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The effect of Swiss-ball core training on trunk endurance and dynamic balance in recreational cricket players: An experimental study

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Abstract
Introduction: A strong core allows an individual the full transfer of forces generated from the ground through the lower extremities, the torso and finally to the upper extremities. A weak core is believed to interrupt the transfer of energy, resulting in reduced sport performance and efficiency and risk of injury to distal limbs.
Methodology: Total 40 subjects were included in the study depending on the inclusion and exclusion criteria. Age group-18-25 yrs**.**, Male subjects were included taking part in recreational cricket activities After taking an informed written consent subjects were divided into 2 groups by using Simple random sampling method.
Materials: Swiss-ball (Size- 65 cm), Yoga Mat, Pen, Pencil, Paper, Plinth, Goniometer, Belt, Adhesive tape**,** Measure tape, Stopwatch.
Y Balance test and Trunk Muscle Endurance Tests scores were taken at the pre intervention (First Day) and post intervention (at 6 weeks of completion of treatment).
Group A: Warm up and cool down exercise along with regular activities
Group B: 6-week swiss ball core training
R**esults:** Statistical analysis was done using SPSS version 25. Within group analysis was done by using Wilcoxon signed rank test and between group analysis was done using Mann whitney u test. Results showed that the Trunk Endurance and Dynamic Balance in recreational cricket players is significantly improved ($p<0.05$) in Swiss-ball core training group.
Conclusion: From the present study it can be concluded that 6 weeks of Swiss-ball core training exercises improve trunk endurance and dynamic balance in recreational cricket players or other physiotherapy interventions such as massage, stretching, Pilates and manual therapy techniques.

Keywords: Swiss-ball, core training, trunk endurance, dynamic balance

Introduction
A strong core allows an individual the full transfer of forces generated from the ground through the lower extremities, the torso and finally to the upper extremities. A weak core is believed to interrupt the transfer of energy, resulting in reduced sport performance and efficiency and risk of injury to distal limbs or to a weak or underdeveloped muscle group.
Lack of dynamic stability in the core has been associated with potential for increased risk for lower extremity injury. Performing exercises on the physioball may increase proprioceptive demands and stress the core muscles more than a linear plane, such as the floor to improve trunk stability and balance in sports.
In fact, recreationally active player may be at higher injury risk or pain during sports participation, as they do not regularly participate in fitness training.

Materials and Methodology
Study design: Experimental study.

Study setting: Colleges and cricket grounds in Ahmedabad.

Study duration: 3 months.

Sample population
Recreational Cricket Players.

Sampling method
Simple Random Sampling.

Sample Size: 40

Individuals were divided into two groups:
Group A: Experimental group (20).
Group B: Control group (20).

Selection criteria
Inclusion Criteria
1. Age group of 18-25 yrs.
2. Male subjects were included.
3. Subjects taking part in recreational cricket activities.
4. Individuals willing to participate.
5. Recreational cricket players. They should be playing for 1-3 hours per session and at least 3 times a week.

Exclusion Criteria
Participants having any previous lower extremity or lower spine pathology or surgery within past 6 months, any neurological, vestibular or visual disorder in past 6 months or taking any medication that could affect balance.

Materials and Apparatus
- Assessment form
- Consent form
- Swiss-ball (Size- 65 cm for 165cm-180cm height) [38]
- Yoga Mat
- Pen, Pencil, Paper
- Plinth
- Goniometer, Belt
- Adhesive tape**,** Measure tape
- Stopwatch

Fig 1: Materials

Outcome measures
Trunk Muscle Endurance Tests: All the subjects performed the following four endurance tests, and minimum of 5 minutes was provided between the tests to facilitate recovery.

Flexor Endurance Test (FET)
Procedure: The FET required subjects to sit on the test table and place the upper body against a support with an angle of 60° from the test table. Both the knees and hips were flexed to 90°. The arms were folded across the chest with the hands placed on the opposite shoulder and feet were placed under stabilizing belt. Subjects were instructed to maintain the body position while the supporting surface was pulled back to begin the test. The test ended when the upper body fell below the 60° angle. The endurance time was recorded in seconds with a stopwatch. The ICC reliability for flexor endurance test is 0.93.

Fig 2: Flexor endurance test

Extensor Endurance Test (EET)
Procedure: The EET required the subject in prone lying with the lower body fixed to the test bed at the ankles, knees, and hips and the upper body extended in a cantilevered fashion over the edge of the test table. The test table surface was approximately 25cm above the resting surface. Subjects rested their upper bodies on the resting surface before starting the test. At the beginning of the test the upper limbs were held across the chest with the hands resting on the opposite shoulders and the upper body was lifted off the rest surface until the upper torso was horizontal to the floor. Subjects were instructed to maintain the horizontal position as long as possible. The endurance time was recorded in seconds with a stopwatch until the subject maintained the horizontal position. The ICC reliability for extensor endurance test is 0.99.

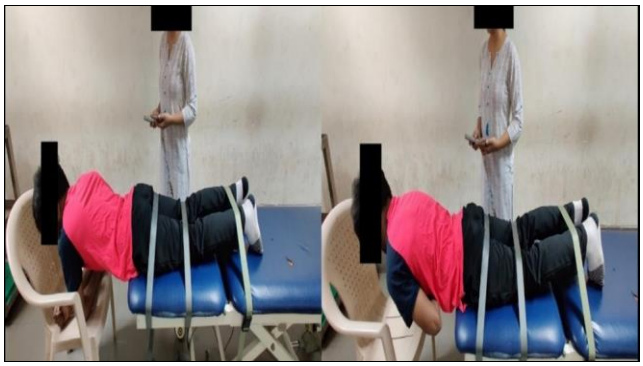


Fig 3: Extensor endurance test

Side Bridge Test (SBT)
Procedure: The SBT consisted of subjects lying on the exercise mat on their sides with legs extended. The top foot was placed in front of the lower foot on the mat for support. Subjects were instructed to lift their hips off the mat to maintain a straight line over their full body length and support them on one elbow kept at 90° and their feet. The opposite hand was held across chest with hand placed on the opposite shoulder. The test ended when the hips returned to the exercise mat. Endurance time was noted in stop watch from the time when hips were off the mat and stopped when returned to mat. The ICC reliability of right-side bridge test is 0.96 and 0.99 for left side bridge test.

Fig 4: Side bridge test

Dynamic balance test

Y Balance Test (YBT): The Y Balance test (YBT) consists of a three-part test that is used to assess lower extremity balance and neuromuscular control to predict lower extremity injury.

