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Respiratory Practices in Yoga

FRANK A. CHANDRA

1. Introduction

In the West changes in respiration have been regarded primarily as signs and symptoms of disease. Mechanisms for abnormal ventilation—malfunction of the respiratory control centers, neuromuscular disease, or excess work of breathing—have been elucidated and therapeutically modified (Guenter, 1984). In the East, however, voluntary modifications of breathing have long been used for treatment of disease and for influencing physiological function of the nervous and other systems of the body. The methods were drawn from disciplines practiced by esoteric communities for spiritual purposes, especially in India. A statuette found in an Indus valley excavation suggested that yogic breath control was well developed in the third millennium BC and was associated with physical and spiritual well-being (Rowland, 1953).

2. Pranayama

As a stage toward meditation, yogis practice a special breathing technique known in Sanskrit as *pranayama*. The essentials of this technique include (1) slowing and regularizing the breath by prolonging the expiratory phase, (2) enhancing abdominal/diaphragmatic breathing, and (3) imposing resistance to both inspiration and exhalation.

FRANK A. CHANDRA (1925–1993) • Formerly, Department of Health, London, England.
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3. *Prolonged Expiration*

In ordinary life, prolonged expiration is associated with diminished cerebral and physical activity and tone (e.g., in yawning, sighing, smoking, or counting to ten in crises). Yogi masters assumed, without investigating causal relationships, that prolonged expiration in breathing exercises would induce mental and physical relaxation. Expiration is therefore usually prolonged to twice the duration of inspiration.

4. *Abdominal/Diaphragmatic Breathing*

In yogic practice, both the diaphragm and the lower ribs are used, in contrast to the use by some singers of the diaphragm alone with chest fully expanded. Abdominal breathing is practiced by concentration on restricting the movement of the upper ribs and on bulging of the upper part of the abdominal wall. Breath-holding in submaximal inspiration is introduced as expertise in the method is developed and it can be done safely.

5. *Increased Resistance*

Resistance to breathing may be imposed at the nose (by closing one nostril with the fingers), or at the mouth (by mouth-breathing through different configurations of lips and tongue) or at the larynx (by voluntarily narrowing the glottic aperture). Pressure on the nostril due to inward compression by the fingers stimulates the mucous membrane and results in increased patency of the nostrils by constriction of resistive and capacitative blood vessels, as also occurs in exercise (Girgis *et al.*, 1974). In addition, it may assist voluntary partial closure of the glottis and may slow the pulse. These effects are mediated through a reflex having the fifth cranial nerve as afferent, and the vagus nerve as efferent (Gooden *et al.*, 1978).

6. *Alternate Nostril Breathing*

Various combinations of alternate nostril occlusion during inhalation or exhalation are used, resulting in stimulation of both nasal cavities and producing changes in temperature, pressure, and airflow characteristics. From experiments in animals, Whicker *et al.* (1978) showed that nasal stimulation caused changes in breathing patterns, which altered resistance without actual change in the intrinsic behavior of the lung airways. It was thought that subtle relations between the upper and lower respiratory tract were probably important to respiratory health (Chapter 2). An increase in pulmonary airflow resistance allows efficient gas exchange in the alveoli and, to maintain this, nasal respiration and stimulation are important (Strong, 1979). Negus *et al.* (1970) showed that if one nostril is closed there is decreased air intake and output and increased intratracheal and intrathoracic negative and positive pressures. The alteration of pressure on the great veins and right atrium helps onward flow of the blood during inspiration. With the right nostril closed, swings of pressure from −10 to +10 mm Hg were measured in the right atrium during inspiration and expiration, respectively. In strong inspiration against resistance, intrapleural pressure can reach −30 mm Hg (Feely *et al.*, 1975).

