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Effectiveness of Static Strengthening with Neuromuscular Electrical Stimulation and Dynamic Strengthening with Ultrasound for Improving Pain, Muscle Strength, and Functional Mobility in Women with Knee Osteoarthritis

Dr. Nancy Sharma[1], Dr. Danish Nouman[2], Dr. Rashmi Kumari[3]
PG Student[1], Associate Professor[2], PG Student
Jyotirao Phule Subharti College of Physiotherapy, SVSU, Meerut[1]

1. ABSTRACT

1.1. Background

Osteoarthritis is a widespread musculoskeletal disorder that causes inflammation in one or more joints. Although the disease can affect any joint in the body, it is most common in the knees. As osteoarthritis progresses, the pain worsens. Almost 6% of all adults have osteoarthritis. Women are more affected than men due to their sedentary lifestyle. Many studies have looked at various treatment options for osteoarthritis. Both static strengthening with neuromuscular electrical stimulation and dynamic strengthening with ultrasound have been shown to be effective in treating musculoskeletal disorders. This study seeks to close this disparity.

1.2. Purpose

The primary purpose of this study is to compare the effectiveness of static strengthening with neuromuscular electrical stimulation and dynamic strengthening with ultrasound in improving pain, muscle strength, and functional mobility in women with knee osteoarthritis.

1.3. Result:

According to the results, women with osteoarthritis in their knees can improve their pain, muscle strength, and functional mobility more effectively with dynamic strengthening exercises with therapeutic ultrasound (US) rather than static strengthening with neuromuscular stimulation (NMES). The variance test showed a significant value of $P<0.05$.

1.4. Keywords:

Static strengthening exercise (SSE), Dynamic strengthening exercise (DSE), Neuromuscular stimulation (NMES), Ultrasound (US), western Ontario and McMaster universities osteoarthritis index (WOMAC), Timed Up and Go (TUG) test.

2. INTRODUCTION

Focused regions of articular cartilage loss within synovial joints, linked to bone hypertrophy and capsule thickening, are the hallmark of osteoarthritis (OA). Clinically, the illness is typified by varying degrees of local inflammation, joint pain, tenderness, movement restriction, crepitus, and sporadic effusion by 2020.[1] osteoarthritis is predicted to rank as the fourth most common cause of disability due to rising life expectancy. Although the disease typically progresses slowly, it can eventually result in joint failure that causes pain and disability.

Although OA can develop in any joint, it most frequently affects the hands, feet, knees, hips, and facet joints.[2] An estimated 9.6% of men and 18.0% of women over 60 have symptomatic osteoarthritis globally, compared to 14–47% in India. Due to the fact that osteoarthritis cannot be reversed, its prevalence rises steadily with age. [3] Osteoarthritis affects more men than women before the age of 45, but it affects women more frequently after that. [4]

Indian women reach menopause at an average age of 46.3 years, while women in Western nations reach menopause at 54 years. [5] Compared to their Western counterparts, this puts Indian women at a higher risk of osteoarthritis at a younger age. It might be brought on by oestrogen loss, particularly during this period near menopause.[6] Although the exact cause of OA is unknown, recent research suggests that it has multiple contributing factors. Age, female sex, obesity, knee bending at work, physical labour, genetic and racial factors, joint trauma, vitamin D deficiency, and chondrocalcinosis are major risk factors for osteoarthritis. [7]

It has been made worse by lifestyle diseases like diabetes, obesity, and inadequate exercise. It is exacerbated by trauma, inflammatory diseases, and improper posture. These issues are exacerbated for women in the perimenopausal age range who gain weight, lose oestrogen protection, and become less mobile and active. [8]

STATIC STRENGTHENING

Muscle contractions without joint movement are a component of static strengthening exercises, sometimes referred to as isometric exercises. Because they strengthen the muscles supporting the knee without putting undue strain on the joint, these exercises are especially helpful for people with osteoarthritis or knee pain. By strengthening the surrounding muscles and improving joint support, isometric exercises can help reduce knee pain. It is also essential for preserving knee stability and function. [9]

3. DYNAMIC STRENGTHENING

Isokinetic exercise is a form of speed-constant training also known as dynamic strengthening exercises, The velocity of the joint motion is constant, excluding acceleration to and deceleration from the designated

speed, and the force is proportional to how hard the individual pushes against the load cell. The exercise can be used at low, moderate, and high speeds for various evaluations and rehabilitation programs and produces reliable results.

