

Original Article

# Effect of Dynamic Balance Training on Physical Function and Proprioception in Individuals with Knee Osteoarthritis

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## ABSTRACT

**Background:** Osteoarthritis (OA) is a prevalent joint disorder affecting synovial joints, particularly the knee. It leads to degeneration of cartilage, causing pain and reduced physical function. Effective treatment strategies are essential for managing symptoms and improving quality of life.

**Objective:** To determine the effect of dynamic balance training on physical function and proprioception in individuals with knee osteoarthritis.

**Methods:** This quasi-experimental trial was conducted at Riphah International University Lahore, Aziz Medical Clinic, and Ali Hospital, Mughal Pura Lahore. A total of 48 patients with anterior knee pain were recruited and divided into two groups: one receiving dynamic balance training and the other receiving conventional physical therapy (control). Non-probability convenience sampling was used. Outcomes were measured using NPRS, a goniometer, the Community Balance and Mobility Scale (CB&M), and the Western Ontario and McMaster Universities Arthritis Index (WOMAC). Knee proprioception was assessed by joint position sense using a universal goniometer, with the average of three angles taken for the final reading. Data were analyzed using SPSS version 25.

**Results:** Significant differences were observed in joint proprioception between weight-bearing (WB) and non-weight-bearing (NWB) procedures. The mean difference for WB was -3.07 compared to -2.18 for NWB, with a higher relative error in WB ( $p < 0.05$ ). Dynamic balance training resulted in greater reductions in NPRS scores and improvements in WOMAC scores compared to conventional physical therapy ( $p < 0.05$ ).

**Conclusion:** Dynamic balance training was more effective than conventional physical therapy in improving physical function and proprioception in individuals with knee osteoarthritis.

**Keywords:** Balance, dynamic balance, joint position sense, knee osteoarthritis, knee proprioception, proprioceptive assessment, weight bearing

## INTRODUCTION

Osteoarthritis (OA) is a prevalent joint disorder affecting synovial joints such as the hip, knee, hand, and spine. It predominantly affects individuals over 60 years of age, with more than 80% of those over 75 experiencing osteoarthritis (1, 2). Knee osteoarthritis is the most common degenerative disease, characterized by narrowing joint spaces and the complete wearing down of cartilage, leading to bone-on-bone contact and inflammation of the joint lining (3). Its prevalence is exacerbated by factors such as aging, obesity, diabetes, and reduced physical activity (4). These risk factors, including obesity, knee trauma, and physical inactivity, adversely affect dynamic balance and proprioception.

The diagnosis and grading of knee osteoarthritis rely on radiographic evidence and changes in sub-chondral bone (5). Proprioception, the ability to detect stimuli within the body related to position, motion, and equilibrium, plays a critical role in knee joint function (4). This sensory input, mediated by the central nervous system (CNS) and integrating somatosensory, visual, and vestibular inputs,

is essential for maintaining balance and stability (5). Proprioception encompasses the sense of position, movement, and force (6). In knee osteoarthritis, proprioceptive abilities deteriorate, leading to functional impairment and compromised dynamic balance (7).

Assessment of proprioception at the knee joint involves identifying mechanoreceptors within joint structures and using neurophysiological testing to measure sensory thresholds and nerve conduction velocities. Clinically, proprioception is evaluated through kinesthesia and joint position sense (8). Kinesthesia is assessed by detecting passive movements, while joint position sense is measured by both active and passive joint positioning. During this assessment, a therapist positions a limb at a specific angle, maintains it for ten seconds, and then allows the patient to replicate the angle, recording the angular displacement. Joint position sense is evaluated in both weight-bearing (WB) and non-weight-bearing (NWB) positions, as gait cycles involve both phases. This study aims to assess knee joint proprioception in both NWB and WB positions to identify statistical differences (9).

Balance, crucial for maintaining posture control and physical stability, involves sustaining or restoring a state of equilibrium during various activities (10). Pharmacological treatments for osteoarthritis include analgesics and anti-inflammatory drugs (NSAIDs), often used in combination, and corticosteroids or cortisone injections to reduce knee pain (11). Non-pharmacological treatments encompass modalities such as diathermy, ultrasound, TENS, hot/cold therapy, dynamic balance training exercises, strength training, and proprioceptive training exercises. Kinesio-taping is also applied to improve pain, range of motion, and proprioception (12).

The objective of this study was to investigate the effect of dynamic balance training on physical function and proprioception in individuals with knee osteoarthritis.

