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Original Article

Immediate Effects of Functional Strength Training on Dynamic Balance in Individuals with Unilateral Knee Osteoarthritis

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Abstract

Background

Knee osteoarthritis causes discomfort, diminished proprioception, and impaired dynamic balance, which can limit daily activities. Exercise continues to be an important part of OA care; however, the immediate effects of a single session of functional strength training on balance and pain are unknown. The purpose of this study was to assess the immediate effects of one session of functional strength exercise on dynamic balance and pain in people with unilateral knee osteoarthritis.

Materials and Methods

The quasi-experimental one-group pre-post study design was used. The study included 39 adults who had been diagnosed with unilateral knee OA using Altman clinical criteria. Each participant did one functional strength training session lasting 30-40 minutes. The Star Excursion Balance Test (SEBT) was used to assess dynamic balance before and after the intervention in all eight directions. The Visual Analogue Scale (VAS) was used to quantify pain intensity. Baseline demographic data, as well as the Knee Injury and Osteoarthritis Outcome Score (KOOS), were collected. SEBT reach distances were adjusted for leg length. Paired t-tests were used to examine pre-post comparisons, with a significance level of $p < 0.05$.

Results

Following the exercise session, all subjects showed statistically significant improvements in SEBT reach distances across all eight directions in both the injured and unaffected limbs. The affected limb improved more significantly, indicating improved neuromuscular activation and postural control. Pain levels indicated by VAS were significantly lower after intervention. KOOS scores indicated intermediate functional capacity, with higher scores in activities of daily living and lower scores in sports and quality of life domains.

Conclusion

A single session of functional strength training resulted in immediate and significant improvements in dynamic balance and pain reduction in those with unilateral knee osteoarthritis. These data support the clinical use of functional strength training as an effective immediate intervention in knee osteoarthritis rehabilitation.

Keywords: *Knee, Osteoarthritis, Postural Balance, Resistance Training*

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Introduction

Osteoarthritis (OA) is a prevalent degenerative joint condition that causes pain, stiffness, and a decreased capacity to perform daily activities. It mostly affects synovial joints, causing progressive cartilage destruction, alterations in the underlying bone, ligaments, joint capsule, and surrounding muscles, as well as joint inflammation [1-3]. Nearly 374 million individuals worldwide suffer from osteoarthritis, with the knee being the most often affected joint [4]. Individuals with knee OA frequently feel discomfort, quadriceps weakness, decreased joint range of motion, and poor balance as a result of diminished proprioception and postural control [5-6].

Exercise is an important part of treating knee osteoarthritis because it reduces pain and improves daily function. Stretching and strengthening activities can aid with mobility and general physical performance [7-8]. Long-term exercise programs have also been demonstrated to enhance balance in patients with knee osteoarthritis [9]. However, the immediate consequences of a single exercise session on dynamic balance remain unclear. Although exercise increases muscle control and stiffness, it is possible that transient weariness will have an effect on balance ability. As a result, examining the short-term effects of exercise is therapeutically significant.

The purpose of this study was to look at the immediate effects of a single exercise session on dynamic balance in people with knee osteoarthritis, utilizing functional balance testing [12].

