

## REVIEW ARTICLE

# A Review of Sudarshan Kriya Yoga for Improving Antioxidant Status and Reducing Anxiety in Adults

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### ABSTRACT

Breathing exercises are frequently advised to promote improved organ function, stress reduction, relaxation, and control over psychophysiological states. It has been demonstrated that yogic breathing, which is the control of breath movement, improves immunological function, autonomic nervous system imbalances, and illnesses linked to stress or psychology. This study aimed to evaluate and present a thorough analysis of the physiological mechanisms, the mind–body connection, and the advantages of Sudarshan Kriya Yoga (SKY) in various therapeutic settings. Medline, PsychINFO, EMBASE, and Google Scholar were among the many internet resources that were looked up. Articles on SKY were chosen after a thorough screening of all the results. We looked through these articles' references to see if there were any more, perhaps pertinent articles. A variety of cyclical breathing rhythms, from slow and soothing to fast and invigorating, are used in SKY, a special kind of yogic breathing technique. An increasing body of research indicates that SKY may be an advantageous, low-risk, low-cost supplement to the treatment of stress, anxiety, depression, post-traumatic stress disorder, medical conditions linked to stress, substance misuse, and the rehabilitation of criminal offenders.

## 1. INTRODUCTION

Stress levels and the disorders they are associated with have increased due to environmental pollution, a faster pace of life, psychological disruptions, dietary habits, and sedentary lifestyles.<sup>[1]</sup> Yoga has been practiced as a healthful way of life and is an old Indian science. Yoga has gained popularity recently as an alternative medicine approach to health.<sup>[2]</sup> The goal of relaxation techniques is to lower stress levels, which helps avoid these undesirable effects. Yogic breathing exercises and yoga are popular forms of relaxation. Pranayama, or yoga breathing, is a special technique for influencing psychological and stress-related diseases and autonomic nerve system balance.<sup>[3]</sup> Sudarshan Kriya Yoga (SKY) is one particular type of these breathing techniques that have been demonstrated to have positive benefits on the mind–body system.

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### 1.1. Sky

The non-profit Art of Living (AOL) Foundation teaches SKY, a sort of cyclical controlled breathing technique with origins in classical yoga that relieves depression. It is composed of four unique parts.<sup>[4]</sup>

## 2. MATERIALS AND METHODS

The four primary SKY breathing techniques are described in detail below.<sup>(5)</sup>

1. Ujjayi, also known as “Victorious Breath,” is the practice of consciously feeling one’s breath contact one’s throat. By controlling airflow and increasing airway resistance during inspiration and expiration, the slow breath technique (2–4 breaths/min) allows each stage of the breath cycle to be precisely lengthened. Subjective experience is attentiveness and a state of tranquility, both mentally and physically.
2. In Bhastrika, also known as “Bellows Breath,” thirty breaths per minute are taken quickly and forcibly. It produces excitement and then relaxation.

3. Three times, “Om” is chanted, each time with a very lengthy expiration.
4. Sudarshan Kriya is a sophisticated type of rhythmic, cyclical breathing with slow, medium, and fast cycles. The Sanskrit title for this practice means “proper vision by purifying action.”

### 3. RESULTS

The AOL Foundation has taught SKY to over 6 million people in 152 countries globally. The following lists potential SKY mechanisms, effects, and advantages.

#### 3.1. Influence of SKY on Physiological Functions

Neurophysiological model of vagus nerve stimulation (VNS) pathways.

SKY consists of a specific sequence of varying breathing rates separated by brief periods of normal breathing. Strained breathing occurs in nature when an animal is defeated in battle.<sup>[6,7]</sup> It inhibits activity, increases brain perfusion, increases attention and vigilance (via vagal afferents), slows heart rate, restores energy, prevents hypoxia/hypercapnia,<sup>[8,9]</sup> and prepares the animal to protect itself.

