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Comparative effects of single-plane and multiplanar neuromuscular training on balance and stability among gym going women

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Abstract
Dynamic balance and stability are essential components of efficient movement and physical performance; particularly in active groups like gym-going women. Dynamic neuromuscular training is widely used to improve balance, postural control, and functional performance by enhancing neuromuscular coordination. While both single-plane and multiplanar training methods are incorporated into rehabilitation and fitness programmes, evidence comparing their effectiveness in healthy gym-going women remains limited. This study seeks to examine the effects of dynamic neuromuscular training conducted in a single plane compared to multiplanar exercises on balance and stability in gym-going women, offering valuable insights for optimizing training strategies to improve lower limb function. This study was conducted among 20 healthy female gym-goers aged 18–25 years who met the study eligibility criteria. Participants were randomly allocated into two groups of ten each. Group A underwent single-plane dynamic neuromuscular training, whereas Group B received multiplanar dynamic neuromuscular training. Both groups participated in supervised training sessions three times per week for six weeks. Dynamic balance was assessed using the Y-Balance Test, and functional stability was evaluated using the Vertical Jump Test before and after the intervention. Data were analysed using paired and unpaired *t*-tests, with the level of statistical significance set at $p < 0.05$. Both groups demonstrated significant improvements in dynamic balance and functional stability following the intervention. The mean Y-Balance Test score increased from 77.35 to 81.71 in the single-plane group and from 78.87 to 85.31 in the multiplanar group. Similarly, the mean Vertical Jump Test score improved from 42.2 cm to 45.0 cm in the single-plane group and from 42.3 cm to 50.4 cm in the multiplanar group. Between-group analysis showed significantly greater improvements in the multiplanar training group for both the Y-Balance Test and the Vertical Jump Test. This study concludes that both training programmes were effective in improving balance and stability among gym-going women. However, multiplanar dynamic neuromuscular training produced greater improvements than single-plane training, suggesting that incorporating movement across multiple planes may provide superior neuromuscular adaptations and functional performance.

Keywords: Dynamic neuromuscular training, single-plane training, multiplanar training, dynamic balance, functional stability, Y-Balance Test, Vertical Jump Test, gym-going women

Introduction
Dynamic neuromuscular training is an exercise approach that integrates strength, balance, proprioception, agility, plyometric, and coordination exercises to enhance sensorimotor control and movement efficiency. They enable individuals to maintain postural control during functional activities and contribute to safe, coordinated movement in both daily life and sports. Adequate neuromuscular control is fundamental to these abilities, as it allows the body to respond effectively to changing movement demands while maintaining joint stability and movement accuracy. [1, 2, 3]
Traditional exercise programmes predominantly emphasise movements performed in the sagittal plane. Although these exercises are effective for developing strength and movement control, many functional and sporting activities require coordinated movement across the sagittal, frontal, and transverse planes.[4, 5, 6]
Multiplanar training challenges the neuromuscular system under conditions that more closely resemble real-life activities, potentially leading to greater improvements in balance, coordination, and functional stability. [7] Regular participation in gym-based exercise has increased considerably among young women, with many programmes incorporating resistance and functional training. Injuries associated with gym-based exercise most commonly affect the shoulder and lower extremities, with muscle and tendon strains being the predominant type of injury reported. These injuries are often linked to inadequate neuromuscular control, poor movement mechanics, or an inability to respond effectively to unexpected changes during physical activity. Training under unpredictable conditions, such as exposure to external perturbations, challenges the neuromuscular system to react quickly and maintain joint stability.
Neuromuscular training (NMT) is a structured exercise approach that enhances sensorimotor function by improving the coordination between the nervous and musculoskeletal systems. [8] It facilitates automatic motor responses through the integration of sensory input and central neural processing, thereby contributing to dynamic joint stability and efficient movement control [9]. A comprehensive neuromuscular training programme incorporates resistance exercises, balance training, core stabilization, agility drills, plyometric activities, and functional movement patterns.

