

# Effectiveness of knee extensor biofeedback training on pain, quadriceps muscle power and activities of daily living in patients with primary knee osteoarthritis

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## ABSTRACT

**Background:** Primary knee osteoarthritis is a common degenerative joint condition associated with pain, quadriceps muscle weakness, and functional limitations. Arthrogenic muscle inhibition reduces voluntary quadriceps activation, limiting the effectiveness of conventional strengthening exercises. Electromyographic biofeedback has emerged as a promising intervention to enhance neuromuscular activation and improve muscle performance.

**Objective:** To evaluate the effectiveness of knee extensor biofeedback training on pain, quadriceps muscle power, and activities of daily living in patients with primary knee osteoarthritis.

**Methods:** A quasi-experimental study was conducted among 10 participants diagnosed with primary knee osteoarthritis. Pain was assessed using the Visual Analogue Scale (VAS), quadriceps muscle power using a handheld dynamometer, and activities of daily living using the KOOS-12 questionnaire. Participants underwent knee extensor strengthening using EMG biofeedback combined with conventional physiotherapy for 4 weeks. Pre- and post-intervention data were analysed using paired t-test.

**Results:** There was a statistically significant reduction in pain (pre:  $6.70 \pm 0.82$ ; post:  $3.40 \pm 0.97$ ;  $t = 8.34$ ,  $p < 0.001$ ), significant improvement in quadriceps muscle power (pre:  $5.77 \pm 1.75$  kg; post:  $7.33 \pm 1.54$  kg;  $t = 7.07$ ,  $p < 0.001$ ), and significant improvement in KOOS-12 scores (pre:  $48.40 \pm 5.87$ ; post:  $64.30 \pm 7.92$ ;  $t = 22.51$ ,  $p < 0.001$ ).

**Conclusion:** Knee extensor biofeedback training combined with conventional physiotherapy is effective in reducing pain, improving quadriceps muscle power, and enhancing activities of daily living in patients with primary knee osteoarthritis.

**Keywords:** Knee osteoarthritis, Biofeedback training, Quadriceps muscle power, Visual analogue scale, KOOS-12, Physiotherapy.

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Osteophyte formation, subchondral bone remodelling, articular cartilage degradation,

## INTRODUCTION

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synovial inflammation, and capsular changes are all hallmarks of primary knee osteoarthritis (OA), a chronic, progressive, degenerative musculoskeletal disorder that eventually results in knee pain, stiffness, and functional limitation. It is commonly acknowledged as a clinical syndrome characterized by joint discomfort, mobility restriction, and a deterioration in activities of daily living (ADL) to varied degrees. As the major weight-bearing joint, the knee is especially susceptible to degenerative changes brought on by age-related structural changes and recurrent mechanical loads. Primary knee OA happens without a known cause and is closely linked to intrinsic factors like aging and biomechanical stress, in contrast to secondary osteoarthritis, which arises after trauma, infection, inflammatory arthritis, or metabolic problems.

Radiographic examination reveals cartilage breakdown, articular space narrowing, subchondral sclerosis, and marginal osteophyte formation as a result of the pathophysiological cascade, which is mediated by inflammatory cytokines and degradative enzymes and involves a contradiction between anabolic and catabolic processes within the cartilage matrix. As the illness worsens, periarticular muscle weakness and synovial inflammation exacerbate symptoms and impair function.

Because primary knee OA is so common and has such a significant impact on movement, independence, and overall quality of life, it is a significant global public health concern. According to recent epidemiological data, the disease affects over 16.9% of people aged 15 and older and nearly 22.9% of people aged 40 and older globally, with an expected 650 million instances in 2020. Due to biological aging of joint tissues and accumulated mechanical stress, the prevalence rises noticeably with age. With a female-to-male ratio of roughly 1.7:1, women are disproportionately impacted in comparison to men. Age, gender, obesity, genetic susceptibility, past joint misuse, kneeling or squatting at work, and muscle weakness, especially in the quadriceps femoris, are known risk factors.

According to community-based studies, knee osteoarthritis affects 20% to 40% of older persons in India, making it one of the main causes of impairment in this population. Indian statistics show a higher frequency among females and substantial correlations with being overweight, leading a sedentary lifestyle, and engaging in culturally specific behaviors such frequent squats and stair climbing, which are consistent with studies from throughout the world. Effective non-pharmacological rehabilitation techniques that reduce pain and restore functional capacity are becoming more and more important due to the chronic nature of the ailment and the drawbacks of long-term pharmaceutical therapy.

