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EFFICACY OF PHYSICAL THERAPY IN MANAGING POST-BURN NEUROPATHIC PAIN: A RANDOMIZED CONTROLLED TRIAL IN PAKISTAN

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Abstract

Background: *Post-burn neuropathic pain (NP) is a common complication that hinders rehabilitation and quality of life. While pharmacologic management is prevalent, physical therapy (PT) offers a non-invasive, cost-effective alternative, especially in low-resource settings. Objective: To evaluate the efficacy of a structured PT program in reducing NP and improving functional outcomes among Pakistani burn patients.*

Methods: *A randomized controlled trial was conducted on 30 adult patients (13 females, 17 males; aged 20–50 years) at Civil Hospital Karachi. Patients with second- or third-degree burns and persistent NP were randomly allocated to PT (n=15) or control (n=15) groups. The PT group received a 4-week protocol of TENS, desensitization, ROM exercises, and functional training. Outcomes assessed were pain (VAS), joint range of motion (ROM), and functional independence (Modified Barthel Index).*

Results: *The PT group showed a significantly greater reduction in VAS pain scores (mean change −3.5 ± 1.0) compared to the control group (−1.2 ± 0.8;*

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p < 0.001). ROM improved by 30° ± 8° and Barthel Index by 22.5 ± 5.2 points in the PT group (both p < 0.001).

Conclusion: *Physical therapy significantly reduces NP and improves mobility and function. PT should be integrated into standard post-burn rehabilitation protocols in Pakistan.*

INTRODUCTION

Burn injuries continue to be a major public health concern worldwide, especially in low- and middle-income countries (LMICs) like Pakistan where limited resources and delayed access to specialized care exacerbate outcomes [1,2]. According to the World Health Organization, over 180,000 deaths annually are attributed to burns, and millions more suffer non-fatal injuries that require prolonged rehabilitation [3]. Post-burn neuropathic pain (NP) is a particularly debilitating sequela, resulting from damage to peripheral or central pain-processing pathways due to thermal or mechanical injury [4,5].

NP differs from nociceptive pain in its mechanism and presentation, often characterized by allodynia, hyperalgesia, and spontaneous pain that persists long after tissue healing [6]. These symptoms can severely affect quality of life, sleep, emotional well-being, and the ability to perform daily activities [7,8]. Conventional pharmacological interventions such as anticonvulsants (gabapentin, pregabalin), tricyclic antidepressants, and opioids remain widely used, but are often associated with side effects like dizziness, sedation, dependency, and limited efficacy in chronic stages [9-11].

The burden of burn injuries in Pakistan is significant, with underreporting and inadequate rehabilitative services in public hospitals [12]. There exists an urgent need for sustainable, low-cost, and effective alternatives for managing NP, especially in low-resource settings. Physical therapy (PT), encompassing modalities like Transcutaneous Electrical Nerve Stimulation (TENS), desensitization techniques, therapeutic exercises, and functional training, is a promising non-invasive approach [13-15].

TENS modulates nociceptive transmission via activation of non-nociceptive A-beta fibers and by stimulating endogenous opioid pathways, reducing pain perception at the spinal level [16,17]. Desensitization techniques retrain central sensitization pathways and have shown efficacy in managing tactile allodynia and reducing hypersensitivity [18,19]. Range of Motion (ROM) exercises not only enhance joint mobility but also facilitate neuroplastic adaptation by promoting synaptic reorganization and cortical remapping [20-22].

Globally, several randomized and observational studies have highlighted the role of physical rehabilitation in mitigating post-burn complications. For example, studies by Suman et al. [23] and Herndon et al. [24] demonstrated that early, structured PT interventions contribute to improved pain control, ROM, and functional independence. A community-based PT approach in pediatric burn survivors by Peña et al. [25] also revealed substantial psychosocial and physical gains.