Numerous studies show that yogic breathing improves physiological indices and cognitive function, although the underlying mechanisms are still unclear. According to biological hypotheses derived from the neurophysiological model of the vagomed neural system (VNS) of yoga breathing, SKY induces VNS and has a variety of autonomic effects, such as altered heart rate, enhanced cognition in Alzheimer’s illness, improved bowel function, etc. A series of breathing exercises with varying durations, intensities, frequencies, and end-inspiratory and end-expiratory holds produces a variety of impulses from various visceral afferents, sensory receptors, and baroreceptors during SKY. These probably influence diverse fiber group within vagus nerves, which in turn induces physiologic changes in organs, glands, and ascending fibers to thalamic generators, the limbic system, and cortical areas. This may account for rapidity and diversity of SKY effects such as experience of calmness and relaxation combined with increased vigilance and attention<sup>[3,5,6]</sup> (for a detailed description of proposed neurophysiological pathways, see Brown and Gerbarg).

Sudarshan Kriya may work such as mechanical hyperventilation and electronic unilateral VNS which lead to stimulation of thalamic nuclei resulting in quieting of the frontal cerebral cortex.

The Ujjayi practice makes the practitioner feel calm. The proposed mechanism would be a shift to parasympathetic dominance through vagal stimulation. Respiratory sinus arrhythmia (RSA) refers to normal heart rate that increases during inspiration and heart rate decreases during expiration. RSA is influenced by sympathetic and vagal (parasympathetic) input and by respiratory rate and volume. Slow yoga breathing induces oscillations of blood pressure and exaggeration of the normal RSA. Low RSA is usually found in individuals with depression, anxiety, panic disorder, and functional dyspepsia. Ujjayi breath increases RSA by increasing parasympathetic influences.<sup>[5]</sup>

Bhastrika stimulates the temporoparietal cortical areas, resulting in rhythms resembling the gamma frequency bands thought to represent the synchronization of neuronal assemblies. Bhastrika also activates the autonomic sympathetic nervous system (SNS) and excites the central nervous system on the electroencephalogram (EEG).<sup>[10,11]</sup> In Kwon *et al.*<sup>[12]</sup> during Bhastrika, people tend to feel excited, which is followed by an emotional calmness that is accompanied by mental

activity and attentiveness. Similar to regular exercise, everyday practice of Bhastrika produces a modest sympathetic stimulation, which may improve the SNSs ability to respond to acute stressors without quickly depleting its reserves.<sup>[5]</sup>

According to scientific research on “Om” chanting, mentally repeating “Om” causes physiological alertness, increases sensitivity to sensory transmission, and synchronization of specific biorhythms.<sup>[13]</sup> EEG alterations were observed in 19 SKY practitioners and compared with the EEG patterns of 16 people who did not practice SKY, yoga, or meditation to investigate the long-term effects of SKY on brain function. When SKY practitioners were compared to controls, there were notable increases in beta activity in the left frontal, occipital, and midline regions of the brain. These findings suggested that SKY practitioners had better mental concentration and awareness. It is noteworthy that the control group, which consisted of doctors and medical researchers, whose line of work necessitates the acquisition and regular application of these precise abilities, showed noticeably lower levels of mental alertness (beta activity) than did SKY practitioners.<sup>[14]</sup>

In summary, activation of the limbic system, hippocampus, hypothalamus, amygdala, and stria terminalis as well as VNS may be responsible for enhanced autonomic function, neuroendocrine release, emotional processing, and social bonding after engaging in SKY practices.

