RELATIONSHIP OF CORE STABILITY WITH UPPER AND LOWER EXTREMITY PERFORMANCE IN COMPETITIVE BADMINTON PLAYERS – AN OBSERVATIONAL STUDY

by

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Dissertation Submitted to the

UTKAL UNIVERSITY Bhubaneswar, Odisha

In Partial fulfillment of the requirements for the degree of

MASTER OF PHYSIOTHERAPY (M.P.T)

In

SPORTS PHYSIOTHERAPY

Under the guidance of

DR. JOSEPH OLIVER RAJ

DEAN

ABHINAV BINDRA SPORTS MEDICINE & RESEARCH INSTITUTE

Bhubaneswar, Odisha

2022-2024

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"RELATIONSHIP OF CORE STABILITY WITH UPPER AND LOWER EXTREMITY PERFORMANCE IN COMPETITIVE BADMINTON PLAYERS – AN OBSERVATIONAL STUDY"** is a bonafide and genuine research work carried out by me under the guidance of Dr. Joseph Oliver Raj, Dean, Abhinav Bindra Sports Medicine and Research Institute, Odisha.

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ACKNOWLEDGEMENT

At the very outset, I express my deepest gratitude to **Dr. Apjit S. Bindra, Chairman, Mr. Abhinav A. Bindra, Founder**, and **Dr. Digpal Ranawat, Executive Director** of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha for giving me this opportunity.

I take this opportunity to convey my heartfelt gratitude to guide **Dr Joseph Oliver Raj, Dean** of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha for their valuable suggestions rendered in giving shape and coherence to this endeavor.

I express my sincere thanks to **Dr. Chinmaya Kumar Patra (Principal)**, and other teaching and non-teaching staff for their support and help to make this dissertation successful.

I also acknowledge with a deep sense of reverence, my gratitude towards my parents, **Ravindra Tanaji Mohite** and **Sanjusha Ravindra Mohite** and my friends have always supported me morally and mentally.

I would like to take this time to thank every participant who participated in this study for their kind cooperation and vital information.

And above all, I can't ignore the blessings of LORD GANPATI in completing this dissertation on time.

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LIST OF ABBREVIATIONS

1. **BMI** – Body Mass Index
2. **CKCUEST** – Closed Kinetic Chain Upper Extremity Stability Test
3. **ICC** – Interclass Correlation Coefficient
4. **LQYBT** – Lower Quarter Y Balance Test
5. **MSEBT** – Modified Star Excursion Balance Test
6. **SEBT** – Star Excursion Balance Test
7. **SLJ** – Standing Long Jump
8. **SMBT** – Seated Medicine Ball Throw
9. **ST** – Squat Test
10. **UE** -Upper Extremity
11. **UQYBT** – Upper Quarter Y Balance Test

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ABSTRACT

RELATIONSHIP OF CORE STABILITY WITH UPPER AND LOWER EXTREMITY PERFORMANCE IN COMPETITIVE BADMINTON PLAYERS – AN OBSERVATIONAL STUDY

BACKGROUND: Among racket sports, badminton is one of the most popular sport across the globe. A wide range of postural alterations, such as leaps, lunges, swift direction changes, and quick arm movements, are used in competitive badminton. The core muscles offer a solid foundation for support during movements of the upper and lower extremities. The Bourban test is characterized as a cost-effective substitute for alternative evaluations that assess trunk strength endurance. Balance, strength and endurance is assessed using various reliable and valid tests.

METHODS: 40 players were taken for this study. Core strength was analyzed using Bourban trunk muscle test. Upper extremity performance was assessed using UQYBT, SMBT and CKCUEST. Lower extremity performance was assessed using LQYBT, SLJ and ST.

RESULTS: The results show that the core relates significantly with UE balance with $p<0.05$, negative correlation with UE strength and significant positive correlation with UE endurance. Only the dorsal chain correlates with LE balance,

strong to moderate correlation between core and LE strength and endurance with $p<0.05$, respectively. The UE and LE balance also correlate significantly with each other with $p<0.05$. The UE and LE strength do not correlate well with each other ($p>0.05$). The endurance tests of both UE and LE also correlate significantly with each other with $p<0.05$.

CONCLUSION: There is significant correlation between core stability and upper and lower extremity performance, according to this study.

KEYWORDS: Badminton player; core stability; bourban trunk muscle test; upper quarter balance test; lower quarter balance test; seated medicine ball throw; closed kinetic chain upper extremity stability test; standing long jump; squat test

RELATIONSHIP OF CORE STABILITY WITH UPPER AND LOWER EXTREMITY PERFORMANCE IN COMPETITIVE BADMINTON PLAYERS – AN OBSERVATIONAL STUDY

INTRODUCTION

Among racket sports, badminton is one of the most popular sport across the globe. Five percent of Indians play badminton, according to the Badminton Association of India. The majority of the body's muscles and physical fitness are needed for the game of badminton, particularly for agility, balance, and muscle power. [1]

High racket and shuttlecock speeds define the game; in elite level clashes, the shuttle is hit at over 250 km/h. [2]

A wide range of postural alterations, such as leaps, lunges, swift direction changes, and quick arm movements, are used in competitive badminton. On the badminton court, movement entails taking the fewest feasible steps to reach the shuttle while retaining good balance and controlling the body.[2]

The entire body's muscles and core are required to respond to demands placed on athletic performance; they serve as a link between the upper and lower extremities, creating a strong foundation and transferring force to the extremities.[1]

The core has been compared to a muscular corset, with the pelvic floor and hip girdle muscles at the bottom and the diaphragm acting as the ceiling. The abdominals are at the front, the erector spinae and gluteals are at the rear. [3] Moreover, the muscles in the core are made up of both slow-twitch and fast-twitch muscle fibers. The local muscular system (deep muscle layer) makes up the majority of the former. Because they are shorter, these muscles are better equipped to govern intersegmental motion and react to changes in posture and external stressors. The transversus abdominis, multifidi, internal oblique, deep transversospinalis, and pelvic floor muscles are important local muscles. [4]

Fast-twitch fibres, on the other hand, make up the entire muscle system (superficial muscle layer). These muscles may produce a significant amount of torque and movement since they are longer and have greater lever arms. The rectus abdominis, external oblique, and quadratus lumborum are important global muscles. [4]

The core muscles often co-contract, stiffening the torso to the point where all muscles become synergists, setting the core musculature apart from the limb musculature. A strong core is thought to enable the movement of force from the lower to the upper body with the least amount of energy loss in the torso. If power is generated but not transferred, it will have a negative impact on a person's ability to run, jump, and throw.[1]

The human body can be broken down into several links, including the trunk, head, upper arm and forearm, thigh, calf, hand, and foot, in the creation of the movement chain hypothesis. A movement chain can be created by connecting each link movably.[5] Human posture and movement state change as a result of

the force acting on the movement chain, which causes changes in each link's relative position. Core muscles serve as hubs in the biological motor chain, which establishes a conduit for the cohesion, transmission, and integration of the upper and lower limbs as well as a fulcrum for the strength of the four limbs.[5]

