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LIST OF SELECTED SCIENTIFIC RESEARCH ARTICLES ON BREATHING

The references are alphabetically sorted.

For each reference the following items are provided:

a) the complete reference spelled under Vancouver Citation Style;
b) its Digital Object Identifier (DOI);
c) the link to the related journal page where the article is published;
d) its abstract and keywords if listed.

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2. A randomized controlled dosing study of Iyengar yoga and coherent breathing for the treatment of major depressive disorder. Impact on suicidal ideation and safety findings.
3. A randomized trial of the immediate effect of Bee-Humming Breathing exercise on blood pressure and heart rate variability in patients with essential hypertension.
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17. Breathing around the clock. An overview of the circadian pattern of respiration.
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19. Breathing at a rate of 5.5 breaths per minute with equal inhalation-to-exhalation ratio increases heart rate variability.
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26. Breathing Exercises Must Be a Real and Effective Intervention to Consider in Women with Fibromyalgia. A Pilot Randomized Controlled Trial.
27. Breathing Focused Mind-Body Approach for Treatment of Posttraumatic Stress Disorder among Children and Adolescents. A Systematic Review.
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29. Breathing. An essential component of bodywork.
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33. Breathwork in body psychotherapy. Clinical applications.
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37. Changes in Heart Rate Variability During Heartfulness Meditation. A Power Spectral Analysis Including the Residual Spectrum.
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43. Controlled Rhythmic Yogic Breathing as Complementary Treatment for Post-Traumatic Stress Disorder in Military Veterans. A Case Series.
44. Defining the Rhythmogenic Elements of Mammalian Breathing.
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49. Effect of Modified Slow Breathing Exercise on Perceived Stress and Basal Cardiovascular Parameters.
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51. Effect of six months pranayama training on stress-induced salivary cortisol response among adolescents. Randomised controlled study.
52. Effect of unilateral forced nostril breathing on tonic accommodation and intraocular pressure.
53. Effects of Diaphragmatic Breathing on Health. A Narrative Review.
54. Effects of Exercise Training on Cardiopulmonary Function and Quality of Life in Elderly Patients with Pulmonary Fibrosis. A Meta-Analysis.
55. Effects of Slow Breathing on Blood Pressure and End Tidal Carbon Dioxide in Hypertension. Randomised Controlled Trial.
56. Effects of Varying Inhalation Duration and Respiratory Rate on Human Airway Flow.

57. Effects of yoga breathing practice on heart rate variability in healthy adolescents. A randomized controlled trial.
58. Efficacy of forced right nostril breathing and selected yogasanas on female obese college students.
59. Estimation of Motion and Respiratory Characteristics during the Meditation Practice Based on Video Analysis.
60. Harnessing the Four Elements for Mental Health.
61. Heart Rate and Breathing Are Not Always in Phase During Resonance Frequency Breathing.
62. Hemisphere specific EEG related to alternate nostril yoga breathing.
63. How Breath-Control Can Change Your Life. A Systematic Review on Psycho-Physiological Correlates of Slow Breathing.
64. How to breathe? Respiratory mechanics and breathing pattern.
65. Hypothesis Pulmonary Afferent Activity Patterns During Slow, Deep Breathing Contribute to the Neural Induction of Physiological Relaxation.
66. Immediate Effect of a Yoga Breathing Practice on Attention and Anxiety in Pre-Teen Children.
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68. Immediate effect of short duration of slow deep breathing on heart rate variability in healthy adults.
69. Immediate effect of slow pace unilateral left nostril breathing with internal breath retention on blood pressure and pulse rate among normal healthy adults.
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71. Inappropriate Timing of Swallow in the Respiratory Cycle Causes Breathing-Swallowing Discoordination.
72. Inclusion of a rest period in diaphragmatic breathing increases high frequency heart rate variability. Implications for behavioral therapy.
73. Influence of Body Position on Breathing and Its Implications for the Evaluation and Treatment of Speech and Voice Disorders.
74. Integrating Breathing Techniques Into Psychotherapy to Improve HRV. Which Approach Is Best?
75. Integrating Music in Breathing Training and Relaxation- II. Applications.
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77. Introducing Social Breathing. A Model of Engaging in Relational Systems.
78. Just Breathe. The Respiratory System.
79. Keeping the pace. The effect of slow-paced breathing on error monitoring.
80. Mindful breath awareness meditation facilitates efficiency gains in brain networks. A steady-state visually evoked potentials study.
81. Modulation of rhythmic movement. Control of coordination.
82. Motivational Non-directive Resonance Breathing as a Treatment for Chronic Widespread Pain.
83. Nasal Reflexes. Implications for Exercise, Breathing, and Sex.
84. Networks within networks. The neuronal control of breathing.
85. Neural processing of respiratory sensations when breathing becomes more difficult and unpleasant.
86. Neuroprotective effects of yoga practice. Age-, experience-, and frequency-dependent plasticity.
87. Peptides, Serotonin, and 9 Breathing. The Role of the Raphe in the Control of Respiration.
88. Periodic Variation in Inspiratory Volume Characterizes Speech as Well as Quiet Breathing.

89. Physical and neural entrainment to rhythm- human sensorimotor coordination across tasks and effector systems.
90. Prolonged Active Prone Positioning in Spontaneously Breathing Non-intubated Patients With COVID-19-Associated Hypoxemic Acute Respiratory Failure With PaO2/FiO2 >150.
91. Psychophysiological Effects of Breathing Instructions for Stress Management.
92. Psychophysiological responses to various slow, deep breathing techniques.
93. Recovery after aerobic exercise is manipulated by tempo change in a rhythmic sound pattern, as indicated by autonomic reaction on heart functioning.
94. Relationship between circadian rhythm and brain cognitive functions.
95. Respiratory rhythm generation and pattern formation. Oscillators and network mechanisms.
96. Respiratory Rhythm, Autonomic Modulation, and the Spectrum of Emotions. The Future of Emotion Recognition and Modulation.
97. Resting Parasympathetic Nervous System Activity is Associated with Greater Antiviral Gene Expression.
98. Rhythmic breathing. Immunological, biochemical, and physiological effects on health.
99. Right uninostril yoga breathing influences ipsilateral components of middle latency auditory evoked potentials.
100. Satisfaction with Online Versus In-Person Yoga During COVID-19.
101. Self-Regulation of Breathing as an Adjunctive Treatment of Insomnia.
102. Sensation of breathlessness and respiratory oxygen cost during cycle exercise with and without conscious entrainment of the breathing rhythm.
103. Short-Term Effects of a Respiratory Telerehabilitation Program in Confined COVID-19 Patients in the Acute Phase. A Pilot Study.
104. Slow yogic breathing through right and left nostril influences sympathovagal balance, heart rate variability, and cardiovascular risks in young adults.
105. Slow-Paced Breathing. Influence of Inhalation/Exhalation Ratio and of Respiratory Pauses on Cardiac Vagal Activity.
106. Spinal metaplasticity in respiratory motor control.
107. Sudarshan Kriya Yoga improves cardiac autonomic control in patients with anxiety-depression disorders.
108. Take a breath and take the turn- how breathing meets turns in spontaneous dialogue.
109. The “Abdominal Circulatory Pump”. An Auxiliary Heart during Exercise?
110. The conditional nature of the "Central Rhythm Generator" and the production of episodic breathing.
111. The diaphragm. More than an inspired design.
112. The Effect of Alternate Nostril Breathing Exercise on Regulation of Blood Pressure in Individuals with Hypertension.
113. The Effect of Diaphragmatic Breathing on Attention, Negative Affect and Stress in Healthy Adults.
114. The Effect of Initial High vs. Low FiO2 on Breathing Effort in Preterm Infants at Birth. A Randomized Controlled Trial.
115. The Effect of Mindfulness-Based Intervention on Brain-Derived Neurotrophic Factor (BDNF). A Systematic Review and Meta-Analysis of Controlled Trials.
116. The effect of unilateral forced nostril breathing on sleep in healthy right-handed men-a preliminary report.
117. The effect of yoga on respiratory functions, symptom control and life quality of asthma patients: A randomized controlled study
118. The entrainment of breathing frequency by exercise rhythm.
119. The fast exercise drive to breathe.
120. The Impact of Resonance Frequency Breathing on Measures of Heart Rate Variability, Blood Pressure, and Mood.

121. The Influence of Sudarshan Kriya Yoga on Sleep Quality in Indian Adults. An Open Trial Pilot Study.
122. The kinesthetic Buddha, human form and function. Part 1- Breathing Torso.
123. The kinesthetic Buddha, human form and function. Part 2- The preparation for lotus.
124. The Mediating Role of Non-reactivity to Mindfulness Training and Cognitive Flexibility. A Randomized Controlled Trial.
125. The MindfulBreather. Motion Guided Mindfulness.
126. The parafacial respiratory group and the control of active expiration.
127. The physiological effects of slow breathing in the healthy human.
128. The preparatory set. A novel approach to understanding stress, trauma, and the bodymind therapies.
129. The Respiratory Modulation of Memory.
130. The role of the central chemoreceptors. A modeling perspective.
131. Transformational Breath Work in Medical Illness. Clinical Application and Evidence of Immunoenhancement.
132. Understanding the Benefits of Standing and Sitting Baduanjin Based on Cardiopulmonary Exercise Testing. An Observational Study.
133. Understanding the Rhythm of Breathing. So Near, Yet So Far.
134. Unilateral nostril breathing influences lateralized cognitive performance.
135. Yoga breathing through a particular nostril is associated with contralateral event-related potential.
136. Yoga-Based Breathing Techniques for Health Care Workers During COVID-19 Pandemic. Interests, Feasibility, and Acceptance.
137. Yogic breathing when compared to attention control reduces the levels of pro-inflammatory biomarkers in saliva. A pilot randomized controlled trial.
138. Yogic practices on oxidative stress and of antioxidant level: a systematic review of randomized controlled trials.

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1. **Van Kerrebroeck B, Maes PJ. A Breathing Sonification System to Reduce Stress During the COVID-19 Pandemic. Front. Psychol. 2021;12:623110.**

doi:10.3389/fpsyg.2021.623110
https://www.frontiersin.org/articles/10.3389/fpsyg.2021.623110/full

Since sound and music are powerful forces and drivers of human behavior and physiology, we propose the use of sonification to activate healthy breathing patterns in participants to induce relaxation. Sonification is often used in the context of biofeedback as it can represent an informational, non-invasive and real-time stimulus to monitor, motivate or modify human behavior. The first goal of this study is the proposal and evaluation of a distance-based biofeedback system using a tempo- and phase-aligned sonification strategy to adapt breathing patterns and induce states of relaxation. A second goal is the evaluation of several sonification stimuli on 18 participants that were recruited online and of which we analyzed psychometric and behavioral data using, respectively questionnaires and respiration rate and ratio. Sonification stimuli consisted of filtered noise mimicking a breathing sound, nature environmental sounds and a musical phrase. Preliminary results indicated the nature stimulus as most pleasant and as leading to the most prominent decrease of respiration rate. The noise sonification had the most beneficial effect on respiration ratio. While further research is needed to generalize these findings, this study and its methodological underpinnings suggest the potential of the proposed biofeedback system to perform ecologically valid experiments at participants' homes during the COVID-19 pandemic.

Keywords: sonification, stress, synchronization, health and well-being, COVID-19.

2. **Nyer M et al. A randomized controlled dosing study of Iyengar yoga and coherent breathing for the treatment of major depressive disorder: Impact on suicidal ideation and safety findings. Complementary Therapies in Medicine 2018;37:136-142.**

https://doi.org/10.1016/j.ctim.2018.02.006
https://www.sciencedirect.com/science/article/abs/pii/S0965229917306283

Highlights

• The most common protocol-related adverse event was muscle soreness, which resolved over the course of the study.
• At screening, BDI-II suicidal ideation item without intent was endorsed by 9 participants; after study completion, 8 out of 9 reported resolution of suicidal ideation.
• This preliminary evidence suggests that yoga and coherent breathing may be safe and effective for the treatment of MDD and may reduce suicidal ideation**.**

Abstract

Background: Yoga interventions offer promise for the treatment of major depressive disorder (MDD), yet their safety and potential impact on suicidal ideation (SI) have not been well documented. This study evaluated the safety of a randomized controlled dose-finding trial of Iyengar yoga plus coherent breathing for individuals with MDD, as well as the potential effects of the intervention on SI without intent.

Methods: Participants with Beck Depression Inventory-II (BDI-II) scores ≥14 and a diagnosis of MDD (using DSM-IV criteria) were randomized to either a low dose group (LDG) or high dose group (HDG) and received a 12-week manualized intervention. The LDG included two 90-min yoga classes plus three 30-min homework sessions weekly. The HDG offered three 90-min classes plus four 30-min homework sessions weekly.

Results: Thirty-two individuals with MDD were randomized, of which 30 completed the protocol. At screening, SI without intent was endorsed on the BDI-II by 9 participants; after completing the intervention, 8 out of 9 reported resolution of SI. There were 17 adverse events possibly-related and 15 definitely-related to the intervention. The most common protocol-related adverse event was musculoskeletal pain, which resolved over the course of the study.

Conclusions: The Iyengar yoga plus coherent breathing intervention was associated with the resolution of SI in 8 out of 9 participants, with mild side effects that were primarily musculoskeletal in nature. This preliminary evidence suggests that this intervention may reduce SI without intent and be safe for use in those with MDD.

Keywords: Yoga, Depression, Suicide, Safety, Iyengar, Breathing, Randomized, Major depressive disorder (MDD).

3. **Ghati N et al. A randomized trial of the immediate effect of Bee-Humming Breathing exercise on blood pressure and heart rate variability in patients with essential hypertension. Explore 2021;17:312-319.**

https://doi.org/10.1016/j.explore.2020.03.009
https://www.sciencedirect.com/science/article/abs/pii/S1550830720301166

Highlights

• Bee-Humming breathing (BHB) is a yogic practice for lifestyle modification.
• BHB exercise significantly augments parasympathetic tone.
• Short BHB session does not decrease blood pressure in hypertensive patients.
• Effect of long term BHB exercise need to be assessed in future studies.

Abstract

Objectives: Bee-Humming Breathing (BHB) exercise is a simple yogic practice recommended for its favorable effect on cardiac physiology, including blood pressure (BP) and autonomic nervous system. However, strong evidence supporting its effectiveness is lacking. The present study was designed to evaluate the immediate effect of BHB exercise on blood pressure parameters and heart rate variability (HRV) in patients with essential hypertension.

Study methods: We conducted a randomized control trial including 70 patients with essential hypertension, randomly allocated to perform either BHB exercise (n=35) or placebo slow breathing exercise (n = 35) for 5-minutes duration. Blood pressure and HRV were measured before, during, and after the practice.
Results: There was no significant decrease in systolic [effect size (95% CI): 2.22 (-13.20, 17.64); p 0.77], diastolic [4.54 (-17.40, 26.48); p 0.68] and mean blood pressures [1.37 (-8.78, 11.52); p 0.78] after BHB exercise in comparison to the control group in our study. The HRV analysis showed a significant increase in the HF power [6.8 (1.47, 12.12); p 0.01], and decrease in the LF power [−26.47 (−34.25, −18.68); p < 0.01] during the recovery phase of the 5-minute BHB exercise in comparison to the control group.
Conclusions: This is the first randomized controlled trial to show that though a single short session of BHB exercise in hypertensive patients does not significantly reduce BP, it significantly augments the parasympathetic tone as indicated by a significant improvement in HRV parameters.
Clinical trial registration number CTRI/2018/08/015215
Keywords: Bee-Humming Breathing Exercise, Bhramari Pranayama, Hypertension, Blood pressure, Heart rate variability, Autonomic nervous system.

4. **da Fonsêca JDM, Resqueti VR, Benício K, Fregonezi G, Aliverti A. Acute Effects of Inspiratory Loads and Interfaces on Breathing Pattern and Activity of Respiratory Muscles in Healthy Subjects. Front. Physiol. 2019;10:993.**

doi: 10.3389/fphys.2019.00993
https://www.frontiersin.org/articles/10.3389/fphys.2019.00993/full
Abstract
Objectives: The aim of this study was to evaluate the acute effects of different inspiratory loads and different interfaces on the breathing pattern and activity of the respiratory muscles.
Methods: Twenty healthy adults were recruited and assigned to two groups (20 and 40% of the Maximal Inspiratory Pressure) by way of randomized crossover allocation.
Subjects were evaluated during quiet breathing, breathing against inspiratory load, and recovery. The measurements were repeated using two different interfaces (nasal and oral). Chest wall volumes and respiratory muscle activity were assessed with optoelectronic plethysmography and surface electromyography, respectively.
Results: During the application of inspiratory load, significant changes were observed in the respiratory rate ($p < 0.04$), inspiratory time ($p < 0.02$), minute ventilation ($p < 0.04$), tidal volume ($p < 0.01$), end-inspiratory volume ($p < 0.04$), end-expiratory volume ($p < 0.03$), and in the activity of the scalene, sternocleiomastoid, and parasternal portion of the intercostal muscles (RMS values, $p < 0.01$) when compared to quiet breathing, regardless of the load level or the interface applied. Inspiratory load application yielded significant differences between using nasal and oral interfaces with an increase in the tidal volume ($p < 0.01$), end-inspiratory volume ($p < 0.01$), and electrical activity of the scalene and sternocleiomastoid muscles ($p < 0.01$) seen with using the nasal interface.
Conclusion: The addition of an inspiratory load has a significant effect on the breathing pattern and respiratory muscle electrical activity, and the effects are greater when the nasal interface is applied.
Keywords: respiratory muscles, healthy subjects, electromyography, plethysmography, physiology.

5. **Saoji AA et al. Additional Practice of Yoga Breathing With Intermittent Breath Holding Enhances Psychological Functions in Yoga Practitioners. A Randomized Controlled Trial. Explore 2018;14:379-384.**

https://doi.org/10.1016/j.explore.2018.02.005
https://www.sciencedirect.com/science/article/abs/pii/S1550830718300065
Abstract
Background and objective: The practice of yoga is associated with enhanced psychological wellbeing. The current study assessed the correlation between the duration of yoga practice with state mindfulness, mind-wandering and state anxiety. Also, we examined if an additional 20 min of yoga

breathing with intermittent breath holding (experimental group) for 8 weeks would affect these psychological variables more than regular yoga practice (control group) alone.
Methods: One hundred sixteen subjects were randomly assigned to experimental (n = 60) and control (n = 56) groups. State mindfulness attention awareness scale (SMAAS), Mind-Wandering Questionnaire (MWQ) and State anxiety inventory were administered at baseline and at the end of 8 weeks.
Results: Baseline assessment revealed a positive correlation between duration of yoga practice with SMAAS scores and negative correlation with MWQ and state anxiety scores. At the end of 8 weeks, both groups demonstrated enhanced psychological functions, but the experimental group receiving additional yoga breathing performed better than the group practicing yoga alone.
Conclusion: An additional practice of yoga breathing with intermittent breath holding was found to enhance the psychological functions in young adult yoga practitioners.
Keywords: Mindfulness, Mind-Wandering, Anxiety, Pranayama, Psychological well being, Kumbhaka.

6. **Serna LY, Mañanas MA, Hernández AM, Rabinovich RA. An Improved Dynamic Model for the Respiratory Response to Exercise. Front. Physiol. 2018;9:69.**

doi:10.3389/fphys.2018.00069
https://www.frontiersin.org/articles/10.3389/fphys.2018.00069/full
Abstract
Respiratory system modeling has been extensively studied in steady-state conditions to simulate sleep disorders, to predict its behavior under ventilatory diseases or stimuli and to simulate its interaction with mechanical ventilation. Nevertheless, the studies focused on the instantaneous response are limited, which restricts its application in clinical practice. The aim of this study is double: firstly, to analyze both dynamic and static responses of two known respiratory models under exercise stimuli by using an incremental exercise stimulus sequence (to analyze the model responses when step inputs are applied) and experimental data (to assess prediction capability of each model).
Secondly, to propose changes in the models' structures to improve their transient and stationary responses. The versatility of the resulting model vs. the other two is shown according to the ability to simulate ventilatory stimuli, like exercise, with a proper regulation of the arterial blood gases, suitable constant times and a better adjustment to experimental data. The proposed model adjusts the breathing pattern every respiratory cycle using an optimization criterion based on minimization of work of breathing through regulation of respiratory frequency.
Keywords: respiratory system, dynamic modeling, exercise simulation, work of breathing, respiratory control, computational modeling.

7. **Tobe M, Saito S. Analogy between classical Yoga/Zen breathing and modern clinical respiratory therapy. Journal of Anesthesia 2020;34:944-949.**

https://doi.org/10.1007/s00540-020-02840-5
https://link.springer.com/article/10.1007/s00540-020-02840-5
Abstract
Anesthesiologists and intensivists are modern-day professionals who provide appropriate respiratory care, vital for patient survival. Recently, anesthesiologists have increasingly focused their attention on the type of spontaneous breathing made by non-intubated patients with pulmonary disease cared for in an intensive care unit, and also patients with chronic pain receiving cognitive behavioral therapy. Prior to our modern understanding of respiratory physiology, Zen meditators recognized that breathing has a significant impact on a person's mental state and general physical well-being. Examples of this knowledge regarding respiration include the beneficial effects of deep inhalation and slow exhalation on anxiety and general wellness.
The classical literature has noted many suggestions for breathing and its psycho-physical effects. In the present review, we examine the effect of classical breathing methods and find an analogy between typical Yoga/Zen breathing and modern clinical respiratory therapy. Evidence is increasing about historical breathing and related meditation techniques that may be effective in modern clinical

practice, especially in the field of anesthesiology, such as in improving respiratory function and reducing chronic pain. Clarification of the detailed mechanisms involved is anticipated.
Keywords: Zen, Spontaneous breathing, Respiratory care.

8. **Bernasconi P, Kohl J. Analysis of co-ordination between breathing and exercise rhythms in man. Journal of Physiology 1993;471:693-706.**

doi:10.1113/jphysiol.1993.sp019923
https://physoc.onlinelibrary.wiley.com/doi/abs/10.1113/jphysiol.1993.sp019923
Abstract
The purpose of the present study was to analyse the incidence and type of coordination between breathing rhythm and leg movements during running and to assess the effect of co-ordination on the running efficiency, as well as to compare the results with those found during cycling.
The experiments were carried out on thirty-four untrained volunteers exercising at two work loads (60 and 80% of subject's physical work capacity 170) on a treadmill. In addition nineteen of the subjects exercised at the same two work loads on a bicycle ergometer. The subjects were running at both work loads in three different modes in randomized order: with normal arm movements, without arm movements and with breathing paced by an acoustic signal which was triggered by the leg movement.
Respiratory variables, oxygen uptake and leg movements were continuously recorded and evaluated on-line. The degree of co-ordination was expressed as a percentage of inspirations and/or expirations starting in the same phase of the step or pedalling cycle.
The average degree of co-ordination was higher during running (up to 40%) than during cycling (about 20%) during both work loads. The difference in the degree of co-ordination between running and cycling is probably not due to the lack of arm movements during cycling since the degree of co-ordination during running with and without arm movements was the same.
The degree of co-ordination during running increased slightly but not significantly with increasing work load and could be increased significantly by paced breathing.
The co-ordination between breathing and running rhythms occurred in three different patterns: (a) breathing was co-ordinated all the time with the same phase of step, (b) co-ordination switched suddenly from one phase of step to another and (c) co-ordination ensued alternatively once on the right and once on the left leg movement. During cycling the pattern described in (a) occurred almost exclusively.
During running with a high degree of co-ordination, oxygen uptake for a given work load was slightly but significantly lower than during running with weak co-ordination.

9. **Bordoni B, Zanier E. Anatomic connections of the diaphragm: influence of respiration on the body system. Journal of Multidisciplinary Healthcare 2013;6:281-291.**

http://dx.doi.org/10.2147/JMDH.S45443
https://www.dovepress.com/anatomic-connections-of-the-diaphragm-influence-of-respiration-on-the--peer-reviewed-fulltext-article-JMDH
Abstract
The article explains the scientific reasons for the diaphragm muscle being an important crossroads for information involving the entire body. The diaphragm muscle extends from the trigeminal system to the pelvic floor, passing from the thoracic diaphragm to the floor of the mouth. Like many structures in the human body, the diaphragm muscle has more than one function, and has links throughout the body, and provides the network necessary for breathing. To assess and treat this muscle effectively, it is necessary to be aware of its anatomic, fascial, and neurologic complexity in the control of breathing. The patient is never a symptom localized, but a system that adapts to a corporeal dysfunction.
Keywords: diaphragm, fascia, phrenic nerve, vagus nerve, pelvis.

10. **Araújo BCL, de Magalhães Simões S, de Gois-Santos V.T. et al. Association Between Mouth Breathing and Asthma. A Systematic Review and Meta-analysis. Current Allergy and Asthma Reports 2020;20:24.**

https://doi.org/10.1007/s11882-020-00921-9
https://link.springer.com/article/10.1007/s11882-020-00921-9
Abstract
Purpose of Review: This systematic review and meta-analysis evaluated the association between asthma and mouth breathing. We performed a systematic search in the PubMed, SCOPUS, Lilacs, Web of Science, Google Scholar and OpenThesis databases.
Recent Findings: Asthma is defined as a heterogeneous disease characterized by variable symptoms of wheezing, shortness of breath, chest oppression and/or cough, and limitation of expiratory airflow. Although several studies have examined the association between asthma and mouth breathing, there are no systematic reviews or meta-analyses that synthesize the available bodies of evidence.
Summary: We used the odds ratio as a measure of the association between asthma and mouth breathing. Summary estimates were calculated using random-effects models, and the risk of bias was estimated using the Newcastle-Ottawa Scale for case-control studies and the National Institutes of Health tool for cross-sectional studies. Nine studies were included in the present systematic review. Data from 12,147 subjects were analyzed, of which 2083 were children and adolescents and 10,064 were adults. We found an association between mouth breathing and asthma in children and adolescents (OR 2.46, 95% CI 1.78–3.39) and in adults (OR 4.60, 95%CI 1.49–14.20). However, limitations were found in the methodological description of the included studies, as well as high heterogeneity among studies evaluating adult populations. This meta-analysis showed an association between mouth breathing and asthma in children, adolescents and adults, but the results should be interpreted with caution. Further studies with standardized criteria for the investigation of mouth breathing are needed.
Keywords: Asthma, Mouth breathing, Child, Adolescent, Adult.

11. **Gerritsen RJS, Band GPH. Breath of Life: The Respiratory Vagal Stimulation Model of Contemplative Activity.**

doi:10.3389/fnhum.2018.00397
https://www.frontiersin.org/articles/10.3389/fnhum.2018.00397/full
Abstract
Contemplative practices, such as meditation and yoga, are increasingly popular among the general public and as topics of research. Beneficial effects associated with these practices have been found on physical health, mental health and cognitive performance. However, studies and theories that clarify the underlying mechanisms are lacking or scarce. This theoretical review aims to address and compensate this scarcity. We will show that various contemplative activities have in common that breathing is regulated or attentively guided. This respiratory discipline in turn could parsimoniously explain the physical and mental benefits of contemplative activities through changes in autonomic balance. We propose a neurophysiological model that explains how these specific respiration styles could operate, by phasically and tonically stimulating the vagal nerve: respiratory vagal nerve stimulation (rVNS). The vagal nerve, as a proponent of the parasympathetic nervous system (PNS), is the prime candidate in explaining the effects of contemplative practices on health, mental health and cognition. We will discuss implications and limitations of our model.
Keywords: meditation, mind-body exercises, mindfulness, respiration, vagus nerve, heart rate variability, cognition, stress.

