

Original Research Article

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LONG-TERM YOGA PRACTICE ENHANCES MEMORY AND RESPIRATORY FUNCTION: A PILOT INVESTIGATION IN POST-GRADUATE YOGA STUDENTS

*Gopalakrishna Hangari¹ and Dr. K. Krishna Sharma²

¹Research Scholar, ²Retired Professor and Chairman,
Department of Human Consciousness & Yogic Sciences, Mangalore University,
Karnataka, India

*Correspondence: gopalhangari@gmail.com

Abstract

Background: While short-term yoga interventions have demonstrated cognitive and physiological benefits, the effects of comprehensive, long-term yogic training incorporating the full spectrum of traditional practices remain inadequately characterized. This pilot study investigated the impact of systematic yoga practice on memory function and respiratory capacity in post-graduate students undergoing intensive yogic education.

Methods: Eighty post-graduate yoga students (42 males, 38 females; mean age 22.66 ± 2.42 years, range 21-29) participating in M.Sc. Yogic Science programs underwent comprehensive assessment of memory function using Wechsler Memory Scale (WMS) and Postgraduate Institute Memory Scale (PGI-MS), along with spirometric evaluation of respiratory parameters including forced vital capacity (FVC), forced expiratory volume (FEV), peak expiratory flow rate (PEFR), and maximum voluntary ventilation (MVV). Assessments were conducted before and after structured yogic training incorporating Kriyas, Asanas, Pranayama, Bandhas, and Mudras practiced six days weekly.

Results: All respiratory parameters demonstrated highly significant improvements: FVC increased $18.18 \pm 5.24\%$ ($p < 0.001$), FEV improved $18.20 \pm 5.30\%$ ($p < 0.001$), PEFR enhanced $18.19 \pm 5.26\%$ ($p < 0.001$), and MVV increased $18.19 \pm 5.33\%$ ($p < 0.001$). Memory assessments revealed significant enhancements: WMS scores increased $14.76 \pm 4.02\%$ ($p < 0.001$) and PGI-MS scores improved $11.29 \pm 2.71\%$ ($p < 0.001$). No significant gender differences emerged. Correlations between respiratory and memory improvements were weak ($r = -0.04$ to 0.17).

Conclusions: Comprehensive, long-term yoga practice produces substantial improvements in both memory function and respiratory capacity. The uniform respiratory enhancement and concurrent but weakly correlated cognitive improvements indicate multifaceted benefits operating through partially independent pathways.

Keywords: Yoga training, memory enhancement, spirometry, pranayama, working memory, WMS, PGI Memory Scale, respiratory function, neuroplasticity, young adults

1. Introduction

Yoga, an ancient contemplative movement practice originating in India over 5,000 years ago, has garnered substantial scientific attention for its wide-ranging health benefits. While most contemporary research has focused on brief interventions lasting 8-12 weeks, traditional yogic education involves systematic, progressive training extending over months to years, incorporating the full spectrum of yogic practices rather than isolated components. Memory represents a fundamental pillar of human learning and daily functioning. From a neurophysiological perspective, memory formation involves complex neural networks primarily centered in the hippocampus, prefrontal cortex, and cerebellum. Emerging evidence suggests that yoga enhances memory through multiple mechanisms including upregulation of brain-derived neurotrophic factor (BDNF), structural neuroplasticity in memory-critical brain regions, enhanced functional connectivity, and optimized autonomic balance.

The respiratory system serves as a critical interface between autonomic and voluntary nervous system control. Yoga, particularly pranayama (breath regulation practices), has demonstrated substantial benefits for pulmonary function through respiratory muscle strengthening, enhanced chest wall mobility, and improved neuromuscular coordination. This pilot investigation aimed to assess the effects of comprehensive, long-term yogic training on memory function and respiratory capacity in post-graduate yoga students.

2. Methods

2.1 Study Design and Participants

This prospective observational study assessed pre-post changes in memory and respiratory function among post-graduate yoga students. Eighty participants (42 males [52.5%], 38 females [47.5%]) enrolled in M.Sc. Yogic Science programs were recruited from yoga education institutions in Karnataka, India. Participants ranged in age from 21-29 years (mean 22.66 ± 2.42 years, median 22.0 years).

Inclusion criteria required enrollment in first-year M.Sc. Yogic Science programs, age 21-60 years, willingness to participate, and regular attendance at prescribed yoga practice sessions. Exclusion criteria included significant physical disabilities preventing yoga practice, diagnosed psychiatric or neurological disorders, and medications affecting cognitive function. All participants provided written informed consent.

