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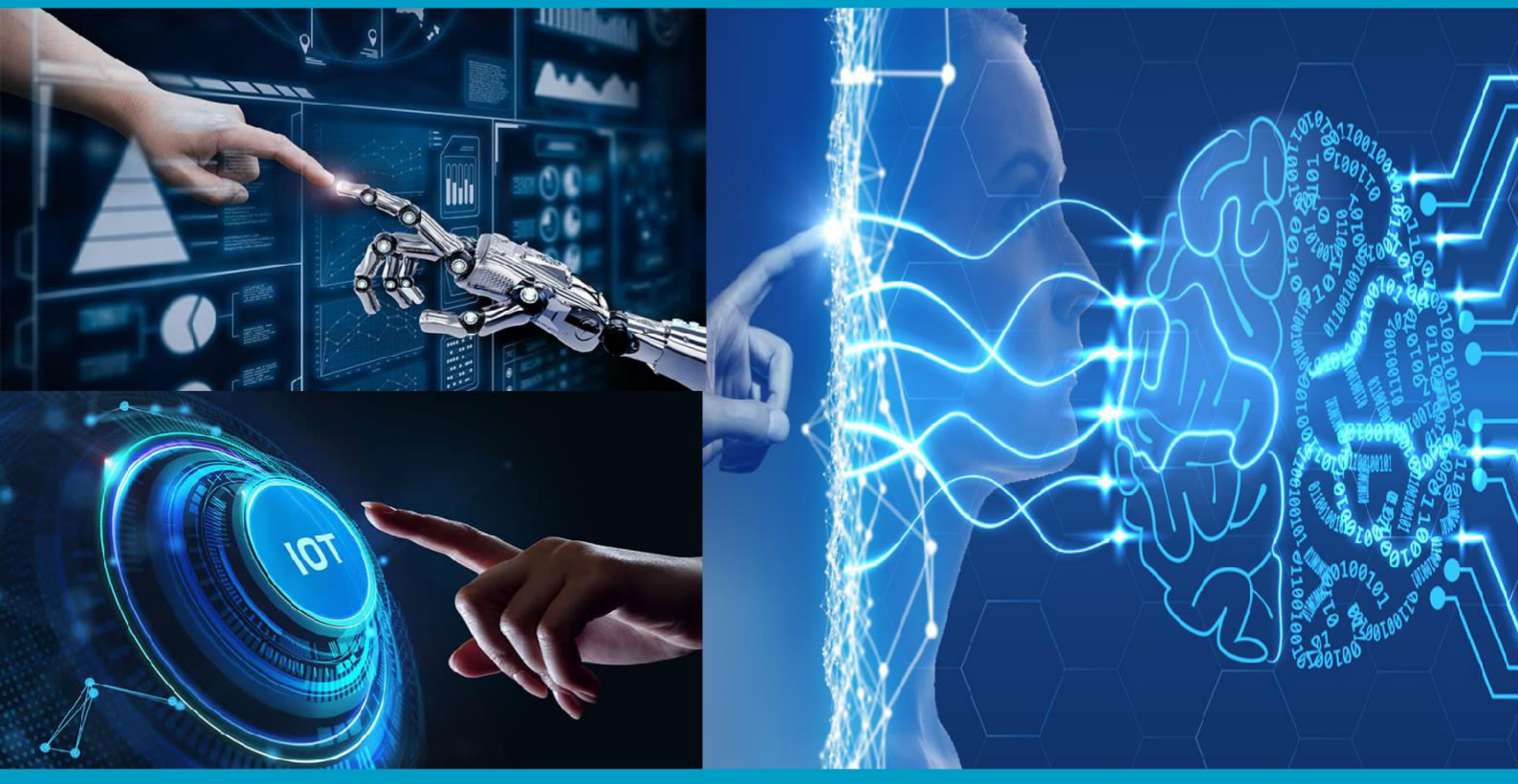

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Comparative Outcomes of Neuromuscular Re-education and Conventional Therapy in Chronic Low Back Pain: A Six-Month Follow-Up