12. **Gerbarg PL et al. Breath Practices for Survivor and Caregiver Stress, Depression, and Post-traumatic Stress Disorder: Connection, Co-regulation, Compassion. OBM Integrative and Complementary Medicine 2019;4:3.**

doi:10.21926/obm.icm.1903045
http://www.lidsen.com/journals/icm/icm-04-03-045
Abstract
Does compassion itself benefit the healing process or does the activation of neurophysiological processes, from which the experience of compassion arises, trigger a cascade of physical and psychological changes that support health and well-being? Exploration of the neurological substrates

of compassion reveals multiple healing pathways that can be activated by mind-body practices. Furthermore, these pathways affect physical health, emotion regulation, and how we perceive and relate to others.
Physiological states affect the capacity for empathy, compassion and understanding. A state of calm alertness based on sympatho-vagal balance may support such high-level prosocial functions. Evidence suggests that polyvagal-informed mind-body practices, particularly Voluntarily Regulated Breathing Practices (VRBPs), efficiently induce such physiological states and that these same states can reduce inflammation and oxidative stress, while improving cardiovascular function, respiratory efficiency, and physical health.
Mind-body practices, such as Coherent or Resonant Breathing can balance, strengthen, and increase the adaptive flexibility of stress response systems, potentially counteracting the detrimental effects of excess stress, neglect, and trauma on emotion regulation, physical health, and the ability to experience love and compassion. Research is needed to support integration of mind-body practices into healthcare systems. The methods being used to study mind-body techniques may be further refined by considering the target symptoms, population being studied, specific parameters of each practice, and methods of teaching subjects.
The current state of global health calls for treatments that can be delivered to large populations by small numbers of healthcare providers under conditions where resources are limited. Slow gentle Coherent or Resonant Breathing and related mind-body practices are low cost, low risk, easily taught, rapidly effective, scalable, non-stigmatizing, and sustainable. At the convergence of neurophysiological research with contemplative and other mind-body practices, we marvel at the possibilities for relieving emotional and physical suffering as well as improving how we relate to one another.
Keywords: Paced breathing, polyvagal, heart rate variability, compassion, caregiver stress, trauma, mind-body, public health, global health, mass disasters.

13. **Niu Y, Wan C, Zhou B, Zhang J, Ma H, Bo Y, Zhang Y, Liu H. Breath Qigong Improves Recognition in Seniors With Vascular Cognitive Impairment. Altern Ther Health Med. 2018;25(1):20-26.**

PMID: 30982783
https://pubmed.ncbi.nlm.nih.gov/30982783/
Abstract
Context: Vascular cognitive impairment (VCI) or vascular dementia is widely considered to be the second-most-common cause of dementia after Alzheimer's disease, accounting for 20% of cases. Little is known about the effectiveness of breath qigong for seniors suffering from VCI or dementia.
Objectives: For seniors with VCI, the study aimed to compare the benefits of qigong practice, cognitive training, and qigong practice + cognitive training in improving cognitive function, memory, executive function, and daily problem-solving ability.
Design: The study was a randomized, controlled pilot study that used a prospective design with repeated measures.
Setting: The study took place at the Tianjin Medical University General Hospital (Tianjin, China).
Participants: Participants were 93 patients with VCI at a clinic at the hospital.
Intervention: The participants were randomly assigned to 1 of 3 groups: (1) qigong practice, an intervention group; (2) cognitive training, a positive control group; or (3) a combination of qigong practice and cognitive training, an intervention group. Participants received the treatments for 3 mo.
Outcome measures: All outcome measures were undertaken at baseline and postintervention. The measures included (1) the Montreal cognitive assessment, (2) the Loewenstein occupational therapy cognitive assessment, and (3) the Barthel activities of daily living index.
Results: All 3 groups showed significant improvements in general cognitive function, memory, executive function, and daily problem-solving ability ($P < .05$).
Conclusion: Qigong practice is an easy and convenient exercise performed at no cost and has the potential to improve the cognitive functions of older adults with mild VCI.

14. **Carter KS, Carter R. Breath-based meditation: A mechanism to restore the physiological and cognitive reserves for optimal human performance. World J Clin Cases 2016;4(4):99-102.**
http://dx.doi.org/10.12998/wjcc.v4.i4.99
http://www.wjgnet.com/2307-8960/full/v4/i4/99.htm
Abstract
Stress can be associated with many physiological changes resulting in significant decrements in human performance. Due to growing interests in alternative and complementary medicine by Westerners, many of the traditions and holistic yogic breathing practices today are being utilized as a measure for healthier lifestyles. These state-of-the-art practices can have a significant impact on common mental health conditions such as depression and generalized anxiety disorder. However, the potential of yogic breathing on optimizing human performance and overall well-being is not well known. Breathing techniques such as alternate nostril, Sudarshan Kriya and bhastrika utilizes rhythmic breathing to guide practitioners into a deep meditative state of relaxation and promote self-awareness. Furthermore, yogic breathing is physiologically stimulating and can be described as a natural "technological" solution to optimize human performance which can be categorized into: (1) cognitive function (i.e. mind, vigilance); and (2) physical performance (i.e. cardiorespiratory, metabolism, exercise, whole body). Based on previous studies, we postulate that daily practice of breathing meditation techniques play a significant role in preserving the compensatory mechanisms available to sustain physiological function. This preservation of physiological function may help to offset the time associated with reaching a threshold for clinical expression of chronic state (i.e. hypertension, depression, dementia) or acute state (i.e. massive hemorrhage, panic attic) of medical conditions. However, additional rigorous biomedical research is needed to evaluate the physiological mechanisms of various forms of meditation (i.e. breath-based, mantra, mindfulness) on human performance. These efforts will help to define how compensatory reserve mechanisms of cardiovascular and immune systems are modulated by breath-based meditation. While it has been suggested that breath-based meditation is easier for beginning practitioners when compared to other forms of meditation more research is needed to elucidate these observations. A breath-based meditation sequence such as Sudarshan Kriya has the potential to help develop an individual's self-awareness and support better integration of the brain (i.e. mind) with other organ systems (i.e. body) for enhanced human performance.
Keywords: Meditation, Breathing technique, Cognitive reserve, Neurophysiology, Stress, Human performance, Emotional regulation.

15. **Gilbert C. Breathing and the cardiovascular system. Journal of Bodywork and Movement Therapies 1999;3(4):215-224.**
https://doi.org/10.1016/S1360-8592(99)80006-0
https://www.sciencedirect.com/science/article/abs/pii/S1360859299800060
Abstract
The close coupling between the systems of breathing and circulation provide potential hazards to physiological function because breathing is subject to conscious control. Emotional input to the respiratory system is often at odds with degree of muscle activity, thereby disrupting the matching of breathing to actual metabolic needs. Hyperventilation is the most common example. Research on the consequences of this mismatch are described in connection with occurrence of coronary vasospasms and angina, effort syndrome, respiratory sinus arrhythmia, cardiac rehabilitation and functional cardiac symptoms. Principles and techniques for training relaxation through breathing awareness and self-regulation are described.

16. **Prasad S, Kumar P, Chen R. Breathing and the Nervous System. Chapter One 3-19. Aminoff's Neurology and General Medicine, Sixth Edition 2021.**
Abstract
Respiration involves pulmonary ventilation, gaseous exchange between lung alveoli and blood, and transport of oxygen and carbon dioxide between the blood, tissues, and interstitial fluids. The nervous

system plays a pivotal role in controlling pulmonary ventilation as it exerts both automatic and voluntary control over breathing. The anatomic pathways involve the cerebral hemispheres, pons, medulla, spinal cord, anterior horn cells, nerves, and neuromuscular junctions, as well as peripheral chemoreceptors and lung mechanoreceptors and the respiratory muscles themselves. Several central and peripheral neurologic disorders can affect respiration adversely, and hypoxia and hypercapnia resulting from respiratory dysfunction may affect the nervous system and produce neurologic complications.

17. **Mortola JP. Breathing around the clock: an overview of the circadian pattern of respiration. Eur J Appl Physiol 2004;91:119-129.**

doi:10.1007/s00421-003-0978-0
https://link.springer.com/article/10.1007/s00421-003-0978-0
Abstract
This article reviews human and animal studies about the circadian patterns of physiological variables involved with the respiratory function. Some measures reflecting the mechanical properties of the lungs, such as functional residual capacity, forced expiratory volumes and airway resistance, change periodically with the time of the day. Also resting pulmonary ventilation (V_E), tidal volume, and breathing rate follow circadian patterns.
In humans, these patterns occur independently of the daily changes in activity, whereas, to some extent, they are linked to changes in the state of arousal. Differently, in some rodents, the circadian oscillations of the breathing pattern occur independently of the daily rhythms of either activity or state of arousal. Recent measurements of the breathing pattern for unlimited periods of time in undisturbed animals have indicated that the circadian changes occur in close temporal phase with those of oxygen consumption, carbon dioxide production, and body temperature. However, none of these variables can fully explain the circadian pattern of breathing, the origin of which remains unclear. Both in humans and in rats the V_E responses to hypercapnia or hypoxia differ at various times of the day. In rats, thedaily differences in V_E responses are buffered by changes in metabolic rate, such that, unlike humans, the hyperventilation (defined as the increase in ventilation–metabolism ratio) remains constant throughout the 24 h. The presence of a biological clock is a major advantage in the adaptation to the environment, although it forces some variables to deviate periodically from their mean value. In humans, these deviations become apparent in conditions of hypoxia. Hence, a daily time-window exists in which the respiratory system is less capable of responding to challenges, a factor which may contribute to the findings that some cardio-respiratory symptoms and diseases peak at particular times of the day.

18. **Heck DH et al. Breathing as a Fundamental Rhythm of Brain Function. Frontiers in Neural Circuits 2017;10:115.**

doi:10.3389/fncir.2016.00115
https://www.frontiersin.org/articles/10.3389/fncir.2016.00115/full
Abstract
Ongoing fluctuations of neuronal activity have long been considered intrinsic noise that introduces unavoidable and unwanted variability into neuronal processing, which the brain eliminates by averaging across population activity (Georgopoulos et al., 1986; Lee et al., 1988; Shadlen and Newsome, 1994; Maynard et al., 1999). It is now understood, that the seemingly random fluctuations of cortical activity form highly structured patterns, including oscillations at various frequencies, that modulate evoked neuronal responses (Arieli et al., 1996; Poulet and Petersen, 2008; He, 2013) and affect sensory perception (Linkenkaer-Hansen et al., 2004; Boly et al., 2007; Sadaghiani et al., 2009; Vinnik et al., 2012; Palva et al., 2013). Ongoing cortical activity is driven by proprioceptive and interoceptive inputs. In addition, it is partially intrinsically generated in which case it may be related to mental processes (Fox and Raichle, 2007; Deco et al., 2011). Here we argue that respiration, via multiple sensory pathways, contributes a rhythmic component to the ongoing cortical activity. We suggest that this rhythmic activity modulates the temporal organization of cortical neurodynamics, thereby linking higher cortical functions to the process of breathing.

Keywords: mind-body, cortical oscillations, respiration, embodied cognition, phase transitions, phase amplitude coupling, proprioception, graph theory.

19. **Lin IM, Tai LM, Fan SY. Breathing at a rate of 5.5 breaths per minute with equal inhalation-to-exhalation ratio increases heart rate variability. International Journal of Psychophysiology 2014;91:206-211.**

http://dx.doi.org/10.1016/j.ijpsycho.2013.12.006
https://www.sciencedirect.com/science/article/abs/pii/S0167876013003346

Abstract
Objectives: Prior studies have found that a breathing pattern of 6 or 5.5 breaths per minute (bpm)was associated with greater heart rate variability (HRV) than that of spontaneous breathing rate.However, the effects of combining the breathing rate with the inhalation-to-exhalation ratio (I:E ratio) on HRV indices are inconsistent. This study aimed to examine the differences in HRV indices and subjective feelings of anxiety and relaxation among four different breathing patterns.
Methods: Forty-seven healthy college students were recruited for the study, and a Latin square experimental design with a counterbalance in random sequences was applied. Participants were instructed to breathe at two different breathing rates (6 and 5.5 breaths) and two different I:E ratios (5:5 and 4:6). The HRV indices as well as anxiety and relaxation levels were measured at baseline (spontaneous breathing) and for the four different breathing patterns.
Results: The results revealed that a pattern of 5.5 bpmwith an I:E ratio of 5:5 produced a higherNN interval standard deviation and higher low frequency power than the other breathing patterns. Moreover, the four different breathing patterns were associated with significantly increased feeling of relaxation compared with baseline.
Conclusion: The study confirmed that a breathing pattern of 5.5 bpmwith an I:E ratio of 5:5 achieved greater HRV than the other breathing patterns. This finding can be applied to HRV biofeedback or breathing training in the future.
Keywords: Breathing pattern, Inhalation-to-exhalation ratio, Heart rate variability.

20. **Gregoski MJ et al. Breathing Awareness Meditation and LifeSkills Training Programs Influence Upon Ambulatory Blood Pressure and Sodium Excretion Among African American Adolescents. Journal of Adolescent Health 2011;48:59-64.**

doi:10.1016/j.jadohealth.2010.05.019
https://www.jahonline.org/article/S1054-139X(10)00261-2/fulltext

Abstract
Purpose: To evaluate the effect of breathing awareness meditation (BAM), Botvin LifeSkills Training (LST), and health education control (HEC) on ambulatory blood pressure and sodium excretion in African American adolescents.
Methods: Following 3 consecutive days of systolic blood pressure (SBP) screenings, 166 eligible participants (i.e., SBP >50th–95th percentile) were randomized by school to either BAM (n = 53), LST (n = 69), or HEC (n = 44). In-school intervention sessions were administered for 3 months by health education teachers. Before and after the intervention, overnight urine samples and 24-hour ambulatory SBP, diastolic blood pressure, and heart rate were obtained.
Results: Significant group differences were found for changes in overnight SBP and SBP, diastolic blood pressure, and heart rate over the 24-hour period and during school hours. The BAM treatment exhibited the greatest overall decreases on these measures (Bonferroni adjusted, *p*s < .05). For example, for school-time SBP, BAM showed a change of –3.7 mmHg compared with no change for LST and a change of −.1 mmHg for HEC. There was a nonsignificant trend for overnight urinary sodium excretion ($p = .07$), with the BAM group displaying a reduction of −.92 ± 1.1 mEq/hr compared with increases of .89 ± 1.2 mEq/hr for LST and .58 ± .9 mEq/hr for HEC group.
Conclusion: BAMappears to improve hemodynamic function andmayaffect sodium handling among African American adolescents who are at increased risk for development of cardiovascular disease.
Keywords: Adolescents, Ambulatory blood pressure, Breathing awareness meditation, Botvin LifeSkills Training, Clinical trial, Sodium excretion.

21. **Kwon JW et al. Breathing Exercise Called the Maximal Abdominal Contraction Maneuver. Medicina 2021;57(2):129.**

https://doi.org/10.3390/medicina57020129
https://www.mdpi.com/1648-9144/57/2/129
Abstract

Background and objectives: The maximal abdominal contraction maneuver (MACM) was designed as an effective and efficient breathing exercise to increase the stability of the spinal joint.
However, it has not been determined whether MACM is more effective and efficient than the maximal expiration method. Thus, the present study was undertaken to investigate whole abdominal muscle thickness changes after MACM.
Materials and Methods: Thirty healthy subjects (17 males and 13 females) participated in this study. An experimental comparison between MACM and the maximal expiration task was conducted by measuring the change of abdominal muscle thickness such as the transverse abdominis (TrA), internal oblique (IO), external oblique (EO) and rectus abdominis (RA) using ultrasound images.
Results: The results indicated that MACM resulted in significantly greater muscle thickness increases of the TrA and RA than the maximal expiration exercise ($p < 0.05$).
Conclusion: MACM provided better exercise than the maximal expiration exercise in terms of increasing spine stability, at least from a co-contraction perspective.
Keywords: breathing exercise, abdominal muscle, core muscle, co-contraction, ultrasound images.
22. **Santino TA, Chaves GSS, Freitas DA, Fregonezi GAF, Mendonça KMPP. Breathing exercises for adults with asthma. Cochrane Database of Systematic Reviews 2020, Issue 3.**

https://doi.org/10.1002/14651858.CD001277
https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD001277.pub4/full#CD001277-abs-0001
Abstract

Breathing exercises have been widely used worldwide as a non-pharmacological therapy to treat people with asthma. Breathing exercises aim to control the symptoms of asthma and can be performed as the Papworth Method, the Buteyko breathing technique, yogic breathing, deep diaphragmatic breathing or any other similar intervention that manipulates the breathing pattern. The training of breathing usually focuses on tidal and minute volume and encourages relaxation, exercise at home, the modification of breathing pattern, nasal breathing, holding of breath, lower rib cage and abdominal breathing.
Objectives: To evaluate the evidence for the efficacy of breathing exercises in the management of people with asthma.
Search methods: To identify relevant studies we searched The Cochrane Library, MEDLINE, Embase, PsycINFO, CINAHL and AMED and performed handsearching of respiratory journals and meeting abstracts. We also consulted trials registers and reference lists of included articles.
The most recent literature search was on 4 April 2019.
Selection criteria: We included randomised controlled trials of breathing exercises in adults with asthma compared with a control group receiving asthma education or, alternatively, with no active control group.
Data collection and analysis: Two review authors independently assessed study quality and extracted data. We used Review Manager 5 software for data analysis based on the random-effects model. We expressed continuous outcomes as mean differences (MDs) with confidence intervals (CIs) of 95%. We assessed heterogeneity by inspecting the forest plots. We applied the Chi^2 test, with a P value of 0.10 indicating statistical significance, and the I^2 statistic, with a value greater than 50% representing a substantial level of heterogeneity. The primary outcome was quality of life.
Main results: We included nine new studies (1910 participants) in this update, resulting in a total of 22 studies involving 2880 participants in the review. Fourteen studies used Yoga as the intervention, four studies involved breathing retraining, one the Buteyko method, one the Buteyko method and

pranayama, one the Papworth method and one deep diaphragmatic breathing. The studies were different from one another in terms of type of breathing exercise performed, number of participants enrolled, number of sessions completed, period of follow-up, outcomes reported and statistical presentation of data. Asthma severity in participants from the included studies ranged from mild to moderate, and the samples consisted solely of outpatients. Twenty studies compared breathing exercise with inactive control, and two with asthma education control groups. Meta-analysis was possible for the primary outcome quality of life and the secondary outcomes asthma symptoms, hyperventilation symptoms, and some lung function variables. Assessment of risk of bias was impaired by incomplete reporting of methodological aspects of most of the included studies. We did not include adverse effects as an outcome in the review.

Breathing exercises versus inactive control

For quality of life, measured by the Asthma Quality of Life Questionnaire (AQLQ), meta-analysis showed improvement favouring the breathing exercises group at three months (MD 0.42, 95% CI 0.17 to 0.68; 4 studies, 974 participants; moderate-certainty evidence), and at six months the OR was 1.34 for the proportion of people with at least 0.5 unit improvement in AQLQ, (95% CI 0.97 to 1.86; 1 study, 655 participants). For asthma symptoms, measured by the Asthma Control Questionnaire (ACQ), meta-analysis at up to three months was inconclusive, MD of -0.15 units (95% CI −2.32 to 2.02; 1 study, 115 participants; low-certainty evidence), and was similar over six months (MD −0.08 units, 95% CI −0.22 to 0.07; 1 study, 449 participants). For hyperventilation symptoms, measured by the Nijmegen Questionnaire (from four to six months), meta-analysis showed less symptoms with breathing exercises (MD −3.22, 95% CI −6.31 to −0.13; 2 studies, 118 participants; moderate-certainty evidence), but this was not shown at six months (MD 0.63, 95% CI −0.90 to 2.17; 2 studies, 521 participants). Meta-analyses for forced expiratory volume in 1 second (FEV1) measured at up to three months was inconclusive, MD −0.10 L, (95% CI −0.32 to 0.12; 4 studies, 252 participants; very low-certainty evidence). However, for FEV_1 % of predicted, an improvement was observed in favour of the breathing exercise group (MD 6.88%, 95% CI 5.03 to 8.73; five studies, 618 participants).

Breathing exercises versus asthma education

For quality of life, one study measuring AQLQ was inconclusive up to three months (MD 0.04, 95% CI -0.26 to 0.34; 1 study, 183 participants). When assessed from four to six months, the results favoured breathing exercises (MD 0.38, 95% CI 0.08 to 0.68; 1 study, 183 participants). Hyperventilation symptoms measured by the Nijmegen Questionnaire were inconclusive up to three months (MD −1.24, 95% CI −3.23 to 0.75; 1 study, 183 participants), but favoured breathing exercises from four to six months (MD −3.16, 95% CI −5.35 to −0.97; 1 study, 183 participants).

Authors' conclusions

Breathing exercises may have some positive effects on quality of life, hyperventilation symptoms, and lung function. Due to some methodological differences among included studies and studies with poor methodology, the quality of evidence for the measured outcomes ranged from moderate to very low certainty according to GRADE criteria. In addition, further studies including full descriptions of treatment methods and outcome measurements are required.

23. Pearson MG. Breathing exercises for asthma: panacea or placebo? Thorax 2007;62:1033-1034. (Editorial)

doi: 10.1136/thx.2007.084707

https://thorax.bmj.com/content/62/12/1033

24. Thomas M, Bruton A. Breathing exercises for asthma. Breathe 2014;10:313-322.

doi:10.1183/20734735.008414

https://breathe.ersjournals.com/content/10/4/312

Abstract

Educational aims: To summarise the evidence of the role of breathing control approaches in the management of asthma.

To provide information on the content of evidence-based breathing exercises programmes

Summary: Asthma is a complex, multi-dimensional condition that affects patients in many ways. Having asthma is inherently stressful and psychological problems are common and associated with poor asthma outcomes. Although most patients in clinical trials can achieve high levels of control with optimised pharmacotherapy, in “real-life” practice, poor control is common, with over-reliance on rescue bronchodilator medication and ongoing symptoms and quality-of-life impairment. Many patients are interested in non-pharmacological treatments to improve asthma control, particularly breathing control exercises but, until recently, the evidence base has been inadequate. The place of breathing exercises has been controversial, partly because some proponents have made exaggerated, implausible claims of effectiveness. Recent evidence, however, has resulted in endorsement of breathing exercises as add-on treatment in asthma in systematic reviews and guidelines.
This review summarises the current evidence of effectiveness of breathing exercises programmes as an adjuvant treatment to pharmacological strategies for people with asthma. The types of breathing training programmes used and the content of effective programmes are discussed. We conclude that patients whose asthma continues to cause symptoms and quality-of-life impairment, despite adequate pharmacological treatment, or who have high bronchodilator use, should be offered access to an effective breathing training programme as a part of holistic, integrated asthma care.
Key points: Asthma is frequently poorly controlled despite effective modern medication; Psychological factors can be as important as physiological ones in affecting symptom perception and disease impact; Breathing exercises can improve patient-reported outcomes and psychological state; Breathing exercises should be offered to all asthma patients with symptoms or impaired quality of life despite standard treatment.

25. **Macêdo TMF, Freitas DA, Chaves GSS, Holloway EA, Mendonça KMPP. Breathing exercises for children with asthma. Cochrane Database of Systematic Reviews 2016, Issue 4.**

doi:10.1002/14651858.CD011017.pub2
https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD011017.pub2/epdf/full
Abstract
Background
Asthma is the most common chronic disease in childhood. Breathing exercise techniques have been widely used by researchers and professionals in the search for complementary therapies for the treatment of asthma.
Objectives: To assess the effects of breathing exercises in children with asthma.
Search methods: We searched for trials in the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, PsycINFO, CINAHL and AMED and handsearched respiratory journals and meeting abstracts. We also consulted trial registers and reference lists of included articles. The literature search was run up to September 2015.
Selection criteria: We included randomised controlled trials of breathing exercises alone versus control or breathing exercises as part of a more complex intervention versus control in children with asthma.
Data collection and analysis: Two review authors independently assessed trial quality and extracted data. The primary outcomes were quality of life, asthma symptoms and serious adverse events. The secondary outcomes were reduction in medication usage, number of acute exacerbations, physiological measures (lung function (especially low flow rates) and functional capacity), days off school and adverse events.
Main results: The review included three studies involving 112 participants. All the included studies performed the comparison breathing exercises as part of a more complex intervention versus control. There were no trials comparing breathing exercises alone with control. Asthma severity of participants from the included studies varied. The studies measured: quality of life, asthma symptoms, reduction in medication usage, number of acute exacerbations and lung function. Breathing exercise techniques used by the included studies consisted of lateral costal breathing, diaphragmatic breathing, inspiratory patterns and pursed lips. One study included in the review did not specify the type of

breathing exercise used. The control groups received different interventions: one received placebo treatment, one an educational programme and doctor appointments, and one was not described. There were no reported between-group comparisons for any of the primary outcomes. We judged the included studies as having an unclear risk of bias.
Authors' conclusions: We could draw no reliable conclusions concerning the use of breathing exercises for children with asthma in clinical practice. The breathing exercises were part of a more comprehensive package of care, and could not be assessed on their own. Moreover, there were methodological differences among the three small included studies and poor reporting of methodological aspects and results in most of the included studies.

26. **Tomas-Carus P et al. Breathing Exercises Must Be a Real and Effective Intervention to Consider in Women with Fibromyalgia: A Pilot Randomized Controlled Trial. The Journal of Alternative and Complementary Medicine 2018;8:825-832.**

doi:10.1089/acm.2017.0335
https://www.liebertpub.com/doi/abs/10.1089/acm.2017.0335
Abstract
Background/Objective: Respiratory problems can aggravate pain located in the coincident areas with tender points in the upper half of the body in patients with fibromyalgia (FM) and easily become fatigued, thus can lead to a decrease in the functionality of daily activities. The purpose of this study was to examine the effects of a breathing exercises program on pain thresholds tolerance on tender points and FM impact on daily life.
Methods/Design: Thirty-five women with FM (age 34–67 years) were randomly assigned to an exercise group (n = 18), performing breathing exercises (30 min/session, 7 times/week; for 12 weeks), or to a control group (n = 17). Pain thresholds tolerance on tender points were measured by the physician using digital pressure algometer and FM impact on daily life was evaluated with the Portuguese version of the Fibromyalgia Impact Questionnaire (FIQ).
Results: After 12 weeks of breathing exercises significant improvements were observed in the mean values of the treatment effects on pain thresholds tolerance on tender points and in the functional capacity to perform daily life, pain, and fatigue in favor of the exercise group. Gains in second rib, occiput, and supraspinatus pairs of the tender points predict improvements in the functional capacity, pain, and fatigue.
Conclusion: Our study demonstrated that breathing exercises produced relevant benefits on pain thresholds tolerance on tender points located in the upper half of the body, some of which predicted improvements in the impact of FM in the functional capacity to perform daily life, pain, and fatigue. These results provide further support of an idea that breathing exercises are a real and effective intervention to consider in women with FM.
Keywords: fibromyalgia, breathing exercises, pain thresholds tolerance, daily life, FIQ.

27. **Kobayashi-Suzuki E, Tachibana Y, Okuyama M, Igarashi T. Breathing Focused Mind-Body Approach for Treatment of Posttraumatic Stress Disorder among Children and Adolescents: A Systematic Review. Journal of Psychology & Psychotherapy 2014;4:3.**

http://dx.doi.org/10.4172/2161-0487.1000142
https://www.longdom.org/open-access/breathing-focused-mindbody-approach-for-treatment-of-posttraumatic-stress-disorder-among-children-and-adolescents-a-systematic-review-2161-0487.1000142.pdf
Abstract
Background: Numerous forms of breathing techniques have been frequently incorporated in treatment of Posttraumatic Stress Disorder (PTSD) for children and adolescents. Whereas major treatment approach such as Trauma-Focused Cognitive Behavioural Therapy (TF-CBT) has incorporated breathing techniques as an auxiliary function to teach relaxation skills, mind-body approach has utilized different kinds of breathing techniques as primary components of intervention. Mind-body approach has been used as an alternative to TF-CBT for both adults and children, and found to be effective in varying degree for adult PTSD. Most of the systematic review on child PTSD has been

conducted on TF-CBT and a systematic review on mind-body approach has been limited to adults PTSD. Hence we decided to conduct a systematic review of published articles on PTSD treatment using mind-body approach with breathing as a primary component for children and adolescents.
Methods: We searched PsychINFO, MEDLINE, Web of Science, and PubMed for eligible articles in addition to hand searching references of the related articles. Interventions that incorporate breathing techniques but do not identify such techniques as a primary component (e.g., TF-CBT) were excluded from the search.
Results: The review found only one Randomized Controlled Trial (RCT), two open trials, and one randomized comparative trial. No quantitative analysis was conducted due to insufficient numbers of studies and statistical heterogeneity. Hence data was synthesized qualitatively.
Conclusions: There is a relative lack of research in breathing techniques and mind-body approach on child and adolescent PTSD. Preliminary data suggest that mind-body approach may be effective for high school students traumatized by war and political conflict, and may be as effective as exposure treatment for children and adolescents traumatized by war and tsunami. Age is a potential factor impacting the efficacy of the approach but is yet to be researched further. Future research is necessary for more controlled trials and large-scale comparison trials, but mind-body approach can be a promising alternative to TF-CBT.

