EFFECTS OF CHOP AND LIFT EXERCISES ON KINETIC CHAIN CONTROL AND POWER IN PACE AND SPIN CRICKET BOWLERS: A RANDOMIZED TRIAL

By

DEEPESH GURJAR

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In

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Under the guidance of

Dr. Asifuzzaman Shahriyar Ahmed

Associate Professor, ABSMARI

ABHINAV BINDRA SPORTS MEDICINE & RESEARCH INSTITUTE

Bhubaneswar, Odisha

2022-2024

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"EFFECTS OF CHOP AND LIFT EXERCISES ON KINETIC CHAIN CONTROL AND POWER IN PACE AND SPIN CRICKET BOWLERS: A RANDOMIZED TRIAL"** is a bonafide and genuine research work carried out by me under the guidance of Dr. Asifuzzaman Shahriyar Ahmed, Associate Professor, Abhinav Bindra Sports Medicine & Research Institute, Bhubaneswar, Odisha.

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Date: Signature

Place: Bhubaneswar, Odisha Deepesh Gurjar

LIST OF ABBREVATIONS

1. **ABSMARI** - Abhinav Bindra Sports Medicine and Research Institute
2. **UQYBT**- Upper Quarter Y-Balance Test
3. **RMBTT**- Rotational Medicine Ball Throw Test
4. **UQYBTD**- Upper Quarter Y-Balance Test Dominant
5. **UQYBTND**- Upper Quarter Y-Balance Test Non-Dominant
6. **SPSS –** Statistical Package of Social Sciences

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ABSTRACT

BACKGROUND: The Effects of Chop and Lift Exercises on Kinetic Chain Control and Power in Pace and Spin Bowlers: A Randomized Trail.

PURPOSE: The aim of the study is to investigate the effects of chop and lift exercises on kinetic chain control in cricket pace and spin bowlers.

METHOD: Forty-two male participants were selected based on specific inclusion and exclusion criteria. Demographic data were collected, and written informed consent was obtained. Participants were categorized into pace and spin groups based on their bowling style. Both groups followed a standardized 6-week training program, consisting of 12 sessions of kettlebell-based chop and lift exercises. Kinetic chain control and power were measured using the upper quarter Y-balance test (UQYBT) and rotational medicine ball throw test (RMBT), with assessments performed on both dominant and non-dominant upper extremities before and after the intervention.

RESULT: Both pace and spin bowlers exhibited significant improvements in kinetic chain control and power, as evidenced by higher scores on the upper quarter y-balance test and the rotational medicine ball throw test ($p<0.05$). however, pace bowlers showed a greater mean improvement in the rotational medicine ball throw test compared to spin bowlers ($p<0.05$). no significant differences were found between groups in the upper quarter y-balance test for either dominant or non-dominant sides ($p>0.05$).

CONCLUSION: Chop and Lift exercises effectively enhanced kinetic chain control and power in both pace and spin cricket bowlers. while both groups experienced comparable gains in balance, pace bowlers achieved greater improvements in rotational power. these findings suggest that although chop and lift exercises are beneficial for both types of bowlers, they may be particularly effective in boosting explosive strength in pace bowlers.

KEYWORDS: chop and lift exercises, cricket, kinetic chain control, power, pace bowlers, rotational medicine ball throw test, spin bowlers, upper quarter y-balance test.

INTRODUCTION

Cricket bowling requires a coordinated and powerful movement of the kinetic chain, involving the lower body, core, and upper body. Proper control and power generation within the kinetic chain is crucial for effective bowling performance.[1]

The ability to throw at high velocity with accuracy is important for good performance in cricket.[2]

Overhead throwing is a movement that occurs in three dimensions, therefore rotational power and mobility can play an integral role in enhancing overhead throws in cricket.[3]

Throwing velocity may be impacted by a kinetic chain with insufficient rotational power and mobility because of the order of proximal to distal connection.[4]

Pace bowlers depend on speed to get a Batsman out, whereas spin bowlers depend on the degree of turn of the ball.[5]

Most pace bowlers are medium-fast to fast in top-level cricket. In general, bowlers of this type are described as "fast" or "fast-medium".[5]

Cricket bowlers depend on a bowling method known as spin bowling to release the ball slowly with the possibility of a sharp deflection after it bounces.[6]

The kinetic chain or kinetic link principle provides both the framework for understanding and analyzing human movement patterns as well as the rationale for the utilization of exercise conditioning and rehabilitation

programs that emphasize the entire body, despite a target joint or anatomical structure being injured.[7]

The kinetic link principle describes how the human body can be considered in terms of a series of interrelated links or segments.[8]

The kinetic chain mechanism involves a coordinated series of motions that begin from the floor and progress up through the legs, hips, trunk, shoulder, arm, wrist, and fingers before the ball is finally released.[9]

The muscles and joints of the trunk, scapulothoracic, scapulohumeral, and distal arm segments make up the upper extremity kinetic chain.[10]

The lower extremity kinetic chain involves the interconnected system of joints and muscles in the lower limbs, including the foot and ankle, lower leg, knee, thigh, and hip. These segments work together to facilitate movement and force production.[11]

Movement of one segment affects segments both proximal and distal to the first segment.[12]

The upper extremity and trunk work together as a series of suggested linkages, with each region depending on the others to function efficiently. Dysfunction in any of these linkages can lead to movement impairments or compensatory patterns that may result in pain or injury. By identifying and addressing dysfunction in these linkages, it may be possible to improve movement efficiency and prevent pain or injury.[13]

In both pace and spin bowling, the kinetic chain mechanism is an important component of the bowling motion. It describes how various muscle groups in

the body are sequentially activated so that they can combine to provide the most force and power possible during the bowling action.[1]

The kinetic chain mechanism involves a coordinated series of motions that begin from the floor and progress up through the legs, hips, trunk, shoulder, arm, wrist, and fingers before the ball is finally released.[1]

The kinetic chain mechanism is used by pace bowlers to produce speed and power throughout their bowling motion. They use a prolonged run-up and a delivery stride that starts with a powerful push-off from the ground, creating momentum that is then transmitted up the legs, hips, trunk, and shoulder to the arm. The ball is subsequently launched with maximal power and speed using the arm, while the required spin and direction are provided by the wrist and fingers.[14]

The kinetic chain mechanism is used by spin bowlers to provide spin and variation in their deliveries. They use a shorter run-up and a delivery stride that involves a hip and trunk rotation to create momentum that is then transmitted up the shoulder and into the arm. The wrist and fingers then offer essential control and direction while the arm is employed to deliver the ball with the most spin and variation.[15]

Chop and lift exercises are commonly used in the rehabilitation and conditioning of athletes, particularly in sports that require strong and explosive movements, such as cricket. These exercises involve a combination of rotational and axial movements, which can help improve the strength and coordination of the trunk, hips, and upper body.[15]

In terms of their effects on bowlers, chop and lift exercises can help improve the kinetic segments involved in the bowling action. The kinetic chain involves a sequence of movements that start from the legs and move upwards through the hips, trunk, shoulder, and arm, ultimately leading to the release of the ball. Proper sequencing and coordination of these movements are essential for generating maximal velocity and accuracy in the delivery of the ball.[17]

Chop and lift exercises can help improve the kinetic segments involved in the bowling action by improving the strength and coordination of the muscles involved in these movements. For example, the chop exercise involves a chopping motion with the arms and upper body, which can help improve rotational power and stability in the trunk and hips. The lift exercise involves a lifting motion with the arms and upper body, which can help improve shoulder strength and coordination.[4]

The movements of the chop and lift are multi-planar (three-plane), requiring the arms, shoulders, torso, hips, and legs to move in a diagonal and spiral pattern. It is possible to practice the exercise while standing, sitting, or half-kneeling.[2] The chop and lift patterns are applications of the upper extremity diagonals that involve the use of bilateral upper extremities.[15]

The chop and lift patterns of bilateral upper extremity proprioceptive neuromuscular facilitation (PNF) have a long history in rehabilitation. When the PNF chop and lift patterns are combined with the half kneeling and tall kneeling postures, the clinician may link the gap between low-level patterns and postures (rolling, crawling, creeping) and high-level, functional patterns and postures (squatting, lunging, stepping, pushing, pulling).[17]

NEED FOR STUDY

1. There is lack in study comparing how different bowlers respond to different strength and conditioning programs, despite the significance of this control for both performance and injury prevention. Filling this gap, this study looks at how chop and lift workouts affect bowlers' pace and spin, as they are known to target different parts of the kinetic chain.
2. By evaluating how chop and lift exercises affect kinetic chain control and power in pace and spin bowlers, this research will offer valuable insights into optimizing training protocols.

