

Research article

# Physiology of nostril breathing exercises and its probable relation with nostril and cerebral dominance: A theoretical research on literature

Upadhyay-Dhungel K<sup>1</sup>, Sohal A<sup>2</sup>

Department of Research and Planning, Think Tank Foundation, Nepal

<sup>1</sup>Director Research and Planning Think Tank Foundation, Jorpati, Nepal; Associate Professor, Janaki Medical College, Nepal

<sup>2</sup>Professor, Janaki Medical College, Janakpurdham, Nepal

## ABSTRACT

This article discuss about scientific basis of benefits of practicing slow *pranayama*, especially alternate nostril breathing *pranayama*. It explains the basis of benefit of alternate nostril breathing exercises and its probable relation with nasal cycle, cerebral dominance and autonomic nervous system.

The airflow through one nostril is greater than next at any point of time which later switches to another. This is called nasal cycle. The nasal cycle lasts from 30 minutes to 2-3 hours. The nasal cycle occurs naturally. This nasal cycle is related with the cerebral dominance. When one nostril is dominant, the contra lateral hemisphere is active. The right nostril breathing leads to increased sympathetic activity while left nostril breathing decreases sympathetic activity and increases parasympathetic tone. So it has been speculated that these three phenomenon viz. nasal cycle, cerebral dominance and autonomic activities are correlated. This review also suggests that practicing alternate nostril breathing (*Nadisodhan pranayama*) regularly keeps the two hemispheres active and balances the sympathetic and parasympathetic activities in the body. Sympathetic or parasympathetic activity alternates automatically in our body which is important for our survival. Due to our hectic and stressful life, this naturally occurring alternate breathing cycle gets disrupted and we suffer from different ailments. These ailments are due to imbalance of autonomic nervous system which can be resolved by practicing alternate nostril breathing, the *Nadisodhan pranayama*. It's just like returning back to nature.

**Key words:** ANB, Autonomic activity, Breathing exercise, Nasal cycle, cerebral dominance, EEG, *Pranayama*

## INTRODUCTION

*Pranayama*, one of the yogic breathing techniques can produce different physiological

responses. Yogic techniques are known to improve physical and mental performances. Patanjali, foremost exponent of yoga, in his Yoga Sutra describes- *Yama, Niyama, Asana*,

Correspondence to:

Kshitiz Upadhyay-Dhungel  
Department of Research and Planning  
Think Tank Foundation, Jorpati, Nepal  
[ttfnepal@gmail.com](mailto:ttfnepal@gmail.com)

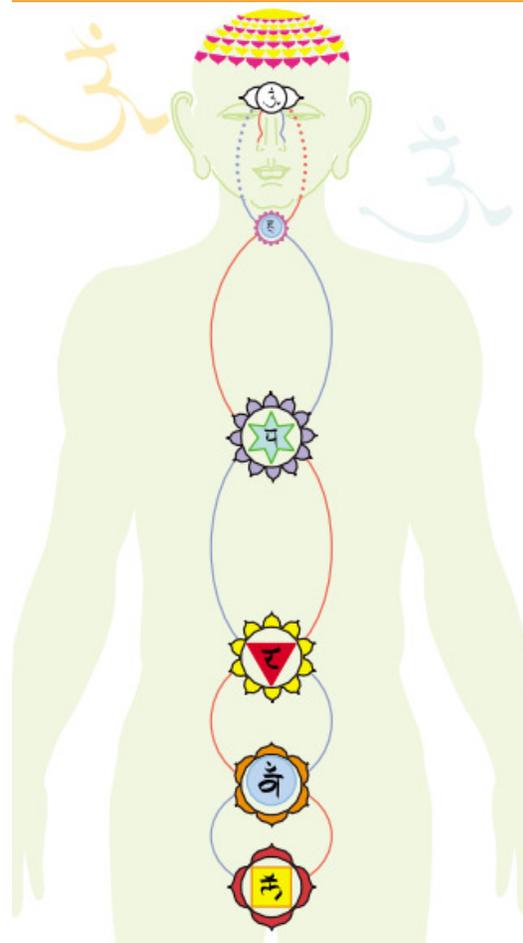
*Pranayama, Pratyahara, Dharana, Dhyana and Samadhi* as eight *angas* (parts) of yoga [1, 2]. Amongst them, in the present materialistic world, the third and fourth part, *Pranayama* and *Asana* (Postures) are considered as very important part and prescribed by modern medicine too. Many physicians now recommend yoga to patients at risk for heart diseases, as well as those with back pain, arthritis, depression and other chronic diseases [3, 4]. The beneficial effects of different *Pranayama* are well reported and have sound scientific basis [1, 5, 6, 7]. This paper tries to analyze the benefits of slow *pranayama*, especially nostril breathing exercises and its probable relationship with cerebral dominance and autonomic activities.