Quadriceps muscular weakness is one among the most common and clinically significant modifiable

impairments linked to primary knee OA. Stabilizing the knee joint, absorbing trauma, and controlling functional movements like walking, stair climbing, and sit-to-stand transitions are all made possible by the quadriceps femoris. Quadriceps strength deficiencies are common in people with knee OA and are closely linked to joint instability, pain intensity, and ADL difficulties. Arthrogenic muscular inhibition, reflexive neuronal suppression brought on by joint effusion and pain, decreased voluntary recruitment of motor units, and disuse atrophy from activity avoidance are some of the mechanisms causing this weakness.

The vastus medialis & vastus lateralis, which are crucial for the best patellofemoral tracking and the creation of knee extensor torque, cannot contract effectively when arthrogenic muscle inhibition interferes with typical neuromuscular activation patterns. Chronic weakness severely reduces functional independence and prolongs a cycle of pain and degeneration by increasing joint loading and mechanical strain on articular surfaces.

Targeted strengthening therapies are the cornerstone of conservative care because quadriceps weakness plays a fundamental role in the pathomechanics of knee OA. Despite their effectiveness, traditional strengthening regimens may be constrained by decreased motor control and pain-related inhibition. In this regard, knee extensor biofeedback conditioning has become a cutting-edge neuromuscular facilitation technique intended to improve quadriceps voluntary activation. Biofeedback allows patients to deliberately adjust the intensity of contractions and enhance motor unit recruitment by providing real-time auditory or visual signals that correlate to muscle activation levels.

Strength results, functional performance, and total ADL capacity may all be improved by biofeedback training, which may increase muscle engagement even in the face of pain by increasing neuromuscular awareness and decreasing inhibitory mechanisms. Increased dynamic knee stability, less joint stress, and possibly less pain perception while weight-bearing activities are all benefits of improved quadriceps activation.

Evaluating the efficacy of such interventions requires a multifaceted and accurate assessment of therapy outcomes. A handheld dynamometer, that provides quantitative information on knee extensor force output and enables systematic comparison of muscle power before and after an intervention, can be used to objectively test quadriceps strength with reliability. The Visual Analogue Scale (VAS), a straightforward, accurate, and extensively used instrument that measures the patient's felt pain intensity on a continuous 10-cm scale, is frequently used to assess subjective pain intensity. Patients with knee OA must have their functional status and activities of daily living evaluated in addition to their pain and strength.

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The Knee Injury & Osteoarthritis Outcome Score-12 (KOOS-12) is a short-form, validated patient-reported outcome measure created especially to evaluate functional limitations and knee-related complaints. Pain, function in daily living (ADL), and knee-related quality of life are the three main categories covered by the KOOS-12, which consists of 12 items taken from the original KOOS. The ADL component assesses challenges that arise when doing daily tasks such standing, bending, walking on level surfaces, ascending stairs, and getting up from a seated position. Responses are converted to a 0–100 scale using a Likert scale for each item; higher scores reflect improved knee function and lessened symptom burden. The KOOS-12 is appropriate for use in both research and clinical settings due to its good validity, responsiveness, and reliability in people with osteoarthritis in the knee.

A thorough framework for evaluating both symptomatic and functional outcomes in people with primary knee OA is provided by the combination of handheld dynamometry for precise muscle strength measurement, VAS for pain assessment, as well as KOOS-12 for functional status and ADL performance evaluation. When combined, these standardized instruments enable a multifaceted comprehension of the efficacy of interventions, especially in research investigating how knee extensor biofeedback training affects pain alleviation, quadriceps muscular power, and everyday functioning abilities.

In conclusion, primary knee osteoarthritis continues to be a common and incapacitating ailment with major national and international health consequences. The disease's primary characteristics are quadriceps muscle weakness along with functional impairment, highlighting the significance of rehabilitation techniques that focus on neuromuscular activation and strength restoration. Assessed using validated outcome measures including handheld dynamometry, VAS, and KOOS-12, knee extensor biofeedback training provides a systematic and scientifically supported method for enhancing pain, muscle function, and everyday living activities in this population.

### Need of the study

One of the main causes of chronic pain, quadriceps weakness, and diminished muscle power is primary knee osteoarthritis, which impairs function and lowers quality of life. The degree of pain, joint instability, and the advancement of the disease are all closely linked to quadriceps weakening. While traditional strengthening activities are advised, arthrogenic muscle inhibition decreases the effectiveness of therapy and restricts efficient voluntary activation. Although EMG biofeedback has demonstrated promise in increasing neuromuscular activation and boosting muscle performance, previous research has produced mixed

results and has mostly concentrated on strength and function with little attention on muscle power. Moreover, there is still a dearth of quasi-experimental data in people with primary knee osteoarthritis. In order to close a significant gap and provide recent information for physiotherapy rehabilitation, this study is to assess the clinical usefulness and efficacy of knee extensor biofeedback training on pain reduction and quadriceps muscle power.