AIM

1. To find the effects of chop and lift exercise on the kinetic chain control in cricket bowlers.
2. To find the effects of chop and lift exercise on power in cricket bowlers.

OBJECTIVES OF THE STUDY

1. To find the effects of chop and lift exercises on kinetic chain control in pace and spin bowlers using Upper Quarter Y Balance Test.
2. To find the effects of chop and lift exercises on power in pace and spin bowlers using rotational medicine throwball test.

HYPOTHESIS

1. **Null Hypothesis (H01):** There will be no significant effects of chop and lift exercise on the kinetic chain control and power of pace bowlers.
2. **Null Hypothesis (H02):** There will be no significant effects of chop and lift exercise on the kinetic chain control and power of spin bowlers.
3. **Alternate Hypothesis (H1):** There will be significant effects of chop and lift exercise on the kinetic chain control and power of pace.
4. **Alternate Hypothesis (H1):** There will be significant effects of chop and lift exercise on the kinetic chain control and power of spin bowlers.

REVIEW OF LITERATURE

1. A study "Kinematic and kinetic comparison of baseball pitching among various levels of development" by Fleisig GS, Barrentine SW, Zheng N, Escamilla RF reported that Kinematic and kinetic comparison of baseball pitching among various levels of development. It found that as pitchers advance, their mechanics become more refined, leading to more efficient and effective pitching motions. Youth pitchers often exhibit less optimal mechanics and higher injury risk, while professional pitchers demonstrate advanced techniques that enhance performance and reduce stress on the arm. The study highlights the importance of proper mechanics and training to improve pitching performance and minimize injury risks.[15]

2. A Study "The Chop and Lift Reconsidered: Integrating Neuromuscular Principles into Orthopaedic and Sports Rehabilitation" authored by Michael L. Voight, Barbara J. Hoogenboom, and Gray Cook, published in the North American Journal of Sports Physical Therapy, explores the application of upper extremity bilateral PNF patterns, specifically the "chop and lift," in orthopaedic and sports rehabilitation. The authors emphasize the significance of transitional postures, such as half-kneeling and tall-kneeling, in assessing core stability and identifying athletic imbalances. These postures are designed to isolate movement deficiencies by minimizing compensatory strategies typically used by the legs. The commentary highlights the importance of reflex stabilization, advocating for the integration of these patterns into rehabilitation practices to enhance neuromuscular function and movement efficiency.[18]

3. A study "The Kinetic Chain Revisited: New Concepts on Throwing Mechanics and Injury" by Chu S K, Jayabalan P, Kibler W B reported that the biomechanics of the overhead throwing motion, focusing on the critical role of the kinetic chain, which involves the coordinated action of body segments from the legs to the arm. It highlights how disruptions in this chain can lead to inefficient throwing mechanics and increase injury risk, particularly in the shoulder and elbow. The article also explores clinical evaluation methods and management strategies for addressing abnormal throwing mechanics and related injuries.[19]

4. A study "Compendium of Isokinetic in Clinical Usage and Rehabilitation Techniques" by Davies G. J. et al. examines the role of proximal-to-distal sequencing in how activating proximal muscles (such as the core and scapula) is crucial for facilitating proper movement in distal segments like the shoulder and arm. This sequencing is fundamental for effective rehabilitation and functional recovery. The study reviews various isokinetic exercises and their application in clinical settings to improve rehabilitation techniques.[13]

5. A study "The influence of lumbopelvic control on shoulder and elbow kinetics in elite baseball pitchers" by Laudner Kevin G, Wong R, Mister K et al. reported that the connection between lumbopelvic control and the forces exerted on the shoulder and elbow during pitching in elite baseball players. The research focuses on how the stability and control of the lumbopelvic region, particularly involving the drive leg, affect shoulder

horizontal torque and elbow valgus torque—both critical factors in reducing injury risk and improving performance. The study, which included 29 elite pitchers, found that better control of the lumbopelvic region is linked to improved throwing mechanics, potentially lowering the likelihood of shoulder and elbow injuries.[20]

6. A study "Exploration of the Y Balance test for assessment of upper quarter closed kinetic chain performance" by Richard B. Westrick reported that the explores the need for reliable functional testing of the upper extremity (UE) in sports rehabilitation, focusing on the Upper Quarter Y-Balance Test (UQYBT). It involved thirty healthy college-aged participants (24 males and 6 females) from the United States Military Academy. The study assessed the reliability of the UQYBT and its relationship with core stability and UE function. Results showed that the UQYBT is a reliable test for unilateral UE performance, with no significant differences between dominant and non-dominant limbs. The findings suggest the UQYBT could be a valuable clinical tool, though further research is needed.[21]

7. A Study "Reliability and Validity of Medicine Ball Toss Tests as Clinical Measures of Core Strength" by Mallory A. Sell et al. investigates three newly developed medicine ball toss tests (MBTs) designed to assess core strength while minimizing the involvement of upper and lower extremities. Involving 20 healthy, physically active participants, the study employed a descriptive design with two testing sessions: the first included isokinetic

strength testing alongside the MBTs, while the second focused solely on the MBTs. The results indicated strong test-retest reliability, with intraclass correlation coefficients (ICCs) ranging from 0.84 to 0.95, suggesting consistent performance across trials. However, the study found a lack of significant correlation between the MBTs and isokinetic strength measures, raising questions about their validity as comprehensive measures of core strength. The authors emphasize the need for further research to refine the MBTs and explore modifications that could enhance their validity, ultimately contributing to the development of effective clinical measures for assessing core strength in athletic training and rehabilitation settings. This research was published in the journal Isokinetic and Exercise Science.[22]

8. A Study titled "Systematic Review and Meta-Analysis on Proximal-to-Distal Sequencing in Team Handball," authored by Ben Serrien and Jean-Pierre Baeyens, was published in the Journal of Human Kinetics, volume 63, in 2018. This systematic review and meta-analysis examine the coordination of joint motions during throwing in elite handball players, specifically analysing a population that includes both male and female athletes from various competitive levels, including national teams and elite leagues. The findings reveal a consistent proximal-to-distal sequencing that begins with pelvis rotation and progresses through trunk rotation, trunk flexion, and shoulder movements. The authors highlight the importance of these biomechanical insights for talent detection and

development, suggesting that understanding this sequencing can aid in identifying athletes with high potential for performance.[23]

9. A Study A segment interaction analysis of proximal-to-distal sequential segment motion patterns authored by Carol A., Putman at el. investigate that Kinetic chain linkages refer to the interconnected system of joints and segments in the body that work together to produce movement. This concept is crucial in biomechanics and rehabilitation, as it highlights how dysfunction in one area can affect overall movement patterns and lead to injuries. The kinetic chain is categorized into open and closed systems, with each segment—comprising bones, muscles, tendons, and ligaments—playing a vital role in maintaining stability and facilitating efficient movement. Understanding these linkages is essential for developing effective rehabilitation strategies and training programs that enhance performance while minimizing injury risk.[24]

METHODOLOGY

Participants:

- A randomized trial was performed on 42 cricket bowlers selected from local cricket academy, Bhubaneswar, Odisha. Ethical clearance was taken from the Institutional ethical committee of Abhinav Bindra Sports Medicine and Research Institute (ABSMARI), Bhubaneswar prior to the commencement of the study. The protocol ID for approval was ABS-IEC-2023-PHY-008. The participants selected were within the age group of 16-25 years and had at least 2-3 years of bowling experience. The purposive sampling method was used. Cricket bowlers both right-handed and left-handed. The players having any kind of recent injury, female cricket bowlers, or PARQ score less than 7 were excluded from the study. The sample were divided equally into 2 groups. (Pace and Spin)

Sample size calculation:

Sample size was calculated in G-Power software using mean (91.63,84.51) and standard deviation (9.7,5.4), effect size (0.906), alpha (0.05), power (0.8).[25]

