RECOMMENDATIONS

Recommendation for future research

Further study can be done to evaluate the role of core stability in other categories of bowlers. In future study can be directed towards evaluating the role of core stability in the batsman, fielder or wicket keeping. Also to find out the difference in male and female cricket players.

Recommendations for the society

The benefit of the results of this study can be used to modify the existing training protocol of the fast bowlers. Adding core stability training will improve the performance of fast bowlers and also will reduce the incidence of their back pain.

Similar study can be conducted for other categories of bowlers like leg spin, off spin, leg break etc and also can be done on batsman, fielders and wicket keeper to find out the role of core stability training to enhance the performance and also to avoid chances of back injury.
Suggestion

1. Further study with bigger sample size is recommended for better results.

2. Further studies using the developed tool are supported; use of better assessment tools will help for getting more accurate and correct data.

3. Future study with professional fast bowlers is recommended for better results.

4. Further study with other age group and elite fast bowler will help to generalize the results of the study.

5. Future study with other sports like tennis will be useful to have baseline data to get the better training techniques.
APPENDICES

APPENDIX- I

PROGRAMME OF CORE STABILITY EXERCISES

SUPINE BENT-KNEE RAISES

This is a fundamental exercise for recruiting the deep abdominal muscles and for lumbo pelvic control. The athlete lies on her back, with knees bent and feet flat on the floor. She then braces the abdominal wall, holding the lumbar spine in a neutral position, and slowly raises one foot 15-30cm off the ground with alternate legs. Common errors when performing this exercise include rocking the pelvis, abdominal protrusion, or an inability to maintain the neutral (midrange) lumbar curve. If this happens, discontinue the exercise for a rest period. Quality more than quantity is stressed.

Progression: The exercise can progress to alternately extending the legs and lowering to the ground. Once the athlete can maintain stability with alternate leg lifts. She can add alternate, overhead arm raises for greater challenge. The arm raises should be performed slowly, while maintaining lower abdominal bracing.
QUADRUPED WITH ALTERNATE ARM/LEG RAISES

This exercise prepares the athlete for the proprioceptively more challenging, more dynamic exercises of the trunk. It specifically engages the *multifidi*—the deep transverse spine stabiliser and extensor of the lumbar spine. The athlete should position herself on all fours. She then braces the abdominal wall as described above. While maintaining a midrange/neutral curve of the lumbar spine, the athlete would raise the right arm and the left leg (opposite upper and lower limbs) into a line with the trunk, while preventing any rocking of the pelvis or spine (excessive transverse- or coronal-plane motion). If it helps to maintain alignment, the athlete may use an object, such as a foam roller or wooden dowel, placed along the spine, for added tactile feedback. The leg should be raised only to the height at which athlete can control any excessive...
motion of the lumbo-pelvic region. She then performs the exercise raising the left arm with the right leg.

**Progression:** A Physioball underneath the trunk can provide significantly more proprioceptive challenge owing to its unstable surface. The goal once again is for the athlete to maintain lumbar stability while the opposite arm and leg are raised slowly.

![Figure 2: Quadruped with Alternate Arm/Leg Raises](image)

**BRIDGING**
Bridging is a fundamental core-stability and gluteal-strengthening exercise. The athlete begins the exercise on her back, in a hook-lying position, with arms resting at her sides. She activates the abdominals and squeezes the gluteal cheeks prior to initiating the movement. The athlete lifts the pelvis and hips off the ground while maintaining neutral lumbar alignment. There should be no rotation of the pelvis. The hips should be aligned with the knees and shoulders in a straight line. The athlete should hold the position for 10sec and then slowly lower the pelvis to the floor.

**Progression:** In the lifted-bridge position, while maintaining neutral lumbar and pelvic alignment, the athlete can lift one foot off the ground and extend the leg. By placing her arms across her chest, she can increase the challenge of stabilising the lumbo-pelvic region. To progress further, the athlete can raise both arms up to the ceiling and then move one arm out to the side. She should bring the arm back to the centre and repeat with the other side.
PRONE PLANK

This is a fundamental, static core-stability exercise. The athlete supports herself with her forearms resting on the mat, elbows bent at 90°, and the toes resting on the mat. The athlete maintains the spine in a neutral position, recruits the gluteal muscles, and keeps the head level with the floor. She is instructed to breathe normally throughout the exercise, while maintaining the abdominal brace. We suggest holding the position for 20sec, working up to one minute for two to three repetitions. No compensatory motion, such as increased lumbar lordosis or sag, should be seen.
**Progression:** In this position, the athlete can add leg lifts for more difficulty: one leg can be lifted off the mat, held for five seconds, and then repeated on the opposite side.

![Figure 4: Prone Plank](image)
SIDE PLANK

This is a fundamental, static core-stability exercise designed to challenge the athlete’s body against gravity in the coronal/frontal plane and is an ideal exercise to train the *quadrates lumborum*. The athlete is lying on her right side with the right arm extended in a straight line up from the shoulder, with the forearm resting on the mat. She then raises the pelvis from the floor and holds it in a straight-line “plank” position. The hips should not be allowed to sag toward the floor. We suggest holding the position for 20sec, working up to one minute holds for two to three repetitions.

