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Art of Living Research Wing

A White Paper Series on Sudarshan Kriya

A White Paper on Sudarshan Kriya and Vagus Nerve

Introduction

What is the Vagus Nerve?

The Vagus Nerve (VN) is the tenth of the twelve Cranial nerves, and the longest one in the human body. It derives its name from Latin word for wandering, due to its extended pathway and diverse functionalities. This meandering nerve extends from the brain to the colon. It has many branches, 20% of which are composed of efferent fibers (carrying information from the brain to the body) and 80% afferent fibers (carrying information from the body to the brain). The Vagus nerve plays a major role in regulating the function of the parasympathetic branch of the Autonomic nervous system (ANS). Its activity is referred to as 'Vagal tone'.

Role of the Vagus Nerve

The many branched fibers from VN allow it to enervate and impact multiple organ systems. Its four main functions include Sensory functions, Special sensory functions, Motor functions and Parasympathetic functions. Sensory functions include providing sensations (information) to the skin and muscles of the external ear and auditory canal, and to visceral organs such as the larynx, heart and gastro-intestinal tract. Special sensory functions include carrying afferent fibers from the root of the tongue and epiglottis to the brain. Motor functions include providing movement and coordination to most of the muscles in the pharynx and larynx. VN is responsible for many functions like initiation of swallowing and phonation (speaking) along with a role in hearing.

One of the most crucial roles of VN is regulation of Parasympathetic functions. The cardiac branches of VN transport parasympathetic innervations to the sino-atrial and atrio-ventricular nodes of the heart. This helps to maintain the heart rate between the normal range of 60-80 beats per minute. The gastro-intestinal branches of VN provide parasympathetic innervation stimulating smooth muscle contraction and glandular secretions allowing the process of digestion to happen easily. Vagus Nerve

is responsible for management and regulation of several functions in the body including heart rate, digestion and fertility. It also has a role in mental health of a person. Several treatments for depression stimulate the Vagus Nerve.

Importance of the Vagus Nerve

The Vagus Nerve is one of the main bi-directional communication highway between the brain and the body. Under relaxed conditions, it is responsible for activation of the parasympathetic system and slowing the heart rate and the breathing, and increasing digestion. However, under stress, the activity shifts to the sympathetic system, increasing the heart rate and breathing. Low vagal tone not only causes cardiovascular diseases and digestion disorders, but also chronic inflammation. It is also associated with poor emotional and attention regulation among children and adults. A strong vagal response helps the body to regulate blood glucose levels and consequently reduces chances of diabetes, cardiovascular disease and stroke.

Sudarshan Kriya Yoga (SKY)

Sudarshan Kriya Yoga is a technique taught by the Art of Living Foundation in more than 156 countries with more than 6 million practitioners across the globe. It 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 air to pass through the lungs. ‘Om’ is chanted three times with prolonged exhalation. Lastly, Sudarshan Kriya rhythmic breathing is done in two variations: long SKY, which is done under Gurudev Sri Sri Ravishankar’s recorded instruction, and short SKY, which 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 Vagus Nerve

Most research studies measure Vagal tone or Vagus nerve activity by measuring the heart rate variability (HRV). The larger the difference between the heart rate between successive heartbeats during inhalation and exhalation, the higher the heart rate variability. Higher HRV corresponds to greater vagal tone, indicating that the body can relax faster after a stressful situation. High HRV indicates healthy Vagus Nerve function.

The following are the research studies that assess the impact of SKY (Long and Short) on Vagus nerve function.

1. Assessment of Vagal tone after Long Sudarshan Kriya Yoga (SKY)

The heart is innervated by the Vagus nerve and sympathetic fibers, both of which are a part of the autonomic nervous system, and regulate the heart rate. Their activity changes, based on if the sympathetic part (fight and flight) of the autonomic nervous system is dominating, or the parasympathetic (rest and digest). Cardiac autonomic tone or the Vagal tone refers to the balance between the two aspects of autonomic nervous system and is a key determinant of heart function and heart health. This tone affects the physiology of the body and vice versa. Breathing is known to modulate the cardiac autonomic tone. Heart rate Variability (HRV) and Skin conductance level (SCL) are well known markers of cardiac autonomic or vagal tone. Bhaskar et al.[1] ,studied the impact of SKY on Vagal tone by measuring the heart rate variability through Electro-cardiogram (ECG). Thirty (30) regular SKY practitioners, ranging from those practicing for only 2 months to those practicing for several years, volunteered for the study. ECG and SCL values were recorded 5 minutes before and after a single long SKY session. The ECG was analyzed to calculate heart rate variability (HRV) and heart rate. A significant reduction in mean heart rate of 12.5% was noticed after long SKY. The low frequency component of HRV representing enhanced sympathetic activity decreased and the high frequency component representing parasympathetic activity increased significantly after long SKY practice. SCL decreased following long SKY, although not significantly. The results indicate that long SKY practice induces significant positive modulations in the vagal tone. High parasympathetic activity leads to high vagal tone. ECG signals indicate an increase in parasympathetic activity and decrease in sympathetic activity, which in turn signifies an improved sympathovagal balance following long SKY. An improved sympathovagal balance bolsters good heart health.