These components work together to improve muscular strength, coordination, proprioception, and overall physical performance. In addition to enhancing athletic performance, neuromuscular training has been shown to improve movement efficiency and functional fitness across a wide range of physically active individuals. In recent years, neuromuscular training has become an integral part of both sports conditioning and rehabilitation programmes. It is widely used to reduce the risk of musculoskeletal injuries, restore lower-limb strength and balance following injury, and facilitate a safe return to physical activity [10],[11],[12][13].

Neuromuscular training is designed to enhance neuromuscular control by improving the coordinated interaction between the nervous system and the musculoskeletal system, thereby promoting functional joint stability [14, 15, 16]. Incorporating balance-based exercises into neuromuscular training programmes enhances coordinated muscle activation around the joints, resulting in improved joint stiffness, postural control, and dynamic stability. These adaptations may also help modify biomechanical factors associated with injury risk, including excessive knee valgus during landing and other high-impact movements [17]. An important objective of neuromuscular training is to improve an individual's ability to maintain control of the body's centre of mass during dynamic activities) [18]. Better control of the centre of mass contributes to efficient movement, improved balance, and enhanced performance during functional and sports-specific tasks [19]. The beneficial effects of neuromuscular training are attributed to adaptations within both the central and peripheral nervous systems. Repeated practice of functional movement patterns enhances communication between sensory receptors, neural pathways, and muscles, enabling faster and more coordinated muscular responses to changing movement demands. These neuromuscular adaptations improve movement efficiency, increase functional joint stability, and may contribute to reducing the risk of sports- and exercise-related injuries. Neuromuscular training has become an important component of both rehabilitation and athletic conditioning because of its ability to improve neuromuscular coordination and movement quality. By enhancing the synchronization and timing of muscle activation, it promotes efficient movement patterns, improves dynamic joint stability, and facilitates precise motor control during complex functional activities [20].

Single-plane training is based on exercises performed mainly within one anatomical plane, most often the sagittal plane. Common examples include squats, forward lunges, step-ups, and jumping activities. These exercises are frequently used in fitness and rehabilitation programmes to develop lower-limb strength, improve movement control, and reinforce basic neuromuscular coordination. Training that emphasises sagittal-plane movement may also influence hip and knee mechanics, muscle recruitment, and landing control during functional activities [21, 22, 23].

In contrast, multiplanar training incorporates movements across the sagittal, frontal, and transverse planes, closely reflecting the multidirectional demands of everyday activities and sports. By combining changes in direction with balance, coordination, and proprioceptive challenges, multiplanar exercises require greater neuromuscular control and postural stability [26]. Previous studies have reported that this approach improves dynamic balance, movement quality, lower-limb alignment, and functional stability while reducing biomechanical factors associated with musculoskeletal injuries. Compared with conventional single-plane or traditional resistance training, multiplanar training has demonstrated superior improvements in dynamic balance, landing mechanics, and overall functional performance [27, 28].

Although neuromuscular training has been widely recognised for improving joint stability, balance, and movement control, limited evidence is available comparing the effectiveness of single-plane and multiplanar dynamic neuromuscular training in healthy gym-going women. Therefore, this study compares the effects of a six-week single-plane and multiplanar dynamic neuromuscular training programme on balance and stability among gym-going women.

Methodology

Aim: This Exploratory study aims to find out and Compare the Effect of Single-planar and Multi-planar Neuromuscular Training in improving Balance and Function by using Y Balance and Vertical Jump Tests.

Selection of the subjects: A total of 20 active gym going women ranging from 18-25 years were selected based on selection criteria using convenience sampling method**.**

Procedure: A total of 20 active gym going women of KG institutions were selected based on the predetermined inclusion and exclusion criteria. Each participant was explained about treatment safety and simplicity of the procedure, and all the participants signed the written consent form. A standardized history consisting of demographic information including age, Body Mass Index and regularity of gym attendance. Body mass index was calculated with a person's body weight (in kilograms) divided by the square of their height (in meters). Y-Balance Test was used to assess the dynamic balance. Anterior, Posteromedial and Posterolateral reach will be measured and the Vertical jump test was done to assess the stability of the individuals. The overall data was collected and taken for analysis. The training sessions were held for 6 Months (3 sessions per week), each 45 minutes per session. Group A received the single planar dynamic neuromuscular training and Group B received Multi planar dynamic neuromuscular training.