Isotonic exercises have also been widely used in athletic and clinical settings. Research suggests that these exercises can prevent sarcopenia and loss of muscle strength should be included in early rehabilitation programs.[10]

One of the non-invasive therapeutic modalities is neuromuscular electrical stimulation (NMES), which physical therapists use to (1) strengthen muscles, (2) minimise muscle hypotrophy, (3) lessen muscle spasm and spasticity, and (4) increase joint range of motion. In the context of treating knee OA, NMES has been proposed as an alternative therapy for strengthening the quadriceps muscles, particularly in older adults who are unable to perform voluntary exercises due to chronic pain and joint stiffness. [11]

Therapeutic ultrasound (US) is a deep heating agent that converts mechanical energy into sound waves. This is accomplished by sending an electrical current through a crystal. The electric current causes the crystal to expand and contract, converting electrical energy into mechanical energy in the form of sound waves (the "piezoelectric effect"). The resulting mechanical sonic energy is absorbed in the target tissue and converted back into thermal energy, causing deeper tissues to heat up. [12]

4. MATERIALS AND METHODOLOGY:

4.1. Objective of the study:

To compare the effectiveness of static strengthening with neuromuscular electrical stimulation versus dynamic strengthening with ultrasound for improving pain, muscle strength, and functional mobility in women with knee osteoarthritis.

4.2. Study design:

A randomized controlled trial (RCT)

4.3. Sampling Method:

A simple random sampling method was used to recruit participants from Jyotirao Phule Subharti college of physiotherapy OPD. The participants were then randomly allocated to one of two groups: Group A (Static Strengthening with NEMS) or Group B (Dynamic Strengthening with Ultrasound therapy).

4.4. Duration of Study:

The study was conducted over a six-week period. Sample Size A total of 80 participants were divided with 40 participants in each group.

4.5. Inclusion criteria:

- Pain, crepitus, stiffness
- Age≥40 years
- Female participants only,
- Pain duration (≥3 months)
- Functional limitations in daily activities,

4.6. Exclusion criteria:

- Joint Diseases: Rheumatoid arthritis, gout, psoriatic arthritis, or other inflammatory arthropathies
- Knee Deformities: Valgus/varus deformities beyond a specific degree
- Total Knee Replacement
- Total knee Arthroplasty
- Recent knee surgeries (within the past 6–12 months)
- Acute Injuries: Recent ligamentous or meniscal injuries
- Fractures

4.7. Tools used in the study:

- WOMAC: for pain score.
- Dynamometer: for Muscle Strength
- Timed Up and Go (TUG) test: for Functional Mobility

5. METHODOLOGY

Participants were randomly divided into two groups. Group A received static strengthening exercise with neuromuscular electrical stimulation (50 Hz, 5s contraction, 15s rest, 20 min/session, 3x/week). while Group B performed dynamic strengthening exercises with ultrasound therapy (1 MHz, 1.5 W/cm², 6 min/session). Both groups received treatment thrice a week for eight weeks. Pain and functional assessments were conducted at baseline, after four weeks, and at the end of the study.

