A Comparative Study of Yoga Therapy and Mckenzie Method Exercises on Stress Biomarkers and Clinical Outcomes in Mechanical Low Back Pain

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***Abstract*—Background: Mechanical low back pain (MLBP) is one of the most common musculoskeletal disorders and a leading cause of disability worldwide. Chronic low back pain is frequently associated with physiological stress responses and systemic inflammation, which may influence pain perception and recovery. Exercise-based rehabilitation approaches such as yoga therapy and the McKenzie method are widely used in the management of mechanical low back pain. However, limited research has examined their comparative effects on stress-related biomarkers such as salivary cortisol and C-reactive protein (CRP) alongside clinical outcomes.**

Objective: The present study aimed to compare the effects of yoga therapy and McKenzie method exercises on stress biomarkers (salivary cortisol and CRP) and clinical outcomes in individuals with mechanical low back pain.

Methods: A comparative randomized experimental study was conducted involving 60 participants with mechanical low back pain aged 30–40 years. Participants were randomly allocated into three groups: Yoga Therapy Group (n=20), McKenzie Method Group (n=20), and Control Group (n=20). The intervention period lasted nine weeks. Clinical outcomes were assessed using the Visual Analog Scale (VAS) for pain intensity and the Oswestry Disability Index (ODI) for functional disability. Stress biomarkers were measured using salivary cortisol and serum CRP levels. Data were analyzed using repeated-measures ANOVA and post-hoc Bonferroni tests with a significance level set at $p<0.05$.

Results: Both intervention groups demonstrated significant improvements in pain intensity and functional disability compared with the control group. The yoga therapy group showed greater reductions in VAS and ODI scores. Additionally, salivary cortisol and CRP levels decreased significantly in the yoga therapy group compared with the McKenzie and control groups.

Conclusion: Yoga therapy and McKenzie method exercises are effective interventions for improving clinical outcomes in mechanical low back pain. However, yoga therapy demonstrated superior effects in reducing physiological stress and inflammatory biomarkers, suggesting that mind–body rehabilitation approaches may provide additional benefits in managing chronic low back pain.

***Index Terms*—Mechanical low back pain, yoga therapy, McKenzie method, stress biomarkers, cortisol, C-reactive protein.**

I. INTRODUCTION

1.1. Mechanical Low Back Pain as a Global Health Concern

Low back pain is one of the most prevalent musculoskeletal disorders worldwide and represents a leading cause of disability and reduced quality of life. Epidemiological studies indicate that nearly 60–80% of adults experience low back pain at some point in their lifetime, with mechanical low back pain (MLBP) accounting for the majority of cases (Fernández-Rodríguez et al., 2022). Mechanical low back pain typically arises from dysfunction of the musculoskeletal structures of the lumbar spine, including intervertebral discs, ligaments, and paraspinal muscles. The condition is often associated with prolonged postural stress, sedentary lifestyles, and occupational risk factors.

In addition to physical discomfort, chronic low back pain has substantial socioeconomic consequences, including decreased work productivity, increased healthcare utilization, and long-term disability (Li et

al., 2023). Because of its multifactorial nature, the management of mechanical low back pain requires comprehensive approaches that address both physical and psychological aspects of the disorder.

1.2. Role of Stress and Inflammation in Low Back Pain

Recent research suggests that chronic pain conditions such as mechanical low back pain are closely linked with physiological stress responses and systemic inflammation. Activation of the hypothalamic–pituitary–adrenal (HPA) axis during chronic stress leads to increased secretion of cortisol, a glucocorticoid hormone that plays a key role in stress regulation (Zaccaro et al., 2018). Elevated cortisol levels have been associated with altered pain perception, immune dysregulation, and delayed tissue recovery.

Another important biomarker involved in chronic pain conditions is C-reactive protein (CRP), an inflammatory marker produced by the liver in response to systemic inflammation. Elevated CRP levels have been reported in individuals with chronic musculoskeletal pain, suggesting that inflammatory processes may contribute to the persistence of low back pain (Barro's dos Santos & Pinto de Castro, 2021). Consequently, assessing both cortisol and CRP levels may provide valuable insights into the physiological stress and inflammatory responses associated with mechanical low back pain.

