

Yoga Breathing, Meditation, and Longevity

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Yoga breathing is an important part of health and spiritual practices in Indo-Tibetan traditions. Considered fundamental for the development of physical well-being, meditation, awareness, and enlightenment, it is both a form of meditation in itself and a preparation for deep meditation. Yoga breathing (pranayama) can rapidly bring the mind to the present moment and reduce stress. In this paper, we review data indicating how breath work can affect longevity mechanisms in some ways that overlap with meditation and in other ways that are different from, but that synergistically enhance, the effects of meditation. We also provide clinical evidence for the use of yoga breathing in the treatment of depression, anxiety, post-traumatic stress disorder, and for victims of mass disasters. By inducing stress resilience, breath work enables us to rapidly and compassionately relieve many forms of suffering.

Key words: yoga; breathing; meditation; depression; post-traumatic stress; anxiety

Mindfulness of in-and-out breathing, when developed and pursued, brings the four frames of reference to their culmination.

Anapanasati Sutta

Peace in our world can only start with peace in our minds.

Sri Sri Ravi Shankar

as increased insulin resistance), oxidative damage by free radicals, and neural degeneration. Is there evidence that these ancient practices can ameliorate stress and the process of aging? If so, how can we understand such effects in Western scientific terms?

Introduction

When we think of aging, we worry about loss of energy, vigor, mental functions, sexual capacity, independence, and the ability to deal with physical or emotional stress. Yoga breathing and meditation have been an integral part of the spiritual practices used for thousands of years by Eastern cultures to deal with these concerns. Neuro-immuno-endocrine changes associated with stress and aging include inflammation, dysregulation of energy utilization (such

Historical Context

Awareness and training of breath are fundamental to Indo-Tibetan yoga and meditation. While Transcendental Meditation has been studied in research institutions since 1963, the scientific study of Tibetan Buddhist and yoga breath practices is relatively new. In the past this has been due to the protective secrecy surrounding these techniques. There have been concerns that if the practices are not taught properly, they could cause harm. Moreover, religious leaders and devotees are reluctant to see treasured traditions taught piecemeal without their spiritual and philosophical underpinnings. Nevertheless, interest in Eastern healing and spiritual practices is growing

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and their techniques are being adapted to diverse cultures and medical settings. As more of the previously hidden techniques become accessible, they provide new areas of research that will enrich Western medicine and science.

Yoga breathing, called pranayama, is one of the Eight Limbs of Yoga that were systematized in Patanjali's yoga sutras (circa 200 B.C.). The life-force or *prana* in Sanskrit is the life-air, vital breath, or *srong-lung* in Tibetan. Life-force-energy is called *chi* in Chinese and *ki* in Japanese traditions. Pranayama translates from Sanskrit as "control of energy" or "expansion of energy."¹ Yoga teachings are found throughout Buddhism. In the 7th century A.D. Ayurvedic Medicine and Buddhism from India reached Tibet. These traditions were further enriched by pre-Buddhist Shamanic, Chinese, and Persian influences. Yogic Science and Buddhism seek to understand the nature of the mind in order to develop awareness, compassion, and enlightenment. Both traditions teach the same basic precept, that there is a bi-directional relationship between the mind and the breath, such that one can affect the mind and consciousness through manipulation of the breath. Breath practices are believed to eliminate toxins and negative "karmic airs," to clear the "subtle pathways" of the "subtle body" (the energy body), and to increase oxygenation to strengthen the physical body. Breathing, visualization, mantra, and movement are used to control the forces of the mind and body to clear a path to enlightenment or the realization of Buddhahood.²

In Thai Buddhism, the emphasis is on the Mindfulness of Breathing as taught in the Anapanasati Sutta, part of the Tipitaka or Pali canon (250 B.C.), the compiled teachings of Buddha. According to the Tipitaka, the pursuit and development of mindfulness of in-and-out breathing leads to the culmination of the four frames of reference: focus on the body, the feelings, the mind, and mental qualities. The four frames of reference bring the seven factors for awakening: mindfulness, analysis and comprehension of the quality of mindfulness, persis-

tence, rapture not-of-the-flesh, serenity (calmness of mind and body), concentration, and equanimity. The seven factors bring clear knowing and release. Thus the process of awakening begins with mindfulness of breathing.³