28. **Brown RP, Gerbarg PL, Muench F. Breathing Practices for Treatment of Psychiatric and Stress-Related Medical Conditions. Psychiatric Clinics of North America 2013;1,121-140.**

http://dx.doi.org/10.1016/j.psc.2013.01.001
https://www.sciencedirect.com/science/article/abs/pii/S0193953X13000026?via%3Dihub
Abstract
Neuroanatomic and brain imaging studies reveal breath-activated pathways to all major networks involved in emotion regulation, cognitive function, attention, perception, subjective awareness, and decision making. Specific breath practices have been shown to be beneficial in reducing symptoms of stress, anxiety, insomnia, posttraumatic stress disorder, obsessive-compulsive disorder, depression, attention deficit disorder, and schizophrenia. The risks of adverse reactions to breath practices can be minimized through patient assessment and by limiting the use of stimulating practices in vulnerable individuals. Technology-assisted breath retraining devices range from mobile phone pacing applications to physiologic biofeedback machines designed to foster therapeutic breath practices using audiovisual cues and/or physiologic feedback. Technology-assisted breath retraining offers alternative or adjunctive methods to clients who are interested in breathing practices. Ideally, initial technology-assisted breath retraining should be accompanied by in-person guided instruction and evaluation.
Keywords: Paced breathing, Pranayama, Resonance breathing, Coherent breathing, Yoga, Qigong, Anxiety, Depression.

29. **Gilbert C. Breathing. An essential component of bodywork. Journal of Bodywork and Movement Therapies 1998;2(2):64-65.**

doi:10.1016/s1360-8592(98)80025-9
https://www.bodyworkmovementtherapies.com/article/S1360-8592(98)80025-9/fulltext

30. **Feldman JL, Mitchell GS, Nattie EE. Breathing: Rhythmicity, Plasticity, Chemosensitivity. Annual Review of Neuroscience 2003;26:239-266.**

doi:10.1146/annurev.neuro.26.041002.131103
https://www.annualreviews.org/doi/10.1146/annurev.neuro.26.041002.131103
Abstract
Breathing is a vital behavior that is particularly amenable to experimental investigation. We review recent progress on three problems of broad interest.
(i) Where and how is respiratory rhythm generated? The preBotzinger Complex is a critical site, whereas pacemaker neurons may not be essential. The possibility that coupled oscillators are involved is considered. (ii) What are the mechanisms that underlie the plasticity necessary for adaptive changes

in breathing? Serotonin-dependent longterm facilitation following intermittent hypoxia is an important example of such plasticity, and a model that can account for this adaptive behavior is discussed. (iii) Where and how are the regulated variables CO2 and pH sensed? These sensors are essential if breathing is to be appropriate for metabolism. Neurons with appropriate chemosensitivity are spread throughout the brainstem; their individual properties and collective role are just beginning to be understood.
Keywords: preBotzinger, pacemaker, neurokinin, serotonin, raphe.

31. **Gilbert C. Breathing: the legacy of Wilhelm Reich. Journal of Bodywork and Movement Therapies 1999;3(2):97-106.**

https://doi.org/10.1016/S1360-8592(99)80029-1
https://www.bodyworkmovementtherapies.com/article/S1360-8592(99)80029-1/fulltext
Abstract
Wilhelm Reich, originally a protégé of Freud, developed his own style of therapy which focused as much on somatic as on verbal analysis. He developed the concept of 'character armour,' habitual patterns of muscle tension and constricted breathing which kept strong feelings from conscious attention by blocking both awareness and expression. His contributions to understanding the emotional inputs to bodily dysfunction, particularly the breathing and muscular systems, are valuable and have been incorporated into many different modern therapies. The methods of bioenergetics are summarized with regard to the use of breathing in therapy, including procedures for reducing emotional blocks by facilitating fuller breathing.

32. **Belli F, Felisatti A, Fischer MA. BreaThink. Breathing affects production and perception of quantities. Experimental Brain Research 2021.**

https://doi.org/10.1007/s00221-021-06147-z
https://link.springer.com/content/pdf/10.1007/s00221-021-06147-z.pdf
Abstract
Cognition is shaped by signals from outside and within the body. Following recent evidence of interoceptive signals modulating higher-level cognition, we examined whether breathing changes the production and perception of quantities. In Experiment 1, 22 adults verbally produced on average larger random numbers after inhaling than after exhaling. In Experiment 2, 24 further adults estimated the numerosity of dot patterns that were briefly shown after either inhaling or exhaling. Again, we obtained on average larger responses following inhalation than exhalation. These converging results extend models of situated cognition according to which higher-level cognition is sensitive to transient interoceptive states.
Keywords: Breathing, Embodied cognition, Interoception, Numerical cognition, Situated cognition.

33. **Himmat KV, Caldwell C. Breathwork in body psychotherapy: Clinical applications. Body, Movement and Dance in Psychotherapy, 2013;(8)4:216–228.**

http://dx.doi.org/10.1080/17432979.2013.828657
https://www.tandfonline.com/doi/abs/10.1080/17432979.2013.828657
Abstract
The use of conscious breathing practices for the purpose of physical, psychological, emotional and spiritual healing has a long and extremely varied history, yet little work has been done to bring these practices into a coherent and unified form that contributes to the field of body psychotherapy (BP). This article focuses on translating theoretical themes developed in a previous publication (Caldwell & Victoria, 2011. Body, Movement and Dance in Psychotherapy, 6(2),89–101) into practical applications in the BP profession. The authors propose six clinical themes for the use of breath in BP, a balanced breathing exercise, and four clinical models for integration into BP practice. Recommendations are made for future research and training in this crucial area of BP.
Keywords: breath, breathwork, body psychotherapy, conscious breathing, breath therapy.

34. **Himmat KV, Caldwell C. Breathwork in body psychotherapy: Towards a more unified theory and practice. Body, Movement and Dance in Psychotherapy 2011;(6)2:89-101.**

doi:10.1080/17432979.2011.574505

https://www.tandfonline.com/doi/abs/10.1080/17432979.2011.574505
Abstract
The use of conscious breathing practices for the purpose of physical, psychological, emotional, and spiritual healing has a long and extremely varied history, yet little work has been done to see if these practices can be brought into a coherent and unified form that contributes to the field of body psychotherapy. This article attempts to meta-analyse the literature and research on breathwork in psychotherapy, with an emphasis on body psychotherapy, and to find common themes so that a general theory of breathwork and guidelines for practice might be developed. This paper provides an overview of the physiology of breathing, a review of the literature on breathwork.
Keywords: breath, breathwork, body psychotherapy, conscious breathing, breathing therapy.

35. **Rain M, Subramaniam B, Avti P, Mahajan P, Anand A. Can Yogic Breathing Techniques Like Simha Kriya and Isha Kriya Regulate COVID-19-Related Stress? Front. Psychol. 2021;12:635816.**

doi:10.3389/fpsyg.2021.635816
https://www.frontiersin.org/articles/10.3389/fpsyg.2021.635816/full
The global impact of Coronavirus Disease 2019 (COVID-19) is tremendous on human life, not only affecting the physical and mental health of population but also impacting the economic system of countries and individual itself. The present situation demands prompt response toward COVID-19 by equipping the humans with strategies to overcome the infection and stress associated with it. These strategies must not only be limited to preventive and therapeutic measures, but also aim at improving immunity and mental health. This can be achieved by yogic breathing techniques. In this perspective, we emphasize the importance of yogic breathing, Simha Kriya and Isha kriya, the simple yet effective breathing techniques.
Keywords: COVID-19, Isha Kriya, novel coronavirus, Simha Kriya, yogic breathing, breathing techniques.

36. **Horton K-K et al. Central Respiration and Mechanical Ventilation in the Gating of Swallow With Breathing. Front. Physiol. 2018;9:785.**

doi:10.3389/fphys.2018.00785
https://www.frontiersin.org/articles/10.3389/fphys.2018.00785/full
Abstract
Swallow-breathing coordination safeguards the lower airways from tracheal aspiration of bolus material as it moves through the pharynx into the esophagus. Impaired movements of the shared muscles or structures of the aerodigestive tract, or disruptions in the interaction of brainstem swallow and respiratory central pattern generators (CPGs) result in dysphagia. To maximize lower airway protection these CPGs integrate respiratory rhythm generation signals and vagal afferent feedback to synchronize swallow with breathing. Despite extensive study, the roles of central respiratory activity and vagal feedback from the lungs as key elements for effective swallow breathing coordination remain unclear. The effect of altered timing of bronchopulmonary vagal afferent input on swallows triggered during electrical stimulation of the superior laryngeal nerves or by injection of water into the pharyngeal cavity was studied in decerebrate, paralyzed, and artificially ventilated cats. We observed two types of single swallows that produced distinct effects on central respiratory-rhythm across all conditions: post-inspiratory type swallows disrupted central-inspiratory activity without affecting expiration, whereas expiratory type swallows prolonged expiration without affecting central-inspiratory activity. Repetitive swallows observed during apnea reset the E2 phase of central respiration and produced facilitation of swallow motor output nerve burst durations. Moreover, swallow initiation was negatively modulated by vagal feedback and was reset by lung inflation. Collectively, these findings support a novel model of reciprocal inhibition between the swallow CPG and inspiratory or expiratory cells of the respiratory CPG where lung distension and phases of central respiratory activity represent a dual peripheral and central gating mechanism of swallow-breathing coordination.
Keywords: swallow, breathing, pulmonary afferents, central pattern generators, plasticity.

37. **Léonard A, Clément S, Kuo C-D, Manto M. Changes in Heart Rate Variability During Heartfulness Meditation: A Power Spectral Analysis Including the Residual Spectrum. Front. Cardiovasc. Med. 2019;6:62.**

doi:10.3389/fcvm.2019.00062

https://www.frontiersin.org/articles/10.3389/fcvm.2019.00062/full

Abstract

Background: Meditation refers to a group of practices commonly proposed to treat stress-related conditions and improve overall wellness. In particular, meditation might exert beneficial actions on heart rate variability (HRV) by acting on autonomic tone with an increase in the vagal activity. The effects of heartfulness meditation (HM) on HRV remain poorly defined.

Methods: We investigated the effects of HM on HRV in a group of 26 healthy subjects. Subjects were regularly practicing this form of meditation on a daily basis. We assessed the HRV and residual HRV (rHRV) at rest and during meditation. We also used as control a period of respiratory rhythm imposed by an auditory signal, with the imposed breathing rhythm being identical to the spontaneous rhythm recorded during meditation.

Results: During deep meditation period, the standard deviation of RR intervals (SDRR), coefficient of variation of RR intervals (CVRR), and total power (TP) were decreased while the low-frequency power (LFP), normalized LFP (nLFP), and normalized residual LFP (nrLFP) were increased as compared with those at rest, suggesting that the global vagal modulation was suppressed while the baroreflex was increased during deep medication.

At the end of meditation, the LFP, residual LFP (rLFP), nLFP, nrLFP, low-/high-frequency power ratio (LHR), and residual LHR (rLHR) were increased while the residual very low-frequency power (rVLFP), normalized high-frequency power (nHFP), and normalized residual HFP (nrHFP) were decreased, as compared with those during paced breathing, suggesting that the vagal modulation was decreased while the sympathetic modulation was increased by deep meditation. During paced breathing period, the SDRR, CVRR, TP, LFP, rLFP, nLFP, nrLFP, LHR, and rLHR were decreased while nHFP and nrHFP were increased as compared with at rest, suggesting that paced breathing could suppress the sympathetic modulation and enhance the vagal modulation.

Conclusion: HMcan induce a suppression of global vagalmodulation and increased the sympathetic modulation and baroreflex. In addition, paced breathing can suppress the sympathetic modulation and enhance the vagal modulation. Unlike studies using other types of meditation, we did not identify evidence of increased vagal tone during HM.

Keywords: meditation, heartfulness, heart rate variability, power spectrum, residual spectrum, vagal, sympathetic, paced breathing.

38. **Backon J, Matamoros N, Tieho U. Changes in intraocular pressure induced by differential forced unilateral nostril breathing, a technique that affects both brain hemisphericity and autonomic activity A pilot study. Graefe's Arch Clin Exp Ophthalmol 1989;227:575-577.**

https://doi.org/10.1007/BF02169455

https://link.springer.com/article/10.1007/BF02169455

Abstract

There is evidence of the central regulation of intraocular pressure, and it has been suggested that vagal tone might be elevated in glaucoma simplex. The nasal cycle, the simultaneous congestion-decongestion response in the nasal cavities, reflects the dynamic lateralization of the autonomic nervous system. Since this lateralization presents with sympathetic activity induced by left brain hemisphere stimulation and parasympathetic activity induced by right hemisphere stimulation, forced unilateral nostril breathing (FUNB) has recently been demonstrated to induce selective contralateral hemispheric stimulation as measured by relative increases in EEG amplitude in the contralateral hemisphere as well as alternating lateralization of plasma catecholamines.

Using this functional vagotomy/sympathectomy, we report the novel finding that right hemispheric activation via left FUNB increases intraocular pressure (IOP) by an average of 4.5 %, whereas left hemispheric stimulation via fight FUNB leads to a significant (25%) decrease in IOP.

39. Telles S, Singh N, Puthige R. Changes in P300 following alternate nostril yoga breathing and breath awareness. BioPsychoSocial Medicine 2013;7:11.

doi:10.1186/1751-0759-7-11

http://www.bpsmedicine.com/content/7/1/11

Abstract

This study assessed the effect of alternate nostril yoga breathing (nadisuddhi pranayama) on P300 auditory evoked potentials compared to a session of breath awareness of equal duration, in 20 male adult volunteers who had an experience of yoga breathing practices for more than three months. Peak amplitudes and peak latencies of the P300 were assessed before and after the respective sessions. There was a significant increase in the P300 peak amplitudes at Fz, Cz, and Pz and a significant decrease in the peak latency at Fz alone following alternate nostril yoga breathing. Following breath awareness there was a significant increase in the peak amplitude of P300 at Cz.

This suggests that alternate nostril yoga breathing positively influences cognitive processes which are required for sustained attention at different scalp sites (frontal, vertex and parietal), whereas breath awareness brings about changes at the vertex alone.

Keywords: Alternate nostril yoga breathing, P300, Breath awareness, Cognitive processes.

40. Khera T, Rangasamy V. Cognition and Pain: A Review. Front. Psychol. 2021;12:673962.

doi: 10.3389/fpsyg.2021.673962

https://www.frontiersin.org/articles/10.3389/fpsyg.2021.673962/full

Abstract

Cognition is defined as the brain's ability to acquire, process, store, and retrieve information. Pain has been described as an unpleasant sensory or emotional experience, and for experiencing pain consciously, cognitive processing becomes imperative. Moreover, evaluation of pain strongly depends on cognition as it requires learning and recall of previous experiences. There could be a possible close link between neural systems involved in cognition and pain processing, and studies have reported an association between pain and cognitive impairment. In this narrative review, we explore the available evidence that has investigated cognitive changes associated with pain.

We also examine the anatomical, biochemical, and molecular association of pain and neuro-cognition. Additionally, we focus on the cognitive impairment caused by analgesic medications. There is a need to improve our understanding of pathophysiology and cognitive impairment mechanisms associated with chronic pain and its treatment. This area provides a diverse opportunity for grounding future research, aiding institution of timely interventions to prevent chronic pain and associated cognitive decline, ultimately improving patient care.

Keywords: cognition, pain, memory, cognitive behavior therapy, chronic pain.

41. Qi X, Tong J, Chen S, He Z, Zhu X. Comparing the Psychological Effects of Meditation- and Breathing-Focused Yoga Practice in Undergraduate Students. Front. Psychol. 2020;11:560152.

doi: 10.3389/fpsyg.2020.560152

https://www.frontiersin.org/articles/10.3389/fpsyg.2020.560152/full

Abstract

Objectives: The present study aimed to compare the psychological effects of meditation- and breathing-focused yoga practice in undergraduate students.

Methods: A 12-weeks yoga intervention was conducted among a group of undergraduate students enrolled in four yoga classes at an academically prestigious university in Beijing, China. Four classes were randomized to meditation-focused yoga or breathing-focused yoga. A total of 86 participants finished surveys before and after the 12-weeks intervention, measuring work intention, mindfulness, and perceived stress. The repeated-measure multivariate analysis of covariance (MANCOVA) followed by univariate analyses were conducted to examine the differences in work intention,

mindfulness, and stress between the two yoga intervention groups over the semester, after controlling for age and gender.
Results: The repeated-measure MANCOVA revealed significant group differences with a median effect size [Wilks' lambda, 3 = 0.90, F(3, 80) = 3.10, p = 0.031,!2 = 0.104]. Subsequent univariate analyses showed that students in the breathingfocused yoga group had significant higher work intentions [F.1; 82/ = 5.22; p = 0.025;!2 p = 0.060] and mindfulness [F.1; 82/ = 6.33; p = 0.014; !2 p = 0.072] but marginally lower stress [F.1; 82/ = 4.20; p = 0.044; !2 p = 0.049] than students in the meditation-focused yoga group.
Conclusion: Yoga practice with a focus on breathing is more effective than that with a focus on meditation for undergraduates to retain energy for work, keep attention and awareness, and reduce stress.
Keywords: meditation, breathing, yoga, work intention, mindfulness, stress.

42. **Molkov Y, Bacak B, Dick T, Rybak I. Control of breathing by interacting pontine and pulmonary feedback loops. Frontiers in Neural Circuits 2013;7:13.**

https://doi.org/10.3389/fncir.2013.00016
https://www.frontiersin.org/articles/10.3389/fncir.2013.00016/full
Abstract
The medullary respiratory network generates respiratory rhythm via sequential phase switching, which in turn is controlled by multiple feedbacks including those from the pons and nucleus tractus solitarii; the latter mediates pulmonary afferent feedback to the medullary circuits. It is hypothesized that both pontine and pulmonary feedback pathways operate via activation of medullary respiratory neurons that are critically involved in phase switching. Moreover, the pontine and pulmonary control loops interact, so that pulmonary afferents control the gain of pontine influence of the respiratory pattern. We used an established computational model of the respiratory network (Smith et al., 2007) and extended it by incorporating pontine circuits and pulmonary feedback. In the extended model, the pontine neurons receive phasic excitatory activation from, and provide feedback to, medullary respiratory neurons responsible for the onset and termination of inspiration. The model was used to study the effects of: (1) "vagotomy" (removal of pulmonary feedback), (2) suppression of pontine activity attenuating pontine feedback, and (3) these perturbations applied together on the respiratory pattern and durations of inspiration (TI) and expiration (TE). In our model: (a) the simulated vagotomy resulted in increases of both TI and TE, (b) the suppression of pontine-medullary interactions led to the prolongation of TI at relatively constant, but variable TE, and (c) these perturbations applied together resulted in "apneusis," characterized by a significantly prolonged TI. The results of modeling were compared with, and provided a reasonable explanation for, multiple experimental data. The characteristic changes in TI and TE demonstrated with the model may represent characteristic changes in the balance between the pontine and pulmonary feedback control mechanisms that may reflect specific cardio-respiratory disorders and diseases.
Keywords: respiratory central pattern generator, brainstem, ventrolateral respiratory column, pre-Bötzinger complex, pontine-medullary interactions, pulmonary feedback, control of breathing, apneusis.

43. **Walker J, Pacik D. Controlled Rhythmic Yogic Breathing as Complementary Treatment for Post-Traumatic Stress Disorder in Military Veterans: A Case Series. Medical Acupuncture 2017;(29)4:232-238.**

doi:10.1089/acu.2017.1215
https://www.liebertpub.com/doi/10.1089/acu.2017.1215
Abstract
Background: Post-traumatic stress disorder (PTSD) is a cluster of symptoms in which a person persistently relives a traumatic event, through recurring thoughts, nightmares, and flashbacks for at least 1 month or more.

There are various behavioral and medical treatment options for PTSD. Mind–body techniques, such as biofeedback and breathing-based stress reduction, have shown some promise in the treatment of PTSD symptoms.
The purpose of this case series was to examine controlled yogic breathing as a complementary treatment of PTSD in military veterans. A retrospective review was performed from 2012 to 2016 in 3 cases, and participant demographics, member statements, and PTSD Checklist—Military Version (PCL-M) scores, pre-and-post course, were extracted.
Cases: Three military veterans with PTSD participated in a standardized 5-day course designed to teach them controlled rhythmic yogic breathing exercises.
Results: Subjectively, all 3 participants reported a decrease in PTSD symptoms after the course. Objectively, all 3 participants had a reduction in their overall PCL-M scores after the course. Among all 3 participants, there were score decreases in the Avoidance and Increased Arousal categories. The most dramatic improvement occurred in the participant with the most severe symptoms.
Conclusions: Controlled yogic breathing, specifically Sudarshan Kriya (SKY), appeared to reduce the symptoms of PTSD in 3 veterans of the Armed Services.
Keywords: post-traumatic stress disorder (PTSD), military veterans, yoga, Sudarshan Kriya, pranayama.

44. **Ramirez JM, Baertsch N. Defining the Rhythmogenic Elements of Mammalian Breathing. Physiology 2018;33:302-316.**

doi:10.1152/physiol.00025.2018
https://journals.physiology.org/doi/full/10.1152/physiol.00025.2018
Abstract
Breathing's remarkable ability to adapt to changes in metabolic, environmental, and behavioral demands stems from a complex integration of its rhythm generating network within the wider nervous system. Yet, this integration complicates identification of its specific rhythmogenic elements. Based on principles learned from smaller rhythmic networks of invertebrates, we define criteria that identify rhythmogenic elements of the mammalian breathing network and discuss how they interact to produce robust, dynamic breathing.

45. **Charland-Verville V et al. Detection of response to command using voluntary control of breathing in disorders of consciousness. Frontiers in Human Neuroscience 2014;8:1020.**

https://doi.org/10.3389/fnhum.2014.01020
https://www.frontiersin.org/articles/10.3389/fnhum.2014.01020/full
Abstract
Background: Detecting signs of consciousness in patients in a vegetative state/unresponsive wakefulness syndrome (UWS/VS) or minimally conscious state (MCS) is known to be very challenging. Plotkin et al. (2010) recently showed the possibility of using a breathing-controlled communication device in patients with locked in syndrome. We here aim to test a breathing-based "sniff controller" that could be used as an alternative diagnostic tool to evaluate response to command in severely brain damaged patients with chronic disorders of consciousness (DOC).
Methods: Twenty-five DOC patients were included. Patients' resting breathing-amplitude was measured during a 5 min resting condition. Next, they were instructed to end the presentation of a music sequence by sniffing vigorously. An automated detection of changes in breathing amplitude (i.e., >1.5 SD of resting) ended the music and hence provided positive feedback to the patient.
Results: None of the 11 UWS/VS patients showed a sniff-based response to command. One out of 14 patients with MCS was able to willfully modulate his breathing pattern to answer the command on 16/19 trials (accuracy 84%). Interestingly, this patient failed to show any other motor response to command.
Discussion: We here illustrate the possible interest of using breathing-dependent response to command in the detection of residual cognition in patients with DOC after severe brain injury.
Keywords: disorders of consciousness, breathing, sniffing, vegetative state, unresponsive wakefulness syndrome, minimally conscious state, diagnosis, brain-computer interface.

46. **Hariharan VP, Srinivasan K, Trakroo M. Effect of Deep Breathing on Cardiac Axis of Young Normal Subjects in Various Postures. A Pilot Study. Journal of Clinical and Diagnostic Research. 2019;13(3):CC01-CC03.**

doi:10.7860/JCDR/2019/39722.12721
https://www.jcdr.net/articles/PDF/12721/39722_CE[Ra1]_F(AC)_PF1(AG_KM)_PFA(KM)_PB(AG_SL)_PN(SL).pdf

Abstract
Introduction: Cardiac axis is altered in many physiological and pathological states. Hence its measurement is important. Position and movements of diaphragm determine the position of heart because the pericardium is firmly attached to the central tendon of the diaphragm. Effect of change in body posture and breathing on cardiac axis has not been well documented. The changes in cardiac axis during deep breathing are greater in aged patients.
Aim: To study the effect of deep breathing on cardiac axis of young normal subjects in various postures.
Materials and Methods: This was a cross-sectional study done on 45 normal healthy volunteers. After 10 min of supine rest, with the help of INCO RMS Vesta 101 electrocardiograph, ECG was recorded in leads I and aVF during eupnea, after maximum inspiration and after maximum expiration. The measurement was repeated in sitting and standing postures. The cardiac axis was calculated from Einthoven triangle. Data was analysed using ANOVA and inter-group was analysed using post-hoc test.
Results: Maximum inspiration produced a significant ($p<0.001$) increase in cardiac axis as compared to eupnea, in supine, sitting and standing postures. Maximum expiration produced a significant decrease in cardiac axis as compared to eupnea only in sitting ($p\leq0.05$) and standing postures ($p\leq0.01$).
Conclusion: Cardiac axis varies with posture as well as breathing. Maximum inspiration produces significant increase in cardiac axis whereas maximum expiration produces an insignificant decrease.
Keywords: Electrical axis of heart, Maximum expiration, Maximum inspiration.

47. **Mamta Amola et al. Effect of Inspiratory Muscle Training and Diaphragmatic Breathing Exercises on Dyspnea, Pulmonary Functions, Fatigue and Functional Capacity in Pregnancy during Third Trimester.**

doi:10.7860/JCDR/2019/41732.13037
https://www.jcdr.net/articles/PDF/13037/41732_CE[Ra1]_F(SHU)_PF1(PoG_KM)_PFA(PoG_SHU)_PN(SL).pdf

Abstract
Introduction: Pregnancy induces various physical and psychological alterations that cause dyspnea, reduced exercise capacity, fatigue, anxiety, altered pulmonary functions, nausea and vomiting. These alterations affect the maternal quality of life.

Aim: To compare the effect of Inspiratory Muscle Training and Diaphragmatic Breathing Exercises on dyspnea, pulmonary functions, fatigue and functional capacity in pregnancy during third trimester.

Materials and Methods: This experimental study was conducted on 34 subjects based on inclusion and exclusion criteria, which were randomly divided into Group A & B. Experimental group A received Inspiratory Muscle Training whereas group B performed Diaphragmatic Breathing Exercises for 4 weeks. The baseline measurement was taken on day one of the study. Dyspnea was assessed by Modified borg scale (MBS), Pulmonary functions (Expiratory Reserve Volume) were assessed by Spirometry, Fatigue was assessed by Multidimensional assessment of fatigue scale (MAFS) and Functional Capacity was assessed by 6 Minute Walk Test. All measurements were repeated at the end of 4th week. The baseline measurements at the end of 4th week were compared using the Independent t-test.

Results: Significant improvement in pulmonary function (ERV from mean value of 0.61 to 0.658) and functional capacity (6 MWT from mean value of 303.43 to 370.88) with decrease in dyspnea (MBS from mean value of 5.7 to 2.06) and fatigue score (from mean value of 31.1 to 22.29) were

found in the group A that received the inspiratory muscle training as compared to group B that received diaphragmatic training. It is suggested that inspiratory muscle training improve the quality of life in pregnancy by reducing the work of breathing.

Conclusion: The Inspiratory muscle training was found to be effective and beneficial in relieving dyspnea, fatigue and improving pulmonary functions. Therefore, it can be used as a part of rehabilitation protocol in pregnancy.

Keywords: Breathlessness, Functional capacity, Lethargy, Pulmonary functions.

48. **Rinku Garg et al. Effect of Left, Right and Alternate Nostril Breathing on Verbal and Spatial Memory. Journal of Clinical and Diagnostic Research. 2016;10(2):CC01-CC03.**

doi:10.7860/JCDR/2016/12361.7197
https://www.jcdr.net/pdf_download.asp?issn=&year=2016&month=February&volume=10&issue=2&page=CC01&id=7197

Abstract

Introduction: Yoga has beneficial effects on memory. In females, left hemisphere of the brain is responsible for verbal memory and right hemisphere is responsible for the spatial memory, while the opposite is true for males.

Aim: Aim of the present was to study the effect of unilateral right nostril breathing, left nostril breathing and alternate nostril breathing on verbal and spatial memory scores.

Materials and Methods: A total of 51 female subjects (age 18-25 years, mean±SD =21.71±3.11) were taken and divided into three groups (n=17). Each group was imparted one of the three different types of nostril breathing practices such as Right Nostril Breathing (RNB), Left Nostril Breathing (LNB) and Alternate Nostril Breathing (ANB) for 1 week for 45 minutes daily. Subjects were given the memory test, before and after 45 minutes of intervention for three consecutive days. Memory tests were performed by using Wechsler Adult Intelligent Scale.