Significance of the Study: Despite this strong global evidence, there is a scarcity of clinical trials evaluating the efficacy of PT for NP management in South Asian or Pakistani populations. Pakistan's tertiary care hospitals face severe gaps in post-burn rehabilitation. This study is significant because it introduces a locally tested, cost-effective PT protocol that may be scaled nationwide. Integrating PT into early burn care in Pakistan could reduce long-term disability and improve return-to-work rates and quality of life.

Objective: To assess the efficacy of a 4-week structured physical therapy program in reducing neuropathic pain and improving mobility and functional independence in adult burn patients at a public-sector hospital in Pakistan.

2. Methods

Study Design:

A single-center, parallel-group, prospective randomized controlled trial (RCT) conducted at the Burns Ward, Civil Hospital Karachi from January to June 2025 with each participant undergoing a 4-week intervention. Thirty adult patients aged 20–50 years with healed second- or third-degree burns and

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persistent NP (VAS ≥ 4) for at least 2 weeks were recruited. Participants were excluded if they:

- Had active infections
- Had cognitive or psychiatric impairment
- Were taking neuropathic medications (e.g., gabapentin)
- Were pregnant or breastfeeding

Sampling and Randomization: Simple random sampling was used. A computer-generated sequence assigned participants into two groups (n=15 each). Allocation was concealed using sequentially numbered, sealed opaque envelopes. Outcome assessors were blinded to reduce bias.

Ethical Considerations: Ethical approval was granted by the Institutional Review Board of Civil Hospital Karachi (Ref: CHK/IRB/2025/089). Written informed consent was obtained from all participants. For non-literate participants, verbal consent was recorded in the presence of a witness. Participant confidentiality was ensured using coded identifiers.

Interventions:

- **Group A (PT Intervention):**
  - TENS therapy (100 Hz, 20 mins/session, 5 days/week)
  - Desensitization therapy (graded texture stimulation)
  - Active and passive ROM exercises
  - Functional ADL training (e.g., bed mobility, grooming, transfer tasks)
- **Group B (Control):**
  - Standard care: Analgesics, wound care, general supervision without physiotherapy

Outcome Measures:

- Pain intensity: Visual Analog Scale (VAS)
- Mobility: Goniometric ROM assessment
- Function: Modified Barthel Index (0–100)

Data Collection: Baseline and post-intervention assessments were conducted by blinded physiotherapists. Adherence was monitored via session logs.

Statistical Analysis: SPSS v26 was used. Descriptive statistics summarized demographic variables. Paired and unpaired t-tests were used to compare intra- and inter-group outcomes. A p-value <0.05 was considered statistically significant.

3. Results

Participant Characteristics

The study enrolled 30 participants equally divided into two groups (PT and control). Baseline data including age, gender, burn severity, and total body surface area (TBSA) were analyzed to ensure comparability between groups. No statistically significant differences were found, confirming that randomization was successful and groups were well matched at the outset.

Table 1. Baseline Demographic and Clinical Characteristics

Variable	PT Group (n=15)	Control Group (n=15)	p-value
Mean Age (years)	34.9 ± 6.7	35.7 ± 7.1	0.72
Gender (F:M)	7 : 8	6 : 9	0.71
Burn Degree (2nd/3rd)	10 : 5	11 : 4	0.68
TBSA (%)	18.2 ± 3.5	17.9 ± 3.2	0.84

Table 1 presents comparable baseline characteristics across both groups, indicating successful randomization and reducing selection bias.

Visual Representation of Pain Reduction

Figure 1 visually presents the reduction in pain intensity as measured by the Visual Analog Scale (VAS) over the 4-week period. The PT group demonstrated a more substantial decline in VAS scores than the control group, highlighting the effectiveness of physical therapy interventions in reducing neuropathic pain post-burn.