Paintings on the walls of the Secret Temple of the Dalai Lama in Lhasa depict ancient Tibetan yoga poses of *trul-khor*. Two forms of Tibetan *trul-khor* movement and breath practices are being taught in the West: Trul-khor and Yantra Yoga. The aim of these practices is to clear away all unwanted obstructions, imbalances (drowsiness and agitation), distractions and negative emotions to enable the practitioner to experience "the natural mind" and remain in the meditative state. In Tibetan the word for yoga, *nejor*, can mean "union." *Nejor* can also mean "original" or "authentic knowledge" or "understanding." This deeper meaning alludes to our original, never-changing condition.⁴ Western psychology would call this the "true self." Although these practices were believed to enhance physical and emotional health as well as to reverse the process of aging, they were primarily used to develop meditative practices and to bring awareness of the "natural state" of the mind. *Trul-khor* movements and breath practices are used when the mind is unclear, unstable, or weak to stabilize and clarify meditation. Exhalation with sounds of *Ha* and *Phat* breaks through mental obstacles while sustaining the natural state of mind. Yantra Yoga was originally taught in the 8th century A.D. in Tibet by Vairocana, a student of Guru Padmasambhava. According to Lama Lobsang Palden Rinpoche who escaped Tibet after the Chinese authorities closed the Tashi Kyil Monastery, Yantra Yoga techniques are healing movements with corresponding breath practices that put the whole body into mudras to circulate and rejuvenate energy. This serves to purify karma, eliminate negativity, and engender peace.⁵

Yoga philosophy considers the greatest stress to come from fluctuations of the mind as it moves toward the things it wants or away from things it dislikes, as it runs towards future

worries, or becomes mired in past mistakes. Even as you read this paper or attend a lecture your mind is in constant motion, shifting into future obligations or past frustrations. When the mind is 100% in the present we experience the calmness, peace, and joy that minimize the effects of stress. Most people agree that being in the present moment is desirable, but they cannot find the way to get there. Yoga breathing rapidly quiets the fluctuations of the mind bringing us into the present moment.⁶

What do these diverse breath traditions have in common? How might they increase longevity? What is the research evidence and what more needs to be done?

Research Evidence

Western scientists and researchers have been studying Buddhist meditation, but there is very little research on Tibetan movement and breath practices. However, the developing evidence on yoga breath techniques can be used to draw inferences and guide research on Buddhist practices.

Yoga breathing can be considered a form of meditation. Moreover, certain breath practices prepare the mind for deeper meditation. Both yoga breathing and meditation can activate the parasympathetic nervous system and induce altered states of consciousness. There are many patterns of breathing and specialized techniques that enhance breath practices such as breathing deeply into the abdomen, breathing against airway resistance, physical postures, holding the breath at different parts of the breath cycle, or breathing alternately through both nostrils, or only one nostril. Extracting the common elements within this diversity and studying the separate and combined effects of yoga practices enriches our understanding of the impact of yoga practices on the self-repair and self-regulatory systems that may increase longevity, resilience, and quality of life.

Our ability to deal with stress has an impact on how we age. A Harvard Medical School study of 1,623 heart attack survivors found

that when subjects became angry their risk of further heart attacks doubled compared to those who remained calm.⁷ In a study of 5,716 middle-aged people, those with the best self-regulatory abilities were 50 times more likely to be alive and without chronic disease 15 years later than those with poor scores on measures of self regulation.⁸ As the only autonomic function easily controlled through voluntary effort, breathing serves as a portal through which imbalances in the stress-response system can be corrected.

For most people, the quality of life is even more important than longevity. The quality of one's life depends upon the quality of one's mind. Stress, overstimulation, excess expectations, and mental turmoil drain our energy and our capacity to enjoy life. Mind-body and spiritual practices offer the sense of peace, joy, and relatedness that sweeten our lives and the lives of those closest to us. Unfortunately, many people who try to learn meditation cannot focus their minds. Some find the practices difficult and austere. Most lack the patience to persist. Trying to meditate while under severe stress sometimes magnifies the subjective sense of distress. In our clinical practices, we find that starting with breath practices gives immediate benefits that most people can experience, lays the ground work for meditation, and prepares the mind for deeper meditation.