Statistical Analysis: Results were analysed by ANOVA with SPSS version 17.0.

Results: Results showed that there was increase in recall of digit span-forward, digit-span backward, associate learning and spatial memory scores with RNB, LNB and ANB, which were statistically highly significant($p<0.005$).

Conclusion: Inclusion of nostril breathing in exercise regimen may be helpful in improving recall of memory.

49. **Naik GS, Gaur GS, Pal GK. Effect of modified slow breathing exercise on perceived stress and basal cardiovascular parameters. Int J Yoga 2018;11:53-8.**

doi:10.4103/ijoy.IJOY_41_16
https://www.ijoy.org.in/temp/IntJYoga11153-4966914_134749.pdf

Abstract

Context: Different types of breathing exercises have varied effects on cardiovascular parameters and the stress levels in an individual. Aim: The aim of this study was to assess the effect of a modified form of isolated alternate nostril, slow breathing exercise on perceived stress, and cardiovascular parameters in young, male volunteers. Settings and Design: This was a randomized control study carried out at Advanced Centre for Yoga Therapy Education and Research, Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry in 2014.

Subjects and Methods: Hundred healthy male volunteers were randomized into control group, n = 50 and slow breathing group (study), n = 50. Slow breathing exercise training was given to study group for 30 min a day, 5 times/week for 12 weeks, under the supervision of certified yoga trainers.

Perceived Stress Scale (PSS) using Cohen's questionnaire, anthropometric parameters such as body mass index (BMI), waist-hip ratio (WHR), and cardiovascular parameters such as heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were recorded at baseline and after 12 weeks. The control group did not receive any intervention. Slow breathing exercise training was provided for the study group. During the study period, one volunteer opted out of the study group due to personal reasons. Results: HR, SBP, DBP, and PSS decreased significantly ($P < 0.05$) in the study

group following 12 weeks slow breathing exercise training, while no significant change (P > 0.05) was observed in BMI and WHR. There was no significant change in the control group.
Conclusion: Twelve weeks of modified slow breathing exercise reduced perceived stress and improved the cardiovascular parameters. The above results indicate that our modified slow breathing exercise is effective in reducing stress and improving the cardiovascular parameters.
Keywords: Blood pressure, heart rate, perceived stress, slow breathing exercise.

50. **Erdogan YG, S. Tasci S. Effect of pranayama breathing technique on asthma control, pulmonary function, and quality of life. A single-blind, randomized, controlled trial. Complementary Therapies in Clinical Practice 2020;38:101081.**

https://doi.org/10.1016/j.ctcp.2019.101081
https://www.sciencedirect.com/science/article/pii/S1744388119308540
Abstract
Objective: This study evaluated the effect of pranayama on asthma control, pulmonary function, and quality of life in people with asthma. Methods: Pranayama was applied to the pranayama group for 20 min once daily for 1 month, and relaxation was applied to the relaxation group similarly in addition to the standard treatment. The outcome measurement tools used were the Asthma Control Test (ACT), Asthma Quality of Life Questionnaire (AQLQ), pulmonary function test (PFT), and patient observation chart. Results: The pranayama group had significantly higher ACT score, overall AQLQ score, and subscale scores than the relaxation group ($p < 0.05$). However, there was no significant difference between the groups in terms of PFT parameters and peak expiratory flow values ($p > 0.05$). Conclusion: Pranayama improved asthma control and asthma-related quality of life in people with asthma, but it did not show a significant difference in PFT values.
Keywords: Asthma, Asthma control, Breathing exercise, Quality of life, Yoga.

51. **Maheshkumar K et al. Effect of six months pranayama training on stress-induced salivary cortisol response among adolescents. Randomised controlled study. Explore 2021. in press.**

https://doi.org/10.1016/j.explore.2021.07.005
https://www.sciencedirect.com/science/article/abs/pii/S1550830721001476
Abstract
Background: A combination of yoga practices has been documented to reduce stress and stress induced cortisol levels. The objective of the current study is to examine the effects of six months of a single pranayama practice (Bhramari [Bhr. P]) on reducing salivary cortisol response to the cold pressor test (CPT) among adolescents.
Methods: Twenty-six healthy adolescents between the ages of 11 and 19 were randomly assigned to either yoga group (n-13) or control group (n-13). Yoga group participants were trained to do Bhr. P for 45 minutes, thrice a week for six months. All participants underwent CPT at baseline and at end of six months. Saliva samples were collected at baseline (t0), at 20 min (t1), 40 min (t2), and 60 min after the CPT (t3).
Results: Contradictory to our hypothesis, participants in the yoga group exhibited a higher salivary cortisol response to the CPT at t1 ($p = 0.04$) when compared to the control group.
However, the t3 salivary cortisol levels showed a statistically significant reduction ($p = 0.03$) in yoga group when compared to the control group. A significant interaction with time ($F (1, 88) = 316.5$, $p = .001$, $\eta p2 :0.91$) and between the group × time ($F (3, 88) = 2.83$, $p = 0.04$, $\eta p2:0.8$) was found after the intervention.
Conclusions: An increase in the cortisol responsiveness observed in the study is an indication of the adaptive capability achieved through regular yoga training, evidenced by an initial rise in cortisol followed by a rapid fall below baseline after 60 minutes. Further research is required to conclusively determine the changes in cortisol levels over time in response to stress in long-term yoga practitioners.
Keywords: Bhramari Pranayama, adolescents, salivary cortisol, stress; cold pressor test.

52. **Chen JC, Brown B, Schmid KL. Effect of unilateral forced nostril breathing on tonic accommodation and intraocular pressure. Clin Auton Res 2004;14:396-400.**

doi:10.1007/s10286-004-0200-4
https://link.springer.com/article/10.1007%2Fs10286-004-0200-4
Abstract
Background: Unilateralforced nostril breathing (UFNB) has specific measurable effects on the autonomic nervous system. Ocular accommodation, which is controlled by the autonomic nervous system, would be expected to be under the influence of UFNB when it is applied. The purpose of this study was to investigate the effect of UFNB on the resting state of the accommodation system, i. e. tonic accommodation (TA), along with measures of intraocular pressure (IOP), blood pressure and heart rate.
Methods: TA levels were measured using the Shin-Nippon autorefractor before and after 20 minutes of UFNB. IOP, blood pressure and heart rate, which are known to be affected by UFNB, were also measured with a noncontact tonometer and an automated blood pressure monitor respectively.
Results. Right and left UFNB produced slight, but not significant changes in TA. However, there was a tendency for left UFNB to produce a greater decrease in TA in subjects with higher base-line TA levels. Right UFNB produced a statistically significant decrease in IOP while the effect of left UFNB on IOP was not significant.
Conclusion: UFNB produced changes in IOP consistent with previous reports. As studied in this trial, UFNB did not have any significant effect on TA. Further studies using a larger sample size are required to investigate the effect of UFNB on the autonomic inputs to the ciliary muscle of the eye and the subsequent measures of tonic accommodation.
Keywords: unilateral forced nostril breathing, tonic accommodation, autonomic nervous system, intraocular pressure.

53. **Hamasaki H. Effects of Diaphragmatic Breathing on Health: A Narrative Review. Medicines 2020;7:65**

doi:10.3390/medicines7100065
https://www.mdpi.com/2305-6320/7/10/65
Abstract:
Background: Breathing is an essential part of life. Diaphragmatic breathing (DB) is slow and deep breathing that affects the brain and the cardiovascular, respiratory, and gastrointestinal systems through the modulation of autonomic nervous functions. However, the effects of DB on human health need to be further investigated.
Methods: The author conducted a PubMed search regarding the current evidence of the effect of DB on health.
Results: This review consists of a total of 10 systematic reviews and 15 randomized controlled trials (RCTs). DB appears to be effective for improving the exercise capacity and respiratory function in patients with chronic obstructive pulmonary disease (COPD). Although the effect of DB on the quality of life (QoL) of patients with asthma needs to be investigated, it may also help in reducing stress; treating eating disorders, chronic functional constipation, hypertension, migraine, and anxiety; and improving the QoL of patients with cancer and gastroesophageal reflux disease (GERD) and the cardiorespiratory fitness of patients with heart failure.
Conclusions: Based on this narrative review, the exact usefulness of DB in clinical practice is unclear due to the poor quality of studies. However, it may be a feasible and practical treatment method for various disorders.
Keywords: diaphragmatic breathing, abdominal breathing, breathing exercise, systematic review, randomized controlled trial, respiratory function.

54. **Li X, Yu R, Wang P, Wang A, Huang H. Effects of Exercise Training on Cardiopulmonary Function and Quality of Life in Elderly Patients with Pulmonary Fibrosis: A Meta-Analysis. Int. J. Environ. Res. Public Health 2021, 18, 7643.**

https://doi.org/10.3390/ijerph18147643
https://www.mdpi.com/1660-4601/18/14/7643
Abstract

(1) Objective: Our objective was to conduct a meta-analysis of randomized controlled trials that have evaluated the benefits of exercise training for elderly pulmonary fibrosis (PF) patients. (2) Methods: Studies in either English or Chinese were retrieved from the China National Knowledge Infrastructure (CNKI) and the Wanfang, PubMed, Web of Science and SPORTDiscus databases from inception until the first week of April 2021. Age, body mass index (BMI), and exercise frequency, intensity, type, and duration were considered for each participant. The specific data recorded were the six-minute walk distance (6MWD), maximal rate of oxygen consumption (peak VO_2), predicted forced vital capacity (FVC% pred), predicted diffusing capacity of the lung for carbon monoxide (DLCO% pred), predicted total lung capacity (TLC% pred), St. George's respiratory questionnaire (SGRQ) total score and a modified medical research council score (mMRC). (3) Results: Thirteen studies comprised this meta-analysis (eleven randomized controlled trials and two prospective studies design), wherein 335 patients were exercised and 334 were controls. The results showed that exercise training increased the 6MWD (Cohen's $d = 0.77$, MD = 34.04 (95% CI, 26.50–41.58), $p < 0.01$), peak VO_2 (Cohen's $d = 0.45$, MD = 1.13 (95% CI, 0.45–1.82), $p = 0.0001$) and FVC% pred (Cohen's $d = 0.42$, MD = 3.94 (95% CI, 0.91–6.96), $p = 0.01$). However, exercise training reduced scores for the SGRQ (Cohen's $d = 0.89$, MD = −8.79 (95% CI, −10.37 to −7.21), $p < 0.01$) and the mMRC (Cohen's $d = 0.64$, MD = −0.58 (95% CI, −0.79 to −0.36), $p < 0.01$). In contrast, exercise training could not increase DLCO% pred (Cohen's $d = 0.16$, MD = 1.86 (95% CI, −0.37–4.09), $p = 0.10$) and TLC% pred (Cohen's $d = 0.02$, MD = 0.07 (95% CI, −6.53–6.67), $p = 0.98$). Subgroup analysis showed significant differences in frequency, intensity, type, and age in the 6MWD results ($p < 0.05$), which were higher with low frequency, moderate intensity, aerobic–resistance–flexibility–breathing exercises and age ≤ 70. Meanwhile, the subgroup analysis showed significant differences in exercise intensity and types in the mMRC results ($p < 0.05$), which were lower with moderate intensity and aerobic–resistance exercises. (4) Conclusions: Exercise training during pulmonary rehabilitation can improved cardiopulmonary endurance and quality of life in elderly patients with PF. The 6MWDs were more noticeable with moderate exercise intensity, combined aerobic–resistance–flexibility–breathing exercises and in younger patients, which all were not affected by BMI levels or exercise durations. As to pulmonary function, exercise training can improve FVC% pred, but has no effect on DLCO% pred and TLC% pred.

Keywords: pulmonary fibrosis, exercise training, elderly health, pulmonary function, chronic diseases.

55. **Srinivasan B, Rajkumar D. Effects of Slow Breathing on Blood Pressure and End Tidal Carbon Dioxide in Hypertension. Randomised Controlled Trial. Journal of Clinical and Diagnostic Research. 2019;13(9):YC01-YC03.**

doi:10.7860/JCDR/2019/42327.13121
https://www.jcdr.net/articles/PDF/13121/42327_CE[Ra1]_F(SHU)_PF1(AJ_SL)_PFA(AJ_SHU)_PN(SL).pdf

Abstract

Introduction: Inhibition of breathing elevates End-tidal Carbon dioxide (EtCO2) and contributes to sustained Hypertension (HT).

Aim: To find out the immediate efficacy of Slow breathing (SB) in controlling Blood Pressure (BP) and its influence on EtCO2 in patients with hypertension.

Materials and Methods: Randomised control parallel group study was undertaken at outpatient department of medicine in Rajah Muthiah Medical College and Hospital, Annamalai University, Chidambaram, Tamil Nadu, India. Forty hypertensive patients were randomly assigned to receive either slow breathing training for half an hour or as controls. For study group, 30 minutes of SB was practised through recorded auditory command. The breathing instruction consists of four seconds of inspiration and 6 seconds of expiration. Main outcome measured BP {Systolic (S) and Diastolic (D)} and EtCO2. Paired sample t-test and independent sample t-test were the statistical tools used for inferential analysis.

Results: The mean drop in SBP and DBP was 12.30±2.79 mmHg and 3.90±4.44 mmHg respectively in study group following training and it was statistically significant. The mean drop in SBP and DBP in controls was 1.05±3.34 and 0.30±2.10, respectively. There was significant reduction in EtCO2 following training in study group, the mean difference was 1.80±2.46. Between group analysis shows that, there was significantly greater reduction in SBP and DBP in study group following training but statistical significance was not achieved for EtCO2.
Conclusion: Practice of slow breathing is effective in immediate reduction of systolic and diastolic BP. EtCO2 could play a role in reducing BP, but long-term study is warranted to better evaluate its role in BP reduction.
Keywords: Breathing training, High blood pressure, Pulmonary stretch receptors.

56. **Gaddam MG, Santhanakrishnan A. Effects of Varying Inhalation Duration and Respiratory Rate on Human Airway Flow. Fluids 2021;6:221.**

https://doi.org/10.3390/fluids6060221
https://www.mdpi.com/2311-5521/6/6/221
Abstract
Studies of flow through the human airway have shown that inhalation time (IT) and secondary flow structures can play important roles in particle deposition. However, the effects of varying IT in conjunction with the respiratory rate (RR) on airway flow remain unknown. Using three-dimensional numerical simulations of oscillatory flow through an idealized airway model (consisting of a mouth, glottis, trachea, and symmetric double bifurcation) at a trachea Reynolds number (Re) of 4200, we investigated how varying the ratio of IT to breathing time (BT) from 25% to 50% and RR from 10 breaths per minute (bpm) corresponding to a Womersley number (Wo) of 2.41 to 1000 bpm (Wo = 24.1) impacts airway flow characteristics. Irrespective of IT/BT, axial flow during inhalation at tracheal cross-sections was non-uniform for Wo = 2.41, as compared to centrally concentrated distribution forWo = 24.1. For a givenWo and IT/BT, both axial and secondary (lateral) flow components unevenly split between left and right branches of a bifurcation. Irrespective of Wo, IT/BT and airway generation, lateral dispersion was a stronger transport mechanism than axial flow streaming. Discrepancy in the oscillatory flow relation Re/Wo2 = 2L/D (L = stroke length; D = trachea diameter) was observed for IT/BT 6= 50%, as L changed with IT/BT. We developed a modified dimensionless stroke length term including IT/BT. While viscous forces and convective acceleration were dominant for lower Wo, unsteady acceleration was dominant for higher Wo.
Keywords: high-frequency oscillatory ventilation, HFOV, inhalation time, respiratory flow.

57. **Kuppusamy M et al. Effects of yoga breathing practice on heart rate variability in healthy adolescents: a randomized controlled trial. Integrative Medicine Research 2020;9:28-32.**

https://doi.org/10.1016/j.imr.2020.01.006
https://www.sciencedirect.com/science/article/pii/S2213422020300068
Abstract
Background: This study was conducted among healthy adolescents to assess the effects of a yoga breathing practice (Bhramari pranayama, Bhr.P) towards cardiac autonomic function using heart rate variability (HRV) parameters.
Methods: Of the 730 eligible subjects screened, 520 healthy adolescents who met the inclusion and exclusion criteria were randomly assigned to either yoga breathing group (n = 260) or control group (n = 260). The yoga breathing group practiced Bhr.P. five days a week for a duration of six months while the control group continued with their daily routine without any intervention. Outcome measures were time and frequency domain of HRV in both groups which were assessed before and after the intervention using Lead II ECG. Linear models were used in the analysis of short term HRV.
Results: After 6 months of yoga breathing, the time domain parameters of short term HRV showed significant ($P < 0.05$) improvement towards the parasympathetic domain. Frequency domain parameters also showed the same direction of changes. In contrast, control group subjects showed a trend towards a sympathetic domain.

Conclusion: The present study showed a positive shift in cardiac autonomic modulation towards parasympathetic predominance after 6 months of yoga breathing practice among apparently healthy adolescents.
Keywords: Yoga, Bhramari pranayama, Autonomic function, Heart rate variability, Adolescents.

58. **Kasturi BK, Deo G. Efficacy of forced right nostril breathing and selected yogasanas on female obese college students. Journal of Complementary and Integrative Medicine 2018;20170070.**

doi:10.1515/jcim-2017-0070
https://www.degruyter.com/document/doi/10.1515/jcim-2017-0070/html
Abstract:
Background: Overweight and obesity are the accumulation of high body adiposity, which can have detrimental health effects and contribute to the developments of numerous non communicable diseases.
Aim: To study the psycho-physiological changes after the practice of forced right nostril breathing and selected yogasanas on obese college students.
Methods: To carry out this study, 32 female subjects aged 18–25 years of age were recruited with informed consent from Priyanka degree college, Hyderabad, Telangana, India. The design was a single group pre-post. Height and weight were recorded and the body mass index (BMI) was calculated using standard procedures and equation. The students were given the practice of forced right nostril breathing for 10 min daily four times a day and some selected yogasanas. The assessments were taken before start of intervention and at the last day after 30 days. The intervention was for 6 days per week which consists of forced right nostril breathing and some selected asanas.
Conclusions: The study exhibited that forced right nostril breathing and selected yogasanas reduces the physiological risk factors. These yogic practices are effective to overcome complications arise due to obesity and are helpful to induce positive psychological changes in obese individual.
Keywords: BMI, forced right nostril breathing, obesity, yogasanas.

59. **Kashevnik, A, Othman W, Ryabchikov I, Shilov N. Estimation of Motion and Respiratory Characteristics during the Meditation Practice Based on Video Analysis. Sensors 2021;21:3771.**

https://doi.org/10.3390/s21113771
https://www.mdpi.com/1424-8220/21/11/3771
Abstract
Meditation practice is mental health training. It helps people to reduce stress and suppress negative thoughts. In this paper, we propose a camera-based meditation evaluation system, that helps meditators to improve their performance. We rely on two main criteria to measure the focus: the breathing characteristics (respiratory rate, breathing rhythmicity and stability), and the body movement. We introduce a contactless sensor to measure the respiratory rate based on a smartphone camera by detecting the chest keypoint at each frame, using an optical flow based algorithm to calculate the displacement between frames, filtering and de-noising the chest movement signal, and calculating the number of real peaks in this signal. We also present an approach to detecting the movement of different body parts (head, thorax, shoulders, elbows, wrists, stomach and knees). We have collected a non-annotated dataset for meditation practice videos consists of ninety videos and the annotated dataset consists of eight videos. The non-annotated dataset was categorized into beginner and professional meditators and was used for the development of the algorithm and for tuning the parameters. The annotated dataset was used for evaluation and showed that human activity during meditation practice could be correctly estimated by the presented approach and that the mean absolute error for the respiratory rate is around 1.75 BPM, which can be considered tolerable for the meditation application.
Keywords: human activity, movement detection, respiratory rate, meditation evaluation, neural networks.

60. **Sarris J, de Manincor M, Hargraves F, Tsonis J. Harnessing the Four Elements for Mental Health. Front. Psychiatry 2019;10:256.**
doi:10.3389/fpsyt.2019.00256
https://www.frontiersin.org/articles/10.3389/fpsyt.2019.00256/full
Abstract
Humans are intimately connected to nature, and our physical and mental health is influenced strongly by our environment. The "elements," classically described in humoral theory as Fire, Water, Earth, and Air, all may impact our mental health. In a contemporary sense, these elements reflect a range of modifiable factors: UV light or heat therapy (Fire); sauna, hydrotherapy, and balneotherapy (Water); nature-based exposure therapy and horticulture (Earth); oxygen-rich/clean air exposure; and breathing techniques (Air). This theoretical scoping review paper details the emerging evidence for a range of these elements, covering epidemiological and interventional data, and provides information on how we can engage in "biophilic" activities to harness their potential benefits. Interventional examples with emerging evidentiary support include "forest-bathing," heat therapy, sauna, light therapy, "greenspace" and "bluespace" exercise, horticulture, clay art therapy activities, and pranayamic yoga breathing exercises. Further robust research is however required to firmly validate many of these interventions, and to establish their therapeutic applications for the benefit of specific mental health disorders.
Keywords: lifestyle, mental health, mood, anxiety, psychological, well-being, nature, lifestyle medicine.

61. **Lehrer PM, Vaschillo EG, Vidali V. Heart Rate and Breathing Are Not Always in Phase During Resonance Frequency Breathing. Applied Psychophysiology and Biofeedback 2020;45:145-152.**
https://doi.org/10.1007/s10484-020-09459-y
https://link.springer.com/article/10.1007%2Fs10484-020-09459-y
Abstract
For many years it has been an axiom among practitioners of heart rate variability biofeedback that heart rate and breathing vary in phase with each other when people do resonance frequency breathing. When people breathe at the frequency of the baroreflex system, about 0.1 Hz, heart rate and blood pressure have been found to oscillate 180° out of phase, while heart rate and breathing are in phase (zero-degree phase). Thus breathing stimulates the baroreflex by augmenting the baroreflex response with each breath, an effect that is magnified by resonance properties in the baroreflex system. The original data on these relationships came from a study of highly athletic healthy young people. To test this relationship we analyzed phase relationship data between cardiac interbeat interval and breathing during 5-min periods of resonance frequency breathing among 24 adults from a recent study of heart rate variability biofeedback to treat adults with mild to moderate currently symptomatic asthma, ages between 18 and 70. For the specific frequency near 0.1 Hz with the highest amplitude of HRV we calculated coherence and phase between cardiac interbeat interval (IBI) and the respiration curve using the WinCPRS program. Among records with coherence > 0.8, we found a phase relationship of 109° rather than the expected 180°, with IBI changes leading breathing. We computed Spearman correlation coefficients between phase and various subject characteristics, including age, gender, height, and asthma severity. We found no relationship between phase and gender, height, or asthma physiology or symptoms. However, when controlled for gender and height, we found a moderate size significant correlation between phase and age, with younger participants having values closer to 180°, $r = 0.47$, $p < 0.03$. It is possible that cardiovascular characteristics of older people affect the phase relationship. Despite the deviation from the in-phase relationship among older individuals, breathing nevertheless stimulated the baroreflex and produced high-amplitude heart rate oscillations. Implications are discussed for HRV biofeedback training protocols. Replication in a healthy population is needed in order to determine the universality of these findings.
Keywords: Psychophysiology, Resonance, Transfer function, Age, Heart rate variability, biofeedback, Protocol.

62. **Telles S, Gupta RK, Yadav A, Pathak S, Balkrishna A. Hemisphere specific EEG related to alternate nostril yoga breathing. BMC Res Notes 2017;10:306.**
doi:10.1186/s13104-017-2625-6
https://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-017-2625-6
Abstract
Background: Previously, forced unilateral nostril breathing was associated with ipsilateral, or contralateral cerebral hemisphere changes, or no change. Hence it was inconclusive. The present study was conducted on 13 normal healthy participants to determine the effects of alternate nostril yoga breathing on (a) cerebral hemisphere asymmetry, and (b) changes in the standard EEG bands.
Methods: Participants were randomly allocated to three sessions (a) alternate nostril yoga breathing (ANYB), (b) breath awareness and (c) quiet sitting, on separate days. EEG was recorded from bilaterally symmetrical sites (FP1, FP2, C3, C4, O1 and O2).
All sites were referenced to the ipsilateral ear lobe.
Results: There was no change in cerebral hemisphere symmetry. The relative power in the theta band was decreased during alternate nostril yoga breathing (ANYB) and the beta amplitude was lower after ANYB. During quiet sitting the relative power in the beta band increased, while the amplitude of the alpha band reduced.
Conclusion: The results suggest that ANYB was associated with greater calmness, whereas quiet sitting without specific directions was associated with arousal. The results imply a possible use of ANYB for stress and anxiety reduction.
Keywords: EEG, Alternate nostril yoga breathing, Cerebral hemisphere symmetry, Breath awareness, Quiet sitting, EEG relative power, EEG bands.

63. **Zaccaro A et al. How Breath-Control Can Change Your Life: A Systematic Review on Psycho-Physiological Correlates of Slow Breathing. Front. Hum. Neurosci. 2018;12:353.**
doi:10.3389/fnhum.2018.00353
https://www.frontiersin.org/articles/10.3389/fnhum.2018.00353/full
Abstract
Background: The psycho-physiological changes in brain-body interaction observed in most of meditative and relaxing practices rely on voluntary slowing down of breath frequency. However, the identification of mechanisms linking breath control to its psychophysiological effects is still under debate. This systematic review is aimed at unveiling psychophysiological mechanisms underlying slow breathing techniques (<10 breaths/minute) and their effects on healthy subjects.
Methods: A systematic search of MEDLINE and SCOPUS databases, using keywords related to both breathing techniques and to their psychophysiological outcomes, focusing on cardio-respiratory and central nervous system, has been conducted. From a pool of 2,461 abstracts only 15 articles met eligibility criteria and were included in the review. The present systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.
Results: The main effects of slow breathing techniques cover autonomic and central nervous systems activities as well as the psychological status. Slow breathing techniques promote autonomic changes increasing Heart Rate Variability and Respiratory Sinus Arrhythmia paralleled by Central Nervous System (CNS) activity modifications. EEG studies show an increase in alpha and a decrease in theta power. Anatomically, the only available fMRI study highlights increased activity in cortical (e.g., prefrontal, motor, and parietal cortices) and subcortical (e.g., pons, thalamus, sub-parabrachial nucleus, periaqueductal gray, and hypothalamus) structures. Psychological/behavioral outputs related to the abovementioned changes are increased comfort, relaxation, pleasantness, vigor and alertness, and reduced symptoms of arousal, anxiety, depression, anger, and confusion.
Conclusions: Slow breathing techniques act enhancing autonomic, cerebral and psychological flexibility in a scenario of mutual interactions: we found evidence of links between parasympathetic activity (increased HRV and LF power), CNS activities (increased EEG alpha power and decreased EEG theta power) related to emotional control and psychological well-being in healthy subjects. Our hypothesis considers two different mechanisms for explaining psychophysiological changes induced

by voluntary control of slow breathing: one is related to a voluntary regulation of internal bodily states (enteroception), the other is associated to the role of mechanoceptors within the nasal vault in translating slow breathing in a modulation of olfactory bulb activity, which in turn tunes the activity of the entire cortical mantle.
Keywords: slow breathing, breath-control, pranayama, paced breathing, EEG, fMRI, HRV, psychophysiology.

64. **Mortola JP. How to breathe? Respiratory mechanics and breathing pattern. Respiratory Physiology & Neurobiology 2019;(261):48-54.**

https://doi.org/10.1016/j.resp.2018.12.005
https://www.sciencedirect.com/science/article/abs/pii/S1569904818303161
Abstract
On theoretical grounds any given level of pulmonary or alveolar ventilation can be obtained at various absolute lung volumes and through many combinations of tidal volume, breathing frequency and inspiratory and expiratory timing. However, inspection of specific cases of newborn and adult mammals at rest indicates that the breathing pattern reflects a principle of economy oriented toward minimal respiratory work. The mechanisms that permit optimization of respiratory cost are poorly understood; yet, it is their efficiency and coordination that permits pulmonary ventilation at rest to require only a minimal fraction of resting metabolism. The sensitivity of the breathing pattern to the mechanical properties implies that tidal volume, breathing rate, mean inspiratory flow or other ventilatory parameters cannot be necessarily considered indicators proportional to the central neural respiratory 'drive'. The broad conclusion is that the breathing pattern adopted by newborn and adult mammals is the one that produces the adequate alveolar ventilation with minimal cost, that is, in full recognition of the mechanical characteristics of the system.
Keywords: Allometry, Breathing frequency, Human infant, Neonatal respiration, Work of breathing.

