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IMPACT OF 4-WEEK CORE STABILITY EXERCISES VERSUS SWISS BALL EXERCISES ON POSTURAL BALANCE IN ADULTS WITH LUMBAR HYPERLORDOSIS: A COMPARATIVE STUDY

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ABSTRACT

***Background**: Lumbar hyperlordosis is characterized by excessive inward curvature of the lumbar spine (>40°) due to imbalance between tight lower back and hip flexors and weak abdominal and gluteal muscles, leading to anterior pelvic tilt, altered centre of gravity, and reduced postural balance. Core muscles, particularly the transversus abdominis and Lumbar Multifidus, act as a natural brace for spinal stability. Both core stability exercises on a stable surface and Swiss ball exercises on an unstable surface are reported to improve neuromuscular control, but their comparative effect on balance in hyperlordotic adults remains underexplored.*

***Objectives:** To compare the effect of 4-week core stability exercises versus Swiss ball exercises on postural balance in adults with lumbar hyperlordosis*

***Materials and Methodology:** Experimental comparative study conducted at Medical College, Latur over 6 months. 80 adults (mean age 22.95-23.13 years) with lumbar hyperlordosis >40°, age 18-30 years, BMI 18-24 kg/m², both genders, were recruited by convenient sampling and randomly allocated 1:1 into Group A - Core Stability Group (n=40) and Group B - Swiss Ball Group (n=40). The intervention was given 3 times/week for 4 weeks, 15-20 minutes per session. Outcome measures: Lumbar lordosis angle by the Flexicurve method, Dynamic Balance by Y-Balance Test (YBT), Static Balance by Single Leg Stance Test (SLST). Pre-post analysis was done using SPSS v25. Wilcoxon Signed-Rank Test for within-group and Mann-Whitney U Test for between-group comparison. p<0.05 was considered significant.*

***Result:** The outcome was a significant improvement (p<0.001) for both groups. Flexicurve dropped from 44.35±2.13 to 40.48±2.50, YBT rose from 77.88±0.94 to 80.73±1.18, and SLST rose from 18.05±1.48 to 20.45±1.22 in the Core Stability Group. Flexicurve dropped from 46.55±2.01 to 40.05±1.83, YBT rose from 77.90±1.88 to 85.58±1.91, and SLST rose from 18.13±1.54 to 22.50±1.83 in the Swiss Ball Group. Flexicurve (6.50±2.38 vs. 3.88±2.38, U=315.00, p<0.001), YBT (7.68±2.21 vs. 2.85±0.86, U=24.50, p<0.001), and SLST (4.38±1.71 vs. 2.40±1.37, U=292.50, p<0.001).*

***Conclusion:** Both interventions demonstrated statistically significant pre- to post-intervention changes in Flexicurve, Y Dynamic Balance, and Single Leg Stance. However, the between-group analysis showed that the Swiss Ball Group demonstrated significantly greater changes than the Core Stability Group across all three outcome measures. The greatest difference between the groups was observed for the Y Dynamic Balance Test.*

***Keywords:** Lumbar Hyperlordosis, Core Stability, Swiss Ball, Postural Balance, Y-balance test, Flexicurve, Single-leg stance*

1. INTRODUCTION

The spine is a vital component of the human musculoskeletal system, with distinctive curvatures that maintain balance and absorb shock. This alignment can be influenced by heredity, environmental conditions, and lifestyle factors, and may change over time due to inactivity and poor postural habits [1]. Lordosis refers to an excessive inward curvature of the spine, frequently observed in the lumbar region. Lumbar hyperlordosis usually occurs because muscles in the lower back and hips become too tight, while the abdominal and gluteal muscles become weak. Lordosis refers to an excessive inward curvature of the spine, frequently observed in the lumbar region. Lumbar hyperlordosis usually occurs because muscles in the lower back and hips become too tight, while the abdominal and gluteal muscles become weak. Lordosis refers to an excessive inward curvature of the spine, frequently observed in the lumbar region. Lumbar hyperlordosis usually occurs because some muscles in the lower back and hips become too tight, while abdominal and gluteal muscles become weak. This imbalance in the core musculature alters pelvic and spinal mechanics [2]. According to the kinesiopathology model, when one component of the movement system fails, it gradually leads to compensatory dysfunction in other regions. Recent studies have reported a high incidence of postural deviations in university students, with 65.7% exhibiting lumbar hyperlordosis [3]. In hyperlordosis, the lower back erector spinae and hip flexors (iliopsoas