1.3. Exercise-Based Rehabilitation Approaches in Low Back Pain

Exercise therapy is widely recognized as a primary non-pharmacological treatment strategy for mechanical low back pain. Therapeutic exercise programs aim to improve spinal stability, strengthen supporting musculature, and restore functional movement patterns. Among the commonly used rehabilitation approaches are the McKenzie method exercises.

The McKenzie method, also referred to as mechanical diagnosis and therapy (MDT), involves repeated spinal movements and postural correction strategies designed to centralize pain and improve spinal alignment (Olaoye et al., 2025). This approach emphasizes patient education and active participation in self-management of symptoms.

Core stabilization exercises focus on strengthening the deep trunk muscles, including the transversus abdominis, multifidus, and pelvic floor muscles. These muscles play an essential role in maintaining spinal stability and preventing excessive mechanical stress on the lumbar region. Evidence suggests that core stabilization programs can improve functional outcomes and reduce pain intensity in patients with chronic low back pain (Li et al., 2023).

1.4. Yoga Therapy as an Integrative Mind–Body Intervention

Yoga therapy has gained increasing recognition as an integrative intervention for musculoskeletal disorders. Unlike conventional exercise programs, yoga integrates physical postures, breathing techniques, and relaxation practices that address both physical and psychological aspects of health. Research has shown that yoga interventions may reduce pain intensity, improve flexibility, and enhance psychological well-being in individuals with chronic low back pain (Oz & Ulger, 2024).

One of the distinctive features of yoga therapy is its ability to regulate physiological stress responses. Breathing techniques and mindfulness practices incorporated in yoga have been shown to influence autonomic nervous system activity and reduce stress-related biomarkers such as cortisol (Zaccaro et al., 2018). These mechanisms suggest that yoga therapy may provide benefits beyond physical rehabilitation by also addressing stress-related factors associated with chronic pain.

1.5. Stress Biomarkers and Clinical Outcomes in Rehabilitation

Understanding the relationship between exercise interventions and stress biomarkers is essential for developing effective rehabilitation strategies. Biomarkers such as salivary cortisol provide a non-invasive measure of physiological stress, while inflammatory markers such as C-reactive protein (CRP) reflect systemic inflammatory responses. Previous studies have reported that exercise-based interventions, including yoga and stabilization exercises, may influence these biomarkers by reducing stress and improving physiological regulation (Poli et al., 2021).

However, most rehabilitation studies have primarily focused on clinical outcomes such as pain intensity

and functional disability, with limited attention given to biological markers of stress and inflammation. Evaluating both physiological biomarkers and clinical outcomes may therefore provide a more comprehensive understanding of the mechanisms underlying therapeutic interventions for low back pain.

1.6. Rationale and Objective of the Study

Although several studies have examined the effectiveness of yoga therapy, McKenzie method, and other exercise programs in the management of low back pain, direct comparisons between these interventions are relatively limited. Moreover, few studies have investigated their effects on stress-related biomarkers such as salivary cortisol and C-reactive protein in individuals with mechanical low back pain. Therefore, the present study aimed to compare the effects of yoga therapy and McKenzie method exercises on stress biomarkers (salivary cortisol and C-reactive protein) and clinical outcomes in individuals with mechanical low back pain. By integrating physiological and clinical measures, this study seeks to contribute to the growing body of evidence supporting comprehensive rehabilitation strategies for chronic musculoskeletal conditions.

II. METHODS

2.1. Study Design

This study employed a comparative randomized experimental design to examine the effects of yoga therapy and McKenzie method exercises on stress biomarkers and clinical outcomes in individuals with mechanical low back pain. The intervention program lasted nine weeks, during which participants engaged in structured therapeutic exercise sessions.

Outcome measurements were obtained at two time points: baseline (pre-intervention) and immediately after completion of the intervention period (post-intervention). The study compared changes in clinical outcomes and physiological stress biomarkers across three groups: Yoga Therapy Group, McKenzie Method Group, and Control Group.