Summary: A study by Bhaskar et al.[1] showed that the parasympathetic activity increased by 13.5% after practice of long SKY. A significant reduction of 12.5% in the mean heart rate was also noticed after long SKY. Both these outcomes signify the positive impact of SKY on heart health and the role of SKY in promoting overall well being through the activation of parasympathetic nervous system and increasing vagal tone.

2. Sudarshan Kriya Yoga improves cardiac autonomic control in patients with anxiety-depression disorder

Cardiac autonomic control (CAC) and cardio-respiratory coupling are important physiological mechanisms modulated by the cardiac vagal tone. A decreased vagal tone in people with anxiety and depression, is associated with a faster heart rate. Breathing practices help create a calm physiological state and improve vagal tone, thus helping lower the heart rate in patients with anxiety and depression. Toschi et al.[2] studied the improvement in CAC in patients with anxiety and depression after the practice of SKY. The study was conducted in Italy, and included a total of 46 patients with a diagnosis of anxiety and/or depression disorder. All the patients had been under stable pharmacological treatment for at least 6 months prior, and were free of hypertension, coronary artery diseases and diabetes. They were divided into two groups: conventional therapy (Control, n=22) and conventional therapy combined with SKY (Treatment, n=24) and received the intervention for 15 days. The SKY group participated in a modified SKY workshop with 10 sessions of approximately two hours/ day, distributed over two consecutive weeks. The control group was instructed about the importance of adhering to pharmacological and psychotherapeutic treatment and were re-evaluated after 15 days. Data was acquired at baseline and on Day 15 of intervention, using ECG, thoracic piezoelectric belt along with standard questionnaires. Data analysis showed that Low frequency component of the HRV, a marker for sympathetic modulation, decreased in the SKY group in comparison to the baseline values. High frequency component of the HRV, a marker for parasympathetic modulation, was higher in the SKY group than the baseline values. The Lf/Hf ratio, a measure of sympathovagal balance, also decreased in the SKY group compared to the control group, indicating that SKY practitioners experienced a higher vagal tone, which is cardioprotective. A significant improvement in cardiorespiratory coupling, the relationship between heart rate and respiration, was also observed in the SKY group. It can be concluded that CAC and cardiorespiratory coupling improves after SKY practice in those affected by anxiety-depression disorder.

Summary: A study evaluating the impact of SKY on Cardiac Autonomic tone among those suffering

from anxiety and depression revealed that Cardiac Autonomic Control and cardiorespiratory coupling improved after only 15 days of SKY practice. Vagal tone is usually lower in anxious and depressed individuals and they exhibit poor heart rate variability. Low frequency component of the HRV, a marker for sympathetic modulation, decreased post SKY, and the high frequency component of the HRV, a marker for parasympathetic activation, increased post SKY. The LF/HF ratio which measures the sympathovagal balance also decreased, indicating that SKY practitioners were experiencing a higher vagal tone, which is cardioprotective.

3. Improvement in workload tolerance with Sudarshan Kriya Yoga : An ECG perspective

Mental workload refers to the quantum of mental resources required to perform a set of concurrent tasks. Sustained high mental workload can cause mental fatigue, diminish performance, and create detrimental health effects in the long run. Workload capacity refers to the brain's ability to process information. A reduced workload capacity leads to a slower information processing by the brain. Level of mental workload can be interpreted through the HRV (heart rate variability) component of the ECG. A study by Chandra et al.[3] assessed the ECG of 25 participants for workload tolerance and stress, pre and post SKY, and compared them with a control group. Of the 25 subjects, 15 were enrolled in the experimental group which learnt, and subsequently practiced SKY for 90 days. The control group consisted of 10 participants who were not provided an intervention. During the assessment, the participants performed 2 different types of tasks - one set of tasks that required low workload capacity (LWL) and another set of tasks that required high workload capacity (HWL) by means of MATB-II. Workload was also assessed by a subjective Workload Rating scale (WRS). Multi-Attribute Task Battery (MATB-II) is a computer-based task designed to evaluate operator's performance and workload consisting of two-dimensional tracking, system monitoring, communication and resource management tasks.The assessment was done on MATB for 5 minutes at baseline and then 8 minutes for LWL and HWL each on Day 0 (pre). Their EEG and ECG were obtained during the tasks and their performance on the task was analysed at the above mentioned point for both experimental and control group. After 30 and 90 days of SKY practice, post data for both the groups was obtained similarly. A significant reduction in subjective scores of workload as determined by workload rating scale for both LWL and HWL in the experimental (SKY) group was noted indicating increased capacity for workload tolerance. Meanwhile their task performance increased. The control group also had a slight reduction in LWL score but their HWL score increased on day 30. The task performance reduced in the control group at Day 30. The experimental group also showed a significant improvement in their sympathovagal balance index (Lf/Hf) on Day 30 compared to the baseline reading, which indicated a reduction in stress with the practice of SKY. Lf/Hf is calculated using the HRV component of ECG. When Lf/Hf values are low, it indicates a reduction in mental stress. Furthermore, the task

