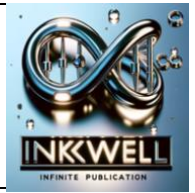




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Original Article

## Evaluating the Efficacy of Kinesthesia, Balance, and Vestibulo-Postural Training in Knee Osteoarthritis Management

Mohammad Miraj<sup>1\*</sup>; Abdul Rahim Shaik<sup>1</sup>; Ittikhar H. Shalla<sup>2</sup>; Uzma Farooq Usman Javed<sup>2</sup>; Abdul Razzak<sup>2</sup>; Basheer Jismitha Neelikatil<sup>2</sup>; Mohammad Alhazmi<sup>3</sup>; Mohammed Mahdi Ali Khawaji<sup>4</sup>

<sup>1</sup> Department of Physical Therapy & Health Rehabilitation, College of Applied Medical Sciences, Majmaah University, Al Majmaah 11952, Saudi Arabia.

<sup>2</sup> Dubai Health, Dubai, UAE.

<sup>3</sup> Rehabilitation Centre, King Fahad Hospital, Jazan, Saudi Arabia.

<sup>4</sup> Physiotherapy Department, Prince Mohammed Bin Nasser Hospital, Jazan, Saudi Arabia.

\*Corresponding Authors: [m.molla@mu.edu.sa](mailto:m.molla@mu.edu.sa)

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### Abstract

**Background:** Knee osteoarthritis (OA) is a common degenerative joint disease that causes pain, reduced mobility, and impaired quality of life. This study compares the efficacy of kinesthesia and balance exercises with isometric strengthening versus Vestibulo-Postural Training (VPT) using a bipodalic stabilometric platform with isometric strengthening in improving muscle strength and functional independence in knee OA patients. **Methods:** Thirty subjects with knee OA, aged between 30-60 years, were randomly assigned to two groups. Group 1 (n=15) received kinesthesia and balance exercises along with isometric strengthening exercises, while Group 2 (n=15) received VPT combined with isometric strengthening exercises. Both groups performed their respective exercise regimens three times a week for four-weeks. Outcomes measured included quadriceps and hamstrings strength using the Manual Muscle Testing (MMT) grading system and functional independence using the Barthel Index score. **Results:** Group 2 demonstrated significantly greater improvements in quadriceps strength (mean change: 1.34 vs. 0.40;  $p < 0.001$ ), hamstrings strength (mean change: 1.07 vs. 0.20;  $p < 0.001$ ), and Barthel Index score (mean change: 20.54 vs. 5.5;  $p < 0.001$ ) compared to Group 1. The between-group analysis confirmed that VPT with isometric strengthening was significantly more effective in enhancing muscle strength and functional independence in knee OA patients. **Conclusion:** VPT using a bipodalic stabilometric platform combined with isometric strengthening exercises significantly improves muscle strength and functional independence in knee OA patients compared to kinesthesia and balance exercises with isometric strengthening. These findings highlight the importance of incorporating dynamic and challenging balance exercises into OA management strategies to optimize patient outcomes and enhance quality of life.

**Keywords:** Knee Osteoarthritis, Kinesthesia Exercises, Balance Training, Vestibulo-Postural Training, Isometric Strengthening, Muscle Strength, Functional Independence.

## Introduction

Knee osteoarthritis (OA) is a prevalent and debilitating condition characterized by the progressive degeneration of joint cartilage and subchondral bone, leading to pain, stiffness, reduced mobility, and impaired quality of life (Felson, 2006; Loeser et al., 2012). It affects millions of people worldwide and is a major cause of disability among older adults (Hunter et al., 2014). Managing knee OA requires a multifaceted approach, combining pharmacological treatments, lifestyle modifications, and physical therapy interventions aimed at reducing symptoms and improving joint function.

Exercise therapy, particularly kinesthesia and balance exercises, has emerged as an effective non-pharmacological intervention for knee OA. These exercises enhance proprioception, neuromuscular control, and joint stability, which are crucial for maintaining functional mobility and reducing fall risk (Fransen et al., 2015; Skou et al., 2018). Additionally, isometric strengthening exercises are commonly incorporated to improve muscle strength around the affected joint, thereby supporting joint function and alleviating symptoms (Bennell et al., 2015).

