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COMPARATIVE EFFECTIVENESS OF SENSORY-MOTOR INTEGRATION AND ROODS APPROACH ON SENSORY AND MOTOR ABNORMALITIES IN PATIENT WITH DIABETIC POLYNEUROPATHY

Original Research

Anbreena Rasool[1]*, Kinza Ehsan[2], Hafsa Naz[2], Saad Ullah Butt[3], Aneela Uma[4], Ayesha Affi[5], Zain Ali[4]
[1]Assistant Professor, Department of Rehabilitation Sciences, The University of Faisalabad, Faisalabad, Pakistan.
[2]Lecturer, The University of Faisalabad, Faisalabad, Pakistan.
[3]The University of Faisalabad, Faisalabad, Pakistan.
[4]Lecturer, Riphah International University, Faisalabad, Pakistan.
[5]Physiotherapist, The University of Faisalabad, Faisalabad, Pakistan.
Corresponding Author: Anbreena Rasool, Assistant Professor, Department of Rehabilitation Sciences, The University of Faisalabad, Faisalabad, Pakistan. assistant.professor.rehab.419@tuf.edu.pk

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ABSTRACT

Background: Diabetic sensory-motor polyneuropathy causes a gradual loss of vibratory, thermal, tactile, and proprioceptive sensations, alongside motor symptoms such as reduced ankle reflexes, mild foot drop, and lower limb weakness, leading to functional limitations like frequent tripping and impaired pincer grasp. Effective therapeutic strategies are essential for managing these symptoms to enhance patients' quality of life. This study investigates the comparative effectiveness of sensory-motor integration and the Rood approach in managing diabetic polyneuropathy symptoms.

Objective: To compare the effects of sensory-motor integration and the Rood approach in improving sensory and motor functions in patients with diabetic polyneuropathy.

Methods: This single-blinded, randomized clinical trial included 64 patients with diabetic polyneuropathy recruited from Allied Hospital Faisalabad and Madina Teaching Hospital. Patients were randomly assigned to either a sensory-motor integration group or a Rood approach group. Both groups received 6 weeks of therapy, with three sessions per week. Sensory function was assessed using the Michigan Neuropathy Screening Instrument (MNSI), muscle strength via the Medical Research Council (MRC) scale, and functional mobility with the Walking Impairment Questionnaire (WIQ). Pre- and post-treatment data were analyzed using SPSS 20.0.

Results: The Rood approach group demonstrated a significant improvement in MNSI History scores, decreasing from a mean of 9.26 ± 2.33 pre-treatment to 5.68 ± 1.49 post-treatment. The sensory-motor integration group showed a mean decrease from 10.21 ± 1.65 to 8.42 ± 1.43. For MRC scale scores, the Rood group improved from 46.95 ± 3.98 to 51.52 ± 3.67, while the sensory-motor integration group rose from 44.79 ± 4.05 to 46.63 ± 4.99. WIQ scores in the Rood group increased from 52.16 ± 9.19 pre-treatment to 62.47 ± 8.42 post-treatment, outperforming the sensory-motor integration group, which rose from 51.63 ± 6.63 to 54.26 ± 6.70.

Conclusion: Both sensory-motor integration and the Rood approach significantly improved sensory and motor function in diabetic polyneuropathy patients. However, the Rood approach was more effective across all measured parameters, suggesting it as a preferable option for enhancing functionality and quality of life in this patient population.

Keywords: Diabetic polyneuropathy, Michigan neuropathy screening instrument, Motor activity, Proprioception, Rehabilitation, Sensory-motor integration, Walking impairment.

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INTRODUCTION

Diabetes mellitus encompasses a spectrum of metabolic disorders primarily characterized by impaired insulin function, either through inadequate insulin production, ineffective insulin action, or both, leading to dysregulated blood glucose levels (1, 2). Among its various types, Type I (insulin-dependent) and Type II (non-insulin-dependent) diabetes are most prevalent. Other forms include gestational diabetes and those resulting from specific genetic abnormalities affecting beta-cell function, pancreatic disease, or medication-induced disruptions in insulin production and action (3). Diabetes-related neuropathies are broadly categorized into generalized, focal, and multifocal types. Generalized neuropathies are further classified into typical and atypical subtypes, with diabetic sensorimotor polyneuropathy (DSPN)—a form of distal sensorimotor polyneuropathy—being commonly identified through nerve conduction abnormalities (4). Another classification differentiates between diffuse neuropathies, including autonomic neuropathy, and atypical forms like mononeuropathy, reflecting the wide impact diabetes has on the nervous system (5). With the global prevalence of diabetes on the rise, there has been a corresponding increase in diabetic peripheral neuropathy (DPN) and its painful manifestations (6). Diagnosing DSPN requires a comprehensive clinical approach that includes patient interviews, physical examinations, and targeted neurological assessments, particularly of cardiovascular and foot health (7). The treatment of DSPN focuses on three primary goals: alleviating symptomatic pain, targeting underlying pathogenic factors, and promoting lifestyle modifications aimed at achieving near-normal glucose levels and minimizing cardiovascular risks. While glucose control and modification of risk factors are central to managing DSPN, the complexity of the condition often necessitates a multimodal treatment strategy, incorporating pharmacological agents and patient education to prevent misdiagnosis and enhance treatment efficacy (8).