65. **Noble DJ, Hochman S. Hypothesis: Pulmonary Afferent Activity Patterns During Slow, Deep Breathing Contribute to the Neural Induction of Physiological Relaxation. Front. Physiol. 2019;10:1176.**

doi:10.3389/fphys.2019.01176
https://www.frontiersin.org/articles/10.3389/fphys.2019.01176/full
Abstract
Control of respiration provides a powerful voluntary portal to entrain and modulate central autonomic networks. Slowing and deepening breathing as a relaxation technique has shown promise in a variety of cardiorespiratory and stress-related disorders, but few studies have investigated the physiological mechanisms conferring its benefits. Recent evidence suggests that breathing at a frequency near 0.1 Hz (6 breaths per minute) promotes behavioral relaxation and baroreflex resonance effects that maximize heart rate variability. Breathing around this frequency appears to elicit resonant and coherent features in neuro-mechanical interactions that optimize physiological function. Here we explore the neurophysiology of slow, deep breathing and propose that coincident features of respiratory and baroreceptor afferent activity cycling at 0.1 Hz entrain central autonomic networks. An important role is assigned to the preferential recruitment of slowly-adapting pulmonary afferents (SARs) during prolonged inhalations. These afferents project to discrete areas in the brainstem within the nucleus of the solitary tract (NTS) and initiate inhibitory actions on downstream targets. Conversely, deep exhalations terminate SAR activity and activate arterial baroreceptors via increases in blood pressure to stimulate, through NTS projections, parasympathetic outflow to the heart. Reciprocal SAR and baroreceptor afferent-evoked actions combine to enhance sympathetic activity during inhalation and parasympathetic activity during exhalation, respectively. This leads to pronounced heart rate variability in phase with the respiratory cycle (respiratory sinus arrhythmia) and improved ventilation-perfusion matching. NTS relay neurons project extensively to areas of the central autonomic network to encode important features of the breathing pattern that may modulate anxiety, arousal, and attention. In our model, pronounced respiratory rhythms during slow, deep breathing also support expression of slow cortical rhythms to induce a functional state of alert

relaxation, and, via nasal respiration-based actions on olfactory signaling, recruit hippocampal pathways to boost memory consolidation. Collectively, we assert that the neurophysiological processes recruited during slow, deep breathing enhance the cognitive and behavioral therapeutic outcomes obtained through various mind-body practices. Future studies are required to better understand the physiobehavioral processes involved, including in animal models that control for confounding factors such as expectancy biases.
Keywords: slow, deep breathing, relaxation, neurophysiological mechanisms, slowly-adapting pulmonary afferents, slow brain rhythms.

66. **Telle S, et al. Immediate Effect of a Yoga Breathing Practice on Attention and Anxiety in Pre-Teen Children. Children 2019;6,84.**

doi:10.3390/children6070084
https://www.mdpi.com/2227-9067/6/7/84
Abstract
Pre-teen children face stressors related to their transition from childhood to adolescence, with a simultaneous increase in academic pressure. The present study compared the immediate effects of 18 min of (i) high frequency yoga breathing with (ii) yoga-based breath awareness and (iii) sitting quietly, on (a) attention and (b) anxiety, in 61 pre-teen children (aged between 11 and 12 years; 25 girls). Attention was assessed using a six letter cancellation task and Spielberger's State Trait Anxiety Inventory STAI-S was used to measure anxiety before and after the three practices, practiced on separate days. Repeated measures ANOVA, followed by Bonferroni adjusted post-hoc analyses showed an increase in total attempts and net scores after high frequency yoga breathing ($p < 0.05$), while wrong attempts increased after yoga based breath awareness ($p < 0.05$). Anxiety decreased comparably after all three interventions. The 25 girls in the group had the same trend of results as the whole group with respect to the attention-based cancellation task, while boys showed no, how since change. For both girls and boys, anxiety decreased after all three 18min interventions. The results suggest that high frequency yoga breathing could be a short, useful school based practice to improve attention and reduce anxiety.
Keywords: pre-teen children, attention, anxiety, yoga breathing, yoga based breath awareness, sitting quietly.

67. **Lalitha S, Maheshkumar K, Shobana R, Deepika C. Immediate effect of Kapalbhathi pranayama on short term heart rate variability (HRV) in healthy volunteers. J Complement Integr Med 2021;18(1): 155-158.**

https://doi.org/10.1515/jcim-2019-0331
https://www.degruyter.com/document/doi/10.1515/jcim-2019-0331/html
Abstract
Objectives: Kapalbhathi Pranayam (Kapal = forehead; bhati = shining) is a breathing exercise that has been practiced to cleanse the frontal brain in traditional practices like yoga. Still, there exists a dearth of literature on the effect of Kapalbhathi pranayama on physiological systems. So this present study was carried out to find the immediate effect of "kapalbhathi Pranayam" practice for the period of 5 min on cardiac autonomic function among the healthy volunteers.
Materials and methods: Apparently 50 healthy volunteers includes both sex were participated. They were randomly divided into Pranayama (n−25) and control (n−25) group.
Pranayama group was practiced kapalbhathi pranayama 5 min (5 cycles) and control group was allowed to do normal breathing (12–16 breath/min). Lead II ECG was recorded for 5 min using simple AD converter before, immediately after practice and 20 min of recovery period.
Results: One way Analysis of variance (ANOVA) followed by post hoc test was done using R statistical software. There was a significant ($p < 0.05$) parasympathetic withdrawal (Root Mean Square of the Successive Differences (RMSSD) –$p < 0.04$ and HF n.u – $p < 0.05$) was found in the pranayama group immediately after practice and its was changed to parasympathetic domination (RMSSD – $p < 0.04$ and HF n.u– $p < 0.05$) after 20 min of recovery period.

Conclusion: The present study suggested that though there was parasympathetic withdrawal immediately after practicing kapalbhathi pranayama, 20 min after the recovery period showed a parasympathetic domination in the pranayama group subjects. However, further studies are required to warrant the findings of this study.
Keywords: cardiac autonomic function, heart rate variability, pranayama, recovery period.
Immediate effect of short duration of slow deep breathing on heart rate variability in healthy adults

68. **Chinagudi S, et al. Immediate effect of short duration of slow deep breathing on Heart Rate Variability in healthy adult. National Journal of Physiology, Pharmacy & Pharmacology 2014;(4)3:233-235.**

doi:10.5455/njppp.2014.4.060520141
http://njppp.com/fulltext/28-1399431673.pdf
Abstract
Background: Various types of breathing exercises have various effects on autonomic nervous system like fast breathing increases sympathetic tone and slow breathing increases parasympathetic tone. But these changes are seen when those exercises are done for long duration. Heart rate variability (HRV) reveals the autonomic status very effectively. So took up the study to know the effects of short duration (5 min) of slow deep breathing on heart rate variability
Aims & Objective: To study the HRV Before and after five minutes of slow deep breathing in healthy adults.
Materials and Methods: 20 healthy adults aged between 30 to 40 years and not practicing any kind of breathing exercises or yoga were involved in the study. Using powerlab, AD Instrument polyrite, HRV was calculated by recording ECG in Lead II for five minutes. Then the participants were made to slow deep breathe for 5 minutes, again HRV was calculated. The time domain parameters of HRV studied were Standard deviation of all normal-to-normal intervals in milliseconds (SDNN) and Root Mean Square Successive Difference in milliseconds (RMSSD). The frequency domain parameters studied were low frequency in normalized units (LF nu), high frequency in normalized units (HFnu) and the ratio of LF to HF (LF/HF ratio). Data was analysed by paired t test.
Results: Heart rate did not show much of variation. There was significant increase in LFnu (46.91±14.51, 60.79±17.29 and p 0.009), decrease in HFnu (43.56±17.59, 30.17±13.52 and p 0.002), increase in LF/HF ratio (1.43±0.84, 3.06±3.22 and p 0.03). SDNN and RMSSD did not show significant change.
Conclusion: Effect of slow deep breathing for a short duration of five minutes in healthy adults who are not practicing any kind of breathing exercise or yoga is shift of the cardiac sympathovagal balance towards the sympathetic predominance.
Key Words: Slow Deep Breathing; Heart Rate Variability (HRV); Short Term Effect.

69. **Jain R. Immediate effect of slow pace unilateral left nostril breathing with internal breath retention on blood pressure and pulse rate among normal healthy adults. Asian Journal of Complementary and Alternative Medicine 2017;(5)16:7-10.**

http://www.acamjournal.com/open-access/immediate-effect-of-slow-pace-unilateral-left-nostril-breathing-with-38.pdf
Abstract
Abstract Introduction: Pranayama is one among the most important yoga practice which regulates or control prana; the vital force there by brings a harmony between body and mind and thus maintains a healthy living. Pranayama has proved to have beneficial effects upon blood pressure and pulse rate. The present study was aimed to determine the immediate effects of 10 minute practice of slow pace unilateral left nostril breathing on blood pressure and pulse rate on normal healthy adults. Methodology: 30 healthy subjects of 20-23 years age group of both sexes were selected randomly from a pool of 350 students of Sree Ramakrishna Medical College of Naturopathy and Yogic sciences. The subjects are asked to practice unilateral left nostril breathing with internal breath retention for 10 minutes. Blood pressure and pulse rate is measured before and after pranayama. Results: Statistical analysis shows reduction of systolic blood pressure (t 6.898, sig 2 tailed .000) and

diastolic blood pressure (t 3.516, sig 2 tailed .001) and also a significant rise of pulse rate (t -10.463, sig 2 tailed .000) Discussion: 10 minutes practice of unilateral left nostril breathing with internal breath retention showed a significant reduction of systolic and diastolic blood pressure with increase of pulse rate. It indicates that it may have an important role to play in hypertensive persons. Large randomized control trials are necessary to prove the better results.
Keywords: Unilateral left nostril breathing (ULLNB), Chandra anuloma viloma pranayama, blood pressure (BP), pulse rate (PR), internal breath retention (IBR), antar kumbaka.

70. **Raghuraj P, Telles S. Immediate Effect of Specific Nostril Manipulating Yoga Breathing Practices on Autonomic and Respiratory Variables. Appl Psychophysiol Biofeedback 2008;33:65-75.**

doi:10.1007/s10484-008-9055-0
https://link.springer.com/article/10.1007/s10484-008-9055-0
Abstract
The effect of right, left, and alternate nostril yoga breathing (i.e., RNYB, LNYB, and ANYB, respectively) were compared with breath awareness (BAW) and normal breathing (CTL). Autonomic and respiratory variables were studied in 21 male volunteers with ages between 18 and 45 years and experience in the yoga breathing practices between 3 and 48 months. Subjects were assessed in five experimental sessions on five separate days. The sessions were in fixed possible sequences and subjects were assigned to a sequence randomly. Each session was for 40 min; 30 min for the breathing practice, preceded and followed by 5 min of quiet sitting. Assessments included heart rate variability, skin conductance, finger plethysmogram amplitude, breath rate, and blood pressure. Following RNYB there was a significant increase in systolic, diastolic and mean pressure. In contrast, the systolic and diastolic pressure decreased after ANYB and the systolic and mean pressure were lower after LNYB. Hence, unilateral nostril yoga breathing practices appear to influence the blood pressure in different ways. These effects suggest possible therapeutic applications.
Keywords: Right nostril yoga breathing, Left nostril yoga breathing, Alternate nostril yoga breathing, Unilateral nostril yoga breathing, Autonomic and respiratory variables.

71. **Yagi N et al. Inappropriate Timing of Swallow in the Respiratory Cycle Causes Breathing–Swallowing Discoordination. Front. Physiol. 2017;8:676.**

doi:10.3389/fphys.2017.00676
https://www.frontiersin.org/articles/10.3389/fphys.2017.00676/full
Abstract
Rationale: Swallowing during inspiration and swallowing immediately followed by inspiration increase the chances of aspiration and may cause disease exacerbation. However, the mechanisms by which such breathing–swallowing discoordination occurs are not well-understood.
Objectives: We hypothesized that breathing–swallowing discoordination occurs when the timing of the swallow in the respiratory cycle is inappropriate. To test this hypothesis, we monitored respiration and swallowing activity in healthy subjects and in patients with dysphagia using a non-invasive swallowing monitoring system.
Measurements and Main Results: The parameters measured included the timing of swallow in the respiratory cycle, swallowing latency (interval between the onset of respiratory pause and the onset of swallow), pause duration (duration of respiratory pause for swallowing), and the breathing–swallowing coordination pattern. We classified swallows that closely follow inspiration (I) as I-SW, whereas those that precede I as SW-I pattern. Patients with dysphagia had prolonged swallowing latency and pause duration and tended to have I-SWor SW-I patterns reflecting breathing–swallows discoordination.
Conclusions: We conclude that swallows at inappropriate timing in the respiratory cycle cause breathing–swallowing discoordination, and the prolongation of swallowing latency leads to delayed timing of the swallow, and results in an increase in the SW-I pattern in patients with dysphagia.
Keywords: aspiration, coordination between breathing and swallowing, phase resetting, dysphagia, deglutition disorders.

72. **Russell MEB, Scott AB, Boggero IA, Carlson CR. Inclusion of a Rest Period in Diaphragmatic Breathing Increases High Frequency Heart Rate Variability: Implications for Behavioral Therapy. Psychophysiology 2017;54(3):358-365.**
doi:10.1111/psyp.12791
https://onlinelibrary.wiley.com/doi/10.1111/psyp.12791
Abstract
Heart rate variability (HRV) is associated with positive physiological and psychological effects. HRV is affected by breathing parameters, yet, debate remains regarding the best breathing interventions for strengthening HRV. The objective of the current study was to test whether the inclusion of a post-exhalation rest period was effective at increasing HRV, while controlling for breathing rate. A within-subjects crossover design was used with 40 participants who were assigned randomly to a breathing pattern including a post-exhalation rest period or a breathing pattern that omitted the post exhalation rest period. Participants completed training on each breathing pattern, practiced for six minutes, and sat quietly during a five-minute washout period between practices. Participants were given instructions for diaphragmatic breathing (DB) at a pace of six breaths/minute with or without a post-exhalation rest period. Recordings of heart rate, breathing rate, HF-HRV, RMSSD, LF-HRV, SDNN were collected before and during each of the breathing trials. HRV indices were derived from Lead one ECG recordings. Pairwise contrasts showed inclusion of a post-exhalation rest period significantly decreased heart rate ($p < .001$) and increased HF-HRV ($p < .05$). No differences were found for breathing rates ($p > .05$), RMSSD ($p > .05$), and SDNN ($p > .05$). Results indicted omission of the post-exhalation rest period resulted in higher LF-HRV ($p < .05$). A post-exhalation rest period improves HF-HRV, commonly associated with self-regulatory control, yet a post-exhalation rest period's importance requires further exploration.

73. **Hoit JD. Influence of Body Position on Breathing and Its Implications for the Evaluation and Treatment of Speech and Voice Disorders. Journal of Voice 1995;(9)4:341-347**
https://doi.org/10.1016/S0892-1997(05)80196-1
https://www.jvoice.org/article/S0892-1997(05)80196-1/fulltext
Abstract
This paper examines how breathing differs in the upright and supine body positions. Passive and active forces and associated chest wall motions are described for resting tidal breathing and speech breathing performed in the two positions. Clinical implications are offered regarding evaluation and treatment of breathing behavior in clients with speech and voice disorders.
Keywords: Body position, Breathing, Speech, Voice.

74. **Steffen PR et al. Integrating Breathing Techniques Into Psychotherapy to Improve HRV: Which Approach Is Best? Front. Psychol. 2021:12:624254.**
doi:10.3389/fpsyg.2021.624254
https://www.frontiersin.org/articles/10.3389/fpsyg.2021.624254/full
Abstract
Introduction: Approaches to improve heart rate variability and reduce stress such as breathing retraining are more frequently being integrated into psychotherapy but little research on their effectiveness has been done to date. Specifically, no studies to date have directly compared using a breathing pacer at 6 breaths per minute with compassion focused soothing rhythm breathing.
Current Study: In this randomized controlled experiment, 6 breaths per minute breathing using a pacer was compared with compassion focused soothing rhythm breathing, with a nature video being used as a control group condition.
Methods: Heart rate variability (HRV) measures were assessed via electrocardiogram (ECG) and respiration belt, and an automated blood pressure machine was used to measure systolic diastolic blood pressure, and heart rate (HR). A total of 96 participants were randomized into the three conditions. Following a 5-min baseline, participants engaged in either 6 breath per minute breathing, soothing rhythm breathing, or watched a nature video for 10 min. To induce a stressful state, participants then wrote for 5 min about a time they felt intensely self-critical. Participants then wrote

for 5 min about a time they felt self-compassionate, and the experiment ended with a 10-min recovery period.
Results: Conditions did not significantly differ at baseline. Overall, HRV, as measured by standard deviation of NN intervals (SDNN), low frequency HRV (LF HRV), and LF/HF ratio, increased during the intervention period, decreased during self-critical writing, and then returned to baseline levels during the recovery period. High frequency HRV (HF HRV) was not impacted by any of the interventions. The participants in the 6 breath per minute pacer condition were unable to consistently breathe at that rate and averaged about 12 breaths per minute. Time by Condition analyses revealed that both the 6 breaths per minute pacer and soothing breathing rhythm conditions lead to significantly higher SDNN than the nature video condition during breathing practice but there were no significant differences between conditions in response to the self-critical and self compassionate writing or recovery periods. The 6 breath per minute pacer condition demonstrated a higher LF HRV and LF/HF ratio than the soothing rhythm breathing condition, and both intervention conditions had a higher LF HRV and LF/HF ratio than the nature video.
Conclusions: Although the 6 breath per minute pacer condition participants were not able to breath consistently at the low pace, both the participants attempting to breathe at 6 breaths per minute as well as those in the soothing rhythm breathing condition effectively increased HR variability as measured by SDNN, and attempting to breathe at 6 breaths per minute led to the highest LF HRV and LF/HF ratio. Both breathing approaches impacted HRV more than watching a relaxing nature video and can potentially be used as key adjuncts in psychotherapy to aid in regulating physiological functioning, although it appears that consistent breathing practice would be needed.
Keywords: HRV, soothing rhythm breathing, 6 breath per minute breathing, psychotherapy, biofeedback.

75. **Fried R. Integrating Music in Breathing Training and Relaxation: II. Applications. Biofeedback and Self-Regulation 1990;(15)2:171-177.**

doi:0363-3586/90/0600-0171506.00/0
https://link.springer.com/article/10.1007%2FBF00999147
Abstract
Psychophysiological observations, especially PETC02 and EEG, during relaxation training with deep-diaphragmatic breathing and mental imagery, suggest that the addition of certain types of music "deepens" breathing and quickens relaxation: PETC02 "normalizes" with decreased respiration rate, and EEG shows decreased average theta and increased alpha. The combined psychophysiological indices suggest that music potentiates the hypometabolic counterarousal state. And clients unanimously report that they enjoy it.
Keywords: music; breathing; diaphragmatic breathing training; CO2 biofeedback; relaxation; hyperventilation; mental imagery; EEG.

76. **Ainslie PN, Duffin J. Integration of cerebrovascular CO2 reactivity and chemoreflex control of breathing: mechanisms of regulation, measurement, and interpretation. Am J Physiol Regul Integr Comp Physiol 2009;296: R1473–R1495.**

doi:10.1152/ajpregu.91008.2008
https://journals.physiology.org/doi/full/10.1152/ajpregu.91008.2008
Abstract
Cerebral blood flow (CBF) and its distribution are highly sensitive to changes in the partial pressure of arterial CO2 (PaCO2). This physiological response, termed cerebrovascular CO2 reactivity, is a vital homeostatic function that helps regulate and maintain central pH and, therefore, affects the respiratory central chemoreceptor stimulus. CBF increases with hypercapnia to wash out CO2 from brain tissue, thereby attenuating the rise in central PCO2, whereas hypocapnia causes cerebral vasoconstriction, which reduces CBF and attenuates the fall of brain tissue PCO2. Cerebrovascular reactivity and ventilatory response to PaCO2 are therefore tightly linked, so that the regulation of CBF has an important role in stabilizing breathing during fluctuating levels of chemical stimuli. Indeed, recent reports indicate that cerebrovascular responsiveness to CO2, primarily via its effects

at the level of the central chemoreceptors, is an important determinant of eupneic and hypercapnic ventilatory responsiveness in otherwise healthy humans during wakefulness, sleep, and exercise and at high altitude. In particular, reductions in cerebrovascular responsiveness to CO2 that provoke an increase in the gain of the chemoreflex control of breathing may underpin breathing instability during central sleep apnea in patients with congestive heart failure and on ascent to high altitude. In this review, we summarize the major factors that regulate CBF to emphasize the integrated mechanisms, in addition to PaCO2, that control CBF. We discuss in detail the assessment and interpretation of cerebrovascular reactivity to CO2. Next, we provide a detailed update on the integration of the role of cerebrovascular CO2 reactivity and CBF in regulation of chemoreflex control of breathing in health and disease. Finally, we describe the use of a newly developed steady-state modeling approach to examine the effects of changes in CBF on the chemoreflex control of breathing and suggest avenues for future research.

Keywords: cerebral blood flow, ventilation, reactivity.

77. **Kaiser N, Butler E. Introducing Social Breathing: A Model of Engaging in Relational Systems. Front. Psychol. 2021:12:571298.**

doi:10.3389/fpsyg.2021.571298
https://www.frontiersin.org/articles/10.3389/fpsyg.2021.571298/full

Abstract

We address what it means to “engage in a relationship” and suggest Social Breathing as a model of immersing ourselves in the metaphorical social air around us, which is necessary for shared intention and joint action. We emphasize how emergent properties of social systems arise, such as the shared culture of groups, which cannot be reduced to the individuals involved. We argue that the processes involved in Social Breathing are: (1) automatic, (2) implicit, (3) temporal, (4) in the form of mutual bi-directional interwoven exchanges between social partners and (5) embodied in the coordination of the brains and behaviors of social partners. We summarize cross-disciplinary evidence suggesting that these processes involve a multi-person whole-brain-body network which is critical for the development of both we-ness and relational skills. We propose that Social Breathing depends on each individual’s ability to sustain multimodal interwovenness, thus providing a theoretical link between social neuroscience and relational/multi-person psychology. We discuss how the model could guide research on autism, relationships, and psychotherapy.

Keywords: non-verbal behavior, implicit processes, shared intentionality, non-linear dynamics, mutual regulation, multi-brain networks, relational systems.

78. **Beverley H, Dorsey J. Just Breathe: The Respiratory System. Medical Terminology for Dummies, Chapter 17, 221-226, 2009, Wiley Publishing.**

doi:10.1002/9781118269251
https://onlinelibrary.wiley.com/doi/book/10.1002/9781118269251

79. **Hoffmann S, Jendreizikb LT, Ettingerc U, Laborde S. Keeping the pace: The effect of slow-paced breathing on error monitoring. International Journal of Psychophysiology 2019;146:217-224.**

https://doi.org/10.1016/j.ijpsycho.2019.10.001
https://www.sciencedirect.com/science/article/abs/pii/S0167876019305100

Abstract

Detecting errors is crucial for adapting one's own actions. Moreover, behavior is often optimized by adapting to maladaptive actions, i.e. errors. In this regard, recent studies and models of error monitoring point to an involvement of emotional states in error monitoring. A psychophysiological correlate of the latter is the error negativity or error-related negativity (Ne/ERN), reflecting partly the functional implementation of anterior cingulate cortex functions. In the present study, we aimed to test whether neurophysiological aspects of error monitoring can be altered by a relaxation technique, i.e. slow-paced breathing. Slow-paced breathing has been shown to increase cardiac vagal activity. According to the neurovisceral integration model, cardiac vagal activity is thought to be a marker of the effectiveness of executive functions. We tested the effect of slow-paced breathing on error

monitoring, i.e. the Ne/ERN and behavioral adaptation in a modified flanker task, a cognitive task during which performance depends on executive control. The Ne was increased following slow-paced breathing compared to a passive control condition. Furthermore, behavioral results indicate that response variability decreased in the slow-paced breathing condition whereas overall performance remained constant. We conclude that slow-paced breathing improves the ability to focus on the task at hand. Thus, the error monitoring system is being supported in keeping the pace, i.e. tracking responses.
Keywords: Error monitoring, Cardiac vagal activity, Slow-paced breathing, Self-control, Anterior cingulate cortex, Cognitive control.

80. Schöne S, et al. Mindful breath awareness meditation facilitates efficiency gains in brain networks. A steady-state visually evoked potentials study. Scientific Reports 2018;8:13687.

doi:10.1038/s41598-018-32046-5
https://www.nature.com/articles/s41598-018-32046-5
The beneficial effects of mindfulness-based therapeutic interventions have stimulated a rapidly growing body of scientific research into underlying psychological processes. Resulting evidence indicates that engaging with mindfulness meditation is associated with increased performance on a range of cognitive tasks. However, the mechanisms promoting these improvements require further investigation. We studied changes in behavioural performance of 34 participants during a multiple object tracking (MOT) task that taps core cognitive processes, namely sustained selective visual attention and spatial working memory. Concurrently, we recorded the steady-state visually evoked potential (SSVEP), an EEG signal elicited by the continuously flickering moving objects, and indicator of attentional engagement.
Participants were tested before and after practicing eight weeks of mindful breath awareness meditation or progressive muscle relaxation as active control condition. The meditation group improved their MOT-performance and exhibited a reduction of SSVEP amplitudes, whereas no such changes were observed in the relaxation group. Neither group changed in self-reported positive affect and mindfulness, while a marginal increase in negative affect was observed in the mindfulness group. This novel way of combining MOT and SSVEP provides the important insight that mindful breath awareness meditation may lead to refinements of attention networks, enabling more efficient use of attentional resources.

81. Jordan LM, Sławinska U. Modulation of rhythmic movement: Control of coordination. Jean-Pierre Gossard, Réjean Dubuc, Arlette Kolta (Eds.) Progress in Brain Research, Vol. 188, 2011, Chapter 12:181-195. Elsevier B.V. ISSN: 0079-6123

doi:10.1016/B978-0-444-53825-3.00017-6
https://www.sciencedirect.com/science/article/abs/pii/B9780444538253000176
Abstract
Three rhythmic movements, breathing, walking, and chewing, are considered from the perspective of the emerging factors that control their coordination. This takes us beyond the concept of a core excitatory kernel and into the common principles that govern the interaction between components of the neural networks that must be orchestrated properly to produce meaningful movement beyond the production of the basic rhythm. We focus on the role of neuromodulators, especially 5-hydroxytryptamine (5-HT), in the production of coordinated breathing, walking, and chewing, and we review the evidence that at least in the case of breathing and walking, 5-HT input to the CPGs acts through the selection of inhibitory interneurons that are essential for coordination. We review data from recently developed mouse models that offer insight into the contributions of inhibitory coordinating neurons, including the development of a new model that has allowed the revelation that there are glycinergic pacemaker neurons that likely contribute to the production of the respiratory rhythm. Perhaps walking and chewing will not be far behind.
Keywords: respiration, mastication, locomotion, spinal cord injury, serotonine, glycine, GABA.

82. **Paccione CE, Jacobsen HB. Motivational Non-directive Resonance Breathing as a Treatment for Chronic Widespread Pain. Front. Psychol. 2019:10:1207.**
doi:10.3389/fpsyg.2019.01207
https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01207/full
Abstract
Chronic widespread pain (CWP) is one of the most difficult pain conditions to treat due to an unknown etiology and a lack of innovative treatment design and effectiveness. Based upon preliminary findings within the fields of motivational psychology, integrative neuroscience, diaphragmatic breathing, and vagal nerve stimulation, we propose a new treatment intervention, motivational non-directive (ND) resonance breathing, as a means of reducing pain and suffering in patients with CWP. Motivational ND resonance breathing provides patients with a noninvasive means of potentially modulating five psychophysiological mechanisms imperative for endogenously treating pain and increasing overall quality of life.
Keywords: chronic widespread pain, non-directive meditation, diaphragmatic breathing, transcutaneous vagal, nerve stimulation, baroreceptor sensitivity, heart rate variability, resonance frequency breathing, motivation.