Materials and Methods

This study used a one-group quasi-experimental pre-post design to examine the immediate effects of a single session of functional strength exercise on dynamic balance and pain in people with unilateral knee osteoarthritis [6, 13]. All tests and interventions were completed during a single visit to Nobel Medical College and Teaching Hospital (NMCTH) in Biratnagar, Nepal. The study was conducted from august 2025 to October 2025. The Institutional Review Committee of NMCTH granted ethical clearance (Reference No: IRC-NMCTH 56/2025), and all participants provided written informed consent. A paired t-test was used to calculate the sample size of a one-group pre-post research. 95% confidence and 80% power were used to estimate a modest effect size of 0.5. This resulted in a sample size of 34 people. After accounting for probable drop-outs, the final sample size was set at 39 individuals. The study used Altman's clinical criteria for knee OA, which included knee pain with at least three of the following: age >40 years, morning stiffness <30 minutes, crepitus, joint tenderness, bony enlargement, or absence of warmth. Exclusion criteria included knee replacement, infectious or inflammatory arthritis, serious medical or neurological disorders, psy-chological conditions, or inability to perform exercises or stand on one leg [13]. A total of 39 subjects were recruited via convenience sampling, with the unaffected limb serving as a control. The Star Excursion Balance Test (SEBT) was used to assess dynamic balance in eight directions [14,18,19], while the Visual Analogue Scale (VAS) was used to assess discomfort [15,16]. The baseline demographic data, as well as the Knee Injury and Osteoarthritis Outcome Score (KOOS), were obtained [17]. Participants completed a structured exercise program that lasted 30-40 minutes and focused on trunk and lower limb alignment, functional strength, and movement quality [6]. The baseline demographic data, as well as the Knee Injury and Osteoarthritis Outcome Score (KOOS), were obtained [17]. Participants completed a structured exercise program that lasted 30-40 minutes and focused on trunk and lower limb alignment, functional strength, and movement quality [6]. SPSS version 27 was used for data analysis. Pre- and post-intervention outcomes were compared using paired-sample t-tests, with $p < 0.05$ considered statistically significant. Pre- and post-intervention outcomes were compared using paired-sample t-tests, with $p < 0.05$ considered statistically significant.

Results

The demographic characteristics of the participants (N = 39) indicate a nearly equal gender distribution, with 48.7% males (n = 19) and 51.3% females (n = 20). The occurrence of knee osteoarthritis was slightly higher in the right limb (53.8%) compared to the left limb (46.2%). The mean age of participants was 54.7 ± 6.4 years, suggesting that most individuals were middle-aged. The participants had an average height of 160 ± 6.3 cm, weight of 71.2 ± 10.6 kg, and leg length of 82.9 ± 5.4 cm.

Table 1: Demographic Characteristic of the participants

	Characteristics	Number	Percentage (%)
Gender	Male	19	48.7
	Female	20	51.3
Osteoarthritis Limb	Right	21	53.8
	Left	18	46.2
Age (Mean ± SD)			54.7 ± 6.4
Height of participants (cm) (Mean ± SD)			160 ± 6.3
Weight of Participants (kg) (Mean ± SD)			71.2 ± 10.6
Leg length (ASIS to Medial Malleolus) (Mean ± SD)			82.9 ± 5.4

Table 2: Paired sample test for experimental (affected) and control (unaffected) group by Star Excursion Balance Test (SEBT)

Direction	Affected			Unaffected		
	Pre-test	Post – test	p-value	Pre-test	Post – test	p-value
Anterior	70.5	73.3	<0.001*	74.3	75.1	<0.001*
Anteromedial	70.2	72.6	<0.001*	72.9	73.6	<0.001*
Medial	64.4	66.6	<0.001*	67.7	68.2	<0.001*
Posteromedial	61.8	63.8	<0.001*	62.9	63.6	<0.001*
Posterior	55.2	57.1	<0.001*	58.8	59.4	<0.001*
Posterolateral	52.2	54.4	<0.001*	54.7	55.1	<0.001*
Lateral	44.1	46.1	<0.001*	47.1	47.9	0.009*
Anterolateral	63.5	65.2	<0.001*	65.9	66.5	<0.001*

*Statistically significant mean difference at 95% Confidence Interval under paired t-test

Following the functional strength training intervention, a statistically significant improvement was observed in the Star Excursion Balance Test (SEBT) scores across all eight directions for the affected leg. The mean anterior reach increased from 70.5 to 73.3 ($p < 0.001$), anteromedial from 70.2 to 72.6 ($p < 0.001$), medial from 64.4 to 66.6 ($p < 0.001$), posteromedial from 61.8 to 63.8 ($p < 0.001$), posterior from 55.2 to 57.1 ($p < 0.001$), posterolateral from 52.2 to 54.4 ($p < 0.001$), lateral from 44.1 to 46.1 ($p < 0.001$), and anterolateral from 63.5 to 65.2 ($p < 0.001$).