### Aim of the study

To evaluate the effectiveness of knee extensor biofeedback training on pain reduction quadriceps muscle power and activities of daily living in patients with primary knee osteoarthritis.

### Objectives of the study

1. To assess the level of pain in patients with primary knee osteoarthritis using the Visual Analogue Scale (VAS).
2. To measure quadriceps muscle strength using a handheld dynamometer.
3. To assess activities of daily living (ADL) using the KOOS-12 (Knee Injury and Osteoarthritis Outcome Score-12) questionnaire.
4. To compare pre- and post-intervention outcomes to determine the effectiveness of knee extensor biofeedback training on primary osteoarthritis

### Hypothesis

#### Null Hypothesis (H<sub>0</sub>):

There will be no statistically significant difference in pain levels, quadriceps muscle power and activities of daily living before and after knee extensor biofeedback training in patients with primary knee osteoarthritis.

#### Alternative Hypothesis (H<sub>1</sub>):

There will be a statistically significant reduction in pain levels, improvement in quadriceps muscle power and activities of daily living following knee extensor biofeedback training in patients with primary knee osteoarthritis.

### REVIEW OF LITERATURE

#### REVIEW RELATED TO EPIDEMIOLOGY

##### David Spitaels et al.,(2020)

To ascertain the epidemiology of osteoarthritis in the knee in general practice, they carried out a study. Over a 20-year period (1996–2015), the current study examined trends in the incidence and prevalence of knee osteoarthritis. Intego, a morbidity registration network based on general practices, provided the data. During the 1996–2015 study period, information from 440–140 distinct patients was accessible. Jointpoint regression analysis was used to calculate trends in the incidence rate and prevalence of osteoarthritis in the knee. Additionally, the Anatomical Therapeutic Chemical Classification code was used to determine the quantity of drug prescriptions, and jointpoint

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regression was used to equally capture trends. Between 1996 and 2015, the overall age-standardized prevalence of osteoarthritis in the knee rose from 2.0% to 3.6%. With an average annualized percentage change (AAPC) of 2.5 (95% CI 2.2 to 2.9), an upward trend was noted. In 2015, the prevalence rates were 3.1%, 5.6%, 9.0%, and 13.9% for the 10-year age groups starting with the 45–54 age group, and 15.0% for those 85 years of age and above. In 2015, the incidence stayed constant at 3.75 (AAPC=-0.5, 95% CI -1.4 to 0.5). A higher burden of osteoarthritis in the knee is confirmed by greater prevalence, multimorbidity, and prescription drug usage. Initiatives to improve care can be prioritized using these trends in the future.

### **Yadav, et al., (2022)**

To ascertain the commonality of primary knee osteoarthritis in India's urban and rural populations, they carried out a study. It was a cross-sectional study conducted in a community. Five metropolises (large cities), five smaller cities close to the metropolis, five towns, and twenty-five villages from these towns' blocks comprised the target population; in other words, five sample groups were covered. After dividing it equally among five sites, we arrived at a minimum sample size (n) of 4680 (936 from each site). Each site's sample size was rounded to 1000. Structured surveys, interviews, and observation of radiological and clinical results were used to gather data. The Kellgren and Lawrence Scale was used to grade OA. In large cities, 33.2% of people had primary knee OA, compared to 19.3% in small cities, 18.3% in towns, and 29.2% in villages. According to the current study, 32.7% of people in large cities led sedentary lives, compared to 28.7% urban villages and 18.1% in towns. Compared to people in cities and towns, about 44.5% of the village's inhabitants worked in physically demanding jobs. Compared to rural areas, urban areas have a much higher frequency of symptomatic primary OA knee. Our findings will help direct future allocation of health care resources plus preventive measures.