Recent advancements in rehabilitation strategies have introduced vestibulo-postural training, which utilizes dynamic balance platforms to challenge and improve postural control and stability. This type of training has shown promise in enhancing proprioceptive feedback and neuromuscular coordination, leading to better functional outcomes in various patient populations, including those with knee OA (Grewal et al., 2015; Bricca et al., 2018). Vestibulo-postural training involves exercises that stimulate the vestibular system and improve balance by challenging the body's ability to maintain stability in different positions and under

various conditions (Mao et al., 2023; Alonso et al., 2023).

Despite the growing body of evidence supporting these exercise interventions, there remains a need to directly compare the efficacy of different training modalities to determine the most effective approach for improving muscle strength and functional independence in knee OA patients. This study aims to fill this gap by comparing the effects of kinesthesia and balance exercises combined with isometric strengthening against vestibulo-postural training using a bipodalic stabilometric platform combined with isometric strengthening. The primary outcomes assessed include quadriceps and hamstrings strength and functional independence measured by the Barthel Index score.

By providing a direct comparison of these exercise interventions, this study seeks to inform clinical practice and optimize rehabilitation strategies for individuals with knee OA, ultimately enhancing their quality of life and functional capabilities. Understanding which exercise regimen yields superior outcomes will enable healthcare providers to design more effective, personalized treatment plans that address the specific needs of knee OA patients, thereby improving their overall health and well-being.

## Methodology

The research sample consisted of 30 patients, with 15 individuals in each group. The participants were between the ages of 30 and 60 years and had knee osteoarthritis. Both males and females were included in the study, and all participants supplied informed consent. The exclusion criteria encompassed rheumatoid or other inflammatory arthritis, septic arthritis, popliteal cyst, stress fractures/reactions, tendonitis, patellofemoral syndrome, medial plica syndrome, referred pain,

ligamentous sprain, meniscal tear, patellar subluxation/dislocation, muscle strain, osteochondral fracture, individuals aged above 60 years, and individuals aged below 30 years.

First group was given the kinesthesia and balance exercises (Diracoglu et al., 2005) along with isometric strengthening exercises. These balance and kinesthesia exercises included modified Romberg exercise (standing in balance with eyes closed) on hard ground and soft surface (on a mat), retro walking (25 m), walking on heels (25 m), walking on toes (25 m), walking with eyes closed (25 m), standing on one extremity for 30 seconds (repeated in both extremities), leaning forward, backward, and to the sides on one extremity (eyes open and closed), and sitting down and standing up from a high chair slowly.

The second group performed vestibulo-postural training using a bipodalic stabilometric platform (Miraj et al., 2024) using a state-of-the-art ProKin 252 balancing platform (ProKin 252, TecnoBody, Italy) along with isometric strengthening exercises. This component included tasks such as maintaining a double-leg stance for 30 seconds with eyes open and closed on both level and inclined surfaces, providing a challenging balance environment to enhance postural control. Each task was performed three times with a one-minute rest between trials to prevent fatigue. The initial 5 seconds of each trial were excluded from analysis to allow for postural stabilization.

The exercises were performed three days a week for a total duration of four weeks. At the end of the four-week period, the strength of the quadriceps and hamstring muscles was tested using the MMT system, and functional outcomes were assessed using the Barthel index score.

The statistical analysis for this study was conducted to compare the efficacy of two distinct

exercise interventions on quadriceps and hamstrings strength, as well as functional outcomes measured by the Barthel's score, in patients with knee osteoarthritis (OA). Descriptive statistics, including mean and standard error (SE), were calculated for pre- and post-assessment values within each group. Paired t-tests were used to assess within-group changes from pre- to post-intervention for each parameter. For between-group comparisons, the mean changes (post-assessment mean minus pre-assessment mean) were calculated for both groups. An independent t-test was then performed to compare these mean changes between the two groups. The pooled standard error was calculated using the standard errors of both groups to determine the standard error of the difference. The t-values and corresponding p-values were derived to assess the statistical significance of differences between the groups. A p-value of less than 0.05 was considered statistically significant, with highly significant results noted for p-values less than 0.001. All analyses were performed using appropriate statistical software, ensuring rigorous evaluation of the intervention effects on muscle strength and functional outcomes in knee OA patients.