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and rectus femoris) become overactive and shortened, while the abdominal muscles and gluteus maximus weaken. This results in anterior pelvic tilt, exaggerated lumbar curve, reduced core stability and impaired balance [4]. Spinal deformity can impair postural control, disrupt muscle function, and reduce movement efficiency and overall physical performance [5]. Balance control plays a vital role in performing everyday activities, both in static positions and dynamic movements [6]. Effective postural control depends on integration of visual, vestibular and somatosensory inputs and motor responses, allowing individuals to maintain stability and adapt to environmental changes [7]. Weakness in core stabilizer muscles following hyperlordosis and its association with pelvic changes can be a potential factor in reducing both static and dynamic balance [8,9]. Core stabilization exercises focus on training deep core muscles that support the spine. The two most important muscles are Transversus Abdominis (TrA), which wraps around the abdomen like a natural corset, and Lumbar Multifidus (LM), which stabilizes vertebrae. When these muscles co-contract, they increase intra-abdominal pressure and create a natural brace, enhancing segmental stability, protecting the spine and improving posture and balance [10,11]. Swiss ball-based core training has been widely emphasized as an effective method to facilitate spinal stability and enhance balance. The unstable surface increases proprioceptive demand, engages both deep and superficial trunk stabilizers, and improves strength, endurance, flexibility and neuromuscular control [12-16]. Despite evidence for each approach, comparative evaluation of stable versus unstable surface core training on balance in hyperlordotic adults remains limited. Therefore, the present study aims to compare the impact of 4-week core stability exercises versus Swiss ball exercises on postural balance in adults with lumbar hyperlordosis.

1.1 Need for the Study: Lumbar hyperlordosis is highly prevalent among young adults due to a sedentary lifestyle, prolonged sitting, and lack of physical activity. It is associated with low back pain, altered biomechanics and reduced balance, increasing the risk of falls and musculoskeletal dysfunction. While both core stability and Swiss ball exercises are commonly used in physiotherapy, there is lack of consensus on superior modality. A comparative study is needed to guide evidence-based prescription and optimize rehabilitation protocols for postural correction and balance improvement.

2. METHODOLOGY

This experimental comparative study was conducted on **adults with lumbar hyperlordosis**. The study was carried out at the **Department of Physiotherapy, Medical College, Latur** over a period of **6 months**. Participants were recruited by **convenience sampling** and were **randomly allocated in a 1:1 ratio** into two groups. The total **duration of the intervention was 4 weeks**, with sessions conducted **3 times per week for 15-20 minutes** per session. The **sample size was 80 participants** (40 in each group), calculated to be 72 as per previous literature but increased to 80 to account for potential attrition. In the present study, the **independent variables** were **core stability exercises and Swiss ball exercises**, while the **dependent variables** were **static and dynamic postural balance**.

2.1 Study Criteria

Inclusion criteria were adults aged **18 to 30 years**, **both male and female**, with a **Body Mass Index (BMI) between 18 to 24 kg/m²**, and a **lumbar hyperlordosis angle greater than 40°** as assessed by the flexicurve method.

Exclusion criteria were history of **lower extremity injury in the past 6 months**, **lower limb surgery in the past 1 year**, presence of any **neurological condition**, congenital spinal deformity or systemic musculoskeletal pathology, and **non-adherence to the protocol** including missed training sessions or incomplete pre- and post-assessment data.

2.2 Aim and Objectives

Aim: To compare the effect of 4-week core stability exercises versus Swiss ball exercises on postural balance in adults with lumbar hyperlordosis.

Objectives: The objectives of the study were (1) to evaluate the effect of 4 weeks of core stability exercises on postural balance in hyperlordotic adults, (2) to evaluate the effect of 4 weeks of Swiss ball exercises on postural balance in hyperlordotic adults, and (3) to compare the effectiveness of core stability versus Swiss ball exercises on postural balance in hyperlordotic adults.

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2.3 Procedure

Approval for the research work was obtained from the Institutional Ethics Committee. The purpose of the study was explained to each participant, and written informed consent was obtained in a language they understood. Participants were screened and recruited for the study on the basis of inclusion and exclusion criteria. After enrollment of hyperlordotic adults, outcome measures were taken for lumbar lordosis through the flexi curve; for dynamic balance with help of Y balance test was used; for static balance-single leg stance test. The total duration of the treatment protocol session was 15 to 20 minutes. Interventions were given three times per week for a total duration of four weeks.