For the unaffected leg, the results also demonstrated statistically significant improvements in Star Excursion Balance Test (SEBT) performance across all eight directions following the functional strength training intervention. The mean anterior reach increased from 74.3 to 75.1 ($p < 0.001$), anteromedial from 72.9 to 73.6 ($p < 0.001$), medial from 67.7 to 68.2 ($p < 0.001$), posteromedial from 62.9 to 63.6 ($p < 0.001$), posterior from 58.8 to 59.4 ($p < 0.001$), posterolateral from 54.7 to 55.1 ($p < 0.001$), lateral from 47.1 to 47.9 ($p = 0.009$), and anterolateral from 65.9 to 66.5 ($p < 0.001$).

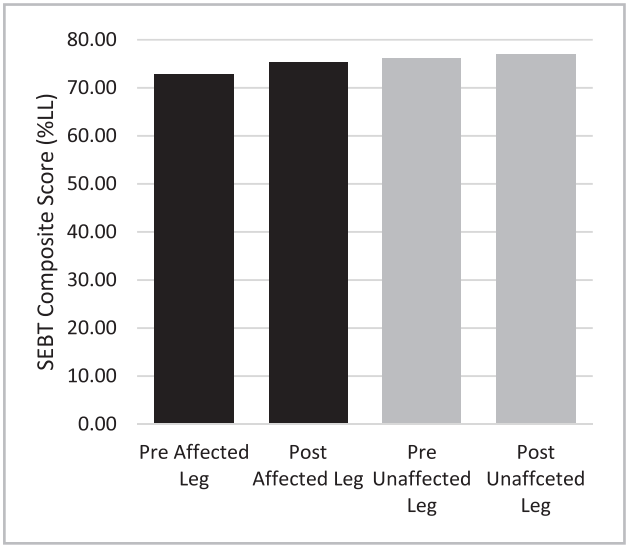

Figure 1: Mean normalized (% of leg length) composite SEBT reach values before and after exercise for both the affected and unaffected legs.

Figure 1 depicts the SEBT composite scores (%LL) for both limbs pre- and post-intervention, showing clear improvement in dynamic balance. The affected limb increased from 72.8%LL to 75.4%LL, while the unaffected limb rose from 76.2%LL to 76.9%LL, indicating a greater enhancement in the affected leg following functional strength training.

Table 3: VAS Pain Score before and after treatment among the participants with affected and unaffected leg

	Mean ± SD	t-value	p-value
VAS Pain score Before treatment	6.1 ± 1.1	5.798	<0.001*
VAS Pain score After treatment	5.1 ± 1.7		

*Statistically significant mean difference at 95% Confidence Interval under paired t-test

The Visual Analogue Scale (VAS) pain score showed a significant reduction following the intervention, decreasing from (Mean ±SD) 6.1 ± 1.1 before treatment to (Mean ±SD) 5.1 ± 1.7 after treatment ($t = 5.798$, $p < 0.001$).

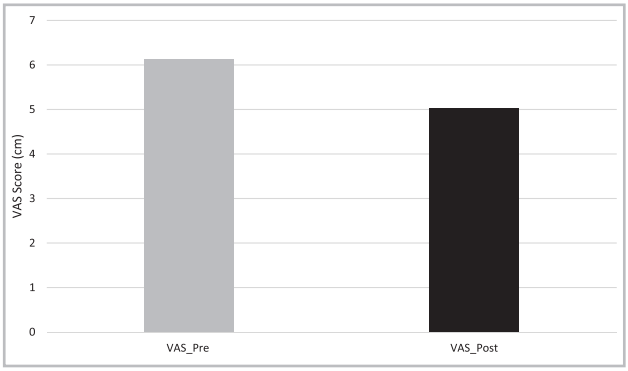

Figure 2: Mean VAS score on a 10 cm continuum from before and after exercise on the affected leg

The bar diagram illustrating the Visual Analogue Scale (VAS) pain scores demonstrates a clear reduction in pain levels following the intervention. The paired-samples t-test showed a significant decrease in the mean VAS score from 6.1 cm before treatment to 5.1 cm after treatment.

