 sets five days per week up to eight weeks.

## Strengthening the pectoralis major

Weathered external shoulder rotation with 45-degree to 60-degree band with elbows bent 90 degrees. Resisted "rowing" shoulder extension with elbow flexion with a band attached to the feet in the long-seated position. Also, resisted "rowing" shoulder extension with elbow flexion towards the abdomen with a band attached to the feet in the mini squat position. Strengthening exercises were involved a physiotherapist supervision session with 12 repetitions and three sets five days per week up to eight weeks.

## Shoulder External Rotator (MET) Muscle Energy Technique

Subject's position: supine on the assessment table, shoulder in 90° abduction and elbow in 90 ° flexion. The therapist stabilized the shoulder in the acromion process with one hand and the therapist's other hand to passively move the subject's arm into the internal rotation position until reaching where a first barrier was felt. Participants were asked to perform a 10-second isometric contraction at 25% toward lateral rotation against the force exerted on the forearm distally. The same pattern should be followed against an opposing force provided on the distal forearm with the internal rotation of the arm in question. Active assisted stretching was applied. Stretching was maintained for 10 seconds, 12 repetitions, and 3 sets 5 days per week up to eight weeks.<sup>18</sup>

## Outcome measures

All outcomes were assessed at baseline, 2nd week, 4th week, and 8th week after the intervention. All instruments used for assessment during the intervention would have good validity and reliability. Here, outcome measures were assessed using a universal goniometer, and a radar gun measured bowling speed.

## Range of Motion

During the test, the range of motion measurements used a goniometer to measure the internal and external rotation of the shoulder in both the dominant and non-dominant arms. Measures with the athlete lying in the lateral decubitus position.<sup>19</sup> In the supine position, the head of the humerus is more likely to slide forward into the glenoid cavity, causing irritation in the anterior part of the shoulder, leading to inaccurate measurements. The athlete can compensate for the lack of range of motion through anterior or posterior rotation of the shoulder.<sup>20</sup>

In the lateral decubitus plane, the humeral head is more advantageous to rotate externally and internally without the humeral head sliding. The investigator who performed this portion of the study was a certified strength and conditioning trainer with seven years of experience and was specifically trained to measure shoulder range of motion using standard tools. The investigator passively moves the arm until the tension reaches and measures the angle of movement.

The intraclass correlation coefficient (ICC) of the trained clinician who performs a full range of shoulder movement tests must be reliable.<sup>20</sup>

## Bowling speed measurement

Measuring bowling speed with radar is similar to measuring the speed of a moving car. Also known as a speed gun, speed measuring equipment consists of a transmitter and a receiver.<sup>21</sup> It measures speed by sending a radio wave reflected by the object along its path. In this case, it is a cricket ball. The weapon receives this echo and applies the principle of the

Doppler effect (the change in the wavelength or frequency of a wave as it approaches or moves away from the observer) and calculates the ball's velocity. The total treatment duration for both groups is 1 hour/session for five days in weeks. Total treatment protocol continued for eight weeks (2 months).