Each subject viewed an YBT instructional video and performed 6 practice trials to minimize the influence of a learning effect. After the instructional video subjects stood on the centre, with the distal aspect of the stance foot at the starting line. While maintaining single leg stance, the subject reached with the free limb in the anterior, posteromedial and posterolateral directions in relation to the stance foot by reaching as far as possible. Subjects completed 3 consecutive trials for each reach direction. The subject returned to the starting position without losing balance after each trial. The subject had a 30-second rest before moving on to the next direction. As per the YBT-LQ protocol, a trial was discarded if the subject (1) failed to maintain unilateral stance, (2) touched down on the reaching foot, or (3) failed to return to the starting position.

Subject's lower limb reach was also normalized to leg length, which was measured from the anterior superior iliac spine to the most distal portion of the medial malleolus.

The results were calculated taking limb length into consideration, to determine a "composite reach distance". The composite score was calculated by summing the reach distance in three directions, dividing by three times limb length, and multiplying by 100.

Fig 5: Anterior reach YBT

Fig 6: Posteromedial reach YBT

Fig 7: Posterolateral reach YBT

Procedure: Ethical clearance was obtained from the institutional ethical committee prior to the study. Screening of the subjects was done according to Physical Activity Readiness Questionnaire (PAR-Q). PAR-Q scale. 55 subjects from different cricket grounds were screened for the eligibility. From that 40 subjects fulfilled the inclusion and exclusion criteria were included in the study.

The purpose and nature of the study was thoroughly explained to the subjects. Subjects included in the Study were explained the whole procedure. Written informed consent was obtained from all subjects and were included in the study according to their willingness. Subjects were allocated into 2 groups: Group A and Group B. On first visit, a complete assessment was done which include the descriptive data for age, height,

weight.
Y Balance distance and Trunk muscle endurance tests scores were taken at the pre intervention (First Day) and post intervention At 6 weeks of completion of treatment).
Total 40 subjects were divided into 2 groups by simple random sampling

Group A: Exercise Group (N=20) Subjects in the exercise group were given Swiss- Ball Core Training with warm up and cool down.

Group B: Control group (N=20) Subjects in the control group were given warm up and cool down exercises and they continued their regular activities.

Group A: Swiss-ball core training

Exercise protocol
Subjects assigned to the exercise group completed a 6-week swiss ball core training, 3 days/week. Subjects performed warm up and cool down exercises: Jogging: 5 mins, Static stretching to major muscle groups: 30 × 2.

1st week
1. Abdominal muscle contraction in crook supine lying position - 3 × 15 repetitions (10sec hold).
2. Abdominal muscle contraction in Quadruped position - 3 × 15 repetitions (10 sec hold).
3. Abdominal contraction in bridging - 3 × 15 repetitions (10 sec hold)

2nd week
1. Abdominal contraction supine - 1 × 20 repetitions (10 sec hold).
2. Swiss-ball abdominal crunch - 2 × 10 repetitions.
3. Swiss-ball back extension - 2 × 10 repetitions.
4. Swiss-ball bridging - 2 × 10 repetitions.
5. Swiss-ball alternate arm and leg extension - 2 × 10 repetitions.
6. Swiss-ball squat - 2 × 10 repetitions.
7. Swiss-ball leg raise - 2 × 10 repetitions.

3rd week
1. Abdominal contraction supine - 1 × 20 repetitions (10 sec hold).
2. Swiss-ball abdominal crunch - 2 × 15 repetitions.
3. Swiss-ball back extension - 2 × 15 repetitions.
4. Swiss-ball bridging - 2 × 15 repetitions.
5. Swiss-ball alternate arm and leg extension - 3 × 12 repetitions.
6. Swiss-ball squat - 3 × 12 repetitions.
7. Swiss-ball leg raise - 3 × 12 repetitions.

4th week
1. Abdominal contraction supine - 1 × 20 repetitions (10 sec hold).
2. Swiss-ball abdominal crunch - 3 × 12 repetitions.
3. Swiss-ball back extension - 3 × 12 repetitions.
4. Swiss-ball bridging with alternate leg lift - 2 × 10 repetitions.
5. Swiss-ball alternate arm and leg extension - 3 × 12 repetitions.
6. Swiss-ball squat - 3 × 12 repetitions.
7. Swiss-ball leg raise - 3 × 12 repetitions.

5th week
1. Abdominal contraction supine - 1 × 20 repetitions (10 sec hold).
2. Swiss-ball Diagonal crunch - 3 × 10 repetitions.
3. Swiss-ball abdominal roll out - 2 × 10 repetitions.
4. Swiss-ball bridging with alternate leg lift - 2 × 10 repetitions (2 sec hold).
5. Swiss-ball alternate arm and leg extension - 3 × 12 repetitions.
6. Swiss-ball squat - 3 × 12 repetitions.
7. Swiss-ball leg raise - 3 × 12 repetitions.

6th week
1. Swiss-ball lunge - 3 × 8 repetitions.
2. Front plank on stability ball - 2 × 10 repetitions.
3. Swiss-ball abdominal roll out - 3 × 10 repetitions.
4. Swiss-ball alternate arm and leg extension - 3 × 12 repetitions.
5. Swiss-ball squat - 3 × 12 repetitions.
6. Swiss-ball leg raise - 3 × 12 repetitions.

Subjects had a 30-second rest between each exercise and a 1-2-minute rest between sets.