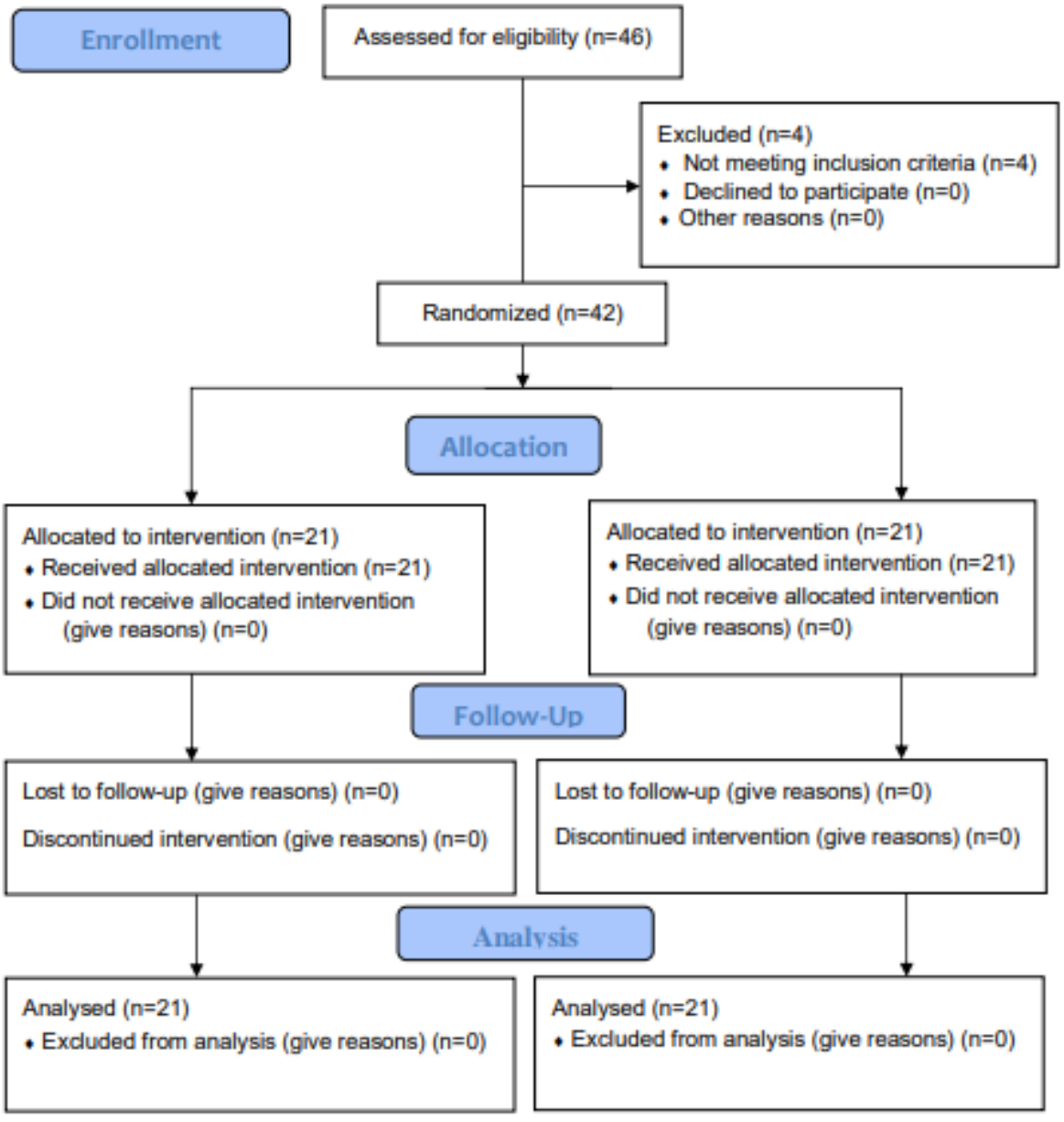
MATERIALS USED

1. Y Balance Test Kit (3 wooden boxes 10 cm)
2. Medicine ball weighing (4 kg)
3. Measuring tape
4. Agility cones
5. Performance recording sheet

6. Kettle bell weighing (2-8 Kgs)

7. Stopwatch (Mobile Application)

FIGURE 1: CONSORT 2010 Flow Diagram



PROCEDURE

- An experimental study was undertaken at a local cricket academy, Bhubaneswar. 42 participants were selected based on the inclusion and exclusion criteria.
- A brief demographic data of all the participants was obtained, written consent was taken from all the participants, and the experimental protocol was explained with its benefits and Precautions. The study duration was 6 weeks which included 12 sessions of experimental protocol. 42 Participants, who cleared the Physical activity readiness questionnaire (PARQ), and the inclusion criteria were divided to pace and spin groups respectively depending upon their bowling pattern.
- Both the groups underwent the same training regime i.e. chop and lift exercise with kettlebell. Power and kinetic chain control were assessed for each participant by rotational medicine ball throw test (RMBT) and upper quarter Y-balance test (UQYBT) respectively. The UQYBT was assessed for both dominant and non-dominant upper extremities. These two outcome measures were assessed prior to the commencement of the study and after 6 weeks.
- There were no adverse events during the training sessions.

❖ **Chop and lift exercise:** Exercises such chop and lift are innovative methods to improve functional strength and core stability by imitating commonplace movements. The lift is the opposite of the chop, lowering weight from above the shoulder to the hip on the same side. The chop is

lifting a weight from a low position on one side of the body to a high position on the opposing side. These workouts are adaptable for varying fitness levels as they work several muscle groups, enhance balance, and can be done with a variety of equipment. They are very helpful in preventing injuries and addressing asymmetries in movement.

Setup for the Half Kneeling Chop and Lift Procedure:

1. Starting Position: Take a half-kneeling stance to start. This position places one knee on the floor and the other foot flat on the ground in front of you.

   -To create a 90-degree angle at both knees, place your left foot flat in front of you if your right knee is on the floor.

   -Make sure your left foot is pointed forward and your right knee is exactly beneath your right hip.

2. Kettlebell Position: - Beginning at the side of your body opposite the knee on the ground, hold the kettlebell with both hands. For example, hold the kettlebell with both hands on the left side of your body if your right knee is bent.

3. The Execution Chop Motion: Chop Down

   a. Throughout the exercise, keep your spine upright and your core active.

   b. Maintaining a straight arm position, rotate your torso to bring the kettlebell diagonally across your body and near the front pocket of your left hip.

   c. Pay attention to starting the action from your hips and core as opposed to only your arms.

d. Return With control and a straight spine, slowly move the kettlebell back to the beginning position.

4. Lift Movement: -

a. Lift Up: - After finishing the chop, move on to the lift. Begin with the kettlebell at your left hip. - Lift the kettlebell diagonally upwards across your body towards the right shoulder, maintaining your arms straight and using your core for stability.

b. Return: - Lower the kettlebell back down to the starting position at your left hip in a controlled manner.

5. Repetitions: -

a. 1.8 to 10 repetitions should be done for each side, switching the kneeling leg after each repetition.

b. Make sure that movements are executed with control and appropriate form to optimize advantages and reduce the chance of harm.

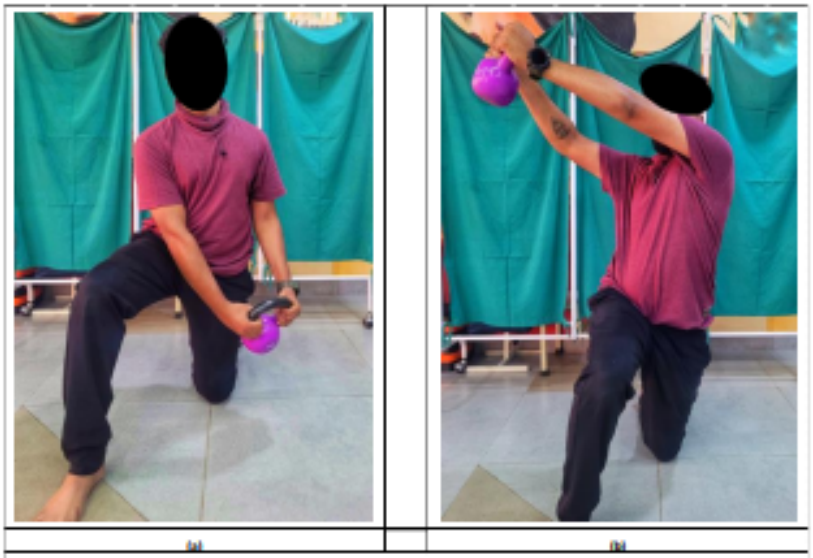


FIGURE 2: CHOP AND LIFT EXERCISES WITH KETTLE BELL IN HALF KNEELING POSITION

CHOP AND LIFT EXERCISE:

Week 1-2: 12 repetitions, 3 sets, 4 kg kettlebell

Week 3-4: 12 repetitions, 3 sets, 6 kg kettlebell

Week 5-6: 12 repetitions, 3 sets, 8 kg kettlebell

(Dosage: 6 weeks, 2 days/week, 40 minutes/day, 15-20 seconds rest between sets, and 1-minute rest between exercises)

Warm-up and cool down were performed each for 10 minutes.