7. Nasal Passages and Nasal Cycles

Yogic theory consistently states that there are important connections between the nasal passages and the psyche. During spontaneous breathing, inhaling through the left nostril is said by most people to have a calming, beneficial, stabilizing effect, while breathing through the right nostril is destabilizing, excitatory, and ultimately enervating. A balance between the two modes is thought to be most suitable for the challenges of daily life, and is put forth as a teleological explanation for the ultradian rhythm of congestion/decongestion that occurs in the nose throughout the day. This cycle of naturally occurring congestion in one nostril with relative decongestion in the other nostril, followed by the reverse, occurs every 1½–4 hours and has been described by yogic practitioners for hundreds of years. Confirmation of this finding has been made in the West (Stoksted, 1952), and central nervous system correlates of nostril laterality documented by Werntz *et al.* (1983). Such cycling might be regulated from a nasal center in the hypothalamus or the medulla, and Eccles (1978) suggests that persons trained in yogic breathing exercises could alter dominance of nasal airflow from one nostril to the other, presumably by developing voluntary control of this autonomic nasal center. Persistence of airflow through one nostril instead of alternation has been shown in allergic rhinitis, septal deviation, and upper respiratory infection (Gray, 1977). A summary of proposed physiological and clinical effects (including hemispheric lateralization) produced by changes from normal nasal breathing are described by Backon (1989).

8. Asthma

In asthma, strong, active expiratory effort does not necessarily reduce the hyperinflation of the lungs since dynamic compression of the airways may further increase resistance (des Jardins, 1984). A low level of positive pressure applied to the expiratory phase of tidal breathing should decrease or prevent premature closure, by increasing the transmural pressure across the intrathoracic airways (Mead, 1960). Thus, slow expiratory effort against resistance, as in the pranayamic expiration, should increase pressure in the airways and delay dynamic compression, allowing a stronger contraction of the expiratory muscles to reduce hyperinflation to some extent.

Nagarathna and Nagendra (1985) found significant improvements in number of attacks, drug use, and peak flow rate in a group of 53 asthmatic patients on yoga therapy, compared with matched control patients. The yoga subjects practiced daily—after training—in a series of breathing, postural, mental, and spiritual exercises. The authors speculated that the physical and mental relaxation produced by yoga had a stabilizing effect on bronchial reactivity, through reduction of vagal efferent activity.

9. *Effects of Pranayama on Carbon Dioxide Levels*

Using inspiration against resistance for 5 seconds, followed by breath-holding for 20 seconds, then expiration against resistance for 10 seconds, Kuvalayananda (1933) found that alveolar CO_2 rose from about 5.5 percent to approx 6.5 percent (i.e., mild respiratory acidosis; see Chapter 7) by about the sixth breath and remained at this level during the final four breaths of the ten-breath cycle. Many of the effects claimed for this type of breathing may be attributable to the rise in alveolar CO_2 and arterial Pa_{CO_2}. Among these effects are:

- Tranquilizing of the cerebral cortex with stimulation of the reticular activating system, resulting in a calm but alert mind.
- Increase in cerebral blood flow without causing headache.
- Vasodilation of the skin blood vessels, producing a sensation of warmth moving over the body.
- In some persons, vasoconstriction of digital blood vessels, resulting in cold fingers.
- Stimulation of certain exocrine glands, producing, for example, increased flow of saliva and sweat.
- Elevation of the threshold of the high pressure baroreceptor in the carotid sinus.
- Shunting of blood from the internal abdominal areas to skin and skeletal muscles.
- Decreased contractility of the inspiratory muscles (Cohen *et al.*, 1982), the laryngeal muscles (Dixon *et al.*, 1974), and the cardiac and skeletal

muscles in general (Cingolani *et al.*, 1969). This does not appear to be due merely to the sense of relaxation produced by the effect of CO_2 on the brain, but may be a direct effect on muscle due to alteration of pH (Juan *et al.*, 1984).

Raised levels of alveolar CO_2 do not result in increased rate and depth of respiration in the trained yoga practitioner because volume is voluntarily controlled to about 50–75 percent of the inspiratory capacity, and rate is fixed at about two breaths per minute in adepts practicing the recommended cycle (5, 20, and 10 seconds, respectively, for inspiration, breath-holding, and expiration).