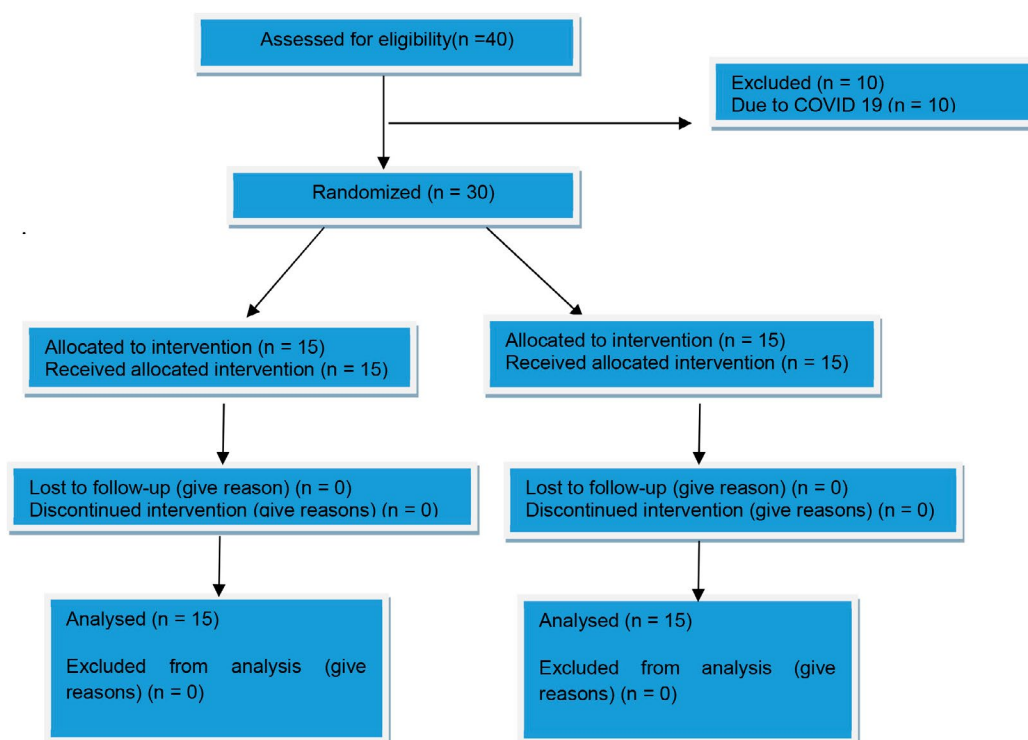
## Statistical analysis

Data were analyzed using statistical software Statistical Package for the Social Sciences (SPSS) 20.0 (Armonk, New York: IBM Corporation). Shapiro- Wilk test was used as the sample size was less than 50 To assess the normality of data. As data followed a normal distribution ( $p \geq 0.05$ ), a parametric test was applicable. Within-group data analysis was performed by ANOVA of repeated measures. The  $p$ -value  $\leq 0.05$  was considered statistically significant. The effect size was calculated by Cohen's  $d$  method for within the group by the formula:  $(M1-M2)/SDPre^{22}$ , where  $M1$  was the Mean of post-intervention value,  $M2$  was the Mean of pre-intervention values, and  $SD$  was the standard deviation of pre-intervention values and post hoc retrospective power analysis was done by using  $G^*$  power software.<sup>23</sup>

## Results

From November 2020 to February 2021, 30 participants were assigned to five days a week of exercise group and control group, Figure 2.

Figure 2. Flow chart of the study



Demographic characteristics of the male rapid launchers are expressed as mean and SD. The analysis revealed no significant difference in Age, Height, Weight, and BMI between the groups, Table 1.

**Table 1.** Demographic characteristics, Weight, Height and BMI in fast cricket players (n = 30)

	Age	Height (m)	Weight (Kg)	BMI (Kg/m <sup>2</sup> )
<b>Strengthening Group (N=15) Mean± SD</b>	21.40±2.36	1.74±.09	71.80±16.77	23.57±4.20
<b>MET Group (N=15) Mean± SD</b>	22.53±1.55	1.70±.04	62.47±8.02	21.49±2.63
<b>p-value</b>	0.131	0.208	0.062	0.117

Abbreviations: N- Participants, MET- Muscle Energy Technique, m- Meter, Kg- Kilogram, SD- Standard Deviation; TEST T Student Independent.

There was a significant difference in IR ROM, ER ROM, and Bowling Speed between Baseline, 2nd week, 4th week, and after 8th week in all variables in Within-group comparisons of Strengthening group, Table 2.

**Table 2.** Within-group comparison of IR ROM, ER ROM and Bowling Speed in Strengthening group of fast cricket players (n = 30)

Variables	Outcome Measures	Mean± SD	p-value	Effect Size
IR ROM	Baseline	54.87±6.78	0.001*	1.91
	After 2 <sup>nd</sup> Week	60.00±6.07	0.001*	
	After 4 <sup>th</sup> Week	62.33±3.85	0.001*	
	After 8 <sup>th</sup> Week	65.00±3.14	0.0001*	
ER ROM	Baseline	66.53±10.59	0.03*	1.16
	After 2 <sup>nd</sup> Week	69.80±9.21	0.03*	
	After 4 <sup>th</sup> Week	71.20±7.26	0.04*	
	After 8 <sup>th</sup> Week	77.00±7.02	0.001*	
Bowling Speed	Baseline	87.13±6.46	0.04*	1.52
	After 2 <sup>nd</sup> Week	90.93±8.01	0.04*	
	After 4 <sup>th</sup> Week	93.60±9.95	0.003*	
	After 8 <sup>th</sup> Week	101.07±11.28	0.0001*	

Abbreviation: IR- Internal Rotator, ER- External Rotator, SD- Standard deviation.