The core muscles offer a solid foundation for support during movements of the upper and lower extremities. To stand on one leg while taking a balance test, the hip and pelvic girdle muscles must be strong and flexible. [1]

The upper body and trunk rotation during smashing actions in racket sports depend on core strength. The kinetic chain is crucial in transmitting energy from the core muscles to the upper body. [6]

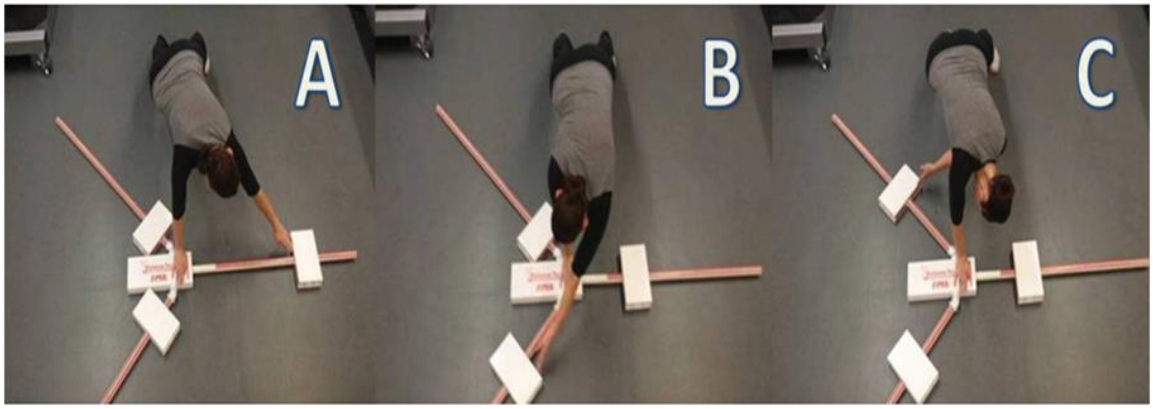
Coordination from the feet to the hand in a single kinetic chain is necessary for an overhead throwing motion. In order to generate and absorb force during the throwing motion, the hip and core muscles are required. The kinetic chain begins to move from the external oblique muscles to the shoulder. This is known as the catch-up phenomena. [7]

The kinetic chain necessitates alternation in one location that results in change throughout the entire system. The changes in the interaction moments affect the forces in the distal segments; these stronger forces put more strain on the muscles, which frequently causes pain perception or actual anatomical injury. [7]

The upper quarter Y balance test, or UQ-YBT, is frequently used to track upper extremity segmental stability and mobility. The UQ-YBT is a closed kinetic chain

performance test that evaluates the upper extremity's proprioception, strength, and range of motion. This test enables the evaluation of the stability and mobility of the thoracic and scapular movements away from the base of support. [8]

The patient must stabilize their body weight during the evaluation in order to test their upper extremities while executing maximal reaching in three directions.[9]



The upper body power tests that are utilized in the literature can be costly, necessitate a high level of technical proficiency, and take a long time to analyze. Medicine ball (MB) throws are a possibly easier way for practitioners and physicians to assess upper body power in a range of populations.

Due to their dynamic effort, multiple planes of motion, and requirement for efficient upper and lower body stabilization during the effort, MB throws have a distinct advantage over other power tests. This could increase the tests' specificity to other functional and sport tasks. The sitting medicine ball throw (SMBT) test is often low-risk, simple to administer, and needs little in the way of supplies. [10]

The Closed Kinetic Chain Upper Extremity Stability Test (CKCUES Test) is a performance assessment that can be used in clinical or recreational contexts without requiring advanced technology. It offers quantitative data (score) for an upper extremity work in the closed kinetic chain (CKC). The test involves counting the number of times a participant in a push-up position can touch his or her supporting hand with the swinging hand in a 15-second period. Both healthcare professionals and clients find the test to be easily applied and understood. [11]

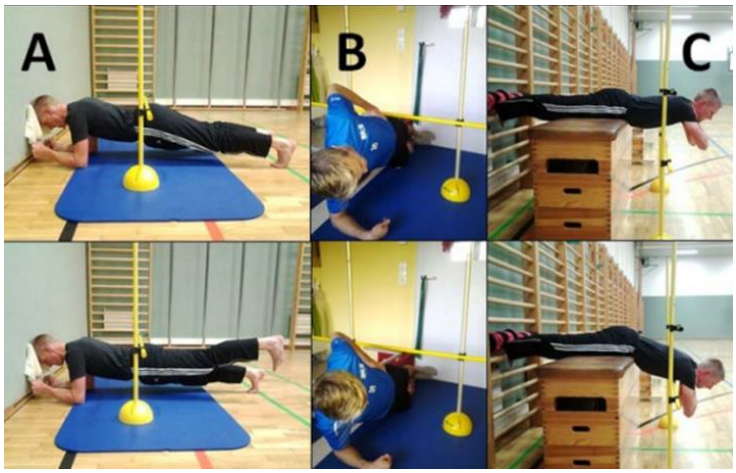
The YBT-LQ, evolved from the Star Excursion Balance Test (SEBT), is a cheap and efficient examination of dynamic balance. Due to its use in athlete screening and injury prevention, especially for lower limb injuries such as knee and ankle injuries, it has become more and more well known. Researchers and clinicians can compare the results of YBT-LQ with SEBT due to its standardized protocol. [12]

The standing long jump (SLJ) is a short test that can be used to gauge an athlete's level of athletic fitness and readiness to resume competition. It takes little equipment to complete. A double-legged leap for distance known as the SLJ is used to evaluate an athlete's lower extremity strength and neuromuscular control by simulating the functional aspects of jumping and landing.[13]

The 60 second squat test is a test which assesses the lower extremity endurance of the athletes.[14]

The Bourban test is characterized as a cost-effective substitute for alternative evaluations that assess trunk strength endurance. It can be used in pre-post comparisons and offers, however only to the extent necessary for sport-specific

normative value comparisons when classifying trunk strength endurance. The test's reliability has already been established. There are four exercises in the Bourban test, one for each area of the trunk: the dorsal chain, the right lateral chain, the left lateral chain, and the ventral chain. [15]



NEED OF THE STUDY

- Badminton is a highly demanding sport which requires use of both the upper extremity as well as the lower extremity. Core is an integral part of the human body that tends to affect the upper and lower limb. To find out how well the core relates to the upper and lower body in competitive badminton players, we will perform this study.
- Finding these associations will have a significant impact on sports rehabilitation and sports performance research and will act as a foundation for prescribing sports-specific exercise regimen and determining the best training methods and guidelines for athletes.
- There is also a paucity of study that compares core stability with both the upper and lower extremity performance. The comparison of upper and lower extremity performance has also not been done.