Increase the weight of the kettlebell gradually as the athlete progresses and becomes stronger and more comfortable with the exercise.

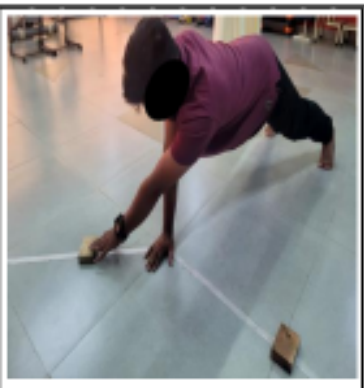
TABLE 1: Dosage and list of exercises

OUTCOME MEASURES:

1. Upper Quarter Y-Balance Test:
    - Starting Position: The individual starts in a push-up position, with their feet no more than twelve inches apart. The hands should be immediately below the shoulders.
    - Reaching Directions: The patient exerts maximal effort and reaches with one hand in three distinct directions: Medial (facing the body), Superolateral (upward and outward) and inferolateral (downward and outward).
    - Recording Distances: The distance reached in each direction is recorded. Each subject is given three practice trials to familiarize themselves with the test.
    - Trial Execution: Following practice, the subject takes the test, with the average of three trials in each direction used for analysis.

- Total Excursion Score: The sum of the distances travelled in each of the three directions determines the total reach distance.
- Normalization: A composite score is computed by multiplying the total excursion distance by three times the upper limb length in order to adjust for limb length. With the use of this technique, upper extremity mobility and stability may be evaluated in a closed kinetic chain fashion.

(A) MEDIAL



(B) SUPEROLATERAL

(C) INFEROLATERAL

FIGURE 3 : UPPER QUARTER Y-BALANCE TEST (UQYBT)

2. Rotational Medicine Ball Throw Test:
   - Stand perpendicular to the start line in a pitching or hitting stance.
   - Hold the medicine ball with both hands, with the back hand on the back of the ball and the front hand under it.
   - Draw the ball back, keeping it between your waist and chest with only a slight bend at the elbows.
   - In one motion, fling the ball up and forward at a 45-degree angle. You are encouraged to fall forward over the line after releasing the ball to maximize distance.
   - Perform 3 attempts, with the best result recorded.

- Scoring: Measure the distance from the starting line to where the ball first lands, recording to the nearest foot. The best of 3 throws is the final score.

FIGURE 4: ROTATIONAL MEDICINE BALL THROW TEST (RMBT)

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS statistical package of social sciences version 25. The normality of the data was found using Shapiro-Wilk test which showed that the data were normally distributed. Descriptive analysis was done while performing interferential statistics using mean and standard deviation. Interferential statistics was done within and between groups using paired-t test and unpaired-t Test respectively. The level of significance (p-value) was kept at ≤0.05.

RESULTS

The study sample comprised 42 participants ranging in age from 16 to 25 years. Demographic and baseline data are presented in **TABLE 2**. The distribution of data for the pace and spin groups was found to be normal **(p>0.05)**. **GRAPH 1** provides a visual representation of the demographic characteristics of both groups.

VARIABLES	PACE	SPIN	P-VALUE
AGE (YEARS)	20.47	20.42	>0.05
HEIGHT (CM)	166	166.95	>0.05
WEIGHT (KG)	62	61.85	>0.05
UQYBT_D_PRE (CM)	113.13	108.74	>0.05
UQYBT_ND_PRE (CM)	103.54	96.64	>0.05
RMBT_PRE (Meter)	7.59	6.98	>0.05

TABLE 2: DEMOGRAPHIC AND PRE-INTERVENTION DATA

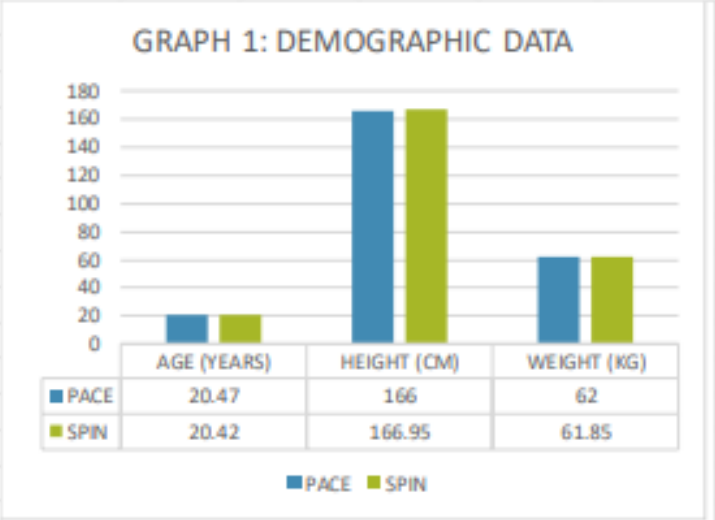


FIGURE 5

In a within-group analysis comparing pre- and post-intervention results of the upper quarter Y-balance test on the dominant side, both the pace and spin groups demonstrated a statistically significant difference **(p<0.05)**. These findings are detailed in **TABLE 3** and visually represented in **GRAPH 2**.

GROUP	PRE	POST	MEAN DIFFERENCE	P-VALUE
PACE	113.13	123.27	10.14	<0.05*
SPIN	108.74	119.37	10.63	<0.05*

TABLE 3: WITHIN GROUP ANALYSIS OF UQYBT_D

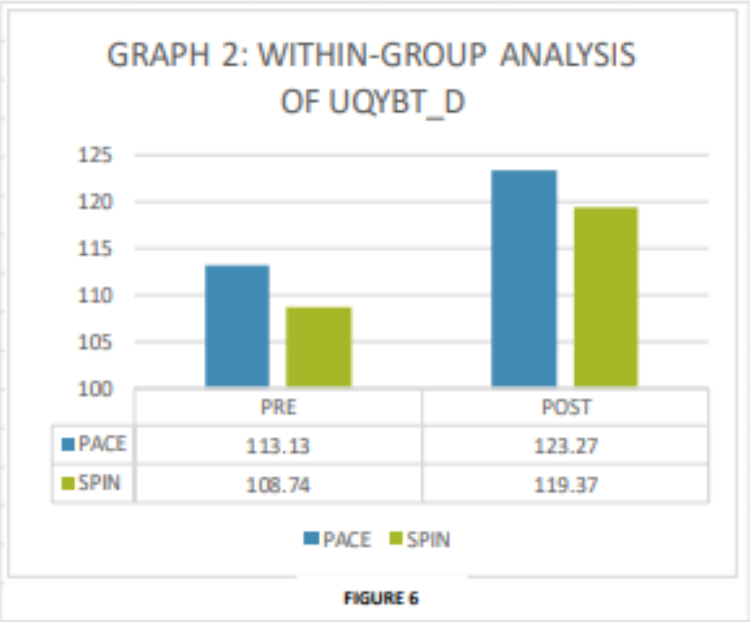


FIGURE 6

In a within-group analysis of pre- and post-intervention performance on the upper quarter Y-balance test for the non-dominant side, both the pace and spin groups exhibited a statistically significant difference **(p<0.05)**. These results are presented in **TABLE 4** and illustrated in **GRAPH 3**.