Many scientific studies have shown that mind-body interventions derived from yoga (including breathing, meditation, physical postures, centering, and visualization) ameliorate stress-related mental and physical disorders including asthma, high blood pressure, cardiac illness, elevated cholesterol, irritable bowel syndrome, cancer, insomnia, multiple sclerosis, and fibromyalgia.⁹⁻¹¹ Reducing sympathetic and increasing parasympathetic nervous system tone are integral to such therapeutic action. Cardiac vagal (parasympathetic) tone has been associated with emotional regulation and empathic response.^{12,13}

Western research confirms the Indo-Tibetan teaching that the relationship between

breathing and emotion is reciprocal.¹⁴ Emotional states can affect respiratory rate, depth, and pattern. On the other hand, voluntarily changing the pattern of breath can account for at least 40% of the variance in feelings of anger, fear, joy, and sadness.¹⁵ Breathing is controlled by both voluntary and involuntary mechanisms with complex feedback involving autonomic networks, brain stem nuclei, limbic system, cortex, and the neuroendocrine system. The voluntary control of breath can modulate autonomic nervous system functions including cardiac vagal tone as measured by heart rate variability,^{1,16} vigilance and attention,¹⁷ chemoreceptor and baroreflex sensitivity,^{18,19} as well as the level of central nervous system excitation.²⁰

A yoga breath program called Sudarshan Kriya Yoga (SKY) has been taught to over 6 million people in 150 countries by the Art of Living Foundation (a non-profit service organization). The reproducible sequence of SKY breath practices has been found to alleviate stress, anxiety, and depression in clinical practice and in research studies. Evidence suggests that SKY acts via mechanisms that are fundamental to increased longevity.

The effects of SKY breath practices that have been observed physiologically and clinically cannot be attributed simply to either hyperventilation or increased oxygenation. Readers interested in a detailed discussion of the neurophysiology and clinical effects of the SKY program on stress and psychiatric disorders are referred to our previous reviews.^{20,21} Here we will briefly mention some plausible mechanisms for the action of breath practices, the benefits for longevity, and some of the evidence for clinical efficacy.

The SKY program has four breath components: three-stage slow resistance breathing, bellows breath, chanting “om,” and Sudarshan Kriya (cyclical breathing). Slow resistance breathing, known as Ujjayi in Sanskrit, means victorious breath (sometimes called ocean breath). Previous research indicates that Ujjayi breathing increases vagal, that is

parasympathetic, activity through numerous mechanisms, including slow breath rate, contraction of the laryngeal musculature, inspiration against airway resistance, prolonged expiration against airway resistance and breath holds. Slow breathing with prolonged expiration was shown to reduce psychological and physiological arousal in an anxiety provoking situation in a randomized study of 70 college students.²²

While simple slow breathing increases parasympathetic activity, Ujjayi breathing amplifies these effects through vagal afferent inputs to the brain and improves heart rate variability (HRV).²³ Numerous disorders are associated with impairment of HRV and respiratory sinus arrhythmia (RSA).²⁴ Low RSA is found in depressed, timid, or fearful infants. Low HRV and low RSA have been associated with anxiety, panic disorder, depression, irritable bowel syndrome, early Alzheimer’s, and obesity.^{25,26}

The second breath practice in the SKY program is Bhastrika (bellows breath), a high frequency, forceful technique similar to Kapalabati. High frequency breathing induces autonomic sympathetic activation and CNS excitation.²⁷ The third component of the SKY program, the “om” chant, improves vagal tone, decreases sympathetic activation, and increases mental alertness in the setting of physiologic relaxation.²⁸

The fourth SKY component is Sudarshan Kriya (SK), a cyclical breath form, believed to harmonize the nervous system. The translation of Sudarshan Kriya is “clear vision through purifying action.” This embodies the Indo-Tibetan principal that the purification of the subtle and physical bodies through breath practices leads to mental clarity, awareness, and wisdom. In our clinical experience, this highly advanced breath practice often evokes deep insight, resolution of emotional conflict, and a subjective sense of new found mental clarity. It also has a strong impact on stress reduction in clinical conditions such as post-traumatic stress disorder, anxiety, and depression.

A significant increase in β -1 and β -2 activity in the left frontal, midline, and occipital regions was noted on EEGs of 19 regular SKY practitioners at rest when compared with 15 healthy age-matched controls.²⁹ Another study of EEGs in 12 volunteers during Sudarshan Kriya followed by meditation showed heightened alertness in all participants as indicated by increased spectral power of α -rhythm in the middle band (10–10.5 cps) in O₁ and O₂ montages ($P < 0.005$). Significant inter-hemispherical asymmetry disappeared with highest α -activity at the end of SK in the centrencephalic mediobasal structures and occipital cortex ($P < 0.05$), suggesting improved inter-hemispheric communication and integrative function ($P < 0.05$).³⁰