Fig 8: Abdominal contraction in supine lying

Fig 9: Abdominal contraction in quadruped position

Fig 10: Abdominal muscle contraction in bridging

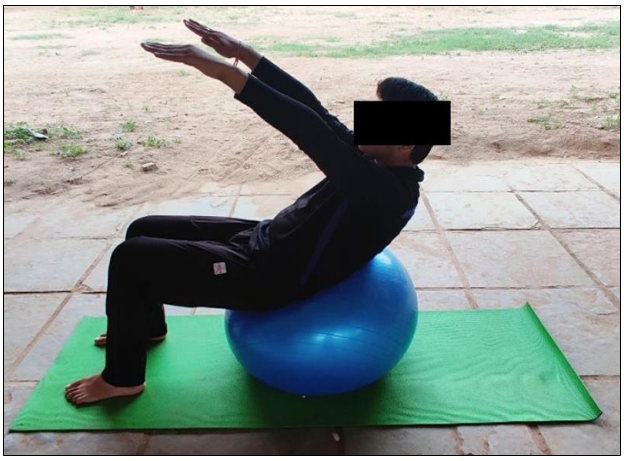


Fig 11: Swiss-ball abdominal crunch

Fig 15: Swiss-ball squat

Fig 12: Swiss-ball back extension

Fig 16: Swiss-ball leg raise

Fig 13: Swiss-Ball Bridge

Fig 17: Swiss-ball bridge with alternate leg lift

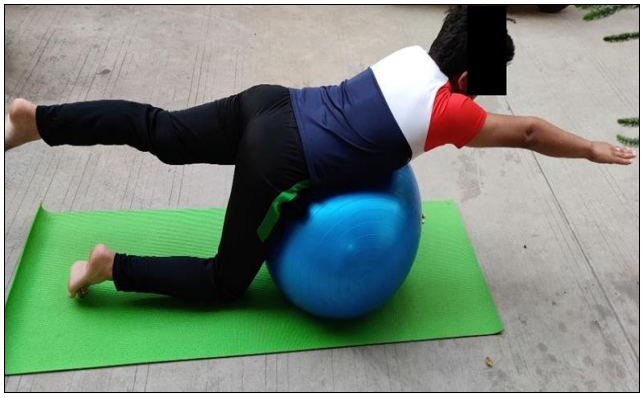


Fig 14: Swiss-ball alternate arm and leg raise

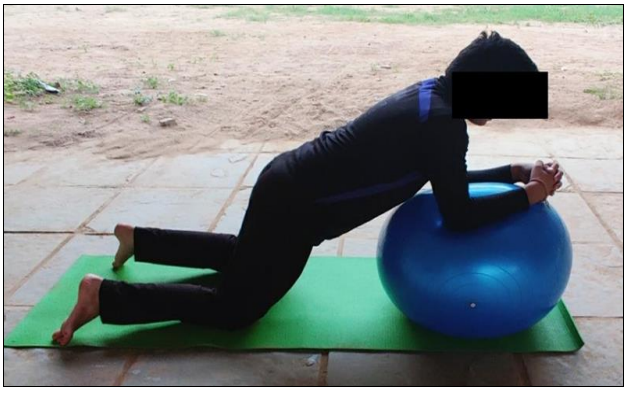


Fig 18: Swiss-ball abdominal roll out

Fig 19: Swiss-ball diagonal crunch

Fig 20: Swiss-ball lunge

Fig 21: front plank on swiss-ball

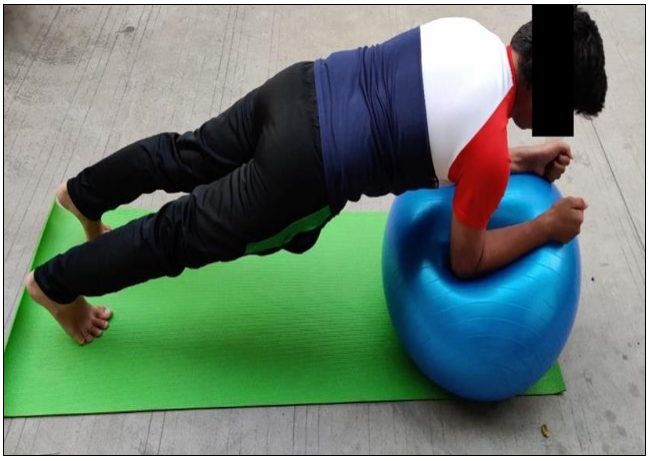


Fig 22: Swiss-ball lunge

Group B: Control group individuals were refrained from Swiss-ball core training and they continued their daily activities and playing along with warm up and cool down exercises.

Results

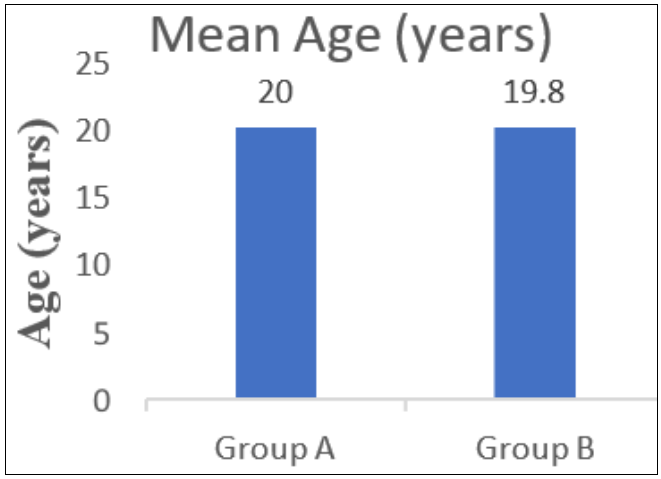
Statistical analysis was done using SPSS version 25. Prior to the application of statistical tests, data was tested for the distribution of normalcy by using Shapiro-wilk test. The data was not normally distributed for all outcome measures. Baseline comparison of data was done and the data was similar at baseline. Within group and between group analyses of outcome measures were done after 6 weeks of completion of intervention. Level of significance was kept at 5% and confidence interval of 95%.

Non-parametric tests were applied for within group and between group analyses. Wilcoxon Signed Rank test was applied to analyse pre and post outcome measures within group, while between group analyses was done using Mann-Whitney U Test.

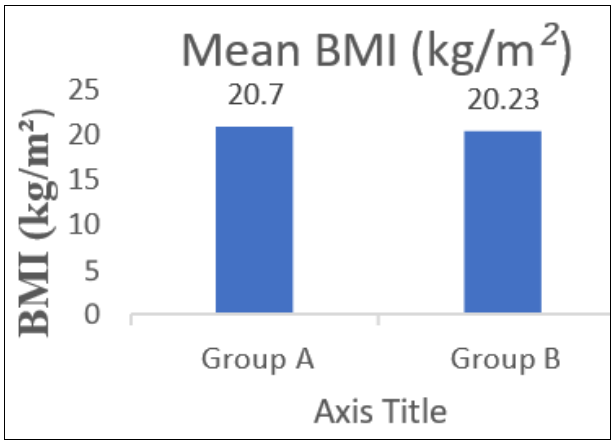
Graph shows the mean age (Years), BMI (kg/m²) and limb length (cms) of all subjects who participated in the study.