Group A: Single Planar Dynamic Neuromuscular Training

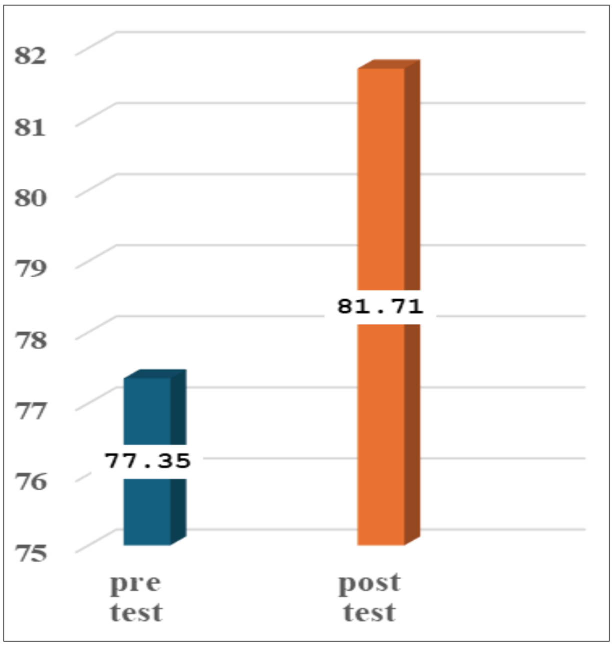
Weeks	Exercise	Sets x Reps
Week 1-2	Bodyweight squats	2 × 10
	Static single-leg stance	2 × 30
	Forward lunges	2 × 10
	Double-leg forward hops	2 × 8
	Step-ups	2 × 10
Week 3-4	Single leg squats with pause	2-3 × 10
	Forward lunges	2-3 × 10
	Step-ups with knee drive	2-3 × 10
	Single-leg Romanian dead lift	2 -3× 8
	Unilateral forward hop	2-3 × 10
Week 5-6	Squat to calf raise	3 × 12
	Walking lunges	3 × 12
	Single leg step-ups	3 × 10
	Single-leg RDL	3 × 10
	Repeated unilateral forward hops	3 × 8

Group B: Multi - Planar Dynamic Neuromuscular Training

Weeks	Exercise	Sets x Reps
Week 1-2	Static balance with trunk rotation	2 × 30
	Side-to-side hops (bilateral)	2 × 8
	Single-leg reach (anterior & lateral)	2 × 8
	Diagonal step-downs	2 × 10
	Lateral lunge	2 × 10

Weeks	Exercise	Sets x Reps
Week 3-4	Lateral hops	2-3 × 8
	Single-leg reach with rotation	2-3 × 8
	Diagonal step-down	2-3 × 10
	Mini band walking	2-3 × 8
	Curtsy lunges	2-3 × 10
Week 5-6	Curtsy lunges with reach	3 × 12
	Multiplanar step-downs	3 × 10
	Single-leg reach with rotation	3 × 10

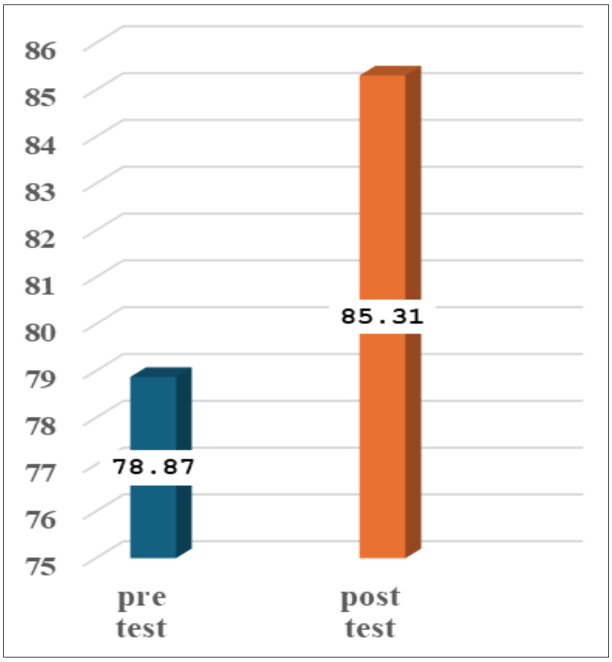
Pre and Post Mean Value – Y Balance Test – Group A