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Figure 1. VAS Pain Score Comparison

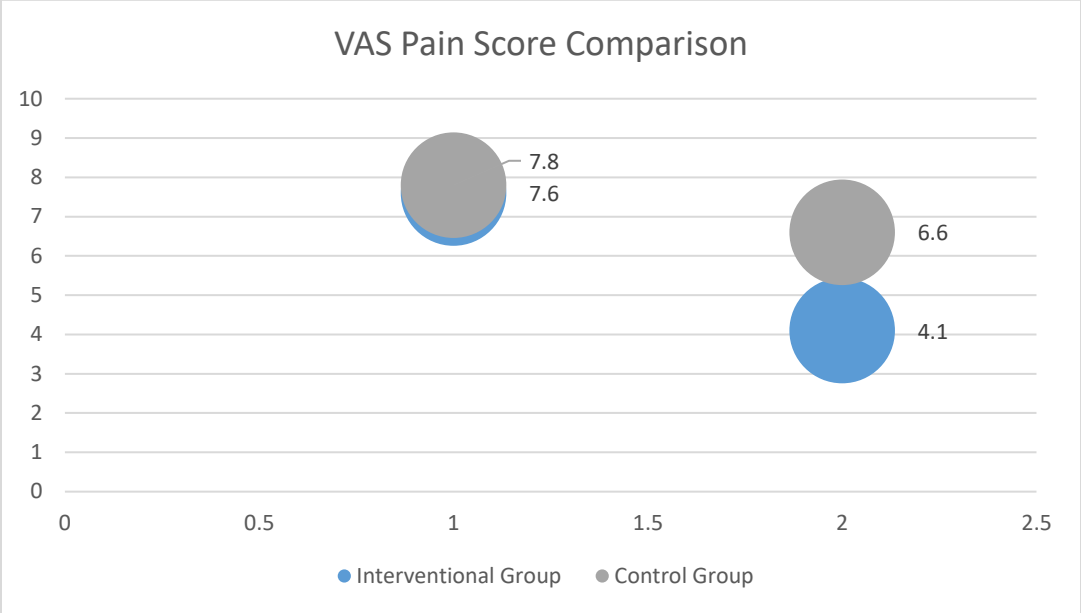

Figure 1 illustrates a significantly greater reduction in VAS scores in the PT group compared to the control group after 4 weeks.

Functional Status Enhancement

The improvements in patients' functional independence as measured by the Modified Barthel Index. Participants in the PT group showed a significantly higher gain in functional scores, reflecting the positive impact of active rehabilitation on daily living activities such as grooming, dressing, and mobility.

Figure 2. Barthel Index Score Gains

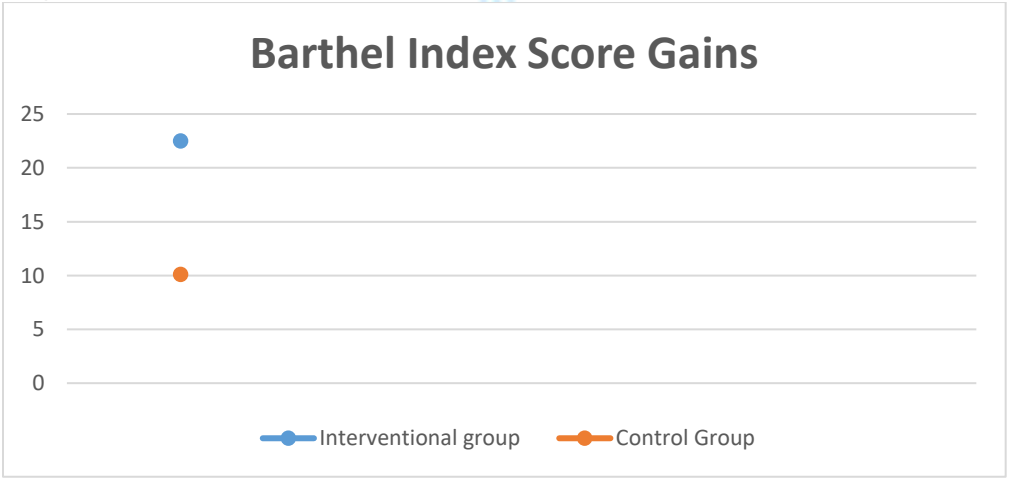

Figure 2 shows improvement in functional independence measured by Modified Barthel Index. Patients receiving PT regained more ADL capacity than controls.