GROUP	PRE	POST	MEAN DIFFERENCE	P-VALUE
PACE	103.54	113.41	9.87	<0.05*
SPIN	96.64	108.98	12.34	<0.05*

TABLE 4: WITHIN GROUP ANALYSIS OF UQYBT_ND

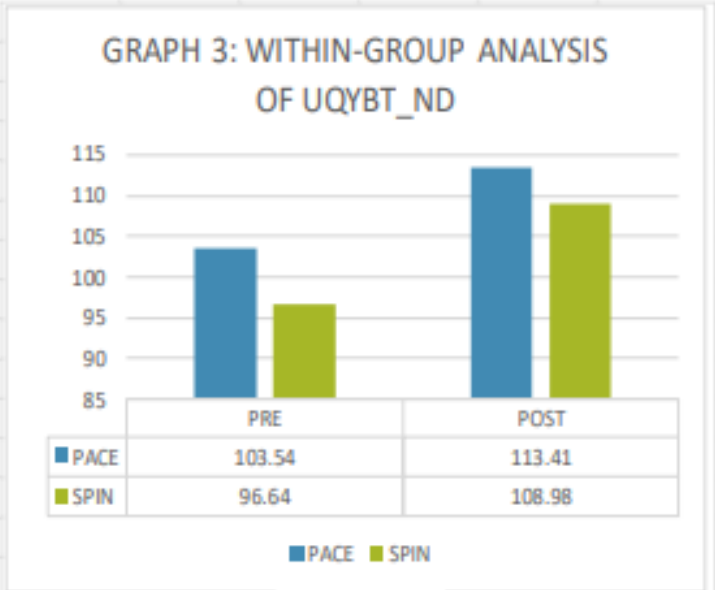


FIGURE 7

In the within-group analysis of pre- and post-intervention results for the rotational medicine ball throw test, both the pace and spin groups demonstrated statistically significant differences **($p<0.05$)**. These findings are summarized in **TABLE 5** and depicted in **GRAPH 4**.

GROUP	PRE	POST	MEAN DIFFERENCE	P-VALUE
PACE	7.59	8.79	1.2	<0.05*
SPIN	6.98	8.14	1.16	<0.05*

TABLE 5: WITHIN GROUP ANALYSIS OF RMBT

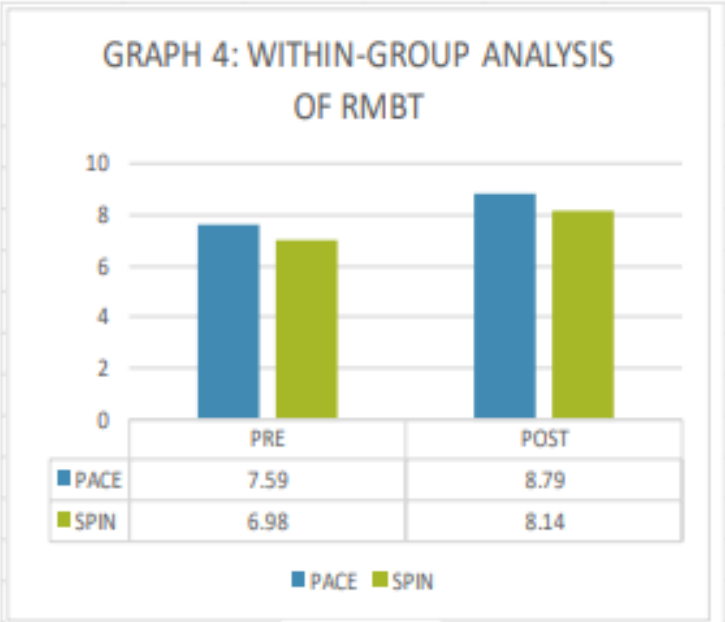


FIGURE 8

The between-group comparison of post-intervention results for the upper quarter Y-balance test on both the dominant **(Graph 5)** and non-dominant sides **(Graph 6)** showed no statistically significant difference **(p>0.05)** between the pace and spin groups. However, the rotational medicine ball throw test **(Graph 7)** indicated a statistically significant difference **(p<0.05)** between pace and spin groups, as presented in **TABLE 6**.

FACTOR	GROUPS	PRE_DATA	POST_DATA	MEAN DIFFERENCE	P-VALUE
UQYBT_D	PACE	113.13	123.27	10.14	>0.05
	SPIN	108.74	119.37	10.63	
UQYBT_ND	PACE	103.54	113.41	9.87	>0.05
	SPIN	96.64	108.98	12.34	
RMBT	PACE	7.59	8.79	**1.2***	**<0.05***
	SPIN	6.98	8.14	1.16	