AIM OF THE STUDY

- To evaluate the relationship of core stability with upper and lower extremity performance in competitive badminton players.

OBJECTIVES OF THE STUDY

- To find the correlation between core stability and upper extremity performance using Bourban Test, UQYBT, SMBT and CKCUEST in competitive badminton players.
- To find the correlation between core stability and lower extremity performance using Bourban Test, LQYBT, SLJ and ST in competitive badminton players.
- To find the correlation between lower and upper extremity performance using UQYBT, SMBT, CKCUEST, LQYBT, SLJ and ST in competitive badminton players.

HYPOTHESIS

Null Hypotheses

- H_{01}: There is no significant relationship of core stability with upper extremity performance in competitive badminton players.
- H_{02}: There is no significant relationship of core stability with lower extremity performance in competitive badminton players.
- H_{03}: There is no significant relationship between upper and lower extremity performance in competitive badminton players.

Alternate Hypotheses

- H_{11}: There is a significant relationship of core stability with upper extremity performance in competitive badminton players.
- H_{12}: There is a significant relationship of core stability with lower extremity performance in competitive badminton players.
- H_{13}: There is a significant relationship between upper and lower extremity performance in competitive badminton players.

REVIEW OF LITERATURE

1. A study “Correlation of core stability with balance, agility and upper limb power in badminton players: a cross-sectional study” by Sohel Ahmed, Avi Saraswat, Vandana Esht reported that Core stability is significantly correlated with balance and agility performance and a non-significant fair positive correlation also exists with core stability and upper limb power which is essential for badminton performance.

2. A study “Correlation between Core Stability and Upper-Extremity Performance in Male Collegiate Athletes” by Shibili Nuhmani reported that Core stability measures are positively correlated with most of the upper-extremity athletic-performance measures in collegiate athletes.

3. A study “Effect of core training on skill related physical fitness performance among soccer players: a systematic review” by Luo S et. al reported that Core training can improve soccer players’ skill-related physical fitness, including their power, speed, balance, and agility.

4. A study “The Effect of Core and Lower Limb Exercises on Trunk Strength and Lower Limb Stability on Australian Soldiers” by Rolf Sellentin and Rhondda Jones concluded that the results from this study support the hypothesis that specific core and balance exercises improve core strength and lower limb balance.

5. A study “Exploration of the Y Balance test for assessment of upper quarter closed kinetic chain performance” by Richard B. Westrick reported that the UQYBT is a reliable UE CKC test that can be used to assess unilateral UE function in a closed chain manner. The UQYBT appears to be most related to dynamic tests involving core stability and UE performance.

6. A study “Reliability and validity of the closed kinetic chain upper extremity stability test” by Dong-Rour Lee suggested that the reliability and validity of the CKCUES test were high. The CKCUES test is expected to be used for clinical tests on upper limb stability at low price.

7. A study “Evaluation of the Bourban Trunk Muscle Strength Test Based on Electromyographic Parameters” by Stephan Becker reported that the Bourban trunk muscle strength test is a valid and economic test instrument for the evaluation of trunk strength (endurance).

METHODOLOGY

- Study Design: Observational Study
- Sampling Technique: Purposive Sampling
- Study Population: Competitive Badminton Players
- Sampling Size: 40
- Study Setting: Badminton Academies in Bhubaneshwar
- Study Duration: 1 year

INCLUSION CRITERIA: -

- Competitive Badminton Players
- Gender: Male and Female
- Age: 18-35 years
- Participating in competitions for 2 or more years.

EXCLUSION CRITERIA: -

- Recent fracture or any musculoskeletal condition strain, sprain, dislocation in less than 6 months.
- Any neurological, cardiac, respiratory diseases.
- Any other medical, surgical, or psychological condition in past 1 year.

STUDY MATERIALS: -

- Consent form
- Information sheet
- Data collection sheet
- Measuring tape
- Medicine ball (2 kgs)
- Benches
- Chalk powder
- Metronome
- Adjustable alignment device

OUTCOME MEASURES: -

Primary Outcome

- Bourban Test

Secondary Outcomes

- Upper Quarter Y Balance Test (UQYBT)
- Seated Medicine Ball Throw (SMBT)
- Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST)
- Lower Quarter Y Balance Test (LQYBT)
- Standing Long Jump (SLJ)
- Squat Test (ST).

PROCEDURE

Ethical clearance was obtained from the ethical committee. Sample selection was based on selection criteria. Recruitment of the participants was carried out from reputed Badminton academies from Bhubaneshwar in India by purposive sampling method. Voluntary participation was ensured and written consent was obtained from the participants. Each subject's age, weight, height, and BMI was recorded, among other demographic details. Every step of the testing process was explained to the participants prior to the final data collection. The strength, endurance and balance, agility for both upper and lower extremity and core stability tests was conducted in this order throughout the entire series. To avoid tiredness, each exam was administered three times, with a 4–5-minute break in between. The following testing process were administered to the subjects:

1. Upper Quarter Y Balance Test

Prior to the test, the participants' upper limb length was measured while they were standing with both feet together, using a 90-degree shoulder abduction from the spinous process of C7 to the tip of the middle finger. One line was taped in the medial direction to identify the first of the three UQYBT testing orientations. The superolateral and inferolateral directions were identified 135 degrees from the medial line. The dominant hand, which is stationary on the floor, was taken into consideration when determining the names of the directions. Initially, the participants positioned the dominant hand in the middle of a grid, which consisted of the medial, superolateral, and inferolateral joints. The participants began in the push-up position, both feet shoulder-width apart, shoes off, and the stationary hand's third metacarpophalangeal joint positioned in the center of the

grid. In the order of medial, superolateral, and inferolateral directions, the participants reached and lightly touched the furthest point in each direction consecutively with their free hand (non-dominant hand). 3 trials will be performed with 15 seconds rest between each trial and 30 seconds rest between right and left side. Reliability of UQYBT was established before testing and the investigator demonstrated good-excellent reliability in all three directions (r = 0.81-0.90). (16)

FIGURE 1

A. MEDIAL

B. SUPEROLATERAL

C. INFEROLATERAL

2. Seated Medicine Ball Throw (SMBT)

The purpose of this test is to assess upper body explosive strength. With their feet apart, legs fully extended, and back against the wall, the participant is seated. The athlete is holding a 2-kg medicine ball in a manner akin to a basketball passing stance with both hands on it. The goal of this test is to throw the ball as far and straight as you can. Centimetres are used to indicate the distance. The test was taken three times with 90 seconds rest in between trials, and the candidate's best score that reflected their performance was retained. (17) The reliability of SMBT is r = 0.94 – 0.98. (10)

