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TWO BREATHS PER MINUTE YOGIC BREATHING

The Physiological Correlates of Breathing Two Breaths per Minute by a Yoga Master

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Abstract

This study explored the physiological correlates of a highly practiced Yoga master while he voluntarily breathed approximately two breaths per minute. Thoracic and abdominal breathing patterns, heart rate, occipital parietal electroencephalograph (EEG), skin conductance level, blood volume pulse, transcutaneous SpO_2, and end-tidal carbon dioxide ($ETCO_2$) were monitored during the following conditions: 3 minutes eyes open pre-baseline, 18 minutes eyes closed self-paced slow breathing, 3 minutes eyes open post-baseline; and 3 minutes eyes closed post-baseline. The pre-baseline mean breathing rate of 18 breaths per minute (Brpm) decreased significantly to 1.9 Brpm during the slow breathing condition. SpO_2 showed no significant change across conditions, $ETCO_2$ increased significantly from 37.8 mm HG during pre-baseline to 43.7 mm HG during slow breathing, heart rate showed no significant change across conditions, and mean alpha EEG activity increased during the slow breathing condition. Implications for meditation and clinical applications are discussed.

Keywords: EEG, alpha, respiration, yoga, $ETCO_2$, SpO_2

The Physiological Correlates of Breathing Two Breaths per Minute by a Yoga Master

Breath control is common to many meditation practices. Yoga teaches that control of breathing and of Prana (life force) is vital to maintaining general health as well as integral to productive meditation (Ramacharaka, 1905; Sovik, 2000). Breath control is the basis for mastering self-regulation as it bridges the conscious and unconscious and the voluntary and autonomic nervous systems. Slow effortless diaphragmatic breathing with a longer post-exhalation pause is associated with increased perception of mental and physical energy, increased feelings of alertness and enthusiasm, and reduced stress (Wood, 1993). Conversely, rapid shallow breathing with decreased end-tidal carbon-dioxide ($ETCO_2$) is associated with stress and arousal (Umezawa, 1993; Fried, 1987). Voluntary control and slowing one's breathing rhythm appears to significantly lower oxygen consumption and metabolic rate (Telles & Desiraju, 1991). A demonstration of breath control was filmed in the movie *Biofeedback Yoga of the West.* In this film a yogi was locked in a completely sealed small cubicle for many hours during which time he should have depleted the oxygen within the cubicle (Hartley, 1974). However, the yogi reported no discomfort and, for the duration of the study, the electroencephalograph (EEG) showed a predominance of alpha activity as his resting brain state (Green & Green, 1977). According to yogic lore, learning very slow breathing of about two breaths per minute is the beginning process to develop control of the mind (consciousness) and the autonomic nervous system (Rama, 1996; Funderburk, 1977; Sovik, 2000). This study explored the physiological correlates of very slow yogic breathing by a well-trained Kundalini Yoga meditator.

Method

Subject

The subject was a 61 year-old male Japanese Yogi with 34 years of experience practicing various forms of yoga. He is founder and Chief Executive Director of his own school of yoga and Institute for Research of Subconscious Psychology in Fukuoka and Tokyo, Japan. The Indian Yoga Culture Federation bestowed the title of Yoga Samrat upon him in 1983 after he demonstrated that he had reached the highest level of proficiency in his discipline. In an earlier study exploring the psychophysiology of meditation, his breathing pattern during meditation was about 6 breaths per minute with a significantly increased phase-locked respiratory sinus arrhythmia (Arambula, Peper, Kawakami & Gibney, 2001). He participated in the breathing research projects in Tokyo, Japan, and at San Francisco State University to explore the physiological correlates of slow breathing and to contribute to scientific inquiries into meditation.

