



THE SCIENCE of BREATH



How the use of breath can eliminate stress, transform negative emotions, support the whole physiology, and restore health and wellness

Vibrant health is the basis for success and happiness in our lives. Although we know what a healthy lifestyle is, we often overlook a key factor – chronic stress – which negatively affects all aspects of our health and well-being, linked even

to life-threatening diseases. The extensive mind-body research literature shows how stress may affect all levels of our physiology. Fortunately, there are methods that can systematically relieve stress and reverse its influences.

Background

All of us would like to create and sustain a high degree of wellness. Health and wellness are more than the mere absence of illness. To be well is to thrive physically, emotionally, and psychologically. We know what we should eat and drink, that we should exercise regularly, and get enough sleep. However, we often overlook one of the most important determinants of wellness - the stress levels in our lives. Chronic stress can break down the smooth interactions in our mind-body complex and negatively affect every aspect of our lives.

A rapidly growing body of research now robustly links psychological and behavioural factors to our physiological states, and to a broad spectrum of diseases. These include both simple diseases like the common cold, as well as chronic and life-threatening ailments ranging from cancer to coronary heart disease, asthma and HIV-1 infection.

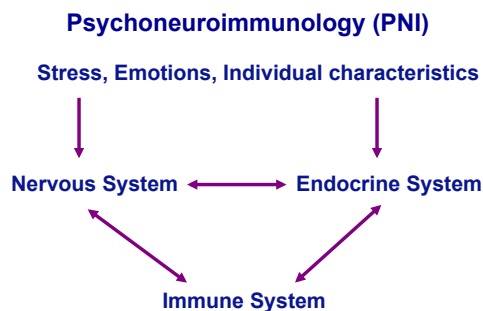


Figure 1. Large body of psychoneuroimmunology (PNI) research has shown that our thoughts and emotions can powerfully affect the brain, endocrine, and immune system function.

How can psychological and behavioural factors affect our physiology and overall well-being so dramatically? A large body of psychoneuroimmunology (PNI) research shows that our thoughts and emotions can powerfully affect the brain, endocrine (hormone), and immune system function. When we are stressed, specific hormones are secreted which may have beneficial effects in the short term, but if sustained for longer periods of time, inhibit the immune system. For example during the final exam period, the activity of disease fighting cytotoxic T-cells (a specialized immune cell) in medical students is decreased 25-fold. Under this condition the immune system is not functioning optimally and it is much easier for pathogenic bacteria and viruses, as well as cancer cells, to thrive in our body. As a result we get sick.

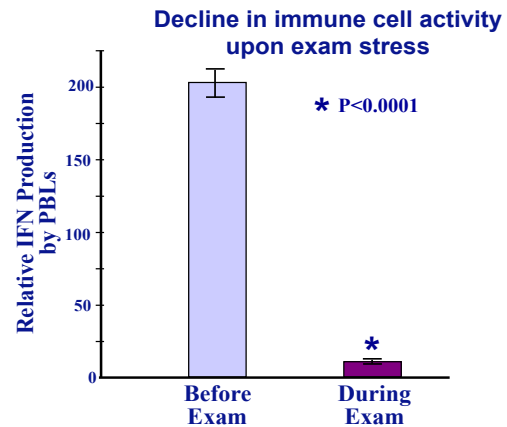


Figure 2. The activity of disease fighting immune cells in medical students is decreased 25-fold under exam stress.

Conversely, “positive” emotions, such as joy, love, and enthusiasm, produce chemical messengers that can affect the brain, endocrine, and immune systems in positive ways. This results in improved resistance to disease and better overall health. Current PNI research has also shown that psychological and immunological functioning can be enhanced through certain stress management programs. One such program that is gaining interest in the medical community is derived from yoga – The yogic science of breath.

Processes to Counter Stress and Increase Wellness

The yogic science of breath is a precise, 5000+ year-old science of health promotion. It is one of the first sciences to recognize the impact of the mind and emotions on creating and restoring optimal health. One of the most comprehensive breathing techniques derived from this science is Sudarshan Kriya (SK). SK is understood to use specific rhythms of breath to eliminate stress, support the various organs and systems within the body, transform overpowering emotions, and restore peace of mind, thus supporting the whole mind-body system.

SK and its accompanying practices (SK&P) have been taught by the Art of Living Foundation to millions of people worldwide, and continue to be independently investigated by modern medical science at universities, hospitals and other research institutions. The following is a summary of some key published findings so far and ongoing research on SK&P.