### **J. Viswanath, et al., (2017)**

To determine the number of patients with osteoarthritis in South Indian hospitals, they carried out a study. The prospective data of 60 patients was gathered at S.V. Ayurvedic Medical College and Hospital. Family medical history, physical activity, disease, addiction, digestive capacity, and other factors were gathered from patients with osteoarthritis. According to the study, 53.33% of people had a prior family history of osteoarthritis, whereas 46.66% did not. 23.33% had an insidious beginning of sickness, while 76.66% had a progressive one. All of them experienced joint pain and swelling. 36.66% had good digestion, 13.33% had bad digestion, and 50% had average digestion. Alcohol addiction affected 30% of patients, followed by smoking and alcohol addiction

(16.66%), tobacco addiction (3.33%), and no addiction (33.33%). 33.33% of patients had regular bowel habits, while 66.66% had irregular ones, 41.66% sedentary, 40% active and 18.33% were moderately active. Infection rates were 40 percent during 0–6 months, 30 percent during 1–2 years, 16.66% during 6–12 months, and 13.33% during 2–5 years. 40% were other seasons, while 60% were the cold season. The current study showed that the probability of osteoarthritis was very high, particularly in those with a history of the condition in their family. Other symptoms included joint pain, progressive disease, average digestive capacity, no addiction, and bowel habits. cold-season patients, those who have been sedentary, irregular, or unwell for the past six months.

### **TAMILNADU EPIDEMIOLOGY**

#### **Deepak D Chitragar, et al.,(2016)**

In a Tamil Nadu, India, tertiary care hospital, they studied the factors linked to osteoarthritis in the knee. With a prevalence from 22% to 39% in India, osteoarthritis (OA) is the most common joint disease and second-most prevalent rheumatological issue. A cross-sectional study was conducted at three Tamilnadu private hospitals. Following informed written consent, a total of 135 patients were interviewed. They were questioned about their postures, symptoms, physical activity, and other things. The largest proportion of patients (37.04%) were between the ages of 61 and 70. The age group of 51 to 60 years (29.63%) came next. The study group included 91 patients, or 67.41 percent, who were female. Just 12 patients (8.89%) lacked literacy. The majority of patients have finished their secondary education. Given the female preponderance, we discovered that 52 patients (38.52%) were housewives. In contrast, 22 patients (16.30%) were laborers. Since 79 (58.52%) of the patients had an obesity BMI, it was a significant predictor of OA. Squatting and cross-legged postures were seen to be used by OA patients in their daily activities. Persistent pain (27.31%) and usage-related pain (42.22%) were the most prevalent symptoms. Crepitus was the most prevalent symptom, followed by bony growth. According to the current study, the most prevalent age group for knee OA is between 61 and 70 years old. The study also reveals that women predominate. One of the most prevalent risk factors is being overweight or obese. Patients who use Indian-style toilets, squat with their legs crossed, and bend throughout daily chores are more likely to be impacted. Usage-related pain is the most prevalent symptom, followed by chronic pain. Crepitus is the most typical symptom, and bony expansion follows.

### **REVIEW ON CONDITION**

#### **Ruizhi Geng, et al., (2023)**

According to a study they carried out, knee osteoarthritis (KOA) is a prevalent chronic articular

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condition in the world. With significant rates of morbidity and disability, it is also the most prevalent type of OA. As the population ages and life expectancy gradually rises, KOA has an impact on patients' quality of life and puts a strain on public health worldwide. The etiology of OA is uncertain, and its pathophysiology is complex. Joints that are subjected to increased loads and levels of activity are frequently affected. OA is more likely to occur in the knee joint since it is the most complicated joint in human beings and it carries the most weight of any joint. Irreversible articular injury can result from KOA lesions that affect the periarticular muscles, joint capsule, synovium, and articular cartilage. Mechanical overload, inflammation, metabolism, hormonal changes, and aging are some of the factors that contribute to the accelerated course of KOA. A comprehensive study of symptoms, signs, imaging, and laboratory test results is the main basis for the medical diagnosis of KOA. There is currently no cure for KOA, and the treatments that are available mostly target symptom management and slowing the course of the condition. Patients with advanced illness are usually the ones who have knee replacement surgery. The epidemiological features, risk factors, histological symptoms, pathogenesis, diagnosis, treatment options, and advancements in KOA research are reviewed in this article.

### REVIEW ON VISUAL ANALOGUE SCALE

**Mst Rabea Begum, et al., (2019)**

The validity and reliability of the visual analogue scale (VAS) for measuring pain were investigated. For this study, a critical examination was conducted. This study includes ten studies in total. Cross-sectional studies make up the majority of study designs. The majority of research employed spearman correlation in their analysis to determine the study's strength. The participants were older than eighteen. The majority of research use a pain measuring scale to measure post-operative discomfort. The scales that were used were the facial pain scale, the color analogue scale, the numerical rating scale, and the visual analogue scale. Most of the investigations demonstrated the validity and reliability of the visual analog scale. It is an interval scale as well. Therefore, this scale can be used as an outcome measure instrument in clinical practice for measuring pain.