Patients with diabetes frequently experience sensorimotor and autonomic neuropathies, which may involve cardiovascular, genitourinary, and gastrointestinal systems. While strict glucose control is the cornerstone of prevention, lifestyle interventions and rigorous diabetic management are recommended for individuals affected by cardiovascular autonomic neuropathy (9). Introduced in 1950, the Rood approach is a neurophysiological method designed to modulate muscle tone in patients with neurological impairments. This technique applies varied stimuli, including manual pressure on tendons, to either inhibit or facilitate muscle responses, benefiting patients with conditions like spasticity (10). The Rood method operates on the principle that motor patterns can be improved through a structured sequence of reflex-based sensory inputs, aiming to modify muscle tone through targeted techniques such as brushing, tapping, and stretching (11). This multimodal approach leverages specific sensory inputs—like light touches or tendon taps—to activate neuromuscular reflexes, providing therapeutic support for individuals with motor control deficiencies (12, 13). Rood's technique can also enhance sensory input to specific muscle groups, supporting improved coordination through methods such as tapping and fascia stimulation with light, brushing movements (14). Sensory integration, conceptualized by A. Jean Ayres, further elaborates on how the nervous system processes sensory inputs to facilitate movement planning and execution (15). Sensory-motor integration relies on the central nervous system's capacity to utilize sensory inputs effectively, improving motor control by enhancing the responsiveness of sensory receptors. In particular, somatosensory stimulation of the lower limbs has been shown to improve sensory input quality, which plays a critical role in maintaining balance, postural control, and stability (16). Techniques such as artificial grass mat stimulation have been employed to activate both cutaneous and subcutaneous receptors, fostering enhanced proprioception and postural control (17). This study aims to address a critical research gap by systematically comparing the effectiveness of different therapeutic interventions in the management of diabetic sensorimotor polyneuropathy, utilizing high-standard assessments to ascertain the most efficient and effective treatment modality for optimizing patient outcomes.

METHODS

A randomized clinical trial was conducted at Madina Teaching Hospital (MTH) and Allied Hospital in Faisalabad from January to May 2022 to evaluate therapeutic approaches for diabetic neuropathy. The study enrolled 38 patients diagnosed with diabetic polyneuropathy at Stage 2b, aged 40 to 75 years, with a history of Type II diabetes mellitus for at least ten years. Participants were selected via simple random sampling based on specific inclusion criteria, while those with Type I diabetes mellitus, complete sensory loss, cardiac arrhythmias, or skin ulcers were excluded. After obtaining informed consent, participants were randomly divided into two groups, using an online generator. One Group received sensory-motor integration therapy, while other Group was assigned the Rood approach.

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Baseline and post-intervention measurements, taken at the end of the six-week period, assessed sensation using the Michigan Neuropathy Screening Instrument and muscle strength using the Medical Research Council (MRC) scale and Walking Impairment Questionnaire.

The sensory-motor integration therapy was structured over six weeks, with sessions held three times per week. Each session incorporated sensory integration through touch stimulation, thermal stimuli, and proprioceptive excitability, while motor integration focused on strengthening exercises, including aerobic and resistance training, along with balance training. Sessions included warm-up and cool-down activities through light stretching. Strengthening exercises comprised abdominal curls, biceps curls, chest presses, leg extensions, seated leg curls, and seated rows, performed at a frequency of 10 repetitions per exercise per session. For Roods Group, the Rood approach emphasized facilitation techniques based on the principles of reciprocal innervation. Quick stretching was performed by stabilizing proximal bony prominences while rotating the distal joint, thereby creating a rapid stretch to the target muscle. Heavy joint compression—defined as a force greater than average body weight applied along the joint's longitudinal axis—was used to promote co-contraction at the compressed joint. Techniques for tactile sensory input included light moving touch, brushing, and icing, while proprioceptive stimulation involved joint compression and stretch applications. These interventions were designed to enhance sensory and motor functionality in patients with diabetic neuropathy, addressing both proprioception and motor control through structured stimuli.