#### 3.2. Influence of SKY on Endocrine System

According to the neurophysiological model of VNS by yogic breathing, it is assumed that SKY mainly exerts its endocrine effect by modulating the hypothalamic–pituitary–adrenal (HPA) axis, which is essential for fight and flight response and survival of humans. It is likely that SKY releases prolactin, vasopressin, and oxytocin through vagal afferents to the hypothalamus and anterior pituitary. Oxytocin enhances the feelings of bonding and affection. It is connected to the functions of the parasympathetic nervous system (PNS) and has a role in controlling the HPA axis. Major depressive disorder was shown to have reduced oxytocin secretion, and it is predicted that this will increase with SKY treatment. It was discovered that prolactin rose.<sup>[7]</sup>

In a research by Janakiramaiah *et al.*, Sudarshan Kriya was the only treatment given to dysthymic individuals as an outpatient. Following the first SKY session, blood tests showed steady cortisol and elevated plasma prolactin. This is significant because a successful antidepressant response may be mediated by higher plasma prolactin. Stable cortisol levels suggest that having SKY is not a stressful experience.<sup>[15]</sup> Another study revealed reduction in stress hormone levels (cortisol and adrenocorticotropic hormone [ACTH]) along with Beck Depression Inventory (BDI) reductions. This may support a biological mechanism of SKY in producing beneficial effects.<sup>[16,17]</sup>

One episode of SKY group practice increased serum brain-derived neurotrophic factor (BDNF) levels but decreased serum cortisol levels. The rise in blood BDNF levels persisted for a minimum of 4 h and was not caused by the circadian rhythm. It was determined that the use of SKY techniques has significant antidepressant benefits that are closely linked to its ability to restore serum BDNF levels to baseline.<sup>[18]</sup>

#### 3.3. Therapeutic Potential of SKY

Studies on the therapeutic implications of SKY in various psychological and clinical conditions are summarized below.

### 3.3.1. Stress, anxiety disorders, depression

SKY has shown considerably lower anxiety levels during various antistress programs in multiple groups, indicating stabilization of mental activity, improved brain function, and stress resilience.<sup>[19-21]</sup> One typical stress symptom that improves with daily SKY practice is insomnia, which is one of the major causes of poor sleep.<sup>[19]</sup> Following SKY training, tsunami refugees have shown a marked improvement in their depression and post-traumatic stress disorder (PTSD) ratings.<sup>[21]</sup> In treating Australian Vietnam War veterans with chronic PTSD,<sup>[22]</sup> a comparative study evaluating the effects of various modalities including Iyengar and Desikachar yoga, Qi Gong, SKY, and a multicomponent yoga intervention (MCYI) revealed that the interventions that used many yoga tools – specifically, SKY, and MCYI – showed the greatest efficacy.<sup>[23]</sup>

To repair the profound emotional wounds and cognitive distortions brought on by trauma, SKY offered a “corrective emotional experience.” To help individuals regain a sense of belonging to a supportive, accepting, and interdependent community where they are respected and accepted, SKY addresses the cognitive and psychodynamic issues associated with feeling alone, abandoned, and shunned by society.<sup>[24]</sup>

Yogic breathing can be taught to large groups in just a few days. SKY literature reported that SKY has been used to relieve stress, anxiety, insomnia, depression, and PTSD after mass disasters such as war (Kosovo, Bosnia, Iraq, and Sudan), earthquakes (Gujarat, India earthquake 2000), floods (Iran 2004),<sup>[25]</sup> terrorism (New York World Trade Center 9/11),<sup>[5]</sup> the Southeast Asia tsunami (2004),<sup>[26]</sup> and Hurricane Katrina.<sup>[25]</sup> When preparing for an emergency, yoga poses should be taken into consideration as an additional form of treatment. By biologically opposing the effects of SNS activation, Sudarshan Kriya might offer an antidote to stress. In a normal situation (in the absence of stress), the practice of rapid breathing interspersed with adequate pauses of slow breathing may provide a tool for relaxation and vivid imagery.<sup>[27]</sup> SKY rapidly improves psychological and physiological symptoms of post-traumatic stress, including insomnia, nightmares, anxiety, depression, hyperarousal, overreactivity to triggers, re-experiencing, emotional numbing, social withdrawal, loss of appetite, and angry outbursts. Anxiety, depression, and PTSD are associated with SNS overactivity or erratic activity and PNS underactivity. Evidence suggests that yoga breathing normalizes SNS activity and increases PNS tone as indicated by heart rate variability.<sup>[25]</sup>