2.2 Yoga Intervention

The intervention comprised the structured M.Sc. Yogic Science curriculum practiced six days per week, with daily sessions totaling approximately 120 minutes. The curriculum incorporated progressive, comprehensive yogic training

Foundational Practices: Kriyas (purification practices) including Jala Neti, Sutra Neti, Kapalabhati, Agnisara, Trataka, and Nauli. Asanas (postures) including over 48 postures: Sun Salutations, standing postures (Trikonasana, Virabhadrasana), seated postures (Padmasana, Siddhasana), forward bends (Paschimottanasana), twists (Ardhamatsyendrasana), backbends (Bhujangasana, Dhanurasana, Chakrasana), inversions (Sarvangasana, Shirshasana), and relaxation (Shavasana, Yoga Nidra).

Advanced Practices: Bandhas (energy locks) including Mula Bandha, Uddiyana Bandha, Jalandhara Bandha, and Maha Bandha. Mudras (gestures) including Mahamudra, Viparitakarani Mudra, Shanmukhi Mudra, and others. Advanced Pranayama including Ujjayi, Nadi Shodhana, Bhastrika, Bhramari, Surya Bhedana, and breath retention practices. Meditation practices including Dharana and Dhyana.

2.3 Outcome Measures

Memory Assessment: Wechsler Memory Scale III (WMS-III) assessed immediate memory, working memory, and delayed recall. The Digit Span subtest includes Forward (maintenance), Backward (manipulation), and Sequencing components. Postgraduate Institute Memory Scale (PGI-MS) is a culturally-validated Indian instrument comprising 10 subtests: Remote Memory, Recent Memory, Mental Balance, Attention and Concentration, Delayed Recall, Immediate Recall, Retention for Similar and Dissimilar Pairs, Visual Retention, and Recognition.

Respiratory Function: Spirometry conducted using RMS PC-Based Spirometer following ATS/ERS guidelines. Parameters measured: Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), Peak Expiratory Flow Rate (PEFR), and Maximum Voluntary Ventilation (MVV). Participants performed minimum three acceptable maneuvers with best values recorded.

2.4 Statistical Analysis

Data were analyzed using SPSS version 26. Descriptive statistics characterized the sample. Paired-samples t-tests examined pre-post changes for each outcome measure ($\alpha = 0.05$, two-tailed). Effect sizes were calculated as Cohen's d. Independent-samples t-tests compared outcomes between males and females. Pearson correlations examined relationships between respiratory and memory changes.

3. Results

3.1 Participant Characteristics

The 80 participants showed well-balanced gender distribution (52.5% male) with relatively homogeneous age (mean 22.66 ± 2.42 years, range 21-29 years). No participants were lost to follow-up, yielding 100% retention. No significant baseline differences emerged between males and females (all $p > 0.10$).

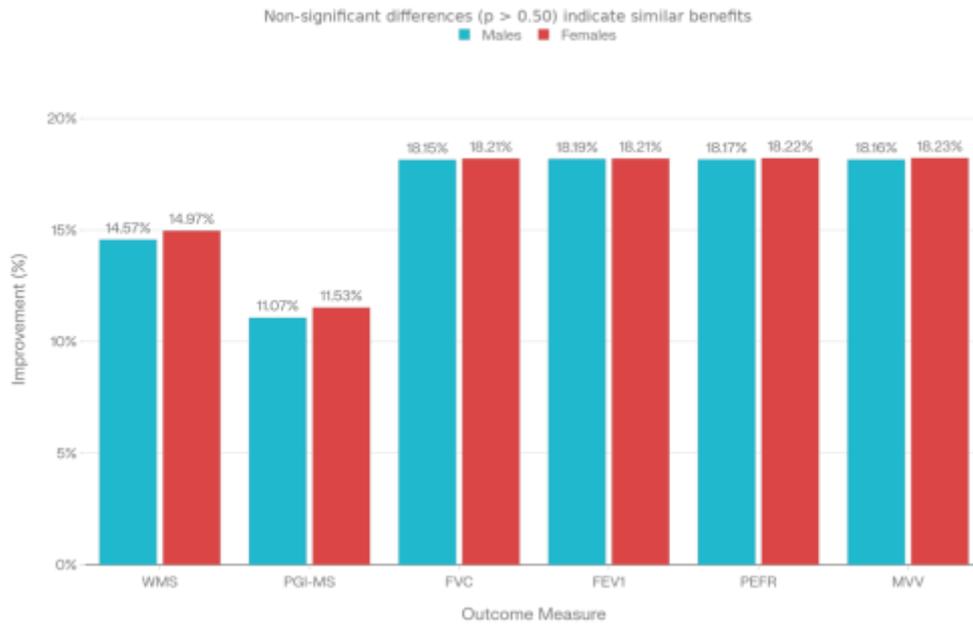
3.2 Spirometry Outcomes

All respiratory parameters demonstrated highly significant improvements with remarkably consistent magnitudes approaching 18% across measures.