RESULTS

The study included 38 participants diagnosed with diabetic neuropathy who were randomly assigned to two treatment groups: the Rood approach group and the MRP (Motor Repatterning Program) group. Demographic analysis revealed that the age range for the Rood group was between 57 and 70 years, with a mean age of 62.47 ± 3.78, while the MRP group ranged from 56 to 70 years with a mean age of 61.47 ± 3.88. Statistical comparisons of age between the groups showed no significant differences, ensuring demographic compatibility between treatment groups.

Within-group analysis using paired sample tests indicated that both treatment groups experienced improvement in neuropathy measures, as assessed by the Michigan Neuropathy Screening Instrument (MNSI). In the Rood group, the pre-treatment MNSI History score averaged 9.26 ± 2.33, while the post-treatment score improved to 5.68 ± 1.49. Similarly, the MRP group showed a reduction in MNSI History score from a pre-treatment mean of 10.21 ± 1.65 to a post-treatment mean of 8.42 ± 1.43. In terms of MNSI Personal scores, the Rood group's mean reduced from 6.32 ± 1.42 to 3.58 ± 1.12 post-treatment, while the MRP group showed a decrease from 6.58 ± 1.26 to 4.95 ± 1.03. Paired sample t-tests indicated significant within-group changes for both groups in MNSI History and Personal scores, with a p-value < 0.05. Between-group comparisons using an independent t-test showed that the Rood group experienced greater improvement in both MNSI History and Personal scores compared to the MRP group, with a statistically significant difference ($p < 0.05$).

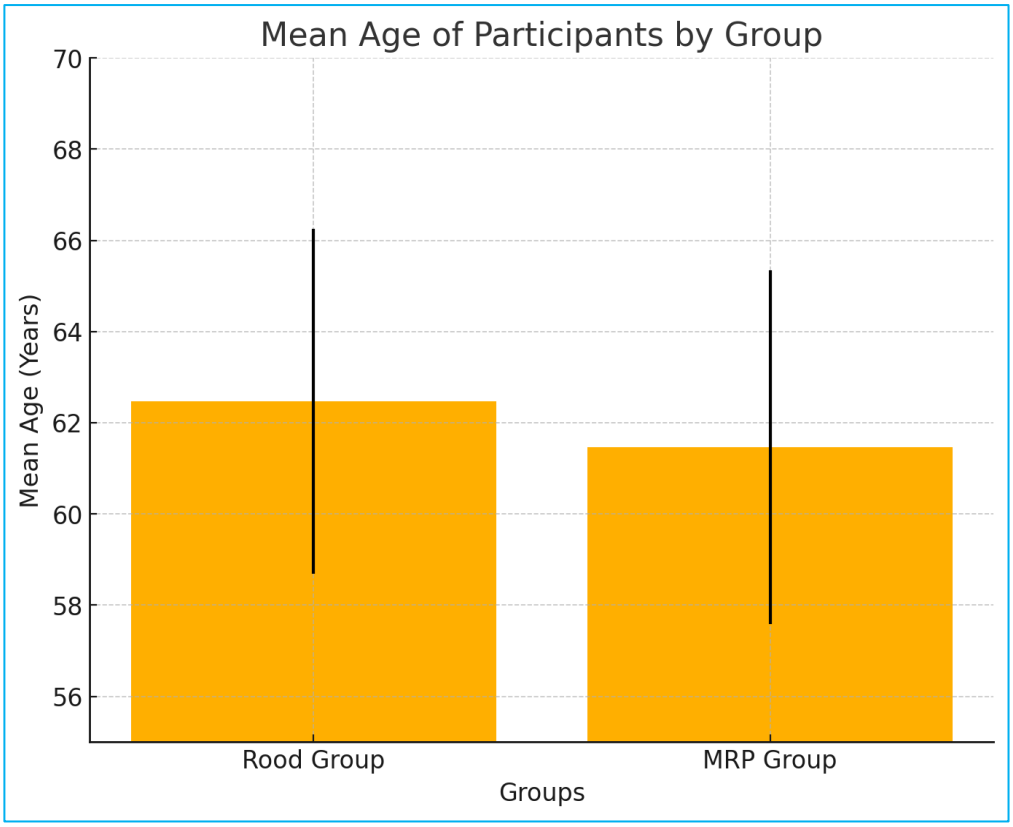

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Table 1: Paired Samples Statistics for Michigan Neuropathy Screening Instrument (MNSI) - History and Personal Scores Pre- and Post-Treatment in Rood and MRP Groups