By regularly practicing the Kriya, SKY training can also help with this shift in perspective by promoting emotional awareness and regulation. “One can skillfully use the breath to transform one’s emotional state,” according to the SKY literature, rather than allowing the emotions to alter the breath and cause physiological changes which may prove unhealthy.<sup>[24,28]</sup>

In the Lancaster Violence Alternative Program, the adolescent subjects, who were offenders of violent crimes with deadly weapon, murder, rape, armed robbery, and terrorist threats against others were included. They all underwent SKY practice following which the Spielberger State-Trait Anxiety Inventory Test showed statistically significant reduction in State anxiety level. Participants also reported that they slept better; did not react to provocation as rapidly; did not experience as much anger; felt less fear at bedtime; and generally expressed that they were more calm.<sup>[29]</sup> Given SKY’s beneficial effects on a range of psychosocial conditions, it is expected that SKY will be a useful addition to the therapy of phobias.<sup>[5]</sup>

## 4. DISCUSSION

P300 event-related potential amplitude is a specific EEG brainwave anomaly found in depressed individuals. By day 30, the P300 amplitude and standard depression scores indicated a significant reduction in depression in the SKY-treated groups. They remained steady and free of depression until day 90, at which point their P300 had returned to normal and was indistinguishable from that of normal controls. Significant improvements in depression symptoms were observed in several other investigations involving dysthymic and melancholy participants following SKY procedures.<sup>[30,31]</sup>

It was also reported that SKY exerts remarkable therapeutic effects in treating dysthymia and unipolar diseases and it may be a more acceptable and efficacious alternative to medical management of dysthymia for both acute treatment and relapse prevention. It has the advantage of fostering the patient’s autonomy and self-reliance besides cutting health-care costs.<sup>[25]</sup>

A comparative study of 45 hospitalized melancholic depressive patients randomized to electroconvulsive therapy (ECT), imipramine, or SKY demonstrated that all three treatments were effective, with ECT being slightly more so than SKY or imipramine.<sup>[32]</sup> SKY improved rapid eye movement latency and slow wave sleep and significantly reduced cortisol; it appears that SKY has powerful biological effects. Compliance with the breathing technique in these studies ranged from 56% to 80%, compared to 50% compliance with prescription antidepressants (with complaints of significant side effects from medications).<sup>[6]</sup>

### 4.1. Alcohol and Tobacco Addiction

Numerous physiological alterations are linked to stress. It is also connected to alcohol and tobacco use habits, both of which promote illness states.<sup>[33]</sup> Reactive nitrogen and oxygen species as well as decreased antioxidant levels appear to be directly linked to the development of alcohol and tobacco-related illnesses.<sup>[34,35]</sup>

Researchers found that 21% of participants who were monitored for up to 6 months after starting SKY were able to limit their tobacco use after completing their conventional therapy for cancer.<sup>[36]</sup>

The antidepressant potential of SKY was examined in sixty alcohol-dependent inpatients. Both before and after the 2 weeks of this intervention, the subjects finished the BDI. Prolactin, ACTH, and morning plasma cortisol levels were assessed both before and after the 2-week period. The antidepressant benefits of SKY were shown in subjects who were alcohol addicted by the results. Cortisol and ACTH levels falling together with BDI levels falling may provide evidence for SKY’s positive effects’ biological mechanism.<sup>[16]</sup>

### 4.2. The Oxidative Stress and Antioxidant Status

Stress genes and several regulatory pathways govern the intricate biological reaction to stress. Internal damage brought on by reactive oxygen species is known as oxidative stress. A growing body of research indicates that long-term psychological stress may raise oxidative stress, which may then lead to aging and the development of heart disease, cancer, arthritis, and other conditions.<sup>[37,38]</sup>