83. **Baraniuk JN, Merck SJ. Nasal Reflexes: Implications for Exercise, Breathing, and Sex. Current Allergy and Asthma Reports 2008;8:147-153.**
doi:10.1007/s11882-008-0025-7
https://link.springer.com/article/10.1007/s11882-008-0025-7
Abstract
Nasal patency, with both congestion and decongestion, is affected in a wide variety of reflexes. Stimuli leading to nasal reflexes include exercise; alterations of body position, pressure, and temperature; neurologic syndromes; and dentistry. As anticipated, the vagal and trigeminal systems are closely integrated through nasobronchial and bronchonasal reflexes. However, perhaps of greater pathophysiologic importance are the naso-hypopharyngeal-laryngeal reflexes that become aggravated during sinusitis. None other than Sigmund Freud saw deeply
beyond the facial adornment and recognized the deeper sexual tensions that can regulate nasal functions and psychoanalytical status. Wine, women, and song are linked with airflow through the nose—the nose, which by any other name would still smell as sweetly.

84. **Garcia AJ, Zanella S, Koch H, Doi A, Ramirez JM. Networks within networks: The neuronal control of breathing. Jean-Pierre Gossard, Réjean Dubuc, Arlette Kolta (Eds.) Progress in Brain Research, Vol. 188, 2011, Chapter 3:31-50. Elsevier B.V. ISSN: 0079-6123.**
doi:10.1016/B978-0-444-53825-3.00008-5
https://www.sciencedirect.com/science/article/abs/pii/B9780444538253000085
Abstract
Breathing emerges through complex network interactions involving neurons distributed throughout the nervous system. The respiratory rhythm generating network is composed of micro networks functioning within larger networks to generate distinct rhythms and patterns that characterize breathing. The pre-Bötzinger complex, a rhythm generating network located within the ventrolateral medulla assumes a core function without which respiratory rhythm generation and breathing cease altogether. It contains subnetworks with distinct synaptic and intrinsic membrane properties that give rise to different types of respiratory rhythmic activities including eupneic, sigh, and gasping activities. While critical aspects of these rhythmic activities are preserved when isolated in in vitro preparations, the pre-Bötzinger complex functions in the behaving animal as part of a larger network that receives important inputs from areas such as the pons and parafacial nucleus. The respiratory network is also an integrator of modulatory and sensory inputs that imbue the network with the important ability to adapt to changes in the behavioral, metabolic, and developmental conditions of the organism. This review summarizes our current understanding of these interactions and relates the emerging concepts to insights gained in other rhythm generating networks.

Keywords: Breathing; Respiratory rhythm generation; Pre-Botzinger complex and interactions.

85. **von Leupoldt A, Bradley MM, Lang PJ, Davenport PW. Neural processing of respiratory sensations when breathing becomes more difficult and unpleasant. Frontiers in Physiology 2010;1:144.**

https://doi.org/10.3389/fphys.2010.00144
https://www.frontiersin.org/articles/10.3389/fphys.2010.00144/full

Abstract

The accurate perception of respiratory sensations is important for the successful management and treatment of respiratory diseases. Previous studies demonstrated that external stimuli such as affective pictures and distracting films can impact the perception and neural processing of respiratory sensations. This study examined the neural processing of respiratory sensations when breathing as an internal stimulus is manipulated and becomes more difficult and unpleasant.

Sustained breathing through an inspiratory resistive load was used to increase perceived breathing difficulty in 12 female individuals without respiratory disease. Using high-density EEG, respiratory-related evoked potentials (RREP) to short inspiratory occlusions were recorded at early versus late time points of sustained loaded breathing. Ratings of perceived intensity and unpleasantness of breathing difficulty showed an increase from early to late time points of loaded breathing ($p < 0.01$ and $p < 0.05$, respectively). This was paralleled by significant increases in the magnitudes of RREP components N1, P2, and P3 ($p < 0.01$, $p < 0.05$, and $p < 0.05$, respectively).

The present results demonstrate increases in the neural processing of respiratory sensations when breathing becomes more difficult and unpleasant. This might reflect a protective neural mechanism allowing effective response behavior when air supply is at risk.

Keywords: brain, breathing difficulty, breathlessness, dyspnea, EEG, neural processing, perception, respiratory-related evoked potential.

86. **Villemure C, Ceko M, Cotton VA, Bushnell MC. Neuroprotective effects of yoga practice: age, experience and frequency-dependent plasticity. Front. Hum. Neurosci. 2015;9:281.**

doi:10.3389/fnhum.2015.00281
https://www.frontiersin.org/articles/10.3389/fnhum.2015.00281/full

Abstract

Yoga combines postures, breathing, and meditation. Despite reported health benefits, yoga's effects on the brain have received little study. We used magnetic resonance imaging to compare age-related gray matter (GM) decline in yogis and controls. We also examined the effect of increasing yoga experience and weekly practice on GM volume and assessed which aspects of weekly practice contributed most to brain size. Controls displayed the well documented age-related global brain GM decline while yogis did not, suggesting that yoga contributes to protect the brain against age-related decline. Years of yoga experience correlated mostly with GM volume differences in the left hemisphere (insula, frontal operculum, and orbitofrontal cortex) suggesting that yoga tunes the brain toward a parasympatically driven mode and positive states. The number of hours of weekly practice correlated with GM volume in the primary somatosensory cortex/superior parietal lobule (S1/SPL), precuneus/posterior cingulate cortex (PCC), hippocampus, and primary visual cortex (V1). Commonality analyses indicated that the combination of postures and meditation contributed the most to the size of the hippocampus, precuneus/PCC, and S1/SPL while the combination of meditation and breathing exercises contributed the most to V1 volume. Yoga's potential neuroprotective effects may provide a neural basis for some of its beneficial effects.

Keywords: yoga, age-related gray matter decline, neuroprotection, magnetic resonance imaging, voxel-based morphometry.

87. **Pilowsky PM. Peptides, Serotonin, and Breathing: The Role of the Raphe in the Control of Respiration. Progress in Brain Research, Volume 209, Chapter 3; 2014;209:169-89.**

http://dx.doi.org/10.1016/B978-0-444-63274-6.00009-6
https://www.sciencedirect.com/science/article/abs/pii/B9780444632746000096

Abstract
Over the last 20 years, it has become clear that many functionally defined autonomic neurons in the brainstem contain many more than one neurotransmitter. Here, the possible role and functions of colocalized neuropeptides in the caudal raphe nuclei of the medulla oblongata are discussed.
Caudal raphe neurons provide an extensive input to neurons throughout the brainstem and spinal cord, including respiratory and cardiovascular neurons. It is concluded that one plausible function of colocalized neuropeptides is to maintain the membrane potential of target neurons within a defined window so that they remain able to function at extremes of activity.
Keywords: serotonin, caudal raphe, neuropeptides, TRH, substance P.

88. **Denny M. Periodic Variation in Inspiratory Volume Characterizes Speech as Well as Quiet Breathing. Journal of Voice 2000;(14)1:34-46.**

https://doi.org/10.1016/S0892-1997(00)80093-4
https://www.jvoice.org/article/S0892-1997(00)80093-4/fulltext
Abstract
Variability in inspired lung volume prior to speech is only partially accounted for by speech-related concerns such as the length and loudness of the planned utterance. Control mechanisms known to influence volume variability in nonspeech breathing could potentially account for some of this variability, but only if they operate during speech as well. This investigation was designed to test for the presence of several such mechanisms during reading aloud. Lung volumes were recorded from 5 normal females as they read silently, then aloud. Inspired volumes were correlated with the volumes of the previous and following expirations and with inspiratory duration. Coefficients of variation were calculated for inspiratory volume, duration, and mean flow. Time-series analyses were used to compare periodicity in inspired volume for quiet and speech breathing. Control mechanisms operating during both quiet breathing and reading aloud included slow oscillations in inspired volume and minimized variability in mean flow. Inspired volume prior to speech was weakly but significantly correlated with preceding and following expired volume. It is concluded that some control strategies typical of quiet breathing contribute to volume variability in speech breathing.
Keywords: Control of breathing, Speech motor control, Pattern of breathing, Speech, Voice.

89. **Ross JM, Balasubramaniam R. Physical and neural entrainment to rhythm: human sensorimotor coordination across tasks and effector systems. Frontiers in Human Neuroscience 2014;8:576.**

https://doi.org/10.3389/fnhum.2014.00576
https://www.frontiersin.org/articles/10.3389/fnhum.2014.00576/full
Abstract
The human sensorimotor system can be readily entrained to environmental rhythms, through multiple sensory modalities. In this review, we provide an overview of theories of timekeeping that make this neuroentrainment possible. First, we present recent evidence that contests the assumptions made in classic timekeeper models. The role of state estimation, sensory feedback and movement parameters on the organization of sensorimotor timing are discussed in the context of recent experiments that examined simultaneous timing and force control. This discussion is extended to the study of coordinated multi-effector movements and how they may be entrained.
Keywords: neuroentrainment, sensorimotor coordination, timekeeping, force control, state estimation, rhythm.

90. **Pierucci P et al. Prolonged Active Prone Positioning in Spontaneously Breathing Non-intubated Patients With COVID-19-Associated Hypoxemic Acute Respiratory Failure With PaO2/FiO2 >150. Front. Med. 2021;8:626321.**

doi:10.3389/fmed.2021.626321
https://www.frontiersin.org/articles/10.3389/fmed.2021.626321/full
Background: The COVID-19 pandemic has led to new approaches to manage patients outside the ICU, including prone positioning in non-intubated patients.

Objectives: To report the use of prolonged active prone positioning in spontaneously breathing patients with COVID-19-associated acute respiratory failure. Spontaneously breathing vs non-invasive respiratory support for COVID19 associated acute respiratory failure.
Methods: Patients with PaO2/FiO2 > 150, with lung posterior consolidations as assessed by means of lung ultrasound, and chest x-ray were studied. Under continuous pulse oximetry (SpO2) monitoring, patients maintained active prone position.
A PaO2/FiO2 < 150 was considered as treatment failure and patients had to be switched to non-invasive respiratory support. Retrospectively, data of 16 patients undergoing who refused proning and underwent non-invasive respiratory support were used as controls. The primary outcome was the proportion of patients maintaining prolonged prone position and discharged home. Secondary outcomes included improvement in oxygenation, hospital length of stay, and 6-month survival.
Results: Three out of 16 (18.7%) patients did not tolerate the procedure. Three more patients showed a worsening in PaO2/FiO2 to <150 and required non-invasive support, two of whom finally needing endotracheal intubation. After 72 h, 10 out of 16 (62.5%) patients improved oxygenation [PaO2/FiO2: from 194.6 (42.1) to 304.7 (79.3.2) ($p < 0.001$)] and were discharged home. In the control group, three out of 16 failed, required invasive ventilatory support, and died within 1 month in ICU. Thirteen were successful and discharged home.
Conclusion: In non-intubated spontaneously breathing COVID-19 patients with PaO2/FiO2 >150, active prolonged prone positioning was feasible and tolerated with significant improvement in oxygenation.
Keywords: COVID-19, prone position, non-intubated, spontaneously breathing, hypoxic respiratory failure.

91. **Ansgar CA et al. Psychophysiological Effects of Breathing Instructions for Stress Management. Appl Psychophysiol Biofeedback 2007;32:89-98.**

doi:10.1007/s10484-007-9034-x
https://link.springer.com/article/10.1007/s10484-007-9034-x
Abstract
Stressed and tense individuals often are recommended to change the way they breathe. However, psychophysiological effects of breathing instructions on respiration are rarely measured. We tested the immediate effects of short and simple breathing instructions in 13 people seeking treatment for panic disorder, 15 people complaining of daily tension, and 15 controls. Participants underwent a 3-hour laboratory session during which instructions to direct attention to breathing and anti-hyperventilation instructions to breathe more slowly, shallowly, or both were given.
Respiratory, cardiac, and electrodermal measures were recorded. The anti-hyperventilation instructions failed to raise end-tidal pCO2 above initial baseline levels for any of the groups because changes in respiratory rate were compensated for by changes in tidal volume and vice versa. Paying attention to breathing significantly reduced respiratory rate and decreased tidal volume instability compared to the other instructions. Shallow breathing made all groups more anxious than did other instructions. Heart rate and skin conductance were not differentially affected by instructions. We conclude that simple and short instructions to alter breathing do not change respiratory or autonomic measures in the direction of relaxation, except for attention to breathing, which increases respiratory stability. To understand the results of breathing instructions for stress and anxiety management, respiration needs to be monitored physiologically.
Keywords: Anxiety, Hyperventilation, Panic, Relaxation, Respiration, Stress.

92. **Gholamrezaei A, et al. Psychophysiological responses to various slow, deep breathing techniques. Psychophysiology 2021;58(2):e13712.**

https://doi.org/10.1111/psyp.13712
https://onlinelibrary.wiley.com/doi/10.1111/psyp.13712
Abstract
Deep breathing exercises are commonly used for several health conditions including pain and hypertension. Various techniques are available to practice deep breathing, whereas possible

differential psychophysiological effects have not been investigated. We compared four deep breathing techniques and examined outcomes in blood pressure variability, respiratory sinus arrhythmia, baroreflex function, and emotional state. Healthy adult volunteers performed pursed-lips breathing, left and right unilateral nostril breathing, and deep breathing with an inspiratory threshold load (loaded breathing), all at a frequency of 0.1 Hz (i.e., controlled breathing) and for three minutes each. Results showed that blood pressure variability was higher during loaded breathing versus other conditions and higher during pursed-lips breathing versus left and right unilateral nostril breathing. Respiratory sinus arrhythmia was higher during loaded breathing versus other conditions and higher during pursed-lips breathing versus left unilateral nostril breathing. The effect of breathing condition on respiratory sinus arrhythmia was mediated by alterations in blood pressure variability. There was no difference between the breathing conditions in baroreflex sensitivity or effectiveness.
Participants rated pursed-lips breathing as more calming and pleasant and with more sense of control (vs. other conditions). Overall, among the four tested deep breathing techniques, loaded breathing was associated with enhanced cardiovascular effects and pursed-lips breathing with better emotional responses, while also enhancing cardiovascular effects (albeit less than loaded breathing). These findings can be informative in applying deep breathing techniques as self-management interventions for health conditions, in which baroreceptors stimulation and autonomic and emotional modulations can be beneficial, such as pain and hypertension.
Keywords: autonomic, baroreflex, breathing exercise, heart rate variability, hypertension, pain.

93. Wallert J, Madison G. Recovery after aerobic exercise is manipulated by tempo change in a rhythmic sound pattern, as indicated by autonomic reaction on heart functioning. Frontiers in Human Neuroscience 2014;8:738.

https://doi.org/10.3389/fnhum.2014.00738
https://www.frontiersin.org/articles/10.3389/fnhum.2014.00738/full
Abstract
Physical prowess is associated with rapid recovery from exhaustion. Here we examined whether recovery from aerobic exercise could be manipulated with a rhythmic sound pattern that either decreased or increased in tempo. Six men and six women exercised repeatedly for six minutes on a cycle ergometer at 60 percent of their individual maximal oxygen consumption, and then relaxed for six minutes while listening to one of two sound pattern conditions, which seemed to infinitely either decrease or increase in tempo, during which heart and breathing activity was measured. Participants exhibited more high-frequent heart rate variability when listening to decreasing tempo than when listening to increasing tempo, accompanied by a non-significant trend towards lower heart rate. The results show that neuropsychological entrainment to a sound pattern may directly affect the autonomic nervous system, which in turn may facilitate physiological recovery after exercise. Applications using rhythmic entrainment to aid physical recovery are discussed.
Keywords: recovery, exercise, anisochronous, sound pattern, autonomic nervous system, heart rate variability, rhythmic entrainment.

94. Xu S, Akiom M, Yuan Z. Relationship between circadian rhythm and brain cognitive functions. Front. Optoelectron. 2021.

https://doi.org/10.1007/s12200-021-1090-y
https://link.springer.com/article/10.1007%2Fs12200-021-1090-y
Abstract
Circadian rhythms are considered a masterstroke of natural selection, which gradually increase the adaptability of species to the Earth's rotation. Importantly, the nervous system plays a key role in allowing organisms to maintain circadian rhythmicity. Circadian rhythms affect multiple aspects of cognitive functions (mainly via arousal), particularly those needed for effort-intensive cognitive tasks, which require considerable top-down executive control. These include inhibitory control, working memory, task switching, and psychomotor vigilance.
This mini review highlights the recent advances in cognitive functioning in the optical and multimodal neuroimaging fields; it discusses the processing of brain cognitive functions during the

circadian rhythm phase and the effects of the circadian rhythm on the cognitive component of the brain and the brain circuit supporting cognition.
Keywords: circadian rhythm, cognition, optical neuroimaging, multimodal neuroimaging.

95. Ghali MGZ. Respiratory rhythm generation and pattern formation: oscillators and network mechanisms. J. Integr. Neurosci. 2019;18(4):481-517.

doi:10.31083/j.jin.2019.04.188
https://jin.imrpress.com/EN/10.31083/j.jin.2019.04.188
Abstract
The respiratory rhythm is generated by the interaction of oscillators disparately distributed throughout the pons, medulla, and spinal cord. According to the classic model, the interaction amongst preBötzinger complex (preBötzC) spontaneously bursting preinspiratory units and Bötzinger complex (BötzC) expiratory cells generates the principal respiratory rhythm, thence relayed caudally to the pattern generating elements and premotoneurons of the rostral and caudal divisions of the ventral respiratory group and bulbospinal units of the dorsal respiratory group. Rhythm and pattern generating elements in the ventrolateral medulla receive powerful phasic and tonic modulatory inputs from diencephalic structures, midbrain,
Kölliker-Fuse, and parabrachial nuclei, retrotrapezoid nucleus, parafacial respiratory group, ventrolateral metencephalon, nucleus tractus solitarius, and brainstem reticular formation, collectively shaping the normal eupneic discharge.
Empirical and computational studies have generated models of respiratory rhythmogenesis and pattern formation variously predicated upon pacemaker, network, or hybrid pacemaker network mechanisms to explain oscillatory behavior and regularity. Network mechanisms critically require the integrity and functionality of inhibitory synaptic neurotransmission. The operation and contribution of inhibitory elements in respiratory rhythm generation and pattern formation are well demonstrated empirically and incorporated in computational network and hybrid models of breathing. Fast inhibitory synaptic neurotransmission utilizes GABAAergic and glycinergic mediated activation of receptor linked chloride conductances, generating an inwardly directed flux of chloride ions mediating membrane voltage hyperpolarization and is required to generate eupneic respiratory patterns in vivo and situ.
Persistence of rhythmicity in the presence of synaptic antagonism of GABAA and glycine receptor mediated fast inhibitory neurotransmission indicates pacemaker generating mechanisms sufficiently capable of independently generating this behavior in vitro and transected intact preparations maintaining the preBötzC as the most rostrally preserved structure. The role of GABAB receptor mediated neuromodulation in respiratory rhythm generation and pattern formation is comparatively significantly less investigated. GABABergic activation of postsynaptic and presynaptic membrane receptors variably upregulates potassium conductances and downregulates calcium conductances. Respiratory rhythm and pattern are powerfully modulated in vivo, in situ, and in vitro by superfusion or localized microinjections of GABABergic agonists and antagonists, though are typically not abolished by these experimental interventions. Directionality and magnitude of these effects exhibit maturational changes. The relative depolarization of chloride reversal potentials during the early neonatal period, with gradual shifts towards normal hyperpolarizing values during development, suggests GABABergic signaling may mediate the inhibitory neurotransmission necessary to generate triphasic eupnea. We review and discuss the role of spontaneously bursting oscillators and network mechanisms predicating upon fast inhibitory synaptic neurotransmission in contributing to respiratory rhythmogenesis and pattern formation.
Keywords: GABAB, neurochemistry, electrophysiology, phrenic, brainstem, respiratory, rhythmogenesis, central pattern generation, inhibition. neonates.

96. Jerath R, Beveridge C. Respiratory Rhythm, Autonomic Modulation, and the Spectrum of Emotions: The Future of Emotion Recognition and Modulation. Front. Psychol. 2020;11:1980.

doi:10.3389/fpsyg.2020.01980

https://www.frontiersin.org/articles/10.3389/fpsyg.2020.01980/full
Abstract
Pulmonary ventilation and respiration are considered to be primarily involved in oxygenation of blood for oxygen delivery to cells throughout the body for metabolic purposes. Other pulmonary physiological observations, such as respiratory sinus arrhythmia, Hering Brewer reflex, cardiorespiratory synchronization, and the heart rate variability (HRV) relationship with breathing rhythm, lack complete explanations of physiological/functional significance. The spectrum of waveforms of breathing activity correlate to anxiety, depression, anger, stress, and other positive and negative emotions.
Respiratory pattern has been thought not only to be influenced by emotion but to itself influence emotion in a bi-directional relationship between the body and the mind.
In order to show how filling in gaps in understanding could lead to certain future developments in mind–body medicine, biofeedback, and personal health monitoring, we review and discuss empirical work and tracings to express the vital role of bodily rhythms in influencing emotion, autonomic nervous system activity, and even general neural activity. Future developments in measurement and psychophysiological understanding of the pattern of breathing in combination with other parameters such as HRV, cardiorespiratory synchronization, and skin conductivity may allow for biometric monitoring systems to one day accurately predict affective state and even affective disorders such as anxiety. Better affective prediction based on recent research when incorporated into personal health monitoring devices could greatly improve public mental health by providing at-home biofeedback for greater understanding of one's mental state and for mind–body affective treatments such as breathing exercises.
Keywords: respiration, respiratory rhythm, emotion, emotion recognition, autonomic nervous system, health monitoring.

97. **Rahal D, et al.Resting Parasympathetic Nervous System Activity is Associated with Greater Antiviral Gene Expression. Brain, Behavior, and Immunity 2021 In Press.**

https://doi.org/10.1016/j.bbi.2021.08.229
https://www.sciencedirect.com/science/article/abs/pii/S0889159121005183
Abstract
Parasympathetic nervous system activity can downregulate inflammation, but it remains unclear how parasympathetic nervous system activity relates to antiviral activity. The present study examined associations between parasympathetic nervous system activity and cellular antiviral gene regulation in 90 adolescents (Mage = 16.3, SD = 0.7; 51.1% female) who provided blood samples and measures of cardiac respiratory sinus arrhythmia (RSA), twice, five weeks apart.
Using a multilevel analytic framework, we found that higher RSA (an indicator of higher parasympathetic nervous system activity)—both at rest and during paced breathing—was associated with higher expression of Type I interferon (IFN) response genes in circulating leukocytes, even after adjusting for demographic and biological covariates. RSA was not associated with a parallel measure of inflammatory gene expression. These results identify a previously unrecognized immunoregulatory aspect of autonomic nervous system function and highlight a potential biological pathway by which parasympathetic nervous system activity may relate to health.
Key words: antiviral gene expression, Type I interferon (IFN) expression, parasympathetic nervous system, autonomic nervous system.

98. **Sharma P, Tapliyal A, Chandra T, Singh S, Baduni H, Waheed SM. Rhythmic Breathing: Immunological, Biochemical, and Physiological Effects on Health. Advances in Mind-Body Medicine 2015;29(1):18-25.**

https://pubmed.ncbi.nlm.nih.gov/25607119/
Abstract
Yoga and breathing techniques have become increasingly popular in recent decades. Sudarshan Kriya (SK) is a type of rhythmic and controlled breathing that involves cyclic breathing in which long breaths are followed by medium and short breaths. Scientific research has been conducted to study

the effects of SK on different physiological parameters. Various studies have shown that the technique is simple and cost effective and can be used as a complementary therapy, together with ongoing conventional treatments, to help people suffering from extreme levels of stress, anxiety, and other physical problems. Studies have demonstrated that SK can play an important role in promoting a healthy lifestyle by improving immunity, antioxidant status, hormonal status, and brain functioning. Trough available scientific evidence and research, the current article aims to review the complementary role of rhythmic breathing (ie, SK) as a practical and effective tool to alleviate stress, improve health, and increase wellness.

99. Raghuraj P, Telles S. Right uninostril yoga breathing influences ipsilateral components of middle latency auditory evoked potentials. Neurol Sci 2004;25:274-280.

doi:10.1007/s10072-004-0354-9

https://link.springer.com/article/10.1007%2Fs10072-004-0354-9

Abstract

Abstract A previous report described selective electrical activity of the cerebral hemispheres with uninostril breathing.

In the present study, middle latency auditory evoked potentials (MLAEPs) were recorded from symmetrical scalp sites during the practice of uninostril yoga breathing.

There were two sessions (40 min each) of right nostril yoga breathing (RNB) and of breath awareness (BAW), with (i) 'before', (ii) test (either RNB or BAW) and (iii) 'after' periods. The participants were 14 male volunteers aged between 18 and 33 years, and the setting was a yoga centre. MLAEPs were recorded from symmetrical scalp sites (C4 and C3). During RNB, the peak amplitudes of two negative components (viz. Na wave and Nb wave) were significantly increased on the right side. Increased peak amplitudes of Na and Nb waves suggested that RNB increased the number of neurons recruited on the right side, suggesting a possible application of RNB in certain psychiatric disorders with cerebral hemispheric imbalance.

Keywords: Right nostril yoga breathing, Breath awareness, Middle latency auditory evoked potentials.

100. Brinsley J, Smout M, Davison K. Satisfaction with Online Versus In-Person Yoga During COVID-19. Online ahead of print.

doi:10.1089/acm.2021.0062

https://www.liebertpub.com/doi/pdf/10.1089/acm.2021.0062

Abstract

Introduction: During COVID-19 restrictions, yoga classes transitioned to online delivery. This report compares the perceived benefits and barriers to online and in-person yoga and determine the preferred format. A secondary aim was to compare how well each format was perceived to produce common benefits of yoga practice.

Materials and Methods: A cross-sectional online survey of Australian participants.

Results: In-person yoga scored highest for providing mental health/mood benefits, physical satisfaction, and feeling energized. Online yoga scored highest for convenience, mental health/mood benefits, and affordability (initial N = 156; follow-up N = 55).

Conclusion: Online yoga was acceptable and perceived to provide improved mental health and mood.

Keywords: yoga, mental health, exercise, e-health, COVID-19.

101. Jerath R, Beveridge C, Barnes VA. Self-Regulation of Breathing as an Adjunctive Treatment of Insomnia. Front. Psychiatry 2019;9:780.

doi:10.3389/fpsyt.2018.00780

https://www.frontiersin.org/articles/10.3389/fpsyt.2018.00780/full

Sleep is a quiescent behavioral state during which complex homeostatic functions essential to health and well-being occur. Insomnia is a very common psychiatric disorder leading to a myriad of detrimental effects including loss of concentration, memory, and performance as well as disease. Current pharmaceutical treatments can be expensive, impairing, unhealthy, and habit-forming. Relaxation techniques, such as meditation target the brain and body in contrast to pharmaceutical

interventions which solely target neurotransmitter systems in the brain. In this article we present a viewpoint on the treatment of insomnia that techniques of slow, deep breathing (0.1Hz) in adjunct to sleep hygiene and relaxation therapies may be highly effective in initiating sleep as well as facilitating falling back asleep. The autonomic nervous system is integral to sleep initiation, maintenance, and disruption. Understanding the relationship between the autonomic nervous system and sleep physiology along with the nature of sleep itself remains a challenge to modern science. We present this perspective in light of a prevailing "dysevolution" theory on the pathology of insomnia that proposes hyper-arousal characterized in part by chronic sympathetic hyperactivation and/or parasympathetic hypoactivation disrupts normal sleep onset latency, sleep quality, and sleep duration. We additionally discuss physiological mechanisms responsible for the effectiveness of the breathing treatment we describe. A better understanding of these mechanisms and autonomic pathologies of insomnia may provide support for the effectiveness of such techniques and provide relief to sufferers of this health epidemic.
Keywords: insomnia, autonomic nervous system, hyper-arousal, evolutionary mismatch hypothesis, paced breathing, slow breathing, cardiorespiratory synchronization.