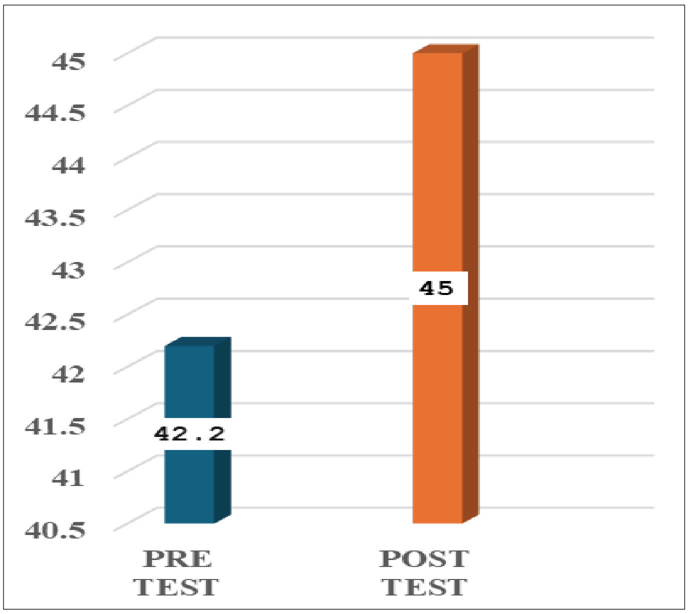
S. No	Group-a	Mean	Mean Difference	Standard deviation	't' Value
1.	Pre-test	77.35	4.36	2.92	4.72
2.	Post-test	81.71			

Pre and Post Mean Value – Y Balance Test – Group B

S. No	Group-b	Mean	Mean Difference	Standard Deviation	't' Value
1.	Pre-test	78.87	6.05	2.10	9.11
2.	Post-test	85.31			



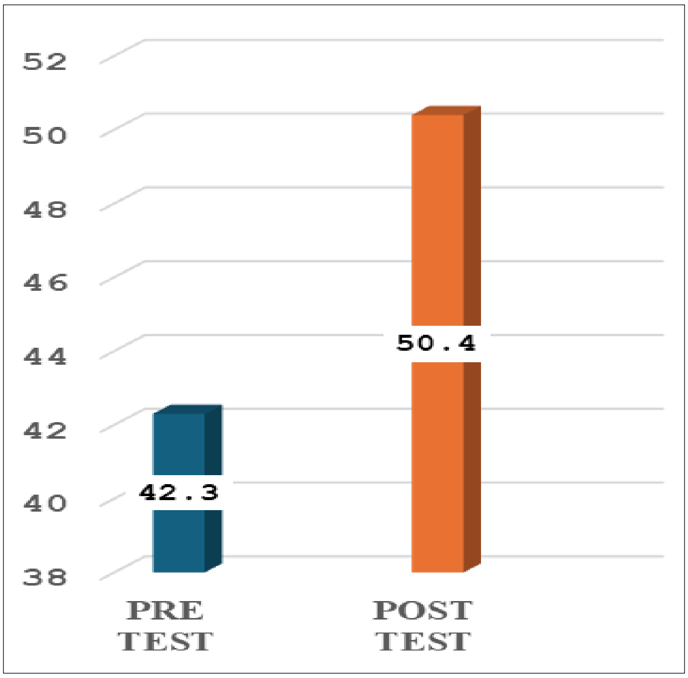
Pre and Post Mean Value – Vertical Jump Test – Group A