### REVIEW ON HAND HELD DYNAMOMETER

**Won Kuel Kim, et al.,(2014)**

By comparing the results with an isokinetic dynamometer, they conducted a study to ascertain the validity and reliability of the hand-held dynamometer (HHD) based on its fixation for measuring isometric knee extensor strength. In this study, twenty-seven female volunteers in good health took part. Three measuring techniques were used to assess the patients in seated & supine

positions: non-fixed HHD, fixed HHD, and isometric knee extension using an isokinetic dynamometer. The patients' knee joints were fixed at a 35° angle from the extended position for the measurement. A Velcro strap was used to secure the HHD to the distal tibia for the fixed HHD measurement, while a hand-held technique without Velcro fixation was used for the non-fixed HHD.

Every measurement was made three times, and the analysis was conducted using the highest peak torque values. When compared to the isokinetic dynamometer results, the data from the fixed HHD approach demonstrated greater validity in comparison to non-fixed method. Fixed HHD and isokinetic dynamometer methods had statistically significant Pearson correlation coefficients ( $r$ ) (supine-right:  $r=0.806$ ,  $p<0.05$ ; seating-right:  $r=0.473$ ,  $p<0.05$ ; supine-left:  $r=0.524$ ,  $p<0.05$ ). In contrast, non-fixed dynamometer and isokinetic dynamometer methods did not have statistically significant Pearson correlation coefficients ( $r$ ), with the exception of the left leg's result ( $r=0.384$ ,  $p<0.05$ ). High inter-rater reliability was demonstrated by both fixed as well as non-fixed HHD techniques. However, after taking into account the intraclass correlation value, the fixed HHD approach demonstrated greater dependability than the non-fixed HHD method (fixed HHD, 0.952-0.984; non-fixed HHD, 0.940-0.963). Fixing HHD while in the supine position improves the validity and reliability of quadriceps strength measurements.

### REVIEW ON KNEE EXTENSOR BIOFEEDBACK TRAINING

**Amanda E Munsch, et al., (2020)**

They studied how quadriceps contractile behavior and gait biomechanics were affected by knee extensor moment biofeedback. People who have knee joint diseases have quadriceps dysfunction, which shows up as decreased knee flexion excursion and a lesser peak knee extensor moment (pKEM) during walking. These alterations may influence the stance phase knee joint loading that is thought to be significant to the risk of osteoarthritis, and they continue even after muscle strengthening. To lower this risk, new rehabilitation techniques are required that more directly increase the mechanical output of the quadriceps during functional activities. We examined the effectiveness of real-time biofeedback during walking to prescribe modifications of  $\pm 20\%$  and  $\pm 40\%$  of typical walking pKEM values in 11 young individuals without injuries as a crucial first step.

We concurrently collected ground response forces, knee joint kinematics, and the behavior of the vastus lateralis (VL) fascicle length variation using ultrasonography. In addition to averaging up to 55% bigger and 51% smaller than normal pKEM readings with concurrent and perhaps beneficial changes in knee flexion excursion, participants successfully responded to real-time biofeedback. The VL

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fascicles primarily supported weight acceptance while walking through isometric, or even modest concentric, action rather than eccentric activity as is typically assumed, even though the VL muscle-tendon unit (MTU) grew longer. In order to induce desired changes in knee joint kinematics thought to be pertinent to the formation of osteoarthritis, targeted pKEM biofeedback may be a helpful scientific and/or rehabilitation technique.

