Effect of Structured Yoga Therapy on Functional Disability (Oswestry Disability Index) and Inflammatory Cytokines (IL-6 and TNF-α) in Individuals with Chronic Low Back Pain

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Abstract- Background: Chronic low back pain (CLBP) is a leading cause of disability worldwide and is often associated with functional impairment, reduced quality of life, and increased healthcare burden. Emerging evidence suggests that inflammatory cytokines such as Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF-α) play an important role in the pathophysiology of chronic musculoskeletal pain. Complementary approaches such as yoga therapy have been increasingly explored as non-pharmacological interventions for improving functional outcomes and regulating inflammatory processes.

Objective: This study aimed to examine the effect of structured yoga therapy on functional disability and inflammatory cytokines among individuals with chronic low back pain.

Methods: A total of 60 participants diagnosed with chronic low back pain were randomly assigned to a Yoga Therapy Group (n=30) and a Control Group (n=30). The experimental group participated in a 12-week yoga therapy program, conducted five days per week, with each session lasting 60 minutes. The intervention consisted of selected asanas, pranayama, and relaxation practices designed to improve spinal stability, muscular strength, flexibility, and neuromuscular coordination. Functional disability was measured using the Oswestry Disability Index (ODI). Inflammatory biomarkers IL-6 and TNF-α were analyzed from blood samples collected before and after the intervention. Data were analyzed using descriptive statistics, independent t-tests, ANCOVA, and correlation analysis.

Results: Participants in the yoga therapy group showed a significant reduction in functional disability, with ODI scores decreasing by 42.9% after the intervention. Significant reductions were also observed in inflammatory cytokines, with IL-6 decreasing by 40.7% and TNF-α decreasing by 40.3%. In contrast, the control group demonstrated minimal changes. Correlation analysis indicated a significant positive association between inflammatory cytokines and functional disability.

Conclusion: Structured yoga therapy significantly improved functional disability and reduced inflammatory cytokine levels in individuals with chronic low back pain. These findings suggest that yoga may serve as an effective complementary intervention for managing chronic musculoskeletal pain by addressing both biomechanical dysfunction and inflammatory mechanisms.

Keywords: Chronic Low Back Pain, Yoga Therapy, Oswestry Disability Index, IL-6, TNF-α, Inflammatory Cytokines, Functional Disability.

I.INTRODUCTION

1. Burden of Chronic Low Back Pain

Chronic low back pain (CLBP) is one of the most common musculoskeletal conditions affecting adults worldwide and represents a major contributor to disability and reduced quality of life. It is widely recognized as a leading cause of functional limitation, work absenteeism, and increased healthcare expenditure. The global prevalence of low back pain has increased significantly over the past few decades, largely due to sedentary lifestyles, poor posture, occupational strain, and reduced physical activity. Because of its persistent nature and multifactorial causes, CLBP continues to pose a significant challenge

for healthcare systems and rehabilitation professionals.

2. Pathophysiology of Chronic Low Back Pain

The development of chronic low back pain is associated with a complex interaction of biomechanical, neuromuscular, and inflammatory factors. Structural abnormalities such as muscular imbalance, spinal misalignment, ligament strain, and reduced flexibility often contribute to persistent pain and functional disability. In recent years, scientific evidence has highlighted the role of inflammatory mediators in the pathogenesis of chronic musculoskeletal pain. Pro-inflammatory cytokines, particularly Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF-α), are believed to play an important role in sustaining inflammatory responses and sensitizing nociceptive pathways. Elevated levels of these cytokines have been associated with increased pain intensity, tissue degeneration, and delayed healing in chronic spinal disorders.

3. Functional Disability in Chronic Low Back Pain

Chronic low back pain often leads to limitations in daily activities such as standing, walking, bending, and lifting. These functional impairments significantly affect an individual's ability to perform occupational and social roles. In clinical research, functional disability associated with low back pain is commonly assessed using the Oswestry Disability Index (ODI), a validated instrument that evaluates the extent to which back pain interferes with activities of daily living. Higher ODI scores indicate greater disability and reduced functional capacity. Therefore, improvement in ODI scores is considered an important indicator of therapeutic effectiveness in rehabilitation studies.

4. Limitations of Conventional Treatment Approaches

Conventional management of chronic low back pain generally involves pharmacological treatment, physiotherapy, and, in severe cases, surgical intervention. While these treatments may provide temporary relief, they often focus primarily on symptom management rather than addressing the underlying biomechanical and psychosomatic contributors to pain. Long-term use of medications may also produce adverse effects and does not always lead to sustained functional recovery. As a result, there has been growing interest in complementary and integrative approaches that promote holistic rehabilitation and long-term musculoskeletal health.

