

Original Article

Clinical Outcomes of Neuro-Musculoskeletal Physiotherapy in Women's Health: A Pre–Post Study

Ayesha Nisar¹, Iqra Shaukat², Feroz Khan³, Maqsood Ur Rehman⁴, Kamran Akbar⁵, Tanzila Rashid⁶, Shahzad Ahmad⁷, Gulalai⁸¹ Physiotherapist, Mahaban Paraplegic and Rehab Centre Topi, Swabi, PakistanORCID: <https://orcid.org/0009-0003-7459-1093>² School of Public Health, Shanghai University of Traditional Chinese Medicine; Master's in Public HealthORCID: <https://orcid.org/0009-0007-4488-3705>³ Physiotherapist, Mahaban Paraplegic and Rehab Centre Topi, Swabi, PakistanORCID: <https://orcid.org/0009-0003-0714-6707>⁴ Physiotherapist, Mahaban Paraplegic and Rehab Centre Topi, Swabi, PakistanORCID: <https://orcid.org/0009-0001-4003-7313>⁵ Lecturer, Institute of Physical Medicine and Rehabilitation, Khyber Medical University, Peshawar, PakistanORCID: <https://orcid.org/0009-0002-3940-1381>⁶ Physiotherapist, Ziauddin Hospital, Karachi, Pakistan⁷ Assistant Professor, Physical Therapy, University of Veterinary and Animal Sciences, Swat, PakistanORCID: <https://orcid.org/0009-0001-6319-7934>⁸ Physiotherapist, Rehman Medical Institution (RMI), Peshawar, Pakistan***Corresponding author: Shahzad Ahmad, drshahzad@uvasswat.edu.pk****"Cite this Article"** Received: 01 March 2026; Accepted: 05 May 2026; Published: 04 June 2026**Author Contributions:** Concept: AN; Design: IS; Data Collection: FK, MR; Analysis: KA; Drafting: TR; Critical Revision: SA, G. **Ethical Approval:** Mahaban Paraplegic and Rehab Centre Topi, Swabi, Pakistan. **Informed Consent:** Written informed consent was obtained from all participants; **Conflict of Interest:** The authors declare no conflict of interest. **Funding:** No external funding; **Data Availability:** Available from the corresponding author on reasonable request; **Acknowledgments:** N/A.

ABSTRACT

Background: Neuro-musculoskeletal disorders are common contributors to pain, restricted mobility, functional disability, and reduced independence among women. Biological factors, pregnancy-related biomechanical changes, repetitive domestic and occupational activities, poor ergonomics, and reduced physical activity may increase women's vulnerability to persistent movement dysfunction and chronic pain. **Objective:** To evaluate the clinical outcomes of a structured six-week neuro-musculoskeletal physiotherapy rehabilitation program among women with neuro-musculoskeletal disorders using pre–post assessment of pain intensity and functional disability. **Methods:** A quasi-experimental single-group pre–post interventional study was conducted at the Department of Physical Therapy, Mahaban Hospital, Topi, Swabi, Pakistan, from January to June 2025. Sixty women aged 20–60 years with neuro-musculoskeletal disorders received physiotherapy three sessions per week for six weeks. The intervention included therapeutic exercise, stretching, strengthening, core stabilization, neuromuscular re-education, manual therapy, postural correction, ergonomic education, functional training, and home exercise. Pain was assessed using the Visual Analog Scale, and functional disability was assessed using condition-specific disability tools. Pre- and post-intervention scores were compared using paired-sample t-tests. **Results:** The mean age was 38.6 ± 9.4 years. Low back pain was the most frequent condition (40.0%). Mean VAS pain score decreased from 7.1 ± 1.3 to 3.2 ± 1.1 , while functional disability score improved from 58.4 ± 10.2 to 31.6 ± 8.7 after intervention ($p < 0.001$). Functional improvement was also observed in postural control, mobility, sitting tolerance, walking endurance, and household activities. **Conclusion:** A structured six-week neuro-musculoskeletal physiotherapy program was associated with significant short-term improvement in pain intensity, functional disability, and daily functional performance among women with neuro-musculoskeletal disorders. **Keywords:** Women's health, neuro-musculoskeletal physiotherapy, rehabilitation, functional disability, pain management, physiotherapy intervention.

INTRODUCTION

Women's health extends beyond reproductive and maternal care and includes neuro-musculoskeletal function as a central determinant of physical independence, daily activity performance, occupational

participation, and quality of life. Neuro-musculoskeletal disorders in women commonly present as low back pain, neck pain, pelvic girdle dysfunction, postural abnormalities, myofascial pain syndromes, impaired motor control, reduced flexibility, proprioceptive deficits, and functional movement limitations. These conditions may occur independently or coexist, producing persistent pain, restricted mobility, reduced tolerance for household and occupational activities, and progressive functional disability. Therapeutic exercise and rehabilitation principles emphasize that restoration of movement, strength, flexibility, neuromuscular coordination, and functional capacity is essential for improving clinical outcomes in such populations (1).

Women may experience a higher burden of neuro-musculoskeletal dysfunction because biological, biomechanical, occupational, and psychosocial factors interact across the lifespan. Sex-related differences in pain perception, hormonal fluctuations, ligamentous laxity, inflammatory responses, and muscle activation patterns may increase vulnerability to persistent pain and movement dysfunction (2). Pregnancy and postpartum biomechanical changes may further contribute to lumbopelvic instability, altered posture, reduced trunk control, and pelvic girdle pain, particularly when appropriate rehabilitation is delayed (3). In addition, repetitive domestic work, prolonged standing, bending, lifting, caregiving responsibilities, poor ergonomic conditions, sedentary behavior, and limited access to early physiotherapy services may compound the risk of chronic neuro-musculoskeletal disability among women.