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Clinical Outcomes at Week 4

Post-intervention outcomes were assessed after the 4-week program. Statistically significant improvements were observed in pain scores, range of motion (ROM), and Barthel Index scores in the PT group compared to the control group. These results demonstrate the clinical efficacy of the structured PT protocol.

Table 2. Clinical Outcomes Before and After Intervention

Outcome	Timepoint	PT Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Pain (VAS)	Baseline	7.6 ± 0.9	7.8 ± 1.1	0.54
	Week 4	4.1 ± 1.0	6.6 ± 1.3	<0.001
ROM Improvement (°)	Week 4	+30 ± 8	+12 ± 6	<0.001
Barthel Gain (points)	Week 4	+22.5 ± 5.2	+10.1 ± 4.7	<0.001

Table 2 summarizes primary outcomes. The PT group demonstrated greater improvements in all domains with high statistical significance.

ROM Progression by Joint

The weekly progress in joint range of motion across affected joints, including the shoulder, elbow, and knee. The PT group exhibited a steady increase in ROM, emphasizing the importance of early mobilization and consistent exercise therapy in burn rehabilitation.

Figure 3. Mean ROM Gain in Affected Joints

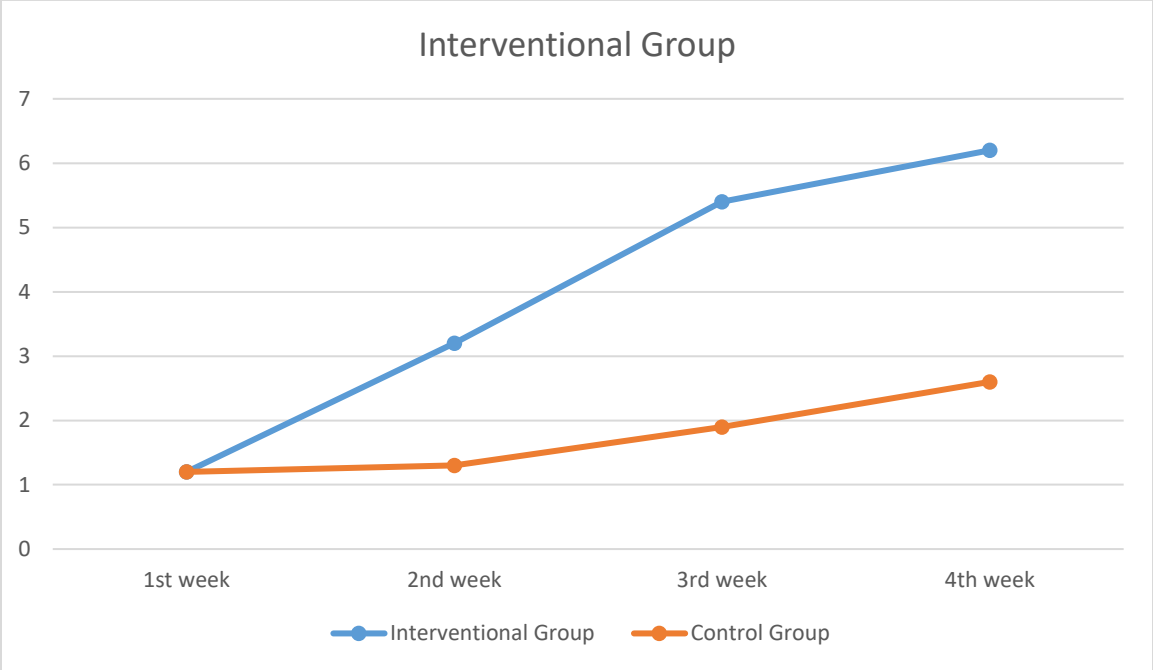

Figure 3 displays a consistent upward trend in ROM across multiple joints in the PT group, emphasizing the benefits of early mobilization.