Research Summary

Improved wellness parameters

To assess possible effects on wellness parameters in healthy individuals, Swedish adults were randomized to either SK&P or to relax in an armchair. Both groups practiced daily for six weeks. Data demonstrate that participants in the SK&P group, but not the control group, significantly lowered their degree of anxiety and depression (Hospital Anxiety Depression Scale), stress (Stress and Energy Test), and also increased their degree of optimism (Life Orientation Test). This suggests that healthy people may improve various aspects of their wellness simply by learning and applying SK&P.

SK&P increases wellness in healthy people

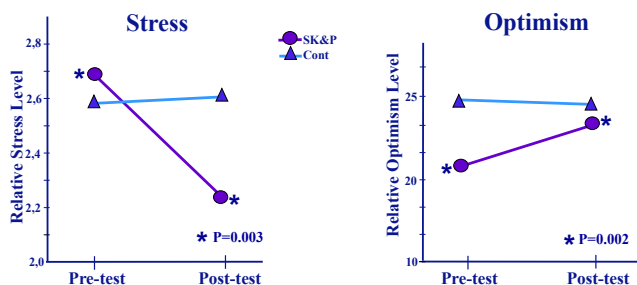


Figure 3. SK&P significantly decreased stress and increased degree of optimism in healthy adults, indicating improvement of wellness.

Effect on Depression

While the industrialized world enjoys a higher life expectancy, it suffers from a relatively high incidence of psychological and mental health disorders. According to a EU Commission publication, more than 27% of adult Europeans experience at least one form of mental health problem each year, most commonly anxiety and depression. In the US anxiety now leads depression as the #1 mood disorder. By 2020 depression is expected to be the highest-ranking cause of disease in the developed world creating a substantial financial burden as well. Thus, new strategies for fighting depression and anxiety are urgently needed.

Several independent studies have shown that SK&P practitioners experience a 68%–73% success rate in the treatment of clinical depression, regardless of severity. Relief from depression, determined by psychiatric evaluation and standard psychiatric measures (Beck Depression Inventory - BDI, Hamilton Depression Rating Scale-HDRS, and others), was experienced within a few weeks. At the three-month follow-ups, patients remained stable and in

Independent research has shown that Sudarshan Kriya and accompanying practices significantly:

- Reduce levels of stress (reduces cortisol – the “stress” hormone)
- Benefit the immune system
- Relieve anxiety & depression (mild, moderate & severe)
- Enhance brain function (increases mental focus, calmness & recovery from stressful stimuli)
- Enhance health, well-being & peace of mind
- Relieves Post Traumatic Stress Disorder (PTSD) symptoms
- Affects the mind-body system at the molecular level

remission. Published studies further suggest that SK&P normalises patients’ brainwave patterns, increases serum prolactin (a “well-being” hormone), and is as effective as standard anti-depressant drug regimens. Yet it is safe, free of unwanted side effects, cost-effective, and self-empowering. Independent studies have also shown significant reductions in both clinical and non-clinical anxiety. An open trial of patients with Generalized Anxiety Disorder who had not responded to prescription medication showed a 73% response rate (HAM-A) after four weeks practice of SK&P. Furthermore, a study of apparently healthy adults showed significant reductions in anxiety (STAI) in four weeks.

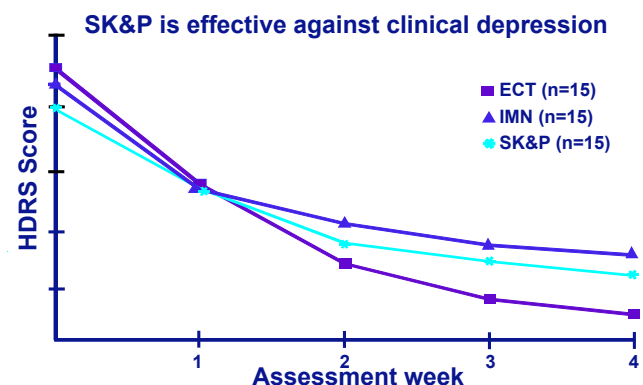


Figure 4. SK&P significantly reduced clinical depression within a few weeks. HDRS, Hamilton Depression Rating Scale; ECT, electroconvulsive therapy; IMN, imipramine (drug).

