

Yoga-Induced Neuroplasticity: Pathways to Psychological Resilience- a pilot study

Dr. Sumana Pothugunta¹, Prof. Chollangi Sri Sai Ratna², Dr. Rupa Selvaraj³, Mr. Bharath Kumar Atluri⁴, Mr. Karanam Kanta Rao⁵, Mr. Pinapareddy Chaitanya Kumar⁶

¹Principal, Sri Visweswara Yoga Research Institute, Tirupathi

² Assistant Professor, Aurora Higher Education and Research Academy, Hyderabad

³Associate Professor, Aurora Higher Education and Research Academy, Hyderabad

⁴Independent Researcher, Gannavaram, Vijayawada

⁵Assistant Professor, Aurora Higher Education and Research Academy, Hyderabad

⁶Assistant Professor, Aurora Higher Education and Research Academy, Hyderabad

Corresponding Author: *

Dr. Sumana Pothugunta

Email ID: sumankrishna78@gmail.com .

Cite this paper as: Dr. Sumana Pothugunta , Prof. Chollangi Sri Sai Ratna , Dr. Rupa Selvaraj , Mr. Bharath Kumar Atluri , Mr. Karanam Kanta Rao, Mr. Pinapareddy Chaitanya Kumar (2025) Yoga-Induced Neuroplasticity: Pathways to Psychological Resilience- a pilot study. Journal of Neonatal Surgery, 14, (1s) 1523-1539

ABSTRACT

Background: Psychological resilience is increasingly recognized as a critical protective factor against stress-related disorders and trauma. Emerging evidence suggests that yoga, as a multidimensional mind-body intervention, promotes adaptive neuroplasticity through modulation of neural, endocrine, and autonomic pathways. However, empirical evidence linking yogic pranayama with resilience, mindfulness, cognitive flexibility, and psychological well-being within a unified neuroplasticity framework remains limited.

Aim and Objective: Aim: To evaluate the impact of yogic pranayama on psychological resilience, mindfulness, cognitive flexibility, and subjective well-being among healthy adults.

Objective: To assess the overall effectiveness of yogic pranayama in enhancing psychological resilience, mindfulness, cognitive flexibility, and subjective well-being.

Methods: A single-group pre-post experimental design was employed involving thirty healthy adult participants (15 males and 15 females). Participants completed a standardized 40-minute yogic pranayama every day for 40 consecutive days, consisting of yogic way of pranayama practices. Psychological outcomes were assessed before and after the intervention using internationally validated instruments including the Connor-Davidson Resilience Scale (CD-RISC-25), Mindful Attention Awareness Scale (MAAS), Cognitive Flexibility Inventory (CFI), and WHO-5 Well-Being Index. Data analysis included descriptive statistics, Shapiro-Wilk normality testing, paired t-tests, Cohen's d effect size estimation, Pearson correlation analysis, and exploratory regression modelling.

Results: The 40-day pranayama intervention was completed by all 30 participants, with a 100% completion rate and no dropouts. Positive and statistically significant improvements were observed in resilience (58.47 ± 8.21 to 71.36 ± 6.94), mindfulness (53.28 ± 7.34 to 66.41 ± 6.18), cognitive flexibility (82.91 ± 9.12 to 95.58 ± 7.41), and psychological well-being (57.73 ± 10.25 to 73.52 ± 8.63), with all outcomes showing $p < 0.001$ and large effect sizes. Strong positive correlations were found among all psychological variables, and regression analysis showed that resilience, mindfulness, and cognitive flexibility significantly predicted psychological well-being, explaining 75.9% of the variance.

Conclusion: The findings of this pilot study provides preliminary evidence that a 40-day yogic pranayama may facilitate psychological resilience through mechanisms consistent with neuroplasticity adaptation. Although direct neuroimaging was not performed, behavioural improvements in resilience, mindfulness, and cognitive flexibility suggest enhanced adaptive functioning. These findings support the integration of yoga into preventive mental health programs and trauma-informed care while highlighting the need for larger randomized controlled trials incorporating neuroimaging biomarkers to validate the neuroplasticity mechanisms underlying yoga-based interventions...

Keywords: Yoga, Yogic Pranayama, Neuroplasticity, Psychological Resilience, Mindfulness, Cognitive Flexibility

.....

INTRODUCTION

Psychological resilience refers to the dynamic capacity of individuals to successfully adapt to adversity, recover from stressful experiences, and maintain psychological well-being despite exposure to significant life challenges (Fletcher & Sarkar, 2016). In recent decades, resilience has emerged as a major focus within psychology, neuroscience, psychiatry, and public health because of its crucial role in preventing mental illness and promoting healthy aging (Zamroziewicz & Barbey, 2016). Increasing levels of occupational stress, emotional burnout, anxiety disorders, depression, and trauma-related conditions have created an urgent need for effective, accessible, and non-pharmacological interventions capable of strengthening adaptive coping mechanisms (Cattaneo & Riva, 2016).

Advances in neuroscience have substantially transformed our understanding of resilience by demonstrating that the human brain retains remarkable capacity for structural and functional reorganization throughout adulthood (McEwen & Karatsoreos, 2015). This adaptive capability, known as neuroplasticity, enables neural circuits to reorganize in response to environmental experiences, learning, and behavioural interventions. Neuroplasticity encompasses multiple biological processes including synaptic remodelling, dendritic branching, neurogenesis, and alterations in functional connectivity between cortical and subcortical brain regions. Contemporary neuroimaging studies have consistently demonstrated that contemplative practices such as yoga and meditation induce measurable changes within neural networks involved in emotional regulation, executive functioning, attentional control, and stress processing (Tolahunase et al., 2018).

Yoga represents one of the oldest all rounded health systems and integrates physical postures (asanas), controlled breathing (pranayama), meditation, relaxation, and ethical principles to promote physical, mental, and spiritual well-being. Unlike interventions targeting isolated psychological symptoms addresses multiple physiological systems simultaneously, including the autonomic nervous system, hypothalamic-pituitary-adrenal (HPA) axis, immune regulation, cardiovascular function, and cognitive-emotional processing. Through (XIAOYAO & Boppadapu, n.d.) regular practice, yoga has been associated with reduced cortisol secretion (Ratna et al., 2024) , improved vagal tone, enhanced parasympathetic activation, decreased inflammatory biomarkers, and improvements in emotional stability (Ratna & Dwarapudi, 2023a) .

Emerging scientific evidence suggests that these physiological adaptations may reflect underlying neuroplastic mechanisms. Functional magnetic resonance imaging (fMRI) studies have reported increased activation and cortical thickness within the prefrontal cortex, anterior cingulate cortex, insula, and hippocampus following long-term yoga and meditation practice. These brain regions are critically involved in executive functioning, emotional regulation, self-awareness, attention, and adaptive stress responses. Concurrently, reductions in amygdala hyperactivity have been associated with decreased fear reactivity and improved emotional resilience. Such findings suggest that yoga may facilitate resilience not only through psychological mechanisms but also by strengthening neural pathways responsible for adaptive cognitive and emotional functioning (Ratna & Dwarapudi, 2023b; Voss et al., 2023).