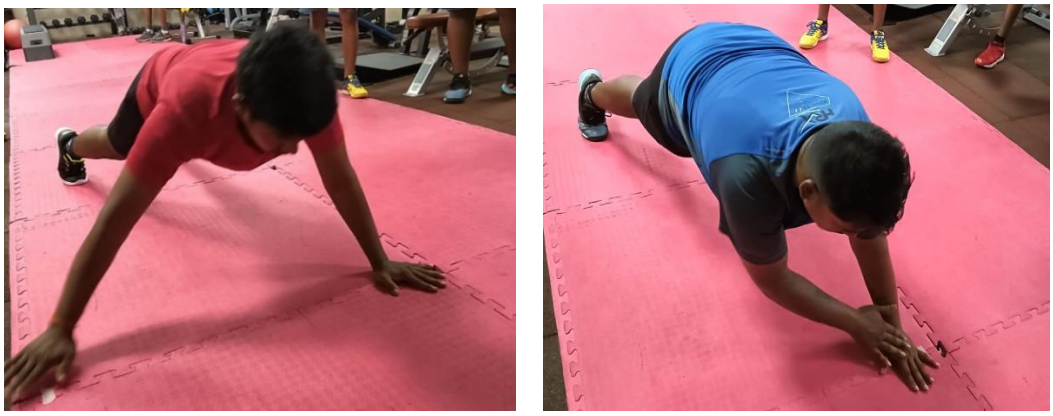
FIGURE 2

SEATED MEDICINE BALL THROW

3. Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST)

The participants were required to assume a push-up stance with both shoulders perpendicular to the hands and hands 91.4 cm apart (designated by two stripes of tape on the floor). The feet were shoulder-width apart, and the lower body and back were in alignment. The dominant hand reached across the body to contact the nondominant hand and then took it back to its initial position. The non-dominant hand then executed the identical motion. The task given to the participant was to alternately touch as many times as they could in fifteen seconds while keeping their push-up form right. Following a single submaximal familiarization session, three maximal performance trials were conducted, separated by 45 seconds of rest. To facilitate additional investigation, the average number of touches was computed. (18) The reliability of CKCUEST found to be is 0.84–0.97. (19)

FIGURE 3



CLOSED KINETIC CHAIN UPPER EXTREMITY STABILITY TEST

4. Lower Quarter Y Balance Test (LQYBT)

It was created to assess unilateral balance and neuromuscular control, two crucial components of almost every sport. The anterior, posteromedial, and posterolateral directions of the SEBT are measured using an instrumented device in the lower quarter Y-balance test. In a supine sleeping position, the participants' stance leg length was initially measured in centimetres, starting from the anterior superior iliac spine and ending at the farthest distal section of the medial malleolus. In order to familiarize themselves with the testing process, participants were permitted to do two test trials in each of the three reach directions prior to the official testing. The subjects were instructed to stand with their great toe at the beginning line and their dominant leg on the middle footplate. Then, while keeping a single-leg stance, participants were urged to push the reach indicator in the red target region as far as they could with the free limb in the anterior, posteromedial, and posterior directions. Participants were required to control their way back to the starting location after each trial.

Two tries in each direction with a 15-second break in between were used to standardize the testing sequence. In regard to the stance foot, the reaching distances were tested anterior, posterolateral, and posteromedial.

Its interrater reliability has an ICC range from 0.99 to 1.00, while its intrarater reliability has an ICC ranging from 0.85 to 0.91.(20)

FIGURE 4

A. ANTERIOR

B. POSTEROMEDIAL

C. POSTEROLATERAL

5. Standing Long Jump (SLJ)

Athletes stood behind a line of tape that was fastened to the ground, with their feet about shoulder-width apart. To measure the distance jumped and hopped, a fabric measuring tape was positioned perpendicular to the tape line, or the beginning point. During testing, each athlete completed three maximal effort SLJs while holding their hands behind their backs. The starting line to the heel furthest back was used to calculate the jump distance. Every athlete received a 30-second rest interval in between each trial. A trial was repeated if the athlete used her arms during the SLJ or if she didn't stick the landing. For data analysis, the mean of three SLJ was employed.

The SLJ has outstanding test-retest reliability, ranging from 0.91 to 0.98.(21)

FIGURE 5

STANDING LONG JUMP

6. Squat Test (ST)

A 60-second squat test was used to measure the muscular endurance of the lower extremities. Placing their feet shoulder-width apart, the participants stood. They were told to squat until their thighs were parallel to the floor, at which point they were to stand back up with their knees slightly bent. They all got 60 seconds to do as many repeats as they could. Only one repetition per participant in the correct format was recorded, and that number was limited to that. (14)

Its interrater reliability has an ICC of 0.79.(22)

FIGURE 6

SQUAT TEST

7. Bourban Test

The Bourban test comprises of four exercises: the dorsal chain, the right lateral chain, the left lateral chain, and the ventral chain, one for each portion of the trunk. A metronome set at 60 beats per minute was used to regulate the movement's pace, and stretched ropes were used to regulate the movement's range. When any of the requirements were broken, a notice was sent out. At the third warning, the test was discontinued.

-Ventral chain

The subjects positioned themselves in a front plank, with their legs, hips, back, and head in a straight line. The test required the participants to raise their straightened legs alternatively to the gluteus maximus level. Every metronome beat required the lifting of one leg. The lower back needed to be in constant contact with the rope at the level of the sacroiliac joint.

-Lateral chain

The participants assumed a side plank posture, placing one hand on their hip. It was necessary to align the hips, back, shoulders, and head in a straight line. In due course, a pelvic drop and lift were carried out. The topic had to be in the reversal point (top or bottom) at every beat.

-Dorsal Chain

In accordance with the beat, the individuals executed a hyperextension within a range of 0–30 degrees. The arms were crossed over the breast, and the spinae iliacae anterior were situated around 4 cm above the margin. The hips, back, and head have to be in a straight line. The trunk had to be in the top or bottom of the reversal point at every beat.

The reliability of bourbon test for ventral chain r = 0.87, lateral chain r = 0.81 and dorsal chain r = 0.80.(15)