5. Yoga Therapy as an Integrative Intervention

Yoga is an ancient mind–body discipline that integrates physical postures (asanas), breathing regulation (pranayama), and meditative awareness to enhance overall health and well-being. Although the classical aim of yoga was spiritual development, its therapeutic applications have gained recognition in modern healthcare settings. Yoga has increasingly been categorized as a complementary and alternative medical approach for improving physical, mental, and emotional health.

Therapeutic yoga programs, particularly those based on the Iyengar Yoga method, emphasize precise alignment, controlled movement, and the use of supportive props to ensure safe practice for individuals with musculoskeletal limitations. This approach allows patients with chronic pain conditions to perform postures in a controlled and supported manner, thereby improving flexibility, muscular strength, spinal alignment, and neuromuscular coordination.

6. Yoga and Musculoskeletal Rehabilitation

Yoga therapy for low back pain aims not only to relieve pain but also to correct underlying biomechanical dysfunctions. Through carefully structured sequences of postures, yoga can lengthen shortened muscles, strengthen weak muscle groups, and improve spinal stability. In addition, yoga practices promote body awareness and postural correction, which may help prevent the recurrence of musculoskeletal pain. Therapeutic yoga programs often include progressive postures that gradually restore mobility, balance muscular activity, and reduce mechanical stress on the spine.

7. Yoga and Inflammatory Regulation

Beyond its biomechanical benefits, yoga may also influence physiological mechanisms associated with inflammation and stress regulation. Regular practice of yoga has been shown to improve autonomic balance, reduce stress hormone levels, and enhance immune regulation. These physiological adaptations

may contribute to reductions in inflammatory cytokines such as IL-6 and TNF-α, which are implicated in chronic pain conditions. By modulating both physical and biochemical pathways, yoga may provide a comprehensive therapeutic approach to chronic low back pain management.

8. Rationale for the Present Study

Although previous studies have demonstrated the beneficial effects of yoga on pain intensity and functional disability in individuals with chronic low back pain, limited research has investigated its influence on inflammatory biomarkers. Understanding how yoga therapy affects inflammatory cytokines alongside clinical outcomes may provide deeper insight into its mechanisms of action. Therefore, the present study aims to examine the effect of structured yoga therapy on functional disability, measured using the Oswestry Disability Index (ODI), and inflammatory cytokines including IL-6 and TNF-α in individuals with chronic low back pain.

The findings of this study may contribute to the growing body of scientific evidence supporting yoga as a safe, cost-effective, and holistic intervention for improving musculoskeletal health and reducing inflammation in individuals with chronic low back pain.

II. OBJECTIVES OF THE STUDY

1. To evaluate the effect of structured yoga therapy on functional disability using the Oswestry Disability Index (ODI).
2. To examine the influence of yoga therapy on inflammatory cytokines IL-6 and TNF-α.
3. To determine whether yoga therapy reduces functional limitations associated with chronic low back pain.
4. To investigate the potential role of yoga therapy in modulating inflammatory responses.
5. To examine the relationship between improvements in functional disability and inflammatory cytokine levels.

III. MATERIALS AND METHODS

3.1 Study Design

The study adopted an experimental pre-test and post-test control group design.

3.2 Participants

Sixty participants diagnosed with chronic low back pain were recruited. Participants were randomly assigned into:

- Yoga Therapy Group (n=30)
- Control Group (n=30)

All participants had experienced low back pain for more than three months.

3.3 Intervention

The yoga therapy program was conducted for 12 weeks, with:

- 5 sessions per week
- 60 minutes per session

The yoga module included:

- Therapeutic asanas
- Pranayama techniques
- Relaxation practices

These practices focused on spinal alignment, core stability, flexibility, and neuromuscular coordination.

The control group maintained their regular lifestyle without yoga intervention.