Effect on Cortisol, the “Stress Hormone”

Several studies have demonstrated significant declines in cortisol levels following regular practice of SK&P. In one study, experienced SK&P practitioners

(Group 1) were compared with beginning practitioners during their first SK&P session (Group 2), and also before learning SK&P, while listening to classical music (Group 3). Among beginners, the fall in cortisol levels was significantly greater during SK&P than when listening to classical music, suggesting that SK&P produces a better relaxation response. In addition, experienced SK&P practitioners had significantly lower blood cortisol levels before the start of the SK&P session than the beginning practitioners. This indicates that the experienced practitioners incur less stress under the demands of daily living. Following the SK&P session both beginning and experienced practitioners demonstrated further significant declines in cortisol levels that regular practice of SK&P develops progressively greater levels of both relaxation and resilience to stress.

Effect on Blood Lactate

Blood lactate is another biochemical measure of stress that has been shown to increase under extended psychological stress. Police cadets constitute a highly stressed group who undergo intense physical and emotional training daily. In one study, some trainees were assigned to learn and regularly practice SK&P while others served as controls. After five months blood was drawn before and after the SK&P practice to determine lactate levels. Before the practice (basal levels), the blood lactate in SK&P practitioners were four times lower than that of controls. After a session of SK&P, there was a further significant drop in blood lactate levels in the SK&P group, whereas no changes were observed in the control group. These results indicate that SK&P induces a state of relaxation.

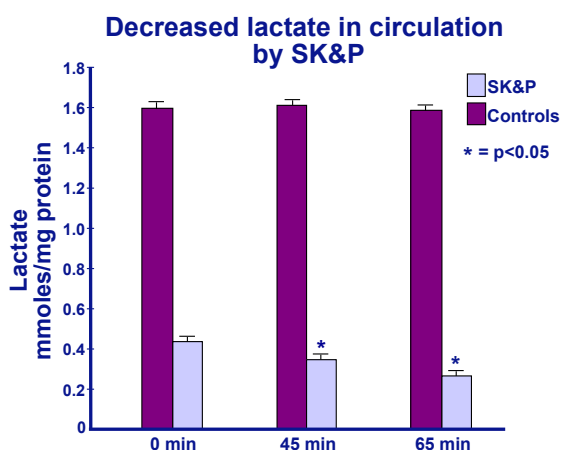


Figure 5. SK&P significantly decreased Lactate (an indicator of tension and stress) in the blood of police trainees. Note the significantly lower level before SK&P that is further decreased upon practice.

Effect on Antioxidant Enzymes

Repeated exposure to environmental pollutants and metabolic by-products result in the formation of free radicals, which contribute to many diseases (including cancer and cardiovascular disease), and the aging process. To counteract free radicals, the human body has a powerful internal defense system in the form of antioxidant enzymes. A study to assess the effect of SK&P on antioxidant enzymes was conducted on the same group of police trainees as above. The levels of three major antioxidant enzymes - superoxide dismutase (SOD), catalase, and glutathione were found to be significantly higher in SK&P practitioners than in the control group after five months at baseline measurement. There was an additional increase in all enzymes after practice of SK&P with no significant change in the control group. These data suggest that people who practice SK&P have an improved antioxidant status and thus an enhanced defense against free radical damage.

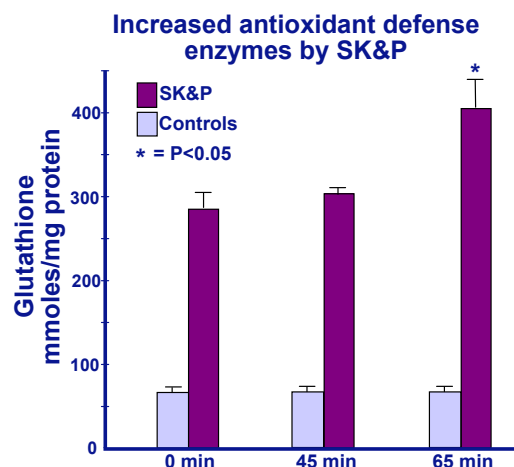


Figure 6. Increased antioxidant enzyme glutathione by SK&P practice. Note the significantly higher level before SK&P that is further increased upon practice.