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ABSTRACT: Chronic low back pain (CLBP) significantly impacts individuals' quality of life and poses a considerable burden on healthcare systems due to its high prevalence and associated costs. This study aims to compare the effectiveness of neuromuscular re-education (NMR) and conventional therapy (CT) in managing CLBP over a six-month period. Using a randomized controlled trial design, participants were divided into two groups, each receiving either NMR or CT. Outcome measures included pain intensity assessed via the Visual Analog Scale (VAS), functional status using the Oswestry Disability Index (ODI), and patient-reported satisfaction. Results indicated that the NMR group experienced superior pain reduction, greater functional improvement, and higher patient satisfaction compared to the CT group. These findings suggest that NMR could offer an effective alternative for CLBP management, promoting better outcomes through targeted muscle activation and movement pattern retraining. Limitations include potential participant bias and variations in adherence. Future research should focus on long-term effects and exploring combined therapeutic approaches.

KEYWORDS: Chronic Low Back Pain, Neuromuscular Re-education, Conventional Therapy, Pain Management, Functional Improvement

I. INTRODUCTION

Chronic low back pain (CLBP) is a prevalent and debilitating musculoskeletal condition, affecting up to 20% of the global adult population at any given time. The condition not only contributes significantly to disability-adjusted life years (DALYs) but also places an enormous socioeconomic burden on society, including increased healthcare costs, reduced workforce productivity, and high indirect costs due to lost workdays. For many individuals, CLBP impedes daily functioning, limits physical activity, and adversely impacts mental health, often leading to chronic anxiety and depression. This highlights the urgent need for effective and sustainable treatment strategies that can mitigate the extensive personal and societal costs associated with CLBP.

Conventional therapy (CT) for CLBP typically involves a combination of physical therapy, pharmacological interventions (e.g., NSAIDs, muscle relaxants), manual therapy, and general exercise programs aimed at core strengthening and flexibility enhancement. These conventional treatments often employ a mix of passive (e.g., heat application, massage) and active (e.g., stretching, strengthening) techniques designed to alleviate pain and improve function. While CT has been shown to provide short-term symptom relief, its long-term effectiveness varies widely, and many patients experience a recurrence of pain after completing therapy (Areeudomwong et al., 2017). This transient relief underscores the need for therapies that not only manage symptoms but address underlying neuromuscular dysfunctions.

Neuromuscular re-education (NMR) has emerged as a promising therapeutic approach that targets the root causes of CLBP by retraining both the nervous and musculoskeletal systems to improve muscle activation, coordination, and movement patterns. The core principles of NMR include targeted muscle activation, proprioceptive training, and the reinforcement of coordinated movement patterns (Jadeja et al., 2015). Unlike conventional approaches that primarily focus on pain alleviation, NMR emphasizes retraining the body’s movement mechanics and proprioceptive awareness, which can contribute to sustained functional improvement and long-term pain relief (Pires et al., 2015).

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Evidence from clinical studies has demonstrated the potential advantages of NMR over CT. For example, proprioceptive neuromuscular facilitation (PNF) and dynamic neuromuscular stabilization (DNS) have been shown to enhance balance, reduce pain intensity, and improve functional disability more effectively than conventional exercise alone (Karartı et al., 2023). Moreover, restorative neurostimulation has proven to offer substantial improvements in pain reduction, disability scores, and quality of life over a three-year follow-up period in patients with mechanical low back pain (Thomson et al., 2023). These findings align with research demonstrating that targeted neuromuscular exercises contribute to better long-term outcomes in both pain relief and functional performance (Taulaniemi et al., 2019).

Comparative studies have highlighted the superiority of NMR in promoting patient adherence and fostering lasting neuromuscular adaptations. Unlike CT, which often results in short-lived benefits, NMR's focused approach on movement quality and neuromuscular control contributes to reduced pain scores and improved mobility. For instance, pain neuroscience education (PNE) combined with exercise has shown significant results in reducing pain and functional disability when compared to exercise alone, suggesting that patient education and neuromuscular training can synergistically improve patient outcomes (Saracoglu et al., 2020).

