A White Paper on Sudarshan Kriya and Lung Function

Introduction

Breathing: A vital function

Breathing is the first act of life, it is also one of the most unconscious acts of life. According to scientific reports, an adult takes more than 23,000 breaths every day. This means in the 10-12 minutes it takes to read this white paper, you would have inhaled and exhaled more than 200 times, most of it unconsciously, without being aware, on an auto pilot. With an average capacity of 500 ml in every breath, we inhale more than 11,000 liters of air every day.

Involuntary breathing is a continuous automatic function controlled by the respiratory centers located in the upper brainstem part of the brain. The respiratory center ensures that we keep breathing, without having to remember, and without any conscious effort. Involuntary breathing creates shifts in breath patterns as we experience emotions, and allows us to breathe continuously even when we rest, like in deep sleep. However, it can be converted into a voluntary function on demand. Activities such as speaking, exercising, singing or swimming require conscious control on our breath, and during these activities, another part of the brain, the cerebral cortex starts controlling the breath. Human ability to consciously regulate breathing has been explored for eons, especially in the Yogic practices and tenets. Different breathing practices have profound effects on mind and body, hence they now form the basis of a variety of relaxation and wellness techniques and mind-body interventions. Sudarshan Kriya Yoga (SKY) is an advanced technique that uses the modulation of breath.

Physiology of Breathing

Breathing or respiration is governed anatomically by lungs. It consists of two process i.e. inhalation and exhalation. While inhalation requires effort, exhalation is a passive process. Flattening of diaphragm during inspiration increases the space in the thoracic cavity within the chest, allowing it to fill itself with maximum air. Expiration happens when the contracted muscles relax, returning the ribcage to its natural convex shape and pushing the air out. Every minute, approximately 10-12 times, the brain sends signals to thoracic muscles and diaphragm to contract. An average of 5 liters of air passes through lungs every minute. Breath rate is also linked to lifestyle, health conditions and physical activity. The parasympathetic system, active while mind and body are calm, slows the breathing rate and vice-versa. Breathing deeply, with a slow and steady inhalation to exhalation ratio, signals the parasympathetic nervous system to calm the body and mind. Most breathing interventions for mental well-being use this phenomenon to calm the mind. The sympathetic system, on the contrary increases the breathing rate. The sympathetic system activity is heightened during stressful situations when our brain activates the fight and flight mode.

Factors affecting Respiratory rate

Respiratory rate is directly linked to the state of mind and is altered by stress and unpleasant emotions. The rate of inhalation and exhalation changes under stress. Under stressful situations, one may breathe heavier or faster. This increases the pressure on the lungs and creates shortness of breath, especially for patients with asthma and pulmonary disorders. During an experience of fear or anxiety, an individual tends to hyperventilate (rapid breathing), which produces tightness in the throat and causes blood CO_2 levels to drop below normal. The stress response in the body produces stress hormones, which cause the blood vessels to constrict in order to deliver more oxygen to the muscles. This process raises blood pressure which can be harmful especially when frequent, sustained or chronic stress is experienced.

Respiration is also affected by age. After age 25, the lung function declines gradually. The amount of air exhaled/inhaled declines with every passing year, and lung capacity decreases, as residual volume, air in the lung at the end of expiration that cannot be pushed out, increases. Additionally, the lung tissue also loses elasticity with age, further reducing the lung capacity and function.

Practices like cigarette smoking destroy lung tissue, block the airways and lead to lung cancer. Excess mucus and swelling in airways may lead to shortness of breath. The fine particles in cigarette smoke

irritate the trachea and vocal chords. Acrolein, a chemical found in cigarette smoke, causes irreversible damage to lung tissue. Carbon monoxide present in tobacco smoke, upon inhalation and entering the blood stream, displaces the oxygen in the blood, depriving the organs of vital oxygenation.

Air pollutants such as nitrogen dioxide, ozone, sulphur dioxide, carbon monoxide and particulate matter cause shortness of breath, wheezing, cough, chest pain and asthma attacks. These pollutants are responsible for blocking the airways and causing lung cancer. Slumped, poor posture also reduces lung capacity and expiratory flow due to restriction of movement of respiratory muscles.

Steps to improve respiration

Improving Lung capacity and pulmonary health requires continuous practice and effort. But few small changes in lifestyle such as breathing correctly, exercising and practicing yogic breathing, when done consistently can quickly improve the lung capacity.