GROUP A – Core Stability

Week 1-2

1. minal contraction in supine position
2. Abdominal drawing in a prone position
3. Abdominal drawing in a squat position
4. Each exercise is done 3 times with 20 repetitions

Week 3

1. Abdominal contraction in a supine position with flexion / shortening the feet (3 times, 20 repetitions each)
2. Abdominal drawing in prone position with flexion/ shortening the feet (3 times, 20 repetitions each)
3. Side bridge for each side (6 times with 10 sec of rest)

Week 4

1. Abdominal contraction in a supine position with limb elevation and closing hands and feet
2. Quadruped position from lifting one foot from behind
3. Trunk rotation with overload/weight (for each side 3 times, each with 20 repetitions)

GROUP B – Swiss Ball Exercises

1. Sitting on Swiss Ball with Both Arms Raised in The Sagittal Plane. Procedure: A participant was instructed to sit on a ball and lift either one or both arms
2. Sitting on Swiss Ball With 90 Degree Hip and Knee Flexed. Procedure: Asked to position themselves on a ball with their feet (heels & soles) on the ground, bend their hips and knees at a 90-degree angle, and hold their position for 20 seconds
3. Anterior / Posterior and Lateral (Right &Left Side) Pelvic Tilt Procedure STEP 1: Place your feet hip-width apart on the floor while seated on a Swiss ball. The feet should be immediately beneath the knees at a 90-degree angle. STEP 2: To begin the exercise, inhale while rolling your tailbone forward, halt, and then roll back as you exhale. For 45 to 60 seconds, repeat this activity
4. Bird Dog Exercise Using Swiss Ball Procedure: STEP 1: Place a Swiss ball under the abdomen as face down on it. STEP 2: The exercise is to inhale deeply before lifting the subject's left arm and right leg. STEP 3: Take a breath, then let it out as the person lowers them again. Move your arms and legs in succession
5. Plank on Swiss Ball Procedure: STEP 1: Put your hands on the ground in front of you with the arms straight and at shoulder-width distance. STEP 2: Place the legs on the ball by raising them . The shin should be in the center of the ball. STEP 3: Maintain the plank position for 30seconds at a time, and as you get more comfortable, extend your holds by another 30 seconds

Outcome Measures

1. Flexicurve
2. Y Dynamic Balance Test
3. Single Leg Stance Test

2.4 Statistical Analysis

Data were entered in Microsoft Excel. After data cleaning, data were imported to Statistical Package for the Social Sciences version 25 and analyzed using the same. Data were analysed for descriptive and inferential statistics. The Wilcoxon Signed-Rank Test was used to compare pre- and post-treatment values within each

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group. The Mann–Whitney U Test was used to compare the magnitude of change between the two independent groups. A p-value of <0.05 was considered statistically significant. Data were presented in tabular and graphical formats. Graphs were plotted in Excel. The study included a total of 80 participants, with 40 participants in each group. The mean age of participants in the Core Stability Group was 23.13 ± 2.16 years, while the mean age in the Swiss Ball Group was 22.95 ± 1.91 years.

3. RESULT

Table 1: Frequency and Percentage distribution of students according to their Age

Group	N	Mean age (years)	SD
Core Stability Group	40	23.13	2.16
Swiss Ball Group	40	22.95	1.91

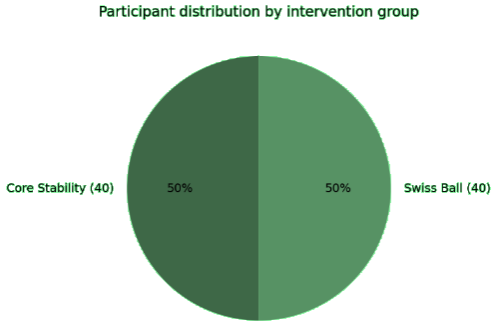
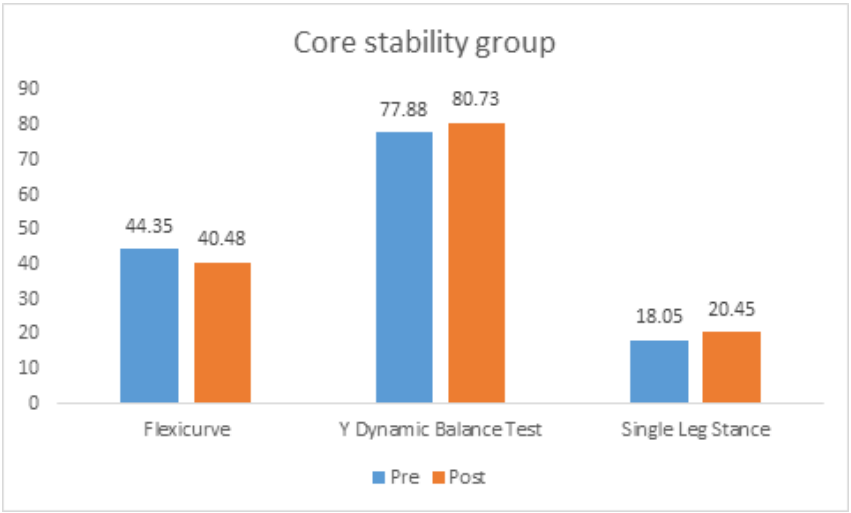


