



SRI SRI INSTITUTE FOR ADVANCED RESEARCH

Art of Living Research Wing

A White Paper Series on Sudarshan Kriya

A White Paper on Sudarshan Kriya and Antioxidants

Introduction

Free Radicals and Oxidative Stress

The body is a host to multiple constant metabolic processes that keep us alive. These processes are largely electrical and chemical in nature. During the chemical process of breaking down nutrients to create energy, the body generates free radicals. Free radicals are normal by-products of metabolic and other reactions in the body and are not harmful in low amounts, however they are harmful in large quantities. One of the most commonly known free radical, reactive oxygen species (ROS), often creates a chain reaction inside a cell leading to potential breaks in cell membranes, which in turn reduces cell integrity and increases cell porosity, all culminating in cell damage and accelerated death. The molecules damaged by free radicals may mutate and create tumors.

Free radicals are neutralized by a class of compounds called antioxidants, and the imbalance between the production of free radicals and their neutralization by antioxidants is called oxidative stress. During high oxidative stress the body accumulates too many free radicals resulting in increased cellular damage. It is also associated with damage to proteins, lipids and DNA. Oxidative stress contributes to development of diseases like diabetes, cardiovascular conditions, cancer, Alzheimer's disease, Parkinson's disease, ulcers and inflammatory disorders, such as arthritis and systemic lupus.

Besides natural physiological processes and aging, several dietary and lifestyle factors may increase oxidative stress in the body. They include diets high in fat and sugar, processed foods, alcohol consumption, air pollution, smoking and exposure to radiation.

Antioxidants

Antioxidants are substances that neutralize free radicals. They are either produced naturally by the body (endogenous), or can be acquired through certain foods and supplements (exogenous). Exogenous antioxidants can be obtained from colorful plant-based foods like berries, mangoes, apricots and vegetables like carrots, pumpkin, spinach and parsley. The details of antioxidants produced naturally by the body are mentioned below:

Endogenous Antioxidants (Naturally produced by the body):

1. **Superoxide Dismutase (SOD)**: This enzyme is present in every cell of the body. Some SODs are even cell organelle specific, e.g, SOD₂ is present in mitochondria while SOD₃ in the extracellular space. SOD constitutes a very important antioxidant defense against oxidative stress in the body, forming the front line of defense against reactive oxygen species (ROS)-mediated injury. SOD catalyzes the conversion of superoxide anion free radical (O₂⁻) into molecular oxygen and hydrogen peroxide (H₂O₂). Promising research is underway to analyze the therapeutic potential of SOD in mitigating several life-threatening diseases such as cancer and neurological disorders.

2. **Glutathione reductase**: Present in each cell of the body, Glutathione reductase catalyzes the reduction of glutathione disulfide (GSSG) to the sulfhydryl form glutathione (GSH) - a critical molecule in resisting oxidative stress and maintaining a neutral environment in the cell.

3. **Glutathione**: This is a principal endo-antioxidant species. In addition to its neutralizing activity on free radicals (FR), it also acts as immune booster, anti-aging agent and skin-whitener. Chemically Glutathione is made up of three amino acids (a tripeptide of cysteine, glycine and glutamic acid) and is found in surprisingly high levels 5 millimolar—concentrations in most cells. It is present in both the oxidized form (GSSG) and reduced (non-oxidised) form (GSH) in a cell, their constant cellular levels maintained by activity of several enzymes. It neutralizes the FRs/oxidants by donating its electrons to them, converting itself from its reduced form GSH (thiol) to its oxidized form (GSSG) in the process. There are various natural ways to increase our glutathione levels, such as consuming sulfur rich foods (nuts, legumes, allium vegetables), increasing Vit-C intake, getting enough sleep, and adding selenium rich foods to the diet (brazil nuts, brown rice, cottage cheese etc.).

4. **Glutathione peroxidase**: This is a cytosolic enzyme which catalyzes the reduction of hydrogen peroxide to water and oxygen, as well as catalyzing the reduction of peroxide radicals to alcohols and

oxygen. Glutathione peroxidase has the capacity to scavenge free radicals. This in turn helps to prevent lipid peroxidation, maintaining intracellular homeostasis as well as redox balance.