Musculoskeletal disorders remain among the leading contributors to years lived with disability worldwide, and low back pain is consistently recognized as one of the most disabling conditions across adult populations (4). In women, spinal pain and related functional limitations may be intensified by repeated exposure to physical workload, reduced participation in structured exercise, and delayed health-seeking behavior. In low-resource and local clinical contexts, including Pakistan, women frequently present to rehabilitation services after symptoms have become persistent, functionally limiting, or recurrent. Although local evidence has described musculoskeletal problems and rehabilitation needs, research evaluating structured physiotherapy outcomes in women-specific neuro-musculoskeletal populations remains limited and methodologically underdeveloped (5).

Neck pain, postural dysfunction, and upper-quarter musculoskeletal symptoms are also increasingly relevant because of prolonged smartphone use, computer-based work, sustained sitting, and forward-head posture. These factors may alter cervical and shoulder muscle recruitment, increase soft-tissue strain, reduce joint mobility, and contribute to chronic pain and disability (6). Pelvic girdle dysfunction represents another clinically important condition in women, particularly during and after pregnancy, where impaired load transfer, poor pelvic stability, and altered neuromuscular control may interfere with walking, standing, transitional movements, and household activities (7). These disorders are not purely structural; chronic pain is frequently accompanied by altered proprioception, impaired postural orientation, poor balance, reduced coordination, and maladaptive motor-control strategies, indicating the need for an integrated neuro-musculoskeletal rehabilitation approach rather than symptom-focused care alone (8).

Neuro-musculoskeletal physiotherapy combines therapeutic exercise, stretching, progressive strengthening, manual therapy, motor-control training, neuromuscular re-education, balance training, postural correction, ergonomic education, and functional movement retraining. This multidimensional approach aims to reduce pain, improve mobility, restore movement efficiency, enhance spinal and pelvic stability, and promote functional independence (9). Exercise-based rehabilitation may improve pain modulation, muscle performance, movement confidence, and functional capacity, particularly when exercises are progressed according to patient tolerance and clinical presentation (10). Manual therapy may provide additional short-term benefit by improving joint mobility, reducing soft-tissue tension, and facilitating participation in active rehabilitation when combined with exercise-based care (11).

International evidence supports the clinical value of physiotherapy interventions for chronic musculoskeletal pain and functional disability. Exercise therapy has been shown to reduce pain and improve disability in patients with non-specific low back pain, while functional movement retraining and cognitive-functional rehabilitation approaches have emphasized the importance of correcting maladaptive movement behavior and improving activity tolerance in chronic pain populations (12,13). Neuromuscular rehabilitation also has theoretical and clinical relevance because proprioception, postural control, and balance are important components of safe and efficient movement, particularly in individuals with persistent pain and impaired functional performance (14). However, despite this broader evidence base, direct local evidence on structured neuro-musculoskeletal physiotherapy outcomes among women remains limited.

Existing studies in Pakistan and comparable regional settings have often focused on isolated musculoskeletal conditions, prevalence estimates, or single-technique interventions rather than comprehensive rehabilitation protocols for women with mixed neuro-musculoskeletal presentations. Some local evidence suggests that core stabilization and routine exercise therapy may improve pain in chronic non-specific low back pain, but such findings do not fully address the wider spectrum of women's neuro-musculoskeletal disorders, including cervical pain, pelvic girdle dysfunction, postural impairment, myofascial pain, and functional movement limitations (15). Furthermore, previous rehabilitation research has been limited by small samples, inconsistent intervention protocols, inadequate reporting of functional outcomes, short follow-up periods, and insufficient consideration of psychosocial and lifestyle factors that may influence pain persistence and rehabilitation response (16).

Therefore, a clinically focused evaluation of structured neuro-musculoskeletal physiotherapy among women is justified to address the gap between international rehabilitation evidence and local women-specific practice needs. Using a PICO framework, the population of interest comprises women aged 20–60 years with neuro-musculoskeletal disorders; the intervention is a structured six-week neuro-musculoskeletal physiotherapy program including exercise therapy, manual therapy, postural correction, neuromuscular re-education, ergonomic education, and functional training; the comparison is within-participant pre-intervention status; and the outcomes are pain intensity, functional disability, mobility, postural control, and daily functional performance. The present study therefore aimed to evaluate the clinical outcomes of a structured six-week neuro-musculoskeletal physiotherapy rehabilitation program among women with neuro-musculoskeletal disorders using pre–post assessment of pain and functional disability.

MATERIALS AND METHODS

A quasi-experimental single-group pre–post interventional study was conducted to evaluate the clinical outcomes of a structured neuro-musculoskeletal physiotherapy rehabilitation program among women with neuro-musculoskeletal disorders. The design was selected to compare within-participant changes in pain intensity and functional disability before and after completion of a standardized six-week physiotherapy intervention. The study was carried out in the Department of Physical Therapy, Mahaban Hospital, Topi, Swabi, Khyber Pakhtunkhwa, Pakistan, over six months from January 2025 to June 2025.

The study population comprised female patients presenting to the outpatient physiotherapy department with clinically diagnosed neuro-musculoskeletal disorders, including chronic low back pain, cervical pain, pelvic girdle dysfunction, postural dysfunction, myofascial pain syndrome, and movement-related functional limitations. Eligible participants were women aged 20–60 years who had pain with associated functional limitation, were able to participate in supervised physiotherapy sessions, and provided written informed consent before enrollment. Women were excluded if they had recent fractures, recent orthopedic surgery, severe cardiopulmonary disease, malignancy, systemic inflammatory disorders, neurological disease associated with cognitive impairment, pregnancy-related medical complications, concurrent rehabilitation treatment, or inability to complete the prescribed physiotherapy sessions.