These findings reinforce the hypothesis that structured PT interventions improve pain modulation, joint flexibility, and patient autonomy in post-burn care.

4. Discussion

The present study affirms that physical therapy can play a pivotal role in the management of post-burn

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neuropathic pain. Our findings showed statistically and clinically significant reductions in pain levels, improvements in joint mobility, and enhanced functional independence following a 4-week structured physiotherapy regimen [24,25]. These results are consistent with existing literature that supports the analgesic and rehabilitative benefits of TENS and active mobilization. TENS has been extensively studied in chronic pain management, with its mechanism rooted in the gate control theory proposed by Melzack and Wall [26], and further supported by Claydon and Chesterton's review of TENS efficacy in neuropathic pain [27].

Desensitization therapy further contributed to reducing abnormal sensory responses in burn scars. Similar results were documented by Rushton [28]. Additionally, the improvement in range of motion aligns with the studies by Thomas et al. and Herndon et al., which emphasized the benefits of early mobilization in preventing contractures and improving neuroplastic outcomes [29,30].

Functional gains observed in the Barthel Index reinforce the importance of early multidisciplinary rehabilitation. Peña et al. demonstrated comparable results in pediatric burn survivors, where community-based exercise yielded substantial improvements in function and psychosocial well-being [31]. The functional training used in our study empowered patients to regain autonomy in essential activities of daily living (ADLs), including dressing, grooming, and transfers. These findings underscore the multifaceted value of physiotherapy in the continuum of burn care.

Furthermore, our study adds critical insight to the South Asian context, where resource limitations often preclude the use of advanced pharmacologic therapies for chronic NP. A PT-based intervention, relying on basic equipment and guided supervision, becomes not only an affordable but also an effective alternative. In many tertiary care hospitals in Pakistan, PT is underutilized or initiated late in the care pathway, often after functional decline has set in. This study calls for a shift in policy and practice, advocating for earlier PT referrals and inclusion in national burn rehabilitation protocols.

The observed safety profile further strengthens the argument for integration. No adverse events were reported in the PT group throughout the intervention phase. Patient compliance was high, with subjective feedback reflecting satisfaction and perceived benefit from therapy. The non-invasive, drug-free nature of PT also avoids the common side effects associated with long-term use of gabapentinoids and opioids, which are known to cause adverse effects including dizziness and dependency [32,33].

These results, though limited by a single-center design and short follow-up period, provide valuable groundwork for larger multicenter studies. They also reinforce global guidelines from the International Society for Burn Injuries and American Burn Association, which recommend early initiation of rehabilitation interventions to enhance long-term recovery outcomes [34-40].

5. Conclusion

This study demonstrated that a structured four-week physical therapy protocol significantly reduces neuropathic pain and improves mobility and functional independence in adult post-burn patients. The low-cost, scalable nature of the intervention makes it particularly suitable for low-resource settings such as public hospitals in Pakistan. Our findings support the early integration of PT into standard burn care to enhance recovery and reduce long-term disability.

6. Limitations

This study is limited by its small sample size, single-center scope, and short duration of follow-up. Lack of double-blinding may introduce some bias. Psychological and quality-of-life outcomes were not evaluated.

7. Future Recommendations

Larger multicenter RCTs with longer follow-up periods are recommended. Future studies should evaluate the impact of PT on quality of life, psychological outcomes, and cost-effectiveness. Capacity building in physiotherapist training and infrastructure support for burn rehabilitation should also be prioritized in national health policy.

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