Groups			Mean	N	Std. Deviation	Std. Error Mean
Roods Group	Pair 1	Pre-Michigen Neuropathy Screening Instruments History	9.2632	19	2.32957	.53444
		Post-Michigen Neuropathy Screening Instruments History	5.6842	19	1.49267	.34244
	Pair 2	Pre-Michigen Neuropathy Screening Instruments Personal	6.3158	19	1.41628	.32492
		Post-Michigen Neuropathy Screening Instruments Personal	3.5789	19	1.12130	.25724
MRP Group	Pair 1	Pre-Michigen Neuropathy Screening Instruments History	10.2105	19	1.65257	.37913
		Post-Michigen Neuropathy Screening Instruments History	8.4211	19	1.42657	.32728
	Pair 2	Pre-Michigen Neuropathy Screening Instruments Personal	6.5789	19	1.26121	.28934
		Post-Michigen Neuropathy Screening Instruments Personal	4.9474	19	1.02598	.23538

Further analysis focused on the Medical Research Council (MRC) scale, which measured muscle strength. Pre-treatment MRC scale mean scores in the Rood group were 46.95 ± 3.98, which increased to 51.53 ± 3.67 post-treatment. The MRP group, in contrast, showed a more modest improvement, with pre-treatment scores of 44.79 ± 4.05 increasing to 46.63 ± 4.99 post-treatment. Paired sample t-tests confirmed significant within-group improvements for both groups ($p < 0.05$). Independent t-test comparisons highlighted that the Rood group achieved a higher degree of improvement in muscle strength, as measured by the MRC scale, compared to the MRP group.

Table 2: Group Statistics for Michigan Neuropathy Screening Instrument (MNSI) - Comparison of History and Personal Scores between Rood and MRP Groups

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Pre-Michigen Neuropathy Screening Instruments History	Roods Group	19	9.2632	2.32957	.53444
	MRP Group	19	10.2105	1.65257	.37913
Post-Michigen Neuropathy Screening Instruments History	Roods Group	19	5.6842	1.49267	.34244
	MRP Group	19	8.4211	1.42657	.32728
Pre-Michigen Neuropathy Screening Instruments Personal	Roods Group	19	6.3158	1.41628	.32492
	MRP Group	19	6.5789	1.26121	.28934
Post-Michigen Neuropathy Screening Instruments Personal	Roods Group	19	3.5789	1.12130	.25724
	MRP Group	19	4.9474	1.02598	.23538

Lastly, in the assessment of functional mobility using the Walking Impairment Questionnaire (WIQ) scores, both groups exhibited improvement from pre- to post-treatment. The pre-treatment WIQ score in the Rood group averaged 52.16 ± 9.19, which rose to 62.47

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± 8.42 post-treatment, indicating a notable enhancement in mobility and functional capacity. The MRP group also demonstrated improvement, with pre-treatment WIQ scores averaging 51.63 ± 6.63 and post-treatment scores rising to 54.26 ± 6.70. Between-group analysis revealed that the Rood group showed a more substantial improvement in WIQ scores than the MRP group, with statistically significant differences ($p < 0.05$).

Table 3: Paired Samples Statistics for Medical Research Council (MRC) Scale - Muscle Strength Pre- and Post-Treatment in Rood and MRP Groups

Groups			Mean	N	Std. Deviation	Std. Error Mean
Roods Group	Pair 1	Pre-Medical Research Council Scales	46.9474	19	3.97874	.91279
		Post-Medical Research Council Scales	51.5263	19	3.67224	.84247
MRP Group	Pair 1	Pre-Medical Research Council Scales	44.7895	19	4.04940	.92900
		Post-Medical Research Council Scales	46.6316	19	4.09892	.94036

Both the Rood and MRP interventions provided measurable benefits in sensory function, muscle strength, and mobility for patients with diabetic neuropathy. However, the Rood approach demonstrated superior improvements across all measured parameters, suggesting that it may offer a more effective therapeutic option for addressing sensory and motor impairments associated with diabetic neuropathy.