Participants were recruited through non-probability convenience sampling during routine outpatient physiotherapy consultations. Potentially eligible patients were screened according to the predefined eligibility criteria, and those fulfilling the criteria were informed about the study objectives, intervention procedures, expected participation requirements, confidentiality of data, and their right to withdraw at any stage without affecting their clinical care. After written informed consent was obtained, participants were enrolled and underwent baseline assessment before initiation of the rehabilitation program.

Baseline data were collected using a structured clinical assessment form. Demographic variables included age, marital status, occupation, and relevant clinical history. Clinical variables included primary diagnosis, duration of symptoms, pain characteristics, affected body region, functional limitations, postural findings, range of motion, muscle strength, flexibility, balance, coordination, neuromuscular control, and functional movement performance. Pain intensity was assessed using the Visual Analog Scale, recorded on a 0–10 scale, where 0 indicated no pain and 10 indicated the worst imaginable pain. Functional disability was assessed using condition-specific disability instruments according to the affected body region, including the Oswestry Disability Index for low back-related disability and the Neck Disability Index for cervical-related disability. Disability scores were interpreted as percentage-based functional limitation scores to allow pre–post comparison of functional status after intervention.

The primary outcome measure was change in pain intensity from baseline to the end of the six-week intervention. The secondary outcome measure was change in functional disability score after completion of treatment. Additional functional outcomes included improvement in sitting tolerance, walking endurance, postural control, household activity performance, and functional mobility. These functional outcomes were assessed clinically at baseline and after intervention through patient-reported functional performance and therapist-administered physical assessment. The final post-intervention assessment was performed after completion of the six-week rehabilitation protocol.

All enrolled participants received a structured neuro-musculoskeletal physiotherapy rehabilitation program for six consecutive weeks. Treatment was delivered three sessions per week, and each session lasted approximately 40–50 minutes.

The intervention included therapeutic exercises, active range-of-motion exercises, mobility exercises, stretching, progressive strengthening, core stabilization training, neuromuscular re-education, postural correction, ergonomic education, manual therapy, functional movement training, and a prescribed home exercise program. Stretching exercises targeted shortened or overactive muscle groups, including hamstrings, hip flexors, lumbar extensors, cervical muscles, upper trapezius, and pectoral muscles, and were performed using static holds of 20–30 seconds. Strengthening exercises targeted core musculature, spinal stabilizers, pelvic stabilizers, and relevant upper- or lower-limb muscle groups using progressive sets and repetitions according to tolerance and clinical need.

Core stabilization training included abdominal drawing-in maneuvers, pelvic tilting, bridging exercises, and spinal stabilization activities to improve trunk control and lumbopelvic stability. Neuromuscular re-education involved balance training, proprioceptive activities, coordination exercises, and motor-control retraining to improve movement quality and functional control.

Manual therapy techniques, including soft-tissue mobilization, myofascial release, joint mobilization, and trigger-point therapy, were applied according to clinical indication and participant presentation. Postural correction training focused on neutral spine positioning, ergonomic sitting and standing, correction of faulty movement patterns, and repeated practice of posture maintenance during functional tasks. Functional training included sit-to-stand practice, walking drills, lifting mechanics, activity pacing, and mobility training relevant to daily household and occupational activities.

Participants were also instructed in a home exercise program consisting of stretching, strengthening, posture correction, stabilization exercises, and functional mobility tasks. Home exercises were prescribed

for five days per week, with one to two sets of 10 repetitions according to exercise type and patient tolerance. Participants were educated regarding activity modification, safe lifting techniques, avoidance of prolonged static postures, household ergonomics, and pacing of daily activities. Treatment progression was based on pain tolerance, movement quality, ability to complete prescribed repetitions, and improvement in functional performance across sessions.

Potential sources of bias were addressed through use of predefined eligibility criteria, standardized baseline and post-intervention assessment procedures, uniform treatment frequency and duration, and structured documentation of intervention components. To reduce measurement variability, pain and disability outcomes were recorded using the same assessment approach before and after intervention. Confounding was minimized by excluding participants receiving concurrent rehabilitation treatment and by applying a consistent six-week treatment protocol across the study population. Participant adherence to supervised sessions and home exercise instructions was monitored during follow-up visits, and outcome data were recorded on standardized forms to maintain consistency and data integrity.

The sample size consisted of 60 female participants. Sample size was determined using a 95% confidence level, 5% margin of error, and expected prevalence from related rehabilitation literature, with adjustment for feasibility of recruitment within the study period and clinical setting. All participants who completed the intervention and had complete pre- and post-intervention outcome data were included in the final analysis.

Data were entered, coded, cleaned, and analyzed using SPSS version 27. Quantitative variables, including age, duration of symptoms, pain score, and functional disability score, were summarized as mean and standard deviation. Categorical variables, including age group, marital status, occupation, and clinical diagnosis, were summarized as frequency and percentage.

Pre- and post-intervention VAS pain scores and functional disability scores were compared using paired-sample t-tests. Mean differences were calculated to estimate the magnitude of pre–post change. A p-value of ≤ 0.05 was considered statistically significant. Subgroup analysis was performed according to clinical condition to describe changes in pain scores among participants with low back pain, cervical pain, pelvic girdle dysfunction, postural dysfunction, and myofascial pain syndrome. Missing data were managed through complete-case analysis, and participants with incomplete physiotherapy sessions or incomplete outcome assessment were excluded from final analysis.