Yogis attribute their ability to resist the normal stimulus for increased ventilation—a rise in alveolar CO_2—to voluntary control over automatic and reflex actions and thus a desirable dominance of mind and will over bodily urges. Stanescu *et al.* (1981), however, attribute these striking changes in fundamental ventilatory responses (to increased alveolar CO_2) to chronic overstimulation of the stretch receptors of the lung. This overstimulation results, through habituation, in decreased vagal information from the receptors.

Pietroni and Pietroni (1989) reviewed the evidence and concluded that respiratory modulation of the autonomic nervous system had a central, and a peripheral, component. Shallow inspiration increased arousal (as shown, for example, by reaction time or the knee jerk reflect), but deep inspiration decreased arousal. Arousal was associated with increased sympathetic, and decreased parasympathetic, discharge. The pranayamic deep inspiration, followed by some seconds of breath holding and then slow expiration, might therefore prolong the inhibition of arousal and contribute to the long-lasting modulation of autonomic activity noted in such an exercise.

An alternative explanation is that the yogi's entire sympathetic nervous system may become less active, as shown by the low blood pressure and metabolic rate seen in many practicing yogis. Medical investigators of yogic physiology have repeatedly observed that these practices produce a decrease in sympathetic tone (Patel, 1975).

10. Underbreathing, Normal, and Overbreathing

Panting is used by dogs and other hairy mammals to cool the body. Stable levels of P_{CO_2} (*eucapnia*) are maintained because it is primarily dead space that is ventilated (see Chapter 2). An analogue in yoga is an advanced practice, bellows breathing (*Bhastrika*), in which adepts breathe at a rate of about 60 (or 120) breaths per minute, using abdominal and expiratory muscles, the latter working from rest point to greater expiration, with the subsequent inspiration being due to reflexive recoil. It has been documented that stable levels of P_{CO_2}

are maintained during Bhastrika (Kuvalayananda and Karambelkar, 1957). If rapid respiration is too shallow, there is primarily dead space ventilation and inadequate alveolar ventilation; therefore, CO_2 is retained (Bradley *et al.*, 1984). On the other hand, deep rapid respiration will produce hypocapnia and the familiar unpleasant sequelae of hyperventilation. It must be borne in mind, however, that some persons find hypocapnia attractive because of the alteration of consciousness or "high" it can cause. In some communities it is actively practiced in rituals, for inducing trances and psychic states that give the performer an enhanced status among his people. A relative insensitivity to pain can occur during these trances, enabling the performer to execute impressive feats, such as, skewering his flesh or suffering beating with whips, without any apparent discomfort (Lum, 1981). In many parts of the world certain nonyogic groups, e.g., some of the cult groups of African origins in Jamaica, use overbreathing and the resulting hypocapnia to procure or enhance trancelike states. West Indians are sometimes admitted to accident and emergency departments in the United Kingdom for "epilepsy," but have no detectable organic lesions. Their histories strongly suggest ritual overbreathing as a causative factor.

The potential value of pranayama in the treatment of hyperventilation is evident, not only because of the slight degree of hypercapnia induced, but also because of the tranquilizing effect and the retraining of respiratory patterns that results. Hyperventilating agoraphobics had an improved response to conventional behavior therapy when the latter was supplemented with breathing retraining (Bonn *et al.*, 1984). Patients were instructed in abdominal/diaphragmatic breathing, slowed to 8–10 breaths per minute.

11. Respiratory Muscles

Various phases of pranayamic breathing have potential for increasing endurance of respiratory muscles in certain circumstances. Inspiratory resistance was used to improve exercise performance in cystic fibrosis (Pardy *et al.*, 1981a,b) and to increase the strength of inspiratory muscles in quadriplegia (Gross *et al.*, 1980). Breath holding after inspiration is advocated by swimming coaches—one deep breath per four arm cycles. The resulting improved performance is said to be due to physiological adaptations facilitated by increased blood CO_2 (Counsilman, 1981).