5. **Catalase:** Catalase is a common enzyme found in nearly all living organisms exposed to oxygen (such as bacteria, plants, and animals), which catalyzes the decomposition of hydrogen peroxide to water and oxygen. It is a very important enzyme in protecting the cell from oxidative damage by reactive oxygen species (ROS).

Antioxidant Status and Your Health

An optimum balance between free radicals and antioxidants are vital in order to keep in check the initiation or progression of any chronic, metabolic, degenerative or life-style associated disease. Human body has a fantastic resilient capacity to maintain homeostasis between the needs of various organs and their functionality, however sometimes the chemical or biological insults to the cells distorts normal physiological actions and effectively converts them into a pathophysiological cascade of reactions. Therefore, it is crucial to maintain a lifestyle that increases antioxidants to support this inherent healing property of the body. It is important to know that we must practice caution when including antioxidants supplements in our diet to avoid any serious side effects or long-term harm. Natural resources of antioxidants are immensely beneficial to health and do not have adverse impacts, unlike the artificial sources of antioxidants which could have adverse effects when taken in large quantities over a long period of time. SKY is one such natural lifestyle factor that has been shown to enhance the natural antioxidant defense mechanisms of the body.

Sudarshan Kriya Yoga (SKY)

Sudarshan Kriya Yoga is a technique taught by the Art of Living Foundation in more than 180 countries with more than 6 million practitioners across the globe. Sudarshan Kriya Yoga is taught in various modules across various age groups in different parts of the world.

SKY is a cyclic rhythmic breathing technique with its roots in traditional yoga. The 25 minutes process includes three yogic components – pranayama, Om chanting and Sudarshan Kriya. The pranayama is done using the Ujjayi breath. Ujjayi involves experiencing the conscious sensation of the breath touching the throat. This slow breathing technique is performed at a rate of 2–4 breaths per minute (bpm). This technique improves lung capacity allowing more passage of air through the

lungs. 'Om' is chanted three times with prolonged exhalation. Lastly, Sudarshan Kriya rhythmic breathing is done in two variations:- Long SKY that is done with recorded instruction by Gurudev Sri Sri Ravishankar and Short SKY. Short SKY can be done at home taking slow (20 bpm), medium (40–50 bpm), and fast (60–80 bpm) breaths. The entire technique is done in a seated posture with eyes closed.

Research studies on Sudarshan Kriya Yoga and Antioxidants

Research studies have assessed the impact of SKY on different arms of antioxidant defense mechanisms which play a key role in maintaining the health of the human body and resisting any detrimental changes or threats to the body.

1. Sudarshan Kriya Yoga Improves Antioxidant Status and Reduces Anxiety in Adults

Anxiety is a common symptom of several mood related psychological disorders and is correlated with lower levels of antioxidants. A prospective study was conducted by Agte and Chiplonkar^[1] to explore the antioxidant profile and level of anxiety in 37 apparently healthy adults after 7 weeks of SKY practice. The study outcomes included the measurement of superoxide dismutase (SOD), lipid peroxidation, malondialdehyde (MDA). SOD was used as an indicator of antioxidant capacity, while lipid peroxidation was used as an indicator of cellular damage mediated by oxidative distress. Malondialdehyde (MDA) was used as a marker for oxidative stress. An increase in MDA causes the cellular lipids to degrade, damaging the cell structure and starting the process for multiple diseases. After two months of SKY practice, a decrease of 21.3% in the anxiety-score was noted, which correlated with a significant increase in SOD levels (by 28%) and reduction in MDA oxidative stress by 13%, indicating an improvement in antioxidant profile during the same time period. A rise in SOD level after 2 months of SKY practice illustrates a higher quantity of the enzyme available to cleave free oxygen radicals, which in turn ensures that free oxygen radicals do not damage the DNA and proteins in the body. One can correlate a steady practice of SKY with improvement in antioxidant profile and reduction in anxiety.