Ethical approval was obtained from the Institutional Research Ethics Committee of Mahaban Hospital, Topi, Swabi, Khyber Pakhtunkhwa, Pakistan, before commencement of data collection. Written informed consent was obtained from all participants before enrollment. Participant confidentiality was maintained by assigning study codes, limiting access to identifiable information, and using anonymized data for analysis. All procedures were conducted according to ethical principles for human participant research, and participants retained the right to withdraw from the study at any stage without penalty or loss of clinical care.

RESULTS

A total of 60 female participants completed the six-week neuro-musculoskeletal physiotherapy intervention and were included in the final analysis. The mean age of the participants was 38.6 ± 9.4 years, with the highest proportion in the 31–40-year age group, representing 22 participants (36.7%). Most participants were married, accounting for 43 cases (71.7%), while 17 participants (28.3%) were unmarried.

Housewives formed the largest occupational group, comprising 31 participants (51.7%), followed by office workers 12 (20.0%), teachers 8 (13.3%), healthcare workers 5 (8.3%), and other occupations 4 (6.7%). The mean duration of symptoms was 8.3 ± 3.7 months. Chronic low back pain was the most frequent clinical condition, affecting 24 participants (40.0%), followed by cervical pain in 15 participants

(25.0%), postural dysfunction in 9 participants (15.0%), pelvic girdle dysfunction in 8 participants (13.3%), and myofascial pain syndrome in 4 participants (6.7%).

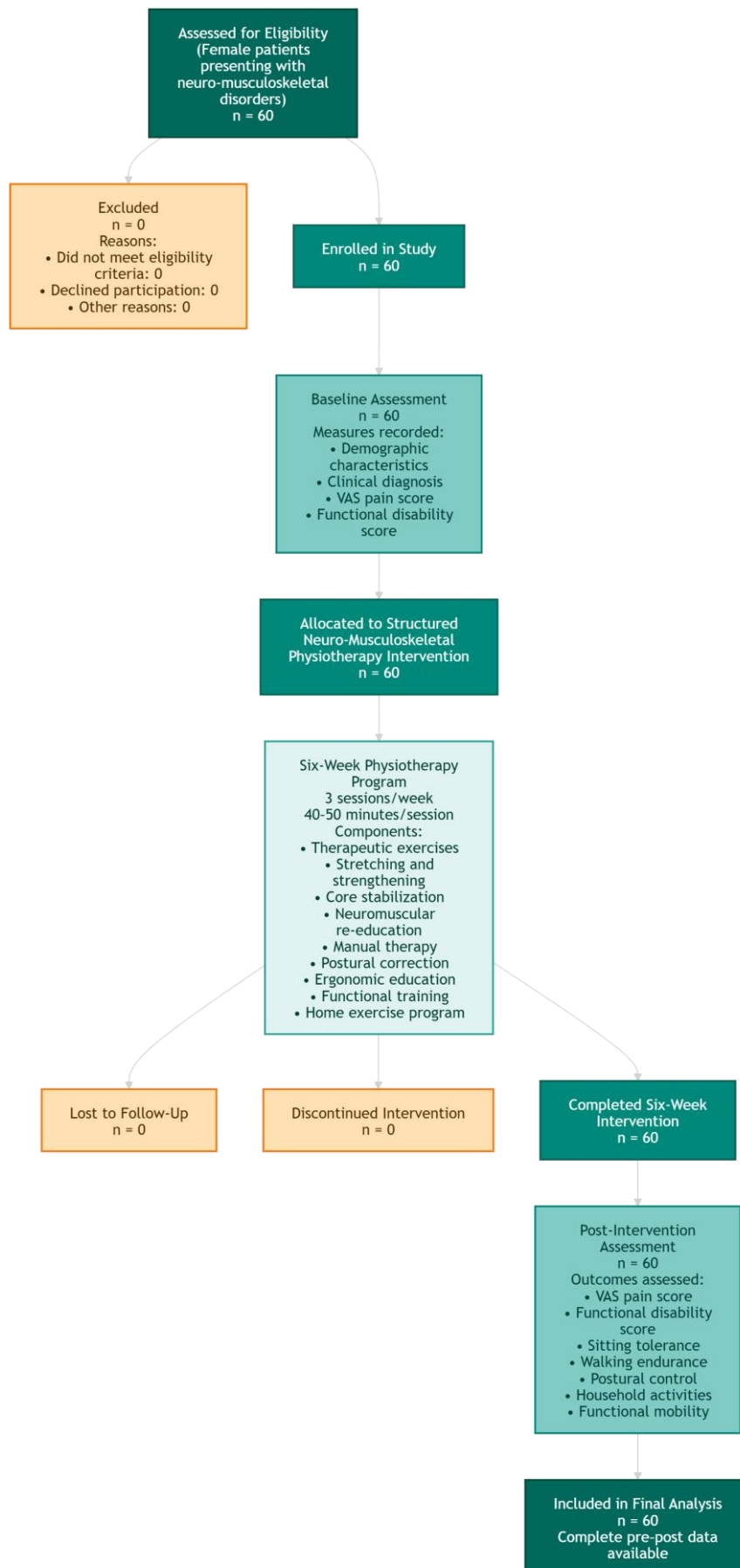


Figure 1. Participant Flow Diagram for the Quasi-Experimental Pre-Post Neuro-Musculoskeletal Physiotherapy Study

A total of 60 eligible female participants were enrolled, completed baseline assessment, received the six-week structured neuro-musculoskeletal physiotherapy program, completed post-intervention assessment, and were included in the final analysis.