Physical Activity

Physical activity requires higher amounts of oxygen to be used by muscles, and creates additional oxygen demand in the body, which in turn, activates the heart and lungs to work harder to meet that demand. Over time, regular exercise and fitness activities increase the lung capacity to bring more oxygen into the bloodstream, so it can be transported to the muscles. Aerobic exercises like walking, jumping, and running increase heart rate and lung capacity, whereas muscle strengthening exercises build up core strength, improve posture and tone the breathing muscles.

Practicing breathing exercises

Breathing exercises strengthen the diaphragm and help us breathe more deeply and efficiently. Deep breathing can clear the extensive mucus accumulated in the airways. Also pursed lip breathing can help in managing breathlessness during respiratory illness.

Measures of Respiration

Breathing capacity is assessed by measurement of lung function through various pulmonary function tests which estimate the amount of air moving in and out of the lungs and how well oxygen enters the blood stream. Normal values vary from person to person depending on their age, gender, height and

race. Spirometer is a common instrument used to measure pulmonary function by measuring the airflow in and out of the lungs. It can be employed to assess the lung function of healthy individuals.

- **Forced Vital Capacity (FVC)** (L): FVC is the largest volume of air that can be forcibly exhaled from lungs after inhaling to maximum capacity. A lowered FVC is a clinical indication of decline in the capacity of lungs to inhale and exhale.

- **Forced expiratory volume in one second (FEV1)** (L): This measures the maximum volume of air exhaled in one second. FEV1 signifies the strength of the lungs to breathe in and out efficiently. Under normal conditions, 80% of the FVC is exhaled in the first second and the rest is emptied in the next 3 to 4 seconds. FEV1 declines by 1 to 2 percent (25 to 30 ml) every year after the age of 25, when the lung function is at its peak . This decline adds up over the course of a lifetime. The FEV1 tests the efficiency of breathing and ease of airflow, without obstruction.

- **Peak expiratory flow rate (PEFR)** (L/s): This represents the maximum expiratory flow rate and determines the speed at which the breath is exhaled out of the lungs. PEFR mainly depends on the voluntary effort and a higher rate of exhalation corresponds to enhanced respiratory muscle strength. A higher peak flow directly indicates a fuller exhalation, and indirectly, a calm state of mind. However, clinically PEFR is used to understand the diaphragmatic strength. Abnormal PEFR may be symptomatic of serious illness or disorders caused by low oxygen flow into the body. Narrowing of airways due to congestion caused by upper respiratory tract illnesses such as flu, can also reduce the expiratory flow rate. A low PEFR can create dizziness, confusion and anxiety. An improvement in PEFR suggests improved lung capacity, which helps sustain the body during periods of intense physical activity.

Sudarshan Kriya Yoga (SKY)

Sudarshan Kriya is a technique taught by the Art of Living Foundation in over 156 countries with more than 6 million practitioners across the globe. It is taught in slightly different 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 a 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, followed by meditation or rest in supine position.

Research studies on Sudarshan Kriya Yoga and Respiration parameters

Several research studies have assessed the impact of SKY on lung function. Following are their summaries:

1. *Improvement in Pulmonary function post Sudarshan Kriya Yoga*

Sayyed et al.[1] studied the effects of Sudarshan Kriya on various physiological parameters including pulmonary function. The study assessed 55 middle aged participants who participated in SKY. Pulmonary function was measured at baseline and post SKY Intervention for all participants. The results of this observational study demonstrated a significant improvement in all measured lung functions as follows: improvement in FVC by 9%, FEV1 by 6%, PEFR by 21.5% and maximum voluntary ventilation by 14.4%. These results signify that lung function improves with SKY. An improvement in maximum voluntary ventilation indicates a higher respiratory muscle endurance, reduced airway resistance and improved movements of thoracic cage. A greater FVC and FEV1 also indicate higher vital capacity and better lung strength.

Summary: An improvement in Forced vital capacity and lowering of obstructive/restrictive severity, shown by 21.5% hike in PEFR, was observed post SKY, indicating that the strength of respiratory muscles was improved in participants who learnt the SKY intervention. PEFR values represent the flow of exhalation, hence improved values depict increased flow rate. Flow rate is a function of time taken to inspire and expire once. The results show restoration of lung capacity which declines with aging.