### ***Pranayama* and its root: explanation in yogic text**

The ancient science of Yoga makes use of voluntary regulation of the breathing to make respiration rhythmic and to calm the mind [1]. This practice is called *Pranayama*. The term *Pranayama* is derived from Sanskrit words '*Prana*' and '*aayama*'. '*Prana*' means life force and '*aayama*' means to control. So *Pranayama* refers to control of Life force [4]. Life force refers to the force that keeps us alive. A cadaver is cadaver because it has no life force in it. If it would have life force (*prana*) it would not have been dead. A person remains alive when he breathes; if he stops breathing he is no more alive. So, many propose that *prana* or life force refers to breathe. So, they say *pranayama* is simply a control of breath. *Pranayama* is a practice of voluntarily modifying the breathing pattern. But yogic text from where the word *Pranayama* is burrowed talks about *Prana* as a subtler thing. They say human have five layers of existence viz. *annamaya kosa, pranamaya kosa, manomayakosa, vijnanamaya kosa, and anandamaya kosa* [8] and the physical body is only one which is called *Annamaya Kosa*.

Beyond *annamaya kosa* (Physical body) is *Pranamaya Kosa* (Pranic body) which consists of 7 *chakras* and 7.2 million (*lakhs*) *nadis*. The Subtle '*Prana*' flows through this *nadis* and *Chakras*. These *Chakras* and *nadis* can be compared and correlated with Nerve plexus and nerve fibers of the anatomical body [9, 10, 11] (See also figure below).

Figure showing seven *chakras* (from Morris K, *The Lancet*, 1998) [11]



So, according to them *Pranayama* is more specifically "Control of *Prana*" and not the control of breathe alone. Many practitioners of yoga correlates *Pranayama* to breathe control because breathe control is one means to "physically" control the *prana*. Patanjali, the foremost exponent of Yoga on his documentation of *Astanga yoga* (eight limbed yoga), described *Pranayama* as fourth limb. *Astanga Yoga* combines scientific technique of right behavior (*Yama* and *Niyama*), proper posture (*asana*), life force control (*Pranayama*), interiorisation of the mind (*pratyahara*), concentration (*dhyana*), developing intuition (*dharna*) and ultimate realization (*Samadhi*) to achieve the final goal, which they call Moksha [4].

The existence of *Pranic* body which consists of 7 chakras and 72 lakhs *nadis* and subtle "*prana*" is not completely accepted by the modern science. Nevertheless, researches are going on to establish the concept of *prana* and *pranamaya kosa* [8-12]. However, the beneficial effects of *Pranayama* as a yogic breathing technique are well reported and documented.

#### ***Pranayama* and its benefit: short review**

*Pranayama* refers to a Rhythmic Breathing Exercise. It is yogic breathing techniques. It has gained its popularity for its beneficial effect in treatment of physiological and psychological disorders.

Various research works done on this topic reveals that it can be used as an adjunctive method of treatment to improve symptoms associated with autonomic, cardiovascular and respiratory disorders [13-17]. It has also been proved to be beneficial in psychological disorders involving stress [18].

There are several types of *pranayama* ranging from nostril to belly breathing. Slow to vigorous

breathing exercises like *Bhastrika* and *Kapalbhati*. It also varies from single nostril to alternate nostril breathing. Different forms of *pranayama* evoke various responses in the subjects depending upon rate, depth and force of respiration [19].