S. No	Group-A	Mean	Meanb Difference	Standard deviation	't' Value
1.	Pre-test	42.2	2.8	1.55	5.71
2.	Post-test	45.0			

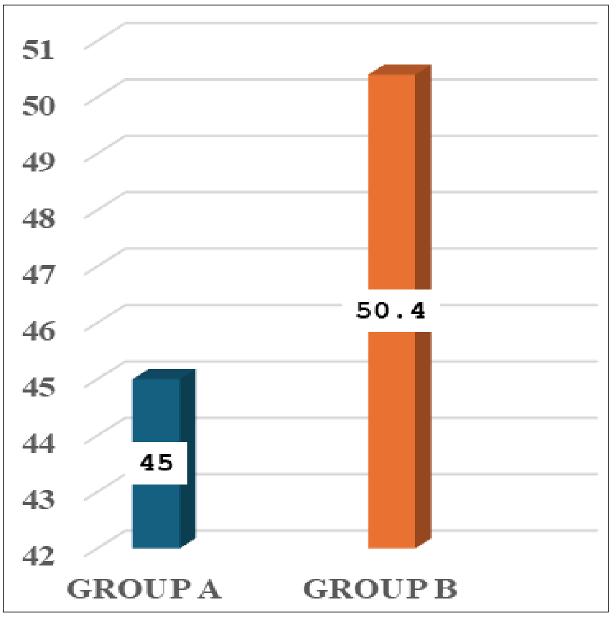
Pre and Post Mean Value – Vertical Jump Test – Group B

S. No	Group-B	Mean	Mean Difference	Standard Deviation	't' Value
1.	Pre-test	42.3	8.1	3.05	8.4



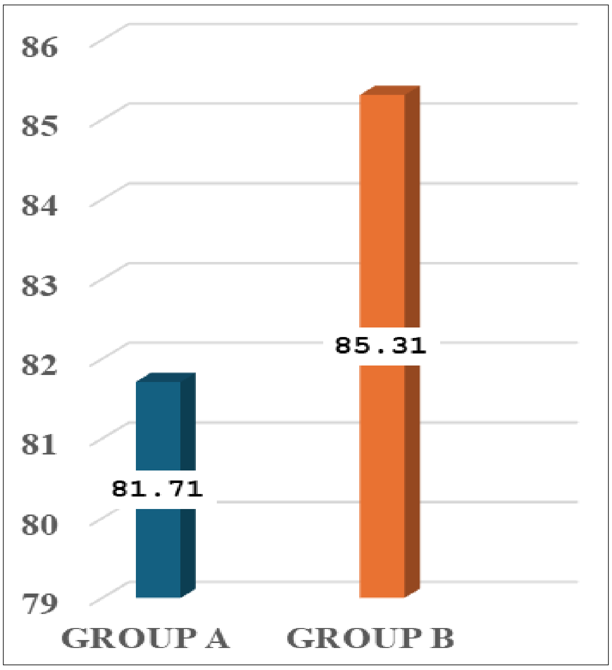
Post – Test Values – Group A Vs Group B
Vertical Jump Test

S. No	Post-test	Mean	Mean difference	Standard deviation	't' Value
1	Group a	45.0	5.4	1.23	4.39
2	Group B	50.4			



Post – Test Values – Group A Vs Group B
Y- Balance Test

S. No	Post-test	Mean	Mean difference	Standard deviation	't' Value
1	Group A	81.71	3.60	1.51	2.38
2	Group B	85.31			



Result

In this study the results were analyzed by using SPSS. Student 't' test was used to compare the difference in test value of the groups. Paired 't' test was used to calculate the mean.

Paired 't' test was used to compare the pre – test and post – test values of Y-Balance test in Group – A was 77.35 and 81.71 and Group – B was 78.87 and 85.31. Data analysis showed that 't' value of Group – A is 4.72 and Group – B is 9.11. This showed that there was a significant improvement in both groups.

Unpaired 't' test was used to calculate the post – test values of Y-Balance test between Group – A and Group – B was 81.71 and 85.31. Data analysis showed that 't' value of post – test values were 8.4. This showed that there was a significant improvement in Group B.