Chart 1: Frequency and Percentage distribution of students according to their Age

Table 2: Comparison within group A mean and standard deviation of flexicurve , y dynamic balance test , single leg stance test before and after intervention

Outcome Measure	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Z	p-value
Flexicurve	44.35 ± 2.13	40.48 ± 2.50	−5.554	<0.001
Y Dynamic Balance Test	77.88 ± 0.94	80.73 ± 1.18	−5.601	<0.001
Single Leg Stance	18.05 ± 1.48	20.45 ± 1.22	−5.557	<0.001

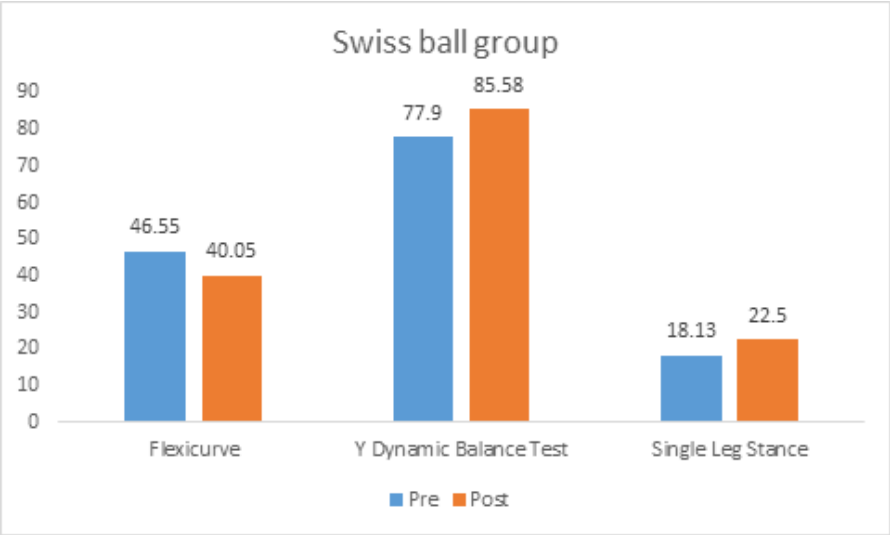


Graph 1: Comparison within group A mean and standard deviation of flexicurve , y dynamic balance test , single leg stance test before and after intervention

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Table 3: Comparison within group B mean and standard deviation of flexicurve , y dynamic balance test , single leg stance test before and after intervention

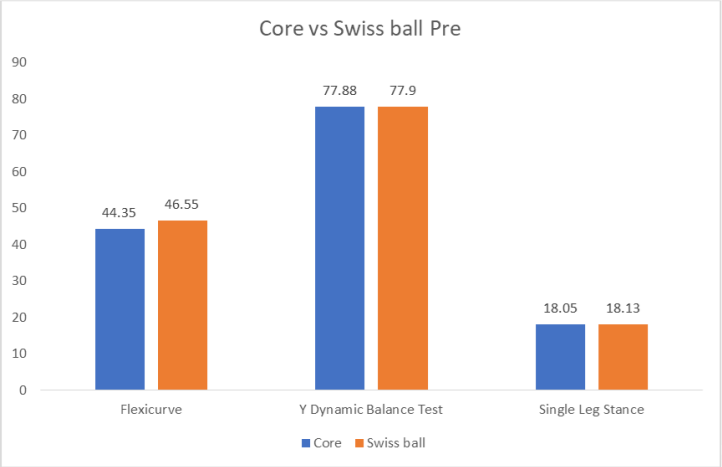
Outcome Measure	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Z	p-value
Flexicurve	46.55 ± 2.01	40.05 ± 1.83	−5.585	<0.001
Y Dynamic Balance Test	77.90 ± 1.88	85.58 ± 1.91	−5.523	<0.001
Single Leg Stance	18.13 ± 1.54	22.50 ± 1.83	−5.545	<0.001