Table 1: Mean age (Years), BMI (kg/m²), and limb length (CMS) of subjects

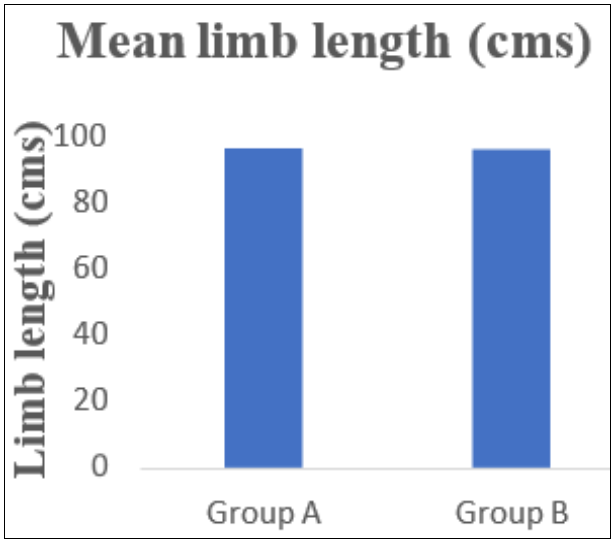
Group	Group A Mean ± SD	Group B Mean ± SD
Age (years)	20±1.98	19.8±1.69
BMI (kg/m²)	20.70±2.13	20.23±1.74
Limb Length (cms)	96.80±5.57	96.50±1.80



Graph 1: Mean Age of subjects in years



Graph 2: Mean BMI of subjects in kg/m²



Graph 3: Mean LIMB LENGTH of subjects in centimeters

Mann-Whitney U test was applied to compare the baseline characteristics of the subjects in both groups. Table shows comparison of age (years), BMI (kg/m²), limb length (cm), flexor endurance test, extensor endurance test, side bridge test, and y balance anterior, posteromedial reach, posterolateral reach.

Table 2: Comparison of baseline characteristics between groups

Characteristics	U-value	P-Value
Age (Years)	168.50	0.938
BMI (kg/m²)	153	0.584
Limb Length (cm)	156.50	0.657
Flexor Endurance Test	126.5	0.175
Extensor Endurance Test	113.5	0.08
Side bridge test	116	0.09
Right side left side	123.50	0.148
Y Balance		
Anterior Reach RT	159	0.715
LT	148	0.494
Posteromedial RT	144	0.412
LT	146.5	0.457
Posterolateral RT	161.50	0.773
LT	158	0.693

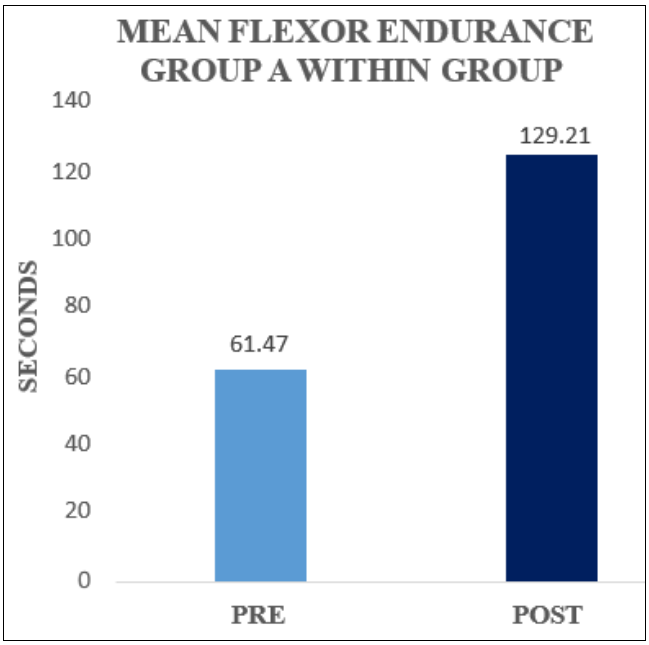
No statistically significant difference was found between both the groups.

Data Analysis

Within group analysis for pre and post Flexor Endurance test (secs) in group A was done by using Wilcoxon-Sign Rank test. Analysis showed statistically significant difference between pre and post intervention Flexor Endurance test in seconds in Group A. (p<0.05)

Table 3: Pre and Post mean Flexor Endurance test (secs) in group A

Group A	Pre Mean ± SD (Seconds)	Post Mean ± SD (Seconds)	Z Value	P Value
Flexor Endurance test	61.47±16.67	129.21±21.06	-3.82	0.000

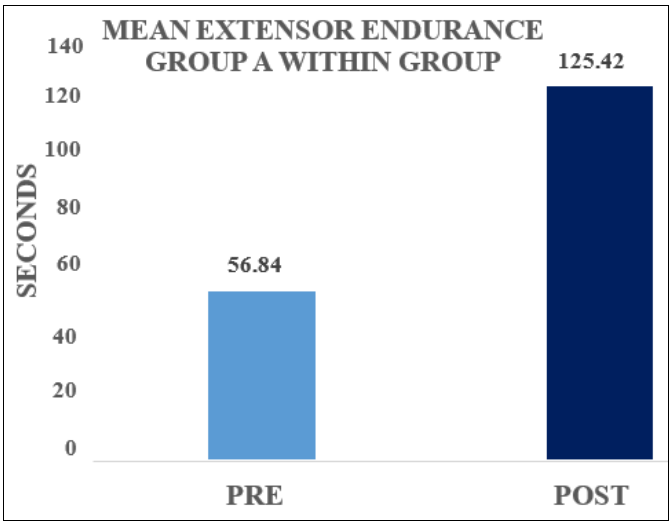


Graph 4: Pre and post mean flexor endurance test (SECS) in Group A

Within group analysis for pre and post Extensor Endurance test (secs) in group A was done by using Wilcoxon-Sign Rank test. Analysis showed statistically significant difference between pre and post intervention Extensor Endurance test in seconds in Group A. (p<0.05).