The same occurred in MET group: a significant difference in IR ROM, ER ROM and Bowling Speed between Baseline, 2nd week, 4th week and After 8th week in all variables in Within-group comparisons, as shown in Table 3.

**Table 3.** Within-group comparison IR ROM, ER ROM and Bowling Speed in MET Group of fast cricket players (n = 30)

Variables	Outcome Measures	Mean± SD	p-value	Effect Size
IR ROM	Baseline	60.00±4.84	0.0001*	1.42
	After 2 <sup>nd</sup> Week	63.27±3.92	0.0001*	
	After 4 <sup>th</sup> Week	63.80±3.59	0.02*	
	After 8 <sup>th</sup> Week	65.87±3.25	0.002*	
ER ROM	Baseline	70.27±6.66	0.002*	1.66
	After 2 <sup>nd</sup> Week	74.33±5.70	0.002*	
	After 4 <sup>th</sup> Week	73.60±5.62	0.103	
	After 8 <sup>th</sup> Week	79.67±4.39	0.0001*	
Bowling Speed	Baseline	90.40±7.67	0.001*	1.39
	After 2 <sup>nd</sup> Week	95.67±10.02	0.001*	
	After 4 <sup>th</sup> Week	95.53±9.64	0.005*	
	After 8 <sup>th</sup> Week	103.67±11	0.0001*	

Abbreviation: IR- Internal Rotator, ER- External Rotator, SD- Standard deviation.

## Discussion

The study's main objective compared the effects of strengthening the shoulder internal rotators and external rotator muscle energy technique on bowling speed in fast cricket players. The study was conducted for one year. The present study results indicate that strengthening the internal rotator muscles of the shoulder and the external rotator MET is effective for fast cricket players. However, there was a greater effect size for internal rotation ROM and bowling speed with muscle strengthening and greater effect size for external rotation ROM in the MET group.

The glenohumeral joint's dynamic stability is likewise dependent on neuromuscular regulation. Proprioception is the afferent neural input to the central nervous system (CNS) from specific nerve endings called mechanoreceptors, an element of neuromuscular control. Mechanoreceptors convey proprioceptive information, modulating reflex activity and joint stiffness to provide shoulder joint stability.<sup>24</sup>

The muscle spindle detects muscle length changes and prevents overstretching and injury. Furthermore, it detects the pace at which the muscle is stretched. Sensory impulses carry this information to the spinal cord via afferent axons. The spindle contains fibres controlled by efferent nerve impulses to respond to the relayed information, helping the spindle avoid an overstretch injury. During the deceleration phase of throwing, this is quite important. The spindles are triggered while the posterior rotator cuff is stretched, prompting reflexive contraction to protect the muscles and the entire shoulder system from over-stretch eccentric damage. The spindles are also triggered during late cocking, when the arm is maximally externally rotated to guard against an external rotation overstretch injury.<sup>24</sup>

The Golgi tendon organs (GTO) are found in the musculotendinous tissue and positioned at different intervals. Each GTO passes a tiny bundle of muscular tendon fibres. This position permits them to send muscle tension feedback to the CNS. The GTO, like the muscle spindles, are responsive to muscle stress. Furthermore, these receptors are programmed for joint location and orientation, allowing recognition of joint movement. Unlike the muscle spindle, which contracts when muscles are tense, the GTO inhibits muscular contraction by relaxing contracting muscles and preventing overstretching injuries.<sup>24</sup>



Participants were homogeneous in both groups at baseline. Participants in the Strengthening group received strengthening of the shoulder internal rotators, and the MET group received the muscular energy technique of the shoulder external rotators. Changes in the rotational range of motion of the glenohumeral joint may be related to the repetitive activity of the shoulder joint causing microtrauma of muscles and ligament structures, causing permanent and repetitive stretching for the anterior capsule, which may produce contracture, especially in the posterior inferior capsule.<sup>25</sup> Based on the results of this study, intrusion with rotational forces and retroversion in the bony humerus can create a rebound of activities. Develop a significant reduction in the range of medial and lateral rotation of the glenohumeral joint.<sup>13,26</sup>

Some of the players have experienced weakness of shoulder internal and external rotators muscle. On the other hand, some players can deliver a ball more than 100 km/h. The speed gun was used to measure the speed of the ball. Both the Strengthening group and MET Group showed significant improvement in internal and external rotators' range of motion and bowling speed in the within-group analysis.