We are currently analyzing neurophysiological data (EEG, EKG, HRV, respirometry, galvanic skin response, and temperature) on beginning and experienced SKY breath practitioners.³¹ Preliminary findings suggest that Sudarshan Kriya (SK) breathing temporarily disrupts the routine patterns (EEG) of the nervous system, taking it through a range of activity, leading to increasingly synchronized rhythms followed by a period of reorganization into a state similar to deep meditation or a dream-like reverie. During SK the EEGs showed increasingly coherent and synchronous alpha (8–10 Hz), more pronounced posteriorly and then spreading over the whole brain cortex. These observations are similar to studies of long-term Transcendental Meditation™ practitioners in whom alpha waves spread forward from the occipital lobes and dominated the entire cortex.³² During the rest period that followed SK, the alpha waves showed even more regularization and slowing as they merged into theta frequencies (6–8 Hz) while retaining the configuration of alpha waves. These synchronous waves showed high amplitudes (30–60 microvolts) with the highest amplitudes occurring in the most advanced practitioners (4–5 years experience). Such findings are consistent with previous studies of aniconic meditation (a state of mental quiescence or transcendence that of-

ten uses awareness of breath as an entry point) including yoga, Zen Buddhist, Kundalini, and QiGong.^{33–39}

Our hypothesis is that yoga breathing provides a neurophysiological “work-out” that leads to greater flexibility and plasticity in the nervous system. Experienced SKY practitioners achieved a remarkable degree of synchrony and coherence on EEG. Hankey³⁹ noted that increased EEG coherence has been associated with experiences of “pure consciousness” and greater brain processing capacity. Experienced Tibetan Buddhist meditators showed greater coherence and synchrony in gamma frequencies (25–43 Hz) during the contemplative practice of “Compassion.”⁴⁰ High amplitude synchronous alpha and theta waves, most pronounced in advanced practitioners, but also found in novices during post-SK rest resembled those found in studies of long-term adepts from other traditions.⁴¹ Greater synchrony has been associated with improved integrative brain functioning and problem-solving.

These studies are of interest not only for the optimization of brain function, but also for their potential anti-aging effect. Finding practices that alter brain function, neuroplasticity, and even the volume of brain tissue⁴² raises the possibility that specific mental practices could be found to preserve brain tissue and slow the process of brain aging.

In yogic terms, Ujjayi quiets the mind. It may also stabilize the cortex through an increase of gamma-aminobutyric acid (GABA), a testable hypothesis. This could protect the brain from possible adverse effects (e.g., seizures) from the faster forms of breathing which may induce high amplitude synchronous brain waves. High frequency breathing activates the sympathetic branch of the autonomic nervous system and probably prepares the brain for increased rapid information processing. SK cyclical breathing may disrupt rigid patterns of communication and function within neural networks, the legacy of accumulated stress, for example, unresolved emotional conflicts or trauma-related emotional schemas.^{43,44} Cyclical

breathing increases heart rate variability and synchronizes different areas of the brain to communicate more effectively. Yogic tradition describes this as “harmonizing the layers of the being.” Although some people have intense physical or emotional experiences associated with stress release during SKY, it usually leads to deep relaxation, a sense of peace and joy, and other spiritual experiences. The breath forms that precede SKY seem to prepare the mind to tolerate and benefit from such experiences.

Brain-derived neurotrophic factor (BDNF) is involved in neurogenesis, neuronal repair, and neuroplasticity. Interventions that increase BDNF, such as exercise and antidepressant treatment, may help preserve brain function.⁴⁵ Conversely, stress and depression suppress neurogenesis through processes that probably involve BDNF.⁴⁶ In Phase I of an ongoing study, SKY practice increased serum levels of BDNF in a group of normal individuals.⁴⁷ If replicated in larger studies, this data would support the theory that SKY breathing enhances neurogenesis and neuroplasticity, processes that are essential for maintenance of brain functions as we age, recovery from trauma, emotional adaptation, and learning.

Preliminary data from several small studies suggests additional pro-longevity effects of SKY practice: improved lipid profile⁴⁸; enhanced immune system function⁴⁹; and increased antioxidant defense enzymes, glutathione (GSH) and superoxide dismutase (SOD), and reduced serum lactate (stress indicator).⁵⁰ Moreover, in a 30-day controlled study of 190 menopausal women, 40 were given an 8 mg estradiol patch (hormone replacement therapy HRT), 40 received 500 mg vitamin E/day, and 60 were given SKY only. Significantly greater decreases in serum malonic dialdehyde (MDA) (a marker of membrane lipid peroxidation) and significantly greater increases in GSH-px and erythrocyte SOD occurred in the women given SKY than in those given either HRT or vitamin E.⁵¹ Further studies are needed to confirm the positive effects

of breath practices on lipid profile, antioxidant systems, and indicators of stress.