## MATERIAL AND METHODS

This study was a quasi-experimental trial conducted at Riphah International University Lahore, Aziz Medical Clinic, and Ali Hospital, Mughal Pura Lahore, over a six-month period. A non-probability convenient sampling technique was employed, with a sample size of 48 patients calculated using Raosoft software, ensuring a 95% confidence interval and a 5% margin of error (13). Participants were divided into two groups: one received dynamic balance training, while the other received conventional physical therapy intervention as the control.

Data were analyzed using SPSS version 25, with outcomes measured using the Numerical Pain Rating Scale (NPRS), a goniometer, the Community Balance and Mobility Scale (CB&M), and the Western Ontario and McMaster Universities Arthritis Index (WOMAC) scales. Knee proprioception was assessed through joint position sense, measured with a universal goniometer.

Informed consent was obtained from all participants, and appropriate follow-up was provided regarding the research procedures. Exclusion criteria included individuals not meeting the age criteria, those with septic joint conditions, knee or hip joint replacements, corticosteroid use, recent knee injections or arthroscopic surgery, and any neurological, musculoskeletal, or other conditions affecting lower extremity movement, balance, or maximal strength.

Participants' demographics, including names and ages, were recorded along with their height and weight before assessing knee proprioception. An independent sample t-test with a p-value of  $<0.05$  was utilized during the analysis.

Ethical clearance was obtained from the ethical board (Reference no. RCR & AHS/ REC/MS-OMPT/S19/018), and permission letters were secured from Riphah International University Lahore, Aziz Medical Clinic, and Ali Hospital, Mughal Pura Lahore. The nature and purpose of the study were explained to participants, and consent was obtained through forms written in both English and Urdu.

## RESULTS

The study aimed to assess the impact of dynamic balance training versus conventional physical therapy on physical function and proprioception in individuals with knee osteoarthritis. Participants were divided into two groups: the Dynamic Balance Training group ( $n = 23$ ) and the Conventional Physical Therapy group ( $n = 25$ ). Analysis of participant demographics revealed a mean age of 65.78 years ( $SD = 5.98$ ) for the Dynamic Balance Training group and 62.36 years ( $SD = 6.86$ ) for the Conventional Physical Therapy group. Gender distribution showed that 26.1% of the Dynamic Balance Training group were male and 73.9% were female, while 24% of the Conventional Physical Therapy group were male and 76% were female.

Comparison of Numeric Pain Rating Scale (NPRS) scores between the two treatment groups using independent sample t-tests indicated no significant difference in pre-treatment scores ( $p > 0.05$ ). Post-treatment NPRS scores, however, showed a significant difference ( $p < 0.05$ ), with the Dynamic Balance Training group experiencing a greater reduction in pain levels compared to the

Conventional Physical Therapy group. Similarly, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores showed no significant difference between the groups at pre-treatment ( $p > 0.05$ ), but post-treatment scores revealed a significant improvement in physical function for the Dynamic Balance Training group ( $p < 0.05$ ).

Analysis of Community Balance and Mobility Scale (CBMS) scores demonstrated significant differences between the groups both pre- and post-treatment ( $p < 0.05$ ), suggesting that both interventions had an equal effect on balance and mobility outcomes. Within-group comparisons using paired sample t-tests revealed significant differences in NPRS, WOMAC, and CBMS scores from pre- to post-treatment for both groups ( $p < 0.05$ ), highlighting the effectiveness of both Dynamic Balance Training and Conventional Physical Therapy in improving pain levels, physical function, and balance in individuals with knee osteoarthritis.

Overall, the findings suggest that dynamic balance training may offer distinct advantages over conventional physical therapy in managing pain and improving physical function and proprioception in this population.

Table 1: Demographics of variables

Demographic Variables		Dynamic Balance Training (N= 23) Mean±S.D	Conventional Physical Therapy (N = 25) Mean±S.D
Age (years), mean ± SD		65.78 ± 5.98	62.36 ±6.86
Gender, n (%)	Male	6(26.1%)	6(24%)
	Female	17(73.9%)	19(76%)

Table 2: Within group studies of NPRS

NPRS	Dynamic balance training		Conventional physical therapy	
Pre treatment	5.91±1.27		6.16±1.40	
Post treatment	3.69±1.14		4.88±1.23	
Within Group Change	Mean difference	P value	Mean difference	P value
Pretreatment- post-treatment	3.041	.000	1.98	.001