For future studies, a comparison between interventions may be suggested to identify whether one technique is superior to another. Thus, it is possible to think about the cost-effectiveness and efficiency of the rehabilitation process.

## Conclusions

The study concludes that a significant improvement in shoulder internal rotators and external rotators' strength leads to improved bowling speed, so the shoulder strength training protocol and muscle energy training can be incorporated for increasing the bowler's speed.

## Authors' contributions

Singha P, Kumar P, and Chahal A participated in the conception, design of the study, analysis and/or interpretation of data, and approval of the manuscript version to be published. Singha P and Chahal A participated in the data acquisition. Singha P participated in the writing of the manuscript. Kumar P and Chahal A critically reviewed the manuscript for important intellectual content.

## Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, corporations and private foundations, etc.) have been declared for any aspect of the submitted work (including, but not limited to grants and funding, advisory board participation, study design, preparation of manuscript, statistical analysis, etc.).

## References

1. Lee J, Kim L, Song H, Kim S, Woo S. The Effect of Glenohumeral Internal Rotation Deficit on the Isokinetic Strength, Pain, and Quality of Life in Male High School Baseball Players. *Ann Rehabil Med*. 2015;39(2):183-90. <https://dx.doi.org/10.5535%2Farm.2015.39.2.183>
2. Johnstone JA, Mitchell A, Hughes G, Watson T, Ford PA, Garrett AT. The Athletic Profile of Fast Bowling in Cricket: A Review. *JStrength Cond Res*. 2013;28(5):1465-73. <https://doi.org/10.1519/jsc.0b013e3182a20f8c>
3. Axe MJ, Strube M, Osinski D, Andrews JR, Snyder-Mackler L. A speed distance-based classification system for injury prevention and research in international and domestic youth baseball players. *Int J Sports Phys Ther*. 2014;9(3):346-55. Cited: PMID: [24944853](https://pubmed.ncbi.nlm.nih.gov/24944853/).
4. Sundaram B, Skn B, Karuppanan S. Glenohumeral rotational range of motion differences between fast bowlers and spin bowlers in elite cricketers. *Int J Sports Phys Ther*. 2012;7(6):576-85. Cited: PMID: [23316421](https://pubmed.ncbi.nlm.nih.gov/23316421/).
5. Wickington KL, Linthorne NP. Effect of Ball Weight on Speed, Accuracy, and Mechanics in Cricket Fast Bowling Katharine. *Sports*. 2017;5(1):18. <https://dx.doi.org/10.3390%2Fsports5010018>
6. Ellenbecker TS, Roetert EP, Bailie DS, Davies GJ, Brown SW. Glenohumeral joint total rotation range of motion in elite tennis players and baseball pitchers. *Med Sci Sport Exerc*. 2002;(16):2052-6. <https://doi.org/10.1097/00005768-200212000-00028>