Table 4: Pre and post mean extensor endurance test (SECS) in Group A

Group A	Pre Mean SD (Seconds)	Post Mean ± SD (Seconds)	Z Value	P Value
Extensor Endurance	56.84±19.49	125.42±20.23	-3.82	0.000

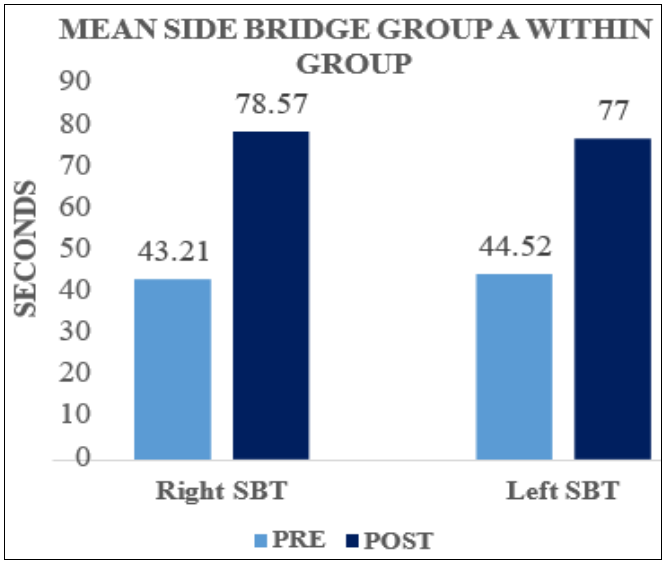


Graph 5: Pre and post mean extensor endurance test (SECS) in Group A

Within group analysis for pre and post Side Bridge test (secs) in group A was done by using Wilcoxon-Sign Rank test. Analysis showed statistically significant difference between pre and post intervention Side Bridge test in seconds in Group A. (p<0.05).

Table 5: Pre and post mean side bridge test (SBT), (SECS) in Group A

Group A	Pre Mean ± SD (Seconds)	Post Mean ± SD (Seconds)	Z Value	P Value
Right SBT	43.21±13.15	78.57±16.19	-3.82	0.000
Left SBT	44.52±15.11	77.0±14.15	-3.82	0.000

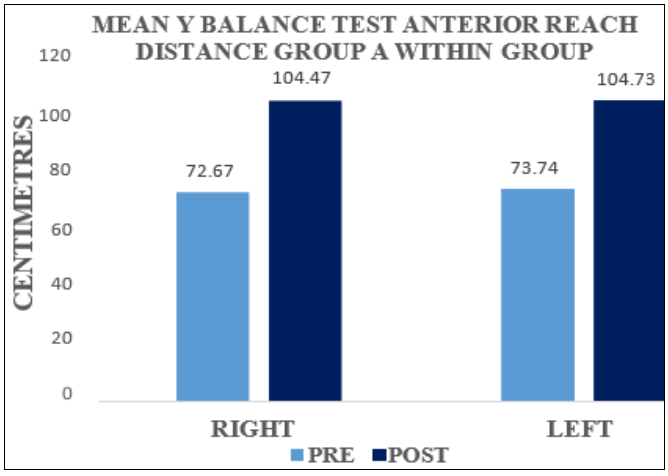


Graph 6: Pre and Post mean Side Bridge test (secs) in group A

Within group analysis for pre and post Y Balance test Anterior reach distance (cms) in group A was done by using Wilcoxon-Sign Rank test. Analysis showed statistically significant difference between pre and post intervention Y Balance test Anterior reach distance in centimeters in Group A. (p<0.05).

Table 6: Pre and Post mean y balance test Anterior reach distance (cm) in group A

Group A	Pre Mean ± SD (cm)	Post Mean ± SD (cm)	Z Value	P Value
Anterior Reach				
Right leg	72.67±8.36	104.472±9.26	-3.82	0.000
Left leg	73.74±6.27	104.73±11.33	- 3.82	0.000

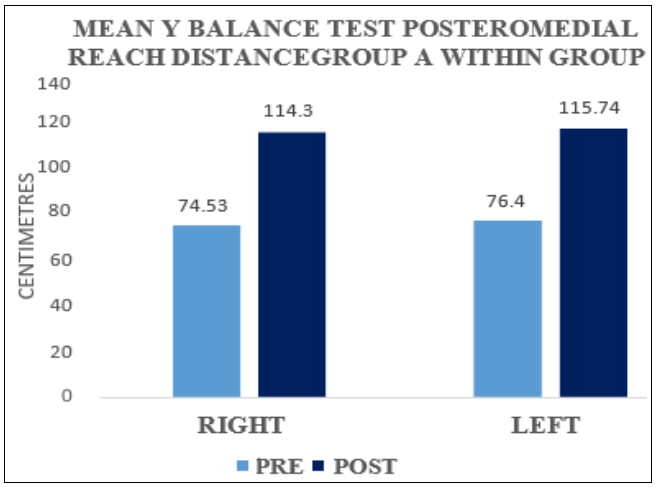


Graph 7: Pre and Post mean y balance anterior reach distance (CMS) in Group A

Within group analysis for pre and post y balance test Posteromedial reach distance (cms) in group A was done by using Wilcoxon-Sign Rank test. Analysis showed statistically significant difference between pre and post intervention Y Balance test Posteromedial reach distance (cms) in Group A. (p<0.05).

Table 7: Pre and Post mean Y balance test Posteromedial reach distance (cm) in group A

Group A	Pre Mean ± SD (cm)	Post Mean ± SD (cm)	Z Value	P Value
Posteromedial Reach				
Right leg	74.53±12.87	114.3±15.28	-3.82	0.000
Left leg	76.40±10.15	115.74±14.23	-3.82	0.000

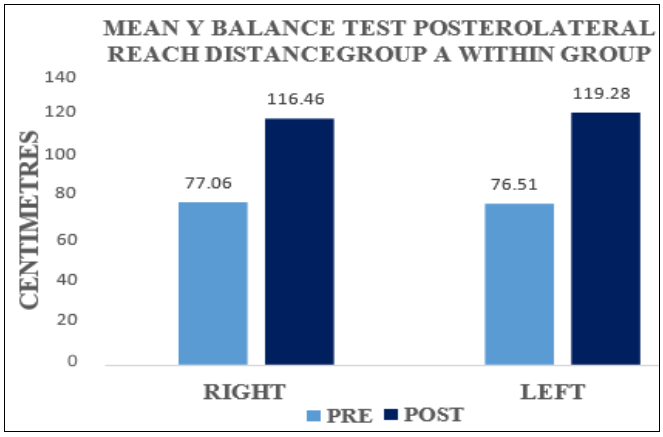


Graph 8: Pre and Post mean y balance posteromedial reach distance (CMS) in Group A

Within group analysis for pre and post Y Balance test Posterolateral reach distance (cms) in group A was done by using Wilcoxon-Sign Rank test. Analysis showed statistically significant difference between pre and post intervention Y Balance test Posterolateral reach distance (cms) in Group A. (p<0.05).