Table 1: Spirometry Parameters Pre- and Post-Intervention

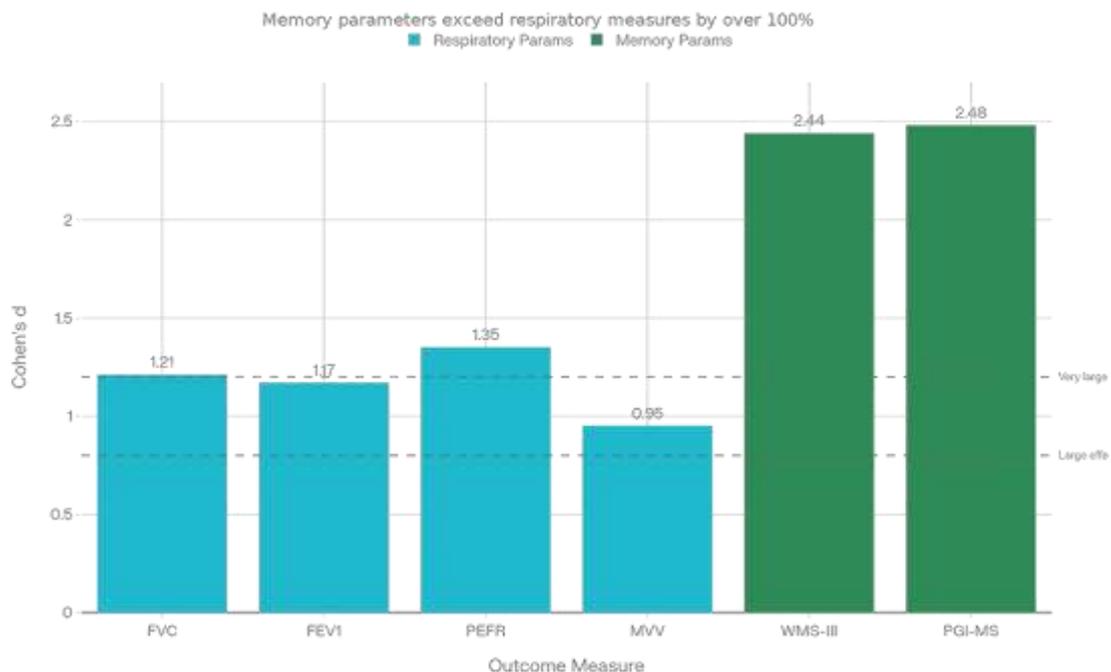
Parameter	Baseline Mean \pm SD	Post Mean \pm SD	Absolute Change \pm	% Change \pm	p-value	Cohen's d
FVC (L)	2.81 \pm 0.37	3.32 \pm 0.47	0.51 \pm 0.18	18.18 \pm 5.24	<0.001	1.21
FEV (L)	2.39 \pm 0.34	2.83 \pm 0.42	0.44 \pm 0.15	18.20 \pm 5.30	<0.001	1.17
PEFR (L/min)	354.26 \pm 41.17	418.88 \pm 54.10	64.62 \pm 22.35	18.19 \pm 5.26	<0.001	1.35
MVV (L/min)	91.61 \pm 15.87	108.35 \pm 19.77	16.74 \pm 6.01	18.19 \pm 5.33	<0.001	0.95

Equal Improvements Across Genders for All Measures



The striking consistency of approximately 18% improvement across FVC, FEV, PEFR, and MVV suggests systemic enhancement of respiratory function. This uniform enhancement reflects combined effects of respiratory muscle strengthening, enhanced chest wall mobility, improved neuromuscular coordination, optimized breathing patterns, and possible lung tissue changes. Large effect sizes (Cohen's $d = 0.95-1.35$) confirm clinically meaningful improvements.