The aim of yoga, according to ancient Vedic texts, was to “cut the seed of sorrow before it sprouts.” This is true not only for the individual enhancing his or her personal development, vital energy, stress resilience, and longevity, but also for the compassionate relief of suffering throughout our world community. SKY breath practices have been used to relieve suffering among masses of civilians and military personnel in the wake of natural and man-made disasters such as floods, earthquakes, wars, and terrorist attacks.⁵² In a wait-list controlled study of 180 village survivors of the 2004 Asian Tsunami who had been living for nine months in refugee camps in Nagapattinam, a short program of Sudarshan Kriya breath techniques dramatically reduced symptoms of post-traumatic stress disorder (PTSD) and depression on standardized measures, PTSD Checklist-Civilian (PCL-C) and Beck Depression Inventory (BDI) in four days and the benefits were sustained at 6-week, 3-month, and 6-month follow-ups.⁵³

In a series of four small open studies of disabled Australian veterans of the Vietnam War with PTSD, Iyengar Yoga improved symptoms of depression, but the addition of pranayama (particularly Ujjayi) and meditation significantly reduced symptoms of PTSD, including anxiety, insomnia, and rage.⁵⁴ A subsequent wait-list controlled study of the SKY Program for 30 disabled Australian Vietnam veterans found that Iyengar Yoga (postures) significantly reduced scores for depression on the Center for Epidemiological Studies-Depression Test (CES-D). However, SKY was significantly more effective in relieving symptoms of PTSD on standardized measures, including the Clinician Administered PTSD Scale (CAPS) and the self-administered PTSD Checklist-Military (PCL-M).⁵⁵

We have found that patients with PTSD from sexual abuse benefit when SKY breathing is combined with traditional psychiatric and psychological therapies.^{56,57}

Three studies, two open and one controlled, found SKY to be effective in treating depression and dysthymia.⁵⁸ In the controlled study of 45 hospitalized patients with severe depression, SKY was equivalent to treatment with 150 mg/day of imipramine (tricyclic antidepressant). Electroconvulsive Therapy (ECT) was only slightly more effective than SKY or imipramine.⁵⁹

The Circle of Knowledge: Future Directions from the Past

The application of modern methodologies to study Indo-Tibetan practices raises many tantalizing questions. For example, what is the relationship of the massive increase in EEG synchrony, coherence, and amplitude observed during breath practices to improved emotional regulatory and cognitive functions? How do breath practices affect mitochondrial function, gene transcription, and DNA repair? Could increasing BDNF prevent age-associated shrinkage of the hippocampus and other brain structures while improving mood and memory? How does the increase in antioxidant enzyme systems impact longevity? Do breathing practices increase cortical GABA as measured on magnetic resonance spectroscopy? What is the potential role of yoga breath training in the treatment of neuro-psychiatric disorders?

Due to space limitations, this paper has focused on research on yoga breath techniques in relation to Buddhist practices. However, these findings are fundamental to all forms of yoga, meditation, and mind-body-spirit practices, including Qigong, Tai Chi, Zen, Aikido, and breath practices of Native Americans, Hawaiians, and others. In Sufism, control of breath is crucial to clearing, directing, and preparing the mind for action as well as for conserving energy.⁶⁰ In the Tao Te Ching, Lao Tzu emphasizes breath control to strengthen the spirit and to induce the tenderness of becoming “like a newborn babe.”⁶¹ It was also said by ancient Taoists that he who learns to breathe like a

baby becomes immortal.⁶² Research on breath practices from many traditions will yield new insights for neurophysiology, longevity, and the clinical treatment of stress-related physical and emotional disorders.