2.2. Sample Size Calculation

Sample size estimation was performed based on previous studies investigating exercise-based interventions for chronic low back pain and stress-related biomarkers. Considering a moderate effect size ($f = 0.25$), statistical power of 0.80, and significance level of $\alpha = 0.05$, a minimum sample size of 54 participants was required for a three-group comparison using repeated-measures ANOVA.

To account for potential dropouts during the intervention period, the final sample size was increased to 60 participants, resulting in 20 participants per group.

2.3. Participants

A total of 60 participants diagnosed with mechanical low back pain were recruited from physiotherapy clinics and rehabilitation centers. Participants were selected using purposive sampling and were randomly allocated into three groups.

Inclusion Criteria

Participants were included if they:

- Were aged between 30 and 40 years
- Had a clinical diagnosis of mechanical low back pain lasting more than six weeks
- Were medically stable and able to participate in exercise-based rehabilitation
- Provided written informed consent

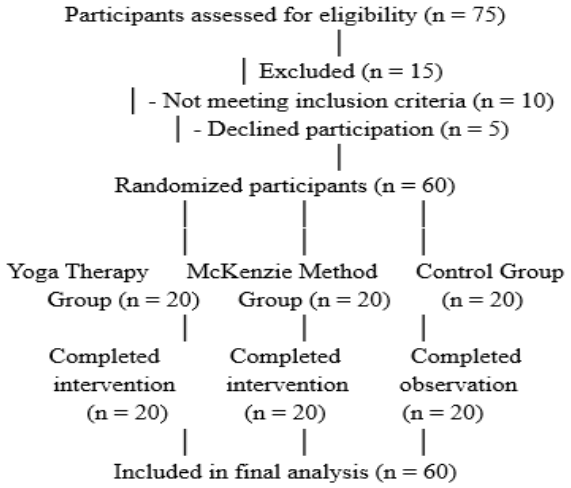
Exclusion Criteria

Participants were excluded if they:

- Had lumbar disc prolapse, spinal fractures, or neurological deficits
- Had undergone previous spinal surgery
- Had inflammatory spinal diseases such as ankylosing spondylitis
- Were participating in other rehabilitation programs

2.4. CONSORT Participant Flow Diagram

The participant recruitment and allocation process is summarized in the CONSORT flow diagram below.



2.5. Intervention Protocol

Yoga Therapy Group

Participants in the yoga therapy group underwent a structured yoga program designed to enhance spinal flexibility, muscular strength, and stress regulation. Sessions were conducted five times per week for nine weeks, with each session lasting 45 minutes.

The program included:

Asanas –

Marjariasana (Cat–Cow Stretch), Uttana Tadasana, Ardha Pavanamuktasana, Supine Pigeon Pose, Parvatasana, Tadasana, Urdhva Hastasana, and Adho Mukha Svanasana

Pranayama –

Slow diaphragmatic breathing techniques

Relaxation –

Guided relaxation

McKenzie Method Group

Participants performed exercises based on the McKenzie Mechanical Diagnosis and Therapy (MDT) protocol.

Exercises included - Repeated lumbar extension in lying, Standing lumbar extension, Postural correction exercises

Sessions were supervised by a physiotherapist and conducted five times per week for nine weeks.

Control Group

Participants assigned to the control group received standard postural education and lifestyle advice but did not participate in a structured exercise program during the intervention period.

2.6. Outcome Measures

Clinical Outcomes

Pain and functional disability were assessed using:

Outcome	Instrument
Pain intensity	Visual Analog Scale (VAS)
Functional disability	Oswestry Disability Index (ODI)

2.7. Statistical Analysis

Baseline measurements were obtained before the start of the intervention program. Following completion of the 9-week intervention period, all outcome variables were reassessed under identical testing conditions.

Data were analyzed using SPSS software, and descriptive statistics were computed as mean ± standard deviation for all variables. Intervention effects were evaluated using repeated-measures ANOVA for within-group changes, one-way ANOVA for between-group comparisons, and Bonferroni post-hoc tests for pairwise differences, with statistical significance set at $p < 0.05$.