When SKY practitioners were compared to non-practitioners, Sharma *et al.* found significantly lower blood lactate levels and higher levels of glutathione, catalase, and superoxide dismutase (SOD). These findings suggest that regular SKY technique practice is linked to lower blood lactate levels and better antioxidant status in practitioners.<sup>[39]</sup>

The effect of SKY on antioxidant enzyme activities in menopausal women was studied. Four groups of women were compared: 40 received hormone replacement therapy (HRT), 40 received 500 mg of Vitamin E daily, 60 practiced SKY daily, and 50 served as controls. Within just 30 days, the SKY group of menopausal women exhibited improved antioxidant levels and was proven superior to the beneficial effects seen with HRT or Vitamin E on the antioxidant levels.<sup>[40]</sup>

An earlier study has reported that SKY practice significantly increases the blood levels of SOD as an indicator of antioxidant status and reduces plasma malondialdehyde (MDA), another such indicator of oxidative stress.<sup>[19]</sup>

### 4.3. Gene Expression Profiling in Practitioners of SKY

An investigation carried out at the All India Institute of Medical Sciences (AIIMS), located in New Delhi, revealed that SKY practitioners had superior antioxidant status at both the enzyme activity and RNA levels. Together with improved stress management, these individuals also had improved immunological function because their lymphocytes had a longer lifespan as a result of the overexpression of pro-survival and anti-apoptotic genes. Thus, it was determined that through transcriptional control, SKY practice may have an impact on immunity, aging, cell death, and stress management.<sup>[37]</sup>

### 4.4. Stress-related Medical Conditions and Immunity

Patients with a variety of medical conditions, such as fibromyalgia, cancer, diabetes, multiple sclerosis, asthma, and neck and back pain, have found SKY to be beneficial, according to research by Gerberg and Brown. Pain and other stress-related symptoms are known to improve with a reduction in stress and anxiety.<sup>[5]</sup>

In a study conducted to assess the effects of SKY on lipid profile, pulmonary function, and hemoglobin concentration, significant improvement was found in all pulmonary function parameters in all subjects over a period of 8 days. Thus, SKY may have therapeutic implication in the adjunctive (non-pharmacological) management of cardiovascular and respiratory diseases.<sup>[41]</sup>

After 4 months of consistent SKY practice, type 2 diabetes individuals showed significant improvements in their blood glucose level, serum total cholesterol, triglycerides, plasma MDA, and lipoperoxidation, according to a follow-up research. The authors proposed SKY as a potentially effective supplemental treatment for individuals with diabetes.<sup>[42]</sup> A recent study discovered that by enhancing the lipid profile and hematological parameters, SKY practice for 3 and 6 weeks assisted an engineering student in overcoming test stress.<sup>[43]</sup>

An EEG (recorded at 19 cortical locations), electrocardiography, heart rate variability, galvanic skin reaction, hand skin temperature, pulse plethysmography, and blood pressure tests were measured in a study evaluating the neurophysiological responses before to, during, and following SKY. The authors found that SKY practice produced significant changes in all physiological measures. The researchers discovered that all physiological parameters showed substantial improvements as a result of SKY practice. The practitioner's health seems to improve with time, becoming more resilient, adaptable, and capable of handling stress-related difficulties. This implies that doing SKY on a regular basis could be beneficial to wellness.<sup>[44]</sup>

Regular SKY practitioners' spirometry tests have revealed improvements in normal healthy adult lung function, which may have implications for treating patients with obstructive airway disease –

asthmatics in particular – as a complementary adjunctive treatment modality.<sup>[45]</sup>

Following SKY practices, there has been a significant reduction in diastolic blood pressure, serum urea, and plasma MDA adducts, a marker of oxidative stress. Most of the study parameters changed in a fashion that reduced values above the normal range while leaving values within the normal range unchanged.<sup>[46]</sup> According to some writers, practicing stress-reduction strategies (SKY practice) can help with both physiological stress activation during daily tasks and improving one's ability to notice distant things.<sup>[47]</sup>