Mindfulness constitutes another central mechanism through which yoga may promote resilience. Mindfulness involves intentionally attending to present-moment experiences with openness, curiosity, and non-judgmental awareness (Chems-Maarif et al., 2025). Increased mindfulness has consistently been associated with improved emotional regulation, reduced rumination, enhanced attentional control, and greater psychological well-being. Similarly, cognitive flexibility—the capacity to modify thinking patterns and behavioural responses according to changing situational demands—plays a fundamental role in adaptive coping and trauma recovery. Individuals demonstrating greater cognitive flexibility are better equipped to reinterpret stressful experiences, regulate emotional responses, and generate effective coping strategies (Cheng et al., 2014)

Although numerous studies have independently investigated the benefits of yoga, mindfulness, or resilience, relatively few have examined these constructs simultaneously within a unified neuroplasticity framework (Dinse, 2020; Peacock, 2026; Price & Duman, 2020). Furthermore, many previous investigations have relied upon heterogeneous interventions, short intervention durations, or isolated outcome measures, limiting comprehensive understanding of yoga-induced psychological adaptation (Ratna et al., n.d.-a). The present pilot study addresses this gap by evaluating the effects of a standardized 40-day yogic Pranayama on resilience, mindfulness, cognitive flexibility, and psychological well-being using internationally validated psychometric instruments.

It is hypothesized that participation in the yogic pranayama will significantly improve all measured psychological outcomes, reflecting behavioural indicators of adaptive neuroplasticity. By exploring the interrelationships among resilience, mindfulness, cognitive flexibility, and well-being, this study aims to contribute to the growing evidence supporting yoga as a scientifically grounded, low-cost, culturally adaptable intervention for promoting mental health, strengthening trauma recovery, and enhancing long-term psychological resilience.

2. LITERATURE REVIEW

Psychological resilience has emerged as one of the most extensively studied constructs in contemporary behavioural neuroscience and positive psychology. It is defined as the dynamic process through which individuals successfully adapt to adversity, recover from traumatic experiences, and maintain psychological functioning despite exposure to significant

stressors. Rather than representing an innate personality trait, resilience is increasingly recognized as a modifiable capacity influenced by biological, psychological, social, and environmental factors. Advances in neuroscience have demonstrated that resilience is closely associated with neuroplasticity, the brain's remarkable ability to reorganize its structural and functional networks in response to experience. This understanding has stimulated growing interest in interventions capable of promoting adaptive neural remodelling, among which yoga has received substantial scientific attention.

Neuroplasticity refers to the continuous ability of the nervous system to modify synaptic connections, generate new neural pathways, and reorganize cortical networks throughout life. Earlier neuroscientific theories suggested that significant brain development ceased during early adulthood. However, modern neuroimaging research has demonstrated that the adult brain remains highly adaptable through mechanisms including synaptogenesis, dendritic arborization, long-term potentiation, neurogenesis, and functional reorganization. These processes enable individuals to acquire new skills, recover from neurological injury, regulate emotional responses, and adapt to changing environmental demands. Consequently, interventions capable of stimulating neuroplasticity have become increasingly important in clinical psychology, psychiatry, cognitive neuroscience, and rehabilitation medicine.

Yoga is a multidimensional mind-body practice originating from ancient Indian philosophy that integrates physical postures (asanas), breathing regulation (pranayama), meditation (dhyana), and relaxation techniques. Unlike conventional physical exercise, yoga simultaneously influences physiological, psychological, cognitive, and emotional processes. Recent scientific evidence indicates that regular yoga practice improves autonomic nervous system regulation by enhancing parasympathetic activity while reducing sympathetic nervous system activation. This shift contributes to lower cortisol secretion, improved heart rate variability, reduced systemic inflammation, enhanced immune function, and improved emotional regulation. Such physiological adaptations are considered important biological mechanisms underlying resilience and psychological recovery (Kala Boppadapu et al., 2024; Ratna et al., n.d.-b; Tyagi & Cohen, 2016).

Neuroimaging studies have further strengthened the scientific basis of yoga-induced neuroplasticity. Functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and structural MRI investigations have reported increased cortical thickness within the prefrontal cortex, anterior cingulate cortex, insular cortex, and hippocampus among long-term yoga practitioners. These brain regions are responsible for executive functioning, attentional control, self-awareness, emotional regulation, learning, and memory consolidation. Simultaneously, reductions in amygdala activation have been associated with decreased fear responses and improved emotional stability. Collectively, these findings suggest that yoga may strengthen neural circuits responsible for adaptive coping and resilience while attenuating neural pathways associated with chronic stress and trauma.

Mindfulness has been identified as one of the principal psychological mechanisms through which yoga exerts its therapeutic effects. Mindfulness involves maintaining deliberate, present-moment awareness without judgment toward internal thoughts, emotions, and external experiences (Ratna, n.d.). Individuals with higher mindfulness demonstrate greater emotional regulation, reduced rumination, improved attentional control, enhanced self-awareness, and lower psychological distress. Scientific investigations have consistently demonstrated that mindfulness meditation produces measurable alterations in functional brain connectivity involving the default mode network, salience network, and executive control network. Because mindfulness forms an integral component of yogic pranayama practice, improvements in mindfulness may represent one behavioural manifestation of yoga-induced neuroplastic adaptation (Ashok et al., 2020).

Another construct receiving increasing attention is cognitive flexibility, defined as the ability to modify thinking patterns, behavioural responses, and problem-solving strategies according to changing environmental demands. Cognitive flexibility enables individuals to reinterpret stressful situations, regulate emotional responses, and adopt adaptive coping strategies rather than maladaptive reactions. Reduced cognitive flexibility has been associated with depression, anxiety disorders, post-traumatic stress disorder (PTSD), obsessive-compulsive disorder, and chronic stress. Conversely, individuals possessing greater cognitive flexibility generally demonstrate superior psychological resilience and emotional well-being. Emerging evidence suggests that yoga enhances executive functioning and attentional regulation, thereby facilitating improvements in cognitive flexibility through repeated engagement of prefrontal cortical networks.

Psychological well-being represents another essential indicator of successful adaptation and mental health. The World Health Organization defines well-being as a state in which individuals recognize their abilities, cope effectively with normal life stressors, work productively, and contribute meaningfully to society. Positive psychological well-being encompasses optimism, life satisfaction, emotional stability, purpose in life, and positive interpersonal relationships. Previous investigations have demonstrated that yoga improves subjective well-being through reductions in stress, anxiety, depression, fatigue, and emotional exhaustion while simultaneously enhancing self-esteem, positive affect, and overall quality of life.