Effect on Lipid Profile

Stress has recently been shown to be a significant contributor to elevated cholesterol levels. A randomized study of engineering students during two periods of exam stress demonstrated significantly lower levels of total cholesterol, low density lipoproteins (LDL or 'bad' cholesterol), and triglyceride levels in SK&P practitioners than in controls after each exam. Prior to exams there were no significant differences in the cholesterol profiles of the two groups, suggesting that practice of SK&P may play a significant role in promoting cardiovascular health.

Effect on Immune Function

Natural killer (NK) cells are the surveillance cells of the immune system capable of destroying tumor cells and infected cells. The effect of SK&P on NK cells was studied on three groups: SK&P practitioners, normal individuals not practicing SK&P, and cancer patients in remission. NK cells were significantly higher in the SK&P group than in either non-practicing individuals or in cancer patients in remission. The cancer patients then learned SK&P. After 12 and 24 weeks of regular practice, there was a significant increase in the NK cell count of cancer patients in remission who practiced SK&P compared with a control group of remitting cancer patients who did not practice SK&P. This is particularly encouraging since cancer survivors have abnormally low levels of NK cells, and NK cells are believed to be important in the body's defense against new and recurring cancers.

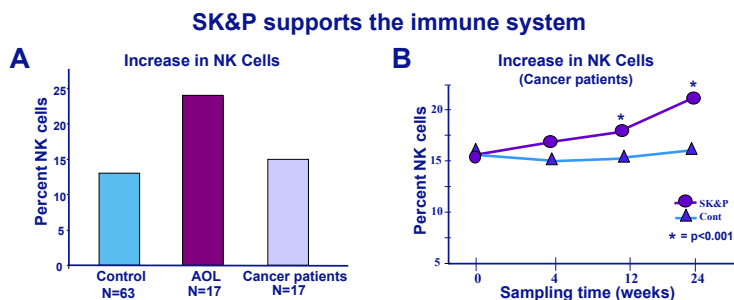


Figure 7. A) NK cell levels in blood were compared in normal controls, normal SK&P practitioners, and cancer patients. B) Cancer patients learned SK&P or were left as controls, and NK cell levels were determined at indicated time points.

Improved Brain Function

To study the long-term effects of SK&P on brain function, EEG (electroencephalogram) changes were recorded in 19 SK&P practitioners outside of the practice of SK&P, and compared with EEG patterns of 16 controls (doctors and researchers who did not practice SK&P, yoga, or meditation). Significant increases in beta activity were observed in the left frontal, occipital, and midline regions of the brain in the SK&P practitioners, as compared to controls. These results are interpreted by neurologists as indicative of increased mental focus/heightened awareness in SK&P practitioners. It is striking to note that SK&P practitioners displayed significantly greater mental alertness (beta activity) than the control group of physicians and medical researchers, whose profession requires development and daily use of these very skills.

EEG activity was also studied during the practice of SK&P in five females of similar age, socioeconomic, and educational backgrounds. This study found an

SK&P increases EEG beta measures indicative of alertness

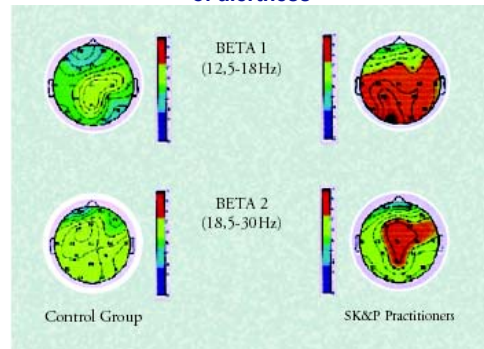


Figure 8. Significant increases in beta activity were observed in the left frontal, occipital, and midline regions of the brain in the SK&P practitioners, as compared to controls (p<0.05).

increase in EEG alpha activity, with interspersed persistence of beta activity. This indicates a state of relaxation co-existing with heightened alertness.

Relief From Post-Traumatic Stress Disorder (PTSD)

Traumatic events, such as natural or man-made disasters, can induce high rates of psychiatric illness, including PTSD, depression and suicidal tendencies. A study of 183 survivors of the 2004 Tsunami living in refugee camps tested the effects of a modified SK&P program alone or followed by a trauma reduction exposure technique (TIR) on PTSD and depression. Subjects who scored 50 or above, indicative of PTSD, on the Post-traumatic Checklist-17 (PCL-17) were assigned to one of three groups: modified SK&P, SK&P+TIR or 6-week wait list (controls). Measures for PTSD (PCL-17) and depression (BDI-21) were performed at baseline and at 6, 12 and 24 weeks. At 6 weeks, and stable through 24 weeks, there was a very significant reduction in PTSD and depression symptoms (65% and 85%, respectively; in the SK&P group with no significant change in the controls. The addition of TIR did not improve results obtained by SK&P alone. These results suggest that SK&P helps relieve psychological distress following mass disasters.