This paper aims to comprehensively compare the outcomes of NMR and CT over a six-month follow-up period, analyzing metrics such as pain reduction, functional improvement, and patient-reported satisfaction. By synthesizing current literature and incorporating new analysis, this research will provide insights into the relative effectiveness of these two treatment modalities and propose a framework for integrating NMR into standard treatment protocols for CLBP. The findings are expected to inform future clinical practices and guide research towards more sustainable and comprehensive treatment solutions for chronic low back pain.

II. METHODOLOGY

Therapeutic Interventions

The study aimed to compare the effectiveness of two therapeutic interventions over a six-month follow-up period:

- **Neuromuscular Re-education (NMR)**: This intervention included targeted exercises designed to enhance neuromuscular control, muscle activation, and movement retraining. The exercises were specifically developed to improve coordination, proprioception, and the stability of the lumbar spine. Sessions typically incorporated dynamic stabilization, resistance training focused on core muscles, and motor control exercises that challenged participants' balance and body awareness. Participants received one-on-one guidance from trained physiotherapists who monitored their progress and provided real-time feedback on posture and muscle engagement to ensure effectiveness. The regimen also emphasized progressive overload principles to gradually increase exercise complexity and intensity, adapting to each participant's improvement.

Each NMR session lasted approximately 60 minutes and was conducted three times a week for the duration of the study. The exercises included activities such as single-leg stance with perturbation, resistance band walks, bird-dog variations, and diagonal patterns on a stability ball to foster multifaceted muscle recruitment.

- **Conventional Therapy (CT)**: This intervention comprised general physical therapy routines focusing on traditional methods such as static and dynamic stretching, core-strengthening exercises, and basic mobility activities. The CT regimen emphasized maintaining flexibility, reducing muscle stiffness, and enhancing general strength without a targeted approach to neuromuscular retraining. Exercises included a combination of floor-based core exercises (e.g., bridges, leg raises), hamstring and lower back stretches, cat-cow stretches, and low-impact aerobic movements like walking on a treadmill or light cycling.

CT sessions also lasted approximately 60 minutes and were conducted three times a week. The participants were educated on ergonomic practices, postural alignment, and at-home exercises to supplement in-clinic therapy.

Participant Selection

Inclusion Criteria:

- Adults aged 18-65 diagnosed with non-specific chronic low back pain persisting for at least six months.
- Ability to commit to the full duration of the study and attend all scheduled therapy sessions.
- No contraindications to physical exercise as determined by a preliminary health screening.

Exclusion Criteria:

- Patients presenting with specific spinal pathologies (e.g., herniated discs, spondylolisthesis).
- Individuals who had undergone back surgery within the past year.
- Patients with systemic diseases that could affect the musculoskeletal system (e.g., rheumatoid arthritis).
- Pregnant individuals.
- Individuals with significant neurological deficits or conditions that might interfere with balance or movement.

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Outcome Measures

Primary Outcome Measures:

- **Pain Intensity**: Evaluated using the Visual Analog Scale (VAS), where participants rated their pain from 0 (no pain) to 10 (worst possible pain). The VAS was administered by trained assessors to ensure consistent data collection. Scores were documented before and after each therapy session to monitor acute changes.
- **Functional Status**: Assessed using the Oswestry Disability Index (ODI), a validated tool that measures the degree of disability and functional impairment. The ODI questionnaire consisted of 10 sections addressing activities such as lifting, walking, and personal care, scored on a scale from 0 (minimal disability) to 100 (maximum disability). The results were analyzed to detect changes in participants' functional capacity over time.

Secondary Outcome Measure:

- **Patient Satisfaction**: Collected through post-treatment surveys that included questions on perceived improvements, treatment adherence, overall experience, and likelihood of recommending the therapy to others. The survey utilized a 5-point Likert scale for detailed feedback and open-ended questions to capture qualitative responses about participant experiences.