Although numerous studies have independently examined yoga, mindfulness, resilience, or cognitive flexibility, relatively few investigations have integrated these variables within a comprehensive neuroplasticity framework. Existing studies frequently focus on clinical populations such as patients with depression, chronic pain, anxiety disorders, or post-traumatic stress disorder, while comparatively limited research has explored healthy adult populations using multidimensional psychological outcome measures. Moreover, many investigations have employed heterogeneous yoga protocols, varying

intervention durations, or non-standardized assessment instruments, making direct comparisons difficult.

The present study addresses these limitations by evaluating a standardized 40-day yogic pranayama using internationally validated psychometric instruments, including the Connor-Davidson Resilience Scale (CD-RISC-25), Mindful Attention Awareness Scale (MAAS), Cognitive Flexibility Inventory (CFI), and WHO-5 Well-Being Index. These instruments possess excellent psychometric properties, with reported Cronbach's alpha coefficients generally exceeding 0.80, thereby ensuring high reliability and validity for measuring the targeted psychological constructs.

Overall, the reviewed literature strongly supports the theoretical proposition that yoga facilitates adaptive neuroplasticity through interconnected physiological and psychological mechanisms. By improving autonomic regulation, enhancing mindfulness, increasing cognitive flexibility, and strengthening resilience, yoga may represent an effective, low-cost, culturally adaptable intervention for promoting psychological health and trauma recovery. Nevertheless, further empirical research employing standardized interventions, robust statistical analyses, and neuroimaging methodologies remains necessary to establish the neural mechanisms responsible for these observed behavioural improvements.

3. RESEARCH GAP

Although substantial evidence supports the beneficial effects of yoga on stress reduction, emotional regulation, mindfulness, and psychological well-being, several important gaps remain within the existing scientific literature. First, most previous studies have investigated these outcomes independently rather than examining resilience, mindfulness, cognitive flexibility, and psychological well-being simultaneously within a unified neuroplasticity framework. Since these psychological constructs are closely interconnected, evaluating them collectively provides a more comprehensive understanding of yoga's multidimensional therapeutic effects.

Second, a considerable proportion of existing research has focused on clinical populations, including individuals diagnosed with depression, anxiety disorders, post-traumatic stress disorder (PTSD), chronic pain, or neurological conditions. Comparatively fewer studies have explored the neuropsychological benefits of yogic pranayama practice among healthy adults. Understanding preventive strategies that strengthen resilience before the onset of psychological disorders has become increasingly important in contemporary mental health research.

Third, methodological limitations continue to affect the interpretation of previous findings. Many investigations have utilized heterogeneous yoga interventions that differ substantially in duration, frequency, intensity, and components. Some studies have focused exclusively on meditation, while others have evaluated only physical postures or breathing techniques. Such variability limits the comparability and reproducibility of research outcomes. The present study addresses this limitation by employing a standardized 40-day yogic pranayama comprising asanas, pranayama, meditation, and guided relaxation.

Another important limitation concerns the psychometric assessment of psychological outcomes. Previous studies have frequently relied on non-standardized or limited assessment instruments, making it difficult to compare findings across investigations. The present study utilizes internationally validated questionnaires with excellent psychometric properties, including the Connor-Davidson Resilience Scale (CD-RISC-25), Mindful Attention Awareness Scale (MAAS), Cognitive Flexibility Inventory (CFI), and WHO-5 Well-Being Index. These instruments possess high internal consistency reliability, ensuring accurate measurement of the targeted constructs.

Additionally, relatively few studies have examined the interrelationships among resilience, mindfulness, cognitive flexibility, and psychological well-being using correlation and regression analyses. Exploring these relationships may provide valuable insights into the mechanisms through which yoga facilitates adaptive psychological functioning. Although neuroimaging evidence increasingly supports yoga-induced neuroplasticity, behavioural investigations integrating multiple psychological indicators remain limited.

Therefore, the present pilot study seeks to bridge these gaps by investigating the effects of a structured 40-day yogic pranayama practice on resilience, mindfulness, cognitive flexibility, and psychological well-being among healthy adults using rigorous statistical analyses and validated psychological assessment tools. The findings are expected to contribute to the growing field of integrative neuroscience and provide preliminary evidence supporting yoga as an accessible intervention for promoting neuroplasticity and psychological resilience.

4. RESEARCH OBJECTIVES

The primary objective of this study is to evaluate the effectiveness of a 40-day yogic pranayama in enhancing psychological resilience and promoting neuroplasticity-related psychological outcomes among healthy adults.

The specific objectives of the study are:

1. To evaluate the effect of a 40-day Yogic pranayama on psychological resilience among adults aged 25–60 years.
2. To determine the impact of regular yogic pranayama practice on dispositional mindfulness.

3. To examine whether yogic pranayama improves cognitive flexibility following the intervention period.
4. To assess changes in psychological well-being after completion of the yoga program.
5. To determine the reliability of the psychological assessment instruments using Cronbach's alpha.
6. To examine the relationships among resilience, mindfulness, cognitive flexibility, and psychological well-being using correlation analysis.
7. To evaluate the magnitude of practice effects through effect size analysis.
8. To explore whether resilience, mindfulness, and cognitive flexibility significantly predict psychological well-being using exploratory regression analysis.

5. RESEARCH HYPOTHESES

The hypotheses of the present study were formulated based on previous empirical evidence and theoretical models of yoga-induced neuroplasticity.

Null Hypothesis (H_0)

There is no statistically significant difference in resilience, mindfulness, cognitive flexibility, or psychological well-being following participation in the 40-day yogic pranayama intervention.

Alternative Hypothesis (H_1)

Participation in the 40-day yogic pranayama intervention produces statistically significant improvements in resilience, mindfulness, cognitive flexibility, and psychological well-being among healthy adults.

In addition, the following secondary hypotheses were examined:

H₂: Resilience is positively associated with mindfulness.

H₃: Cognitive flexibility is positively associated with psychological well-being.

H₄: Mindfulness positively predicts resilience after the yogic pranayama practice.

H₅: Resilience, mindfulness, and cognitive flexibility together significantly predict psychological well-being.

The hypotheses were tested using descriptive statistics, Shapiro-Wilk normality testing, paired t-tests (or Wilcoxon signed-rank tests where appropriate), Pearson correlation analysis, exploratory regression analysis, Cohen's d effect size estimation, and Cronbach's alpha reliability analysis. Statistical significance was determined at a significance level of $p < 0.05$.

6. MATERIALS AND METHODS

This section describes the methodological framework adopted to evaluate the effects of a structured 40-day yogic pranayama intervention on psychological resilience, mindfulness, cognitive flexibility, and psychological well-being among healthy adults. It outlines the study design, research setting, participant recruitment process, eligibility criteria, yogic pranayama practice protocol, psychological assessment tools, ethical considerations, and statistical analysis methods. A standardized and systematic approach was employed to ensure the reliability, validity, and reproducibility of the findings. All pilot study procedures were conducted in accordance with accepted ethical research principles, and validated psychometric instruments were used to assess changes in psychological outcomes before and after the practice. The methodological framework was designed to provide preliminary evidence regarding the effectiveness of yogic pranayama as a non-pharmacological intervention for promoting adaptive neuroplasticity and psychological resilience.