2. *Impact of Sudarshan Kriya Yoga on pulmonary function among first year medical students*

A study by Ahmad et al.[2] evaluated the efficacy of SKY in improving the pulmonary function of 30 first year medical college students. Pulmonary function was measured using spirometry at baseline, and on the 7th, 30th, and 90th day of SKY practice post intervention. An improvement in all pulmonary function parameters was observed. A significant 9.4% rise in PEFR function post 30 days of SKY practice was seen. The results showed further improvement of 14.8% in PEFR post 90 days of practice. The vital capacity improved by 11.9% on the 90th day of SKY practice, indicating that regular practice of SKY is correlated with improvement in lung capacity. Improved lung capacity and pulmonary function optimize delivery of oxygen to the bloodstream. Young people are often engaged in strenuous physical and mental activities. Poor oxygenation can impair their ability to execute these activities. An improvement in PEFR correlates with increased respiratory muscle strength, and reduced odds of developing obstructive disorders like asthma and wheezing.

Summary: A study looking at the impact of SKY on pulmonary health of medical college students demonstrated that practice of SKY technique improves lung function. Continuous practice of SKY for 90 days showed an increase of 14.8% in PEFR, even in healthy young adults. An improvement in PEFR correlates with increased respiratory muscle strength, and reduced odds of developing obstructive disorders like asthma and wheezing.

3. *Immediate effect of Sudarshan Kriya Yoga on Lung Function in healthy adults*

A stressful modern lifestyle, accompanied by long periods of sedentary activity with poor posture and suboptimal breathing, can impair lung function and reduce the oxygen saturation in the bloodstream. Physical activity and yogic practices have been shown to improve lung capacity. A study by Bodi et al.[3] investigated the effects of SKY practice on pulmonary function by means of spirometry. The study evaluated 63 adults, between the ages of 18-45 years, who participated in the SKY program. The following outcomes were measured: Forced expiratory volume in one second (FEV1), Forced vital capacity (FVC), and Peak expiratory flow rate (PEFR). Spirometry, usually performed as a routine test in symptomatic patients of lung disease, also provides information about pulmonary function and respiratory capacity in healthy individuals, breathing under normal conditions, and can help detect abnormalities in asymptomatic patients. The spirometry results demonstrated that the lung function of SKY practitioners improved significantly within a week of practice. A 6.6% increase was noticed in FVC

- the amount of air forcefully exhaled after inhalation. A healthy vital capacity is required to ensure optimal amount of oxygen saturation in the blood. A 1.9% improvement was noticed in FEV1 post SKY practice, indicating that efficiency of exhalation within the first second also improved in the study subjects. FEV1 decreases naturally with age. Regular SKY practice may have the potential to reduce this decline. Optimal lung function is an important requirement for physical performance. As the physical activity increases, the oxygen demand of the body also climbs . An improved forced expiratory volume in one second also determines the ease with which the air is exhaled out of the lungs. This capacity is reduced with exposure to air pollutants, and environmental allergens etc. which obstruct the airways and contribute to development of severe obstructive disease like asthma and Chronic obstructive pulmonary disorder (COPD).

The study also demonstrated a significant improvement of 13.3 % in Peak expiratory flow rate (PEFR) amongst SKY practitioners. PEFR, also known as peak flow, measures the rate at which air flows out of the lungs. It measures forced exhalation and is an important indicator of healthy respiratory activity. A healthy peak flow indicates that airways are open and free of obstruction and PEFR is a good measure of expiratory effort.

Summary: SKY increases lung capacity in its practitioners. A study of healthy adults showed a 6.6% improvement in FVC which signifies greater lung volume available for inhalation/exhalation. A 1.9 % improvement in FEV1 was also observed indicating healthy airways and improved respiratory muscle strength. Finally, the PEFR showed an impressive improvement of 13.3%, indicating an efficient airflow and expiratory effort. This study highlights the importance of SKY in improving vital lung capacity and the ease of breathing without difficulty.

4. *Effect of Sudarshan Kriya Yoga on Peak expiratory flow rate in Adults*

A cross-sectional study by Parmar et al.[4] measured the peak expiratory flow rate and other physiological parameters between 50 SKY practitioners and 50 controls. The SKY group consisted of participants who had been practicing SKY for 3 months consistently, and the control group consisted of those who had not learnt the SKY practice. The control group participants were asked to meditate with their eyes closed and observe the free flow of thoughts in their mind. The SKY practitioners practiced the SKY intervention. The hemodynamic responses of the participants were calculated before and after the practice (SKY for SKY group and free flow meditation for the control group). The control group did not show any change in the PEFR values after 1 hour of meditation, while in the SKY group, a 16.1% rise in the PEFR was noted post intervention, indicating a slower rate of breathing and increased strength of respiratory muscles post SKY.