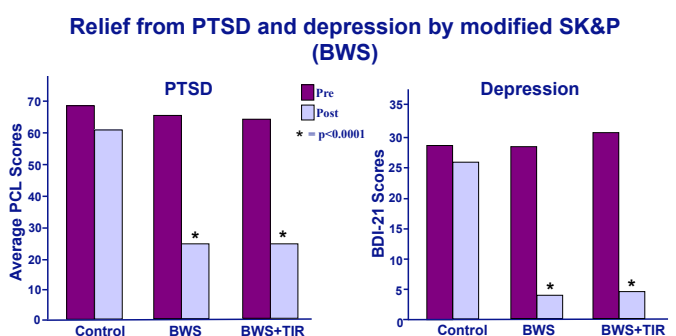


Figure 9. A modified form of SK&P (BWS) either alone or in combination with a trauma reduction program (TIR) was tested on survivors of the 2004 tsunami. These data suggest that SK&P effectively relieves both PTSD and depression symptoms, regardless of TIR.

Improved Emotion Regulation

Difficulties regulating emotional responses to events in our lives plays a critical role in mood, anxiety, and personality disorders. The ability to calm strong emotional reactions by mentally re-framing the meaning of events (called cognitive reappraisal) was studied in SK&P practitioners and controls. While initially both groups successfully reduced their negative feelings, neurophysiological correlates captured by EEG recordings found that the effect of reappraisal persisted longer in the SK&P group. This indicates that SK&P can help regulate the emotional response and thus promote psychological wellness.

Effect on gene expression

The blueprint of our physiology is contained in the DNA that is present in the nucleus of all cells in our body. The knowledge in the DNA is contained in packets of information called genes. Genes can be either turned on or off in response to environmental cues in a process called gene expression. For all physiological processes, as well as in pathological conditions, it is ultimately changes in gene expression that determines the final state (phenotype) of the cell, tissue, and the organism.

One study assessed 42 SK&P practitioners and 42 non-practitioners. Antioxidant enzyme levels in the blood were compared with their gene expression levels in circulating immune cells. There was a better antioxidant status both at the enzyme level, and corresponding gene expression patterns, in immune cells of SK&P practitioners. This is consistent with results summarized above and suggests that the effects of SK&P on antioxidant enzymes are due, at least in part, to changes in gene expression.

In another study, short term (within two hours) global changes (for all of the genes) in gene expression were investigated upon SK&P practice in 10 subjects. Blood was drawn immediately before and after SK&P (on two separate occasions), or a control regimen of nature walk + listening to classical music (also on two separate occasions in the same subjects). Gene expression profiles in circulating immune cells were determined. The expression of about four times more genes was affected by SK&P compared with the control regimen. Most of the differentially expressed genes in the SK&P group were distinct belonging to different gene families. These findings suggest that the beneficial effects of SK&P on different levels of the physiology may be mediated by molecular events.

SK&P effects on gene expression

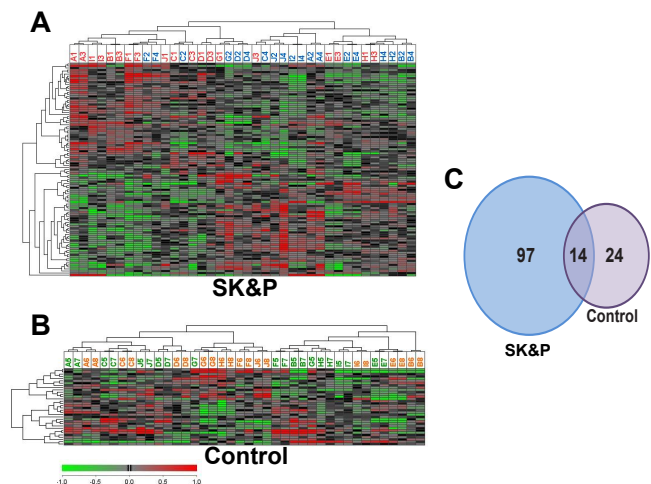


Figure 10. Rapid effects of SK&P on global gene expression profile in healthy subjects. A) SK&P effects. B) Control regimen effects. C) Venn diagram showing the number of genes regulated by SK&P and control, and their intersection. See Qu et al. 2013 for more information.