6.1 Study Design

The present investigation employed a single-group pre-test–post-test pilot experimental design to evaluate the effects of a structured 40-day yogic pranayama on psychological resilience, mindfulness, cognitive flexibility, and psychological well-being among healthy adults. A pilot design was considered appropriate because the primary objective was to assess the feasibility, preliminary effectiveness, and potential psychological benefits of the intervention before conducting larger randomized controlled trials. The pre-post design enabled each participant to serve as their own control, thereby reducing inter-individual variability and allowing direct comparison of baseline and post-intervention outcomes.

The intervention was conducted over a continuous period of 40 consecutive days, during which participants attended a supervised 40-minute yogic pranayama session every morning. Psychological assessments were administered immediately before the commencement of the intervention (baseline) and within two days after completion of the program (post-intervention). This design facilitated evaluation of changes attributable to the yoga practice while maintaining consistency in measurement procedures.

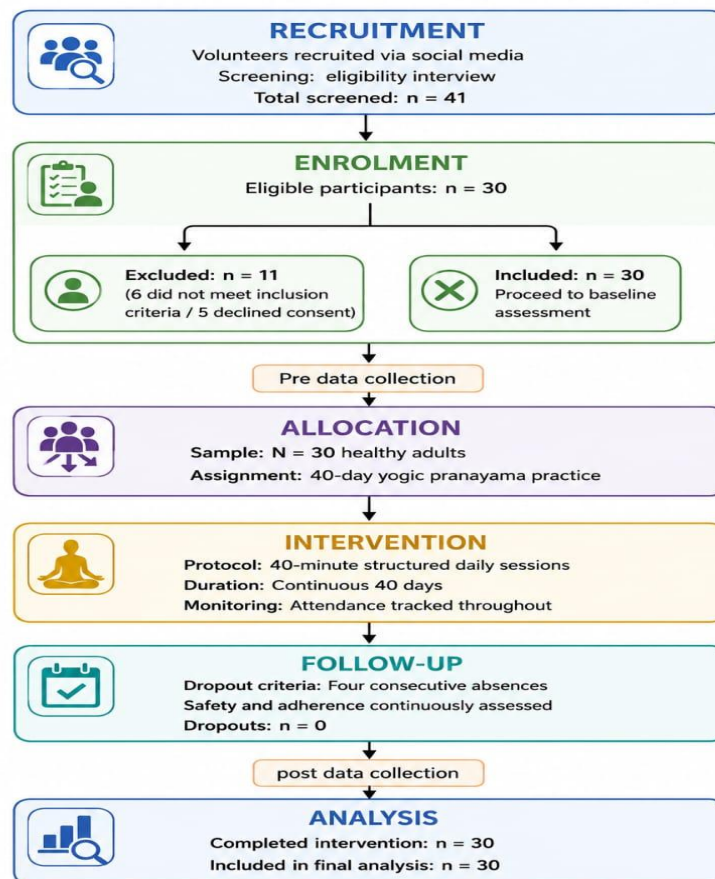


Fig 1: One Group Pre-test Post-test Design

6.2 Study Setting

The study conducted in Tirupati, guided and supervised by qualified, experienced, and certified yoga teachers. Sessions were conducted in a systematic and uniform way to ensure uniformity among participants and compliance with the established intervention protocol. Individuals of all genders were recruited, and informed consent was secured from each participant. Confidentiality was upheld by assigning each participant a distinct code and ensuring that all personal information was securely safeguarded, with access restricted solely to the research team. before enrolment. During the intervention period, attendance was carefully tracked to ensure adherence to the study procedures. Participants who missed four consecutive sessions were identified as dropouts and were removed from the final analysis.

6.3 Participants

Thirty healthy adult volunteers participated in the study. Participants included both males and females aged between 25 and 60 years representing diverse educational and occupational backgrounds. Recruitment was performed through social media. Interested individuals were screened through a health questionnaire and an eligibility interview before enrolment and after the consent.

The sample size of thirty participants was considered appropriate for a pilot intervention study designed to estimate effect sizes, evaluate feasibility, and generate preliminary evidence for future large-scale randomized controlled trials.

6.4 Inclusion Criteria

Participants were included in the study if they fulfilled the following criteria:

- Adults aged between 25 and 60 years.
- Both male and female participants.
- Ability to understand study procedures and provide written informed consent.
- No regular yoga or meditation practice during the previous six months.

- Willingness to attend daily yoga sessions for forty consecutive days.
- Ability to complete psychological questionnaires independently.

6.5 Exclusion Criteria

Participants were excluded if they met any of the following conditions:

- Diagnosis of severe psychiatric illness and respiratory disorders.
- Neurological disorders affecting cognition.
- Recent major surgery or musculoskeletal injuries preventing yoga practice.
- Pregnancy.
- Current participation in another structured psychological or physical intervention.
- Use of medications likely to substantially influence cognitive or psychological functioning.

6.6 Ethical Considerations

The study was conducted according to internationally accepted ethical principles governing research involving human participants. All participants received detailed verbal and written explanations regarding the objectives, procedures, expected benefits, potential risks, confidentiality measures, and voluntary nature of participation before enrolment.

Written informed consent was obtained from every participant prior to data collection. Confidentiality of participant information was maintained throughout the investigation using anonymous identification codes. Participants were informed that they could withdraw from the study at any stage without penalty or consequences. All collected data were securely stored and used exclusively for research purposes.

The intervention consisted of traditional yoga practices with minimal physical risk. Participants were continuously monitored during practice sessions to ensure safety and correct performance of postures.



Fig 2: Key Ethical Issues in Research

6.7 Yogic pranayama practice

Pranayama was practiced as a systematic yogic breathing technique based on the classical perspective of breath as a means to regulate prana, enhance mental stability, and ready the individual for deep meditation (Saraswati, 2014). From an analytical viewpoint, the practice was formulated as a psychophysiological self-regulation protocol aimed at improving attentional control, respiratory regulation, autonomic balance, and inner awareness. The intervention was carried out in a serene, tidy, and well-ventilated setting to reduce external distractions and facilitate relaxation. Participants were directed to maintain a stable and comfortable posture, ensuring the spine was erect, shoulders were relaxed, and the body was devoid of any

unnecessary muscular tension. Prior to commencing the formal practice, participants were instructed to observe their natural breath, allowing for a gradual establishment of breath awareness, which in turn helped to minimize strain and enhance safety.