TABLE 6: BETWEEN GROUPS ANALYSES OF MEAN DIFFERENCES

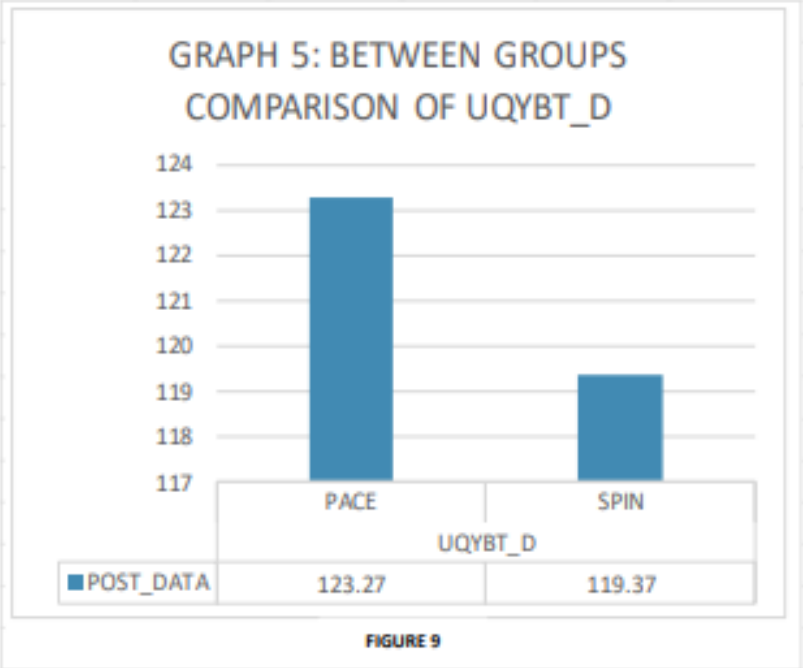


FIGURE 9

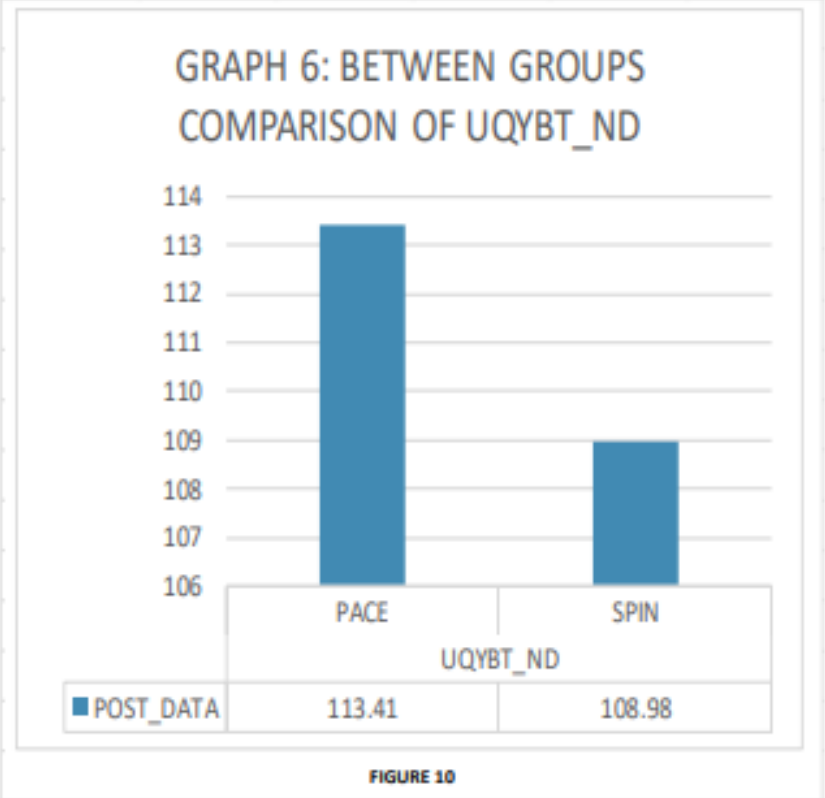


FIGURE 10

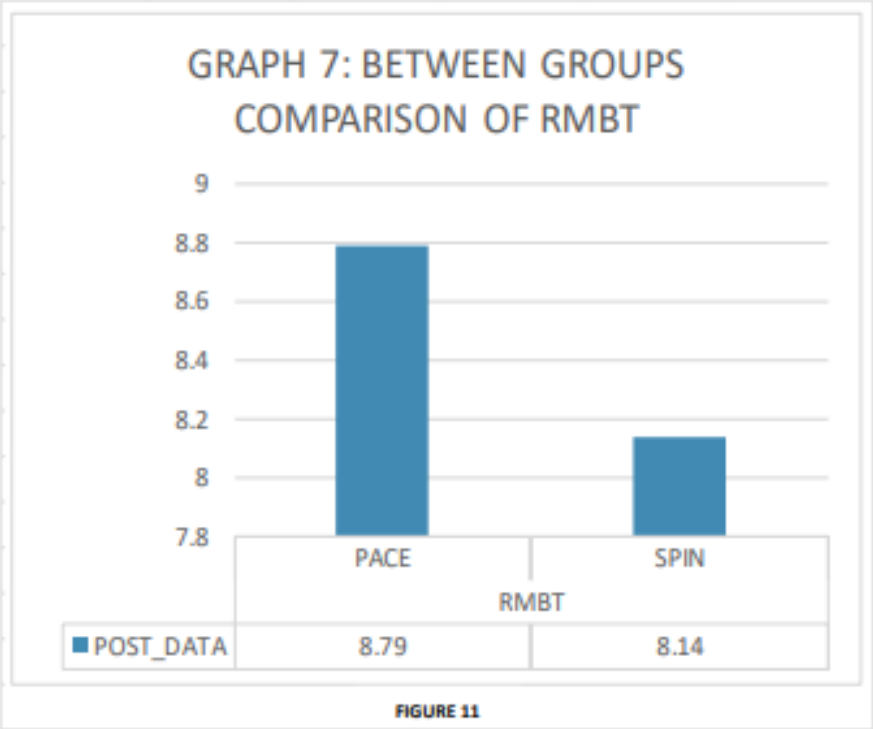


FIGURE 11

The within- and between-group comparisons demonstrated that both groups improved in kinetic chain control and power, as measured by the upper quarter Y-balance test and the rotational medicine ball throw test. However, when comparing the mean differences in the rotational medicine ball throw test between groups, the pace group showed a greater mean difference between pre- and post-intervention values than the spin group, indicating that the pace group achieved more significant gains in this test. In contrast, the upper quarter Y-balance test for both the dominant and non-dominant sides revealed no statistically significant difference between the groups, suggesting that the pace and spin groups experienced similar improvements in this area.

DISCUSSION

This study examined the effects of chop and lift exercises on kinetic chain control and power in cricket bowlers, offering valuable insights into the training adaptations of both spin and pace bowlers.

The intervention involved a six-week regimen of kettlebell chop and lift exercises, with outcomes measured through the upper quarter Y balance test and the rotational medicine ball throw test. While the between-group results indicated no significant differences ($p>0.05$) for upper quarter Y-balance test and statistically significant difference ($p<0.05$) for rotational medicine ball throw test, the within-group analyses revealed significant improvements ($p<0.05$), highlighting the effectiveness of the intervention.

The kinetic chain was a crucial concept in understanding athletic performance, particularly in sports like cricket, where complex movements are involved. It refers to the interconnected groups of body segments, joints, and muscles that work together to produce movement. In cricket, efficient kinetic chain function is essential for actions such as bowling, batting, and throwing, where energy transfer from the ground through the body to the ball is vital for performance. Effective energy transfer is fundamental to maximizing performance in cricket. Any inefficiencies or "leaks" in the kinetic chain—such as excessive movement or instability—can result in decreased power output and increased injury risk. [7]

The significant improvement in the rotational medicine ball throw test among pace bowlers indicated that kettlebell chop and lift exercises were particularly effective in developing the explosive power required for high-velocity bowling. This finding aligns with the work of Fleisig et al. (1999), who highlighted the

importance of explosive strength for generating the substantial force required in sports like baseball pitching, a demand that parallels the requirements of pace bowling. The focus of the chop and lift exercises on rotational stability and core engagement, especially in a half-kneeling position, likely enhanced the body's ability to efficiently produce and transfer force—key elements for optimal pace bowling performance.[15]

The effectiveness of these exercises in enhancing rotational power was reinforced by evidence showing the crucial role of proximal-to-distal sequencing in athletic movements. Kibler (1994) emphasized that this sequencing is vital for efficient force generation in sports. In this study, the focus on core stability and rotational force generation in a half-kneeling position likely improved performance in rotational tasks, which are essential for cricket bowlers.[16]

The lack of significant differences in the upper quarter Y-balance test suggested that chop and lift exercises enhanced balance and stability similarly for both pace and spin bowlers. This finding aligned with research indicating that balance exercises can effectively improve upper body stability across various athletic groups. The absence of varying results between the interventions suggested that both methods similarly affected balance, independent of the bowling style.[19]

Overall, this study's findings suggested that, although the comparison between spin and pace bowlers did not yield significant differences, the within-group improvements indicated that both types of bowlers benefited from the kettlebell exercises. This aligned with previous research that emphasizes the role of strength and conditioning in enhancing athletic performance through improved kinetic chain function and stability.[26]

The significant within-group improvements observed in the upper quarter Y balance test and the rotational medicine ball throw test suggested that the chop and lift exercises effectively enhanced both balance and power. These outcomes are critical for bowlers, as balance is essential for maintaining proper technique during delivery, and power is crucial for achieving higher bowling speeds and greater accuracy.[22,27]

The results of this study underscored the importance of incorporating specific strength and conditioning exercises, such as kettlebell chop and lift movements, into the training regimens of cricket bowlers. By improving kinetic chain control and power, coaches can help athletes enhance their performance while potentially reducing the risk of injury. This approach aligned with current best practices in sports science, which advocate for a comprehensive training strategy that addresses both strength and functional movement patterns. [2,4]

The study demonstrated that both groups improved in kinetic chain control and power, as evidenced by significant changes in the upper quarter Y-balance test ($p<0.05$) and the rotational medicine ball throw test ($p<0.05$).However, when comparing the mean differences in the rotational medicine ball throw test between groups, the pace group showed a greater mean difference between pre- and post-intervention values than the spin group, indicating that the pace group achieved more significant gains in this test **($p<0.05$)**. In contrast, the upper quarter Y-balance test for both the dominant **($p>0.05$)** and non-dominant **($p>0.05$)** sides revealed no statistically significant difference between the groups, suggesting that the pace and spin groups experienced similar improvements in this area.

CONCLUSION

In conclusion, the experimental study highlights the effectiveness of kettlebell chop and lift exercises in improving kinetic chain control and power in cricket bowlers. While the lack of significant differences between groups may suggest that both spin and pace bowlers respond similarly to the training intervention, the within-group improvements point to the potential benefits of targeted strength training. Future research could explore the long-term effects of such interventions and their impact on competitive performance in cricket.

LIMITATIONS

1. The study exclusively involved male cricket bowlers to control for physiological differences between genders.
2. The study did not include a control group that did not undergo any intervention. Including a control group could help isolate the effects of the chop and lift exercises from other factors that could influence the results.
3. The sample size of 42 male participants may limit the applicability of the findings to larger populations or to female cricketers.

FUTURE SCOPE

- Future research could benefit from extending the duration of interventions to better understand the long-term impacts of chop and lift exercises on cricket bowlers' performance and injury prevention.
- Including a more diverse participant group, such as female bowlers and those with different injury histories, could offer a broader perspective on how chop and lift exercises affect various individuals.
- Adding more performance and biomechanical assessments could provide a deeper insight into how chop and lift exercises influence kinetic chain control and power.
- Comparative studies could evaluate how chop and lift exercises stack up against other strength and conditioning programs to identify the most effective strategies for improving performance and minimizing injury risk in cricket bowlers.

SUMMARY

The study investigated how a structured training program featuring chop and lift exercises affected male cricket bowlers, both pace and spin types. Spanning six weeks, the program included 12 sessions where participants performed kettlebell exercises aimed at boosting their power and kinetic chain control.

Forty-two male bowlers were chosen based on specific criteria, and their performance was assessed with two main tests: the rotational medicine ball throw test (RMBT) for power and the upper quarter Y-balance test (UQYBT) for kinetic chain control in both dominant and non-dominant arms.

The results showed that both pace and spin bowlers improved their performance metrics significantly, with pace bowlers making more notable gains in the RMBT. However, no significant differences were found in the UQYBT scores between the two types of bowlers, suggesting that both groups experienced similar improvements in kinetic chain control. Overall, the study concluded that the training program was effective in enhancing the athletic performance of the participants, suggesting that such exercises could be beneficial in cricket training regimens.

DATA AVAILABILITY STATEMENT

The datasets produced and/or analyzed in this study are not publicly accessible due to privacy and confidentiality concerns but can be obtained from the corresponding author upon reasonable request. The detailed original data underlying the findings of this study, including raw measurements and analysis files, are securely stored and can be accessed upon request for research and verification purposes.