Slow yogic breathings are accepted as one of the most practical relaxation techniques and hold a great deal of potential in treatment of psychological and autonomic disorders [1, 4]. They are known for improving cardiovascular profiles and pulmonary functions [1, 7]. Slow *pranayama* like *savitri pranayama*, *sitkari*, *anuloma viloma pranayama*, *nadi suddhi pranayama* (Alternate nostril breathing), are well known among slow breathing exercises. Slow type *pranayama* has been proved to be beneficial in treatment of respiratory diseases like asthma and other COPD, Cardiovascular diseases like hypertension, autonomic imbalances, and psychological and stress related disorders [16-20]. While doing slow types of *pranayama*, the practitioners of *Pranayama* not only tries to breath but at the same time tries to keep his attention on the act of breathing, leading to concentration. This act of concentration removes his attention from worldly worries and "de-stress" him. This may decrease release of adrenaline i.e. decrease sympathetic activity and hence decrease in heart rate, respiratory rate, blood pressure etc. [1, 7]. Prakasamma M et al. from his study showed that patients with pleural effusion practicing alternate nostril breathing demonstrated a quicker re-expansion of the lungs in most of the measures of lung functions in comparison with control group who went through physiotherapy [21].

Slow yogic breathing, characterized as regular-slow frequency respiration with or without breath retention has been reported to cause short-term and long-term changes in cardio-respiratory parameters. Short-term effects of slow *pranayamic* breathing include decreased heart rate, blood pressure [1, 22] and oxygen consumption [23]. The effect also includes increased galvanic skin resistance [24] (a nonneural response), and amplitude of theta waves [25]. Increase in theta amplitude and delta waves during breath retention and slow breathing are indicative of a parasympathetic dominance while alpha and beta waves signify sympathetic activity [25]. Long-term effect of *pranayamic* breathing includes improvement in autonomic functions; specifically with slow breathing *pranayama*- there is a noted increase in parasympathetic activity and a decrease in sympathetic dominance [16]. It has been suggested that the cardio-respiratory system can be normalized through rhythmic breathing exercises [26, 27]. Both the short and long-term effects of *pranayamic* breathing indicate a dynamic alteration of the autonomic system. Slow *pranayama* has a strong tendency of improving or balancing the autonomic nervous system through enhanced activation of parasympathetic nervous system. Reduction in oxidative stress levels with decreased number of free radicals may explain in part the beneficial long term impact of *pranayama* on the cardiopulmonary system [7]. In contrast to other slow *pranayamic* breathing exercises, right nostril, left nostril, and both nostrils breathing have been shown to increase baseline oxygen consumption which is indicative of sympathetic discharge [24]. However, left nostril breathing has been shown to increase

volar galvanic skin resistance interpreted as a reduction in sympathetic nervous activity [24]. Although short *pranayamic* breathing practices including nostril breathing are capable of altering the functions of autonomic nervous system, more research works are required to fully understand their mechanism and clinical benefits.

From whatever has been found, the alteration in information processing at the primary thalamocortical level inducing modification in neural mechanisms regulating the respiratory system may contribute to *pranayama's* beneficial pulmonary effects [28]. Increased melatonin production has been reported after a regimen of slow breathing *pranayamic* exercises which has been attributed to *pranayama's* tendency to create a sense of relaxation and well being in the subject [29]. Some have made speculation that *pranayama* alters autonomic responses by increasing vagal tone and decreasing sympathetic discharges [30]. A decrease in breathing frequency can increase synchronization of brain waves eliciting delta wave activity indicating parasympathetic dominance [31]. Although these mechanisms provide some clues to *pranayama's* mechanism, the neural mechanism that causes this body-wide autonomic shift is still unclear [22]. Some has proposed that *pranayama* balances the autonomic nervous system through stretch-induced inhibitory signals of abdominal muscles (specifically the diaphragm) and even nerve endings in the nose [25, 32]. Jerath et al. hypothesized that voluntary, slow, deep breathing functionally resets the autonomic nervous system through stretch-induced inhibitory signals and hyper polarization currents propagated through both neural and non-neural tissue which synchronizes neural

elements in the heart, lungs, limbic system, and cortex. They also proposed that deep *pranayamic* breathing, dynamically modulates the autonomic nervous system by generating two physiologic signals: (1) *Pranayama* increases frequency and duration of inhibitory neural impulses by activating stretch receptors of the lungs during above tidal volume inhalation as in the Hering Breuer's reflex (2) *Pranayama* heightens generation of hyperpolarization current by stretch of connective tissue (fibroblasts) localized around the lungs [19].