102. Takano N, Deguchi H. Sensation of breathlessness and respiratory oxygen cost during cycle exercise with and without conscious entrainment of the breathing rhythm. Eur J Appl Physiol 1997;76:209-213.

doi:10.1007/s004210050238
https://link.springer.com/article/10.1007%2Fs004210050238
Abstract
The conscious entrainment of respiratoryrhythm to exercise rhythm (ENT) has been hypothesized to alleviate breathing discomfort and reduce the oxygen (O2) cost of ventilation with a resulting decrease in total O2 uptake .V_ O2. during rhythmic exercise. This hypothesis has been tested in the study reported here. Eight female subjects performed cycle exercise at 50 rpm under two work load conditions of 40% and 60% of maximal V_ O2. During a 30-min exercise period at each work load, each subject was asked to breathe under two conditions for 15 min each: (1) spontaneously (non-ENT run), and (2) deliberately entraining the breathing rhythm to the cycling rhythm at preferred coupling ratios of the two rhythms (ENT run). In the ENT run, most subjects chose a ratio of 1:2. In each run, pulmonary ventilation (V_E), total V_ O2 and the breathlessness sensation (BS) were measured at 4±5 min. BS was assessed according to a Borg category scale. The remaining 10 min of each 15-min run were allotted for measurement of the O2 cost of ventilation (DV_ O2=DV_E), assessed by a hypercapnia-induced hyperventilation method in which the V_ O2 of the respiratory muscles (V_ O2RM) was calculated by multiplying DV_ O2=DV_E by the prevailing V_E. On aver-age, there were no significant di.erences in any of the variables, V_ O2; DV_ O2=DV_E; V_ O2RM and BS, between the non-ENT and ENT runs performed at any work load. However, there were wide variations among the subjects in the differences (D) between the two runs, and significant correlations were found between DV_ O2 vs DV_E; DV_ O2 vs DV_ O2RM, and D BS vs DV_O2RM of individual subjects. These results indicate that reductions of the total V_ O2 and BS with ENT could occur in subjects in whom the V_ O2RM decreased during ENT.
Keywords Exercise, Respiration, Rhythm coordination, Oxygen cost of breathing.

103. Gonzalez-Gerez, JJ et al. Short-Term Effects of a Respiratory Telerehabilitation Program in Confined COVID-19 Patients in the Acute Phase: A Pilot Study. Int. J. Environ. Res. Public Health 2021;18:7511.

https://doi.org/10.3390/ijerph18147511
https://www.mdpi.com/1660-4601/18/14/7511
Abstract
The COVID-19 pandemic has caused distress for healthcare providers due to the respiratory problems it causes, among others. In this situation, rehabilitation of the respiratory system has been suggested and implemented in different COVID-19 patients. This study evaluated the feasibility and effectiveness of a novel program based on breathing exercises through telerehabilitation tools in

COVID-19 patients with mild to moderate symptomatology in the acute stage. Forty subjects were randomized in an experimental group, based on pulmonary rehabilitation, and in a control group, of which the subjects did not perform physical activity. Thirty-eight subjects, with nineteen in each group, completed the one-week intervention. We performed measurements using the Six-Minute Walk Test, Multidimensional Dyspnoea-12, Thirty-Second Sit-To-Stand Test, and Borg Scale. Both groups were comparable at baseline. Significant differences were found for all of the outcome measures in favour of the experimental group. Ninety percent adherence was found in our program. A one-week telerehabilitation program based on respiratory exercises is effective, safe, and feasible in COVID-19 patients with mild to moderate symptomatology in the acute stage.
Keywords: COVID-19, physical therapy specialty, telerehabilitation, breathing exercises.

104. Pal GK, Agarwal A, Karthik S, Pal P, Nanda N. Slow Yogic Breathing Through Right and Left Nostril Influences Sympathovagal Balance, Heart Rate Variability, and Cardiovascular Risks in Young Adults. N Am J Med Sci. 2014;6(3):145-151.

doi:10.4103/1947-2714.128477
https://www.najms.org/temp/NorthAmJMedSci63145-3603558_100035.pdf
Abstract
Background: Specific nostril breathing is known to influence autonomic functions. Aim: The study was to assess the effects of right nostril breathing (RNB) and left nostril breathing (LNB) on heart rate variability (HRV) and cardiovascular functions. Material and Methods: Eighty-five student volunteers were divided into three groups: RNB group (n = 30), LNB group (n = 30), and control group (n = 25). RNB and LNB group subjects practiced right and left nostril breathing, respectively, every day 1 h for 6 weeks. The control group did not practice nostril breathing. Cardiovascular parameters and spectral indices of HRV were recorded before and after 6-week practice of nostril breathing. In RNB and LNB groups, prediction of rate-pressure product (RPP) by low-frequency to high-frequency ratio (LF-HF) of HRV was assessed by bivariate logistic regression. Results: HRV indices representing sympathetic activity were increased in the RNB group and indices representing parasympathetic activity were increased in LNB group following 6-week nostril breathing. Prediction of LF-HF to RPP, the marker of cardiovascular risks, was more significant (OR 2.65, P = 0.005) in the LNB group compared to the RNB group (OR 1.452, P = 0.016). Conclusions: Short-term practice of LNB improves vagal tone, increases HRV, and promotes cardiovascular health of medical students. Practice of RNB increases sympathetic tone and could jeopardize cardiovascular health.
Keywords: Autonomic functions, Cardiovascular risk, Heart rate variability, Nostril breathing, Sympathovagal balance.

105. Laborde S, et al. Slow-Paced Breathing: Influence of Inhalation/Exhalation Ratio and of Respiratory Pauses on Cardiac Vagal Activity. Sustainability 2021;13:7775.

https://doi.org/10.3390/su13147775
https://www.mdpi.com/2071-1050/13/14/7775
Abstract
Slow-paced breathing has been shown to enhance the self-regulation abilities of athletes via its influence on cardiac vagal activity. However, the role of certain respiratory parameters (i.e., inhalation/exhalation ratio and presence of a respiratory pause between respiratory phases) still needs to be clarified. The aim of this experiment was to investigate the influence of these respiratory parameters on the effects of slow-paced breathing on cardiac vagal activity. A total of 64 athletes (27 female; Mage = 22, age range = 18–30 years old) participated in a within-subject experimental design. Participants performed six breathing conditions within one session, with a 5 min washout period between each condition. Each condition lasted 5 min, with 30 respiratory cycles, and each respiratory cycle lasted 10 s (six cycles per minute), with inhalation/exhalation ratios of 0.8, 1.0, 1.2; and with or without respiratory pauses (0.4 s) between respiratory phases. Results indicated that the root mean square of successive differences (RMSSD), a marker of cardiac vagal activity, was higher when exhalation was longer than inhalation. The presence of a brief (0.4 s) post-inhalation and post-exhalation respiratory pause did not further influence RMSSD. Athletes practicing slow-paced

breathing are recommended to use an inhalation/exhalation ratio in which the exhalation phase is longer than the inhalation phase.
Keywords: cardiac vagal activity, slow-paced breathing, respiratory parameters. RMSSD.

106. Fields DP, Mitchell GS. Spinal metaplasticity in respiratory motor control. Frontiers in Neural Circuits 2015;9:2.

https://doi.org/10.3389/fncir.2015.00002
https://www.frontiersin.org/articles/10.3389/fncir.2015.00002/full
Abstract
A hallmark feature of the neural system controlling breathing is its ability to exhibit plasticity. Less appreciated is the ability to exhibit metaplasticity, a change in the capacity to express plasticity (i.e., "plastic plasticity"). Recent advances in our understanding of cellular mechanisms giving rise to respiratory motor plasticity lay the groundwork for (ongoing) investigations of metaplasticity. This detailed understanding of respiratory metaplasticity will be essential as we harness metaplasticity to restore breathing capacity in clinical disorders that compromise breathing, such as cervical spinal injury, motor neuron disease and other neuromuscular diseases. In this brief review, we discuss key examples of metaplasticity in respiratory motor control, and our current understanding of mechanisms giving rise to spinal plasticity and metaplasticity in phrenic motor output; particularly after pre-conditioning with intermittent hypoxia. Progress in this area has led to the realization that similar mechanisms are operative in other spinal motor networks, including those governing limb movement. Further, these mechanisms can be harnessed to restore respiratory and non-respiratory motor function after spinal injury.
Keywords: respiratory control, respiratory plasticity, metaplasticity, spinal cord, motor neuron, intermittent hypoxia, phrenic motor neuron.

107. Toschi-Dias E et al. Sudarshan Kriya Yoga improves cardiac autonomic control in patients with anxiety-depression disorders. Journal of Affective Disorders 2017;214:74-80.

http://dx.doi.org/10.1016/j.jad.2017.03.017
https://www.sciencedirect.com/science/article/pii/S0165032716316020
Abstract
Background: Several studies have demonstrated that adjuvant therapies as exercise and breathing training are effective in improving cardiac autonomic control (CAC) in patients with affective spectrum disorders. However, the effects of Sudarshan Kriya Yoga (SKY) on autonomic function in this population is unknown. Our objective was to test the hypothesis that SKY training improves CAC and cardiorespiratory coupling in patients with anxiety and/or depression disorders.
Methods: Forty-six patients with a diagnosis of anxiety and/or depression disorders (DSM-IV) were consecutively enrolled and divided in two groups: 1) conventional therapy (Control) and 2) conventional therapy associated with SKY (Treatment) for 15 days. Anxiety and depression levels were determined using quantitative questionnaires. For the assessment of CAC and cardiorespiratory coupling, cardiorespiratory traces were analyzed using monovariate and bivariate autoregressive spectral analysis, respectively.
Results: After 15-days, we observed a reduction of anxiety and depression levels only in Treatment group. Moreover, sympathetic modulation and CAC were significantly lower while parasympathetic modulation and cardiorespiratory coupling were significantly higher in the Treatment compared to Control group.
Conclusions: Intensive breathing training using SKY approach improves anxiety and/or depressive disorders as well as CAC and cardiorespiratory coupling. These finding suggest that the SKY training may be a useful nonpharmacological intervention to improve symptoms and reduce cardiovascular risk in patients with anxiety/depression disorders.
Keywords: Sudarshan Kriya Yoga, Affective disorders, Cardiac autonomic control, Cardiorespiratory coupling.

108. Rochet-Capellan A, Fuchs S. Take a breath and take the turn: how breathing meets turns in spontaneous dialogue. Phil. Trans. R. Soc. 2014;B 369:20130399.
http://dx.doi.org/10.1098/rstb.2013.0399
https://royalsocietypublishing.org/doi/10.1098/rstb.2013.0399
Abstract
Physiological rhythms are sensitive to social interactions and could contribute to defining social rhythms. Nevertheless, our knowledge of the implications of breathing in conversational turn exchanges remains limited. In this paper, we addressed the idea that breathing may contribute to timing and coordination between dialogue partners. The relationships between turns and breathing were analysed in unconstrained face-to-face conversations involving female speakers. No overall relationship between breathing and turn-taking rates was observed, as breathing rate was specific to the subjects' activity in dialogue (listening versus taking the turn versus holding the turn). A general inter-personal coordination of breathing over the whole conversation was not evident. However, specific coordinative patterns were observed in shorter time-windows when participants engaged in taking turns. The type of turn taking had an effect on the respective coordination in breathing. Most of the smooth and interrupted turns were taken just after an inhalation, with specific profiles of alignment to partner breathing. Unsuccessful attempts to take the turn were initiated late in the exhalation phase and with no clear inter-personal coordination. Finally, breathing profiles at turn-taking were different than those at turn-holding. The results support the idea that breathing is actively involved in turn-taking and turn-holding.
Keywords: breathing, dialogue, turn-taking, inter-personal coordination, respiration, adaptation.

109. Uva B, Aliverti A, Bovio D, Kayser B. The "Abdominal Circulatory Pump": An Auxiliary Heart during Exercise? Front. Physiol. 2016;6:411.
doi:10.3389/fphys.2015.00411
https://www.frontiersin.org/articles/10.3389/fphys.2015.00411/full
Abstract
Apart from its role as a flow generator for ventilation the diaphragm has a circulatory role. The cyclical abdominal pressure variations from its contractions cause swings in venous return from the splanchnic venous circulation. During exercise the action of the abdominal muscles may enhance this circulatory function of the diaphragm. Eleven healthy subjects (25 ± 7 year, 70 ± 11 kg, 1.78 ± 0.1 m, 3 F) performed plantar flexion exercise at ~4 METs. Changes in body volume (ΔVb) and trunk volume (ΔVtr) were measured simultaneously by double body plethysmography. Volume of blood shifts between trunk and extremities (Vbs) was determined non-invasively as ΔVtr-ΔVb. Three types of breathing were studied: spontaneous (SE), rib cage (RCE, voluntary emphasized inspiratory rib cage breathing), and abdominal (ABE, voluntary active abdominal expiration breathing). During SE and RCE blood was displaced from the extremities into the trunk (on average 0.16 ± 0.33 L and 0.48 ± 0.55 L, $p < 0.05$ SE vs. RCE), while during ABE it was displaced from the trunk to the extremities (0.22 ± 0.20 L $p < 0.001$, $p < 0.05$ RCE and SE vs. ABE respectively). At baseline, Vbs swings (maximum to minimum amplitude) were bimodal and averaged 0.13 ± 0.08 L. During exercise, Vbs swings consistently increased (0.42 ± 0.34 L, 0.40 ± 0.26 L, 0.46 ± 0.21 L, for SE, RCE and ABE respectively, all $p < 0.01$ vs. baseline). It follows that during leg exercise significant bi-directional blood shifting occurs between the trunk and the extremities. The dynamics and partitioning of these blood shifts strongly depend on the relative predominance of the action of the diaphragm, the rib cage and the abdominal muscles. Depending on the partitioning between respiratory muscles for the act of breathing, the distribution of blood between trunk and extremities can vary by up to 1 L. We conclude that during exercise the abdominal muscles and the diaphragm might play a role of an "auxiliary heart."
Keywords: exercise, cardiac output,venous return,splanchnic circulation, inferior vena cava.

110. Fong AY, Zimmer MB, Milsom WK. The conditional nature of the "Central Rhythm Generator" and the production of episodic breathing. Respiratory Physiology & Neurobiology 2009:168:179-187.

doi:10.1016/j.resp.2009.05.012
https://www.sciencedirect.com/science/article/pii/S1569904809001633
Abstract
Episodic breathing patterns have been observed in species of all vertebrate classes under certain conditions and/or at certain times in development. This breathing pattern can be considered part of a continuum between no breathing and continuous breathing. In birds and mammals it is also generally part of a developmental continuum in which episodic breathing occurs early in development and rarely in adults. Production of this pattern appears to be an intrinsic property of the medullary rhythm generating mechanism (possibly due to interactions between different rhythm generating sites) that is stabilized by pontine or midbrain inputs and, in intact animals, is primarily regulated by afferent inputs from chemoreceptors and pulmonary stretch receptors; i.e. there is a hierarchy of control. In all cases, episodes appear to be produced by quantal expression of a fundamental rhythm. At present NO, GABAA and glycine mediated processes, and possibly m-opioid receptor mediated processes, are implicated in the clustering of breaths into episodes. The inter-breath interval, which may occur at either the end of the inspiratory or the expiratory phase in different species, is the primary regulated variable in this pattern. The biological significance of clustering breaths into episodes may relate to reducing the oxidative cost of breathing, enhancing gas exchange or minimizing oxidative damage to tissues.

111. The diaphragm: More than an inspired design. Journal of Bodywork & Movement Therapies 2017;21:342-349. Editorial.

http://dx.doi.org/10.1016/j.jbmt.2017.03.013
https://www.bodyworkmovementtherapies.com/article/S1360-8592(17)30036-0/fulltext
Abstract
There is arguably no other muscle in the human body that is so central literally and figuratively to our physical, biochemical and emotional health as the diaphragm. From its most obvious role in respiration, to its less obvious roles in postural stability, spinal decompression, fluid dynamics, visceral health and emotional regulation, the diaphragm has a repertoire of function that is broad by any muscle's standards.
In this editorial, the two accompanying papers by Montes et al. (2017) and by McCoss et al. (2017) provide new insights into the diaphragm's interconnected role with trunk stability and, via a somato-somatic reflex, the effects of the diaphragm release on nociception in the neck, respectively.
The diaphragm has long been considered a key part of the trunk's stability mechanism by Strength & Conditioning Coaches (Chek, 1994) and Rehabilitation specialists (Lee, 1998) alike; it is considered frequently underactive by specialists in breathing rehabilitation (Chaitow, 2014); it is found to be a key muscle in those therapists working with somato-emotional release (Manheim and Lavett, 1989); and is considered a metaphorical and literal transitional point between the reptilian functions of the body and the mammalian limbic-emotional functions of the body. Osteopaths have long considered the respiratory diaphragm part of a multidiaphragm system for regulating pressure within body compartments (starting with cranial dura, then sequentially the suboccipital group; the supra-hyoid group, muscles of the nasopharynx, glottis and sphenoid-ethmoid palate; the pleural dome and cervicothoracic fascia (Paoletti, 2015); the diaphragm proper; and the pelvic floor (Keleman, 1989)).
Conclusion
The diaphragm is a complex, composite muscle, derived from body tissues ranging from the neck, the thoracic wall, the lumbar spine and the esophagus. Its role is multifactorial, from breathing to digestion, from stability to regulation of emotional state. To work effectively with the diaphragm therefore requires a broad understanding, an holistic approach and, most likely, a multidisciplinary team. Although this editorial is by no means exhaustive, it hopefully provides a glimpse into the breadth of interactions this muscle has; and may facilitate more fruitful clinical interventions, helping the reader to see that the diaphragm is more than just an inspired design.

112. Uğur G, Uysal H. The Effect of Alternate Nostril Breathing Exercise on Regulation of Blood Pressure in Individuals with Hypertension. Turk J Cardiovasc Nurs 2020;11(26):125–131.

doi: 10.5543/khd.2020.92905

https://jag.journalagent.com/kvhd/pdfs/KVHD-92905-RESEARCH_ARTICLE-UGUR.pdf

Abstract

Objective: In this study as a simple randomization method was aim to evaluate the effect of alternate nostril breathing exercise on regulation of blood pressure in individuals with hypertension.

Methods: The study was conducted between October 2017 and March 2018 with patients (n=76) with essential hypertension who visited the internal medicine outpatient clinic of a training and research hospital. The patients (n=76) were divided into experimental and control groups according to the inclusion criteria. Patients in the experimental group (n=37) performed alternate nostril breathing exercise and those in the control group (n=39) sat silently for 15 min/day for a period of two weeks. The pre- and post-intervention blood pressure of patients in the two groups was measured in the clinic at the end of the first and second week; the pre- and post-intervention measurements of blood pressure were performed at home daily for two weeks.

Results: The study included 72.4% female patients and 27.6% male patients; the mean age of the patients was 52.4±6.9 years. The mean systolic blood pressure (SBP) of patients in the experimental group measured at the clinic in the second week was approximately 4 mmHg lower than that of the control group ($p<0.05$). In addition, the mean SBP of patients in the experimental group measured at home in the second week was approximately 3 mmHg lower than that of the control group ($p<0.05$).

Conclusion: Alternate nostril breathing exercises in addition to pharmacological treatment may regulate the blood pressure in patients with hypertension.

Keywords: Blood pressure; breathing exercises; hypertension; nursing; yoga.

113. Ma X, et al. The Effect of Diaphragmatic Breathing on Attention, Negative Affect and Stress in Healthy Adults. Front. Psychol. 2017;8:874.

doi:10.3389/fpsyg.2017.00874

https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00874/full

Abstract

A growing number of empirical studies have revealed that diaphragmatic breathing may trigger body relaxation responses and benefit both physical and mental health. However, the specific benefits of diaphragmatic breathing on mental health remain largely unknown. The present study aimed to investigate the effect of diaphragmatic breathing on cognition, affect, and cortisol responses to stress. Forty participants were randomly assigned to either a breathing intervention group (BIG) or a control group (CG). The BIG received intensive training for 20 sessions, implemented over 8 weeks, employing a real time feedback device, and an average respiratory rate of 4 breaths/min, while the CG did not receive this treatment. All participants completed pre- and post-tests of sustained attention and affect. Additionally, pre-test and post-test salivary cortisol concentrations were determined in both groups. The findings suggested that the BIG showed a significant decrease in negative affect after intervention, compared to baseline. In the diaphragmatic breathing condition, there was a significant interaction effect of group by time on sustained attention, whereby the BIG showed significantly increased sustained attention after training, compared to baseline. There was a significant interaction effect of group and time in the diaphragmatic breathing condition on cortisol levels, whereby the BIG had a significantly lower cortisol level after training, while the CG showed no significant change in cortisol levels. In conclusion, diaphragmatic breathing could improve sustained attention, affect, and cortisol levels. This study provided evidence demonstrating the effect of diaphragmatic breathing, a mind-body practice, on mental function, from a health psychology approach, which has important implications for health promotion in healthy individuals.

Keywords: breathing technique, mental health, real-time feedback, relaxation, sustained attention.

114. Dekker J, et al. The Effect of Initial High vs. Low FiO2 on Breathing Effort in Preterm Infants at Birth: A Randomized Controlled Trial. Front. Pediatr. 2019;7:504.

doi:10.3389/fped.2019.00504
https://www.frontiersin.org/articles/10.3389/fped.2019.00504/full
Abstract
Background: Infants are currently stabilized at birth with initial low FiO2 which increases the risk of hypoxia and suppression of breathing in the first minutes after birth. We hypothesized that initiating stabilization at birth with a high O2 concentration, followed by titration, would improve breathing effort when compared to a low O2 concentration, followed by titration.
Methods: In a bi-center randomized controlled trial, infants <30 weeks gestation were stabilized at birth with an initial O2 concentration of 30 or 100%, followed by oxygen titration. Primary outcome was minute volume of spontaneous breathing. We also assessed tidal volumes, mean inspiratory flow rate (MIFR) and respiratory rate with a respiratory function monitor in the first 5 min after birth, and evaluated the duration of mask ventilation in the first 10 min after birth. Pulse oximetry was used to measure heart rate and SpO2 values in the first 10 min. Hypoxemia was defined as SpO2 < 25th percentile and hyperoxemia as SpO2 >95%. 8-iso-prostaglandin F2α (8iPGF2α) was measured to assess oxidative stress in cord blood and 1 and 24 h after birth.
Results: Fifty-two infants were randomized and recordings were obtained in 44 infants (100% O2-group: n = 20, 30% O2-group: n = 24). Minute volumes were significantly higher in the 100% O2-group (146.34 ± 112.68 mL/kg/min) compared to the 30% O2-group (74.43 ± 52.19 mL/kg/min), p = 0.014. Tidal volumes and MIFR were significantly higher in the 100% O2-group, while the duration of mask ventilation given was significantly shorter. Oxygenation in the first 5 min after birth was significantly higher in infants in the 100% O2-group [85 (64–93)%] compared to the 30% O2-group [58 (46–67)%], p < 0.001. The duration of hypoxemia was significantly shorter in the 100% O2-group, while the duration of hyperoxemia was not different between groups. There was no difference in oxidative stress marker 8iPGF2α between the groups.
Conclusion: Initiating stabilization of preterm infants at birth with 100% O2 led to higher breathing effort, improved oxygenation, and a shorter duration of mask ventilation as compared to 30% O2, without increasing the risk for hyperoxia or oxidative stress.

115. Gomutbutra P, Yingchankul N, Chattipakorn N, Chattipakorn S, Srisurapanont M. The Effect of Mindfulness-Based Intervention on Brain-Derived Neurotrophic Factor (BDNF): A Systematic Review and Meta-Analysis of Controlled Trials. Front. Psychol. 2020;11:2209.

doi:10.3389/fpsyg.2020.02209
https://www.frontiersin.org/articles/10.3389/fpsyg.2020.02209/full
Abstract
Background: This systematic review aims to answer three questions. First, how much do mindfulness-based interventions (MBIs) affect peripheral brain-derived neurotrophic factor (BDNF)? Second, do mindfulness exercise–based interventions (exercise-MBIs) and mindfulness meditation–based interventions (meditation-MBIs) affect peripheral BDNF differently? Third, does the age of participants and the accumulative hours of MBI practice affect peripheral BDNF?
Methods: We included randomized controlled trials comparing MBI and no intervention in adults (age >18 years) who reported peripheral BDNF. Database searches included PubMed, CINAHL, CENTRAL, PsyInfo, and Scopus. Two reviewers independently selected the studies and assessed the trial quality. We used the standardized mean difference (SMD) as the effect size index and conducted moderator analyses.
Results: Eleven studies are included in this systematic review. Five studies applying exercise-MBI and three studies applying meditation-MBI are included in the meta-analysis (N = 479). The pooled effect size shows a significantly greater increase of peripheral BDNF in MBI groups compared to the control groups (k = 8, N = 479, SMD = 0.72, 95% CI 0.31–1.14, I2= 78%). Significantly more increases of BDNF in the MBI groups are found in both subgroups of exercise-MBI and meditation-MBI. The effect sizes of both subgroups are not significantly different between subgroups ($\chi 2 = 0.02$,

p = 0.88). We find no significant correlation between the effect sizes and the age of participants (r = −0.0095, p = 0.45) or accumulative hours of MBI practice (r = 0.0021, p = 0.57).
Conclusion: The heterogeneous data of this small sample-size meta-analysis suggests that MBI can increase peripheral BDNF. Either exercise-MBI or meditation-MBI can increase peripheral BDNF.

116. Ozturk D et al. The effect of unilateral forced nostril breathing on sleep in healthy right-handed men: a preliminary report. Sleep and Breathing 2018;22:769-772.

https://doi.org/10.1007/s11325-018-1648-0
https://link.springer.com/article/10.1007%2Fs11325-018-1648-0
Abstract
Purpose Although we spend about one-third of our lives in sleep and recognize its necessity for good health, sleep has only been partially elucidated in the last century. The nasal cycle of congestion and decongestion during sleep has various effects on human physiology. The aim of the present study was to investigate the effect of unilateral forced nostril breathing on sleep.
Methods Twenty-one healthy male volunteers aged 18–24 years were included in the study. Only individuals with right-hand dominance were included. Subjects were observed during sleep for three nights under different conditions: no obstruction (normal sleep) on the first night, right nasal obstruction on the second night, and left nasal obstruction on the third night.
Results The main findings of our study are that sleep efficiency, NREM stage III, and total sleep duration were greater during left nasal obstruction (right nostril dominant respiration), while apnea-hypopnea index (AHI), frequency of periodic limb movements, and oxygen desaturation were higher during right nasal obstruction (left nostril dominant respiration).
Conclusion The nasal cycle has a significant impact on sleep which is reflected in sleep recordings. Our result supports that nasal obstructions, due to deviations, concha hypertrophy, or congestion/decongestion, might affect the physiology of respiration and sleep. Nasal obstruction should be taken into consideration when evaluating patients in sleep laboratories and further studies are required to elucidate the situation in the patients with nasal obstruction.
Keywords: Sleep, Nasal cycle, Forced nostril breathing.

117. Turan GB, Tan M. The effect of yoga on respiratory functions, symptom control and life quality of asthma patients: A randomized controlled study. Complementary Therapies in Clinical Practice 2020;38:101070.

https://doi.org/10.1016/j.ctcp.2019.101070
https://www.sciencedirect.com/science/article/pii/S1744388119308060
Abstract
This study was conducted to find out the effect of yoga applied to asthma patients on the patients' respiratory functions, symptom control and quality of life. The sample of the study consisted of a total of randomly chosen 112 asthma patients, 56 in the experimental group and 56 in the control group, who met the research criteria and who agreed to participate in the study. A total of 12 yoga sessions, 2 sessions a week for 6 weeks, was applied to the patients in the experimental group. The patients in the control group did not receive any intervention. In the intragroup comparison of average pre-test and post-test scores of respiratory function and Asthma Control Test (ACT) and Asthma Quality of Life Scale (AQLQ) total and sub-dimension scores of the patients in the experimental and control group, the difference was found to be statistically significant ($p < 0.05$). In addition, post-test score averages were found to increase in the experimental group, while they were found to decrease in the control group. It was found that yoga influenced respiratory functions, symptom control and quality of life positively in asthma patients.
Keywords: Asthma, Patient, Nursing, Yoga.

118. Bechbache RR, Duffin J. The entrainment of breathing frequency by exercise rhythm. J. Physiol. 1977:272:553-561.

doi:10.1113/jphysiol.1977.sp012059
https://physoc.onlinelibrary.wiley.com/doi/10.1113/jphysiol.1977.sp012059
Abstract

The incidence of entrainment of breathing frequency by the rhythm of exercise was detected by a cross-correlation of the two frequencies.
During moderate, steady-state exercise on a bicycle ergometer at 50 rev/min, eight of fifteen volunteers (53 %) showed entrainment when pedalling speed was kept constant with a metronome, and three of fifteen volunteers (20 %) showed entrainment when pedalling speed was kept constant with a speedometer.
At 70 rev/min, in a second group of fifteen volunteers, the results were nine of fifteen (60 %) and five of fifteen (33 %) respectively.
During moderate, steady state exercise on a treadmill, in a third group of fifteen volunteers, eight of 15 volunteers (53 %) showed entrainment while walking, and twelve of fifteen volunteers (80 %) showed entrainment while unniing.
It is concluded that the rhythm of exercise is likely to affect the rhythm of breathing and that this controlling factor.