FIGURE 7

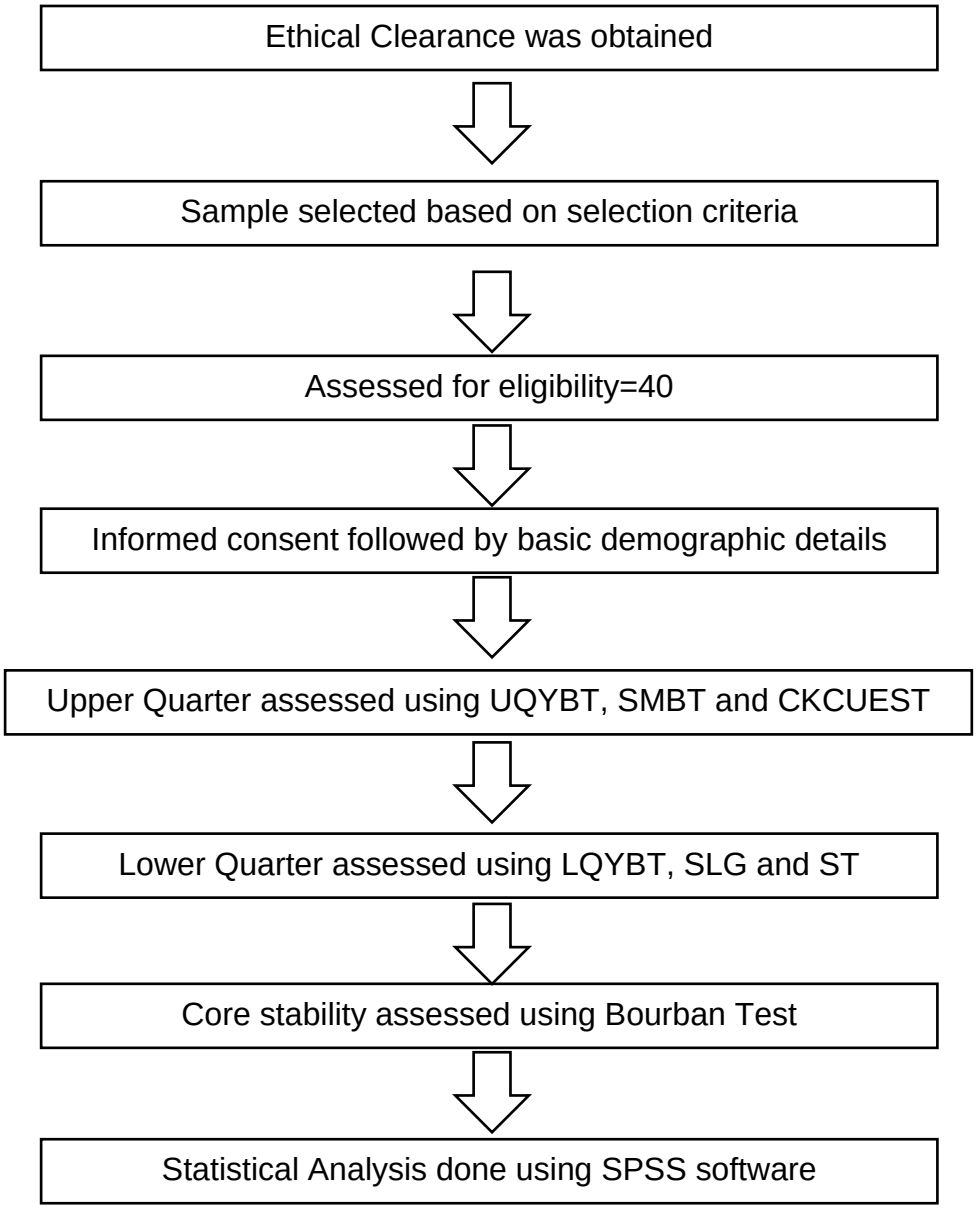
A. VENTRAL

B. DORSAL

C. RIGHT LATERAL

D. LEFT LATERAL

Methodology flow chart



SAMPLE SIZE ESTIMATION

A sample size of 33 subjects was estimated using a medium effect size of 0.5, a power of 0.95, and a level of significance set at 0.05. 40 participants were included in the study to account for any dropout rate.

RESULTS

The data collected in fragmented form was presented in an orderly manner and tabulated form in Excel. Data was analysed using SPSS software. Normality was taken out using Shapiro Wilk test represented in Table 1. Descriptive statistics summarize or describe the characteristics of data set in Table 2. In inferential statistics, Spearman correlation coefficient was used to measure the linear correlation between two variables shown in Table 3,4,5.

TABLE 1

	Shapiro-Wilk		
	Statistic	df	Sig.
UQYBT-D	.920	40	.008
UQYBT-ND	.896	40	.001
SMBT	.868	40	.000
CKCUEST-D	.945	40	.053
CKCUEST-ND	.919	40	.007
LQYBT-D	.822	40	.000
LQYBT-ND	.903	40	.002
SLJ	.916	40	.006
ST	.875	40	.000
VENTRAL	.828	40	.000
DORSAL	.900	40	.002
RIGHT-LAT	.807	40	.000
LEFT-LAT	.874	40	.000

The data for UQYBT, SMBT, CKCUEST-ND, LQYBT, SLJ, ST, VENTRAL, DORSAL, RIGHT and LEFT LATERAL chains of Bourban Trunk Muscle Test

does not follow normal distribution. The data for CKCUEST-D follows normal distribution. Therefore, as the data is not normally distributed, Spearman Test will be used for correlation statistics.

TABLE 2

Demographic Characteristics

	MEAN	STANDARD DEVIATION	95% CI (LOWER– UPPER LIMIT)
AGE	23.4500	2.87295	22.53-24.36
HEIGHT	169.8078	6.17052	167.83-171.78
WEIGHT	68.5018	13.06282	64.32-72.67
BMI	23.9075	4.22850	22.55-25.25

FIGURE 8

Frequency Histogram of Age

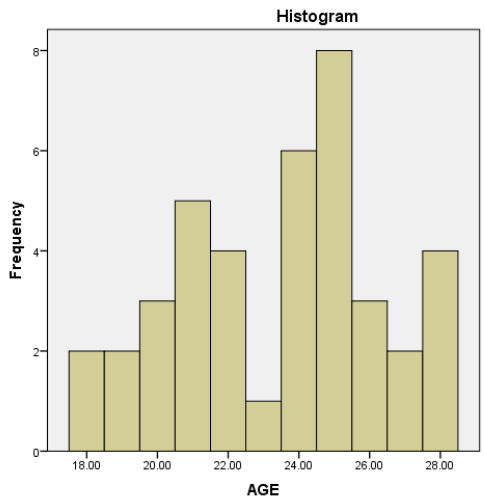


FIGURE 9

Frequency Histogram of BMI

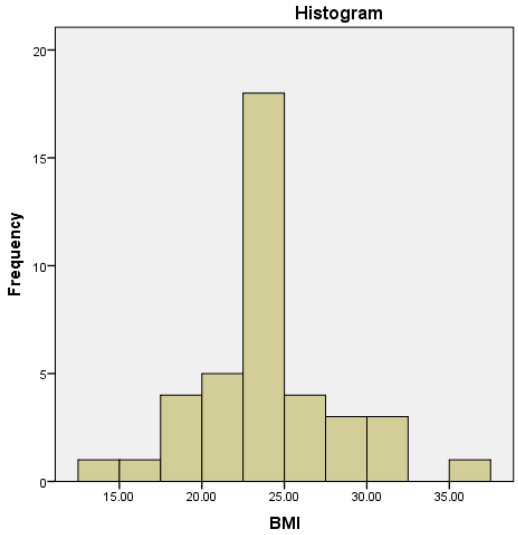


TABLE 3

Correlation between Core Stability and Upper Extremity Performance

	UQYBT				SMBT		CKCUEST			
	D		ND				D		ND	
	r	p	r	p	r	p	r	p	r	p
VENTRAL	.589	.000	.562	.000	-.374	.009	.105	.259	.836	.000
DORSAL	.754	.000	.780	.000	.031	.425	.442	.002	.539	.000
RIGHT LATERAL	.438	.002	.384	.007	-.089	.292	.234	.073	.461	.001
LEFT LATERAL	.617	.000	.557	.000	-.227	.080	.132	.208	.519	.000

It was found that there is moderate positive correlation between UQYBT of dominant side with Ventral and Right Lateral chain of core and strong positive correlation with Dorsal and Left Lateral chain. Similarly, it was reported that

UQYBT of non-dominant side has moderate positive correlation with Ventral and Left Lateral chain of core, strong positive correlation with Dorsal chain and weak positive correlation with Right Lateral chain.