Graph 2: Comparison within group B mean and standard deviation of flexicurve, y dynamic balance test , single leg stance test before and after intervention

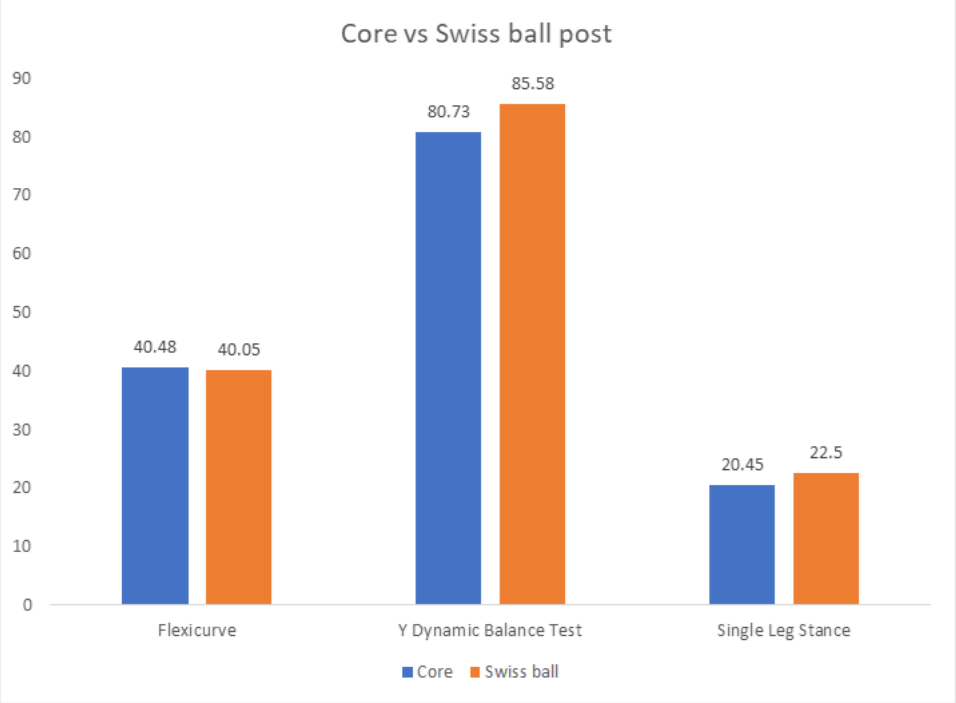
Table 4: Comparison within group B mean and standard deviation of flexicurve, y dynamic balance test , single leg stance test before and after intervention

Outcome Measure	Core Stability Group (n=40) Mean difference± SD	Swiss Ball Group (n=40) Mean difference ± SD	Mann–Whitney U	Z	p-value
Flexicurve	3.88 ± 2.38	6.50 ± 2.38	315.000	−4.733	<0.001
Y Dynamic Balance Test	2.85 ± 0.86	7.68 ± 2.21	24.500	−7.544	<0.001
Single Leg Stance	2.40 ± 1.37	4.38 ± 1.71	292.500	−4.965	<0.001

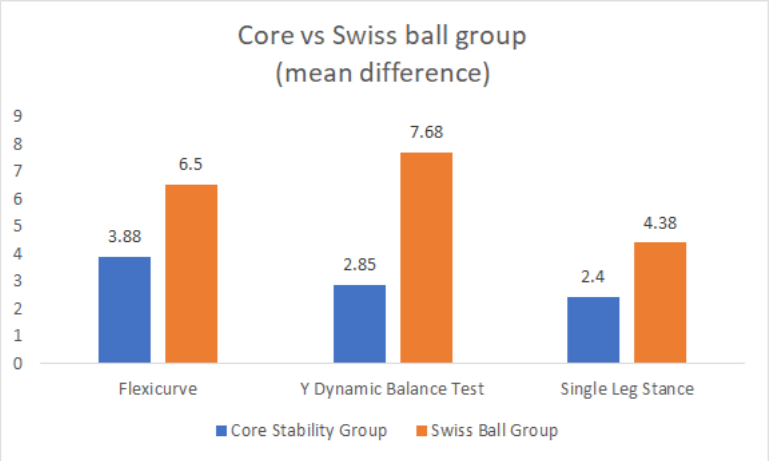


Graph 3: Comparison within group B mean and standard deviation of flexicurve, y dynamic balance test, single leg stance test before and after intervention

