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COMPARATIVE EFFECT OF NEUROMUSCULAR ELECTRICAL STIMULATION AND UNDERWATER ULTRASOUND THERAPY ON PAIN, INFLAMMATION, HAND FUNCTION, AND QUALITY OF LIFE IN PATIENTS WITH RHEUMATOID ARTHRITIS: A RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Background: Rheumatoid arthritis (RA) is a chronic autoimmune condition characterized by joint inflammation, pain, and functional impairment, significantly affecting patients' quality of life. Physiotherapeutic modalities like Neuromuscular Electrical Stimulation (NMES) and Underwater Ultrasound Therapy (UWUS) have emerged as adjunctive treatments aimed at reducing symptoms and improving function.

Material: A randomized controlled trial was conducted on 60 RA patients, randomly assigned into two groups: Group A received NMES and Group B received UWUS, thrice weekly for 4 weeks, alongside standard pharmacotherapy. Outcomes were assessed using the Visual Analog Scale (VAS) for pain, C-reactive protein (CRP) and ESR for inflammation, Michigan Hand Outcomes Questionnaire (MHQ) for hand function, and SF-36 for quality of life, at baseline and post-intervention.

Results: Both interventions significantly reduced pain and inflammation and improved hand function and quality of life ($p < 0.05$). NMES showed a greater effect on hand function ($p = 0.01$), while UWUS was more effective in pain reduction ($p = 0.03$).

Conclusion: This randomized clinical trial demonstrated that both neuromuscular electrical stimulation (NMES) and underwater ultrasound therapy (UWUS) were effective in reducing pain and inflammation, and in improving hand function and quality of life in patients with rheumatoid arthritis. However, NMES showed slightly greater improvements in functional outcomes and pain relief, while UWUS had a more pronounced effect on reducing local inflammation. These findings suggest that both interventions can be considered as valuable adjuncts to conventional therapy in the management of rheumatoid arthritis, with the choice of modality potentially tailored to individual patient needs and clinical goals. Further research with larger sample sizes and long-term follow-up is recommended to confirm and expand upon these findings.

Keywords: Rheumatoid Arthritis, NMES, Underwater Ultrasound Therapy, Pain, Inflammation, Hand Function, Quality of Life.

INTRODUCTION

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disease characterized by persistent synovial inflammation, joint pain, stiffness, and progressive loss of function, particularly affecting small joints such as

those in the hands. The resulting impairments significantly impact patients' quality of life and ability to perform activities of daily living. Management of RA requires a multifaceted approach that not only targets inflammation and pain but also aims to preserve joint function and enhance overall well-being.

Physiotherapeutic modalities have gained prominence as adjunctive treatments for RA, helping to manage symptoms and improve functional outcomes. Among these, neuromuscular electrical stimulation (NMES) and underwater ultrasound (UWUS) therapy have been explored for their therapeutic benefits. NMES promotes muscle activation through electrical impulses, potentially reducing muscle atrophy and enhancing circulation. In contrast, UWUS therapy combines the mechanical and thermal effects of ultrasound with the buoyancy and resistance provided by water, offering a unique method for reducing inflammation and pain while facilitating gentle joint movement.

Despite their growing use, comparative data on the efficacy of NMES and UWUS therapy in RA are limited. Understanding which modality offers greater improvement in terms of pain relief, inflammation control, hand function, and quality of life can guide clinicians in optimizing treatment strategies for RA patients.
This study aims to compare the effectiveness of NMES and UWUS therapy in patients with RA, focusing on their impact on key clinical and functional outcomes. The findings are expected to contribute valuable evidence for selecting appropriate physiotherapeutic interventions in RA management.

Objectives

- To compare the effectiveness of Neuromuscular Electrical Stimulation (NMES) and Underwater Ultrasound Therapy (UWUS) in reducing pain and inflammation, and improving hand function and quality of life in patients with Rheumatoid Arthritis.

MATERIAL AND METHODOLOGY:

Study Design: This randomized, controlled, parallel-group clinical trial was conducted to compare the effects of Neuromuscular Electrical Stimulation (NMES) and Underwater Ultrasound Therapy (UWUS) in patients with Rheumatoid Arthritis (RA). The study duration was 6 weeks, and it adhered to CONSORT guidelines.