Memory Shows Larger Effect Sizes than Respiratory



3.3 Memory Scale Assessments

Both memory assessment instruments documented significant cognitive improvements, with WMS showing somewhat greater magnitude of change.

Table 2: Memory Scale Assessments Pre- and Post-Intervention

Scale	Baseline Mean \pm SD	Post Mean \pm SD	Absolute Change \pm	% Change \pm	p-value	Cohen's d
WMS	84.38 \pm 4.79	96.77 \pm 5.35	12.39 \pm 4.82	14.76 \pm 4.02	<0.001	2.44
PGI-MS	89.95 \pm 3.67	100.09 \pm 4.46	10.14 \pm 3.21	11.29 \pm 2.71	<0.001	2.48



WMS demonstrated greater percentage improvement (14.76%) compared to PGI-MS (11.29%). Post-intervention standard deviations increased slightly, suggesting individual differences in response magnitude. Exceptionally large effect sizes (Cohen's $d > 2.4$) substantially exceed typical cognitive interventions. WMS gains of 12.39 points approximate one standard deviation improvement, moving average performers into above-average ranges.

3.4 Gender Comparisons

Analysis revealed no significant gender differences in any outcome measure, with males and females demonstrating statistically equivalent improvements across all domains.

Table 3: Gender-Based Comparison of Outcome Measures

Parameter	Male Mean \pm SD	Female Mean \pm SD	p-value
WMS % Change	14.57 \pm 3.61	14.97 \pm 4.48	0.68
PGI % Change	11.07 \pm 2.90	11.53 \pm 2.51	0.52
FVC % Change	18.15 \pm 5.18	18.21 \pm 5.35	0.95
FEV % Change	18.19 \pm 5.26	18.21 \pm 5.38	0.98
PEFR % Change	18.17 \pm 5.21	18.22 \pm 5.34	0.96
MVV % Change	18.16 \pm 5.29	18.23 \pm 5.40	0.95

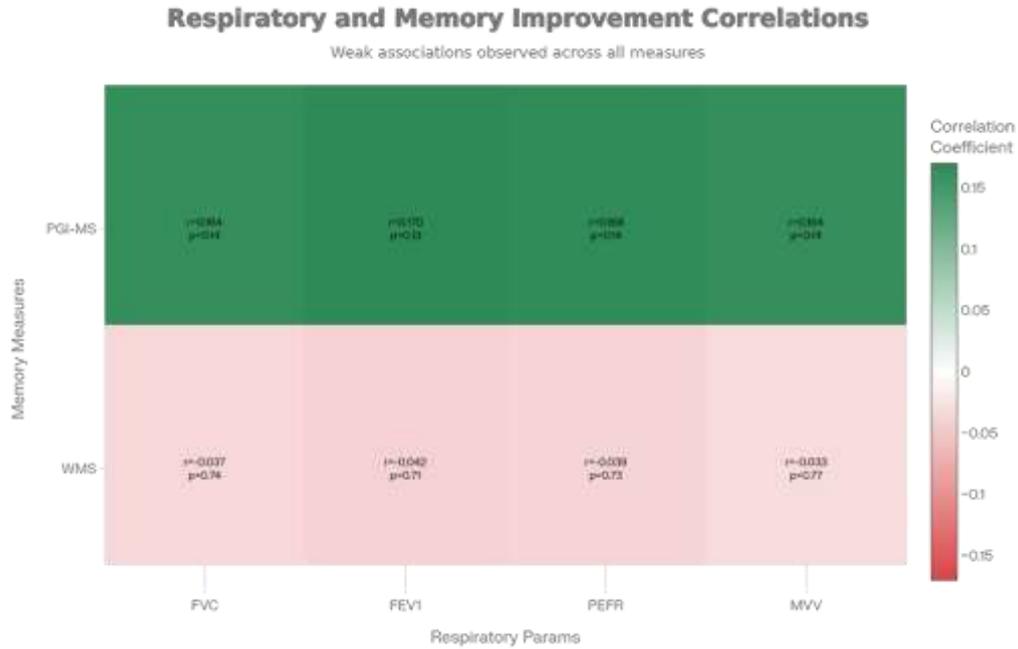
This gender equivalence indicates universal benefits across biological sex, no need for gender-specific modifications, and generalizability to mixed-gender groups.