Table 8: Pre and Post mean y balance test poster lateral reach distance (cm) in Group A

Group A	Pre Mean ± SD (cm)	Post Mean SD (cm)	Z Value	P Value
Posterolateral Reach				
Right leg	77.06±10.44	116.46±13.37	-3.82	0.000
Left leg	76.51±11.09	119.28±15.40	-3.82	0.000

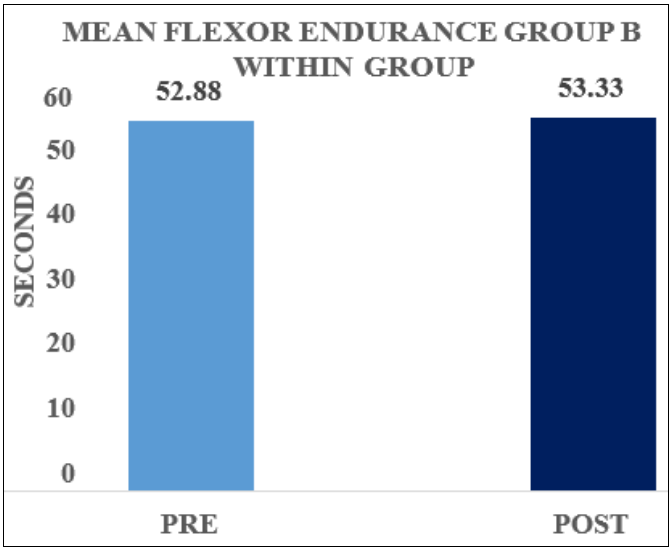


Graph 9: Pre and Post mean y balance Posterolateral reach distance (CMS) in Group A

Within group analysis for pre and post Flexor Endurance test (secs) in group B was done by using Wilcoxon-Sign Rank test. Analysis showed no statistically significant difference between pre and post intervention Flexor Endurance test in seconds in Group B (p>0.05).

Table 9: Pre and Post mean Flexor Endurance test (secs) in group B

Group B	Pre Mean ± SD (seconds)	Post Mean ± SD (seconds)	Z Value	P Value
Flexor Endurance test	52.88±8.39	53.33±8.70	-1.408	0.159

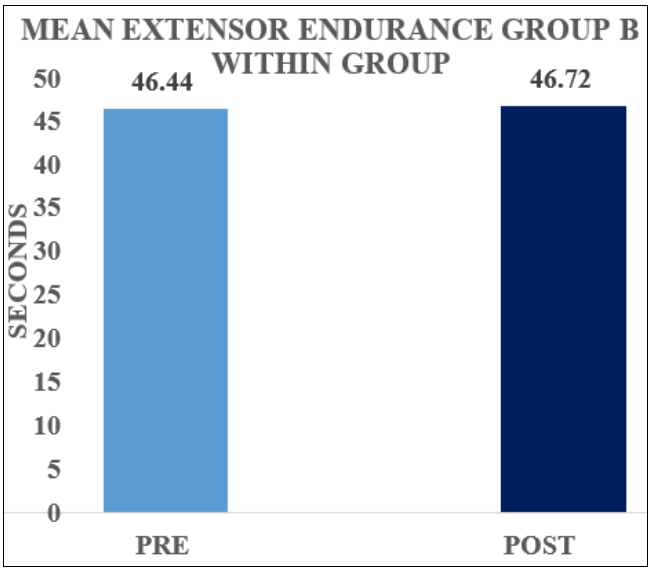


Graph 10: Pre and post mean flexor endurance test (SECS) in Group B

Within group analysis for pre and post Extensor Endurance test (secs) in group B was done by using Wilcoxon-Sign Rank test. Analysis showed no statistically significant difference between pre and post intervention Extensor Endurance test in seconds in Group B (p>0.05).

Table 10: Pre and post mean extensor endurance test (SECS) in Group B

Group B	Pre Mean ± SD (Seconds)	Post Mean ± SD (Seconds)	Z Value	P Value
Extensor Endurance test	46.44±6.13	46.72±6.02	-0.96	0.337

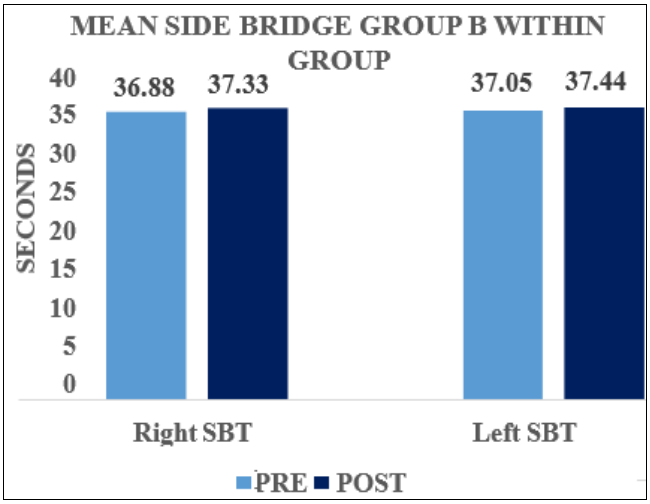


Graph 11: Pre and post mean extensor endurance test (SECS) in Group B

Within group analysis for pre and post Side Bridge test (secs) in group B was done by using Wilcoxon-Sign Rank test. Analysis showed no statistically significant difference between pre and post intervention Side Bridge test in seconds in Group B (p>0.05).

Table 11: Pre and post mean side bridge test (SBT) (SECS) in Group B

Group B	Pre Mean ±SD (Seconds)	Post Mean ±SD (Seconds)	Z Value	P Value
Right SBT	36.88±4.35	37.33±4.02	-1.63	0.102
Left SBT	37.05±3.79	37.44±4.13	-0.798	0.425

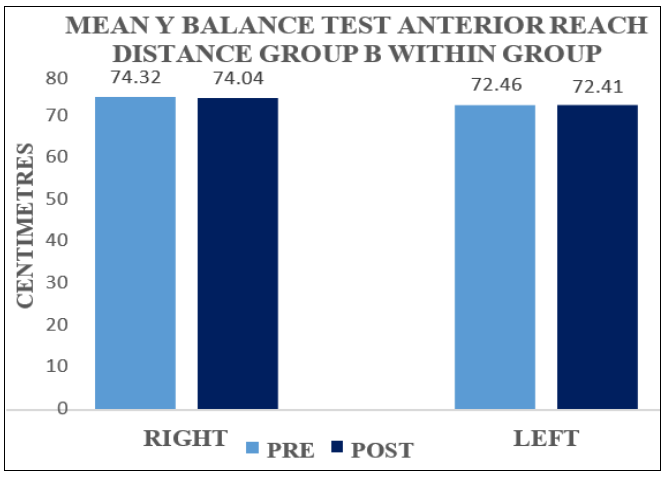


Graph 12: Pre and Post mean Side Bridge test (secs) in group B

Within group analysis for pre and post Y Balance test Anterior reach distance (cms) in group B was done by using Wilcoxon-Sign Rank test. Analysis showed no statistically significant difference between pre and post intervention Y Balance test Anterior reach distance in centimeters in Group B (p>0.05).