## Result

For the first group received kinesthesia and balance exercises (Table 1), the mean quadriceps strength increased from 3.13 to 3.53, and hamstrings strength increased from 3.73 to 3.93. The Barthel's score mean improved from 72.5 to 78 post-exercise regime. Statistical analysis revealed that the change in Barthel's score was statistically significant ( $t = 2.95$ ,  $p < 0.05$ ), indicating a meaningful improvement in functional status. However, the changes in quadriceps and hamstrings strength were not statistically significant (quadriceps:  $t = 0.86$ ,  $p >$

0.05; hamstrings:  $t = 0.02, p > 0.05$ ), suggesting no significant change in muscle strength with this exercise regimen.

In contrast, the second group vestibulo-postural training using a bipodalic stabilometric platform (Table 2) showed substantial improvements

across all parameters. Quadriceps strength increased significantly from 3.06 to 4.4 ( $t = 6.09, p < 0.001$ ), and hamstrings strength improved from 3.53 to 4.6 ( $t = 6.29, p < 0.001$ ). The Barthel's score mean increased significantly from 68.46 to 89 ( $t = 414.20, p < 0.001$ ), indicating a highly significant enhancement in functional status.

**Table 1:** Effect of Kinesthesia and Balance Exercises with Isometric Strengthening on Knee Osteoarthritis Patients (Group 1)

Parameters	Pre-Test Mean+SD N=15	Post-Test Mean+SD N=15	SE	t	P
Quadriceps Strength	3.13±0.51	3.53+0.44	0.69	0.86	0.404
Hamstrings Strength	3.73±0.14	3.93+0.48	0.17	0.02	0.985
Barthel's Score	72.5±6.33	78+ 5.94	1.86	2.95	0.011*

Key: SD-Standard Deviation; N-Number; SE- Standard Error; \*Significant

**Table 2:** Effect of Vestibulo-Postural Training with Isometric Strengthening on Knee Osteoarthritis Patients (Group 2)

Parameters	Pre-Test Mean+SD N=15	Post-Test Mean+SD N=15	SE	t	P
Quadriceps Strength	3.06+0.19	4.4+0.57	0.22	6.09	0.001*
Hamstrings Strength	3.53+0.15	4.6+0.44	0.17	6.29	0.001*
Barthel's Score	68.46+4.53	89+6.29	2.85	414.20	0.001*

Key: SD-Standard Deviation; N-Number; SE- Standard Error; \*Significant

**Table 3:** Comparative Analysis of Strength and Functional Improvement Between Kinesthesia and Balance Exercises (Group 1) and Vestibulo-Postural Training (Group 2) in Knee Osteoarthritis Patients

Parameters	Group 1 Mean Diff. N=15	Group 2 Mean Diff. N=15	Mean Diff. Changes	Pooled SE	t	P
Quadriceps Strength	0.40	1.34	0.94	0.187	5.03	0.001*
Hamstrings Strength	0.20	1.07	0.87	0.062	14.03	0.001*
Barthel's Score	5.5	20.54	15.04	0.878	17.13	0.001*

Key: SD-Standard Deviation; N-Number; SE- Standard Error; \*Significant; Diff.-Difference

The group receiving of Vestibulo-Postural Training with Isometric Strengthening exercises demonstrated significantly greater improvements in both quadriceps and hamstrings strength, as well as Barthel's score compared to the first group. These findings underscore the efficacy of tailored exercise interventions in enhancing muscle strength and functional outcomes among knee osteoarthritis patients.