Summary: Antioxidants are key in preventing cellular damage from free radicals. Natural antioxidant production decreases as age, stress levels and anxiety increase. Regular practice of SKY for 30 minutes a day, across the 7 week study period, showed an improvement in both the anxiety

and antioxidant profile. Assessment of biomarkers revealed reduced plasma MDA levels (a marker for oxidative stress) by 13%, along with increased SOD levels by 28%. SOD is an antioxidant enzyme which cleaves free oxygen radicals. This improvement in oxidative stress correlated with lower anxiety scores.

2. Whole blood analysis of antioxidant enzyme and gene expression profiling in practitioners of Sudarshan Kriya Yoga

A cross-sectional (single time point assessment) study by Sharma et al.^[2] investigated the effects of SKY on oxidative stress molecules. The oxidative stress is mitigated by antioxidants present in the body. An excess of oxidative stress can damage DNA by creating reactive oxygen molecules.

Antioxidant enzymes: Glutathione peroxidase, glutathione, catalase and superoxide dismutase, were measured in the whole blood samples from 42 healthy SKY practitioners and 42 controls. Expression of the genes involved in regulating oxidative stress mechanisms was also measured. The results demonstrated an improved antioxidant status, both in terms of amount of enzyme and expression of the genes that regulates the enzyme activity among SKY practitioners as compared to controls.

The SKY practitioners showed a 56.5% higher gene expression level of Glutathione peroxidase, which correlated with 25.8% higher levels of glutathione in their blood (nmol/ml) as compared to controls. The Mn SOD gene was expressed 86.5% more in SKY practitioners which correlated with 23.6% higher levels of SOD enzyme (nmol/ml) in their blood as compared to controls. Higher expression of glutathione S-transferase, antioxidant Cu-Zn and catalase genes were also noticed in the SKY practitioners. The results also showed an up-regulation of antiapoptotic Bcl-2 along with Cox-2 gene in SKY practitioners. These genes prolong the lifespan of lymphocytes, a type of immune cell and inhibit their cell death.

Summary: A study evaluating gene expression and antioxidant activity showed higher levels of antioxidant enzymes amongst the SKY practitioners. The SKY practitioners showed a 56.5% higher gene expression level of Glutathione peroxidase, which correlated with 25.8% higher levels of glutathione in their blood (nmol/ml) as compared to controls. The Mn SOD gene was expressed 86.5% more in SKY practitioners which correlated with 23.6% higher levels of SOD enzyme (nmol/ml) in their blood as compared to controls. Assessment of gene expression showed an up-regulation of antioxidant and antiapoptotic genes among the SKY practitioners. These genes help in extending the lifespan of immune cells.

3. Impact of Sudarshan Kriya Yoga on Blood Lactate Level and Antioxidant Status

Acute psychological stress increases the oxidative stress in the body, which in turn contributes to the pathophysiology of chronic diseases like cancer and diabetes. A study done by Sharma et al.^[3] demonstrated that, with the practice of SKY, antioxidant level improves and level of blood lactate, a marker of stress and impaired oxygen delivery, drops sharply. Ten (10) SKY practitioners (> 5 months practice) and 14 non-SKY practitioners, from the police training college, Delhi, India, were enrolled in the study to examine the effect of SKY practice on antioxidant and blood lactate levels. Blood samples were collected during one Long SKY session at three distinct timepoints i.e. just before SKY, at 45 minutes into SKY (post SKY) and at 65 minutes after SKY to determine the blood lactate, catalase enzyme, Superoxide dismutase and glutathione levels. Lower blood lactate levels demonstrate improved muscular functions including that of cardiac muscles and overall greater homeostasis in the body. The samples were also collected from non-SKY practitioners at the same time points. Results showed that blood lactate level was lowered by 70% in practitioners of SKY, as compared to non-SKY controls post SKY. Intragroup (between the same group) comparison demonstrated a significant decrease of 25.96% in blood lactate levels at 45 min time point and 36.1% decrease at 65 min time point among SKY practitioners, while non-SKY group did not show any appreciable differences for either of the time points. Four fold rise in basal blood glutathione, an antioxidant, was also noticed for SKY practitioners along with 51.6% higher levels of catalase enzyme and 2.5 times higher levels of superoxide dismutase (SOD), as compared to the non-practitioners of SKY. SOD Level was higher in the SKY group at post-SKY 65 min time point by 53%. Therefore the study demonstrated that SKY improves antioxidant status with practice.