Although many studies have shown the benefits of *pranayama* techniques, there are some reports that indicate risks associated especially with fast breathing exercises. If not carried out properly, fast breathing *pranayama* can cause hyperventilation and may hyperactivate the sympathetic nervous system [33] which may stress the body. In one case study, Pneumothorax has been reported as a result of fast breathing '*Kapabhati pranayama*' [34]. However, "*Kapalabhati*" has been shown to promote decarboxylation and oxidation mechanisms in the lungs which is believed to "quiet" the respiratory centers [35]. Such fast breathing exercises like *bhastrika* and *kapalabhati* seems to activate sympathetic activity [36] and long term practice may be helpful in decreasing body fat and central obesity. Some studies indicate that deep breathing similar to slow breathing *pranayama* may agitate symptoms of bronchial hyperactivity. Deep breathing induced parasympathetic activity is correlated with bronchial hyperactivity in asthmatics [37]. It is possible that *pranayamic* parasympathetic activity may elicit bronchial hyperactivity in asthmatics as well.

### **Alternate nostril breathing (ANB):**

Alternate nostril breathing refers to the *Nadisuddhi Pranayama*. *Nadisuddhi* means "purification of subtle energy paths". This *pranayama* is a slow type of *pranayama* in which inhalation and exhalation are through alternative nostrils for successive respiratory cycles. when the respiratory cycle of inhalation and exhalation is completed through the right nostril exclusively then it is called "*Surya Anuloma Viloma Pranayama (SAV)*" which literally means "heat generating breathing particle" When the practitioners completes the cycle through the left nostril alone the practice is called "*Chandra Anuloma Viloma Pranayama (CAV)*" which means a heat dissipating or cooling practice [38]. The *SAV pranayama* is popularly called Right nostril breathing (RNB) exercises and *CAV pranayama* is called Left nostril breathing (LNB) exercises in scientific literatures.

### **Yogic explanation of Nadisodhan pranayama**

In the yogic system of breathing, the right nostril dominance corresponds to activation of '*Pingala*' subtle energy channel; related to sympathetic arousal and left nostril to '*Ida*' subtle energy channel, corresponding to parasympathetic activation [1, 10, 15]. *Pranayama* effects the proper balance between '*Ida*' and '*Pingala*' i.e. Sympathetic and parasympathetic activity and gain spiritual upliftment and enlightenment through *Sushumna*, the third *Nadi*. The '*Sushumna*' *Nadi* is supposed to exist at centre where the flow of '*Prana*' (subtle life force) through the two *Nadis*: '*Ida*' and '*Pingala*' meet in the body. *Nadisuddhi* means 'purification of subtle energy path'. Thus this *Nadisudhi pranayama* (ANB exercise) purifies all three *Nadis* and various other *Nadis* throughout the body [1, 39, 40]. Proper chenalization of the '*prana*' through those *Nadis* viz '*Ida*', '*Pingala*'

and 'Sushumna' help in awakening of 'Kundalini-Shakti' (coiled serpentine energy at base) and leading her systematically through six different *chakras* to the seventh Crown or 'Shahasrar Chakra'. When this takes place the individual becomes fully conscious, awakened, and illumined. Then one attains the highest state of 'Samadhi'. This state is the ultimate goal of original yoga practice [41].