III. RESULTS

Table 1 Pain Intensity (VAS): Pre- and post-intervention scores and ANOVA comparison

Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference
Yoga Therapy	7.45 ± 1.12	3.12 ± 0.94	−4.33
McKenzie Method	7.38 ± 1.09	3.86 ± 1.05	−3.52
Control Group	7.41 ± 1.15	6.78 ± 1.20	−0.63

ANOVA Source	SS	df	MS	F	p
Between Groups	52.43	2	26.21	18.74	<0.001*
Within Groups	79.67	57	1.40	—	—
Total	132.10	59	—	—	—

Note. VAS = Visual Analog Scale. $p < 0.05$ indicates statistical significance.

Table 2 Functional Disability (ODI): Pre- and post-intervention scores and ANOVA comparison

Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference
Yoga Therapy	48.7 ± 5.2	21.8 ± 4.4	−26.9
McKenzie Method	47.9 ± 5.5	26.3 ± 4.7	−21.6
Control Group	48.2 ± 5.3	44.9 ± 5.1	−3.3

ANOVA Source	SS	df	MS	F	p
Between Groups	842.15	2	421.08	24.62	<0.001*
Within Groups	974.34	57	17.09	—	—
Total	1816.49	59	—	—	—

Note. ODI = Oswestry Disability Index. $p < 0.05$ indicates statistical significance

Table 3 Salivary Cortisol: Pre- and post-intervention levels and ANOVA comparison

Group	Pre-Test Mean ± SD (µg/dL)	Post-Test Mean ± SD (µg/dL)	Mean Difference
Yoga Therapy	21.6 ± 2.4	15.3 ± 2.1	−6.3
McKenzie Method	21.2 ± 2.3	18.7 ± 2.2	−2.5
Control Group	21.4 ± 2.5	21.0 ± 2.6	−0.4

ANOVA Source	SS	df	MS	F	p
Between Groups	128.77	2	64.38	16.52	<0.001*
Within Groups	222.18	57	3.90	—	—
Total	350.95	59	—	—	—

Note. $p < 0.05$ indicates statistical significance.

Table 4 C-reactive protein (CRP): Pre- and post-intervention levels and ANOVA comparison

Group	Pre-Test Mean ± SD (mg/L)	Post-Test Mean ± SD (mg/L)	Mean Difference
Yoga Therapy	4.52 ± 0.86	2.41 ± 0.72	−2.11
McKenzie Method	4.47 ± 0.88	3.36 ± 0.79	−1.11
Control Group	4.50 ± 0.91	4.38 ± 0.93	−0.12

ANOVA Source	SS	df	MS	F	p
Between Groups	18.63	2	9.31	12.47	<0.001*
Within Groups	42.54	57	0.75	—	—
Total	61.17	59	—	—	—

Note. CRP = C-reactive protein. $p < 0.05$ indicates statistical significance.

Table 5 Bonferroni post-hoc comparison between intervention groups

Comparison	Interpretation	p
Yoga Therapy vs McKenzie Method	Significant improvement in VAS, ODI, cortisol, and CRP	<0.05
Yoga Therapy vs Control Group	Highly significant improvement	<0.001
McKenzie Method vs Control Group	Moderate but significant improvement	<0.05

Summary of Findings

Pain Intensity (VAS)

A repeated-measures ANOVA demonstrated a significant difference in pain intensity across the three groups following the intervention ($F(2,57) = 18.74$, $p<0.001$). Post-hoc Bonferroni analysis indicated that participants in the yoga therapy group showed significantly greater reductions in VAS scores compared with both the McKenzie method group ($p<0.05$) and the control group ($p<0.001$).

Functional Disability (ODI)

Analysis of functional disability scores revealed significant improvements across groups ($F(2,57) = 24.62$, $p<0.001$). Participants in the yoga therapy group demonstrated the largest reduction in ODI scores compared with the McKenzie method and control groups.

Salivary Cortisol

Salivary cortisol levels showed a significant reduction following the intervention ($F(2,57) = 16.52$, $p<0.001$). The yoga therapy group exhibited the greatest decrease in cortisol concentrations compared with the McKenzie method group ($p<0.05$) and the control group ($p<0.001$).