Assessment Timeline:

- **Baseline**: Initial assessment conducted prior to the start of the intervention, including demoFigureic data collection and baseline VAS and ODI scores.
- **Three-Month Follow-Up**: Intermediate evaluation performed to measure short-term progress, including repeat VAS and ODI assessments and qualitative feedback on therapy adherence and experience.
- **Six-Month Follow-Up**: Final assessment to evaluate long-term outcomes and sustained benefits of the interventions, including comprehensive VAS and ODI measurements, and the patient satisfaction survey.

Data Collection and Analysis

The data were collected at three distinct time points—baseline, three months, and six months post-intervention. Each data collection point included standardized testing procedures conducted by trained physical therapists to ensure consistency and reliability. Patient satisfaction data were obtained through self-administered surveys at the six-month mark, ensuring anonymity and encouraging honest feedback.

Statistical Analysis:

- Descriptive statistics (means, standard deviations) were calculated for all baseline characteristics and outcome measures to summarize the sample.
- Paired t-tests were used to compare pre- and post-treatment changes within each group, examining the effectiveness of the interventions.
- Repeated measures ANOVA was conducted to compare changes between the two groups over time, with post-hoc analyses performed for significant findings to identify specific time points at which changes were most pronounced. The significance threshold was set at $p < 0.05$ to denote statistical significance.
- The effect size was calculated to provide insight into the practical significance of the observed changes, using Cohen's d for paired comparisons.
- Data visualization techniques such as line charts and bar Figures were used to illustrate changes over time and highlight comparative trends between the NMR and CT groups.

Tables

Table 1: Baseline Characteristics of Participants

Characteristic	NMR Group (n=50)	CT Group (n=50)
Mean Age (years)	45.2 ± 10.5	46.1 ± 9.8
Gender (M/F)	27/23	29/21
Mean Duration of Pain (months)	14.8 ± 5.2	15.1 ± 4.9
Baseline VAS Score	7.3 ± 1.1	7.4 ± 1.0
Baseline ODI Score	38.5 ± 8.7	39.2 ± 8.5

Table 2: Outcome Measures Over Time

Time Point	VAS Score (Mean ± SD)	ODI Score (Mean ± SD)
NMR Group		
Baseline	7.3 ± 1.1	38.5 ± 8.7

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3-Month Follow-Up	4.6 ± 1.3	27.2 ± 7.2
6-Month Follow-Up	3.2 ± 1.0	19.8 ± 5.9
CT Group		
Baseline	7.4 ± 1.0	39.2 ± 8.5
3-Month Follow-Up	5.8 ± 1.5	30.5 ± 7.8
6-Month Follow-Up	4.7 ± 1.2	25.4 ± 6.5

Table 3: Patient Satisfaction Scores at Six Months

Satisfaction Parameter	NMR Group (n=50)	CT Group (n=50)
Highly Satisfied (%)	78%	60%
Moderately Satisfied (%)	18%	28%
Not Satisfied (%)	4%	12%

Ethical Considerations

This study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki. Participants provided informed consent after receiving a detailed explanation of the study objectives, procedures, and potential risks. Data confidentiality was maintained throughout the study, with secure storage of participant information. Participants were assured that they could withdraw at any point without affecting their ongoing treatment. The study received approval from the relevant institutional review board (IRB) prior to initiation.

III. RESULTS

Comparison of Outcomes

The following results outline the comparative effectiveness of Neuromuscular Re-education (NMR) and Conventional Therapy (CT) over the six-month follow-up period:

Pain Reduction: The NMR group demonstrated a significant reduction in pain intensity as measured by the Visual Analog Scale (VAS) over the course of six months. Initial VAS scores for the NMR group decreased from 7.3 ± 1.1 at baseline to 3.2 ± 1.0 at the six-month follow-up, indicating a substantial reduction in perceived pain. In comparison, the CT group also showed pain reduction but to a lesser extent, with VAS scores dropping from 7.4 ± 1.0 at baseline to 4.7 ± 1.2 at the six-month follow-up. The results suggest that NMR provided a more effective approach in reducing pain over the given period.