### **Nasal cycle and Alternate nostril breathing (Nadisodhan Pranayama)**

The airflow through one nostril is greater than next at any point of time which later switches to another. This is called nasal cycle [14]. The nasal cycle lasts for 30 minutes to 2-3 hours [42]. Kayser, renowned rhinologist define nasal cycle as a phenomenon of the alternating congestion, decongestion response of erectile tissue of nasal turbinate and septum of two nostrils, which effectively altered the unilateral nasal resistance and was existent on account of prevailing sympathetic or parasympathetic tone [14]. Sympathetic vasoconstriction will decrease air resistance allowing greater passage of air while parasympathetic vasodilatation will increase nasal resistance and will decrease the air flow. Thus the alteration may reach the transition point where air flow may be transiently equal bilaterally. The observation gains strength from the fact that in Horner's syndrome nasal cycle is absent on denervated side [14, 43]. It means that we are naturally breathing through alternate nostril. This is somewhat similar to what the yogic text says about *Nadisodhan pranayama* or alternate nostril breathing exercises. *Nadisodhan pranayama* is one of the important *pranayama* suggested by yogic text and it is one of the most practiced one. Here the person first exhale through left nostril and inhale through the same (with their right nostril closed) and then exhale through right nostril -

again inhaling through right nostril and exhaling through the left nostril. This completes one cycle of *Nadisodhan pranayama* [1].

### **Unilateral Nostril breathing and Autonomic function**

The recent studies have revealed that breathing through a particular nostril can alter metabolism and autonomic activities [24]. In their one month long study, they found that the 'right nostril *Pranayama*' group showed a significant increase, of 37% in baseline oxygen consumption. The 'alternate nostril' *Pranayama* group showed an 18% increase, and the left nostril *Pranayama* group also showed an increase of 24%. They attributed this increase in metabolism to increased sympathetic discharge. The 'left nostril *Pranayama*' group showed an increase in volar galvanic skin resistance, interpreted as a reduction in sympathetic nervous system activity supplying the sweat glands. These results suggest that breathing selectively through either nostril could have a marked activating effect or a relaxing effect on the sympathetic nervous system.

The subject practicing right nostril breathing alone which is also called *Surya anuloma viloma pranayama* (SAV) [33] shows significant increase in oxygen consumption (17%) and in systolic blood pressure (*mean increase 9.4 mm Hg*) and a significant decrease in digit pulse volume which was interpreted as sympathetic stimulating effect [23]. SAV practice involves sitting in a comfortable posture with spine straight and closing the left nostril with ring and middle finger. In contrast subject practicing left nostril breathing (where the practitioner sits in comfortable posture closing his right nostril and inhale and exhale through left nostril alone) shows significant decrease in blood pressure, respiratory rate Heart rate after 8 weeks [15].

This type of pranyaama is also called *Chandra anuloma viloma pranayama* (CAV) [23].

### **Nasal cycle, cerebral hemispheric activity and autonomic functions**

As we discussed earlier also that the airflow through one nostril is greater than next at any point of time which alters later. The nasal cycle which lasts for 25 minutes to 2-3 hours is closely related to the next ultradian rhythm of cerebral dominance that lasts for 1.5-3 hours in an awake human [44, 45]. Several researchers have shown that the nasal cycle is correlated in an inversely coupled fashion to the alternating dominance of activity in the two cerebral hemispheres, suggesting a common mechanism of regulation which is mainly mediated via autonomic nervous system [42]. Radio enzymatic measurement of nor epinephrine, epinephrine, and dopamine in blood sampled simultaneously from both arms every 7.5 minutes for a period of 3-6 hours demonstrated alternating high levels of catecholamine in one of the two arms. This alternating lateralization of neurotransmitters was observed in 7 out of 7 experiments using resting human male subjects. The ratio of nor epinephrine in the two arms also parallels the pattern of airflow in the nasal cycle. This study suggests that the autonomic nervous system may alternate in activity through paired structures [42]. Human studies of the nasal cycle and forced uni-nostril breathing have demonstrated that integrated EEG amplitudes are greater over the hemisphere contralateral to the dominant (less congested) or unblocked nostril [46, 47].

In a next study a significant relationship was obtained between the pattern of nasal airflow with normal breathing and relative spatial vs verbal performance. However, forced uni-nostril breathing had no effect on performance [48]. But in similar next study, the forced nostril

breathing in one nostril produces a relative increase in the EEG amplitude in the contralateral hemisphere. This phenomenon was demonstrated in 5 out of 5 untrained subjects [46].