Equipment

The physiological data were collected with a ProComp+ with Biograph 2.0 software (Thought Technology, Ltd.). Abdominal and thoracic respiration patterns were recorded with strain gauges placed at the level of the umbilicus (abdominal) and just below the axilla (thoracic). Bipolar EEG was recorded with silver/silver chloride electrodes from the left occipital (O1) and the left parietal (P3) with the reference attached to the left earlobe. Traditional bandwidths for delta (2-4Hz), theta (4-8Hz), alpha (8-13Hz), sensory-motor rhythm (SMR) (13-

15Hz), and beta (15-20Hz) were used in the analyses. Blood volume pulse (BVP) was recorded with a photoplethysmograph from the distal phalange of the left middle finger and heart rate (HR) was derived from the BVP signal. Skin conductance level (SCL) was recorded from the right palm. Transcutaneous SpO_2 was recorded with a BCI International finger oximeter from the distal phalange of the right index finger and $ETCO_2$ was recorded with a BCI International Handheld Capnometer with a sampling line placed inside the right nostril. Transcutaneous SpO_2, HR, and $ETCO_2$ values were recorded by hand and linked to the time markers of the Biograph recording. The sensor attachments and locations are shown in Fig. 1.

Figure 1. Sensors as attached to the subject.

Procedures

After the subject changed into loose fitting clothing that he uses for meditation, sensors were attached. While under continuous observation by a number of onlookers, he sat in a chair while the equipment was calibrated. Sitting quietly, the sequential conditions consisted of: 3 minutes eyes open pre-baseline, 18 minutes eyes closed self-paced slow breathing, 3 minutes eyes open post-baseline; and 3 minutes eyes closed post-baseline.

Results

There was a large decrease in respiration rate from 18 breaths per minute (Brpm) during pre-baseline to 1.9 Brpm during the slow breathing condition. The respiration rate increased to 11.8 Brpm during eyes open post-baseline and dropped to 7.3 Brpm during eyes closed post-baseline. There was a slight increase in SCL from 4.1 μMhos during the eyes open pre-baseline to 6.8 μMhos during the slow breathing condition, with a significant increase in the first post-baseline condition when he opened his eyes. EEG activity showed changes in mean amplitude of alpha activity from 3.5 μV during the eyes open pre-baseline to 12.9 μV during the slow breathing condition, to 3.3 μV during the eyes open post-baseline, and 18.6 μV during the eyes closed post-baseline, as shown in figure 2. There was no significant change in HR from pre-baseline (72.5 beats per minute (bpm); SD 2.8 bpm) to the slow breathing condition (70.6 bpm; SD 3.1 bpm). There was a significant increase in HR from the slow breathing condition to post-baseline (73.8 bpm; SD 4.2 bpm; P=0.01). HR tended to increase at the end of each exhalation and slightly decrease during inhalation. A representative 1-minute recording of the pre-baseline and the slow breathing conditions is shown in figure 3.