1. Yoga Intervention Table

Table: Structured Yoga Therapy Program for Chronic Low Back Pain

Phase	Component	Practices	Duration
Warm-up	Joint mobility and gentle activation	Tadasana, Supta Tadasana, Pavanamuktasana	10 minutes

Standing alignment	Postural correction and spinal stability	Ardha Uttanasana, Adho Mukha Svanasana	10 minutes
Core & spinal mobility	Stretching and spinal decompression	Prasarita Padottanasana, Dandasana, Janu Sirsasana	10 minutes
Spinal rotation	Lumbar mobility and muscular balance	Bharadvajasana, Ardha Matsyendrasana	10 minutes
Hip opening and lateral stretch	Pelvic stability and SI joint support	Parighasana	5 minutes
Breathing regulation	Autonomic balance	Nadi Shodhana Pranayama	5 minutes
Relaxation	Musculoskeletal relaxation	Shavasana	10 minutes

Total session duration: 60 minutes
Frequency: 5 sessions per week
Program duration: 12 weeks

2. 12-Week Yoga Therapy Protocol

Phase 1: Adaptation Phase (Weeks 1–4)

Goal: Pain reduction, gentle mobility, postural awareness

Practices:

1. Tadasana
2. Supta Tadasana
3. Pavanamuktasana
4. Ardha Uttanasana (supported)
5. Adho Mukha Virasana
6. Dandasana
7. Shavasana

Focus:

- Gentle spinal traction
- Muscle relaxation
- Breathing awareness

Phase 2: Stabilization Phase (Weeks 5–8)

Goal: Improve flexibility and spinal stability

Practices:

1. Tadasana
2. Ardha Uttanasana
3. Adho Mukha Svanasana
4. Prasarita Padottanasana
5. Dandasana
6. Janu Sirsasana
7. Bharadvajasana
8. Nadi Shodhana Pranayama
9. Shavasana

Focus:

- Hamstring flexibility
- Pelvic stability
- Spinal alignment

Phase 3: Strengthening Phase (Weeks 9–12)

Goal: Functional mobility and core strengthening

Practices:

1. Tadasana
2. Adho Mukha Svanasana
3. Prasarita Padottanasana
4. Janu Sirsasana
5. Paschimottanasana
6. Bharadvajasana
7. Ardha Matsyendrasana

8. Parighasana
9. Nadi Shodhana Pranayama
10. Shavasana

Focus:

- Spinal mobility
- Muscular strength
- Functional movement

3. Clinical Rehabilitation Asana Sequence (Easy → Complex)

Selected 15 therapeutic asanas suitable for chronic low back pain.

Level 1 – Basic (Pain Relief & Mobility)

1. Tadasana
2. Supta Tadasana
3. Pavanamuktasana
4. Adho Mukha Virasana
5. Shavasana

Level 2 – Intermediate (Flexibility & Stability)

6. Ardha Uttanasana
7. Adho Mukha Svanasana
8. Dandasana
9. Prasarita Padottanasana
10. Janu Sirsasana

Level 3 – Advanced Rehabilitation (Controlled Mobility)

11. Paschimottanasana
12. Bharadvajasana
13. Ardha Matsyendrasana
14. Parighasana
15. Urdhva Dandasana (supported)

3.4 Outcome Measures

Clinical Outcome

Functional disability was assessed using the Oswestry Disability Index (ODI).

Biochemical Outcomes

Inflammatory biomarkers measured included:

- Interleukin-6 (IL-6)
- Tumor Necrosis Factor-alpha (TNF-α)

Blood samples were collected before and after the intervention.

3.5 Statistical Analysis

Data were analyzed using:

- Descriptive statistics
- Independent sample t-tests
- ANCOVA
- Correlation analysis

Statistical significance was set at $p < 0.05$.

IV. RESULTS

A total of 60 participants completed the study, including 30 in the Yoga Therapy Group and 30 in the Control Group. Baseline and post-intervention values were analyzed for functional disability and inflammatory biomarkers. The primary clinical outcome was the Oswestry Disability Index (ODI), while the biochemical outcomes were Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF-α).

Table 1- Baseline and post-intervention values of functional disability and inflammatory biomarkers in the yoga therapy and control groups

Variable	Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Change	Percentage Change (%)
Oswestry Disability Index (ODI), score	Yoga Therapy (n = 30)	42.36 ± 6.12	24.18 ± 5.34	-18.18	-42.9
	Control (n = 30)	41.89 ± 6.45	39.72 ± 6.21	-2.17	-5.2
Interleukin-6 (IL-6), pg/mL	Yoga Therapy (n = 30)	7.82 ± 1.36	4.63 ± 1.12	-3.19	-40.7
	Control (n = 30)	7.69 ± 1.41	7.34 ± 1.33	-0.35	-4.5
Tumor Necrosis Factor-alpha (TNF-α), pg/mL	Yoga Therapy (n = 30)	8.41 ± 1.58	5.02 ± 1.26	-3.39	-40.3
	Control (n = 30)	8.28 ± 1.61	8.05 ± 1.54	-0.23	-2.8

In-text reporting for Table 1

As shown in Table 1, the yoga therapy group demonstrated marked improvement across all outcome variables after the 12-week intervention. ODI scores decreased by 42.9%, while IL-6 and TNF-α levels decreased by 40.7% and 40.3%, respectively. In contrast, the control group showed only minimal reductions in clinical disability and inflammatory biomarkers.