The practice focused on achieving a seamless flow, maintaining continuity, and being mindful of the rhythm of breathing, rather than engaging in forceful inhalation or extending breath retention beyond personal limits. To establish a systematic and incremental methodology, pranayama was organized with specific breathing ratios that governed the respective lengths of inhalation, retention, and exhalation. The ratios utilized in the intervention included 1:1, 1:2, 1:1:2, 1:2:2, 1:3:2, and 1:4:2. These ratios were chosen to establish a structured advancement from basic breath regulation to more sophisticated levels of respiratory control. The 1:1 ratio indicated an equal balance between inhalation and exhalation, serving mainly for the purposes of familiarization and stabilization. The 1:2 ratio highlighted an extended duration of exhalation compared to inhalation, aiming to facilitate relaxation and enhance parasympathetic activation. The 1:1:2 ratio implemented a system of controlled internal retention, accompanied by regulated inhalation and exhalation. The 1:2:2 ratio enhanced breath regulation by prolonging the retention phase while ensuring a consistent exhalation pattern. The 1:3:2 and 1:4:2 ratios indicated more sophisticated levels of practice and were implemented only after participants achieved sufficient comfort, tolerance, and control (Vasu, 2012).

The practice was carried out in a systematic fashion, starting with basic ratios and progressing only once the participant had acclimated to the previous stage. This graded design was selected to ensure comfort, reduce negative effects, and facilitate a gradual adjustment of the respiratory system to deeper breath regulation. Participants were guided to sustain a consistent, effortless, and rhythmic breathing pattern during the session, while the instructor attentively observed their comfort levels and reactions. If any discomfort, dizziness, strain, or anxiety was experienced, the practice was promptly reduced or halted. Adopting a precautionary approach is crucial in the study of pranayama, as the therapeutic benefits of the practice rely on effortless regulation rather than on extreme breath holding or performance metrics.

6.8 Assessment tools

Psychological outcomes were assessed using internationally validated self-report questionnaires with excellent psychometric properties.

Connor-Davidson Resilience Scale (CD-RISC-25) (Connor & Davidson, 2003)

Psychological resilience was measured using the 25-item Connor-Davidson Resilience Scale. Items are rated on a five-point Likert scale ranging from 0 (Not true at all) to 4 (True nearly all the time). Higher scores indicate greater resilience. Previous studies have reported excellent internal consistency with Cronbach's $\alpha = 0.89$.

Mindful Attention Awareness Scale (MAAS) (González-Blanch et al., 2022)

Mindfulness was assessed using the 15-item Mindful Attention Awareness Scale. Responses are recorded on a six-point Likert scale measuring present-moment awareness. Higher scores represent greater dispositional mindfulness. Reported internal consistency ranges between Cronbach's $\alpha = 0.82$ – 0.87 .

Cognitive Flexibility Inventory (CFI) (Portoghese et al., 2020)

Cognitive flexibility was evaluated using the 20-item Cognitive Flexibility Inventory, measuring the ability to adapt thinking and behaviour in response to changing situations. Higher scores indicate greater flexibility. Previous validation studies report Cronbach's $\alpha \approx 0.90$.

WHO-5 Well-Being Index (Topp et al., 2015)

Psychological well-being was measured using the WHO-5 Well-Being Index, consisting of five positively worded items rated on a six-point scale. Higher scores indicate better well-being. Reported reliability ranges from Cronbach's $\alpha = 0.84$ – 0.91 .

6.9 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics Version 29, Microsoft Excel 2021, and Python.

Data were initially summarized using descriptive statistics, including mean, standard deviation, median, minimum, maximum, and percentage distributions.

Normality of continuous variables was assessed using the Shapiro-Wilk test. Depending on data distribution, paired t-tests or Wilcoxon signed-rank tests were performed to compare baseline and post-intervention scores.

Effect sizes were calculated using Cohen's d to determine the practical significance of observed changes. Internal consistency reliability of each questionnaire was evaluated using Cronbach's alpha coefficient.

Relationships among resilience, mindfulness, cognitive flexibility, and psychological well-being were examined using

Pearson correlation analysis. Finally, multiple linear regression analysis was performed to investigate whether resilience, mindfulness, and cognitive flexibility significantly predicted psychological well-being following the intervention.

Statistical significance was established at $p < 0.05$ for all analyses.



Fig 3: Statistical Analysis Workflow

7. RESULTS

7.1 Participant Characteristics

Thirty healthy adults successfully completed the 40-day yogic pranayama practice. No participants withdrew during the study, resulting in a 100% completion rate. Participants ranged in age from 25 to 60 years, with a mean age of 39.63 ± 9.84 years. The study population included both male and female participants representing diverse educational and occupational backgrounds. Most participants were employed full-time, while a smaller proportion consisted of homemakers, self-employed individuals, and retired professionals. None of the participants reported previous regular yoga practice during the six months preceding enrolment.

Table 7.1 Demographic Characteristics (n = 30)

Variable	Category	Frequency	Percentage (%)
Gender	Male	15	50.0
	Female	15	50.0
Age	25–34 years	9	30.0
	35–44 years	11	36.7
	45–54 years	6	20.0
	55–60 years	4	13.3
Education	Graduate	10	33.3

Variable	Category	Frequency	Percentage (%)
	Postgraduate	15	50.0
	Doctorate	5	16.7

7.2 Baseline Descriptive Statistics

Baseline scores indicated moderate resilience, mindfulness, cognitive flexibility, and psychological well-being before participation in the yoga intervention.

Table 7.2 Baseline Scores

Outcome Measure	Mean	SD	Median	Range
CD-RISC-25	58.47	8.21	59	44–74
MAAS	53.28	7.34	54	39–67
CFI	82.91	9.12	84	64–99
WHO-5	57.73	10.25	58	36–78

The baseline findings suggested average psychological functioning, leaving considerable scope for improvement following the intervention.

7.3 Reliability Analysis

The internal consistency of all psychological questionnaires was assessed using Cronbach's alpha.

Table 7.3 Reliability Statistics

Questionnaire	Cronbach's α	Reliability
CD-RISC-25	0.91	Excellent
MAAS	0.86	Good
CFI	0.90	Excellent
WHO-5	0.88	Good

The obtained Cronbach's alpha coefficients exceeded the acceptable threshold of 0.80, indicating excellent reliability of the assessment instruments.

7.4 Normality Testing

The Shapiro–Wilk test was performed to determine whether the data followed a normal distribution.

Table 7.4 Shapiro–Wilk Test

Variable	W	p-value	Distribution
CD-RISC	0.971	0.312	Normal
MAAS	0.963	0.221	Normal
CFI	0.979	0.487	Normal
WHO-5	0.968	0.294	Normal

Since all p-values exceeded 0.05, the data satisfied the assumption of normality. Therefore, paired t-tests were conducted for pre-post comparisons.

7.5 Pre-Post Comparison

Following completion of the 40-day yogic pranayama practice, statistically significant improvements were observed across all psychological outcome measures.