SMBT showed weak negative correlation with Ventral chain and Left Lateral chain, very weak positive correlation and negative correlation with Dorsal chain and Right Lateral chain respectively.

It was reported that there is very weak positive correlation of CKCUEST of dominant side with Ventral and Left Lateral chains, weak positive correlation with Right Lateral chain and moderate positive correlation with Dorsal chain. But, the CKCUEST of non-dominant side shows very strong positive correlation with Ventral chain and moderate positive correlation with Dorsal and both Lateral chains.

TABLE 4

Correlation between Core Stability and Lower Extremity Performance

	LQYBT				SLJ		ST	
	D		ND					
	r	p	r	p	r	p	r	p
VENTRAL	.157	.166	.206	.101	.779	.000	.536	.000
DORSAL	.578	.000	.648	.000	.861	.000	.557	.000
RIGHT LATERAL	.112	.245	.011	.474	.732	.000	.275	.043
LEFT LATERAL	.071	.331	.094	.282	.677	.000	.459	.001

It was found that the LQYBT of dominant side has very weak positive correlation with Ventral, Right and Left Lateral chains and moderate positive correlation with Dorsal chain. Similarly, LQYBT of non- dominant side has weak positive correlation with Ventral, very weak positive correlation with Right and Left Lateral chains and strong positive correlation with Dorsal chain.

The SLJ shows very strong positive correlation with Dorsal chain and strong positive correlation with Ventral, Right and Left Lateral chains.

It was reported that the ST has moderate positive correlation Ventral, Dorsal and Left Lateral chains and weak positive correlation with Right Lateral chain.

TABLE 5

Correlation Between Upper and Lower Extremity Performance

	LQYBT-D		LQYBT-ND		SLJ		ST	
	r	p	r	p	r	p	r	p
UQYBT-D	.475	.001	.686	.000	.640	.000	.673	.000
UQYBT-ND	.484	.001	.728	.000	.639	.000	.709	.000
SMBT	.403	.005	.015	.469	.115	.240	-.523	.000
CKCUEST-D	.237	.075	-.060	.355	.506	.000	-.298	.031
CKCUEST-ND	-.134	.205	.109	.252	.534	.000	.632	.000

It was reported that the LQYBT of dominant side has moderate positive correlation with UQYBT and SMBT, weak positive correlation with CKCUEST (dominant) and very weak negative correlation with CKCUEST (non-dominant).

The LQYBT of non-dominant side has strong positive correlation with UQYBT, very weak positive correlation with SMBT and CKCUEST (non-dominant) and very weak negative correlation with CKCUEST (dominant).

The SLJ has strong positive correlation with UQYBT, moderate positive correlation with CKCUEST and very weak positive correlation with SMBT.

The ST has strong positive correlation with UQYBT and CKCUEST (non-dominant), moderate negative correlation with SMBT, and weak negative correlation with CKCUEST (dominant).

DISCUSSION

Among racquet sports, badminton is thought to be the fastest because of its fast-paced gameplay. Played mostly with overhead shots, competitive badminton requires exceptional footwork. Singles demands exceptional physical abilities and involves patient positioning; doubles, on the other hand, necessitates full-out aggression throughout the game and is frequently played at a very rapid tempo. (16) Athletes need to be strong, agile, fast, precise, and have aerobic endurance. It's a technical sport as well, requiring the development of complex racquet movements and high motor coordination. (23)

According to Dinshaw N. Pardiwala et al., despite being a noncontact sport, badminton has a considerable risk of injury. This is approximately the same as the frequency of injuries in other racquet sports like squash and tennis, and the prevalence of injuries is far higher than is often believed. Most badminton injuries are the consequence of excessive cumulative loads and secondary to overuse. (23)

According to Høy et al. players between the ages of 18 and 25 had a higher injury incidence (45 per 1,000 per year). Moreover, the frequency was 42 per 1000 people annually for those over 25 years of age. (24) In competitive badminton players, injury incidence varies between 0.9 and 7.38 per 1000 h, where 1 h is equal to 1 h participation of sport by one player. (23)

A study by Vindya Vimani Senadheera stated that when competitive badminton players across all age categories were taken into consideration, the majority of badminton-related injuries were recorded as overuse injuries. Overuse was cited as the cause of 98.5% of all upper limb injuries, whereas it was the cause of

26% of knee injuries, 17% of ankle injuries, and 79% of back injuries. (25) Therefore, with the reference to additional standard published articles for this study the age criteria were taken from 18-35 years old badminton players.

In a study by Julian Bauer, the goal was to find out how the mobility and stability of the shoulder (measured by the Upper Quarter Y Balance test [YBT-UQ]) and the throwing velocity of 32 adolescent male sub-elite handball players related to their core muscle strength endurance. The results showed significant positive correlations between Core Stability and Upper Quarter Y Balance Test. Based on their findings, adolescent male sub-elite handball players who have stronger core muscles also have superior shoulder mobility and stability and can throw the ball with a somewhat faster velocity. (26) In this study, it shows that there is significant moderate to strong correlation between core stability and upper extremity balance.

According to the current study, the seated medicine ball throw showed a negative correlation with the core stability. This is consistent with the study by Chris Sharrock et al., who showed that the medicine ball throw and the core stability test have a negative correlation (r –0.389, $p = 0.023$). Individuals with higher core stability test scores showed a larger negative correlation ($r = –0.527$) with the medicine ball throw. (27)

In a recent study by Kara et al., the association study showed that the CKCUEST and the YBT-UQ were, respectively, linked to trunk flexor and lateral endurance of the dominant side. (28) Our study also showed very weak to moderate correlations of CKCUEST of dominant side with core stability and moderate to strong association of CKCUEST of non-dominant side with core stability.

Nawaf Almutair et al. stated in his research study done among hospital staff that the plank test of isometric core muscle strength showed a weak to moderate positive significant correlation with the right and dominant anterior, posteromedial, and composite score on the lower limb MSEBT, as well as significantly with non-dominant anterior reach.(29) This is consistent with our study which shows moderate to strong positive correlation between LQYBT and Dorsal whereas it shows very weak to weak positive correlation with other chains.