Table 4: KOOS score of subscales Pain, Symptoms, Activities of Daily Living, Sport and Recreation, and Quality of Life

Subscale	Mean ± Standard Deviation
Symptoms	64.7 ± 16.8
Pain	64.5 ± 14.9
ADL	68.5 ± 14.8
Sports	56.7 ± 19.9
QoL	48.6 ± 14.7

*A score of 100 indicates no knee problems and 0 indicates extreme knee problems.

The KOOS subscale analysis revealed moderate functional outcomes among participants, with the highest mean score observed in Activities of Daily Living (ADL) (68.5 ± 14.8), indicating relatively better daily function. Symptoms (64.7 ± 16.8) and Pain (64.5 ± 14.9) showed comparable moderate levels, while Sports/Recreation (56.7 ± 19.9) and Quality of Life (QoL) (48.6 ± 14.7).

Discussion

This study investigated the immediate effects of functional strength training on functional ability, pain, and balance in individuals with unilateral knee osteoarthritis. There were almost equal numbers of men and women among the 39 middle-aged participants, with somewhat more cases affecting the right knee. Participants reported diminished pain, increased functional performance, and evident and statistically significant improvement in dynamic balance after completing the training.

Although both limbs improved, the affected side's improvement in SEBT performance was more evident. This shows that functional strength training is an effective way to address limb asymmetry related to OA. Reduced joint degeneration progression rates and increased biomechanical efficiency have been associated with improved symmetry [20]. For both the affected and unaffected legs, the SEBT findings revealed significant increases in reach distance in all eight directions. The results obtained suggest enhanced proprioception, neuro-muscular control, and lower limb functional stability following the training session. The intervention effectively revealed impaired biomechanics associated with OA, greater improvement in the affected limb. These findings are in line with previous studies proving that strengthening the quadriceps and hip muscles enhances sensorimotor function and postural control in knee OA patients, improving joint stability and reduces functional impairments [21-22]. Furthermore, improving dynamic balance might reduce the risk of fall and promote mobility for daily tasks, which have significance in individuals with OA [23].

After the intervention, the VAS score showed a substantial decrease in pain, suggesting that functional strength training helped with pain management. This is in line with studies finding that exercise therapy, resistance training, and balance training are important in reducing knee pain while improving strength and function through reducing mechanical stress on articular structure and improving joint support [21,24-25]. According to systematic reviews and meta-analyses, Exercise generally assist in pain management, although the type of comfort can vary depending on the form, intensity, and duration of the program. Since chronic pain adversely affects muscular activation and balancing techniques, the observed pain reduction may have further contributed to increased performance in the SEBT. Therefore, compared to patients with severe knee OA, the combined effect of strengthening and pain management possibly enhanced confidence in the affected limb with milder forms of knee OA [25-26].

The KOOS scores suggest that daily activities, sports engagement, and quality of life are all somewhat functioning. In line with improvements in dynamic balance and pain, higher ratings on the ADL subscale indicate that participants were better able to carry out everyday tasks with less difficulty. Lower ratings on the quality of life (QoL) and Sports/Recreation subscales, however, suggest that some high-demand functional

activities are still restricted in people with OA. This could be explained by ongoing joint deterioration, a fear of moving, or a decline in physical confidence. Previous research has shown that long-term OA affects engagement in high-load and leisure activities [27].

A prior study found that patients with osteoarthritis in the knee have comparatively low health-related quality of life, with functional status significantly positively correlated with quality of life. Health-related quality of life is influenced by a number of sociodemographic characteristics and knee function, but it is adversely affected by advanced age, longer disease duration, and more severe pain, according to regression models. Therefore, improving quality of life has to be a primary therapeutic objective in the treatment of osteoarthritis in the knee [28-30].

Conclusion

The findings suggest that even a single session of functional strength exercise can enhance dynamic balance and reduce pain in individuals with unilateral knee OA. Improved reach performance reflects better proprioception and motor control, while pain reduction may support more confident movement. Although limitations persist in higher-demand activities, this short-term response highlights the value of incorporating functional strengthening into early OA management to support daily function and overall well-being.

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Conflict of interest: None

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