Ongoing Studies

In addition to the research that is summarized above, there are a number of additional studies that are currently ongoing some of which are highlighted below.

Department of Neurosciences, Fatebenefratelli Hospital in Milan, Italy is conducting a randomized, controlled study on patients with depression, generalized anxiety, and panic attacks. It includes 70 patients learning SK&P and 70 controls to assess possible changes in depression, general anxiety, and cognitive functions using standard self-report questionnaires and clinical interviews. In addition, cardiological and respiratory states are tested using Respiratory Sinus Arrhythmia (RSA), a naturally occurring variation in heart rate during the breathing cycle. A pilot experiment from 2009 suggests that depression is decreased by 60%, social psychosis and anxiety by 40%, and significant improvements in cognitive functions and RSA. The study will be finished by summer 2014.

Cancer Clinic, Oslo University Hospital Ullevaal, Oslo, and University of Oslo, Norway is conducting a study on breast cancer patients. It is a controlled and randomized trial with 60 patients in each arm of the study. The measurements are made at the time of recruitment, after the SK&P intervention, and six months after the SK&P intervention. The rates of psychological disturbances, such as depression, anxiety, and stress, are being evaluated as well as the stress hormone cortisol in saliva. Proinflammatory cytokine production and components of the antioxidant enzyme system in blood is being measured. The study is scheduled to be finished in 2015.

Center for Investigating Healthy Minds, University of Wisconsin-Madison, USA, is conducting a research project on the effects of SK&P for Veterans returning from war who have PTSD. Pilot results suggest that there are significant reductions in PTSD and anxiety.

The Semel Institute for Neuroscience and Human Behavior at University of California, Los Angeles, USA, is conducting a neuroimaging study to determine the effects of SK&P on the brain's emotional response. The investigators are also examining the effects of the Youth Empowerment Seminar (YES!) (a program for teenagers which includes training in SK&P) on measures of emotional well-being in high school students. They have shown that YES! reduces impulsiveness, a tendency that can lead to risky behavior, such as drug abuse. Preliminary results also show that YES! increases empathy among teenagers. The group is planning a study to determine how YES! may improve the recovery of teenagers in residential substance abuse treatment facilities by reducing stress and impulsive behavior.

Investigators affiliated with Stanford University School of Medicine, USA, are conducting a study of YES!. Findings suggest that YES! may be effective in increas-

ing self-esteem, identity, self-efficacy, concentration and emotion regulation and in reducing both aggressive behavior and attitudes towards the acceptable use of aggression. Expected completion date of this project is mid 2014.

Investigators associated with the University of Ottawa, Canada are investigating the effects of YES! among diverse ethnicities and gender. Pilot data suggests YES! is effective across gender and ethnicity in reducing risk factors for substance abuse, aggression, and academic failure and for increasing developmental assets. Developmental assets are characteristics that enable youth to thrive and become contributing members of society. Expected completion date of this project is the end of 2014.

Research Triangle Institute of Atlanta, Georgia, USA is completing a study of YES+ (a program for young adults aged 18-30 that includes training in SK&P). Pilot data suggests that participation in YES+ is associated with increased serenity and emotion regulation and decreased fatigue, sorrow and fear. Expected completion date is mid-2014. Future larger studies including physiological measures are planned.

Conclusions

The subjective reports of increased health, vitality, well-being, and peace of mind by tens of thousands of SK&P practitioners are consistent with research findings: Studies suggest an overall strengthening of the mind-body system. EEG, blood cortisol, and lactate levels reflect a state of relaxation, yet alertness. Significant increases in NK cells and antioxidant enzymes suggest that regular practice may help prevent many serious diseases. Robust effects on PTSD and depression symptoms indicate that SK&P relieves psychological distress. Measurable

changes at the level of gene expression suggest that the effects of SK&P span all levels of the physiology, from molecular to organ systems.

Thus, even though further studies are certainly needed, these findings point to the powerful health restoration and promotion effects of these time-honored practices that can be employed to increase wellness in healthy people and used as adjunct tools in therapy.



The Art of Living Foundation, founded by Sri Sri Ravi Shankar, is a non-profit educational and humanitarian organisation, and a Non-Governmental Organisation of the United Nations in special consultative status with the UN's Economic and Social Council.