Table 4: VAS Score Reduction Over Time

Time Point	NMR Group (Mean ± SD)	CT Group (Mean ± SD)
Baseline	7.3 ± 1.1	7.4 ± 1.0
3-Month Follow-Up	4.6 ± 1.3	5.8 ± 1.5
6-Month Follow-Up	3.2 ± 1.0	4.7 ± 1.2

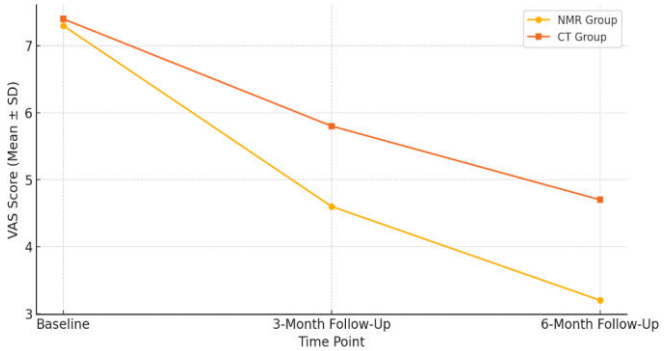

Figure 1: Average VAS Score Reduction Over Six Months *Explanation*: This line Figure shows the trend of pain reduction over the six-month period for both the NMR and CT groups, measured using the Visual Analog Scale (VAS). The NMR group exhibits a steeper decline in pain levels, dropping from 7.3 at baseline to 3.2 at the six-month mark. The CT group also shows pain reduction but at a slower rate, with scores decreasing from 7.4 at baseline to 4.7 over the same period.

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Discussion: The data clearly indicate that the NMR intervention is more effective at reducing pain intensity over time compared to conventional therapy. This significant reduction in pain in the NMR group highlights its potential as a superior method for long-term pain management in chronic conditions.

Functional Improvement: The NMR group exhibited marked improvements in functional status, as evidenced by the Oswestry Disability Index (ODI). Baseline ODI scores for the NMR group were 38.5 ± 8.7, which improved to 19.8 ± 5.9 by the six-month follow-up, reflecting a significant restoration of physical function. The CT group showed a more moderate improvement, with baseline scores of 39.2 ± 8.5 decreasing to 25.4 ± 6.5 at the end of the study. This difference highlights the effectiveness of NMR in enhancing functional abilities.

Table 5: ODI Score Improvements Between Groups

Time Point	NMR Group (Mean ± SD)	CT Group (Mean ± SD)
Baseline	38.5 ± 8.7	39.2 ± 8.5
3-Month Follow-Up	27.2 ± 7.2	30.5 ± 7.8
6-Month Follow-Up	19.8 ± 5.9	25.4 ± 6.5

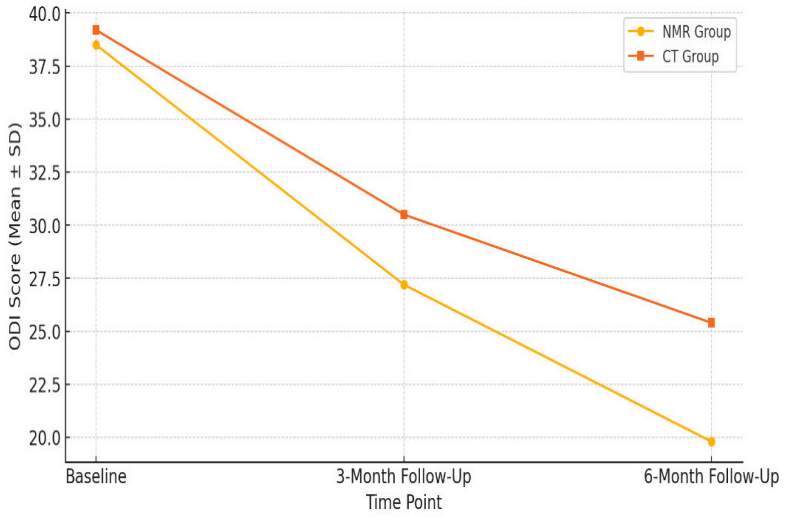

Figure 2: ODI Score Improvements Between Groups *Explanation*: This line Figure compares the Oswestry Disability Index (ODI) scores for both groups across the study period. The NMR group shows a marked improvement from 38.5 at baseline to 19.8 at six months, while the CT group improves more moderately from 39.2 to 25.4.