Table 1. Demographic and Baseline Clinical Characteristics of Participants (n=60)

Variable	Category / Measure	Frequency (n)	Percentage (%) / Mean ± SD
Age	Mean age		38.6 ± 9.4 years
Age group	20–30 years	18	30.0
	31–40 years	22	36.7
	41–50 years	14	23.3
	51–60 years	6	10.0
Marital status	Married	43	71.7
	Unmarried	17	28.3
Occupation	Housewife	31	51.7
	Office worker	12	20.0
	Teacher	8	13.3
	Healthcare worker	5	8.3
	Other	4	6.7
Symptom duration	Mean duration		8.3 ± 3.7 months
Clinical condition	Low back pain	24	40.0
	Cervical pain	15	25.0
	Pelvic girdle dysfunction	8	13.3
	Postural dysfunction	9	15.0
	Myofascial pain syndrome	4	6.7

Pain intensity showed a marked reduction after completion of the intervention. The mean Visual Analog Scale score decreased from 7.1 ± 1.3 at baseline to 3.2 ± 1.1 after treatment, producing a mean reduction of 3.9 points.

This change was statistically significant using paired-sample analysis ($p < 0.001$). Based on the available aggregate standard deviations, the standardized mean change using the average pre–post standard deviation was large at 3.25, indicating a substantial reduction in pain intensity over the six-week treatment period.

Functional disability also improved substantially, with mean disability score decreasing from 58.4 ± 10.2 before intervention to 31.6 ± 8.7 after intervention. The absolute mean reduction was 26.8 points, and the change was statistically significant ($p < 0.001$). The standardized mean change using the average pre–post standard deviation was 2.84, indicating a large improvement in functional status.

Table 2. Pre- and Post-Intervention Pain and Functional Disability Outcomes (n=60)

Outcome Measure	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference	Relative Reduction (%)	Standardized Mean Change*	p-value
Visual Analog Scale pain score	7.1 ± 1.3	3.2 ± 1.1	3.9	54.9	3.25	<0.001
Functional disability score	58.4 ± 10.2	31.6 ± 8.7	26.8	45.9	2.84	<0.001

*Standardized mean change was calculated from the available aggregate data as mean difference divided by the average of the pre- and post-intervention standard deviations. Pain reduction was observed across all diagnostic categories.

Participants with low back pain had the largest absolute reduction in VAS score, decreasing from 7.4 ± 1.1 to 3.1 ± 1.0 , with a mean reduction of 4.3 points and a relative reduction of 58.1%. Participants with postural dysfunction showed a reduction from 6.8 ± 1.3 to 3.0 ± 1.0 , corresponding to a 3.8-point reduction and 55.9% relative improvement.

Cervical pain improved from 6.9 ± 1.4 to 3.3 ± 1.2 , with a mean reduction of 3.6 points. Pelvic girdle dysfunction improved from 7.0 ± 1.2 to 3.5 ± 1.1 , with a 3.5-point reduction, while myofascial pain syndrome improved from 7.2 ± 1.5 to 3.4 ± 1.3 , with a 3.8-point reduction. All condition-specific pre–post comparisons were statistically significant at $p < 0.001$.

Table 3. Change in Pain Scores According to Clinical Condition

Clinical Condition	n	Pre-Intervention VAS Mean ± SD	Post-Intervention VAS Mean ± SD	Mean Difference	Relative Reduction (%)	Standardized Mean Change*	p-value
Low back pain	24	7.4 ± 1.1	3.1 ± 1.0	4.3	58.1	4.10	<0.001
Cervical pain	15	6.9 ± 1.4	3.3 ± 1.2	3.6	52.2	2.77	<0.001
Pelvic girdle dysfunction	8	7.0 ± 1.2	3.5 ± 1.1	3.5	50.0	3.04	<0.001
Postural dysfunction	9	6.8 ± 1.3	3.0 ± 1.0	3.8	55.9	3.30	<0.001
Myofascial pain syndrome	4	7.2 ± 1.5	3.4 ± 1.3	3.8	52.8	2.71	<0.001

Functional improvement was also observed across daily activity domains after the intervention. Postural control showed the highest frequency of improvement, with 51 participants (85.0%) classified as improved and 9 participants (15.0%) not improved. Functional mobility improved in 50 participants (83.3%), while sitting tolerance improved in 49 participants (81.7%). Household activity performance improved in 48 participants (80.0%), and walking endurance improved in 46 participants (76.7%). Across the five functional domains, the proportion of participants showing improvement ranged from 76.7% to 85.0%, indicating consistent functional gains beyond pain reduction alone.

Table 4. Functional Improvement After Six-Week Physiotherapy Intervention (n=60)

Functional Variable	Improved n (%)	Not Improved n (%)	Improvement-to-Non-Improvement Ratio
Sitting tolerance	49 (81.7)	11 (18.3)	4.45:1
Walking endurance	46 (76.7)	14 (23.3)	3.29:1
Postural control	51 (85.0)	9 (15.0)	5.67:1
Household activities	48 (80.0)	12 (20.0)	4.00:1
Functional mobility	50 (83.3)	10 (16.7)	5.00:1

Overall, the six-week neuro-musculoskeletal physiotherapy intervention was associated with statistically significant and clinically meaningful improvements in both primary pain and secondary disability outcomes. Pain intensity decreased by 54.9%, while functional disability decreased by 45.9%. The greatest diagnostic-category pain reduction was observed among participants with low back pain, with a 4.3-point VAS decrease, whereas the smallest absolute reduction was observed among participants with pelvic girdle dysfunction, with a 3.5-point VAS decrease. Functional gains were most frequently observed in postural control and functional mobility, with improvement rates of 85.0% and 83.3%, respectively.