The Art of Living Foundation's International Research and Health Promotion Center (IRHPC) welcomes scholarly research on its programs from all interested parties. If you would like to conduct or collaborate on research, or would like more information about our research and health-promotion programs, please contact the IRHPC, at:

Asian Centre: research@vmmvp.org

European Centre: research@aoluniversity.org

North American Centre: research@artofliving.org

www.aolresearch.org



Art of Living Foundation
Bad Antogast 1.
77728 – Oppenau, Germany
www.artofliving.org

Selected References

- Janakiramaiah, N., Gangadhar, B.N., Naga Venkatesha Murthy, P.J., Harish, M.G., Subbakrishna D.K., Vadamurthachar A. (2000). Antidepressant efficacy of Sudarshan Kriya Yoga (SKY) in melancholia: a randomized comparison with Electroconvulsive therapy (ECT) and Imipramine. *Journal of Affective Disorders*. 57:255-9.
- Bhatia, M., Kumar, A., Kumar, N., Pandey, R.M., and Kochupillai, V. (2003). Electrophysiologic evaluation of Sudarshan Kriya: an EEG, BAER, and P300 study. *Indian J. Physiol. Pharmacol.* 47, 157-163.
- Sharma, H., Sen, S., Singh, N.K. Bhardwaj, V. Kochupillai, N. Singh (2003). Sudarshan Kriya practitioners exhibit better antioxidant status and lower blood lactate levels. *Biological Psychology* 63:281-291.
- Kochupillai, V., Kumar, P., Singh, D., Aggarwal, D., Bhardwaj, N., Bhutani, M., DAS, S.N. (2005). Effect of rhythmic breathing (sudarshan kriya and pranayam) on immune functions and tobacco addiction. *Ann NY Acad Sci.* 1056:242-52.
- Vadamurthachar, A., Janakiramaiah, N., Hegde, J.M., Shetty, T.K., Subbakrishna, D.K., Sureshbabu, S.V., Gangadhar, B.N. (2006). Antidepressant efficacy and hormonal effects of Sudarshan Kriya Yoga (SKY) in alcohol dependent individuals. *J Affect Disord.* 94, 249-253.
- Kjellgren, A., Bood, SA, Axelsson, K, Norlander, T, Saatcioglu, F.(2007). Wellness through a comprehensive Yogic breathing program – A controlled pilot trial. *BMC Complement Altern Med.* 7:43-50

Sharma H, Datta P, Singh A, Sen S, Bhardwaj NK, Kochupillai V, Singh N. (2008). Gene expression profiling in practitioners of Sudarshan Kriya. *J Psychosom Res.* 64:213-8

Descilo, T., Vadamurthachar, A., Gerbarg, P.L., Nagaraja, D., Gangadhar, B. N., Damodaran, B., Adelson, B., Braslow, L. H., Marcus, S., Brown, R. P. (2009). Effects of a yoga breath intervention alone and in combination with an exposure therapy for post-traumatic stress disorder and depression in survivors of the 2004 South-East Asia tsunami. *Acta Psychiatr Scand.*, 121:289-300

Gootjes, L., Franken, I.H.A., and Van Strien, J.W. (2011) Cognitive emotion regulation in yogic meditative practitioners - Sustained modulation of electrical brain potentials. *Journal of Psychophysiology* 25:87-94

Ghahremani, D.G., Oh, E.Y., Dean, A.C., Mouzakis, K., Wilson, K.D., London, E.D. (2013). Effects of the Youth Empowerment Seminar on Impulsive Behavior in Adolescents. *J Adolesc Health.* 2013 Apr 16. pii: S1054-139X(13)00105-5.

Qu, S., Olafsrud, S.M., Meza-Zepeda, L.A., Saatcioglu, F. (2013). Rapid Gene Expression Changes in Peripheral Blood Lymphocytes upon Practice of a Comprehensive Yoga Program. *PLoS One.* 8(4):e61910.

Carter, J.J., Gerbarg, P.L., Brown, R.P., Ware, R.S., D'Ambrosio, C., Anand, L., Dirlea, M., Vermani, M., and Katzman, M.A. (2013). Multi-Component Yoga Breath Program for Vietnam Veteran Post Traumatic Stress Disorder: Randomized Controlled Trial. *J Trauma Stress Disor Treat* 2:3.