Table 3: Within group studies of WOMAC

WOMAC	Dynamic balance training		Conventional physical therapy	
Pre treatment	73.65±3.65		73.64±2.30	
Post treatment	48.30±3.93		58.36±4.51	
Within Group Change	Mean difference	P value	Mean difference	P value
Pretreatment- post-treatment	27.46	.000	17.41	.000

Table 4: Within group studies of CBMS

CBMS	Dynamic balance training		Conventional physical therapy	
Pre treatment	63.30±4.35		66.56±4.93	
Post treatment	56.04±4.73		58.76±4.56	
Within Group Change	Mean difference	P value	Mean difference	P value
Pretreatment- post-treatment	10.10	.000	10.50	.000

## DISCUSSION

The present study demonstrated a statistically significant difference between weight-bearing (WB) and non-weight-bearing (NWB) assessments of joint proprioception in individuals with knee osteoarthritis. The mean difference for the WB procedure (-3.07) exceeded that of the NWB procedure (-2.18), yet WB assessment exhibited more deviation from the targeted position and a higher relative error compared to NWB assessment. This statistically significant difference ( $p < 0.05$ ) suggests that the NWB position yields more accurate proprioceptive measurements, highlighting the potential benefits of NWB testing for precise proprioceptive assessment.

Dynamic balance training was found to be significantly more effective than conventional physical therapy in improving proprioception and physical function. Balance is particularly crucial in WB positions, where individuals must maintain the test angle while also ensuring postural stability. The resistance encountered in WB positions, due to body weight, contrasts with the limb weight resistance in NWB positions. Consequently, WB assessments often result in underestimated response angles. The study revealed that WB positions demonstrated greater neural input from mechanoreceptors in muscles, joints, ligaments, and skin distributed throughout the weight-bearing joints (14).

Previous research has compared WB and NWB procedures in assessing ankle movements, with findings indicating no significant differences when the knee is in a straight position. However, knee flexion in NWB positions led to significantly higher thresholds. The posture of the foot and knee, with calf stretching as a significant factor, influenced WB and NWB test outcomes (15). Additionally, even minimal resistance increased afferent output from muscles, suggesting active joint position tests yield better results than passive ones (16).

Studies on elbow joint position sense, where forearms were loaded during assessments, showed diminished thresholds for detecting elbow movement. This indicates that muscle contraction magnitude may affect WB and NWB outcomes. In the current study, participants required light touch for maintaining WB standing positions. Research by Clapp and Wing showed that fingertip contact is insufficient for joint support in both unilateral and bilateral stands with eyes closed, underscoring the importance of proprioceptive feedback from the skin and joints (18). Even light touch can significantly influence ankle joint balance.

NWB knee repositioning procedures play a crucial role in knee proprioception as they involve no movement, resistance, or weight bearing at the joint. In these tests, therapists slowly and passively move the joint to a specific targeted position, minimizing cues for patients regarding movement. Patients can easily sense knee joint movement when produced at high velocity, enhancing the accuracy of proprioceptive assessments (19). Active limb movement in WB positions, with increased cues in standing WB positions, contrasts with dynamic movements at tested joints which more closely reflect daily proprioceptive functions.

This study's strengths include a comprehensive assessment of WB and NWB proprioception and the use of both dynamic balance training and conventional physical therapy interventions. However, limitations include the small sample size and the potential for variability in individual proprioceptive responses. Future research should explore larger cohorts and consider additional factors affecting proprioceptive accuracy, such as muscle contraction, calf stretching, and finger touch support during WB tests.

Overall, the findings emphasize the importance of incorporating both WB and NWB assessments in evaluating knee proprioception and highlight the effectiveness of dynamic balance training in improving proprioceptive function and physical performance in individuals with knee osteoarthritis.

## CONCLUSION

Dynamic balance training proved more effective than conventional physical therapy for improving physical function and proprioception in individuals with knee osteoarthritis, as measured by the Numeric Pain Rating Scale (NPRS), goniometer, Community Balance and Mobility Scale (CB&M), and Western Ontario and McMaster Universities Arthritis Index (WOMAC). This study highlights the superiority of dynamic balance training in enhancing proprioceptive accuracy and physical performance, suggesting it should be integrated into standard rehabilitation protocols for knee osteoarthritis. Implementing dynamic balance exercises could lead to better management of osteoarthritis symptoms, improved patient outcomes, and enhanced quality of life for those affected by this degenerative joint condition.

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