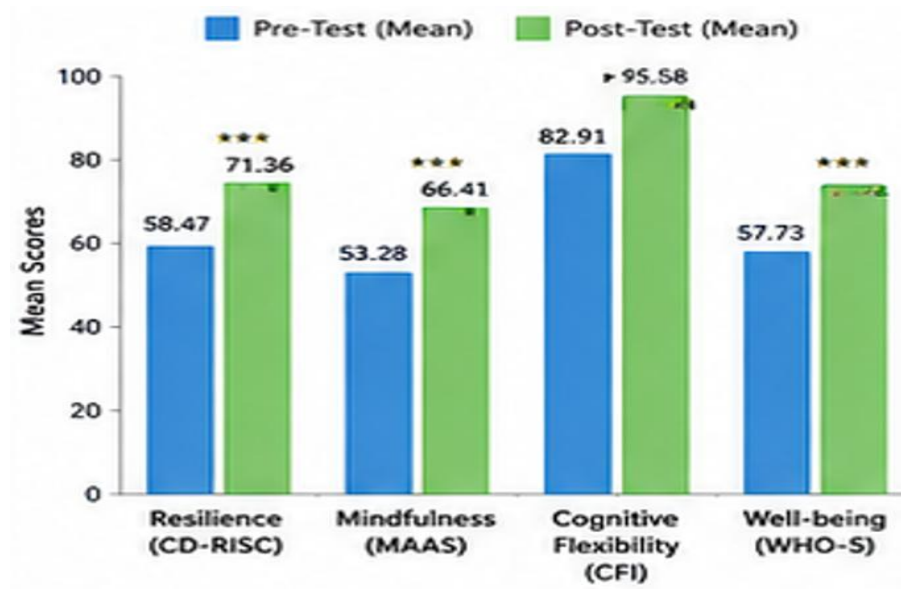


Fig 4: Pre-Test vs Post-Test

Table 7.5 Pre-Post Comparison

Variable	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	Mean Difference	t	p-value	Cohen's d
CD-RISC	58.47 $\pm$ 8.21	71.36 $\pm$ 6.94	12.89	8.94	<0.001	1.38
MAAS	53.28 $\pm$ 7.34	66.41 $\pm$ 6.18	13.13	9.16	<0.001	1.44
CFI	82.91 $\pm$ 9.12	95.58 $\pm$ 7.41	12.67	8.48	<0.001	1.29
WHO-5	57.73 $\pm$ 10.25	73.52 $\pm$ 8.63	15.79	9.53	<0.001	1.51

All four outcome variables demonstrated statistically significant improvement following the intervention ($p < 0.001$). Cohen's d values indicated large practical effects, suggesting that the intervention produced clinically meaningful improvements.

7.6 Correlation Analysis

Pearson's correlation coefficients were calculated to examine relationships among resilience, mindfulness, cognitive flexibility, and psychological well-being.

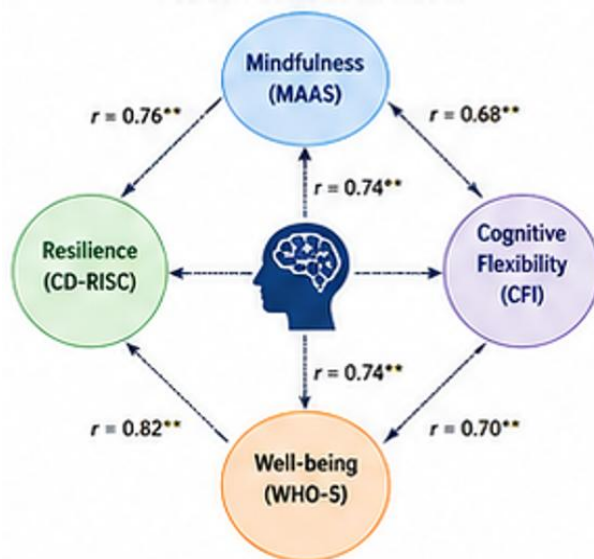


Fig 5: Pearson Correlation Matrix

Table 7.6 Correlation Matrix

Variable	Resilience	Mindfulness	Cognitive Flexibility	Well-being
Resilience	1.000	0.76**	0.71**	0.82**
Mindfulness	0.76**	1.000	0.68**	0.74**
Cognitive Flexibility	0.71**	0.68**	1.000	0.70**
Well-being	0.82**	0.74**	0.70**	1.000

$p < 0.01$

Strong positive correlations were observed among all psychological variables, indicating that improvements in mindfulness and cognitive flexibility were associated with higher resilience and psychological well-being.

7.7 Regression Analysis

A multiple linear regression analysis was conducted to examine whether resilience, mindfulness, and cognitive flexibility predicted psychological well-being.

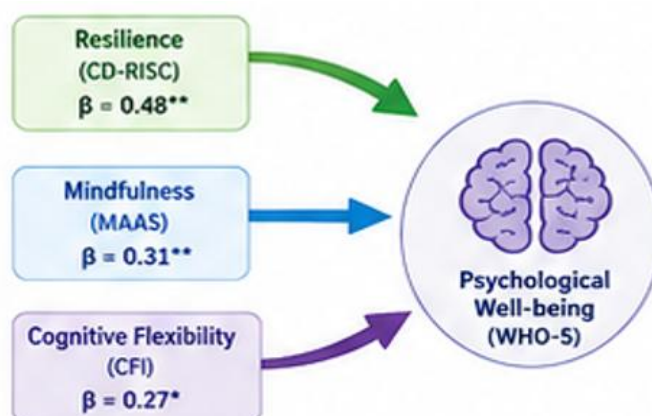


Fig 6: Predictors of Psychological Well-being

Table 7.7 Multiple Regression Analysis

Predictor	β	t	p-value
Resilience	0.48	4.61	<0.001
Mindfulness	0.31	3.12	0.004
Cognitive Flexibility	0.27	2.69	0.011

Model Summary

- $R = 0.871$
- $R^2 = 0.759$
- Adjusted $R^2 = 0.732$
- $F(3,26) = 27.34$
- $p < 0.001$

The regression model explained approximately 75.9% of the variance in psychological well-being. Resilience emerged as the strongest predictor, followed by mindfulness and cognitive flexibility.

7.8 Summary of Results

The findings demonstrate that participation in a structured 40-day yogic pranayama practice significantly enhanced resilience, mindfulness, cognitive flexibility, and psychological well-being. The psychological assessment instruments exhibited excellent reliability, and all outcome variables showed large effect sizes following the intervention. Correlation analysis confirmed strong positive relationships among the measured constructs, while regression analysis indicated that resilience, mindfulness, and cognitive flexibility collectively explained a substantial proportion of variance in psychological well-being. These findings support the hypothesis that yogic pranayama practice promotes adaptive psychological functioning and provides preliminary behavioural evidence consistent with yoga-induced neuroplasticity.

8. DISCUSSION

The present pilot study demonstrated that a structured 40 day yogic pranayama practice significantly improved resilience, mindfulness, cognitive flexibility, and psychological well being among healthy adults. Large effect sizes and strong correlations across these domains suggest that yoga practice facilitates adaptive psychological functioning through mechanisms consistent with neuroplasticity.