In a review study, Khalsa [44] explains that the endogenous alternation of right and left dominance ranges in periodicity from about 25 to 300 min with peaks between 90-200 min during waking and around 100 min during sleep. He also noted that there is a lateralized ultradian rhythm of EEG during wakefulness and there is a correlation between hemispheric dominance and the nasal cycle. He also proposed that this rhythm of cerebral dominance plays an important role in cognitive performance, memory processes, visual perception, levels of arousal and performance, mood, and individual and social behavior [44]. In a recent study, Telles et al. demonstrated that the letter-cancellation task, which is a left-hemisphere dominant task scores were significantly improved following right and alternate nostril yoga breathing, i.e., there were fewer errors after right or alternate nostril breathing [49].

Jella showed that spatial task performance was significantly enhanced during left nostril breathing in both males and females and verbal task performance was greater during right nostril breathing, but not significant [50]. These results suggest the possibility of a close relation between alternate nostril breathing and contralateral cerebral activity. If so, then the single nostril breathing and alternate nostril breathing can be developed as non-invasive approach in the treatment of states of psychopathology involving lateralized cerebral dysfunction.

## CONCLUSION

From the above literatures and discussion it is clear that the nasal cycle is a natural phenomenon. This phenomenon works to balance the sympathetic and parasympathetic activity in the body. In another way we can say that sympathetic or parasympathetic activity alternates automatically in our body which is important for our survival. Due to our hectic and stressful life, this naturally occurring alternate breathing cycle gets disrupted and we suffer from different ailments. And these ailments are due to imbalance of functions of autonomic nervous system and can be resolved by practicing alternate nostril breathing (*Nadisodhan pranayama*). It's just like returning back to nature. Practicing ANB regularly keeps our both hemispheres (brain) active and also keeps both the autonomic nervous system in balance. Further empirical researches are needed in this field to establish these facts and to find medical and psychological implications.

The next speculation that can be drawn from this review is: nasal cycle, hemispheric activity and autonomic activity in our body are correlated. More precisely, when we breathe through one nostril (normally or forcefully), suppose through right nostril then activities of our contra-lateral hemisphere (left hemisphere) increases and simultaneously sympathetic nervous system will be predominant and vice versa. This interesting phenomenon can be used for non invasive treatment for balancing the autonomic nervous system, cardio-respiratory diseases and treatment of states of psychopathology involving lateralized cerebral dysfunction.

## REFERENCES

1. Upadhyay-Dhungel K, Malhotra V, Sarkar D, Prajapati R. Effect of alternate nostril breathing exercise on cardiorespiratory functions. *Nepal Med Coll J.* 2008; 10(1):25-27.
2. Bhaduri S. *Yoga-sutra of Patanjali* (translation). D.K Printworld (P) Ltd. New Delhi, 2000.
3. Becky R. The benefits of yoga. *JOY: The Journal of Yoga* 2003; 2: 1. Available at <http://www.godconsciousness.com/joy/thebenefitsofyoga> as accessed on 4th January, 2007.
4. Bijlani RL. Yoga (section 17). In *Understanding Medical Physiology: A textbook for medical students*. R. L. Bijlani (Ed). Jaypee Brothers, New Delhi, 1995; pp.871-910.
5. Joshi LN, Joshi VD, Gokhale LV. Effect of short term *pranayam* on ventilatory functions of lung. *Indian J Physiol Pharmacol.* 1992; 36: 105-8.
6. Raghuraj P, Ramakrishnan AG, Nagendra HR, Telles S. Effect of two selected yogic breathing techniques on heart rate variability. *Indian J Physiol Pharmacol.* 1998; 42: 467-72.
7. Bhattacharya S, Pandey US, Verma NS. Improvement in oxidative status with yogic breathing in young healthy males. *Indian J Physiol Pharmacol.* 2002; 46: 349-54.
8. Srikanta SS, Nagarathna R, Nagendra HR. Yogic management of diabetes mellitus In: *Yoga for diabetes mellitus*. Swami vivekanda yoga prakashan, Bangalore, India, 2003.
9. Joshi BC. Neurology in ancient India: Ajna cakra- A Physiological reality. *Ind J of Hist of Sci.* 1987; 22(4): 292-315.
10. Swami Ramdev. Chapter: Hatha yoga and Satkarma. In: *Yoga sadhana and Yog chikitsa rahasya*. Divya prakashan. Divya yog mandir (trust). Kanakhal. Haridwar, p 114-20, 2004.
11. Morris K. Meditating on yogic science. *The Lancet* 1998; 351: 1038.
12. Subbalakshmi N.K., Saxena S.K., Urmimala, D'Souza Urban J.A. Immediate effect of *Nadisodhan Pranayama* on some selected parameters of cardiovascular, pulmonary and higher functions of brain. *Thai J Physiological Sci.* 2005; 18(2):10-16.
13. Madanmohan, Udupa K, Bhavanani AB, Vijayalakshmi P, Surendiran A. Effect of slow and fast *Pranayams* on reaction time and Cardiorespiratory variables. *Indian J Physiol Pharmacol* 2005; 49: 313-318.