Senescence is feared when it is associated with helplessness, dependency, and loss of the quality of life. Further research may confirm that it is possible to enhance our well being and longevity by learning early in life to cultivate and sustain the vital qualities of youth, as Lao Tzu suggests, by cultivating the tenderness of the babe, learned most easily through breathing.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. Sovik, R. 2000. The science of breathing—the yogic view. *Prog. Brain Res.* **122**: 491–505.
2. Clifford, T. 1990. *Tibetan Buddhist Medicine and Psychiatry*: 84. Samuel Weiser, Inc. York Beach, ME.
3. Anapanasati Sutta [Mindfulness of Breathing] MN118. In: *Tipitaka*. Translated by Bhikkhu. 2006. Access to Insight. <http://www.accesstoinsight.org/tipitaka/mn/mn.118.than.html> viewed 3/17/07.
4. Chaoul-Reich, A. 2001. Spinning the Magical Wheel. *The Snow Lion Newsletter*. **N53**: 1–5. Snow Lion Publications. www.snowlionpub.com/pages/N53_1.php viewed 3/18/07.
5. Giles, D. 2004. Yantra Yoga with Lama Lobsang Palden. <http://www.lamalobsang.com/yogachicago.htm> viewed 3/16/01.
6. Feuerstein, G. 1998. *The Yoga Tradition: It's History, Literature, Philosophy, and Practice*. Hohm Press. Prescott, AZ.
7. Mittleman, M.A., M. Maclure, J.B. Sherwood, et al. 1995. Triggering of acute myocardial infarction onset by episodes of anger. Determinants of Myocardial Infarction Onset Study Investigators. *Circulation* **92**: 1720–1725.
8. Frentzel-Beyme, R. & R. Grossarth-Maticek. 2001. The interaction between risk factors and self-regulation in the development of chronic diseases. *Int. J. Hyg. Environ. Health* **204**: 81–88.
9. Becker, I. 2000. Uses of yoga in psychiatry and medicine. In *Complementary and Alternative Medicine and*

- Psychiatry*. P.R. Muskin, Ed., pp. 107–145. American Psychiatric Press, Inc. Washington, D.C.
10. Benson, H. 1996. *Timeless Healing: The Power and Biology of Belief*, pp. 222–234. Scribner. New York, NY.
 11. Jacobs, G.D. 2001. Clinical applications of the relaxation response and mind-body interventions. *J. Altern. Complement. Med.* **7**(Suppl 1): S93–S101.
 12. Beauchaine, T. 2001. Vagal tone, development, and Gray's motivational theory: toward an integrated model of autonomic nervous system functioning in psychopathology. *Dev. Psychopathol.* **13**: 183–214.
 13. Porges, S.W. 2001. The polyvagal theory: phylogenetic substrates of a social nervous system. *Int. J. Psychophysiol.* **42**: 123–146.
 14. Ley, R. 1999. The modification of breathing behavior. Pavlovian and operant control in emotion and cognition. *Behav. Modif.* **23**: 441–479.
 15. Philippot, P., C. Gaetane & S. Blairy. 2002. Respiratory feedback in the generation of emotion. *Cogn. Emotion* **16**: 605–607.
 16. Lehrer, P., Y. Sasaki & Y. Saito. 1999. Zazen and cardiac variability. *Psychosom. Med.* **61**: 812–821.
 17. Fokkema, D.S. 1999. The psychobiology of strained breathing and its cardiovascular implications: a functional system review. *Psychophysiology* **36**: 164–175.
 18. Bernardi, L., A. Gabutti, C. Porta, *et al.* 2001. Slow breathing reduces chemoreflex response to hypoxia and hypercapnia, and increases baroreflex sensitivity. *J. Hypertens.* **19**: 2221–2229.
 19. Spicuzza, L., A. Gabutti, C. Porta, *et al.* 2000. Yoga and chemoreflex response to hypoxia and hypercapnia. *Lancet* **356**: 1495–1496.
 20. Brown, R.P. & P.L. Gerbarg. 2005. Sudarshan Kriya Yoga Breathing in the treatment of stress, anxiety, and depression: Part I – Neurophysiological model. *J. Altern. Complement. Med.* **11**: 189–201.