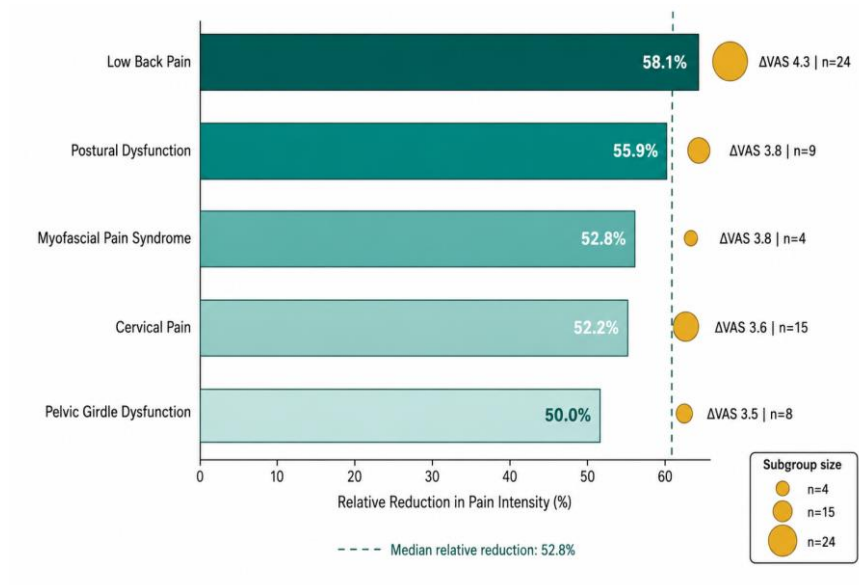


Figure 2. Pain-Response Gradient Across Neuro-Musculoskeletal Conditions After Six Weeks of Physiotherapy

The figure demonstrates a clinically meaningful pain-response gradient across diagnostic subgroups, with relative VAS reduction ranging from 50.0% in pelvic girdle dysfunction to 58.1% in low back pain. Low back pain showed the greatest absolute improvement, with a 4.3-point reduction in VAS score

among 24 participants, followed by postural dysfunction with a 3.8-point reduction and 55.9% relative improvement. Cervical pain, myofascial pain syndrome, and pelvic girdle dysfunction also showed substantial improvement, with relative reductions of 52.2%, 52.8%, and 50.0%, respectively. The median relative pain reduction across conditions was 52.8%, indicating that the six-week neuro-musculoskeletal physiotherapy intervention produced consistent pain improvement across heterogeneous clinical presentations.

DISCUSSION

The present study demonstrated significant short-term improvement in pain intensity and functional disability among women with neuro-musculoskeletal disorders following a structured six-week physiotherapy rehabilitation program. Pain intensity decreased from a mean VAS score of 7.1 ± 1.3 before intervention to 3.2 ± 1.1 after intervention, reflecting an absolute reduction of 3.9 points and a relative reduction of 54.9%. Functional disability also improved substantially, with mean disability scores decreasing from 58.4 ± 10.2 to 31.6 ± 8.7 , corresponding to a 26.8-point reduction and 45.9% relative improvement. These findings indicate that a multimodal neuro-musculoskeletal physiotherapy approach incorporating therapeutic exercise, stretching, strengthening, core stabilization, neuromuscular re-education, manual therapy, postural correction, ergonomic education, and functional training was associated with meaningful improvement in pain and functional performance among women with diverse neuro-musculoskeletal presentations.

The observed reduction in pain is clinically important because participants presented with moderate-to-severe baseline pain, and the post-intervention mean score shifted toward a lower pain-intensity range after six weeks of treatment. This improvement may be explained by the combined effects of active exercise, manual therapy, neuromuscular retraining, and postural correction. Exercise-based rehabilitation can improve pain through enhanced muscle activation, improved joint mobility, increased circulation, reduced fear of movement, and improved tolerance for functional activity. Strengthening and stabilization exercises may also improve load distribution across the spine, pelvis, and extremities, thereby reducing mechanical strain during daily activities. These findings are consistent with previous evidence showing that therapeutic exercise can reduce pain and disability in chronic low back pain and related musculoskeletal conditions (12). The improvement also supports the role of movement retraining approaches that target maladaptive posture, altered movement behavior, and impaired functional control in chronic pain populations (13).

Functional disability improved alongside pain reduction, suggesting that the intervention produced benefits beyond symptom relief. The decline in disability score from 58.4 to 31.6 indicates that participants experienced better capacity to perform routine activities after treatment. This functional improvement is particularly relevant in women's health because household work, caregiving responsibilities, occupational tasks, prolonged standing, repetitive bending, and lifting activities can intensify musculoskeletal symptoms and restrict daily participation. Improvement in functional disability may have resulted from increased strength, better spinal and pelvic control, improved flexibility, enhanced neuromuscular coordination, and education regarding safe movement strategies. Core stabilization exercises, including abdominal drawing-in maneuvers, pelvic tilting, bridging, and spinal stabilization activities, may have contributed to improved lumbopelvic control and movement efficiency, which are important for women with low back pain, pelvic girdle dysfunction, and postural impairment (14).

Condition-specific analysis showed that pain reduction occurred across all diagnostic categories. Participants with low back pain demonstrated the greatest absolute and relative improvement, with VAS scores decreasing from 7.4 ± 1.1 to 3.1 ± 1.0 , representing a 4.3-point reduction and 58.1% relative improvement. This finding is clinically plausible because the intervention included several components directly relevant to low back pain management, including core stabilization, lumbar mobility exercises,

strengthening of spinal and pelvic stabilizers, ergonomic training, and functional movement practice. Previous clinical evidence has also supported the effectiveness of core stabilization and exercise-based therapy in reducing pain among patients with chronic non-specific low back pain (15). The improvement among women with low back pain in this study reinforces the practical importance of combining active rehabilitation with education and functional retraining rather than relying on passive treatment alone.