**Progression:** The top foot can be raised to increasingly challenge the core and gluteal musculature.

![Figure 5: Side Plank](image-url)
Advanced lumbo-pelvic stability

Once the athlete demonstrates good stability with all static core exercises, they can be replaced with more advanced exercises on the Physioball detailed below. These exercises should be performed at least two times per week to maximise results. The athlete progresses to two sets of 10-15 repetitions. Quality is more important than quantity; the athlete must maintain lumbar neutral and keep the spine in perfect alignment throughout the exercises.

SEATED MARCHING ON A PHYSIOBALL

This exercise is more difficult because the athlete positions her body against gravity in a seated position on an unstable surface. The athlete begins by sitting upright on a Physioball, with the lumbar spine in a neutral position (midrange). She places her feet hip width apart. While bracing the abdominal muscles, she lifts one leg and foot off the ground. (The limb does not need to be lifted very high, just enough to be off the ground—approximately 5cm to start.) The athlete should focus on controlling the weight shifting to the weight-bearing limb while maintaining lumbo-pelvic stability.
Progression: Once lumbo-pelvic stability can be maintained with alternate leg lifts, the athlete can add opposite arm lifts.

SPINAL FLEXION ON PHYSIOBALL

The athlete pre-activates her abdominal brace in the starting position and maintains this as she rolls back into spinal extension. She then slowly raises the body, focusing the rotation in the thoracic spine. Picture the head and neck as a rigid block on the thoracic spine to prevent
flexing the cervical spine. The athlete concentrates on attempting to touch the bottom of her ribs to her pelvis (ASIS). The hands can be placed over the ears to eliminate pulling on the neck.

**Progression:** The athlete holds a 2.0 to 4.0kg medicine ball in front of the chest with the arms extended (see Figure 7b).

![Figure 7: Spinal Flexion on Physioball](image)

**ALTERNATE LEG BRIDGE WITH SHOULDERS ON BALL**

The athlete starts this exercise by sitting on the Physioball and walking forward with his feet on the ground, slowly leaning back until his back rests on the ball. This is called the *bridge position*. The head, neck, and shoulder blades should be supported on the ball. Knees should be
bent at a 90° angle, with feet on the ground. While bracing the abdominal muscles, the athlete raises the foot and extends the leg off the ground. The weight will be shifted to one side, and the athlete should focus on maintaining stability of the lumbo-pelvic region. The athlete should strive for stability and balance, while holding this position for 10sec and alternating lower limbs.

**Progression:** The athlete lifts the arms up in the air or out to the sides.

![Figure 8: Alternate Leg Bridge with Shoulders on Ball](image)

**LEG CURLS ON A PHYSIOBALL**

The purpose of this dynamic exercise is to recruit both actions of the hamstrings—hip extension and knee flexion—while maintaining dynamic stability of the lumbar spine. In a supine position on the floor, the athlete places both feet on the Physioball. (Shoes should be removed to allow increased proprioception from the exteroceptors of the feet.) The athlete keeps her arms on the floor at the sides of the body for balance.
and raises the hips off the ground until the knees, hips, and shoulders create a straight line. She should focus on holding the spine in a neutral midrange position. In this position, the athlete then pushes the ball forward with the feet while maintaining the bridge. The goal is to keep the pelvis elevated (hip extension) as both legs extend and flex at the knees. While the knees extend and flex from this elevated bridge position, the athlete focuses on maintaining lumbo-pelvic stability.

**Progression:** The athlete can continue with single leg hamstring curls in the same position (see Figure 9b).
ABDOMINAL ROLLOUT

The athlete kneels behind the ball, with both hands on the ball. Keeping the abdominal muscles raced and lower back in a neutral position, she then rolls the ball away from her body a short distance until there is a straight line from the shoulder to hips. While maintaining alignment, she pulls the ball back to short distance, then pushes it away again. The movement should occur only at the shoulders, not the back.

**Progression:** The athlete can gradually straighten the body until she is up on her toes. There should be a straight line from the back of the head to the knees. Now she can again move the ball away and back toward the body a short distance with the arms.
**SQUAT BALL THRUST**

Keeping the abdominal muscles braced and lower back and shoulder blades in a neutral position, the athlete uses her abdominal contraction to move the ball forward and back. Keep the spine in neutral alignment throughout the movement. If the exercise shown is too challenging, start with the shins instead of the toes on the ball.

**Progression:** The athlete can perform the exercise with only one foot on the ball (see Figure 11b).
Development of balance and motor control

The following movements require reflexive control. The athlete can establish this control using an unstable surface and taking advantage of the numerous proprioceptors in the soles of the feet, and by activating the neck muscles, which contribute greatly to postural regulation. This sensory-motor training is an attempt to provide the sub-cortex with a basis for movement that is progressively more challenging. It involves exercises that stimulate balance, coordination, precision and skill acquisition.