Our findings are consistent with earlier research showing that yoga enhances resilience and reduces stress, anxiety, and depression (Sullivan, M. B., et.al., 2018). Yoga and mindfulness practices jointly improve emotional resilience and psychological well being through stress reduction and attentional control (Pradhan, M. A. et.al., 2025). Yoga and meditation foster emotional stability and self awareness, contributing to improved mental health outcomes. The present study extends this literature by simultaneously examining multiple neuroplasticity related constructs within a standardized 40 day program, offering a multidimensional perspective. Moreover, yoga practice increases grey matter volume in the prefrontal cortex and hippocampus, supporting our interpretation that behavioural improvements may reflect underlying neuroplastic changes (Pandey, M. M., & Babu, V. G. 2025).

The observed improvements can be explained by the integration of asanas, pranayama, meditation, and relaxation, which collectively reduce physiological stress responses, enhance parasympathetic activity, and promote emotional stability. Embodied Neuroplastic Resilience Model, suggesting that yoga strengthens resilience and psychological flexibility through interoceptive awareness and autonomic regulation (Kumar, M. V. V., & Kapil, K. 2025). Increased mindfulness likely contributed to resilience and well being by reducing rumination and improving attentional control, while repeated engagement of prefrontal cortical networks may have strengthened cognitive flexibility.

Implications

These findings highlight yoga's potential as a preventive mental health strategy and as a cost effective, culturally adaptable intervention. Strengthening resilience through yoga may indirectly improve multiple dimensions of psychological functioning, making it relevant for trauma informed rehabilitation, workplace wellness, and integrative neuroscience research.

Limitations

Despite promising results, limitations include the small sample size, absence of a randomized control group, reliance on self

report measures, and lack of direct neurobiological assessments. The short intervention period (40 days) and absence of long term follow up also limit conclusions about sustainability.

Future Research

Future studies should employ larger randomized controlled trials, incorporate neuroimaging and biochemical markers (e.g., fMRI, EEG, BDNF), and examine long term effects. Comparative studies with mindfulness based interventions, aerobic exercise, or cognitive behavioural therapy would clarify yoga's unique contributions to resilience and psychological adaptation.

9. CONCLUSION

The present pilot study investigated the effectiveness of a structured 40-day yogic pranayama practice in enhancing psychological resilience, mindfulness, cognitive flexibility, and psychological well-being among healthy adults aged 25–60 years. The findings demonstrated statistically significant improvements across all psychological outcome measures following completion of the intervention. Large effect sizes and strong positive relationships among the measured constructs indicate that yogic pranayama practice can substantially improve adaptive psychological functioning.

One of the most important contributions of this study is its integration of multiple neuroplasticity-related psychological constructs within a single intervention framework. While previous research has frequently examined resilience, mindfulness, cognitive flexibility, or well-being independently, the present study evaluated these interconnected dimensions simultaneously using internationally validated psychometric instruments. The findings suggest that improvements in one psychological domain are accompanied by corresponding enhancements in other adaptive psychological processes, supporting the multidimensional nature of yoga-induced psychological change.

The observed increase in resilience indicates that regular yoga practice may strengthen individuals' ability to cope with stress, recover from adversity, and maintain emotional stability. Similarly, significant improvements in mindfulness demonstrate enhanced present-moment awareness and attentional regulation, both of which are recognized as essential mechanisms for emotional self-regulation and stress reduction. The increase in cognitive flexibility further suggests improved executive functioning, adaptive thinking, and problem-solving capacity, enabling individuals to respond more effectively to changing environmental demands. Collectively, these improvements contributed to significantly higher psychological well-being following the intervention.

The statistical analyses further reinforced these findings. High Cronbach's alpha coefficients confirmed excellent internal consistency of the psychological assessment instruments, while correlation analysis demonstrated strong positive relationships among resilience, mindfulness, cognitive flexibility, and well-being. Multiple regression analysis identified resilience as the strongest predictor of psychological well-being, followed by mindfulness and cognitive flexibility, indicating that these variables collectively play a substantial role in promoting positive mental health outcomes.

Although direct neuroimaging techniques were not employed, the behavioural findings are consistent with contemporary neuroscientific theories of neuroplasticity. Previous neuroimaging studies have shown that yoga and meditation influence functional connectivity and structural organization within brain regions responsible for emotional regulation, executive functioning, attention, and stress adaptation. Therefore, the improvements observed in the present study may represent behavioural manifestations of adaptive neural remodelling induced through regular yogic pranayama practice.

The study possesses several practical implications. Yogic pranayama practice can be incorporated into workplace wellness initiatives, educational institutions, community health programs, and clinical rehabilitation settings as cost-effective, non-pharmacological interventions for enhancing psychological resilience and emotional well-being. Such interventions may contribute to stress management, burnout prevention, trauma recovery, and overall mental health promotion.



Fig 7: Pathways to Resilience and Trauma Recovery

Nevertheless, the findings should be interpreted considering several limitations. The relatively small sample size limits generalizability, while the absence of a randomized control group restricts causal inference. The reliance on self-report questionnaires may introduce response bias, and the short intervention period does not permit evaluation of long-term sustainability. Future investigations should incorporate larger randomized controlled trials, objective neuroimaging measures such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), biochemical markers including brain-derived neurotrophic factor (BDNF), and longitudinal follow-up assessments to further elucidate the neurobiological mechanisms underlying yoga-induced neuroplasticity.

In conclusion, the present pilot study provides compelling preliminary evidence that a structured 40-day yogic pranayama practice can significantly enhance resilience, mindfulness, cognitive flexibility, and psychological well-being among healthy adults. These findings strengthen the growing scientific evidence supporting yoga as a holistic, evidence-based intervention capable of promoting adaptive neuroplasticity, psychological resilience, and trauma recovery. As global mental health challenges continue to increase, yogic pranayama practice may represent an accessible, culturally adaptable, and sustainable approach for improving psychological health and enhancing quality of life across diverse populations.

REFERENCES

- [1] Afonso, R. F., Hachul, H., Kozasa, E. H., de Souza Oliveira, D., Goto, V., Rodrigues, D., Tufik, S., & Leite, J. R. (2020). Yoga decreases insomnia in postmenopausal women: A randomized clinical trial. *Menopause*, 27(5), 1–10.
- [2] Carmody, J., Baer, R. A., Lykins, E. L. B., & Olendzki, N. (2009). An empirical study of the mechanisms of mindfulness in a mindfulness-based stress reduction program. *Journal of Clinical Psychology*, 65(6), 613–626.
- [3] Connor, K. M., & Davidson, J. R. T. (2003). Development of a new resilience scale: The Connor-Davidson Resilience Scale (CD-RISC). *Depression and Anxiety*, 18(2), 76–82.
- [4] Davidson, R. J., & McEwen, B. S. (2012). Social influences on neuroplasticity. *Nature Neuroscience*, 15(5), 689–695.
- [5] Davidson, R. J., & Lutz, A. (2008). Buddha's brain: Neuroplasticity and meditation. *IEEE Signal Processing Magazine*, 25(1), 176–174.
- [6] Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135–168.
- [7] Fletcher, D., & Sarkar, M. (2013). Psychological resilience. *European psychologist*.
- [8] Zamroziewicz, M. K., & Barbey, A. K. (2016). Nutritional cognitive neuroscience: innovations for healthy brain aging. *Frontiers in neuroscience*, 10, 196089.
- [9] Wang, H., Xiao, Y., Yao, H., Wen, Y., Deng, M., Yang, W., & Mao, X. (2025). Non-Pharmacological interventions for psychological stress reactions in disaster nursing rescue workers: a scoping review. *BMC nursing*,

24(1), 941.