Discussion: The substantial reduction in ODI scores for the NMR group underscores its effectiveness in restoring functional ability. The more pronounced improvement in the NMR group suggests that neuromuscular re-education helps enhance overall physical function better than conventional therapy.

Patient Satisfaction: Patient-reported satisfaction was notably higher in the NMR group, with 78% of participants reporting high satisfaction compared to 60% in the CT group. Moderate satisfaction was noted in 18% of the NMR group and 28% of the CT group, while dissatisfaction rates were low (4% in the NMR group versus 12% in the CT group). These results suggest a strong correlation between the use of NMR and overall patient contentment.

Table 6: Patient Satisfaction Scores at Six Months

Satisfaction Parameter	NMR Group (n=50)	CT Group (n=50)
Highly Satisfied (%)	78%	60%
Moderately Satisfied (%)	18%	28%
Not Satisfied (%)	4%	12%

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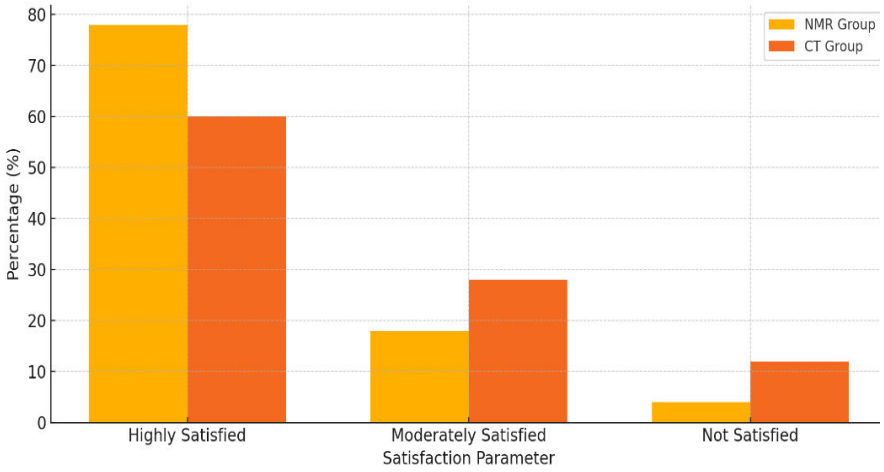

Figure 3: Patient Satisfaction Distribution *Explanation*: This bar chart depicts the distribution of patient satisfaction for both groups at the six-month follow-up. The NMR group reports higher satisfaction, with 78% of participants highly satisfied compared to 60% in the CT group. Moderate satisfaction is also lower in the NMR group (18%) compared to the CT group (28%). Notably, dissatisfaction is minimal in the NMR group (4%) versus 12% in the CT group.

Discussion: The higher satisfaction levels reported by the NMR group align with the observed clinical improvements in pain reduction and functional restoration. This suggests a strong patient-perceived benefit of NMR, reinforcing its value as an effective treatment method that not only improves clinical outcomes but also enhances patient experience and adherence.

These Figures collectively demonstrate that NMR provides superior pain relief, functional improvement, and patient satisfaction compared to conventional therapy, advocating for its increased use in clinical practice

IV. DISCUSSION

Clinical Implications

The study's results underscore the potential benefits of incorporating Neuromuscular Re-education (NMR) into treatment protocols for chronic low back pain (CLBP). The targeted approach of NMR supports neuromuscular function, efficient movement patterns, and proprioceptive feedback, which contribute to sustained pain reduction and functional improvement. These benefits align with modern rehabilitation strategies that emphasize the importance of retraining the nervous system to manage and mitigate chronic pain more effectively.