Participants with postural dysfunction also demonstrated substantial improvement, with VAS scores decreasing from 6.8 ± 1.3 to 3.0 ± 1.0 , corresponding to a 3.8-point reduction and 55.9% relative improvement. This response may be attributed to postural correction training, ergonomic education, strengthening of stabilizing musculature, and repeated practice of neutral spine positioning. Postural dysfunction is often associated with prolonged sitting, sustained static positions, forward-head posture, poor workplace ergonomics, and repetitive activity patterns. These factors can alter muscle recruitment and increase strain on cervical, thoracic, and lumbar structures. Previous work on symptomatic office workers has shown that sustained keyboard work and postural demands may influence neck and shoulder muscle activity patterns, supporting the need for posture-focused rehabilitation strategies (16). Therefore, the improvement observed in postural dysfunction suggests that education and active movement retraining may be valuable components of women's neuro-musculoskeletal rehabilitation.

Cervical pain improved from 6.9 ± 1.4 to 3.3 ± 1.2 , with a mean reduction of 3.6 points and 52.2% relative improvement. This improvement may reflect the combined influence of cervical mobility exercises, stretching of the upper trapezius and pectoral muscles, strengthening of postural muscles, ergonomic correction, and manual therapy where clinically indicated. Cervical pain is frequently influenced by prolonged screen use, sustained neck flexion, static occupational posture, and altered cervical muscle recruitment. The reduction in cervical pain after intervention suggests that a structured multimodal program can improve symptoms when it addresses both local impairments and contributing postural or ergonomic factors.

Participants with pelvic girdle dysfunction had a 3.5-point reduction in VAS score, from 7.0 ± 1.2 to 3.5 ± 1.1 , representing 50.0% relative improvement. Although this was the lowest relative reduction among the diagnostic groups, it still represented a meaningful decrease in pain. Pelvic girdle dysfunction may involve altered load transfer, impaired pelvic stability, ligamentous laxity, reduced trunk control, and movement-related pain, particularly in women with pregnancy-related or postpartum biomechanical changes. Rehabilitation approaches targeting stabilization, motor control, hip and pelvic strengthening, and functional activity modification are therefore clinically relevant. The findings align with the rationale that pelvic girdle pain requires integrated management focused on stability, movement control, and functional restoration (3,17).

Myofascial pain syndrome showed improvement from 7.2 ± 1.5 to 3.4 ± 1.3 , with an absolute reduction of 3.8 points and relative reduction of 52.8%. This improvement may be related to stretching, soft-tissue mobilization, myofascial release, trigger-point therapy, strengthening, posture correction, and activity modification. Myofascial pain is often influenced by sustained muscle tension, repetitive strain, poor posture, stress-related muscle guarding, and reduced movement variability. The observed improvement suggests that combining manual techniques with active rehabilitation may reduce pain while improving functional movement tolerance.

Functional activity outcomes further supported the clinical value of the intervention. Postural control improved in 51 participants (85.0%), functional mobility in 50 participants (83.3%), sitting tolerance in 49 participants (81.7%), household activities in 48 participants (80.0%), and walking endurance in 46 participants (76.7%). These improvements are important because women with neuro-musculoskeletal pain often seek care not only for pain relief but also for restoration of daily activity capacity. Improvement in postural control and mobility may reflect better neuromuscular coordination, enhanced proprioceptive input, improved muscle performance, and increased confidence in movement. Balance, proprioception, and postural orientation are important components of motor control and

functional stability, particularly in individuals with persistent pain and impaired movement patterns (14). The high improvement rate in postural control suggests that neuromuscular re-education and movement retraining were clinically relevant components of the rehabilitation protocol.

The findings also highlight the importance of a comprehensive rehabilitation model for women's health. Women may experience neuro-musculoskeletal symptoms through interacting biological, biomechanical, occupational, and lifestyle-related mechanisms. Hormonal influences, pregnancy-related changes, repetitive household work, caregiving responsibilities, prolonged static postures, reduced physical activity, and delayed consultation may all contribute to chronic pain and functional limitation (2,16). A rehabilitation program that integrates strengthening, flexibility, motor control, ergonomic training, and functional practice is therefore better aligned with the multidimensional nature of women's neuro-musculoskeletal disorders than isolated symptom-based treatment. The present results support the clinical utility of structured physiotherapy services within women's rehabilitation settings, particularly where access to early preventive care and supervised exercise programs remains limited.

The magnitude of improvement observed in pain and disability should be interpreted in the context of the study design. Because the study used a single-group pre-post design without a control group, the observed improvements represent within-participant change after intervention rather than definitive comparative effectiveness against usual care, no treatment, or another rehabilitation approach. Natural recovery, regression toward the mean, patient expectation, increased attention from therapists, home exercise adherence, and changes in daily activity patterns may have contributed to the observed outcomes. However, the consistent direction of improvement across pain, disability, diagnostic subgroups, and functional activity domains suggests that the structured rehabilitation program was associated with broad clinical improvement over the six-week treatment period.

Several methodological considerations should be acknowledged when interpreting these findings. The sample size was modest, and participants were recruited from a single clinical setting using convenience sampling, which may limit generalizability to other populations and healthcare contexts. The absence of long-term follow-up prevents determination of whether improvements were maintained after completion of supervised therapy. The inclusion of multiple neuro-musculoskeletal conditions reflects real-world physiotherapy practice but also introduces clinical heterogeneity. In addition, psychosocial factors, physical activity level, body mass index, occupational workload, pain chronicity, sleep quality, and adherence to home exercise may influence rehabilitation outcomes and were not analyzed as independent predictors. Future research using randomized controlled designs, larger multicenter samples, standardized condition-specific outcome measures, longer follow-up periods, and adjustment for psychosocial and lifestyle factors would provide stronger evidence regarding the effectiveness and durability of neuro-musculoskeletal physiotherapy among women.