Table 12: Pre and Post mean y balance test Anterior reach distance (cm) in Group B

Group B	Pre Mean ± SD (cm)	Post Mean ± SD (cm)	Z Value	P Value
Anterior Reach				
Right leg	74.32±5.66	74.04±5.641	-0.22	0.826
Left leg	72.46±4.60	72.41±4.40	- 0.70	0.482

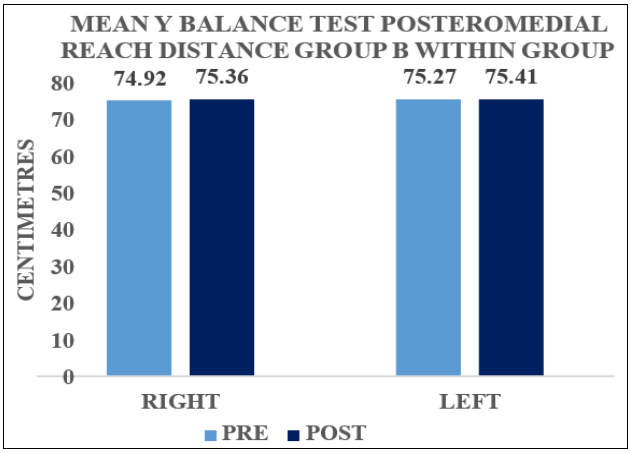


Graph 13: Pre and Post mean y balance anterior reach distance (CMS) in Group B

Within group analysis for pre and post Y Balance test Posteromedial reach distance (cms) in group B was done by using Wilcoxon-Sign Rank test. Analysis showed no statistically significant difference between pre and post intervention Y Balance test Posteromedial reach distance (cms) in Group B (p>0.05).

Table 13: Pre and Post mean y balance test posteromedial reach distance (cm) in Group B

Group B	Pre Mean ± SD (cm)	Post Mean ± SD (cm)	Z Value	P Value
Posteromedial Reach				
Right Leg	74.92±6.64	75.36±6.49	-1.68	0.09
Left Leg	75.27±5.88	75.41±5.75	-0.85	0.37

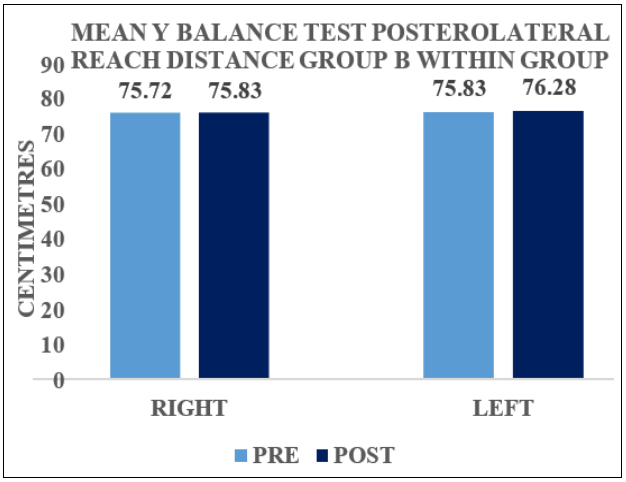


Graph 14: Pre and Post mean Y balance Posteromedial reach distance (cms) in group B

Within group analysis for pre and post Y Balance test Posterolateral reach distance (cms) in group B was done by using Wilcoxon-Sign Rank test. Analysis showed no statistically significant difference between pre and post intervention Y Balance test Posterolateral reach distance (cms) in Group B (p>0.05).

Table 14: Pre and Post mean Y balance test posterolateral reach distance (cm) in group B

Group B	Pre Mean ± SD (cm)	Post Mean ± SD (cm)	Z Value	P Value
Posterolateral Reach				
Right leg	75.72±6.13	75.83±6.07	-1.42	0.88
Left leg	76.03±5.81	76.28±5.09	-1.25	0.20

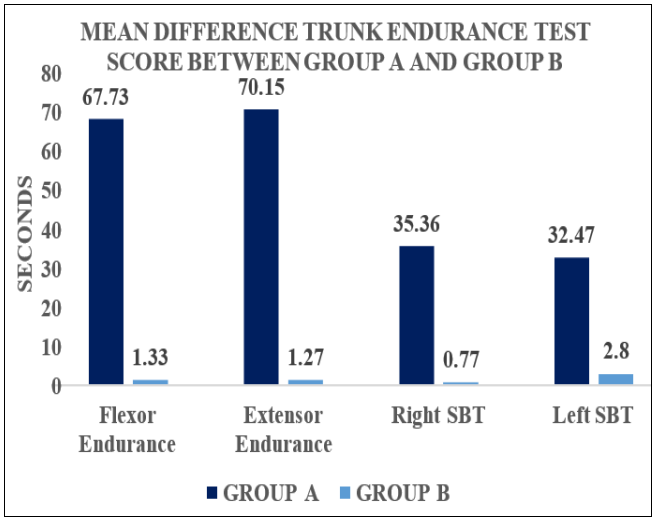


Graph 15: Pre and post mean y balance Posterolateral reach distance (CMS) in Group B

Between group analysis was done was done using Mann Whitney U test for the differences of Flexor, Extensor, Right and Left Side Bridge endurance score (seconds). Analysis showed statistically significant difference between Group A compared to group B.