### REVIEW ON KNEE INJURY AND OSTEOARTHRITIS OUTCOME SCORE(KOOS)

**B Gandek, et al., (2019)**

They conducted a study to assess the validity, responsiveness, and reliability of KOOS-12, a 12-item condensed version of the 42-item Knee Injury and Osteoarthritis Outcome Score (KOOS), which yields a summary knee impact score as well as Pain, Function, and Quality of Life (QOL) scale scores. The FORCE-TJR research group included 1,392 knee osteoarthritis (OA) patients who underwent KOOS before to, and six and twelve months following, total knee replacement (TKR). The KOOS-12 comprises the 4-item KOOS QOL scale, function items about standing, getting up from a sitting position, getting in and out of a car, and twisting/pivoting, as well as a pain frequency item & three items assessing pain during progressively challenging tasks (sitting/lying, walking, stairs). The KOOS-12, full-length KOOS, KOOS-PS, and KOOS, JR were compared for percent computable scale scores, floor and ceiling effects, internal consistency reliability, validity (scale correlations, tests of known groups validity using one-way analysis of variance (ANOVA)), and responsiveness (effect sizes, standardized response means). Internal consistency reliability was  $\geq 0.90$  for the KOOS-12 Summary score and above 0.70 for all KOOS-12 scales. The KOOS-12 Pain, Function, and QOL scales had satisfactory validity and responsiveness, and their results were equivalent to those of similar full-length KOOS scales. The KOOS-12 Summary score had the largest effect sizes and standardized answer means, and it was most responsive in differentiating between groups that varied in global judgments of post-TKR change in physical capabilities. In TKR patients with moderate to severe OA, KOOS-12 was a viable and dependable substitute for KOOS. It offered three domain-specific as well as summary knee impact scores with a significantly lower respondent burden.

### METHODOLOGY

#### Study Design

To assess the impact of knee extensor biofeedback training on pain, quadriceps muscle power and activities of daily living in patients with primary knee osteoarthritis, a quasi-experimental pre-post intervention study will be carried out. At baseline and at the end of the intervention period, participants will be evaluated.

#### Study Setting

#### Study Population

Participants aged 40–55 years diagnosed with primary knee osteoarthritis based on clinical and radiographic criteria were recruited.

#### Sampling Technique

A convenient sampling technique will be used to recruit eligible participants who meet the inclusion criteria during the study period.

#### Sample Size

A total of 10 participants will be included in the study

#### Study Duration

The total duration of the study will be 5 months. Each participant will undergo intervention for 4 weeks, with assessments conducted at baseline and at the end of the intervention period.

#### Inclusion Criteria

1. Patients aged between **40 and 55 years**.
2. Clinically and radiographically diagnosed cases of **primary knee osteoarthritis (Kellgren–Lawrence Grade I–II)**.
3. Presence of **unilateral knee pain** persisting for more than **3 months**.
4. Pain intensity of **(4-7) on the Visual Analogue Scale (VAS)**.
5. Ability to perform active knee extension against gravity.
6. Both male and female participants willing to comply with the intervention protocol.
7. Participants who provide **written informed consent** to participate in the study.

#### Exclusion Criteria

1. Secondary osteoarthritis due to **trauma, inflammatory arthritis (e.g., rheumatoid arthritis), metabolic disorders, or infection**.
2. Participants diagnosed with **severe osteopenia or osteoporosis (T-score  $\leq -2.5$ )**
3. History of **knee surgery within the past 6 months**.
4. Presence of **neurological disorders** affecting lower limb motor control (e.g., stroke, peripheral neuropathy).
5. Severe **cardiovascular or pulmonary conditions** contraindicating exercise participation.
6. Intra-articular steroid injection in the affected knee within the **previous 3 months**.
7. Cognitive impairment or any condition that interferes with the ability to understand instructions or follow the biofeedback training protocol.

#### Outcome Measures

**Independent Variable:** Knee extensor biofeedback training with conventional therapy

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**Dependent variables**

1. **Pain** – Visual Analogue Scale (VAS)
2. **Quadriceps Muscle Power** – Measured using standardized dynamometric/functional power assessment
3. **Activities of Daily Living (ADL)** – Assessed using the KOOS-12 questionnaire

**Monitoring of Study Implementation and Quality Assurance:**

Every subject had the same electrode placement, workout routine, number of repetitions, and length of treatment. To guarantee consistency and dependability, outcome measures were evaluated through the use of standardized techniques. Throughout the trial, participant compliance and attendance were documented. Immediately after assessment, all data were recorded and their accuracy confirmed. To guarantee safety, participants were watched for any unfavorable incidents throughout the intervention time.

**Procedure**

The purpose of this pre-post experimental investigation was to assess how well knee extensor biofeedback training affected patients with primary knee osteoarthritis in terms of pain, quadriceps muscle power, and daily living activities. Prior to the study's start, the Committee of Institutional Ethics granted ethical approval, and each participant provided signed informed permission. Participants between the ages of 40 and 55 who had been confirmed to have primary knee osteoarthritis were chosen based on criteria for inclusion and exclusion. After giving their consent, eligible participants were enrolled after being told about the study's methodology. Baseline measurements were taken before the intervention. The Visual Analog Scale (VAS) was used to measure the degree of pain. A standardized handheld dynamometric assessment method was used to quantify the power of the quadriceps muscle. To evaluate functional state and daily living activities, the KOOS-12 questionnaire was used.