C-Reactive Protein (CRP)

Similarly, CRP levels demonstrated a statistically significant reduction across groups ($F(2,57) = 12.47$, $p<0.001$). Post-hoc comparisons indicated significantly lower CRP levels in the yoga therapy group compared with the control group.

IV. DISCUSSION

The present study investigated the comparative effects of yoga therapy, McKenzie method exercises, and a control condition on stress biomarkers and clinical outcomes in individuals with mechanical low back pain. The results demonstrated significant improvements in pain intensity and functional disability in both intervention groups compared with the control group. Notably, the yoga therapy group showed the most pronounced improvements in both clinical outcomes (VAS and ODI scores) and stress biomarkers (salivary cortisol and CRP levels). These findings suggest that mind–body exercise interventions may provide broader therapeutic benefits than conventional mechanical exercise approaches.

Study Strengths

This study possesses several methodological strengths. First, the randomized comparative design allowed for direct evaluation of two commonly used rehabilitation approaches within the same population of individuals with mechanical low back pain. Second, the study incorporated both clinical outcomes and physiological biomarkers, providing a multidimensional assessment of treatment effectiveness. Third, the use of salivary cortisol as a non-invasive biomarker enabled reliable measurement of physiological stress responses associated with chronic pain conditions. Finally, the nine-week structured intervention period ensured adequate exposure to the rehabilitation programs, increasing the validity of the observed clinical improvements.

4.1. Comparison of Clinical Outcomes (Pain and Functional Disability)

Both the yoga therapy and McKenzie method groups demonstrated significant reductions in pain intensity and functional disability compared with the control group. These findings are consistent with previous studies reporting that exercise-based rehabilitation programs improve spinal mobility, muscular strength, and functional performance in patients with chronic low back pain (Fernández-Rodríguez et al., 2022).

Participants in the McKenzie method group experienced notable improvements in pain and disability scores. The McKenzie approach focuses on repeated spinal movements and postural correction techniques that aim to centralize pain and restore lumbar spinal mechanics. Previous research has demonstrated that the McKenzie method effectively reduces mechanical stress on the lumbar spine and enhances patient self-management strategies (Olaoye et al., 2025). The improvement observed in the McKenzie group in the present study may therefore be attributed to improved spinal alignment and repeated movement therapy that promotes disc and joint mobility.

However, the yoga therapy group showed greater reductions in pain and disability compared with the McKenzie group. This finding may be explained by the holistic nature of yoga therapy, which integrates physical postures, breathing techniques, and relaxation practices. Yoga postures enhance spinal flexibility and muscular strength, while breathing exercises and meditation contribute to improved neuromuscular relaxation and pain modulation. Previous studies have reported that yoga interventions can reduce chronic low back pain and improve functional outcomes through enhanced muscular endurance and improved posture (Oz & Ulger, 2024).

The control group, which did not participate in a structured intervention, showed minimal improvement in pain and disability. This result further supports the

importance of active rehabilitation strategies in managing mechanical low back pain.

4.2. Effects on Stress Biomarkers

A key objective of the present study was to evaluate the influence of rehabilitation interventions on stress biomarkers, specifically salivary cortisol and C-reactive protein (CRP). The results indicated that the yoga therapy group experienced the greatest reduction in cortisol levels, suggesting a significant improvement in physiological stress regulation.

Cortisol is a primary hormone associated with activation of the hypothalamic–pituitary–adrenal (HPA) axis during stress. Chronic elevation of cortisol has been associated with increased pain sensitivity, inflammation, and delayed recovery in musculoskeletal disorders (Zaccaro et al., 2018). The reduction in cortisol levels observed in the yoga group may therefore reflect improved stress regulation and autonomic balance.

Yoga therapy incorporates controlled breathing and relaxation techniques, which have been shown to activate the parasympathetic nervous system and reduce sympathetic activity. These physiological changes may contribute to reduced cortisol secretion and improved emotional regulation (Poli et al., 2021). Consequently, yoga therapy may address both physical and psychological components of chronic pain.

The McKenzie method group also demonstrated moderate reductions in cortisol levels; however, these reductions were smaller compared with those observed in the yoga therapy group. While mechanical exercise approaches improve musculoskeletal function, they may not directly influence psychological stress responses to the same extent as mind–body interventions.