Summary: The present study suggests that regular practice of SKY leads to a better antioxidant status in its practitioners, as compared to non-practitioners. Blood lactate levels are lower by 25.96% in the SKY group suggesting decreased muscular fatigue. The study also noticed a profound rise in antioxidant enzyme activity of the SKY group: 4 fold increase in glutathione, 51.6% in catalase and 2.5 times in superoxide dismutase enzyme, during the SKY practice.

4. Immediate impact of Sudarshan Kriya Yoga on antioxidant levels among hypertensive patients

Agte et al.^[4] studied the effect of SKY on biochemical markers and antioxidant levels in hypertensive patients. The study enrolled 26 mild hypertensives and 26 healthy adults, between the ages of 30–60 years, to assess the effect of Sudarshan Kriya Yoga practice as complementary therapy in addition to medication for hypertension. Assessments were done prior to, and after 2 months of SKY practice. The most appealing observation, common to the majority of the study parameters, was that the higher values were lowered, normal values were unaltered and lower values were increased up to normality. In the hypertensives, there was a significant decrease in plasma MDA (malondialdehyde), an oxidative stress marker, by 22.3% in women and 18.8% in men. MDA is responsible for the disintegration of cell membrane due to lipid degradation. These results demonstrated a positive impact of SKY on the health of hypertensives, as well as of normal controls, by maintaining normal levels of urea (marker of healthy kidney function), and keeping the oxidative stress (MDA) at minimum.

Summary: In patients with hypertension, there was a significant decrease in plasma MDA (malondialdehyde), an oxidative stress marker, by 22.3% in women and 18.8% in men, after practicing SKY for 2 months. By keeping oxidative stress at a minimum, the risk of heart disease due to hypertension is lowered.

5. Sudarshan Kriya Yoga and Quality of life after menopause

The biological effects of free radicals are minimized in vivo by a wide spectrum of antioxidant defense mechanisms such as vitamin E, vitamin C, carotenoids and antioxidant enzymes. Free radicals and peroxides are involved in the pathogenesis of various diseases including atherosclerosis, inflammatory diseases, cancer etc and are thought to precipitate the aging process. Synthetic Oestrogen (hormone replacement therapy (HRT)) has antioxidant properties and provides a protective effect against atherosclerosis, osteoporosis, uro-genital atrophy and other diseases associated with menopause and aging. Geetha et al.^[5] studied the effect of SKY practice on antioxidant enzymes in a group of menopausal women (n=190). Women between the ages 45-60 years, who did not smoke or drink alcohol were enrolled in the study, and divided into three groups. Group 1 (n=40) received hormone replacement therapy (HRT). Group 2 (n=40) received 500mg/day of vitamin E orally. Group 3 (n=60) practiced SKY daily. The remaining 50 menopausal women did not receive any intervention

and acted as controls. Antioxidant enzyme activity was measured by assessing the concentrations of plasma Superoxide Dismutase and GSH px (Plasma glutathione peroxidase) in all the subjects before and after 30 days of their respective treatment. Levels of plasma MDA , which is a marker of oxidative stress, was also measured. High levels of SOD, GSHpx and low levels of plasma MDA are indicators of low oxidative stress and improved health. An increase of 211% in SOD levels and 111.7% in GSHpx levels and corresponding decrease of 66% in serum MDA was observed in women who were practicing SKY, as compared to the women in all the other groups, HRT, Vit E and control groups. This study demonstrated that practice of SKY could be beneficial to menopausal women by increasing in vivo levels of antioxidants. SKY provides a possibility of slowing down inflammatory diseases, such as cancer and atherosclerosis.

Summary: Free radicals and peroxides are involved in the pathogenesis of various diseases including atherosclerosis, inflammatory diseases, cancer etc. and are thought to precipitate the aging process in women. After 30-day practice of SKY, a group of menopausal women documented an increase in antioxidant enzymes. An increase of 211% in Superoxide Dismutase SOD and 111.7% in GSHpx (Plasma glutathione peroxidase) levels with a corresponding decrease of 66% in serum Malondialdehyde (a marker of oxidative stress) was observed. High levels of SOD, GSHpx and low levels of plasma MDA are indicators of low oxidative stress and improved health. High levels of antioxidant enzymes can reduce inflammation, cancer and atherosclerosis, as well as slow down aging.