A study by Thomas W Nesser whose aim of research was to determine the correlations between different strength and power measures and core stability in athletes who had both strength and power. The study's findings indicate that performance and strength have a moderate relationship with core stability. (30)

In this study, it was found that SLJ has very strong positive correlation with Dorsal chain and strong positive correlation with Ventral, Right and Left Lateral chains.

According to Shaikh et al., when compared to the core power measures of the 60-second maximal squat test, the study's findings demonstrate that core muscle endurance is essential for peak performance and should not be disregarded. It also shows a stronger correlation with performance variables like the medicine ball throw test, vertical jump test, 40-yard dash test, and T test. (31) Our findings suggest weak to moderate correlation of squat test with the core stability test.

Our findings also show a moderate to strong relationship between upper and lower quarter balance tests. It shows very weak positive correlation between the

upper and lower strength tests. Whereas, looking at the endurance tests, squat tests correlates negatively with CKCUEST of dominant side and positively correlates to non-dominant side.

CONCLUSION

In competitive badminton players, the study result shows that there is positive moderate to strong correlation between core stability and upper extremity balance, negative very weak to weak correlation between core stability and upper extremity strength and positive very weak to strong correlation between core stability and upper extremity endurance.

It also shows positive very weak to strong correlation between core stability and lower extremity balance, positive strong to very strong correlation between core stability and lower extremity strength and positive weak to moderate correlation between core stability and lower extremity endurance.

Lastly, the study shows moderate to strong relationship between upper and lower quarter balance tests, very weak positive correlation between the upper and lower strength tests. Whereas, looking at the endurance tests, squat tests correlates negatively with CKCUEST of dominant side and positively correlates to non-dominant side.

LIMITATIONS

There are few limitations to our study. Firstly, the study was done using a small sample size. Secondly, participants were not equally divided according to gender. Lastly, the participants were not analyzed according to their different level of competition.

FUTURE SCOPE OF STUDY

This study possesses a scope for the coaches and professional trainers to implement core stability training in the rehabilitation program in sports that require the use of kinetic chain. Different other sports such as Tennis, Golf, Squash, Hockey, etc. can be assessed in the future using our methodology. Also, both the genders can be compared with each other in future studies.

SUMMARY

Among racket sports, badminton is one of the most popular sports across the globe. A wide range of postural alterations, such as leaps, lunges, swift direction changes, and quick arm movements, are used in competitive badminton. The core muscles offer a solid foundation for support during movements of the upper and lower extremities. The Bourban test is characterized as a cost-effective substitute for alternative evaluations that assess trunk strength endurance. Balance, strength and endurance was assessed using various reliable and valid tests.

This study's aim was to evaluate the relationship between core stability with upper and lower extremity performance in competitive badminton players. Also, the objective of the study was to establish an association between upper and lower extremity performance.

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ANNEXURE: 1

CONSENT FORM

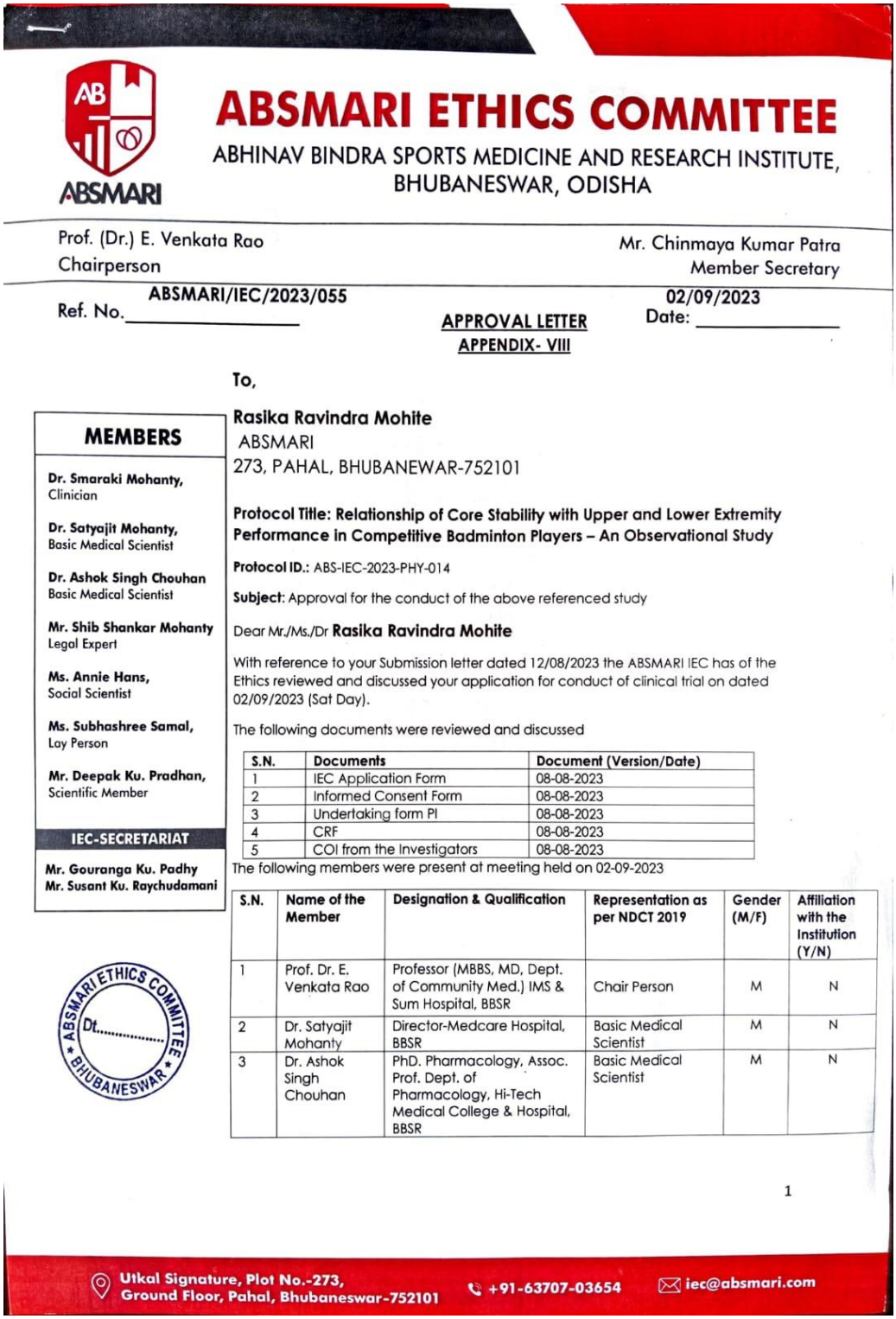
I confirm that I have understood about Relationship of Core Stability with Upper and Lower Extremity Performance in Competitive Badminton Players as explained by Miss Rasika Mohite and is as mentioned in her study which is taking place under the guidance of Prof. Joseph Oliver Raj, Dean, Abhinav Bindra Sports Medicine and Research Institute (ABSMARI) and co-guidance of Dr Arpita Panda, Ass. 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