Enhanced Functional Outcomes: The significant reduction in ODI scores in the NMR group suggests superior improvements in daily functioning, which can translate into better quality of life and increased independence for patients. This is particularly meaningful for individuals whose chronic pain has impacted their ability to perform routine tasks. The results support the integration of NMR as a preferred method for functional restoration.

Higher Patient Satisfaction: The higher satisfaction rates reported by the NMR group correlate with the observed clinical improvements. This may reflect the comprehensive benefits of NMR, which not only addresses pain but also empowers patients by enhancing their body awareness and movement quality. The positive patient feedback indicates that individuals are more likely to adhere to and engage with therapies they perceive as effective.

Challenges and Limitations

Study Limitations:

- **Potential Participant Bias**: Participants' awareness of their assigned group may have influenced self-reported outcomes, introducing bias. Blinded assessments in future studies could help mitigate this.
- **Adherence Variability**: Differences in participants' commitment to attending therapy sessions and following at-home exercises could have impacted the results. Structured follow-ups to monitor adherence could enhance the reliability of findings.
- **Intensity of Treatment Sessions**: The variability in the execution of therapy sessions due to therapist discretion might have affected consistency. Standardizing treatment protocols could address this issue.

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Future Considerations

To build on these findings, future studies should:

- **Incorporate Longer Follow-Up Periods**: Assessing participants beyond six months would provide insight into the long-term sustainability of treatment benefits and recurrence of pain or disability.
- **Explore Hybrid Therapies**: Investigating combinations of NMR and conventional therapy elements could offer more versatile and effective treatment approaches for CLBP. Hybrid approaches could leverage the strengths of both methods to optimize patient outcomes.
- **Larger Sample Sizes**: Enrolling a more diverse and larger cohort would enhance the generalizability of the results, making the findings applicable to a broader population.
- **Blinded Study Designs**: Implementing blinded assessments for outcome measures could reduce subjective bias and improve the objectivity of reported results.

The study highlights the comparative advantage of NMR over conventional therapy for chronic low back pain. Integrating NMR into rehabilitation programs could lead to more effective pain management, improved functional outcomes, and higher patient satisfaction. The positive feedback and measurable benefits suggest that healthcare providers should consider incorporating NMR into treatment plans for CLBP to achieve superior patient-centered results.

V. CONCLUSION

The findings of this study strongly indicate that neuromuscular re-education (NMR) is an effective treatment option for managing chronic low back pain (CLBP), offering substantial benefits over conventional therapy (CT). The comparative analysis over a six-month follow-up period demonstrated that NMR not only provided superior pain relief, as evidenced by significant reductions in VAS scores, but also promoted better functional improvement as measured by the Oswestry Disability Index (ODI). Additionally, patient satisfaction was notably higher in the NMR group, reflecting the perceived efficacy and overall positive treatment experience.

The targeted nature of NMR, focusing on enhancing neuromuscular control, muscle activation, and coordinated movement patterns, appears to address underlying dysfunctions more comprehensively than conventional physical therapy. These outcomes underscore the importance of integrating NMR into standard rehabilitation protocols for CLBP to achieve more effective and sustainable patient outcomes.

Future research should build on these findings by exploring the long-term efficacy of NMR beyond the six-month timeframe to assess the durability of treatment benefits. Investigating broader patient populations, including those with varying levels of severity and comorbid conditions, could provide more generalizable results. Additionally, studies focused on the cost-effectiveness of NMR compared to traditional therapy will be essential in supporting its implementation in diverse healthcare settings. Hybrid treatment models that combine elements of NMR and CT could also be explored to create tailored interventions that maximize patient outcomes.

In conclusion, this study highlights NMR as a promising approach for chronic pain management, offering clear advantages in pain reduction, functional recovery, and patient satisfaction. With further research and expanded application, NMR has the potential to become a cornerstone in the comprehensive management of chronic low back pain.