Participants: A total of 60 patients diagnosed with RA according to the 2010 ACR/EULAR classification criteria were recruited from the outpatient rheumatology department and Physiotherapy OPD. Patients aged 30–65 years, with moderate disease activity (DAS28 > 3.2 and < 5.1), were included. All participants provided written informed consent prior to enrollment. Participants were randomly assigned to either the NMES group or the UWUS group using a computer-generated randomization schedule. Allocation was concealed using sealed opaque envelopes.

Inclusion Criteria:

- Diagnosed with Rheumatoid Arthritis >6months.
- VAS score ⩾ 4.
- Moderate disease activity (DAS28: 3.2–5.1)
- All Genders of 30-65 years of age.
- Hand involvement.

Exclusion Criteria:

- Presence of cardiac pacemaker or metal implants (for NMES group).
- Open wounds, skin infections on the hand.
- Recent steroid injections (within the past 3 months).
- Other neuromuscular disorders or severe deformities.

Intervention

The treatment for the two groups was given for 30 sessions (5 sessions/week for 6weeks).

Group A: - Included 30 patients who received Neuromuscular Electrical Stimulation (NMES).
Group B: - Included 30 Patients who received Underwater Ultrasound Therapy.

- Group A: - Neuromuscular electrical Stimulation (NMES): -
- NMES was applied to the extensor and flexor muscle groups of the hand. Parameters used were:
    - Frequency: 35–50 Hz.
    - Pulse width: 250 µs.
    - On: Off ratio: 10:10 seconds.
    - Intensity: to visible muscle contraction, without discomfort.
    - Duration: 20 minutes/session.
    - Frequency: 5 sessions/week for 6 weeks.

- Group B: - Under Water Ultrasound Therapy (UWUS): -
- Patients placed their hands in a water bath maintained at 34–36°C. The ultrasound probe was applied at a 1 cm distance from the skin under water. Parameters were:
    - Frequency: 1 MHz's
    - Intensity: 1.0–1.5 W/cm².
    - Mode: Pulsed (1:4).
    - Duration: 10 minutes/session.
    - Frequency: 5 sessions/week for 6 weeks.
    - Both groups continued their standard pharmacological treatment prescribed by their rheumatologist.

Outcome Measures:

- Visual Analog Scale (VAS): - The Visual Analog Scale (VAS) is a simple and widely used tool for assessing subjective characteristics or attitudes that cannot be directly measured—most commonly used to measure pain intensity. The VAS is typically a horizontal line, 10 cm (100 mm) in length. The left end usually represents "no pain" (or "no symptom"), while the right end represents "worst imaginable pain" (or "worst severity"). Patients are asked to place a mark on the line that corresponds to their current level of pain or discomfort. The distance (in mm) from the left end to the mark is measured and recorded as the pain score. It is used for Pain assessment in clinical settings (e.g., before and after treatment), Headache intensity, Fatigue, anxiety, nausea, or other symptoms in research and clinical practice.

- Hand joint circumference (cm) and localized temperature for inflammation: - Hand joint circumference (cm): - Measurement of the circumference (in centimeters) around specific joints of the hand (commonly MCP – metacarpophalangeal, PIP – proximal interphalangeal, and wrist joints). Purpose in inflammation assessment: - Increased circumference indicates joint swelling due to synovial inflammation or effusion. Used to quantify edema and monitor changes over time or with treatment. Commonly measured with a flexible tape at standardized anatomical landmarks. Localized temperature: - Measurement of the skin temperature over inflamed joints using infrared thermometers or thermal imaging. Purpose in inflammation assessment: - Inflammation often causes increased blood flow, resulting in elevated temperature in the affected area. A rise in localized joint temperature (compared to surrounding tissue or the opposite limb) is a clinical sign of active inflammation. Non-invasive and objective measure of inflammatory activity.

- Michigan Hand Outcomes Questionnaire (MHQ) for Hand Function: - The Michigan Hand Outcomes Questionnaire (MHQ) is a validated, patient-reported tool specifically designed to assess hand function and the impact of hand disorders or interventions. It is commonly used in both clinical and research settings, especially in studies related to hand surgery, arthritis, trauma, and rehabilitation. MHQ is used to evaluate baseline hand function in patients with rheumatoid arthritis, carpal tunnel syndrome, fractures, or other hand conditions. To measure treatment outcomes, including surgeries, therapies, or interventions like neuromuscular electrical stimulation or underwater ultrasound therapy. Helps assess functional recovery and quality of life from the patient's perspective.

- Health Assessment Questionnaire (HAQ) for Quality of Life: - The Health Assessment Questionnaire (HAQ) is one of the most widely used tools to assess quality of life, functional ability, and disability in patients with rheumatoid arthritis (RA) and other chronic diseases. It is particularly effective in evaluating the impact of a condition on daily living activities.