Various devices are useful to progressively challenge balance, including a balance board with a whole sphere underneath the board (which creates multi-planar instability) or a rocker-board with a curved surface underneath the board (which allows single-plane motion). Dynamic foam rollers are an inexpensive alternative to the boards that also can be used to challenge balance, proprioception, and
stability. These include half-rollers and full-sized rollers. Two other items that are invaluable to challenge balance and core stability and aid proprioceptive training in the standing position are the Bosu Balance Trainer and the Dyna Disk (these can be used interchangeably.) The Bosu has two functional surfaces that integrate dynamic balance with sports-specific or functional training: the domed surface is convex, the other side is flat and can be used for less challenge. The Dyna Disk is an air-filled plastic disc that can be firmly inflated. It has a smaller diameter than the Bosu and can be used like the Bosu Trainer, as it creates an increased proprioceptive challenge to the athlete while standing on it. The Dyna Disk is unstable and does not have a base like the Bosu trainer.

FORWARD/BACKWARD ROCKING

In this exercise, a rocker-board is used to challenge balance in the frontal plane of motion. Standing on the rocker-board with both feet in perfect postural alignment, the athlete gently rocks forward and backward. (To maintain ideal posture, the athlete can create an imaginary line through the joints of the ankle, knee, hip, and shoulder. The ear should align in a straight line with these joints, with no excessive extension [swayback] of the lumbar spine or anterior pelvic rotation.) While rocking, there should be no excess body movement in the coronal
or transverse planes. This exercise should be performed for several minutes. The goal is to optimally align the spinal curves and lower extremities.

**Progression:** The athlete can progress to a slight flexed-knee position, with fast and slow movements to stimulate the righting reflexes and balance reactions. She also can progress the stepping motion to the three axes of motion.

Figure 12: Forward/Backward Rocking

**SINGLE-LEG BALANCE—3 PLANES**
This next exercise progresses the athlete to a single-leg stance. The rocker-board is used in the three planes of motion. This exercise also can be performed with a balance board, which is more demanding as it incorporates all planes of motion simultaneously. The athlete takes one step forward while maintaining alignment and balance, controlling aberrant motion, mimicking a forward running motion. The goal is to maintain lumbo-pelvic alignment. The athlete controls movement in the three planes of motions by placing her feet in various positions on the board. The athlete then alternately steps forward and backward onto the rocker-board.

**Progression:** Once the athlete achieves static stability and can remain stable while standing on the rocker board, she can add an accessory motion. The athlete can swing the arm and the non-weight-bearing opposite leg (as though mimicking running). No excessive motion in the pelvis or lumbar spine should occur during the swing phase.
WEIGHT TRANSFERS WITH PROPER ALIGNMENT

The preceding exercise progresses to “falling” onto an unstable surface. Figure 14 shows a rocker-board and “falling” onto a circular balance board. Again, the emphasis is on spinal alignment from the head to the sacrum. The athlete steps forward quickly and catches herself from falling over with a quick forward movement of the leg onto the board.
Figure 14: Weight Transfers with Proper Alignment

Functional Movement Training

Functional movements require acceleration, deceleration, and dynamic stabilisation. A functional exercise regimen specific to the demands of running includes single-leg drills, three-dimensional lunges, resistive diagonal patterns of the upper and lower extremities, and tri-planar movement sequences. Athletes can progress through the three planes of motion by performing similar exercises on balance boards, the Dyna Disk or Bosu type trainers, as static trunk and core stability have been mastered. Once these exercises are performed at a high level, the coach can be assured the athlete has the necessary core stability to start plyometric drills.
SINGLE-LEG BALANCE WITH HIP FLEXION

This exercise provides a functional movement pattern that is similar to running. The exercise seeks to increase stability of the lower abdominal muscles while using a forward motion at the hip. The exercise is designed to develop sagittal-plane control. While balancing on one leg, the athlete imitates a running motion. As the upper thigh is lifted forward in a running motion, she concentrates on maintaining the abdominal brace and lumbo-pelvic stability while avoiding excessive anterior or posterior pelvic rotation. The athlete raises the opposite arm simultaneously into flexion, while maintaining postural alignment with an erect spine, allowing only the extremities to move.

**Progression:** Once the athlete can maintain lumbar spine stability without effort, she can attach a pulley or resistive cord to the ankle to increase the challenge to the hip flexors
MULTI-DIRECTIONAL LUNGES

The athlete begins this exercise with a forward lunge. Again, the emphasis is on maintaining a neutral spine position and abdominal brace throughout the entire movement. As the athlete steps forward, knee flexion of the forward leg is limited to 90°. The knee joint should be over the ankle joint and the patella aligned with the second toe. The lower part of the leg should be perpendicular to the ground, as shown in Figure 16.

**Progression:** Once strength and stability in the forward (sagittal) plane have been achieved, the athlete can begin stepping out at oblique angles, creating a narrower lunge or a wider lunge in the coronal or
transverse planes. The athlete can also step out onto an unstable surface such as a Bosu Trainer or Dyna Disk, which vastly increase the proprioceptive and dynamic core-stability challenge.

Figure 16: Multi-directional Lunges