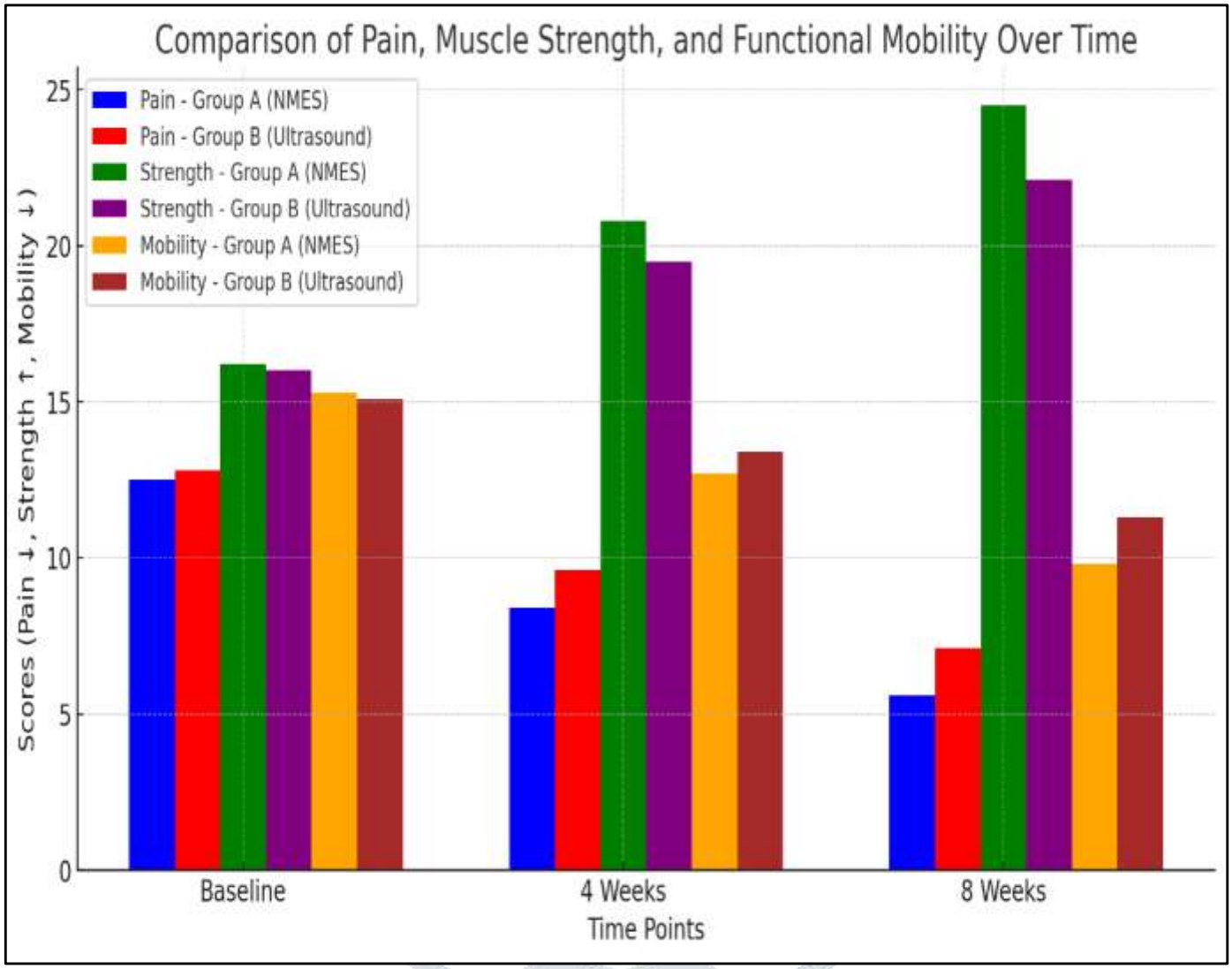
6. RESULTS AND DATA ANALYSIS

Parameter	Group A (Static Strengthening with NMES) (Mean ± SD)	Group B (Dynamic Strengthening with Ultrasound Therapy) (Mean ± SD)
Demographic Data		
Mean Age (Years)	52.3 ± 5.6	51.8 ± 5.2
Mean Pain Duration (Months)	7.2 ± 2.1	7.5 ± 2.3

Pain Assessment (WOMAC Score)		
Baseline	12.5 ± 2.4	12.8 ± 2.1
4 Weeks	8.4 ± 1.9	9.6 ± 2.0
8 Weeks	5.6 ± 1.6	7.1 ± 1.8
Muscle Strength (Dynamometer Score in kg)		
Baseline	16.2 ± 2.8	16.0 ± 3.1
4 Weeks	20.8 ± 3.2	19.5 ± 3.0
8 Weeks	24.5 ± 3.6	22.1 ± 3.4
Functional Mobility (TUG Test in Seconds)		
Baseline	15.3 ± 2.7	15.1 ± 2.5
4 Weeks	12.7 ± 2.2	13.4 ± 2.1
8 Weeks	9.8 ± 2.0	11.3 ± 2.2

6.1. Statistical Analysis:

A paired t-test was performed for within-group analysis, and an independent t-test was used to compare between-group differences. Group A demonstrated a statistically significant improvement in all parameters compared to Group B ($p<0.05$).



6.2. Discussion

The study compared the effectiveness of static strengthening with neuromuscular electrical stimulation (NMES) and dynamic strengthening with ultrasound in improving pain, muscle strength, and functional mobility in women with knee osteoarthritis. Results showed that dynamic strengthening with ultrasound therapy was more effective than NMES in reducing pain levels, muscle strength, and functional mobility. The WOMAC pain index showed that both intervention groups had significantly lower pain levels, with the dynamic strengthening group showing greater overall improvement due to improved circulation, tissue healing, and muscle engagement. Dynamic strengthening with ultrasound therapy resulted in a more significant increase in quadriceps strength, consistent with previous research by Lee et al., which found that isotonic and isokinetic resistance training combined with ultrasound therapy can increase muscle hypertrophy and endurance [10].

7. Conclusion

NMES, combined with static strengthening, has shown superior outcomes in managing knee osteoarthritis symptoms in women, particularly those with OA, enhancing muscle strength and functional mobility.

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