 21. Brown, R.P. & P.L. Gerbarg. 2005. Sudarshan Kriya Yoga breathing in the treatment of stress, anxiety, and depression: Part II: Clinical applications and guidelines. *J. Altern. Complement. Med.* **11**: 711–717.
 22. Cappel, B.M. & D.S. Holmes. 1984. The utility of prolonged respiratory exhalation for reducing physiological and psychological arousal in non-threatening and threatening situations. *J. Psychosom. Res.* **28**: 265–273.
 23. Telles, S. & T. Desiraju. 1992. Heart rate alterations in different types of pranayamas. *Indian J. Physiol. Pharmacol.* **36**: 287–288.
 24. Carney, R.M., R. D. Saunders, K.E. Freedland, *et al.* 1995. Association of depression with reduced heart rate variability in coronary artery disease. *Am. J. Cardiol.* **76**: 562–564.
 25. Friedman, B.H. & J.F. Thayer. 1998. Autonomic balance revisited: panic anxiety and heart rate variability. *J. Psychosom. Res.* **44**: 133–151.
 26. Haug, T. T., S. Svebak, T. Hausken, *et al.* 1994. Low vagal activity as mediating mechanism for the relationship between personality factors and gastric symptoms in functional dyspepsia. *Psychosom. Med.* **56**: 181–186.
 27. Roldan, E. & C. Dostalek. 1985. EEG patterns suggestive of shifted levels of excitation effected by hathayogic exercises. *Act. Nerv. Super. (Praha)* **27**: 81–88.
 28. Telles, S., R. Nagarathna, & H. R. Nagendra. 1995. Autonomic changes during “OM” meditation. *Indian J. Physiol. Pharmacol.* **39**: 418–420.
 29. Bhatia, M., A. Kumar, N. Kumar, *et al.* 2003. Electrophysiologic evaluation of Sudarshan kriya: an EEG, BAER, P300 study. *Indian J. Physiol. Pharmacol.* **47**: 157–163.
 30. Snyder, N.A., N.O. Agarkova, E.G. Lyulyakina, *et al.* 2006. The bioelectrical brain activity in humans who practiced Sudarshan Kriya. *Proceedings World Conference Expanding Paradigms: Science, Consciousness & Spirituality*. Feb 2006. All India Institute of Medical Sciences. New Delhi, India.
 31. Larsen, S., W. Yee, P.L. Gerbarg, *et al.* 2006. Neurophysiological markers of Sudarshan Kriya Yoga practices: a pilot study. *Proceedings World Conference Expanding Paradigms: Science, Consciousness and Spirituality*. Feb 2006. All India Institute of Medical Sciences. New Delhi, India.
 32. Hankey, A. 2006. Studies of advanced stages of meditation in the Tibetan Buddhist and Vedic traditions. I: A comparison of general changes. *Evid. Based Complement Alternat. Med.* **3**: 513–521.
 33. Aftanas, L.I. & S.A. Golosheikine. 2001. Human anterior and frontal midline theta and lower alpha reflect emotionally positive state and internalized attention: high-resolution EEG investigation of meditation. *Neurosci. Lett.* **310**: 57–60.
 34. Kamei, T., Y. Toriumi, H. Kimura, *et al.* 2000. Decrease in serum cortisol during yoga exercise is correlated with alpha wave activation. *Percept. Mot. Skills* **90**: 1027–1032.
 35. King, R. & A. Brownstone. 1999. Neurophysiology of yoga meditation. *Int. J. Yoga Ther.* **9**: 9–17.
 36. Kubota, Y., W. Sato, M. Toichi, *et al.* 2001. Frontal midline theta rhythm is correlated with cardiac autonomic activities during the performance of an attention demanding meditation procedure. *Brain Res. Cogn. Brain Res.* **11**: 281–287.
 37. Kugler, J.E. 1982. Mediation and the electroencephalogram. *Electroencephalogr. Clin. Neurophysiol. Suppl.* 391–398.
 38. Mason, L.I., C.N. Alexander, F.T. Travis, *et al.* 1997. Electrophysiological correlates of higher states of consciousness during sleep in long-term practitioners of