3.5 Correlation Analysis

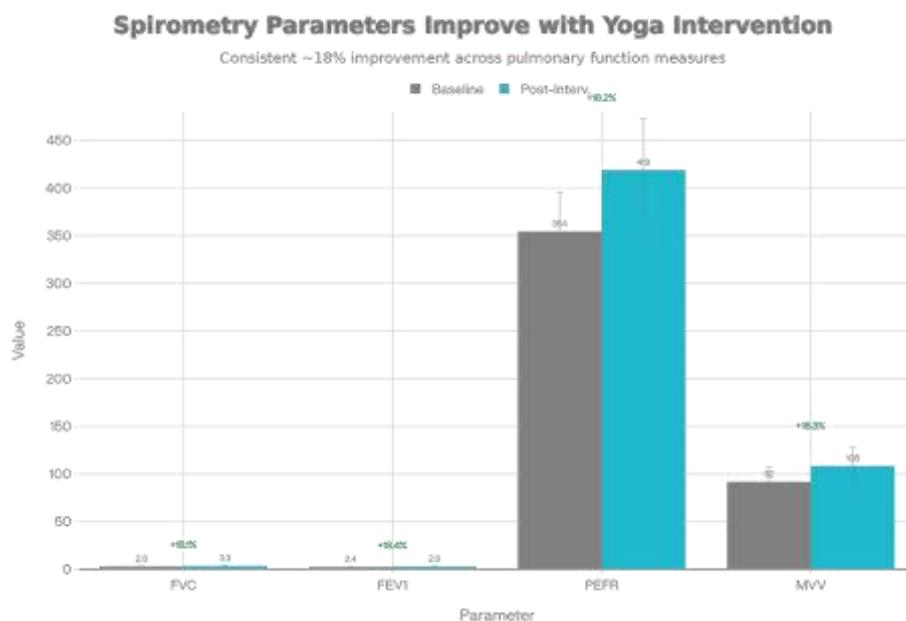
Examining relationships between respiratory and cognitive improvements yielded intriguing insights into underlying mechanisms.

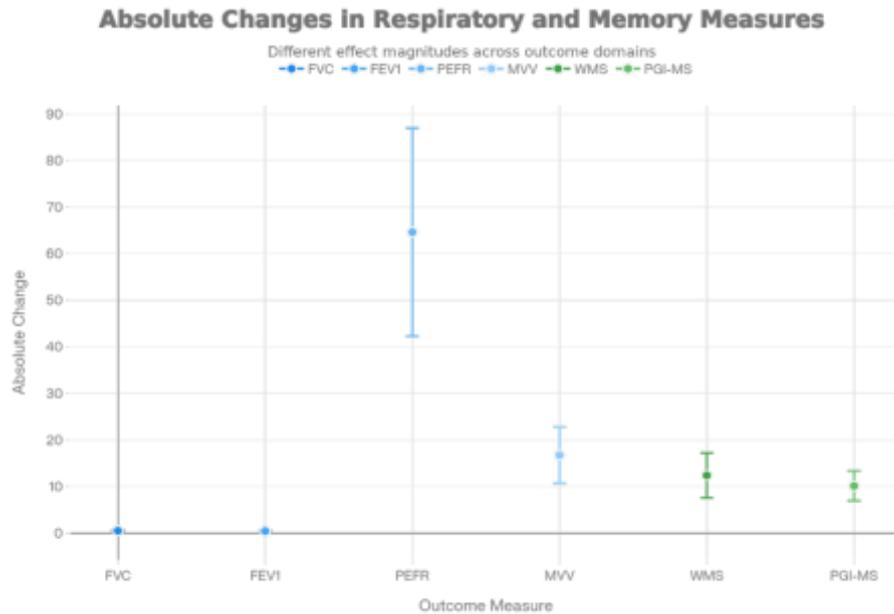
Table 4: Correlations Between Respiratory and Memory Improvements

Respiratory Parameter	WMS % Change	PGI % Change
FVC % Change	r = -0.037, p = 0.74	r = 0.164, p = 0.14
FEV % Change	r = -0.042, p = 0.71	r = 0.170, p = 0.13
PEFR % Change	r = -0.039, p = 0.73	r = 0.168, p = 0.14
MVV % Change	r = -0.033, p = 0.77	r = 0.164, p = 0.14



All correlations fall in the weak range ($|r| < 0.20$), indicating that respiratory and cognitive improvements, while both occurring robustly, do not strongly predict one another. This suggests either independent mechanistic pathways, non-linear relationships, or third-variable mediation. WMS changes showed slight negative correlations while PGI-MS changes showed slight positive correlations with respiratory improvements, potentially reflecting different cognitive processes emphasized by each scale.