12. Valsalva Maneuver

This procedure, which involves an expiratory effort with the glottis closed after a full inspiration, is avoided in Eastern breathing practices because of its possible harmful effects. The Valsalva maneuver can produce intrathoracic pressures of up to 100–150 mm Hg (Charlier *et al.*, 1974). To prevent syncope from an unintentional Valsalva effect, pranayama practitioners are advised to breathe in submaximally (i.e., less than the inspiratory capacity), especially when breath holding follows the end of inspiration.

13. Comparison of Pranayama and Mechanically Assisted Ventilation

Although resembling, in the *expiratory* phase, various forms of mechanical respiratory assistance now in clinical use, the yogic *inspiratory* phase is quite different from that in any form of assisted ventilation, even intermittent positive pressure ventilation (IPPV), in which positive pressure is given during inspiration only. Unlike mechanical ventilation, pranayamic breathing does not embarrass the venous return and cardiac output during each cycle of respiration. Its full use in clinical medicine awaits exploration.

14. Abdominal Pressures

During performance of yogic postures (*asanas*), breathing is controlled primarily to adjust pressures in the abdomen. Forward bending of the spine tends to increase intraabdominal pressure. The performer is therefore advised to let the breath out slowly and gradually during a full forward bending posture (head on fully extended knees while standing (Fig. 1A) or sitting (Fig. 1B); to hold the breath in expiration during maintenance of this full spinal flexion; and then to breathe slowly in as the spine is straightened again into the erect standing or sitting position. Adepts who can hold the full position for several minutes are advised to breath normally during this time. Conversely, when doing exercises causing extension of the spine beyond the upright position, the performer gradually breathes in; holds the position while breathing naturally; and then breathes out while straightening up. Thus, in the extreme flexion of the spine known as the *plough* (Fig. 1C), intraabdominal pressure remains at approx 10 mm Hg, as it does in a spinal extension posture, the *fish* (1D).

Riemenschneider and Shields (1981) described the movement of lymph through the valves of the thoracic duct during the negative intrathoracic pressure of inspiration. This effect is likely to be enhanced by the ancient yogic exercise of maximal inspiratory effort against the closed glottis after full expiration, recently termed the *Mueller maneuver* (Mines, 1986). Subsequent diminution of the negative pressure, as normal breathing is resumed, will move the lymph upwards out of the chest into the subclavian veins, as the valves of the thoracic duct prevents reflux. This upward movement of lymph increases as intrathoracic

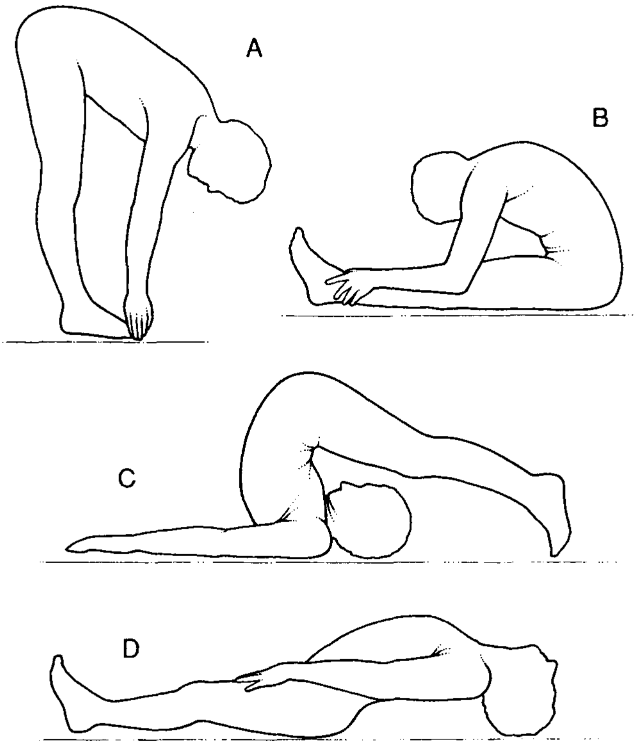

Figure 1. Yoga postures (asanas).

pressure becomes positive with the next expiration, and more so if this expiration is against resistance. This enhanced movement of lymph has nutritive and immunological significance (Damshek, 1963).