CONFLICT OF INTEREST

The authors state that the research was carried out without any commercial or financial ties that could be interpreted as a potential conflict of interest.

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ANNEXURE:1

CONSENT FORM

I _____, aged ___ years, confirm that I have understood about plyometric and high intensity interval training procedure and its potential benefits on athletes as explained by Deepesh Gurjar and is as mentioned in his study which is taking place under the guidance of Dr. Asifuzzaman Shahriyar Ahmed (PT), Associate professor, Abhinav Bindra sports medicine and research institute (ABSMARI) and, co-guidance of Dr. Gayatri Upasana Acharya (PT), Assistant Professor, ABSMARI.

I understand that my participation is voluntary and I'm free to withdraw at any time, without giving any reason.

I understand that confidentiality will be maintained.

I voluntarily agree to and give my consent to be a part of the above-mentioned study.

Signature Date

ANNEXURE:2

ASSESSMENT FORM

Name: Dominant hand:

Age/Gender: Type of bowler:

Height: Weight:

Pre- and post-intervention data:

1.Upper Quarter Y-Balance Test (UQYBT) (in centimetres)

TRAIL	Upper Quarter Y-Balance Test (UQYBT)		
	Medial	Supero-lateral	Infero-lateral
TRAIL 1			
TRAIL 2			
TRAIL 3			

2.Rotational Medicine Ball Throw Test (in meters)

TRIALS	Pre-Intervention	Post-Intervention
Trial 1		
Trial 2		
Trial 3		
Final (Highest) score		

Physical Activity Readiness Questionnaire:

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:**	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:**	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:**	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

ANNEXURE:3

ICE INSTUTIONAL ETHICAL COMMITTEE

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2023/049

Date: 12/08/2023

APPROVAL LETTER

APPENDIX- VIII

To,

DEEPESH GURJAR
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Effects of Chop and Lift Exercises on Kinetic Chain Control and Power in Cricket pace and spin Bowlers: A Randomised Trial

Protocol ID.: ABS-IEC-2023-PHY-008

Subject: Approval for the conduct of the above referenced study

Dear Mr./Mrs./Dr **DEEPESH GURJAR**

With reference to your Submission letter dated 12/08/2023 the ABSMARI IEC has of the Ethics reviewed and discussed your application for conduct of clinical trial on dated 12/08/2023 (Sat Day).

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	08-08-2023
2	Informed Consent Form	08-08-2023
3	Undertaking form PI	08-08-2023
4	CRF	08-08-2023
5	COI from the Investigators	08-08-2023

The following members were present at meeting held on 12-08-2023

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor [MBBS, MD, Dept. of Community Med.] IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Satyajit Mohanty	Director-Medcare Hospital, BBSR	Basic Medical Scientist	M	N
3	Dr. Ashok Singh Chauhan	PhD. Pharmacology, Assoc. Prof. Dept. of Pharmacology, Hi-Tech Medical College & Hospital, BBSR	Basic Medical Scientist	M	N

MEMBERS

Dr. Smaraki Mohanty, Clinician

Dr. Satyajit Mohanty, Basic Medical Scientist

Dr. Ashok Singh Chauhan Basic Medical Scientist

Mr. Shib Shankar Mohanty Legal Expert

Ms. Annie Hans, Social Scientist

Ms. Subhashree Samal, Lay Person

Mr. Deepak Ku. Pradhan, Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

ABSMARI ETHICS COMMITTEE BHUBANESWAR

1

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ANNEXURE:4

MASTERCHART

PACE-BOWLERS																													
Sr. No.	Age	Height	Weight	Upper Quarter Y-Balance Test																Rotational Medicine Ball Throw Test									
				Medial				Supero-lateral				Infero-lateral				Composite Score				RMBT Pre				RMBT Post					
				D-Pre	D-Post	ND-Pre	ND-Post	D-Pre	D-Post	ND-Pre	ND-Post	D-Pre	D-post	ND-Pre	ND-Post	D-Pre	D-Post	ND-Pre	ND-Post	TRAIL 1	TRAIL 2	TRAIL 3	BEST	TRAIL 1	TRAIL 2	TRAIL 3	BEST		
1	18	157	54	98	99.25	82.5	90.5	78	84.6	72.5	79.1	56.5	62.6	52.5	58.6	94.72	103.98	87.55	96.28	7.21	7.2	7.3	7.3	9.04	9.05	8.85	9.85		
2	22	164	71	97.5	105.2	85.35	94.25	77.5	83.9	69.2	75.6	56.5	62.7	53.5	59.9	102.33	111.28	93.9	101.54	6.78	6.8	8.1	8.1	9.85	11.1	11.88	11.1		
3	17	159	65	117	125.6	98.5	106.4	74.5	81.4	71.5	78.1	83.5	89.7	69.5	75.7	124.64	134.48	108.55	117.94	7.89	8.4	7.8	8.4	8.31	8.87	9.4	9.4		
4	25	164	49	109.5	117.7	96.4	104.8	52.5	59.3	58.5	65.5	86.5	93.9	79.5	85.7	115.65	125.61	109.09	119.14	6.37	7.5	7.2	7.5	8.98	9.41	9.39	9.41		
5	19	162	62	68.5	78	70.1	79.3	70	76.8	59.5	65.9	68.5	74.8	75.5	81.7	95.83	105.37	87.64	105.04	8.83	6.6	8.7	8.7	6.36	9.2	7.84	9.2		
6	20	168	58	113.5	119.7	105	113.2	63.5	70.5	57.5	64.1	88.5	94.9	72.5	78.9	124.64	133.84	108.42	120.28	7.56	8.3	6.9	8.3	7.42	8.56	8.89	8.89		
7	21	164	77	118.2	126.8	98.4	106.4	77.5	84.1	68.5	75.3	92.5	98.6	87.3	93.5	126.4	135.74	111.49	120.7	6.95	7.8	8.6	8.1	8.75	9.64	9.48	9.64		
8	24	165	53	134.5	147.1	114.6	123.2	90.5	97.3	88.5	94.9	93.5	99.7	98.5	106.2	147.45	159.3	139.35	150.13	7.12	6.9	7.2	7.2	8.84	7.19	6.96	8.84		
9	18	166	72	116.5	125.6	108.6	116.8	64.5	71.1	61.7	68.3	82.5	88.7	78.3	84.5	126.37	136.88	121.76	129.3	8.17	7.1	8.5	7.6	7.68	7.52	9.1	9.1		
10	23	167	66	124.6	123.8	107.4	115.8	61.8	68.4	62.4	69.2	61.4	67.6	58.4	64.8	107.217	117.02	102.79	112.52	6.23	8.2	7.9	8.2	7.24	8.69	7.96	8.69		
11	19	167	59	123.5	133.8	114.5	122.9	82.5	89.7	78.4	85.2	83.7	90.1	77.3	83.5	133.34	143.42	124.36	134.21	7.34	7.3	7.1	7.34	7.48	7.84	7.42	7.84		
12	18	167	68	120.5	129.6	104.2	113.3	85.5	94.8	82.4	89.2	83.5	89.7	78.3	84.7	126.49	137.63	119.89	129.98	7.67	8.4	7.7	8.4	8.24	8.78	9.37	9.37		
13	25	168	57	122.5	131.2	105.2	113.6	82.2	88.7	64.3	70.7	84.6	90.8	80.5	86.7	123	131.8	107.24	115.22	6.45	6.7	8.6	7.8	8.02	7.94	7.42	8.02		
14	21	169	51	104.8	113.1	102.5	111.1	84	90.8	72.5	79.1	79.5	85.9	71.6	77.8	125.169	135.19	115.04	125.02	8.89	7.9	7.1	8.09	7.93	8.89	7.88	8.89		
15	20	169	64	113.5	121.4	87.2	95.6	56.5	63.7	44.2	50.6	67.5	73.7	61.2	67.4	100.53	110	81.86	90.79	7.83	6.4	8.2	8.2	8.09	7.12	8.32	8.32		
16	22	171	50	105.3	114.6	98.2	106.8	59.2	65.9	56.4	62.8	62.4	68.6	59.6	65.8	102.73	112.78	96.98	106.94	6.84	7.24	7.14	6.84	6.56	8.4	7.5	8.4		
17	24	172	74	98.2	107.4	89.4	97.7	64.3	70.7	59.3	65.9	78.5	84.7	66.4	72.6	112.82	123.833	100.7	110.58	6.94	7.24	7.08	6.94	7.48	7.2	6.5	7.48		
18	17	172	70	85.41	96.24	105.5	88.9	48.4	58.6	47.5	56.3	61.41	69.4	58.54	66.5	79.35	91.15	85.99	86.05	6.84	7.02	6.58	6.84	6.88	7.6	6.8	7.6		
19	16	173	60	106.05	116.17	99.85	108.03	63.56	70.56	56.21	63.22	74.85	80.74	67.36	73.41	100.27	110.06	91.94	100.68	6.46	6.34	6.13	6.46	7.84	6.5	6.2	7.84		
20	23	172	52	104.67	117.46	99.76	107.81	62.29	69.85	55.71	62.33	73.58	80.55	66.65	73.13	97.78	108.88	98.29	98.89	6.21	6.08	5.97	6.21	8.14	8.1	7.6	8.14		
21	20	173	75	107.05	119.73	99.71	110.55	62.02	69.19	54.89	61.93	73.66	80.56	66.43	72.71	109.33	121.38	99.56	110.44	6.95	5.93	5.77	6.95	7.05	7.4	8.6	8.6		
MEAN	20.47619	166.8571	62.2381	107.6524	116.9262	98.70133	106.8448	69.56048	76.6619	63.88619	70.63238	75.82381	82.29571	70.44667	76.84524	113.3393	123.2773	103.5424	113.4129	7.101429	7.207143	7.408095	7.59381	7.911333	8.371429	8.217143	8.791429		
SD	2.874353	4.519798	8.887959	14.39433	14.73827	10.81249	11.34469	11.75332	11.59084	11.87062	10.98982	11.5455	11.45186	11.4283	11.51798	16.19428	16.25916	14.81474	15.48678	0.838152	0.748645	0.868497	0.708939	0.871627	1.186125	1.199555	0.864582		