Summary of Research Findings :

- Anxiety and stress are correlated with increase in oxidative stress. Antioxidants are important to prevent cellular damage from oxidative stress caused by free radicals. Natural antioxidant production decreases with aging, as well as increasing stress and anxiety levels.
- Regular practice of SKY for 30 minutes a day, across the 7 week study period, showed an improvement in the antioxidant profile. Assessment of biomarkers revealed reduced plasma MDA levels : a marker for oxidative stress, and increased levels of SOD by 28%, after 7 weeks of SKY practice. SOD is an antioxidant enzyme which cleaves free oxygen radicals. This improvement in oxidative stress correlated with lower anxiety scores.

- A Study evaluating gene expression and antioxidant activity showed higher levels of antioxidant enzymes amongst the SKY practitioners. The SKY practitioners showed a 56.5% higher gene expression level of Glutathione peroxidase, which correlated with 25.8% higher levels of glutathione in their blood (nmol/ml) as compared to controls. The Mn SOD gene was expressed 86.5% more in SKY practitioners which correlated with 23.6% higher levels of SOD enzyme (nmol/ml) in their blood as compared to controls. Assessment of gene expression showed an up-regulation of antioxidant and antiapoptotic genes among the SKY practitioners. These genes help in extending the lifespan of immune cells.
- Another study on regular practice of SKY suggests that SKY leads to a better antioxidant status in its practitioners, as compared to non-practitioners. Blood lactate levels are lower by 25.96% in SKY group after SKY practice suggesting a relaxation response. The study also noticed a profound rise in antioxidant enzyme activity of the SKY group: 4 fold increase in glutathione, 51.6% in catalase and 2.5 times in superoxide dismutase enzyme, after the SKY practice.
- A study on hypertensive patients demonstrated a significant decrease in plasma MDA (malondialdehyde), an oxidative stress marker, by 22.3% in women and 18.8% in men, after practicing SKY for 2 months. By keeping oxidative stress at a minimum, risk of hypertension complications are monitored.
- Free radicals and peroxides are involved in the pathogenesis of various diseases including atherosclerosis, inflammatory diseases, cancer etc. and are thought to precipitate the aging process in women. After a 30-day practice of SKY, a group of menopausal women documented an increase in antioxidant enzymes. An increase of 211% in Superoxide Dismutase SOD and 111.7% in GSHpx levels with a corresponding decrease of 66% in serum Malondialdehyde (a marker of oxidative stress) was observed. High levels of SOD, GSHpx and low levels of plasma MDA are indicators of low oxidative stress and improved health. High levels of antioxidant enzymes can reduce inflammation, cancer and atherosclerosis, as well as slow down aging.

Conclusion

Human physiology and psychology are interlinked. Antioxidants are an important resource for the body to prevent cellular damage arising from the oxidative stress created by free radicals. Many research studies have investigated changes in antioxidant levels with SKY practice and have shown a positive impact of SKY on antioxidant levels. Additionally, the antioxidants serve as the functional basis for other biological and physiological substances in the body. Above mentioned studies

demonstrate a profound increase in the antioxidant enzyme activity levels with SKY practice. Oxidative stress markers like MDA were noted to have a reduction following SKY practice. Expression of genes encoding for antioxidant activity was also noted to increase with SKY practice. Therefore, SKY is a natural, cost efficient method to improve the antioxidant levels.

About Sri Sri Institute for Advanced Research

Sri Sri Institute for Advanced Research (SSIAR) is the research wing of the Art of Living, founded under Ved Vignan Maha Vidya Peeth (VVMVP) Trust. SSIAR's mission is to apply the science of Global Ancient Knowledge Systems to the current modern challenges. It's vision is to become an internationally renowned center of excellence for scientific enquiry into Global Ancient Knowledge Systems.

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