Negative intrathoracic pressures are transmitted to the abdomen via the diaphragm, and to the soft walls and interiors of the viscera of the abdomen and the chest. An increase in transmural pressures would be expected in blood vessels, gut, gall bladder, pelvis of the kidneys, urethra, and urinary bladder. Hypotheses have been generated that such effects would dilate extensible tubular structures, causing increased blood flow in organs of the chest and abdomen, and clearance of obstructing debris from ducts and hollow viscera, etc.

15. Hormonal Effects

Yogic physicians claim that breathing practices can affect many physiologic parameters, including output of several hormones. Udupa and colleagues' subjects practiced pranayamic breathing for seven minutes, rest for five minutes and then Bhastrika for ten minutes. After six months of daily practice, decreased total serum lipids and increased plasma cortisol, urinary 17-hydroxy- and 17-ketosteroids were observed (Udupa *et al.*, 1975).

16. Meditation

Most types of meditation can be assigned to either one or two major classes: the excitatory (ergotropic), hyperarousal class and the calming (trophotropic), hypoarousal class (Fischer, 1971), each associated with appropriate changes in blood pressure, pulse, respiratory and metabolic rates, and EEG. The excitatory (Kundalini) types (Eliade, 1958) of meditation may use the Bhastrika breathing or else a mild overbreathing, while the calming types of meditation [expounded by the sage Patanjali (late BC to early AD)] involve special types of slow, controlled breathing, often with breath retention. The latter are practiced in the early stages of diaphragmatic breathing (pranayama) and later during the induction of meditation.

In a Western study documenting central nervous system correlates of breathing patterns, Timmons *et al.* (1972) found that the relaxed presleep state (characterized by EEG alpha activity) was usually associated with abdominal-dominant breathing. In stage I or stage II sleep, thoracic breathing tended to increase in amplitude while abdominal breathing decreased. In the transition from wakefulness to sleep, changes in EEG patterns (waxing and waning of alpha activity, appearance of theta waves, etc.) were tightly linked to changes in abdominal/thoracic amplitudes. The authors concluded that their findings were compatible with claims of yogis, Zen Buddhists, and others who use breathing techniques to facilitate attainment of special states of consciousness. The findings are also relevant to anecdotal accounts of yogis who claim that pranayama induces calmness and relaxation but increases mental alertness: neurophysiologists recognize the EEG alpha state as compatible with relaxed wakefulness.

17. Conclusion

This brief account of the effects of a few pranayamic breathing techniques suggests that the traditional teachings of yogic masters can prove to be an interesting and rewarding field for scientific investigation. Such studies would not only increase our knowledge of basic physiological mechanisms, but would also point the way to new, simpler, and less costly methods for treatment of respiratory and other disorders.

18. Guidelines for Therapists

Pranayamic type breathing is likely to be of some benefit to people suffering from anxiety disorders, hyperventilation, cystic fibrosis, emphysema, cardiac failure, asthma, and some forms of epilepsy. Bhastrika type breathing may help mild depressives and asthmatics, and perhaps assist in evacuation of excess liquid and semiliquid material from the lungs in chronic obstructive pulmonary disease and bronchiectasis. However, patients should not be referred to yoga teachers unless a firm medical diagnosis has been made, and the teacher is known to understand the condition. Great care should be taken not to use inappropriate treatment; e.g., Bhastrika should not be taught to hyperventilators, epileptics, or cases of angina pectoris, nor should pranayama be used by depressives.

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For further information about yoga and its practices, please refer to:

Yoga Journal (published by the California Yoga Teachers Association, 2054 University Avenue, Berkeley, California 94704).

Yoga and Health (published by Yoga Today Ltd, 21 Caburn Crescent, Lewes, East Sussex BN7 1NR, England).

Yoga Biomedical Trust
P.O. Box 140
Cambridge CB4 3SY
England