Despite these limitations, the study has several strengths. It used a structured six-week rehabilitation protocol, assessed both pain and functional disability, and included multiple clinically relevant functional outcomes such as sitting tolerance, walking endurance, postural control, household activities, and functional mobility. The intervention reflected routine physiotherapy practice by combining active exercise, neuromuscular re-education, manual therapy, postural correction, ergonomic education, and functional training. This pragmatic approach increases the clinical relevance of the findings for rehabilitation settings managing women with mixed neuro-musculoskeletal presentations.

Overall, the results indicate that a six-week structured neuro-musculoskeletal physiotherapy program was associated with significant short-term reductions in pain intensity and functional disability among women with neuro-musculoskeletal disorders. Improvements were observed across low back pain, cervical pain, pelvic girdle dysfunction, postural dysfunction, and myofascial pain syndrome, with the greatest relative pain reduction seen in low back pain and the highest functional improvement observed in postural control and functional mobility. These findings support the role of integrated physiotherapy

rehabilitation in improving pain, movement performance, and daily functional capacity among women with neuro-musculoskeletal conditions.

CONCLUSION

The present study concluded that a structured six-week neuro-musculoskeletal physiotherapy rehabilitation program was associated with significant short-term improvement in pain intensity, functional disability, postural control, mobility, walking endurance, sitting tolerance, and household activity performance among women with neuro-musculoskeletal disorders. Pain intensity decreased from 7.1 ± 1.3 to 3.2 ± 1.1 , while functional disability improved from 58.4 ± 10.2 to 31.6 ± 8.7 after intervention, indicating meaningful clinical gains in both symptom reduction and functional capacity. Improvements were observed across low back pain, cervical pain, pelvic girdle dysfunction, postural dysfunction, and myofascial pain syndrome, with the greatest relative pain reduction noted among participants with low back pain. These findings support the use of integrated physiotherapy care that combines therapeutic exercise, strengthening, stretching, core stabilization, neuromuscular re-education, manual therapy, postural correction, ergonomic education, and functional training for women experiencing pain-related movement dysfunction and daily activity limitation. Early referral to physiotherapy and structured rehabilitation management may help reduce progression toward chronic disability and improve functional independence in women's health rehabilitation settings.

REFERENCES

1. Kisner C, Colby LA, Borstad J. *Therapeutic Exercise: Foundations and Techniques*. Philadelphia: F.A. Davis; 2017.
2. Fillingim RB, King CD, Ribeiro-Dasilva MC, Rahim-Williams B, Riley JL III. Sex, gender, and pain: a review of recent clinical and experimental findings. *J Pain*. 2009;10(5):447-485.
3. Vleeming A, Albert HB, Ostgaard HC, Sturesson B, Stuge B. European guidelines for the diagnosis and treatment of pelvic girdle pain. *Eur Spine J*. 2008;17(6):794-819.
4. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396(10258):1204-1222.
5. Hossen AA. *Effectiveness of Mulligan Mobilization with Conventional Physiotherapy for Knee Osteoarthritis: A Randomized Controlled Trial*. Bangladesh Health Professions Institute, Faculty of Medicine, University of Dhaka; 2024.
6. Szeto GP, Straker LM, O'Sullivan PB. A comparison of symptomatic and asymptomatic office workers performing monotonous keyboard work—1: neck and shoulder muscle recruitment patterns. *Man Ther*. 2005;10(4):270-280.
7. Pregnancy-related pelvic girdle pain. [Reference details incomplete in source manuscript].
8. Shumway-Cook A, Woollacott MH. *Motor Control: Translating Research into Clinical Practice*. Philadelphia: Lippincott Williams & Wilkins; 2007.
9. Brody LT, Hall CM. *Therapeutic Exercise: Moving Toward Function*. Philadelphia: Wolters Kluwer; 2018.
10. Richardson C, Hodges P, Hides J. *Therapeutic Exercise for Lumbopelvic Stabilization*. Edinburgh: Elsevier; 2004.

11. Coulter ID, Crawford C, Hurwitz EL, Vernon H, Khorsan R, Booth MS, et al. Manipulation and mobilization for treating chronic low back pain: a systematic review and meta-analysis. *Spine J.* 2018;18(5):866-879.
12. Hayden JA, van Tulder MW, Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain. *Cochrane Database Syst Rev.* 2005;(3):CD000335.
13. O'Sullivan PB. Cognitive functional therapy. 2018. [Reference details incomplete in source manuscript].
14. Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? *Age Ageing.* 2006;35 Suppl 2:ii7-ii11.
15. Akhtar MW, Karimi H, Gilani SA. Effectiveness of core stabilization exercises and routine exercise therapy in management of pain in chronic non-specific low back pain: a randomized controlled clinical trial. *Pak J Med Sci.* 2017;33(4):1002-1006.
16. Nicholas MK, Linton SJ, Watson PJ, Main CJ; "Decade of the Flags" Working Group. Early identification and management of psychological risk factors, "yellow flags," in patients with low back pain: a reappraisal. *Phys Ther.* 2011;91(5):737-753.
17. Wahid E, Ullah K, Khalil S, Khan MS, Raja AJ. Immediate effect of sustained natural apophyseal glides (SNAGs) on prolapsed intervertebral disc (PIVD) in patients with low back pain: a pre-post experimental study. *Insights J Health Rehabil.* 2025;3(4):362-368.