After completing their normal therapy, cancer patients were investigated by Kochupillai *et al.* At 12 and 24 weeks of the practice, SKY dramatically enhanced natural killer (NK) cells in comparison to baseline. There was no effect on T-cell subsets after SKY either in the study group or among controls.<sup>[36]</sup>

A study using flow cytometry was conducted at AIIMS to count NK cells and T-lymphocyte subsets (T-helper and suppressor T lymphocytes) in the peripheral blood of cancer patients, normal controls, and AOL teachers to see whether there had been any changes in these groups. The investigators found that compared to cancer patients, AOL teachers and normal controls had considerably more total T cells and their T-helper subgroup. When NK cells were compared to normal and cancer patients, there was a noticeable difference in the number of NK cells found in AOL teachers. The NK cell population of cancer patients and normal participants did not differ significantly. Given that all other characteristics were identical in both AOL teachers and normal participants, it is possible to link the larger number of NK cells in AOL teachers to their AOL practice (Sudarshan Kriya).<sup>[48]</sup> This finding supports the literature on yoga which has found that it can prevent immune suppression following early-stage breast cancer surgery.<sup>[49,50]</sup>

In a study of women diagnosed with breast cancer, significant improvement in quality of life, spiritual well-being, positive states of mind, and perceived stress was observed upon completing SKY training and was maintained at 5-week follow-up.<sup>[51]</sup> The subjects were evaluated 2 weeks before the SKY practice, 8 days after the SKY practice, and after 5 weeks of regular practice.

SKY induces relaxation and increases antioxidant defense and NK cells in the body. These observations have important implications for cancer, as they would suggest that (i) SKY may have a preventive role against cancer; (ii) SKY may be effective as a secondary preventive measure, after curative treatment of cancer; and (iii) in metastatic cancer, SKY may delay the progression of cancer and improve the survival and/or quality of life.<sup>[52]</sup>

A study was carried out to measure the changes in psychological well-being of individual living with human immunodeficiency virus/acquired immunodeficiency syndrome following SKY practice. The authors reported significant improvements immediately after the Sudarshan Kriya and Practices (SK and P) intervention, which was not sustained at the final follow-up, perhaps due to insufficient sample size to power the study. Qualitative interviews indicated improvements in day-to-day living.<sup>[53]</sup>

### 4.5. SKY Practice and Spirituality

Overall, human transformation or spirituality is an aspect that science is just beginning to measure. In a study carried out using a spiritual quotient questionnaire to quantify the change in the people



who attended AOL course, it was found that a 4-day SKY training workshop completely transformed the outlook of people toward life.<sup>[54]</sup>

## 5. CONCLUSION

The science that deals with the body, breath, mind, soul, and ultimately the universe itself is the ancient yogic science of breath. Breath is thought to connect the mind with the universal force, much like a thread connects a kite flyer to their kite. At present, medical research is validating and unearthing many of the traditional health practices from ancient societies around the world. One innovative technique that is being thoroughly studied to demonstrate its efficacy as an evidence-based treatment is SKY. In addition to reducing stress and anxiety, SKY has also been shown to be beneficial in the treatment of PTSD, depression, medical conditions linked to stress, substance abuse, and the rehabilitation of criminal offenders. SKY practices are cost-effective, well-tolerated tools that can be easily integrated into diverse community care models. SKY relieves stress and develops an individual's mind-body-spirit so that they can be happier, healthier, and possibly even longer lived. In the competitive modern world, in which stress and anxiety are part of everyday life, adding a time-honored, evidence-based breathing program like SKY may facilitate a healthy life.

To evaluate SKY's therapeutic potential in the treatment of bipolar disorder, dissociative disorders, schizophrenia, and other illnesses brought on by stress, more research is required.

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Nil.

## 11. DATA AVAILABILITY

This is an original manuscript, and all data are available for only review purposes from the principal investigators.

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