- the Transcendental Meditation program. *Sleep* **20**: 102–110.
39. Satyanarayana, M., K.R. Rajeswari, N.J. Rani, *et al.* 1992. Effect of Santhi Kriya on certain psychophysiological parameters: a preliminary study. *Indian J. Physiol. Pharmacol.* **36**: 88–92.
 40. Lutz, A., L.L. Greischar, N.B. Rawlings, *et al.* 2004. Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proc. Natl. Acad. Sci. USA* **101**: 16369–16373.
 41. Kasamatsu, A. & T. Hirai. 1966. An electroencephalographic study on the zen meditation (Zazen). *Folia Psychiatr. Neurol. Jpn.* **20**: 315–336.
 42. Lazar, S.W., C.E. Kerr, R.H. Wasserman, *et al.* 2005. Meditation experience is associated with increased cortical thickness. *Neuroreport* **16**: 1893–1897.
 43. Bucci, W. 2001. Pathways of emotional communication. *Psychoanalytic Inquiry* **20**: 40–70.
 44. Gerbarg, P.L. 2006. Yoga and neuro-psychoanalysis. In *Bodies in Treatment: The Unspoken Dimension*. F.S. Anderson, Ed. The Analytic Press, Inc. Hillsdale, NJ. In press.
 45. Brownlee, C. 2006. Buff and brainy. Exercising the body can benefit the mind. *Science News* **169**: 122–124.
 46. Malberg, J.E. & L.E. Schechter. 2005. Increasing hippocampal neurogenesis: a novel mechanism for antidepressant drugs. *Curr. Pharm. Des.* **11**: 145–155.
 47. Pan, N.L., C.F. Liao, M.J. Jiang, *et al.* Feb 2006. Serum levels of brain-derived neurotrophic factor before and after the practice of Sudarshan Kriya. *Proceedings World Conference Expanding Paradigms: Science, Consciousness & Spirituality*. All India Institute of Medical Sciences. New Delhi, India. 156–160.
 48. Geetha, H. 2002. Sudarshan Kriya and health. Science of Breath. *International Symposium on Sudarshan Kriya, Pranayam, & Consciousness*. March 2002. All India Institute of Medical Sciences. New Delhi, India.
 49. Das, S.N., V. Kochupillai, D. Singh, *et al.* 2002. Flow-cytometric study of T-cell subset and natural killer cells in peripheral blood of Art of Living teachers, normal subjects and cancer patients. *Proceedings Science of Breath International Symposium on Sudarshan Kriya, Pranayam & Consciousness*. March 2002. All India Institute of Medical Sciences. New Delhi, India.
 50. Sharma, H., D. Aggarwal, S. Sen, *et al.* 2002. Effects of Sudarshan Kriya on antioxidant status and blood lactate level. *Proceedings Science of Breath International Symposium on Sudarshan Kriya, Pranayam & Consciousness*. March 2002. All India Institute of Medical Sciences. New Delhi, India.
 51. Geehta, H., H. Chitra, N.S. Kubera, *et al.* 2006. Effect of Sudarshan Kriya on menopausal women. *Proceedings World Conference Expanding Paradigms: Science, Consciousness & Spirituality*. Feb 2006. All India Institute of Medical Sciences. New Delhi, India.
 52. Gerbarg, P.L. & R.P. Brown. 2005. Yoga: a breath of relief for Hurricane Katrina refugees. *Curr. Psychiatry* **4**: 55–67.
 53. Descilo, T., A. Vedamurthachar, P.L. Gerbarg, *et al.* 2006. Comparison of a yoga breath-based program and a client-centered exposure therapy for relief of PTSD and depression in survivors of tsunami disaster. *Proceedings World Conference Expanding Paradigms: Science Consciousness and Spirituality*. Feb 2006. All India Institute of Medical Sciences. New Delhi, India. 64–78.
 54. Carter, J.J. & G.G. Byrne. 2004. A two year study of the use of yoga in a series of pilot studies as an adjunct to ordinary psychiatric treatment in a group of Vietnam War veterans suffering from post traumatic stress disorder. <http://www.therapywithyoga.com>, 1–11.
 55. Carter, J.J. & G.G. Byrne. 2006. PTSD Australian Vietnam veterans: yoga adjunct treatment, two RCT's: MCYI and SKY. *Proceedings World Conference Expanding Paradigms: Science, Consciousness and Spirituality Proceedings*. Feb 2006. All India Institute of Medical Sciences. New Delhi, India.
 56. Sageman, S. 2002. How SK can treat the cognitive, psychodynamic, and neuropsychiatric problems of post traumatic stress disorder. *Proceedings Science of Breath International Symposium on Sudarshan Kriya, Pranayam and Consciousness*. March 2002. All India Institute of Medical Sciences. New Delhi, India.
 57. Sageman, S. 2004. Breaking through the despair: spiritually oriented group therapy as a means of healing women with severe mental illness. *J. Am. Acad. Psychoanal. Dyn. Psychiatry* **32**: 125–141.
 58. Janakiramaiah, N., B.N. Gangadhar, P.J. Naga Venkatesha Murthy, *et al.* 1998. Therapeutic efficacy of Sudarshan Kriya Yoga (SKY) in dysthymic disorder. *NIMHANS Journal*, 21–28.
 59. Janakiramaiah, N., B.N. Gangadhar, P.J. Naga Venkatesha Murthy, *et al.* 2000. Antidepressant efficacy of Sudarshan Kriya Yoga (SKY) in melancholia: a randomized comparison with electroconvulsive therapy (ECT) and imipramine. *J. Affect. Disord.* **57**: 255–259.
 60. Bair, P. 1988. *Living From the Heart. Heart Rhythm Meditation*: 109–186. Three Rivers Press. New York, NY.
 61. Wei, H. 1982. *The Guiding Light of Lao Tzu*: 51 & 164. Theosophical Publishing House. Wheaton, IL.
 62. Huang, W-S. 1973. *Fundamentals of Tao Chi Chuan*: 174–188. South Sky Book Company. Hong Kong.