7. Aginsky KD, Lategan L, Stretch RA. Shoulder injuries in provincial male fast bowlers — predisposing factors. *Sport Med*. 2004;16(1):25–8. <https://doi.org/10.17159/2413-3108/2004/v16i1a190>
8. Keller RA, De Giacomo AF, Neumann JA, Limpisvasti O, Tibone JE. 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. <https://doi.org/10.1177/1941738118756577>
9. Gregory PL, Batt ME, Wallace WA. Comparing injuries of spin bowling with fast bowling in young cricketers. *Clin J Sport Med*. 2002;12(2):107–12. <https://doi.org/10.1097/00042752-200203000-00007>
10. Marsh JA, Wagshol MI, Boddy KJ, Connell MEO, Briend SJ, Lindley KE, et al. Effects of a six-week weighted-impliment throwing program on baseball pitching velocity, kinematics, arm stress, and arm range of motion. *PeerJ*. 2018;10(4):e6003. <https://doi.org/10.7717/peerj.6003>
11. Juneja H, Verma SK, Khanna G. Isometric Peak Force of Shoulder Rotators in Cricketers with and without History of Shoulder Pain. *J Exerc Sci Physiother*. 2011;7(1):42–9. <http://dx.doi.org/10.13140/RG.2.1.4888.2089>
12. Reed ML, Begalle RL, Laudner KG. Acute effects of muscle energy technique and joint mobilization on shoulder tightness in youth throwing athletes. *Int J Sports Phys Ther*. 2018;13(6):1024–31. Cited: PMID: [30534468](https://pubmed.ncbi.nlm.nih.gov/30534468/).
13. Crockett HC, Gross LB, Wilk KE, Schwartz ML, Reed J, O'Mara J, et al. Osseous Adaptation and Range of Motion at the Glenohumeral Joint in Professional Baseball Pitchers. *Am J Sport*. 2002;30(1):20–6. <https://doi.org/10.1177/03635465020300011701>
14. Dhillon H, Dhillon S, Dhillon MS. Current Concepts in Sports Injury Rehabilitation. *Indian J Orthop*. 2017;51(5):529–36. [https://doi.org/10.4103/ortho.ijortho\\_226\\_17](https://doi.org/10.4103/ortho.ijortho_226_17)
15. Singla D, Hussain ME, Moiz JA. Effect of upper body plyometric training on physical performance in healthy individuals: A systematic review. *Phys Ther Sport*. 2018;29:51–60. <http://dx.doi.org/10.1016/j.ptsp.2017.11.005>
16. Doig GS, Simpson F. Randomization and allocation concealment: a practical guide for researchers. *J Crit Care*. 2005;20(2):187–91. <https://doi.org/10.1016/j.jcrc.2005.04.005>
17. Boutron I, Moher D, Altman DG, Schulz KF, Ravaud P. CONSORT Statement to Randomized Trials of Nonpharmacologic Treatment. *Ann Intern Med*. 2020;167(1):40–7. <https://doi.org/10.7326/m17-0046>
18. Sehgal S, Sen S, Dhawan A. Effects of Muscle Energy Technique in Increasing Range of Motion and Strength of Glenohumeral Internal Rotator , in Athletes with Glenohumeral Effects of Muscle Energy Technique in Increasing Range of Motion and Strength of Glenohumeral Internal Rotator. *Am J Sport Sci*. 2016;4(2):43–8. <http://dx.doi.org/10.11648/j.ajss.20160402.14>
19. Ellenbecker TS, Roetert EP, Piorkowski PA, Schulz DA. Glenohumeral joint internal and external rotation range of motion in elite junior tennis players. *J Orthop Sports Phys Ther*. 1996;24(6):336–41. <https://doi.org/10.2519/jospt.1996.24.6.336>
20. Juneja H, Verma SK, Khanna GL. Isometric peak force of shoulder rotators in cricketers with and without history of shoulder pain. *J. Exer. Sci. & Physiotherapy*. 2011;7(1):42–9. <http://dx.doi.org/10.13140/RG.2.1.4888.2089>
21. Thomas SJ, Swanik KA, Atc À, Swanik C, Huxel KC. Glenohumeral Rotation and Scapular Position Adaptations After a Single High School Female Sports Season. 2009;44(3):230–7. <https://dx.doi.org/10.4085%2F1062-6050-44.3.230>
22. Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice*. 3aed. Filadélfia: F. A. Davis Company; 2013
23. Keefe DJO. Brief Report: Post Hoc Power, Observed Power, A Priori Power, Retrospective Power, Prospective Power, Achieved Power: Sorting Out Appropriate Uses of Statistical Power Analyses. *Commun Methods Meas*. 2010;24(4):291–9. <https://doi.org/10.1080/19312450701641375>
24. Nocera JR. Effects of throwing on rotator cuff strength and proprioception [thesis] [Internet]. Las Vegas: University of Nevada; 2004. Available from: <https://digitalscholarship.unlv.edu/cgi/viewcontent.cgi?article=2691&context=rteds>
25. Reagan KM, Meister K, Horodyski MB, Werner DW, Carruthers C, Wilk K. Humeral retroversion and its relationship to glenohumeral rotation in the shoulder of college baseball players. *Am J Sports Med*. 2002;30(3):354–60. <https://doi.org/10.1177/03635465020300030901>
26. Reinold MM, Wilk KE, Macrina LC, Sheheane C, Dun S, Fleisig GS, et al. Changes in shoulder and elbow passive range of motion after pitching in professional baseball players. *Am J Sports Med*. 2008;36(3):523–7. <https://doi.org/10.1177/0363546507308935>