Paired 't' test was used to compare the pre – test and post – test values of Vertical jump test in Group – A was 42.2 and 45.0 and Group – B was 42.3 and 50.4. Data analysis showed that 't' value of Group – A is 5.71 and Group – B is 8.4. This showed that there was a significant improvement in both groups.

Unpaired 't' test was used to calculate the post – test values of Vertical jump test between Group – A and Group – B was 45 and 50.4. Data analysis showed that 't' value of post – test values were 4.39. This showed that there was a significant improvement in Group B.

Paired 't' test concluded that there was a significant increase of pre and post-test values on dynamic neuromuscular training in single plane and multi plane on dynamic balance and stability.

Unpaired 't' test showed that there was a significant difference between dynamic neuromuscular training in single plane and multi plane on dynamic balance and stability.

Discussion

The purpose of this study is to compare the effect of dynamic neuromuscular training in single plane v/s multi plane on function and balance among gym going women. A total of 20 participants who fulfilled inclusive and exclusive criteria were selected by simple random sampling method, out of them 10 were allotted in group A and 10 in group B.

Prior to the training both the groups underwent warm up and stretching. Group A underwent single planar dynamic neuromuscular training whereas Group B underwent single planar dynamic neuromuscular training, dynamic balance was tested with the use of Y-balance test whereas functional stability was tested using vertical jump test.

Statistical analysis was done using paired 't' test, was used to find the difference within the group and unpaired 't' test was used to find the difference between the groups.

Neuromuscular training (NT) is a strength and fitness training method that combines sport-specific and fundamental movements, including resistance, balance, core strength, dynamic stability, agility exercises, and plyometrics, to improve skills and health-related fitness.

NT aims to enhance speed, reaction speed, agility, coordination, and endurance among athletes. NT, which has grown in popularity in recent years, are used to prevent injuries and improve the performance of athletes by regaining leg power, strength, and balance after an injury.

The NT improves nerve-muscle control while increasing the stability of functioning joints. Neuromuscular training focuses on the activities that support the brain by training nerves and muscles to enhance the connection between the athlete's body and subconscious mind.

Dynamic neuromuscular training can improve the overall balance and function of the individuals. After 6 weeks of training intervention, Dynamic balance on Y-balance test shows performance improvement. Functional stability was improved on vertical jump test when comparing to the pre and post training values.

The unpaired t test values of group A and group B. the values are (8.4) and (4.39), which was greater than the tabulated t value of (2.101) which shows that there was significant improvement in group B when compared to Group A. Hence dynamic neuromuscular training is effective on improving dynamic balance and function.

Conclusion

The aim of the study is to find the effect of dynamic neuromuscular training in single plane v/s multi plane on dynamic balance and stability among gym going women.

20 players were selected and divided into 2 groups using simple random sampling. Group A members underwent single planar dynamic neuromuscular training whereas Group B underwent multi planar dynamic neuromuscular training for 8 weeks.

In Dynamic balance and stability, Dynamic balance was measured using Y-balance test and stability was measured using Vertical jump test. Both pre and post-test measures obtained, by use of these values within group analysis and between group analyses was done. Based on findings the result was obtained.

This study rejects the null hypothesis and accepts the alternate hypothesis. The study concludes that the dynamic neuromuscular training was improving the dynamic balance and stability among the gym going women.

Limitations and Recommendations

- The Study was conducted on a smaller sample size.
- The Study focuses on two training techniques and includes only few parameters, analysed only the balance and stability on female gym going women.
- The study focuses only on female gym goers with in the age group of 18-25 only.
- Certain factors such as climatic conditions, nutritional factors and activity of daily living could not be controlled during the study**.**
- Further studies can be done using larger sample size and can be done for various age population also.
- Similar studies can be done at various duration of training and different training programs can be used.
- Further studies can use other outcome parameters for intervention.
- Study can be done by using male subjects also.
- Study can be done for various age populations.
- Study can be done with longer durations with longer follow up period to assess long term benefits.

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