ETHICAL COMMITTEE CLEARANCE CERTIFICATE



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/2023/055

Date: 02/09/2023

APPROVAL LETTER
APPENDIX- VIII

MEMBERS

Dr. Smaraki Mohanty, Clinician

Dr. Satyajit Mohanty, Basic Medical Scientist

Dr. Ashok Singh Chouhan 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

To,

Rasika Ravindra Mohite
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Relationship of Core Stability with Upper and Lower Extremity Performance in Competitive Badminton Players – An Observational Study

Protocol ID.: ABS-IEC-2023-PHY-014

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr **Rasika Ravindra Mohite**

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 02/09/2023 (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 02-09-2023

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 Chouhan	PhD. Pharmacology, Assoc. Prof. Dept. of Pharmacology, Hi-Tech Medical College & Hospital, BBSR	Basic Medical Scientist	M	N

ABSMARI ETHICS COMMITTEE Dt. BHUBANESWAR

1

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

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/2023/055

Date: 02/09/2023

MEMBERS

Dr. Smaraki Mohanty, Clinician

Dr. Satyajit Mohanty, Basic Medical Scientist

Dr. Ashok Singh Chouhan 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

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
4	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
5	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
6	Mr. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
7	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
8	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
9	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the trial in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and requests to be provided a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

ABSMARI ETHICS COMMITTEE Dt. BHUBANESWAR

Yours sincerely

Mr. Chinmaya Kumar Patra
Member Secretary
ABSMARI Ethics Committee
Pahal, Bhubaneswar

Member Secretary
ABSMARI ETHICS COMMITTEE

2

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ANNEXURE: 3

PROFORMA FORMAT

Name:

Age:

Dominance:

Height:

Weight:

BMI:

Years of experience:

Upper limb length:

Lower limb length:

1. Upper Quarter Y Balance Test

	TRIAL 1		TRIAL 2		TRIAL 3		COMPOSITE SCORE	
	D	ND	D	ND	D	ND	D	ND
MEDIAL								
SUPEROLATERAL								
INFEROLATERAL								

2. Seated Medicine Ball Throw

	TRIAL 1	TRIAL 2	TRIAL 3
SMBT			

3. Closed Kinetic Chain Upper Extremity Stability Test

	TRIAL 1	TRIAL 2	TRIAL 3
DOMINANT			
NON-DOMINANT			

4. Lower Quarter Y Balance Test

	TRIAL 1		TRIAL 2		TRIAL 3		COMPOSITE SCORE	
	D	ND	D	ND	D	ND	D	ND
ANTERIOR								
POSTEROLATERAL								
POSTEROMEDIAL								

5.Standing Long Jump

	TRIAL 1	TRIAL 2	TRIAL 3
SLJ			

6.Squat Test

	NO. OF REPETITIONS
ST	

7. Bourban Trunk Muscle Test

	TIME TAKEN TO COMPLETE
VENTRAL	
DORSAL	
RIGHT LATERAL	
LEFT LATERAL	

MASTERCHART

SR. NO.	UQYBT		SMBT	CKCUEST		LQYBT		SLJ	ST	Bourban			
	Comp. Score					Comp. Score				Ventral	Dorsal	Lateral	
	Dominant	Non-dominant		Dominant	Non-dominant	Dominant	Non-dominant					Right	Left
1	66.67	73.14	248	11	26	95.23	98.41	189	49	119	52	49	44
2	76.78	84.72	379	14	20	102.15	124.7	162	51	47	61	14	17
3	81.8	89.84	391	23	25	98.1	110.41	221	52	110	112	80	48
4	73.51	81.85	512	20	13	107.25	116.27	189	45	37	59	33	27
5	49.81	57.34	425	17	14	94.31	99.8	117	29	23	11	15	14
6	76.07	82.94	442	26	18	104.54	110.84	197	35	98	62	36	31
7	63.85	72.09	437	23	17	79.35	95.26	151	43	33	34	17	23
8	61.04	72.09	514	28	18	101.89	100.3	197	43	53	75	18	16
9	62.85	73.09	435	22	16	78.36	96.25	150	45	35	37	17	21
10	60.04	69.04	514	27	18	100.98	101.24	195	41	52	71	20	18
11	62.85	72.09	437	23	15	77.35	96.24	151	43	36	34	15	23
12	82.5	89.84	381	25	26	98.1	108.51	219	52	109	112	78	48
13	77.85	85.86	379	14	20	101.15	122.56	162	50	47	62	14	18
14	63.95	72.09	455	21	18	77.56	95.85	153	43	33	34	19	23
15	48.81	57.34	425	17	14	93.31	99.56	117	18	25	13	15	19
16	67.67	72.14	249	14	25	95.89	99.41	189	49	119	56	45	44
17	76.08	82.94	442	26	18	103.54	109.41	195	36	98	62	39	35
18	72.51	81.85	526	20	14	106.24	115.26	189	45	39	59	36	26
19	81.5	89.84	389	24	25	98	111.84	220	51	110	110	81	48
20	50.89	56.87	422	17	14	95.34	98.35	117	29	23	11	15	15
21	62.04	72.09	514	29	20	101.98	100.89	199	44	56	73	18	16
22	64.85	70.68	437	23	17	77.39	94.56	151	43	33	35	20	23
23	65.67	72.14	245	13	24	93.54	99.41	189	47	117	52	49	46
24	75.62	82.94	442	25	18	101.26	108.57	195	35	98	61	38	31
25	75.78	84.72	375	13	20	101.56	120.65	165	51	45	62	15	19
26	82.8	88.85	391	23	24	98.65	109.98	208	52	110	112	79	48
27	73.51	81.85	511	19	13	105.52	114.56	185	47	40	56	34	29
28	76.07	82.94	442	27	19	103.52	111.85	192	35	98	62	36	31
29	64.85	70.95	437	23	17	78.35	94.56	151	44	49	36	17	25
30	49.81	57.34	420	18	15	96.54	98.56	117	29	26	14	18	14
31	75.78	84.72	379	14	20	101.57	122.54	167	52	47	61	14	19
32	66.67	72.14	244	12	24	94.51	99.56	189	49	106	54	51	46
33	73.51	81.85	512	21	13	104.56	114.67	190	45	37	59	33	27
34	64.85	72.58	437	22	18	75.52	97.32	153	44	41	36	22	24
35	77.78	84.72	381	14	20	100.69	123.45	161	51	47	64	14	16
36	49.81	58.34	425	19	14	95.68	98.45	119	28	29	15	18	14
37	76.07	82.94	445	26	19	102.54	106.57	197	35	88	61	37	30
38	74.51	81.85	512	21	13	102.76	117.68	183	45	37	58	35	27
39	66.67	75.45	251	11	27	91.25	99.57	185	48	118	51	48	44
40	82.4	89.84	393	25	25	99.82	110.68	219	51	112	111	79	47