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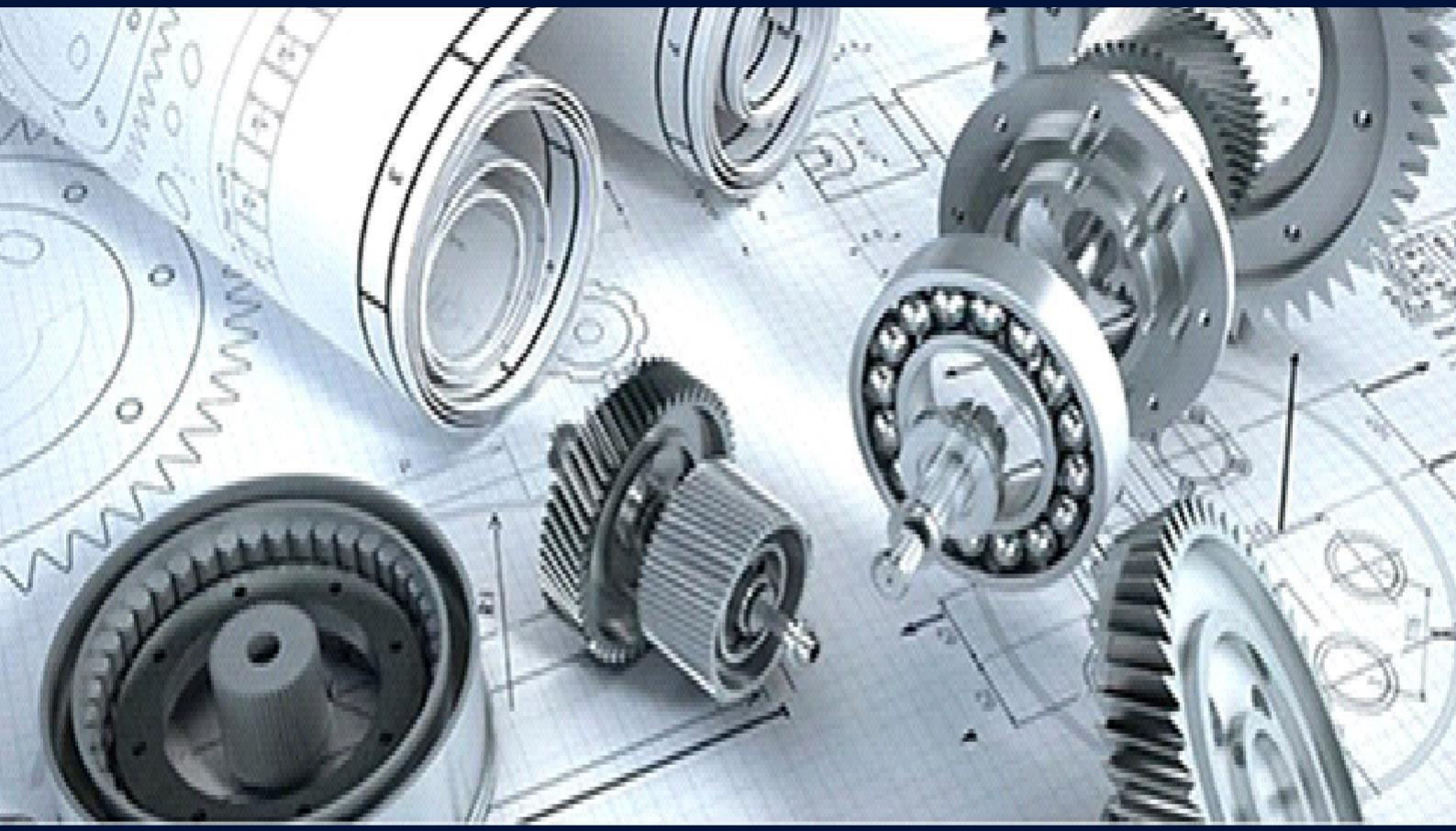

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