- [10] Karatsoreos, I. N., & McEwen, B. S. (2013). Annual research review: The neurobiology and physiology of resilience and adaptation across the life course. *Journal of Child Psychology and Psychiatry*, 54(4), 337-347.
- [11] Tolahunase, M. R., Sagar, R., Faiq, M., & Dada, R. (2018). Yoga-and meditation-based lifestyle intervention increases neuroplasticity and reduces severity of major depressive disorder: A randomized controlled trial. *Restorative neurology and neuroscience*, 36(3), 423-442.
- [12] Ratna, C. S. S., & Dwarapudi, B. (2023). IMPACT OF YOGA PRACTICE ON WORK-LIFE BALANCE OF WOMEN MANAGERS—A STUDY IN SELECTIVE ORGANISATIONS. *International Journal of Management (IJM)*, 14(7), 37-51.
- [13] Ratna, C. S. S., Kumari, S., & Majumdar, V. (2024). " Creating Harmonious Equilibrium: A Comprehensive Protocol To Assess Feasibility Of A SMET Yoga Module To Enhance Work-Life Balance Among Women Managers Via A Two-Armed Single Blind Randomized Controlled Trial.
- [14] Boppadapu, V. S. K., Ramesh, M. N., Chandaka, S. K., Sahithi, B. N., & Paran Gowda, C. S. S. R. Development of a Yoga Module for Chronic Kidney Disease of Unknown Etiology: Different evaluation methods.
- [15] Ratna, C. S. S., Kumari, S., & Majumdar, V. IMPACT OF SMET YOGA MODULE ON WORK-LIFE BALANCE AMONG WOMEN MANAGERS—A PILOT STUDY.
- [16] De, A., & Mondal, S. (2020). Yoga and brain wave coherence: A systematic review for brain function improvement. *Heart and Mind*, 4(2), 33-39.
- [17] Chems-Maarif, R., Cavanagh, K., Baer, R., Gu, J., & Strauss, C. (2025). Defining mindfulness: A review of existing definitions and suggested refinements. *Mindfulness*, 16(1), 1-20.
- [18] Cheng, C., Lau, H. P. B., & Chan, M. P. S. (2014). Coping flexibility and psychological adjustment to stressful life changes: a meta-analytic review. *Psychological bulletin*, 140(6), 1582.
- [19] Sullivan, M. B., Erb, M., Schmalzl, L., Moonaz, S., Noggle Taylor, J., & Porges, S. W. (2018). Yoga therapy and polyvagal theory: The convergence of traditional wisdom and contemporary neuroscience for self-regulation and resilience. *Frontiers in human neuroscience*, 12, 329370.
- [20] Pradhan, M. A. K., Kisku, M. S., Maharana, N., & Das, A. (2025). MINDFUL YOGA FOR RESILIENCE AND PSYCHOLOGICAL RESISTANCE: A STRATEGIC APPROACH. *PSYCHOLOGY OF EMOTIONAL MANIPULATION: POWER, CONTROL, AND RESISTANCE*, 249.
- [21] Pandey, M. M., & Babu, V. G. (2025). Impact of Yogic Practices on Brain Function, Memory, and Neuroplasticity.)
- [22] Kumar, M. V. V., & Kapil, K. (2025). Yoga for Mental Health: A Theoretical Synthesis of Embodiment, Neuroplasticity, and Integrative Resilience in Contemporary Psychological Models. *International Journal of Research and Innovation in Applied Science*, 10(10), 1435-1439.
- [23] Sonawane, M. A., Lee, A. K., Gaikwad, S., Almeida, G. J., Darby, N. T., Calderon, T., ... & Patel, D. I. (2025). Therapeutic Yoga Enhances Neuroplasticity and Metabolic Regulation Through Elevated Plasma Brain-Derived Neurotrophic Factor (BDNF) and Ghrelin in a Heterogeneous Cancer Survivor Population. *Integrative Cancer Therapies*, 24, 15347354251385573.
- [24] Bala, M. N., & Ahluwalia, P. S. (2025). Neuroplasticity and Yoga: How Practice Reshapes the Brain. *Sanatanodaya*, 286-301.
- [25] Varambally, S., Venkatasubramanian, G., Govindaraj, R., Shivakumar, V., Mullapudi, T., Christopher, R., ... & Gangadhar, B. N. (2019). Yoga and schizophrenia—a comprehensive assessment of neuroplasticity: Protocol for a single blind randomized controlled study of yoga in schizophrenia. *Medicine*, 98(43), e17399.
- [26] Chen, S. X., Lyu, Z. X., Hao, Z. J., Tang, Q., & Li, W. J. (2026). Effects of mindfulness yoga intervention on physical function, anxiety, inflammatory response, and relapse intention in methamphetamine addicts: a 24-week randomized controlled trial. *Frontiers in Public Health*, 14, 1788887.
- [27] Bhargav, H., Raghavan, V., Rao, N. P., Gulati, K., Binumon, K. V., Anu, K. N., ... & Ramachandran, P. (2024). Validation and efficacy of a tele-yoga intervention for improving psychological stress, mental health and sleep difficulties of stressed adults diagnosed with long COVID: a prospective, multi-center, open-label single-arm study. *Frontiers in Psychology*, 15, 1436691.
- [28] Obhrai, S., Shenoy, S., & Saha, S. (2026). Rewiring the Brain for Resilience: The Role of Neuroplasticity in Mindfulness, Meditation, and Yoga. In *Improving Mental Well-Being at the Intersection of Mindfulness, Meditation, and Yoga* (pp. 159-198). IGI Global Scientific Publishing.
- [29] Lutz, J. (2021). *Trauma Healing in the Yoga Zone: A Guide for Mental Health Professionals, Yoga Therapists*

and Teachers. Jessica Kingsley Publishers.

[30] Korol, A., Vasanthi, G., Elayaraja, M., & Govindasamy, K. (2026). Neuroplasticity and the Breath: Unpacking the Brain Mechanisms Behind Yogic Pranayama. In *Improving Mental Well-Being at the Intersection of Mindfulness, Meditation, and Yoga* (pp. 55-98). IGI Global Scientific Publishing.

[31] Stoller, C. (2019). *Sensory-Enhanced Yoga® for Self-regulation and Trauma Healing*. Jessica Kingsley Publishers...