performance improved among the SKY group while the task performance in the control group reduced after the 30 days practice. The results showed that SKY had a beneficial effect on stress regulation, which in turn improved the stress tolerance and task performance for both high and low mental workloads. That is, the SKY practitioners could perform tasks that require higher and lower mental workloads with more ease and less stress than before doing SKY.

Summary: A study conducted to assess the workload stress tolerance among SKY and non-SKY practitioners, demonstrated that SKY practitioners developed improved tolerance and task performance for both high and low mental workload after SKY. Their sympathovagal balance also improved significantly, indicating that SKY diminished stress in their system. This indicates that SKY allows one to manage stressful situations more effectively.

4. Improvement in Vagal tone after Sudarshan Kriya Yoga among college students

The Yes Plus (SKY Campus) workshop teaches SKY and associated wellness techniques to young adults to help them manage stress and boost their well-being. Goldstein et al.[4] conducted a study, based in Atlanta Georgia, to assess the effects of SKY on recovery from physiological stress among college students. The study enrolled 29 students. ECG, along with a stationary bicycle challenge, was used to measure cardiac vagal tone and rate of recovery for heart rate at baseline and after 4 weeks of SKY practice. The Inter-beat interval (IBI), i.e the gap between two heart beats, is related to the recovery for heart rate and HRV. Heart rate variability (HRV) measures changes in the time intervals between consecutive heartbeats. IBI is a good indicator of parasympathetic or sympathetic dominance in the body and HRV. Higher IBI indicates higher HRV. The IBI in the recovery phase increased from baseline to 4-week follow-up for the SKY group. A 48% increase in the mean IBI recovery rate was observed between baseline and 4-week assessment for SKY practitioners. The reduced time taken for achieving heart rate recovery can be due to improvement in autonomic regulation. An increase in the IBI slope during the recovery phase post the cycling challenge indicates that it took lesser time for the heart to recover its heart rate and HRV. This may be due to the enhanced parasympathetic activity ,vagal tone and sympthovagal balance attributable to SKY practice.

Summary: A study evaluated the impact of SKY on recovery post experiencing physiological stress. ECG and interbeat interval recovery rate was measured for 29 college students in Atlanta post a bicycle challenge at baseline and after 4 weeks of SKY practice. A 48% mean improvement in the Inter-beat interval recovery of students post 4 weeks of SKY practice was observed. An increase in IBI

slope of recovery indicated enhanced parasympathetic activity ,vagal tone and sympthovagal balance attributable to SKY practice. This indicates that SKY allows one to recover faster from a physically stressful situation

5. Effect of Sudarshan Kriya Yoga on cardiac autonomic tone (vagal tone)

A study by Kharya et al.[5] compared the mental and physiological state of participants who experienced either the SKY intervention or the Prana yoga intervention (PY), and compared them with a group that received no intervention. 60 healthy volunteers participated in the study and were randomly divided into SKY, PY and a control group of 20 participants each. Cardiac vagal tone was measured by ECG for 5 minutes. The ECG was further processed to calculate Heart Rate Variability (HRV). The frequency domain parameters including Low frequency (Lf) and High frequency (Hf) band power, and Lf/Hf ratio were calculated for the ECG. The HRV results were only analyzed at baseline and on the 150th day of practice. The practice of SKY demonstrated an overall increase in HRV, an increase in parasympathetic component (High frequency (Hf) band power) and a decrease in sympathetic component (Low frequency (Lf) band power). The Lf:Hf ratio curve plotted over time for pattern A (subjects with low level Lf power) and B (subjects with high level Lf power) showed convergence in the SKY group. Sympathovagal balance is the ratio of balance between absolute low frequency and high frequency. It indicates stable cardiovascular function and improved balance between sympathetic and parasympathetic activity in the body, which was observed with the practice of SKY. Such convergence was not observed in control group.