Summary: The measure of PEFR is an important parameter to predict healthy lungs and airways. Evaluation of regular SKY practitioners demonstrated an increase in lung capacity, PEFR in particular, after SKY practice. The study showed 16.1% improvement in the PEFR post SKY, showing improved expiratory flow and lung health.

5. *Comparative study of Pulmonary Function between Sudarshan Kriya Yoga Practitioners and Sedentary individuals*

A study conducted by Acharya et al.[5] investigated the effects of Sudarshan Kriya Yoga on pulmonary function of healthy males between the ages of 18-55 years. The pulmonary function of 50 SKY practitioners was compared with 50 sedentary workers who engaged in physical activity for less than 20 minutes a day. The pulmonary function parameters measured via spirometry were: forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC and Peak expiratory flow rate (PEFR). All the measured pulmonary function parameters were found to be better in the SKY group. The mean FVC value was higher by 6.3%, the mean FEV1 value by 6.2% and PEFR was found to be higher by 7.7% among the SKY group compared to the control sedentary group. Highest improvement was noticed in PEFR, indicating strengthening of the respiratory muscles and increased ability for slow respiration as a result of yogic practices. A robust PEFR enables a full inspiration and expiration, and is an indicator of healthy lungs. The authors concluded that the practice of breathing techniques such as SKY is key to maintaining good lung health, especially given the present day sedentary lifestyle .

Summary: A study investigated the benefits of SKY on pulmonary function of sedentary middle aged population. The study compared the lung capacity between SKY practitioners and those with sedentary life-style, and found a 6.3% increase in FVC among SKY practitioners. FEV1 was also higher by 6.2%, and PEFR by 7.7% among the SKY group, indicating improved vital capacity, core strength and deeply relaxed state of mind as a function of slower breaths. The study highlights the importance of SKY in restoring the vital capacity to normal volumes which otherwise declines with age. The study indicates that people who practice SKY have improved lung capacity, and stronger and flexible respiratory muscles. This study is an indicator of the benefit of SKY in maintaining good pulmonary function, especially with a sedentary lifestyle.

6. *Pulmonary function profile of Sudarshan Kriya Yoga practitioners*

A cross-sectional study was conducted by Kale et al.[6] on 100 healthy volunteers (50 in the SKY group and 50 in the control group). Participants in the SKY group included those who had been practicing SKY for more than a year, and hence were labeled as long term practitioners. FEV1, FVC, PEFR and Mean breath holding time were measured. The results were then categorized into two age groups i.e 21-30 age group and 31-40 age group and compared. Both the age groups showed a significant improvement in pulmonary function parameters of SKY practitioners when compared to the age matched control group : 18.2% increase in FVC, 19.8% in FEV1, 21.2% in Breath holding time and 21% rise in PEFR for 21-30 age group; and 19.1% increase in FVC, 21.6% in FEV1, 21.7% in breath holding time and 21.6% in PEFR for 31-40 age group . Improvement in PEFR is a function of strengthened respiratory muscles. The Bhastrika section of the SKY practice trains the lungs to release the dead air to maximum capacity. A reduced dead air volume helps ensure that more fresh air enters the lungs and is available for oxygen exchange. This promotes healthy oxygenation of the blood and tissues. Also, clear airways enable faster exhalation and inhalation of the air. Breath holding time is an index of oxygen reservoir in an individual. Improved breath holding time is essential for athletes to improve endurance and performance. Long term practice of SKY promotes lung health and can help prevent major respiratory complications like COPD and asthma.

Summary: Kale in her study compared long-term SKY practitioners with non-SKY practitioners and found a significant increase of 18-22% in all the lung function parameters in SKY practitioners. A higher score on lung function tests signifies open and healthy airways, an improvement in lung capacity, and stronger respiratory muscles. Breath holding time increases the time available for exchange of gases, ensuring an oxygen rich air and improved endurance. The study concluded that SKY can be practiced regularly as a preventive measure for pulmonary disorders

Summary of Research Findings:

6 studies exploring the impact of Sudarshan Kriya on Lung function are covered in this white paper. Most of the studies use spirometer as a tool to measure lung function. There are 3 studies that measure the lung function before and after SKY. The other 3 studies compare lung function parameters between existing SKY practitioners and a non practicing control group.

A summary of the white paper and enclosed research findings can be found below :

1. **Important facts around breath**

- Breathing is the most vital act of life. Respiration is responsible for delivering oxygen to the blood and removing carbon dioxide.
- An average adult breathes more than 23,000 times in a day, inhaling almost 11000 L of air. Reports shows that most individuals under use their lung capacity.
- Respiratory rate is directly linked to the state of mind and is altered by stress and unpleasant emotions. The rate of inhalation and exhalation changes under stress.
- Breathing is a rare physiological function that can be switched between involuntary and voluntary control on demand.