Similarly, reductions in C-reactive protein levels were more pronounced in the yoga therapy group compared with the McKenzie group. CRP is a widely recognized inflammatory biomarker associated with systemic inflammation and chronic pain conditions. Exercise interventions have been shown to reduce inflammatory markers by improving metabolic regulation and immune function (Barros dos Santos & Pinto de Castro, 2021). The additional reductions observed in the yoga group may reflect the combined effects of physical activity and stress reduction on inflammatory pathways.

4.3. Psychophysiological Mechanisms of Yoga Therapy

The superior outcomes observed in the yoga therapy group may be explained by several physiological and psychological mechanisms. First, yoga postures improve musculoskeletal flexibility and core strength, which may reduce mechanical stress on the lumbar spine. Second, breathing techniques regulate respiratory patterns and enhance autonomic nervous system balance, promoting parasympathetic dominance. Third, mindfulness and relaxation components reduce psychological stress and emotional tension, which are known contributors to chronic pain.

The integration of these components may create a multidimensional therapeutic effect, addressing both the physical and psychological factors associated with mechanical low back pain. Previous research suggests that interventions targeting both stress regulation and musculoskeletal function may be particularly effective in chronic pain management (Li et al., 2023).

4.4. Clinical Implications

The findings of this study have important implications for the management of mechanical low back pain. While conventional exercise approaches such as the McKenzie method remain valuable in rehabilitation, incorporating mind–body practices such as yoga therapy may provide additional benefits by addressing stress-related physiological mechanisms.

Healthcare professionals and rehabilitation specialists may therefore consider integrating yoga-based interventions into comprehensive rehabilitation programs for individuals with chronic low back pain. Such integrative approaches may improve both clinical outcomes and psychological well-being.

4.5. Study Limitations and Future Directions

Despite the promising findings, several limitations should be acknowledged. First, the study sample size was relatively small, which may limit the generalizability of the results. Second, the intervention duration was limited to nine weeks, and longer intervention periods may produce more substantial physiological adaptations. Third, only two stress biomarkers were assessed, and additional biomarkers such as inflammatory cytokines or heart rate variability may provide further insights into the

physiological mechanisms of rehabilitation interventions.

Future studies should include larger sample sizes, longer intervention periods, and additional physiological markers to better understand the long-term effects of yoga therapy and other rehabilitation approaches on stress and inflammation in chronic pain conditions.

V. CONCLUSION

The present study compared the effects of yoga therapy, McKenzie method exercises, and a control condition on stress biomarkers and clinical outcomes in individuals with mechanical low back pain. The findings demonstrated that both yoga therapy and McKenzie method interventions significantly improved pain intensity and functional disability compared with the control group. However, yoga therapy produced greater reductions in stress biomarkers, specifically salivary cortisol and C-reactive protein (CRP), indicating enhanced regulation of physiological stress and inflammatory responses.

The superior outcomes observed in the yoga therapy group suggest that mind–body interventions may provide broader therapeutic benefits by addressing both the biomechanical and psychophysiological aspects of chronic low back pain. While the McKenzie method primarily targets mechanical spinal dysfunction and postural correction, yoga therapy integrates physical postures, breathing techniques, and relaxation practices that may contribute to improved neuromuscular function, reduced psychological stress, and enhanced autonomic balance.

These findings highlight the potential value of incorporating yoga therapy into multidisciplinary rehabilitation programs for mechanical low back pain. Integrating mind–body approaches with conventional physiotherapy interventions may offer a more comprehensive strategy for managing chronic musculoskeletal conditions.

Nevertheless, the study has certain limitations, including the relatively small sample size and limited intervention duration. Future research should involve larger randomized controlled trials with extended follow-up periods and additional physiological biomarkers to further clarify the mechanisms underlying the therapeutic effects of yoga-based interventions.

In conclusion, yoga therapy appears to be an effective complementary intervention for improving both clinical and physiological outcomes in mechanical low back pain. Its ability to influence stress biomarkers alongside pain and disability measures suggests that yoga may play a valuable role in holistic rehabilitation strategies for chronic musculoskeletal disorders.

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