Table 4: Paired Samples Statistics for Walking Impairment Questionnaire (WIQ) Score - Functional Mobility Pre-and Post-Treatment in Rood and MRP Groups

Groups				Mean	N	Std. Deviation	Std. Error Mean
Roods Group	Pair 1	Pre-Walking Questionnaire Score	Impairments	52.1579	19	9.19096	2.10855
		Post-Walking Questionnaire Score	Impairments	62.4737	19	8.41539	1.93062
MRP Group	Pair 1	Pre-Walking Questionnaire Score	Impairments	51.6316	19	6.62663	1.52025
		Post-Walking Questionnaire Score	Impairments	54.2632	19	6.69861	1.53677

DISCUSSION

The findings of this study align with the principles established by Struppler and Weindl, who emphasized the necessity of maintaining a delicate balance between sensory input and motor output for effective engagement within multisensory contexts (18). Sensorimotor integration, defined as the central nervous system's process of incorporating somatosensory input to influence motor programming, serves as the foundation for therapeutic approaches aimed at restoring functional motor skills (19). This study applied this principle by comparing two distinct treatment approaches—Rood's approach and sensory-motor integration—to determine which was more effective for enhancing sensory-motor balance in patients with diabetic polyneuropathy. Patients with diabetic neuropathy commonly experience both positive and negative sensory symptoms, along with associated muscle weakness. Negative symptoms include numbness, balance issues, and injury susceptibility due to reduced sensation, whereas positive symptoms involve sensations such as burning, prickling, and tingling. These symptoms, coupled with muscular weakness, compromise functional independence. Rood's approach, a neurophysiological treatment rooted in central nervous system reflexes, has been shown to facilitate motor improvements by using

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structured sensory stimuli to activate primitive reflexes that contribute to motor control (20). This study builds upon the work of Patel and Kadam, who demonstrated improvements in sensory integration and muscle strength in diabetic polyneuropathy patients using Rood's approach, with evaluations over a three-month period (21). In contrast, this study applied a six-week intervention period, comparing Rood's approach with a sensory-motor integration program to ascertain which yielded more rapid and significant improvements.

A distinctive strength of this study lies in its comparison of two established therapeutic methods to determine the more effective approach for diabetic neuropathy. Limited literature exists on direct comparisons between Rood's approach and sensory-motor integration in diabetic populations, highlighting the novelty of this research. The findings indicated that Rood's technique provided greater improvements in sensory and motor integration than the motor relearning program (MRP), or sensory-motor integration program. Notably, the study demonstrated that significant benefits could be achieved within a relatively short treatment duration, which is advantageous for clinical applications aiming for efficient outcomes. The results align with similar studies conducted on different populations. Bordoloi and Deka demonstrated the efficacy of a modified Rood's approach in enhancing muscle strength among post-cerebral hemorrhagic patients, while other researchers have shown the benefits of sensory integration therapy for sensory processing disorders in children with autism (21). These studies, though focused on diverse populations, support the effectiveness of Rood's approach for achieving motor and sensory improvements. However, this study differs by targeting a diabetic population with polyneuropathy, where the integration between sensory input and motor output is particularly crucial given the progressive and disabling nature of diabetic neuropathy.

Diabetic neuropathy (DN) impacts both somatic and autonomic nerves, typically progressing in a distal, symmetric pattern. It is among the most severe complications of diabetes, resulting in motor dysfunctions, including impaired balance, gait disturbances, increased fall risk, and physical disability (22). These motor deficiencies reflect disruptions in the interplay between the peripheral nervous system (PNS) and central nervous system (CNS), underscoring the importance of motor relearning for restoring patients' independence in daily activities. Effective sensory information processing is essential not only for injury prevention but also for enhancing patients' quality of life (23, 24). This study had certain limitations. It did not evaluate balance, despite evidence that sensory and motor impairments make balance the third most common issue in patients with type II diabetes. Additionally, the intervention period was relatively short, which may limit the generalizability of the findings regarding long-term outcomes. Further studies with extended treatment durations and additional focus on balance training could provide more comprehensive insights into optimal rehabilitation strategies for diabetic neuropathy.

CONCLUSION

Diabetic polyneuropathy primarily affects the distal extremities, where sensory deficits and neuropathic pain significantly impact patients' quality of life. Individuals with diabetic neuropathy often experience motor impairments, including balance issues, gait instability, and an increased risk of falls, leading to higher rates of physical disability. This study concluded that both Rood's technique and the motor relearning program offer therapeutic benefits for addressing sensory and motor impairments in diabetic neuropathy. However, Rood's approach proved to be more effective in enhancing sensory-motor function, ultimately supporting improved daily activity performance and quality of life for individuals with diabetes.

Author	Contribution
Anbreena Rasool	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Kinza Ehsan	Methodology, Investigation, Data Curation, Writing - Review & Editing
Hafsa Naz	Investigation, Data Curation, Formal Analysis, Software
Saad Ullah Butt	Software, Validation, Writing - Original Draft
Aneela Uma	Formal Analysis, Writing - Review & Editing
Ayesha Affi	Writing - Review & Editing, Assistance with Data Curation
Zain Ali	Writing - Review & Editing, Assistance with Data Curation

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