2. **Research measuring changes in Lung function before and after SKY**

- SKY increases lung capacity in its practitioners. A study assessed 55 middle aged participants who participated in SKY intervention. Pulmonary function was measured at baseline and post SKY Intervention. The results showed an immediate improvement in the vital capacity and reduced obstructive severity. An improvement in FVC by 9%, FEV1 by 6%, PEFR by 21.5% and maximum voluntary ventilation by 14.4% was observed post SKY, indicating improved strength of respiratory muscles among participants who learnt SKY. PEFR represent the flow of exhalation, hence improved values depict increased flow rate. Flow rate is a function of time taken to inspire and expire once. The results showed restoration of the lung capacity which declines with aging.

- A study looking at the impact of SKY on pulmonary health of 30 medical college students demonstrated that practice of SKY technique improves lung function. Continuous practice of SKY for 90 days showed a significant increase of 11%-15% in all pulmonary function parameters, even in healthy young adults. A significant 9.4% rise in PEFR function post 30 days of SKY practice was observed. The results showed further improvement of 14.8%in PEFR post 90 days of practice. The vital capacity improved by 11.9% on the 90th day of SKY practice, indicating that regular practice of SKY is correlated with improvement in lung capacity. Improvement in PEFR correlates with increased respiratory muscle strength, and reduced odds of developing obstructive disorders like asthma and wheezing.

- A study on 63 healthy adults between the ages of 18-45 showed an immediate improvement of 6.6% in FVC, which indicates a greater lung volume available for inhalation/exhalation, after learning SKY. A 1.9 % improvement in FEV1 was also observed, indicating healthy airways and improved lung strength. Finally, the PEFR showed an impressive improvement of 13.3%, indicating an efficient airflow and expiratory effort. This study highlights the importance of SKY in improving vital lung capacity and the ease of breathing without difficulty.

3. **Research studies comparing existing SKY practitioners to controls:**

- The measure of PEFR is an important parameter to predict healthy lungs and airways. A study on 50 SKY practitioners and 50 control subjects demonstrated an increase in lung capacity, PEFR in particular, after 3 months SKY practice. The study showed a 16.1% improvement in the PEFR post SKY, indicating improved expiratory flow and lung health

- A study investigated the benefits of SKY on pulmonary function of sedentary middle aged population. The study compared the lung capacity between SKY practitioners and those with sedentary life-style, and found a 6.3% increase in FVC among SKY practitioners. FEV1 and PEFR also were higher by 6.2%, and 7.7% respectively among the SKY group, indicating improved vital capacity, core strength and deeply relaxed state of mind as a function of slower breaths. The study highlights the importance of SKY in restoring the vital capacity to normal volumes which otherwise declines with age. The study indicates that people who practice SKY have improved lung capacity, and stronger and flexible respiratory muscles. This study is an indicator of the benefit of SKY in maintaining good pulmonary function, especially with a sedentary lifestyle.

- Kale in her study compared long-term SKY practitioners with non-SKY practitioners and found a significant increase of 18-22% in all the lung function parameters for SKY practitioners. A higher score on lung function tests signifies open and healthy airways, an improvement in lung capacity, and stronger respiratory muscles. A 21.5% higher breath holding time was observed in the SKY group along with 21.3% higher PFER, 18.7% higher FVC and 20.7% FEV1. Breath holding time increases the time available for exchange of gases, ensuring an oxygen rich air and improved endurance. The study concluded that SKY can be practiced regularly as a preventive measure for pulmonary disorders.

Conclusion:

Optimal lung function is essential for good health. Lung function can be supported and enhanced by breathing techniques and physical exercise. Various studies exploring the impact of Sudarshan Kriya Yoga on respiratory function validate that the practice of SKY improves lung function. Forced vital capacity, Peak expiratory flow rate and forced expiratory volume showed significant increase after SKY practice in multiple studies on various populations. Both novice and long term adult SKY practitioners, of all ages, displayed improved lung function post SKY.

Improved forced vital capacity implies a greater lung volume available for inspiration/expiration, a higher forced expiratory volume in one second indicates open and healthy airways, free of obstruction, while rise in PEFR signifies expanded capacity, better function of respiratory muscles and an efficient rate of breathing. An improvement in lung function correlates with a higher saturation of blood oxygenation and a good heart health.

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