14. Srivastav RD, Jain N, Singhal A. Influence of alternate nostril breathing on Cardiorespiratory and autonomic functions in healthy young adults. *Indian J Physiol Pharmacol.* 2005; 49: 475-483.
15. Jain N, Srivastav RD, Singhal A. The effects of Right and Left nostril breathing on cardiorespiratory and autonomic parameters. *Indian J Physiol Pharmacol.* 2005; 49: 469-474.
16. Pal GK, Velkumary S, Madanmohan. Effect of short-term breath exercises on autonomic functions in normal human volunteers. *Indian J Med Res.* 2004; 120:115-121.
17. Brown RP, Gerbarg PL. Sudarshan kriya yogic breathing in the treatment of stress, anxiety and depression: part 1-neurophysiological model. *J Altern Complement Med.* 2005; 11(1):189-201.
18. Ravindra PN, Madanmohan PP. Effect of *pranayam* (yogic breathing) and shavasana (relaxation training) on the frequency of benign ventricular ectopics in two patients with palpitations. *Int J Cardiol.* 2006; 108: 124- 125.
19. Jerath R, Edry JW, Barnes VA, Jerath V. Physiology of long *pranayamic* breathing: Neural respiratory elements may provide a mechanism that explains how slow deep breathing shifts the autonomic nervous system. *Med Hypoth.* 2006; 67: 566-571.
20. Cooper S, Osborne J, Newton S, Harrison V, Thompson CJ, Lewis S and Tattersfield A. Effect of two breathing exercises (Buteyko and *pranayama*) in asthma: a randomised controlled trial. *Thorax* 2003; 58:674-79.
21. Prakasamma M, Bhaduri A. A study of yoga as a nursing intervention in the care of patients with pleural effusion. *J Adv Nurs.* 1984; 9(2):127-33.
22. Singh S, Malhotra V, Singh KP, Madhu SV, Tandon OP. Role of yoga in modifying certain cardiovascular functions in type 2 diabetic patients. *J Assoc Physician Ind.* 2004; 52:203-6.
23. Telles S, Desiraju T. Oxygen consumption during *pranayamic* type of very slow-rate breathing. *Indian J Med Res.* 1991; 94:357-63.
24. Telles S, Nagarathna R, Nagendra HR. Breathing through a particular nostril can alter metabolism and autonomic activities. *Indian J Physiol Pharmacol.* 38:133-7, 1994.
25. Austin JH. *Zen and the brain.* Cambridge (MA): MIT Press; 1998.
26. Gopal KS, Anantharaman V, Balachandra S, Nishith SD. The cardio-respiratory adjustments in '*Pranayam*' with and without "Bandhas" in '*Vajrasana*'. *The Ind J Med Sci.* 1973; 27:686-692.
27. Iyengar BKS. *Light on pranayama: the yogic art of breathing.* New York: Crossroad; 1998.
28. Telles S, Catherine J, Venkatesh S, Desiraju T. Alterations of auditory middle latency evoked potentials during yogic consciously regulated breathing and attentive state of mind. *Int J Psychophysiol.* 1992; 14(3):189-98.
29. Harinath K, Malhotra AS, Pal K, Prasad R, Kumar R, Kain TC, Rai L, Sawhney RC. Effects of Hatha Yoga and Omkar Meditation on Cardiorespiratory Performance, Psychologic Profile, and Melatonin Secretion. *The Journal of Alternative and Complementary Medicine* 2004;10 (2):261 -268.
30. Bhargava R, Gogate M, Mascarenhas J. Autonomic responses to breath holding and its variations following *pranayama*. *Indian J Physiol Pharmacol* 1988; 32(4):257-64.
31. Busek P, Kemlink D. The influence of the respiratory cycle on the EEG. *Physiol Res.* 2005; 54:327-33.
32. Milieiae D, Mladina R, Daniae D, Prgomet D, Leoviae D. Influence of Nasal Fontanel Receptors on the Regulation of Tracheobronchal Vagal Tone. *Croat Med J.* 1998; 39 (4).
33. Telles S, Nagarathna R, Nagendra HR. Physiological measures of right nostril breathing. *J Altern Complement Med.* 1996; 2:479-84.
34. Johnson D, Tierney M, Sadighi P. Kapalabhati *pranayama*: breath of fire or cause of pneumothorax? A case report. *Chest* 2004; 125(5):1951-2.
35. Desai B, Gharote M. Effect of Kapalabhati on blood urea, creatinine and tyrosine. *Act Nerv Super (Praha)* 1990; 32 (2): 95-8.
36. Stancak A Jr., Kuna M, Srinivasan, Vishuddhadevananda S, Dostalek C. *Kapalbhati*-Yogic cleansing exercises, I. Cardiovascular and respiratory changes. *Homeost Health Dis.* 1991; 33 (3): 126-134.
37. Kallenbach J et al. Reflex heart rate control in asthma. Evidence of parasympathetic overactivity. *Chest* 1985; 87(5): 644-8.
38. Malhotra VM, et al. Chandra anuloma viloma *pranayama* modifies autonomic activity of heart. *BAPT* 2008; 2 (1): 27-28.
39. Bharkher DL. Chapter: The Astanga yoga. In: *Yoga and Human Health.* Deepara Press; Kathmandu 2004: pp. 7, 48-9.
40. Swami Sacchidananda Visudhadev. "*Pranayama*: breathing control exercise" In: *Character-Science [Charecterology].* Centre for stato-dynamic international movement. Ktm 2005: 261-75.