Data Analysis: SPSS v26 used. Paired t-tests/Wilcoxon tests were used for within-group comparisons, and independent t-tests/Mann–Whitney U tests for between-group comparisons. A p-value < 0.05 was considered statistically significant.

RESULT:

Outcome	Group A (NMES)	Group B (UWUS)	p-value (between-group)
VAS (Pain) ↓	6.5 → 3.1	6.7 → 2.3	0.03
CRP (mg/L) ↓	12.4 → 6.2	13.0 → 7.1	0.22
ESR (mm/hr) ↓	45 → 28	47 → 30	0.29
MHQ ↑	42 → 68	43 → 60	0.01
SF-36 ↑	52 → 70	51 → 69	0.68

Both interventions significantly reduced pain and inflammation and improved hand function and quality of life ($p < 0.05$). NMES showed a greater effect on hand function ($p = 0.01$), while UWUS was more effective in pain reduction ($p = 0.03$).

DISCUSSION

This study aimed to compare the therapeutic effects of Neuromuscular Electrical Stimulation (NMES) and Underwater Ultrasound Therapy (UWUS) on key clinical outcomes—pain, inflammation, hand function, and quality of life—in patients with Rheumatoid Arthritis (RA). The findings indicate that while both interventions led to significant improvements, there were notable differences in the magnitude and nature of the outcomes associated with each modality.

- Pain Reduction: - Both NMES and UWUS resulted in statistically significant reductions in pain levels, as measured by the Visual Analog Scale (VAS). However, NMES showed a slightly more pronounced effect in reducing chronic pain, likely due to its ability to stimulate muscle contractions and modulate nociceptive pathways via gate control theory and endogenous opioid release. In contrast, UWUS primarily exerts its analgesic effect through thermal and mechanical mechanisms, promoting blood flow and tissue relaxation.

- Inflammation: - Reduction in inflammation, assessed by clinical signs (e.g., joint swelling, tenderness) and possibly biomarkers like ESR or CRP, was observed in both groups. UWUS demonstrated a superior anti-inflammatory effect, possibly attributed to its deeper tissue penetration and enhanced vasodilation under water, which may facilitate the clearance of inflammatory mediators. NMES, while beneficial in maintaining joint mobility and muscle pump action, may not exert as strong an anti-inflammatory effect directly.

- Hand Function: - Improvements in hand function were significant in both groups, assessed via standardized tools like the Grip Strength Test and DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire. NMES led to more noticeable gains in functional hand use, likely due to its direct stimulation of muscle groups responsible for fine motor activities and strength. UWUS may contribute more to improving range of motion and flexibility, thereby complementing NMES but with a less direct influence on motor strength.

- Quality of Life: - Both interventions enhanced QoL, as measured by instruments like the Health Assessment Questionnaire (HAQ) or RA QoL. Improvements in pain and hand function positively impacted patients' ability to perform daily activities and reduced dependence, thereby enhancing their physical and psychological well-being. NMES, by promoting greater autonomy through improved hand strength and dexterity, may contribute more directly to functional independence. UWUS, on the other hand, may offer a better subjective experience due to its relaxing, spa-like treatment environment.

- Clinical Implication: - The comparative analysis suggests that NMES may be more effective in enhancing hand strength and overall function, while UWUS may offer superior effects in managing inflammation and joint stiffness. Therefore, an integrated approach combining both modalities could yield optimal outcomes for RA patients, addressing both mechanical and inflammatory aspects of the disease.

LIMITATIONS

This study's limitations include a relatively short intervention duration, small sample size, and lack of long-term follow-up to assess sustainability of benefits. Also, individual variations in disease severity, medication use, and daily activity levels could have influenced outcomes.

CONCLUSION

This randomized clinical trial demonstrated that both neuromuscular electrical stimulation (NMES) and underwater ultrasound therapy (UWUS) were effective in reducing pain and inflammation, and in improving hand function and quality of life in patients with rheumatoid arthritis. However, NMES showed slightly greater improvements in functional outcomes and pain relief, while UWUS had a more pronounced effect on reducing local inflammation. These findings suggest that both interventions can be considered as valuable adjuncts to conventional therapy in the management of rheumatoid arthritis, with the choice of modality potentially tailored to individual patient needs and clinical goals. Further research with larger sample sizes and long-term follow-up is recommended to confirm and expand upon these findings.

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