Table 15: Comparison of mean difference in trunk endurance test score (Seconds) between Group A and Group B

Trunk Endurance test	Mean difference of Trunk Endurance test score (Seconds)		U Value	P Value
	Group A	Group B		
Flexor	67.73±15.64	1.33±0.76	0.000	0.000
Extensor	70.157±21.81	1.27±1.12	0.000	0.000
Rt. Side bridge	35.36±9.35	0.77±0.94	0.000	0.000
Lt. Side bridge	32.47±13.49	1.11±1.18	0.000	0.000



Graph 16: Comparison of mean differences in Trunk endurance test score (seconds) between group A and group B

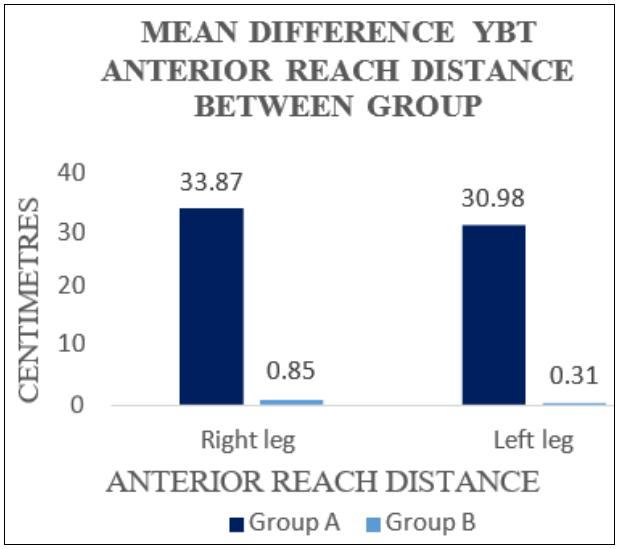
Between group analysis was done was done using Mann Whitney U test for the differences of Y Balance test for Anterior, Posteromedial and Posterolateral reach distances in centimeters. Analysis showed statistically significant difference between Group A compared to Group B.

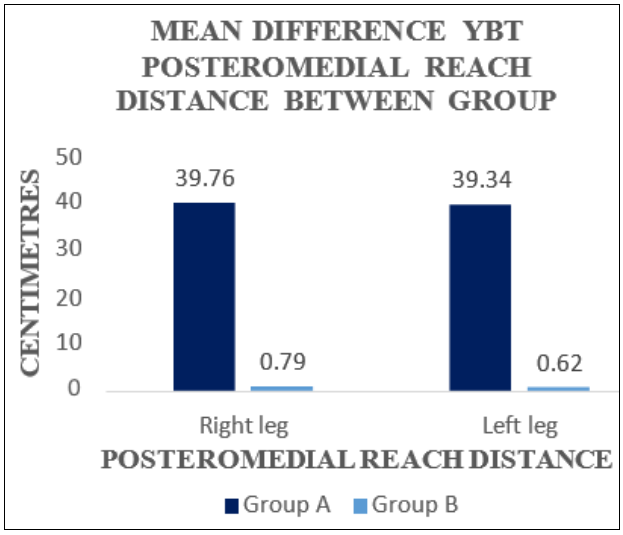
Table 16: Comparison of Mean difference in Y Balance test reach distance (cms) between group A and group B

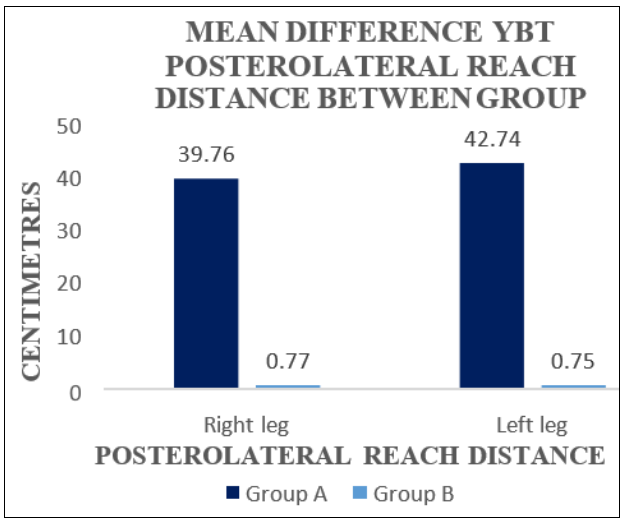
Y Balance Test	Mean difference of Y Balance Test reach distance (cms)		U Value	P Value
	Group A	Group B		
Anterior				
Right Leg	33.87±12.89	0.85±1.16	0.000	0.000
Left Leg	30.98±11.40	0.31±0.51		
Posteromedial				
Right leg	39.76±15.87	0.79±0.57	0.000	0.000
Left leg	39.34±14.70	0.62±0.35		
Posterolateral				
Right leg	39.76±13.43	0.77±0.78	0.000	0.000
Left leg	42.74±18.46	0.75±0.73		

Above results showed that the Trunk Endurance and Dynamic Balance in recreational cricket players is significantly improved in Swiss-ball core training group.

Thus, the null hypothesis is rejected and the alternate hypothesis "There is a significant effect of Swiss-ball core training on Trunk Endurance and Dynamic Balance" holds true.







Graph 17, 18 and 19: Comparison of Mean difference in Y Balance test reach distance (CMS) between Group A and Group B

Discussion

From the results of the present study, trunk endurance time for Flexor, Extensor, right and left side bridge test and Y balance test in three reach directions anterior, posteromedial and posterolateral showed statistically significant difference from the pre and post training after six weeks in swiss-ball core training group. Thus, the results of the present study suggest that Swiss-ball core training can improve trunk endurance and dynamic balance in recreational cricket players.

In the present study, subjects were required to do swiss-ball exercises against such unstable surface. It is evident that performing abdominal and back exercises on unstable surfaces stressed the musculature and activated the neuroadaptive mechanisms that led to the early phase gains in stability and proprioceptive activity proposed by Ludmila M. *et al.* (2003) [13]. Behm *et al.* (2010) [14] suggested that the primary purpose of instability training is to improve core stability rather than strength, to improve balance and improve proprioceptive capabilities. The neural adaptation includes more efficient neural recruitment patterns, increased nervous system activation, improved synchronization of motor units and a lowering of neural inhibitory reflexes.

Study done by Anoop Aggarwal *et al.* (2010) [8] showed similar results in improvements in trunk endurance, as measured by Abdominal fatigue test, Sorenson test, Side bridge test and front plank test after 6 weeks of core training. A statistically significant difference was found after 6 weeks of completion of training in all trunk endurance tests. They stated that performance on the core endurance isometric tests is directly related to the ability of deep lumbar stabilizer muscles to sustain submaximal isometric contraction for extended time period. This endurance in turn is related to the stable maintenance of spinal posture as well as prevention of low back pain.

Conclusion

From the present study it can be concluded that 6 weeks of swiss- ball core training exercises improve trunk endurance and dynamic balance in recreational cricket players.

Clinical Implication

The swiss-ball core training program used in this study may serve to be more beneficial than traditional core training exercises in improving trunk endurance and dynamic balance that may help in reducing the potential for low back injuries in recreational players as well as in improving dynamic movements in sport activities.

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