SPIN-BOWLERS																											
St. No.	Age	Height	Weight	Upper Quarter Y-Balance Test																Rotational Medicine Ball Throw Test							
				Medial				Supero-lateral				Infero-lateral				Composite Score				RMBT Pre				RMBT Post			
				D-Pre	D-Post	ND-Pre	ND-Post	D-Pre	D-Post	ND-Pre	ND-Post	D-Pre	D-post	ND-Pre	ND-Post	D-Pre	D-Post	ND-Pre	ND-Post	TRAIL 1	TRAIL 2	TRAIL 3	BEST	TRAIL 1	TRAIL 2	TRAIL 3	BEST
1	19	169	60	82.5	91.7	83.2	92.3	61.5	68.9	58.5	66.1	69.7	74.9	62.5	69.6	79.28	88.2	76.47	85.39	6.04	6.95	6.67	6.95	7.28	6.3	7.3	7.3
2	18	172	56	92.4	102.7	88.4	99.9	48.5	56.1	42.8	50.2	67.4	76.7	59.5	66.7	84.67	95.73	77.52	88.13	6.85	6.42	6.28	6.85	6.39	7.7	8.7	8.7
3	25	174	69	76.5	86.6	74.3	84.9	55.4	63.3	45.5	53.1	71.5	78.9	70.6	78.6	79.76	89.72	74.66	84.54	7.38	7.26	7.28	7.38	7.71	8.2	7.9	8.2
4	24	168	48	87.5	97.2	85.9	96.2	55.5	63.4	52.8	60.2	66.4	74.6	62.4	71.3	90.64	101.81	87.05	98.57	6.98	7.48	7.39	7.48	6.99	6.9	8.1	8.1
5	22	178	67	90.5	99.9	82.5	92.8	55.2	64.1	54.5	61.9	60.2	67.8	59.2	67.4	85.79	96.58	81.75	92.54	7.36	7.22	6.94	7.36	7.9	7.8	7.4	7.9
6	21	170	55	91.5	100.8	83.5	93.2	52.3	59.9	45.2	52.6	72.8	81.3	63.7	71.8	95	106.14	84.38	95.43	7.12	7.56	7.39	7.56	8.01	7.8	8.5	8.5
7	23	179	62	114.7	123.7	108.6	117.9	87.4	95.3	79.8	87.2	90.3	97.6	87.9	96.2	116.86	128.69	112.31	122.47	7.75	8.24	7.48	8.24	8.95	8.36	7.8	8.85
8	17	164	76	102.4	111.8	98.2	107.6	79.5	87.1	72.6	80.2	98.4	106.6	96.4	104.8	119.78	130.55	114.18	125.04	6.84	6.19	6.56	6.84	7.42	8.3	8.1	8.3
9	16	172	58	98.3	107.5	92.5	102.7	84.4	92.2	85.6	93.1	94.2	102.4	93.7	100.8	106.09	115.74	104.13	113.63	6.48	6.72	6.37	6.72	6.76	6.8	7.6	7.6
10	19	173	73	103.5	114.3	81.2	91.5	74.5	81.9	68.5	75.9	88.5	95.7	58.4	66.5	122.44	123.16	87.8	98.69	7.24	6.89	6.96	6.96	7.59	7.5	8.4	8.4
11	21	159	46	134.2	122.6	94.5	103.9	89.4	97.3	88.5	96.4	92.5	99.7	74.3	81.9	135.2	145.93	117.48	128.85	6.28	6.74	6.12	6.74	7.84	6.6	7.2	7.84
12	18	158	78	109.7	118.3	91.4	102.6	67.5	74.9	61.7	69.1	93.5	103.6	81.2	89.4	111.39	122.13	88.84	107.44	6.21	6.48	6.67	6.67	8.12	7.9	8.2	8.12
13	20	159	72	104.2	113.9	104.6	114.2	69.4	76.9	59.4	67.8	79.5	89.7	61.2	69.9	115.57	128.08	102.83	115.02	6.08	5.92	5.92	7.3	7.4	8.4	8.6	8.6
14	17	160	69	98.3	107.5	101.4	111.1	81.2	88.9	64.3	72.7	84.3	93.4	59.6	68.4	108.55	119.25	92.71	103.78	6.04	6.14	6.24	6.24	7.21	6.7	7.1	7.21
15	23	162	54	102.5	110.7	108.5	117.9	74.1	82.1	72.5	79.9	84.6	94.9	66.4	74.2	134.56	126.18	108.5	119.29	5.94	6.24	6.09	6.24	6.87	7.3	7.9	7.9
16	25	161	64	101.8	112.2	106.2	115.3	86.2	93.7	68.4	76.8	74.6	84.2	69.8	78.3	138.28	130.67	109.86	121.8	6.34	7.08	6.48	7.08	8.23	8.1	7.5	8.23
17	22	164	62	110.92	120.05	95.46	116.09	87	94.63	76.87	84.93	91.49	101.42	72.71	81.17	108.39	118.39	91.12	105.8	6.99	6.35	6.15	6.99	7.49	7.5	8.2	8.2
18	24	165	60	112.42	121.51	96.51	117.65	88.98	96.6	78.41	86.52	92.78	102.9	72.98	81.48	129.58	130.49	100.77	116.11	5.47	6.22	6.94	7.5	6.72	7.4	8.6	8.6
19	16	166	49	113.92	122.98	97.55	119.22	90.97	98.57	79.95	88.11	94.07	104.38	73.25	81.8	126.14	133.3	105.8	121.99	5.82	6.24	6.88	6.88	7.98	8.2	8.3	8.3
20	19	167	68	115.42	124.44	98.6	120.79	92.95	100.54	81.49	89.69	95.37	105.85	73.52	82.11	123.47	134.48	103.09	118.93	5.91	6.56	6.02	6.56	8.05	7.1	7.9	8.05
21	20	167	52	116.92	125.91	99.64	122.36	94.94	102.51	83.03	91.28	96.66	107.35	75.79	82.43	130.17	141.66	108.21	124.91	5.62	6.17	5.76	6.17	7.8	7.9	8.1	8.1
MEAN	20.42857	166.9524	61.85714	101.9095	111.2519	93.403	106.6719	75.08762	82.80238	67.61571	75.41571	83.75095	92.56571	71.09762	79.27571	108.3433	119.3752	96.64095	108.9881	6.511429	6.717619	6.599524	6.88619	7.548095	7.56	7.971429	8.142857
SD	2.890872	6.12127	9.296697	11.64584	11.37128	9.538911	11.6095	15.15362	15.67809	14.61294	14.39175	11.81994	12.48728	11.10257	11.07112	16.65913	16.8204	13.57571	14.19591	0.649302	0.588454	0.521267	0.502857	0.626982	0.630238	0.478689	0.423286