41. Swami Rama. . "Awakening Kundalini". <http://www.himalayaninstitute.org/ArticleRead.aspx?code=48> as accessed on 4<sup>th</sup> January 2007.
  42. Kennedy B, Ziegler MG, Shannahoff-Khalsa DS. Alternating lateralization of plasma catecholamines and nasal patency in humans. *Life Sci.* 1986; 38:1203-14.
  43. Keuning J. On the nasal cycle. *Int Rhinol.* 1968; 99-136.
  44. Khalsa DS. The ultradian rhythm of alternating cerebral hemispheric activity. *Int J Neurosci.* 1993; 70:285-98.
  45. Khalsa DS, Boyle MR, Buebel ME. The effects of unilateral forced nostril breathing on cognition. *Int J Neurosci.* 1991; 57(3-4):239-49.
  46. Werntz DA, Bickford RG, Khalsa DS. Selective hemispheric stimulation by unilateral forced nostril breathing. *Hum Neurobiol.* 1987; 6(3): 165-71.
  47. Werntz DA, Bickford RG, Bloom FE, Khalsa DS. Alternating cerebral hemispheric activity and the lateralization of autonomic nervous function. *Hum Neurobiol.* 1983; 2:39-43.
  48. Klein R, Pilon D, Prosser S, Shannahoff-Khalsa D. Nasal airflow asymmetries and human performance. *Biol Psychol.* 1986; 23(2):127-37.
  49. Telles S, Raghuraj P, Maharana S, Nagendra HR. Immediate effect of three yoga breathing techniques on performance on a letter-cancellation task. *Percept Mot Skills* 2007; 104:1289-96.
  50. Jella SA, Khalsa DS. The effects of unilateral forced nostril breathing on cognitive performance. *Int J Neurosci.* 1993; 73:61-8.
- .....