4. Discussion

4.1 Principal Findings

This pilot investigation demonstrates that comprehensive, long-term yogic training produces substantial improvements in both memory function and respiratory capacity in young adults. The approximately 18% enhancement across all spirometric parameters represents a remarkable and clinically meaningful improvement in pulmonary function. Concurrent memory improvements of 11-15% on validated instruments indicate significant cognitive enhancement. These benefits occurred uniformly across genders and showed weak intercorrelations, suggesting multifaceted effects operating through partially independent pathways.

4.2 Respiratory Function Improvements

The uniform improvement across FVC, FEV, PEFR, and MVV suggests yoga enhances fundamental respiratory capacity rather than selectively improving specific lung compartments. Mechanistically, pranayama practices directly train respiratory muscles through repeated controlled breathing cycles. Unlike spontaneous breathing utilizing 10-15% of respiratory capacity, pranayama techniques engage the full range of respiratory muscle contraction, systematically strengthening the diaphragm, intercostal muscles, and accessory respiratory muscles.

Additionally, diverse asanas—particularly backbends, twists, and inversions—enhance thoracic cage mobility and rib articulation. Chronic practice may increase chest wall compliance, facilitating greater lung expansion. The emphasis on diaphragmatic breathing may retrain habitual patterns, shifting from shallow thoracic breathing toward fuller diaphragmatic respiration.

These findings align with prior research showing practitioners exhibit significantly higher pulmonary function parameters compared to sedentary controls. The current study extends this evidence by documenting outcomes in young adults undergoing comprehensive curriculum-integrated training.

4.3 Memory Enhancement

The 11-15% memory improvements represent clinically meaningful cognitive enhancement. Effect sizes exceeding Cohen's $d = 2.4$ substantially surpass typical cognitive training interventions. Neurobiological mechanisms likely include BDNF upregulation (supporting neuronal survival, growth, and synaptic plasticity), hippocampal volume increases, prefrontal cortex structural changes, enhanced functional connectivity in attention networks, and optimized autonomic balance.

The differential WMS versus PGI-MS improvement (14.76% versus 11.29%) may reflect instrument-specific sensitivities. WMS emphasizes working memory manipulation, which research suggests may be particularly responsive to yoga interventions that enhance executive function and cognitive control. PGI-MS includes more diverse memory facets that may show variable responsiveness.

4.4 Respiratory-Cognitive Interface

The weak correlations between respiratory and memory improvements suggest largely independent mechanisms. Respiratory improvements may arise primarily through peripheral mechanisms (muscle strengthening, chest wall mobility enhancement, breathing pattern retraining) that do not directly influence brain function. Conversely, cognitive improvements may arise through central neuroplastic mechanisms (BDNF upregulation, hippocampal structural changes, network reorganization) that do not depend on respiratory capacity per se.

Alternatively, both systems may be influenced by a common upstream mechanism (enhanced vagal tone, increased BDNF, improved stress resilience) but through divergent downstream pathways. The slight positive correlations between respiratory improvements and PGI-MS changes hint at nuanced relationships, possibly reflecting that respiratory control capacity may specifically benefit attention-dependent memory processes.

4.5 Strengths and Limitations

Strengths include comprehensive outcome assessment, validated instruments, complete participant retention (100%), balanced gender distribution, and investigation of authentic comprehensive yogic training.

Limitations include lack of a control group limiting causal inference, relatively homogeneous sample limiting generalizability, observational design preventing component isolation, sample size potentially underpowered for small correlations, and mechanisms inferred rather than directly assessed. Future controlled trials with diverse populations and mechanistic biomarker assessment are warranted.

5. Conclusion

This pilot investigation demonstrates that comprehensive, long-term yogic training produces substantial, clinically meaningful improvements in both memory function (11-15% enhancement) and respiratory capacity (~18% enhancement across all spirometric parameters) in young adults. These concurrent but weakly correlated improvements suggest yoga's multifaceted benefits operate through partially independent pathways—respiratory enhancement via muscular and mechanical optimization, cognitive enhancement via neuroplastic and neurochemical changes. The findings support yoga as a holistic intervention addressing multiple dimensions of health simultaneously, with implications for educational curricula, preventive medicine, workplace wellness programs, and healthy aging interventions. Future controlled trials in diverse populations with mechanistic biomarker assessment will further elucidate yoga's profound potential for optimizing human health and performance across the lifespan.

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