Summary: SKY positively modifies stress coping behavior and initiates appropriate balance in cardiac autonomic tone. SKY practitioners achieve sympathovagal balance, which is based on their initial vagal tone. Sympathovagal balance is the ratio of balance between absolute high frequency and low frequency. Those with very low vagal tone experience an increased vagal tone, while others with very high vagal tone experience a decrease, bringing both groups to optimal vagal function.

Summary of Research Findings :

The Vagus Nerve is the hub of bidirectional communication between the brain and internal organ systems of the body. Activity of vagus nerve is called vagal tone. Healthy Vagus nerve is represented as the ability of the body to switch between sympathetic and parasympathetic activity easily Under relaxed conditions, it is responsible for activation of the parasympathetic system, slowing the heart

rate and the breathing, and increasing digestion. However, under stress, the activity shifts to the sympathetic system like increasing the heart rate.

- Low vagal tone is a contributing factor for gut disorders and cardiovascular diseases.
- Heart Rate variability (HRV) is an index of cardiac vagal tone. Increased heart rate variability shows shows the ability of the body to tolerate stress or recover from stress while low HRV shows that a person is more prone to cardiovascular risk.
- A study by Bhaskar et al. showed that the parasympathetic activity increased by 13.5% after practice of long SKY. A significant reduction of 12.5% in the mean heart rate was also noticed after long SKY. Both these outcomes signify the positive impact of SKY on heart health and the role of SKY in promoting overall well being through the activation of parasympathetic nervous system and increasing vagal tone.
- People with anxiety and depression have reduced parasympathetic activity and low Vagal tone. A study evaluating the impact of SKY on Cardiac Autonomic tone among those suffering from anxiety and depression revealed that Cardiac Autonomic Control and cardiorespiratory coupling improved after only 15 days of SKY practice. Vagal tone is usually lower in anxious and depressed individuals and they exhibit poor heart rate variability. Low frequency component of the HRV, a marker for sympathetic modulation, decreased post SKY, and the high frequency component of the HRV, a marker for parasympathetic activation, increased post SKY. The Lf/Hf ratio which measures the sympathovagal balance also decreased, indicating that SKY practitioners were experiencing a higher vagal tone, which is cardioprotective.
- A study conducted to assess the workload stress tolerance among SKY and non-SKY practitioners, demonstrated that SKY practitioners developed improved tolerance for both high and low mental workload after SKY. Their sympathovagal balance also improved significantly, indicating that SKY diminished stress in their system. This indicates that SKY allows one to manage stressful situations more effectively.
- A study evaluated the impact of SKY on recovery post experiencing physiological stress. ECG and interbeat interval recovery rate was measured for 24 college students in Atlanta post a bicycle challenge at baseline and after 4 weeks of SKY practice. A 48% mean improvement in the Inter-beat interval recovery of students post 4 weeks of SKY practice was observed. An increase in IBI slope of recovery indicates enhanced parasympathetic activity and vagal tone correlated to SKY practice.
- In a study on adults,SKY positively modified stress coping behavior and initiated appropriate balance in cardiac autonomic tone. SKY practitioners achieved sympathovagal balance, which was based on

their initial vagal tone. Sympathovagal balance is the ratio of balance between absolute high frequency and low frequency. Those with very low vagal tone experience an increased vagal tone, while others with very high vagal tone experience a decrease, bringing both groups to optimal vagal function.

Conclusion

The activity of the Vagus nerve (Vagal tone) is an important physiological process for good health. Vagal tone improves parasympathetic activity responsible for health of many involuntary actions in the body. Improved Heart Rate Variability is a physiological indicator of Vagal tone. All the studies indicated significant improvement in HRV of SKY practitioners. Low frequency component of HRV indicating sympathetic activity has been shown to reduce in SKY practitioners, and high frequency component of HRV indicating parasympathetic activity has been shown to significantly rise. The LF/HF ratio also decreases indicating an improved sympathovagal balance in the body. Scientific studies provide strong evidence that Sudarshan Kriya Yoga has a positive impact on Vagus Nerve activity and brings sympathovagal balance in the body.

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 and share the science of Global Ancient Knowledge Systems to the challenges of today. Its vision is to become an internationally renowned center of excellence for scientific enquiry into Global Ancient Knowledge Systems.

This white paper is authored by SSIAR team consisting of Divya Kanchibhotla, Saumya Subramanian and Dr. Somya Ramrakhyani.

For any questions, kindly contact divya.kanchibhotla@artofliving.org

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