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Graph 4: Comparison Between Group A and Group B mean and standard deviation of flexicurve , y dynamic balance test , single leg stance test After intervention



Graph 5: Comparison between Group A and Group B mean and standard deviation of flexicurve, y dynamic balance test, single leg stance test before and after intervention

Within-group analysis using Wilcoxon Signed-Rank Test showed statistically significant improvement in all three outcomes in both groups ($p<0.001$).

In Group A, lumbar lordosis angle reduced by mean 3.88°, indicating postural correction. Dynamic balance improved by 2.85% and static balance by 2.40 sec.

In Group B, lordosis reduced by 6.50°, dynamic balance improved by 7.68% and static balance by 4.38 sec, indicating larger effect.

Between-group analysis using Mann-Whitney U Test revealed significantly greater mean difference in Swiss Ball Group compared to Core Stability Group for flexicurve ($p<0.001$), YBT ($p<0.001$) and SLST ($p<0.001$). Greatest between-group difference was observed for Y-Balance Test ($U=24.50$, $Z=-7.544$), suggesting Swiss ball training is more effective for dynamic balance enhancement.

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4. DISCUSSION

The study investigated the comparative efficacy of 4-week core stability versus Swiss ball exercises on postural balance in adults with lumbar hyperlordosis. Findings demonstrated that both interventions significantly reduced lumbar lordosis angle and improved static and dynamic balance. However, Swiss ball group showed superior improvement across all outcomes.

The reduction in lumbar lordosis can be explained by improved length-tension relationship. Core stability training facilitates activation of TrA and multifidus, increasing lumbopelvic stability and correcting anterior pelvic tilt [10,11]. Abdominal drawing-in and bridging exercises strengthen weak abdominals and glutes while stretching tight hip flexors, thereby restoring optimal alignment.

Superior efficacy of Swiss ball exercises is consistent with Cosio-Lima et al. [13] and Lehman et al. [14], who reported greater core muscle activation on unstable surface. Unstable surface provides continuous proprioceptive challenge, demanding greater neuromuscular control, co-contraction of deep and superficial stabilizers, and improved feed-forward postural adjustments. This explains greater improvement in Y-Balance Test, which requires dynamic neuromuscular control beyond static holding.

Improvement in Single Leg Stance Test indicates enhanced static balance due to better centre of gravity control and lumbopelvic stability [6,8]. Swiss ball training enhances vestibular and somatosensory integration due to instability, leading to better static balance retention.

Biomechanically, correction of hyperlordosis brings centre of gravity within base of support, reducing mechanical strain on lumbar facet joints and paraspinal muscles, thus improving balance efficiency [4,5]. Clinically, improved balance reduces risk of falls, improves functional performance and reduces low back pain predisposition.

Our findings align with recent studies supporting early physiotherapy intervention for postural correction. Exercise therapy, posture training and ergonomic correction play essential role in maintaining optimal alignment [5,10].

Limitations: Short duration (4 weeks), no long-term follow-up, convenience sampling, age limited to young adults (18-30), and lack of EMG analysis for muscle activation. Future studies should include longer follow-up, broader age range, and electromyographic evaluation.

5. CONCLUSION

Both interventions demonstrated statistically significant pre- to post-intervention changes in Flexicurve, Y Dynamic Balance, and Single Leg Stance. However, the between-group analysis showed that the Swiss Ball Group demonstrated significantly greater changes than the Core Stability Group across all three outcome measures. The greatest difference between the groups was observed for the Y Dynamic Balance Test.

Ethical Declaration

Ethical approval was obtained from institutional ethics committee of Maharashtra institute of physiotherapy, Latur. all participant were informed about objectives and procedures, and written informed consent was obtained. Participation was voluntary, and confidentiality and anonymity were maintained.

Conflict of Interest

The authors declare that there is no conflict of interest regarding publication of the manuscript

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Author Declaration

The authors declare that this manuscript is original, has not been published previously and is not under consideration for publication elsewhere.

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