**Interventions:**

Participants received knee extensor strengthening using electromyographic (EMG) biofeedback in combination with conventional physiotherapy treatment. The intervention was administered for a duration of 4 weeks, with sessions conducted 5 days per week.

S. No	Pain	Quadriiceps Muscle Power (Kg)	KOOS-12 question naire
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	P re te st	Po st tes t	Pr e te st	Po st tes t	Pre test	Post test
1	7	4	4.2	5.5	42	64
2	7	3	5.8	7.1	48	68
3	6	4	4.6	5.9	51	72
4	6	4	7.2	8.6	39	60
5	8	2	3.5	6.5	55	76
6	8	5	3.4	5.8	46	67
7	6	3	6.5	7.2	52	74
8	6	2	6.9	8.1	44	66
9	6	4	7.1	8.1	58	79
10	7	3	8.5	10.5	49	70

**Statistical analyses:**

Data were analysed using IBM SPSS Software. Descriptive statistics were calculated as mean and standard deviation. Normality of data was assessed using the Shapiro–Wilk test. Pre- and post-intervention differences in pain, quadriceps muscle power, and KOOS-12 scores were analysed using the paired t-test. Effect size was calculated using Cohen's d. The level of significance was set at  $p < 0.05$ .

**Table 1: Pain (VAS)**

Test	Mean	SD	Calculated value	Table t value	Level of significance
Pre-test	6.70	0.82	8.34	2.262	$p < 0.001$ (Highly significant)
Post-test	3.40	0.97			

The mean pain score measured using Visual Analogue Scale reduced from  $6.70 \pm 0.82$  in the pre-test to  $3.40 \pm 0.97$  in the post-test following knee extensor biofeedback training combined with conventional physiotherapy. The calculated t value (8.34) was greater than the table t value (2.262) at 0.05 level of significance, indicating a statistically highly significant reduction in pain. This result suggests that the intervention was effective in reducing pain in patients with primary knee osteoarthritis.

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**Table 2: Quadriceps Muscle Power:**

Test	Mean	SD	Calculated t value	Table t value	Level of significance
Pre-test	5.77	1.75	7.07	2.262	p < 0.001 (Highly significant)
Post-test	7.33	1.54			

The mean quadriceps muscle power increased from  $5.77 \pm 1.75$  kg in the pre-test to  $7.33 \pm 1.54$  kg in the post-test. The calculated t value (7.07) exceeded the table t value (2.262), indicating a statistically highly significant improvement. This demonstrates that knee extensor biofeedback training combined with conventional physiotherapy was effective in improving quadriceps muscle power in patients with primary knee osteoarthritis.

**Table 3: Activities of Daily Living (KOOS-12):**

Test	Mean	SD	Calculated t value	Table t value	Level of significance
Pre-test	48.40	5.87	22.51	2.262	p < 0.001 (Highly significant)
Post-test	64.30	7.92			

The mean KOOS-12 score improved from  $48.40 \pm 5.87$  in the pre-test to  $64.30 \pm 7.92$  in the post-test. The calculated t value (22.51) was greater than the table t value (2.262), indicating a statistically highly significant improvement. This finding suggests that knee extensor biofeedback training combined with conventional physiotherapy significantly improved activities of daily living in patients with primary knee osteoarthritis.

### DISCUSSION:

To find out if real-time feedback could alter walking mechanics and muscle activation patterns, Amanda et al. examined the impact of knee extensor moment biofeedback upon gait biomechanics along with quadriceps contractile behavior. According to the scientists, improved quadriceps activation & improved knee joint loading patterns in the stance phase resulted from biofeedback that targeted the knee extensor moment during walking. Participants showed improved quadriceps contractile behavior, higher extensor moment generation, as well as improved control over knee flexion. These results imply that knee extensor moment biofeedback could be a useful tactic for enhancing neuromuscular function and gait mechanics, especially in people

with quadriceps weakness or knee joint disease such as osteoarthritis.

In individuals who have primary knee osteoarthritis (OA), the current study sought to assess the impact of knee extensor biofeedback conditioning on quadriceps muscle power and pain reduction. The results showed a quantifiable increase in quadriceps muscular strength after the intervention period and a statistically significant decrease in pain severity. These findings lend credence to the idea that training the quadriceps with biofeedback improves neuromuscular activation and helps people with knee OA operate better.