The between-group analysis (Table 3) revealed significant differences in the improvements of quadriceps strength, hamstrings strength, and Barthel's score between the two groups. For quadriceps strength, the first group showed a mean change of 0.40, while the second group exhibited a substantially greater mean change of 1.34. The difference in mean changes between the groups was 0.94, with a highly significant p-value of less than 0.001 ( $t = 5.03$ ). Similarly, hamstrings strength improved by a mean change of 0.20 in the first group compared to 1.07 in the second group. The difference in mean changes was 0.87, also highly significant with a p-value of less than 0.001 ( $t = 14.03$ ). In terms of functional outcomes measured by the Barthel's score, the first group experienced a mean change of 5.5, while the second group had a mean change of 20.54. The difference in mean changes was 15.04, with a highly significant p-value of less than 0.001 ( $t = 17.13$ ). These results indicate that the second group, which included vestibulo-postural training along with additional balance and kinesthesia exercises, showed significantly greater improvements in both muscle strength and functional independence compared to the first group.

## Discussion

In this study, we investigated the effectiveness of two distinct sets of balance and kinesthesia

exercises on quadriceps and hamstrings strength, as well as functional outcomes measured by the Barthel's score, in patients diagnosed with knee OA. The results of our study demonstrated significant improvements in both quadriceps and hamstrings strength, as well as functional outcomes, following a structured exercise regimen, with notable differences between the two intervention groups. Specifically, the group that received vestibulo-postural training along with additional balance and kinesthesia exercises exhibited substantially greater improvements compared to the group that received traditional kinesthesia and balance exercises with isometric strengthening.

The between-group analysis revealed that the second group showed a mean change in quadriceps strength of 1.34, compared to 0.40 in the first group, with a highly significant difference ( $p < 0.001$ ). Similarly, hamstrings strength improved by 1.07 in the second group, compared to 0.20 in the first group, with a highly significant difference ( $p < 0.001$ ). The Barthel's score, a measure of functional independence, increased by 20.54 in the second group, compared to 5.5 in the first group, again showing a highly significant difference ( $p < 0.001$ ).

These findings align with previous research emphasizing the critical role of proprioceptive and vestibular training in enhancing neuromuscular control, joint stability, and overall functional outcomes in knee osteoarthritis (OA) patients (Fibel et al., 2015; Leslie, 2000; Uivaraseanu et al., 2022). The significant improvements in the second group underscore the importance of incorporating challenging vestibulo-postural tasks into rehabilitation programs. Such tasks likely provide a more intense stimulus for neuromuscular adaptation, leading to greater



enhancements in muscle strength and functional capacity (Farrokhi et al., 2013; Skou et al., 2018).

The effectiveness of the vestibulo-postural training observed in this study suggests that exercises which incorporate dynamic and multi-planar movements may be more beneficial for patients with knee OA than traditional static exercises. This is consistent with the findings of other studies that have highlighted the benefits of proprioceptive and balance training in improving postural control and reducing fall risk (Bricca et al., 2018; Grewal et al., 2015).

Moreover, the highly significant improvements in the Barthel's score indicate that the second group's exercise regimen not only enhanced muscle strength but also had a profound impact on the patients' functional independence and quality of life. This aligns with the broader literature advocating for comprehensive exercise programs that address both strength and functional performance in OA management (Fransen et al., 2015; Skou et al., 2019).

However, it is essential to acknowledge the limitations of our study. The relatively small sample size and short-term follow-up period limit the generalizability and long-term implications of our findings. Future studies with larger, more

diverse populations and extended follow-up periods are needed to validate the sustainability and broader applicability of these exercise interventions. Additionally, individual variations in response to exercise interventions were not extensively explored, warranting further investigation into personalized rehabilitation strategies for knee OA patients.

## Conclusion

Vestibulo-postural training using a bipodalic stabilometric platform combined with isometric strengthening exercises significantly improves muscle strength and functional independence in knee OA patients compared to kinesthesia and balance exercises with isometric strengthening.

Our study contributes valuable insights into the role of vestibulo-postural training in enhancing muscle strength and functional outcomes in knee OA patients. These findings underscore the importance of integrating dynamic and challenging balance exercises into comprehensive OA management strategies to optimize patient outcomes, reduce symptom severity, and improve overall quality of life.

## Disclosure of interest

The authors report no conflict of interest.

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