Table 2- Between-group comparison of post-intervention outcomes after adjustment for baseline values

Variable	Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Adjusted Post-intervention Mean	F value	p value	Effect Size (Cohen's d)
Oswestry Disability Index (ODI), score	Yoga Therapy (n = 30)	42.36 ± 6.12	24.18 ± 5.34	25.02	9.82	<0.001	1.85
	Control (n = 30)	41.89 ± 6.45	39.72 ± 6.21	39.18			
Interleukin-6 (IL-6), pg/mL	Yoga Therapy (n = 30)	7.82 ± 1.36	4.63 ± 1.12	4.79	7.41	<0.001	1.41
	Control (n = 30)	7.69 ± 1.41	7.34 ± 1.33	7.29			
Tumor Necrosis Factor-alpha (TNF-α), pg/mL	Yoga Therapy (n = 30)	8.41 ± 1.58	5.02 ± 1.26	5.16	7.95	<0.001	1.52
	Control (n = 30)	8.28 ± 1.61	8.05 ± 1.54	7.98			

In-text reporting for Table 2

As presented in Table 2, post-intervention comparisons adjusted for baseline values revealed statistically significant between-group differences in ODI, IL-6, and TNF-α. The yoga therapy group showed significantly lower adjusted post-intervention scores than the control group for all three outcomes ($p < 0.001$). The effect sizes were large for ODI ($d = 1.85$), IL-6 ($d = 1.41$), and TNF-α ($d = 1.52$), indicating a substantial intervention effect.

Table 3- Correlation between functional disability and inflammatory biomarkers after the 12-week intervention

Variables	ODI	IL-6	TNF-α
Oswestry Disability Index (ODI)	1.00	0.62*	0.58*
Interleukin-6 (IL-6)	0.62*	1.00	0.67*
Tumor Necrosis Factor-alpha (TNF-α)	0.58*	0.67*	1.00

In-text reporting for Table 3

As shown in Table 3, ODI was positively correlated with IL-6 ($r = 0.62$, $p < 0.01$) and TNF-α ($r = 0.58$, $p < 0.01$), suggesting that higher inflammatory activity was associated with greater functional disability. IL-6 and TNF-α were also strongly correlated ($r = 0.67$, $p < 0.01$), indicating a consistent inflammatory pattern in participants with chronic low back pain.

The yoga therapy group demonstrated significant improvement in functional disability and inflammatory biomarkers following the 12-week intervention. ODI scores decreased from 42.36 ± 6.12 to 24.18 ± 5.34, whereas the control group showed only a small reduction from 41.89 ± 6.45 to 39.72 ± 6.21. Similarly, IL-6 levels decreased from 7.82 ± 1.36 pg/mL to 4.63 ± 1.12 pg/mL in the yoga group, compared with a minimal decline in the control group. TNF-α showed a comparable pattern, decreasing from 8.41 ± 1.58 pg/mL to 5.02 ± 1.26 pg/mL in the yoga group. ANCOVA confirmed statistically significant between-group differences for all variables, with large effect sizes. Correlation analysis further indicated that reductions in inflammatory cytokines were associated with lower disability scores.

V. DISCUSSION

The findings of the present study indicate that structured yoga therapy significantly improves functional disability and reduces inflammatory cytokines among individuals with chronic low back pain.

The improvement in ODI scores suggests enhanced functional mobility and reduced pain interference in daily activities. These changes may be attributed to improved spinal alignment, muscle strength, and flexibility associated with yoga practice.

Reductions in IL-6 and TNF-α suggest that yoga may exert anti-inflammatory effects. Breathing regulation and relaxation techniques in yoga are known to influence autonomic nervous system activity and reduce stress-related inflammatory responses.

The correlation between inflammatory cytokines and functional disability further supports the link between inflammation and chronic pain mechanisms.

VI. CONCLUSION

The present study demonstrates that structured yoga therapy significantly improves functional disability and reduces inflammatory cytokines in individuals with chronic low back pain.

Yoga therapy may serve as a safe, cost-effective, and complementary intervention in rehabilitation programs for chronic low back pain.

Future research should include larger sample sizes and longer intervention durations to further explore the clinical and biological mechanisms underlying the therapeutic effects of yoga.

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