119. Duffin J. The fast exercise drive to breathe. J Physiol 2014;592.3:445-451.

doi:10.1113/jphysiol.2013.258897
https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/jphysiol.2013.258897

Abstract
This paper presents a personal view of research into the exercise drive to breathe that can be observed to act immediately to increase breathing at the start of rhythmic exercise. It is based on a talk given at the Experimental Biology 2013 meeting in a session entitled 'Recent advances in understanding mechanisms regulating breathing during exercise'. This drive to breathe has its origin in a combination of central command, whereby voluntary motor commands to the exercising muscles produce a concurrent respiratory drive, and afferent feedback, whereby afferent information from the exercising muscles affects breathing. The drive at the start and end of rhythmic exercise is proportional to limb movement frequency, and its magnitude decays as exercise continues so that the immediate decrease of ventilation at the end of exercise is about 60% of the immediate increase at the start. With such evidence for the effect of this fast drive to breathe at the start and end of rhythmic exercise, its existence during exercise is hypothesised.
Experiments to test this hypothesis have, however, provided debatable evidence. A fast drive to breathe during both ramp and sine wave changes in treadmill exercise speed and grade appears to be present in some individuals, but is not as evident in the general population. Recent sine-wave cycling experiments show that when cadence is varied sinusoidally the ventilation response lags by about 10 s, whereas when pedal loading is varied ventilation lags by about 30 s. It therefore appears that limb movement frequency is effective in influencing ventilation during exercise as well as at the start and end of exercise.

120. Steffen PR, Austin T, De Barros A, Brown T. The Impact of Resonance Frequency Breathing on Measures of Heart Rate Variability, Blood Pressure, and Mood. Front. Public Health 2017;5:222.

doi:10.3389/fpubh.2017.00222
https://www.frontiersin.org/articles/10.3389/fpubh.2017.00222/full

Abstract
Heart rate variability biofeedback (HRVB) significantly improves heart rate variability (HRV). Breathing at resonance frequency (RF, approximately 6 breaths/min) constitutes a key part of HRVB training and is hypothesized to be a pathway through which biofeedback improves HRV. No studies to date, however, have experimentally examined whether RF breathing impacts measures of HRV. The present study addressed this question by comparing three groups: the RF group breathed at their determined RF for 15 min; the RF + 1 group breathed at 1 breath/min higher than their determined RF for 15 min; and the third group sat quietly for 15 min. After this 15-min period, all groups participated in the Paced Auditory Serial Addition Task (PASAT) for 8 min, and then sat quietly during a 10-min recovery period. HRV, blood pressure, and mood were measured throughout the experiment. Groups were not significantly different on any of the measures at baseline. After the

breathing exercise, the RF group reported higher positive mood than the other two groups and a significantly higher LF/HF HRV ratio relative to the control group, a key goal in HRVB training ($p < 0.05$). Additionally, the RF group showed lower systolic blood pressure during the PASAT and during the recovery period relative to the control group, with the RF + 1 group not being significantly different from either group ($p < 0.05$). Overall, RF breathing appears to play an important role in the positive effect HRVB has on measures of HRV.
Keywords: resonance frequency breathing, heart rate variability, blood pressure, mood, biofeedback.

121. Kanchibhotla D, Parekh SG, Harsora P, Kulkarni S. The Influence of Sudarshan Kriya Yoga on Sleep Quality in Indian Adults: An Open Trial Pilot Study. Sleep and Vigilance 2021.

https://doi.org/10.1007/s41782-021-00146-4
https://link.springer.com/article/10.1007%2Fs41782-021-00146-4
Abstract
Purpose Sudarshan Kriya Yoga (SKY) is an advanced yogic breathing technique with a demonstrated impact on human physical and mental health. Even so, very few studies have observed its effect on sleep. This is the first study evaluating the impact of SKY as an intervention on sleep quality among Indian population. This study assessed both the immediate and prolonged effect of SKY on sleep quality. The secondary objective of the study was to evaluate the association between frequency of SKY practice and sleep quality.
Methods This was a single arm open-trial study, which included 473 participants. All participants underwent a 3-day SKY workshop offered by the Art of Living, and were assessed for sleep quality using the Pittsburgh Sleep Quality Index (PSQI) questionnaire, administered to the participants before the program (pre-intervention), immediately after the program (postintervention), and at Day 40 (D40) after the program. Responses were grouped according to age, gender, and frequency of practice. The impact of the frequency of SKY practice on sleep quality was also investigated.
Results The quality of sleep improved with SKY practice across the study population. Women recorded inferior quality of sleep at the beginning of the study, but experienced a greater improvement in sleep quality after the SKY practice, as compared to men. The younger population seemed to benefit over the long-term, while the older population had an immediate improvement in sleep quality, however, they were not able to sustain it. The effect size varied with the frequency of practice. Sleep quality improved markedly among those who practiced SKY daily, indicating an association between the frequency of SKY practice and its efficiency in improving sleep quality.
Conclusion The results demonstrate the efficacy of SKY in improving sleep quality across populations, irrespective of gender or age. This is indicative of the beneficial role of SKY in treating psychological disorders such as insomnia. The effect varies with the frequency of practice, with more frequent practice yielding better quality of sleep.
Keywords: Sudarshan Kriya Yoga (SKY), Yogic breathing, Sleep quality, Insomnia.

122. Ong L. The kinesthetic Buddha, human form and function. Part 1: Breathing Torso. Journal of Bodywork and Movement Therapies 2007;11:214-222.

doi:10.1016/j.jbmt.2007.04.004
https://www.bodyworkmovementtherapies.com/article/S1360-8592(07)00042-3/fulltext
Abstract
Buddhist statues may provide kinesthetic lessons relating the human body's actions and the spiritual life. This two-part paper presents a descriptive analysis of a statue of a meditating Buddha sitting in lotus pose. The statue, from the ancient Javanese monument, Borobudur, is correlated with Iyengar yoga and therapeutic soft-tissue manipulation. In addition, discussion is presented of the statue as a history of Hindu pranayama and Buddhist meditation practices. The three-dimensional modeling of the Buddha's torso is evaluated from the perspective of anatomy and the movement arts. A resulting somatic vocabulary presents Asian art without emphasizing textual discourse and analysis of esthetic motifs so that the art presents a kinesthetic lesson on the ideal connection between the human body's

actions and the spiritual life. Central to this paper is the presumption that sculpture depicts the kinesthetics of breathing but must be carefully teased apart from historical anachronism.
Keywords: Borobudur, Buddha, Diaphragm, Kinesthetic, Lotus pose, Meditation, Piriformis, Psoas, Respiratory kinetics.

123. Ong L. The kinesthetic Buddha, human form and function. Part 2: The preparation for lotus. Journal of Bodywork and Movement Therapies 2007;11:340-51.

doi:10.1016/j.jbmt.2007.04.002
https://www.bodyworkmovementtherapies.com/article/S1360-8592(07)00044-7/fulltext

Abstract
Buddhist statues may provide kinesthetic lessons relating the human body's actions and the spiritual life. This two-part paper presents a descriptive analysis of a statue of a meditating Buddha sitting in lotus pose. The statue, from the ancient Javanese monument, Borobudur, is correlated with Iyengar yoga and therapeutic soft-tissue manipulation. In addition, discussion is presented of the statue as a history of Hindu pranayama and Buddhist meditation practices. The three-dimensional modeling of the Buddha's torso is evaluated from the perspective of anatomy and the movement arts. A resulting somatic vocabulary presents Asian art without emphasizing textual discourse and analysis of esthetic motifs so that the art presents a kinesthetic lesson on the ideal connection between the human body's actions and the spiritual life. Central to this paper is the presumption that sculpture depicts the kinesthetics of breathing but must be carefully teased apart from historical anachronism.
A practical description is offered of a series of yogic poses, preparatory to adopting the lotus pose, based on the concepts elaborated on in part 1.
Keywords: Borobudur, Buddha, Ideokinesis, Iyengar yoga, Kinesthetic, Lotus pose, Meditation, Piriformis, Psoas.

124. Zou Y, Li P, Hofmann SG, Liu X. The Mediating Role of Non-reactivity to Mindfulness Training and Cognitive Flexibility: A Randomized Controlled Trial. Front. Psychol. 2020;11:1053.

doi: 10.3389/fpsyg.2020.01053
https://www.frontiersin.org/articles/10.3389/fpsyg.2020.01053/full

Mindfulness training has been shown to have a beneficial effect on cognitive flexibility. However, little is known about the mediators that produce this effect. Cross-sectional studies show that there might be a link between Non-judgment, Non-reactivity and cognitive flexibility. Longitudinal studies examining whether Non-judgment or Nonreactivity mediate the effectiveness of mindfulness training on improving cognitive flexibility are lacking. The present study aims to test the effect of mindfulness training on increasing cognitive flexibility and to test whether this effect is mediated by Nonjudgment or Non-reactivity. We conducted a single-blind randomized controlled trial in 54 nonclinical high-stress participants between October 2018 and January 2019. Participants were randomly assigned to a Mindfulness Based Stress Reduction (MBSR) group or a waitlist control group. The experimenters were blind to the group assignment of participants. The MBSR group received 8-weekly sessions (2.5-h per week) and a one-day retreat (6-h), and was required to accomplish a 45-min daily formal practice during the intervention. The waitlist control group did not receive any intervention during the waiting period and received a 2-day (6-h per day) mindfulness training after the post-intervention. The primary outcome was self-report cognitive flexibility and perceived stress administered before and after MBSR. The secondary outcome was self-report mindfulness skills (including Non-reactivity and Non-judgment) measured at pre-treatment, Week 3, Week 6, and post-intervention. For cognitive flexibility, mixed model repeated-measure ANOVA results showed that there were significant main effects of Time, Group and a significant interaction of Time by Group. Follow-up ANOVA indicated that the MBSR group was associated with greater improvements in cognitive flexibility than the waitlist. Path analysis results showed that the effect of the treatment on cognitive flexibility at post-treatment was fully mediated by Non-reactivity at Week 6. The mediation effects of Non-reactivity at Week 3, and Non-judgment at Week 3 and Week 6 were not significant. Our findings support the

efficacy of MBSR on improving cognitive flexibility. Non-reactivity is an important element of the effectiveness of MBSR training on cognitive flexibility.
Keywords: Mindfulness Based Stress Reduction, cognitive flexibility, non-reactivity, mediation, mechanism.

125. Mole TB, et al. The MindfulBreather: Motion Guided Mindfulness. Front. Hum. Neurosci. 2017;11:613.

doi:10.3389/fnhum.2017.00613
https://www.frontiersin.org/articles/10.3389/fnhum.2017.00613/full
Abstract
For millennia, humans have focused their attention on the breath to develop mindfulness, but finding a scientific way to harness mindful breathing has proven elusive. Existing attempts to objectively measure and feedback on mindfulness have relied on specialist external hardware including electroencephalograms or respirometers that have been impractical for the majority of people learning to meditate. Consequently, training in the key skill of breath-awareness has lacked practical objective measures and guidance to enhance training. Here, we provide a brief technology report on an invention,
The MindfulBreatherr that addresses these issues. The technology is available to download embedded in a smartphone app that targets, measures and feedbacks on mindfulness of breathing in realtime to enhance training. The current article outlines only the technological concept with future studies quantifying efficacy, validity and reliability to be reported elsewhere.
The MindfulBreather works by generating Motion Guided Mindfulness through interacting gyroscopic and touchscreen sensors in a three phase process: Mindfulness Induction (Phase I) gives standardized instruction to users to place their smartphone on their abdomen, breathe mindfully and to tap only at the peak of their inhalation. The smartphone's gyroscope detects periodic tilts during breathing to generate sinusoidal waveforms. Waveform-tap patterns are analyzed to determine whether the user is mindfully tapping only at the correct phase of the breathing cycle, indicating psychobiological synchronization. Mindfulness Maintenance (Phase II) provides reinforcing pleasant feedback sounds each time a breath is mindfully tapped at the right time, and the App records a mindful breath. Lastly, data-driven Insights are fed back to the user (Phase III), including the number of mindful breaths tapped and breathing rate reductions associated with parasympathetic engagement during meditation. The new MGM technology is then evaluated and contrasted with traditional mindfulness approaches and a novel Psychobiological Synchronization Model is proposed.
In summary, unlike existing technology, the MindfulBreather requires no external hardware and repurposes regular smartphones to deliver app-embedded Motion-Guided Mindfulness. Technological applications include reducing mindwandering and down-regulation of the brain's default mode through enhanced mindful awareness.
By objectively harnessing breath awareness, The MindfulBreather aims to realize the ancient human endeavor of mindfulness for the 21st century.
Keywords: meditation, mindfulness training, default mode, realtime, MindfulBreather, motion guided mindfulness, psychobiological synchronization model, mindfulness assessment.

126. Pisanski A, Pagliardini S. The parafacial respiratory group and the control of active expiration. Respiratory Physiology & Neurobiology 2019;265:153-160.

https://doi.org/10.1016/j.resp.2018.06.010
https://www.sciencedirect.com/science/article/pii/S1569904818301009
Abstract
Breathing at rest is typically characterized by three phases: active inspiration, post-inspiration (or stage 1 expiration), and passive expiration (or stage 2 expiration). Breathing during periods of increased respiratory demand, on the other hand, engages active expiration through recruitment of abdominal muscles in order to increase ventilation. It is currently hypothesized that different phases of the respiratory rhythm are driven by three coupled oscillators: the preBötzinger Complex, driving inspiration, the parafacial respiratory group (pFRG), driving active expiration and the post-inspiratory

Complex, driving post-inspiration. In this paper we review advances in the understanding of the pFRG and its role in the generation of active expiration across different developmental stages and vigilance states. Recent experiments suggest that the abdominal recruitment varies across development depending on the vigilance state, possibly following the maturation of the network responsible for the generation of active expiration and neuromodulatory systems that influence its activity. The activity of the pFRG is tonically inhibited by GABAergic inputs and strongly recruited by cholinergic systems.
However, the sources of these modulatory inputs and the physiological conditions under which these mechanisms are used to recruit active expiration and increase ventilation need further investigation. Some evidence suggests that active expiration during hypercapnia is evoked through disinhibition, while during hypoxia it is elicited through activation of catecholaminergic C1 neurons. Finally, a discussion of experiments indicating that the pFRG is anatomically and functionally distinct from the adjacent and partially overlapping chemosensitive neurons of the retrotrapezoid nucleus is also presented.
Keywords: Parafacial respiratory group (pFRG), Active expiration, Expiratory abdominal muscles, Sleep, Brainstem development.

127. Russo MA, Santarelli DM, O'Rourke D. The physiological effects of slow breathing in the healthy human. Breathe 2017;13:298-309.

http://doi.org/10.1183/20734735.009817
https://breathe.ersjournals.com/content/13/4/298
Abstract
Slow breathing practices have been adopted in the modern world across the globe due to their claimed health benefits. This has piqued the interest of researchers and clinicians who have initiated investigations into the physiological (and psychological) effects of slow breathing techniques and attempted to uncover the underlying mechanisms.
The aim of this article is to provide a comprehensive overview of normal respiratory physiology and the documented physiological effects of slow breathing techniques according to research in healthy humans.
The review focuses on the physiological implications to the respiratory, cardiovascular, cardiorespiratory and autonomic nervous systems, with particular focus on diaphragm activity, ventilation efficiency, haemodynamics, heart rate variability, cardiorespiratory coupling, respiratory sinus arrhythmia and sympathovagal balance.
The review ends with a brief discussion of the potential clinical implications of slow breathing techniques. This is a topic that warrants further research, understanding and discussion.

128. Payne P, Crane-Godreau MA. The preparatory set: a novel approach to understanding stress, trauma, and the bodymind therapies. Front. Hum. Neurosci. 2015;9:178.

doi:10.3389/fnhum.2015.00178
https://www.frontiersin.org/articles/10.3389/fnhum.2015.00178/full
Abstract
Basic to all motile life is a differential approach/avoid response to perceived features of environment. The stages of response are initial reflexive noticing and orienting to the stimulus, preparation, and execution of response. Preparation involves a coordination of many aspects of the organism: muscle tone, posture, breathing, autonomic functions, motivational/emotional state, attentional orientation, and expectations. The organism organizes itself in relation to the challenge. We propose to call this the "preparatory set" (PS). We suggest that the concept of the PS can offer a more nuanced and flexible perspective on the stress response than do current theories. We also hypothesize that the mechanisms of body-mind therapeutic and educational systems (BTES) can be understood through the PS framework. We suggest that the BTES, including meditative movement, meditation, somatic education, and the body-oriented psychotherapies, are approaches that use interventions on the PS to remedy stress and trauma. We discuss how the PS can be adaptive or maladaptive, how BTES

interventions may restore adaptive PS, and how these concepts offer a broader and more flexible view of the phenomena of stress and trauma. We offer supportive evidence for our hypotheses, and suggest directions for future research. We believe that the PS framework will point to ways of improving the management of stress and trauma, and that it will suggest directions of research into the mechanisms of action of BTES.
Keywords: somatic experiencing, preparatory set, body-oriented psychotherapy, stress, mindbody, trauma, post-traumatic stress disorder, meditative movement.

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Abstract
After introducing the respiratory control system, a previously developed model of the respiratory chemoreflexes, based on rebreathing test data, is briefly described. This model is used to gain insights into the respiratory chemoreflex characteristics of a selection of individuals, and so discover the role of their central chemoreceptors. The chemoreflex model characteristics for each individual were estimated by adjusting the model parameters so that its predictions fit their rebreathing test results. To gain a steady state description of the control of breathing at rest the chemoreflex model is combined with a model of the cerebrovascular reactivity and converted from PCO2 to [H+] chemoreceptor inputs. This description is used to illustrate how acid–base and cerebrovascular reactivity factors affect the environment of the central chemoreceptors and determine their role in breathing control. Finally, a dynamic model incorporating the chemoreflex model, acid–base and cerebrovascular reactivity is used to show the role of the central chemoreceptors in stabilizing breathing during sleep at altitude.
Keywords: Respiration, Chemoreflexes, Modeling.

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Abstract
The term "transformational breath work" commonly refers ro techniques which use the breath for inducing altered states of consciousness to promote healing on any level. This paper describes common elements of transformational breath work and rationale for its use in medical illness. It then describes the use of one form, Evocative Breath Therapy ™ within a group mind/body medicine program. The technique employs an hour-long, four-stage process of focused awareness on the breath accompanied by guided imagery and evocative music. It is designed to induce an altered state of consciousness that promotes expanded self-awareness, selfacceptance, self-compassion, a sense of inner peace, and release of emotional and physical tension. A pilot study was conducted ro determine the impact of EBTTM on one indicator of immune function, salivary immunoglobulin A (S-IgA). A heterogeneous sample of forty-five adults (21 cancer patients, 22 healthy others, 2 with other illnesses) contributed saliva samples before and immediately after the experience. A 46.3% increase in S-IgA was found ($p = 0.0123$, paired differences t-tesr). There were no significant differences between cancer patients and others. Effect strength was moderate, .278. Leave-one-out analysis found the effect strength to decrease only marginally, suggesting the results are likely generalizeable to independent random samples. Issues in the use of transformational breath work in clinical programs and implications for further research are discussed.

Keywords: Breath therapy, breath work, immunoenhancement, salivary IgA, energy medicine, mind/body medicine, behavioral medicine, guided imagery.

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doi:10.1089/acm.2020.0458

https://www.liebertpub.com/doi/full/10.1089/acm.2020.0458

Abstract

Objectives: Although Baduanjin (a traditional Chinese physical activity) has been reported to promote general health, the optimal exercise intensity and kinematic characteristics of this intervention remain poorly understood. This investigation aimed to quantify and compare the exercise intensities of traditional standing Baduanjin (TB) and sitting Baduanjin (SB) using cardiopulmonary exercise testing, to further clarify the sources of the previously observed benefits of this modality.

Study design: Observational study.

Interventions: Healthy individuals were recruited to perform TB, SB, and cycling (in order) until they reached their ventilatory threshold. Intensity-relevant parameters based on type of exercise and specific time points (exercise start and the end of the 2nd, 4th, 6th, and 8th set of motion) were compared between TB and SB with ventilatory threshold as control.

Results: Forty individuals (18 male and 22 female) completed the trial. Significant differences in peak oxygen uptake, metabolic equivalent of task, and Borg scale existed among the three exercise types, indicating a decreasing overall exercise intensity in the order of ventilatory threshold, TB, and SB. All parameters except the respiratory exchange ratio fluctuated significantly across the time points.

Conclusions: Both TB and SB resulted in a significantly lower exercise intensity when compared with the ventilatory threshold established through cycling exercise. The benefits of Baduanjin might be explained partly by its appropriate exercise intensity and intermittent intensity pattern. Baduanjin might be a potential alternative to existing schemes for exercise rehabilitation.

Keywords: Baduanjin, exercise test, cardiopulmonary exercise testing, ventilatory threshold, exercise intensity.

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https://www.annualreviews.org/doi/10.1146/annurev-physiol-040510-130049

Abstract

Breathing is an essential behavior that presents a unique opportunity to understand how the nervous system functions normally, how it balances inherent robustness with a highly regulated lability, how it adapts to both rapidly and slowly changing conditions, and how particular dysfunctions result in disease. We focus on recent advancements related to two essential sites for respiratory rhythmogenesis: (a) the preBotzinger Complex (preB otC) as the site for the generation of inspiratory rhythm and (b) the retrotrapezoid nucleus/parafacial respiratory group (RTN/pFRG) as the site for the generation of active expiration.

Keywords: preBotzinger Complex, retrotrapezoid nucleus, parafacial respiratory group, central pattern generation, brain stem.

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https://www.sciencedirect.com/science/article/pii/0278262689900286

Abstract

Relative nostril efficiency (nasal cycle) is related to hemispheric EEG differences and performance on cognitive tasks. We investigated how unilateral forced nostril breathing influences spatial and verbal performance. Right-handed males and females performed both tasks under either left-nostril, right-nostril, or free-breathing conditions. Unilateral breathing affects performance differently in

males and females. It influences male performance ipsilaterally on both tasks: Their spatial performance is better during right-nostril breathing, and their verbal performance is better during left-nostril breathing. Unilateral breathing influences female performance contralaterally, but only on the spatial task: Their spatial performance is better during left-nostril breathing. These differences within and between sexes may exist because unilateral nostril breathing differentially activates the two hemispheres and thereby facilitates performance, or because attempts of the brain to control the nasal cycle unilaterally interfere with performance.

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Abstract

Background: In earlier studies uninostril yoga breathing was shown to influence the activity of the cerebral hemispheres differently, based on (i) auditory evoked potentials recorded from bilateral scalp sites, and (ii) performance in hemisphere-specific tasks. But change in P300 (event-related potential generated when subjects attend to and discriminate between stimuli) from bilateral scalp sites when subjects were practicing uni- and alternate-nostril breathing are yet to be explored.

Aim: The present study was designed to determine whether or not immediately after uninostril or alternate nostril yoga breathing there would be a change in the ability to pay attention to a given stimulus.

Materials and Methods: Twenty-nine healthy male volunteers, with ages between 20 and 45 years were randomly allocated to five sessions, viz., (i) right-, (ii) left-, (iii) alternate-nostril yoga breathing, (iv) breath awareness and (v) no intervention, each for 45 min on separate days. The P300 event related potential was recorded using an auditory oddball paradigm from sites on the left (C3) and right (C4), referenced to linked earlobes, before and after each session.

Results: Post-hoc analysis with Bonferroni adjustment showed that the P300 peak latency was significantly lower at C3 compared to that at C4, following right nostril yoga breathing ($P<0.05$).

Conclusion: These results suggest that right nostril yoga breathing facilitates the activity of contralateral (left) hemisphere, in the performance of the P300 task.

Key words: Contralateral changes, P300, uni-nostril yoga breathing.

136. Narayan S et al. Yoga-Based Breathing Techniques for Health Care Workers During COVID-19 Pandemic: Interests, Feasibility, and Acceptance. The Journal of Alternative and Complementary Medicine Volume 2021;27(8):706-709.

doi:10.1089/acm.2020.0536

https://www.liebertpub.com/doi/10.1089/acm.2020.0536

Abstract

Objectives: The authors explored the feasibility of virtual yoga-based breathwork and meditation among health care workers (HCW) during the COVID-19 pandemic.

Methods: Consented employees of a large cancer center accessed a video of breathwork called "Simha Kriya'' to be practiced for 4 weeks.

Results: of 217 participants who expressed interest within 2 weeks, 90 were recruited to the study in 1 month and 100 in 2 months. Of 69 participants who provided data between weeks 1 and 4, 77% perceived the intervention as useful.

Conclusions: Yoga-based breathing practices were feasible and acceptable among HCW in the setting of a pandemic.

Keywords: yoga, COVID-19, health care workers, pranayama, breathwork, mind–body practices.

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https://bmccomplementmedtherapies.biomedcentral.com/articles/10.1186/s12906-016-1286-7
Abstract
Background: Self-report measures indicate that Yoga practices are perceived to reduce stress; however, molecular mechanisms through which YB affects stress are just beginning to be understood. While invasive sampling such as blood has been widely used to measure biological indicators such as pro-inflammatory biomarkers, the use of saliva to measure changes in various biomolecules has been increasingly recognized. As Yoga practice stimulates salivary secretion, and saliva is considered a source of biomarkers, changes in salivary cytokines before and after Yogic breathing exercise as specified in an ancient Tamil script, Thirumanthiram, were examined using a Cytokine Multiplex to compare to Attention Control (AC) group.
Methods: Twenty healthy volunteers were randomized into two groups stratified by gender (N = 10 per YB and AC groups); The YB group performed two YB exercises, each for ten minutes, for a total of twenty minutes in a single session as directed by a trained Yoga instructor. The AC group read a text of their choice for 20 min. Saliva was collected immediately after YB training at 0, 5, 10, 15 and 20 min and analyzed by Multiplex enzyme linked immunosorbent assay (ELISA).
Results: The levels of interleukin (IL)-1β, IL-8, and monocyte chemotactic protein −1 (MCP-1) were significantly reduced in YB group when compared to AC group. The level of reduction of IL-8 was significant at all time points tested, whereas IL-1β showed reduction at 15 and 20 min time points ($p < 0.05$), and MCP-1 level was marginally different at 5–20 min. There were no significant differences between YB and AC groups in the salivary levels of IL-1RA, IL-6, IL-10, IL-17, IP-10, MIP-1b, and TNF-α.
Conclusions: These data are the first to demonstrate the feasibility of detecting salivary cytokines using multiplex assay in response to a Yoga practice.
Keywords: Yoga, Yogic breathing, Thirumanthiram, Pranayama, Salivary biomarkers, Cytokines, Multiplex, Pro-inflammatory, Stress, Tamil.

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Abstract
Many clinical trials have evaluated the oxidative stress reduction and enhancement of antioxidant status following yogic practices, but a review has not been reported earlier. Present study is designed to systematically review the effect of yogic practices on oxidative stress and antioxidant status.
Using the MEDLINE, EMBASE SCOPEMED, and Indian database electronic searches were performed through August 2016 using the keywords yoga AND oxidative stress OR antioxidant which yielded 97 studies. Selections were made to include only experimental studies written in English, published in peer-reviewed journals and investigating the effects of regular yogic practices on oxidative stress and antioxidant status in these studies.
Search yielded a total of 97 trials, 11 met rigorous criteria for final systematic review. Healthy population showed overall enhancement of antioxidant status and reduced oxidative stress following yogic practices. Diabetic patients showed increased glutathione, vitamin C content and superoxide dismutase activity and decreased malondialdehyde content following yogic practices. Prediabetic and hypertensive patients showed reduced malondialdehyde content following yogic practices. Renal disease patients showed decreased protein oxidation, and increased superoxide dismutase activity following yogic practices. Regular yogic practices can improve antioxidants and reduce oxidative stress in healthy, diabetic, prediabetic, hypertensive and renal disease patients. Studies on other disease population have rarely been reported and studies are very few to conclude strongly.
Keywords: antioxidants; oxidative stress; redox status; yoga.