One well-established disability in primary knee OA is quadriceps weakness, which is closely linked to increased pain intensity, unstable joints, and decreased functional performance. Joint inflammation, effusion, along with nociceptive input all cause arthrogenic muscular inhibition (AMI), which restricts voluntary muscle activation therefore lowers the creation of extensor torque. The neuromuscular facilitation resulting from biofeedback training may be responsible for the increase in quadriceps strength seen in this study. Biofeedback overcomes inhibitory reflex pathways by improving cortical awareness and also motor unit recruitment during muscular contraction through real-time auditory or visual feedback. Increased voluntary activation and better isometric force output as determined by a handheld dynamometer were probably facilitated by this mechanism.

There are several possible explanations for the reported decrease in pain intensity following the operation. Strengthening the quadriceps improves the stability of the knee joint and lessens aberrant mechanical strain on degenerative articulating surfaces. Reduced peripheral nociceptive stimulation results from improved shock absorption throughout weight-bearing exercises, which lessens the strain on the synovium and subchondral bone. Moreover, large-diameter afferent fibers are stimulated by active muscular contraction and may use spinal gating processes to modify pain perception. Pain may be reduced by improved periarticular tissue circulation and metabolic exchange, which may also help to reduce the buildup of inflammatory mediators.

In patients with primary knee osteoarthritis (OA), knee extensor biofeedback training reduces pain and improves quadriceps muscle strength through a combination of neuromuscular, biomechanical, as well as neurophysiological mechanisms. Due in great part to arthrogenic muscle inhibition (AMI), some reflexive neural inhibition brought on by painful joints, inflammation, and effusion, quadriceps weakness is one of the main pathological characteristics of knee OA. Despite having intact muscle tissue, AMI limits the voluntary recruitment of the quadriceps muscle by interfering with normal motor neuron excitability. By providing real-time

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visual or auditory cues that correlate to muscle activation levels, biofeedback training improves voluntary recruitment of motor units and cortical awareness. By overcoming inhibitory reflex circuits, this procedure helps the knee extensors regain their ideal neuromuscular control.

By improving the connectivity across peripheral mechanoreceptors with central motor pathways, biofeedback improves sensorimotor integration from a neurophysiological standpoint. Muscle contractions become more effective and coordinated when cortical remodeling and motor learning are enhanced through repeated stimulation with augmented feedback. Strengthening of the isometric and dynamic quadriceps is a result of increased activation of high-threshold motor components and improved firing frequency. Consistent activation improves muscular cross-sectional area, increases force-generating ability, and causes hypertrophic changes over time, all of which increase quadriceps muscle power.

Stronger quadriceps muscles are biomechanically linked to better alignment and stability of the knee joint when bearing weight. Increased extensor torque lessens stress on degenerative articular surfaces and aberrant joint loading. Better shock absorption reduces mechanical irritation of the synovial fluid and subchondral bone during locomotion and functional activities including stair climbing and also sit-to-stand transitions. The loop of discomfort and protective muscle inhibition is broken by this decrease in excessive joint stress, enabling more effective movement patterns and enhanced functional performance.

Neurophysiological modulation of pain mechanisms can also account for the pain reduction linked to knee extensor biofeedback training. Increased muscular activation lowers inflammatory mediators in the joint area by improving regional blood flow and metabolic exchange. Additionally, according to the gate control theory of pain, vigorous muscular contraction activates large-diameter afferent fibers, which may block nociceptive transmission in the spinal cord level. Reduced mechanical strain and increased joint stability also lessen peripheral nociceptive input, which lowers the perceived degree of pain as determined by instruments like the Visual Analogue Scale (VAS).

Furthermore, biofeedback training fosters movement assurance and psychological confidence. Real-time feedback promotes active engagement in rehabilitation, lessens kinesiophobia (fear of movement), and validates successful muscle activation. This cognitive-behavioral element improves exercise program adherence and indirectly supports functional gains in everyday life tasks.

### Conclusion

According to the current study, individuals who have primary knee osteoarthritis can benefit from knee extensor biofeedback training as an intervention to

improve quadriceps muscle power and reduce discomfort. The results show a significant decrease in pain intensity as judged by the Visual Analogue Scale and a significant improvement in quadriceps strength as measured using handheld dynamometry. The intervention's therapeutic relevance is further supported by gains in functional performance as well as activities of daily living (as determined by the KOOS-12, if applicable).

Biofeedback training improves knee joint stability & functional mobility by resolving arthrogenic muscle inhibition and increasing quadriceps neuromuscular activation. Thus, in the conservative treatment of primary knee osteoarthritis, knee extensor biofeedback sessions might be regarded as a useful supplement to traditional physiotherapy. To prove long-term efficacy and wider therapeutic relevance, more extensive randomized controlled trials were advised.

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