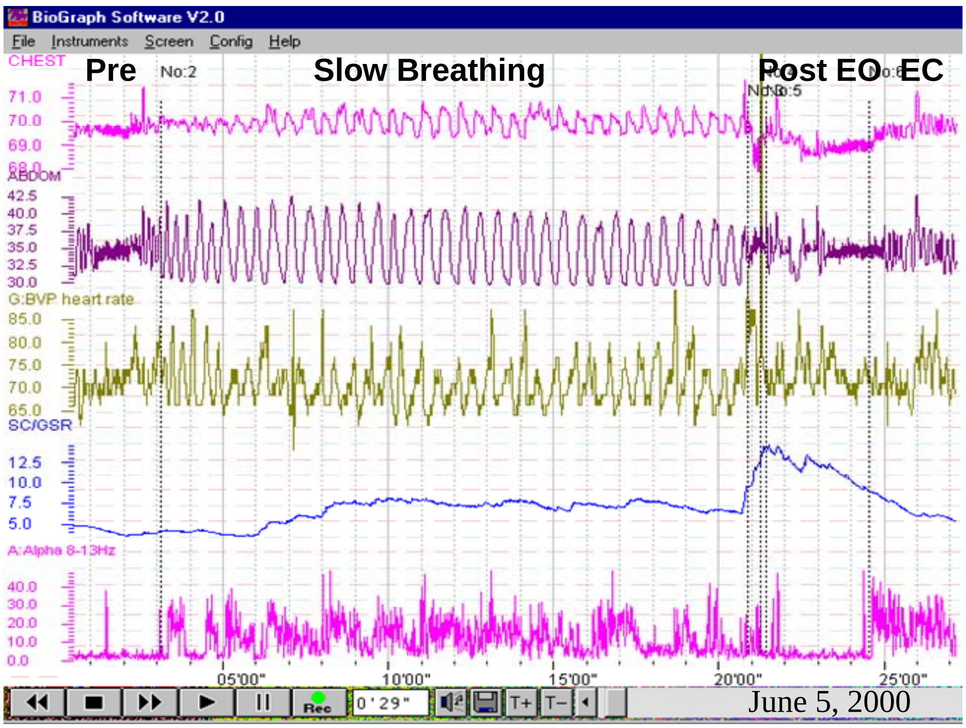

Figure 2. Physiological recording of Pre (baseline), Slow Breathing, Post (baseline) EO (Eyes open) and EC (Eyes closed). During the slow breathing the subject's mean breathing rate was 1.9 Brpm and there was a large change in abdominal strain gauge measures. The major orienting response occurred when he shifted from slow breathing to eyes open post-baseline condition as shown by the rapid increase of skin conductance.

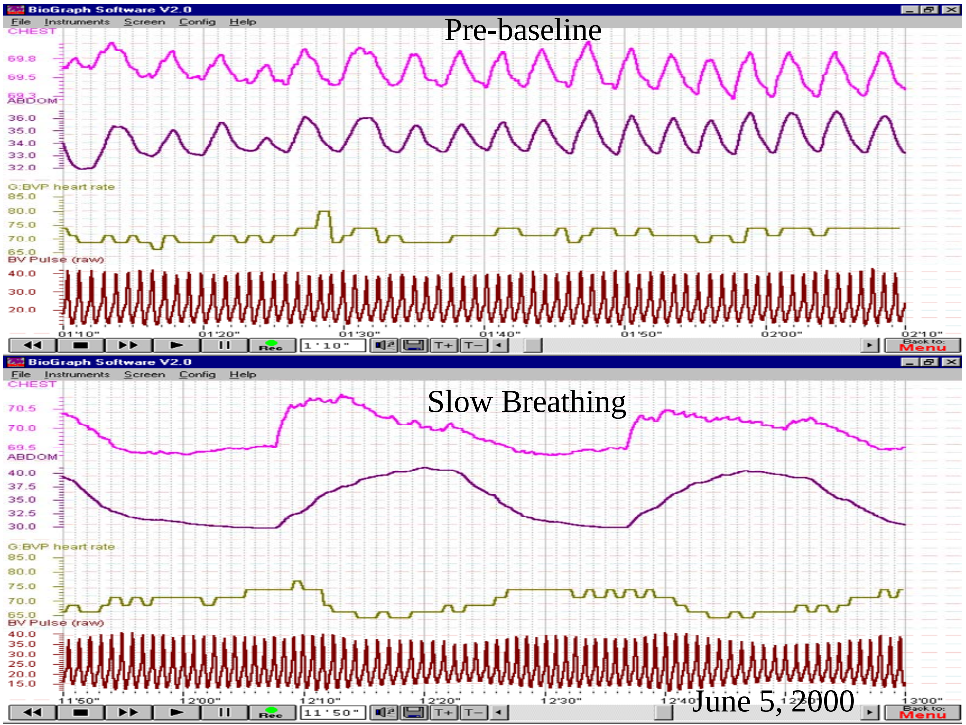

Figure 3. Representative 1 minute recordings of respiration, BVP and heart rate during pre-baseline and slow breathing conditions.

There was an increase in mean amplitude alpha EEG activity and a trend toward increased theta activity during the slow breathing condition, which was similar to the eyes closed post-baseline. There was no increase in Delta activity as shown in Figures 4.

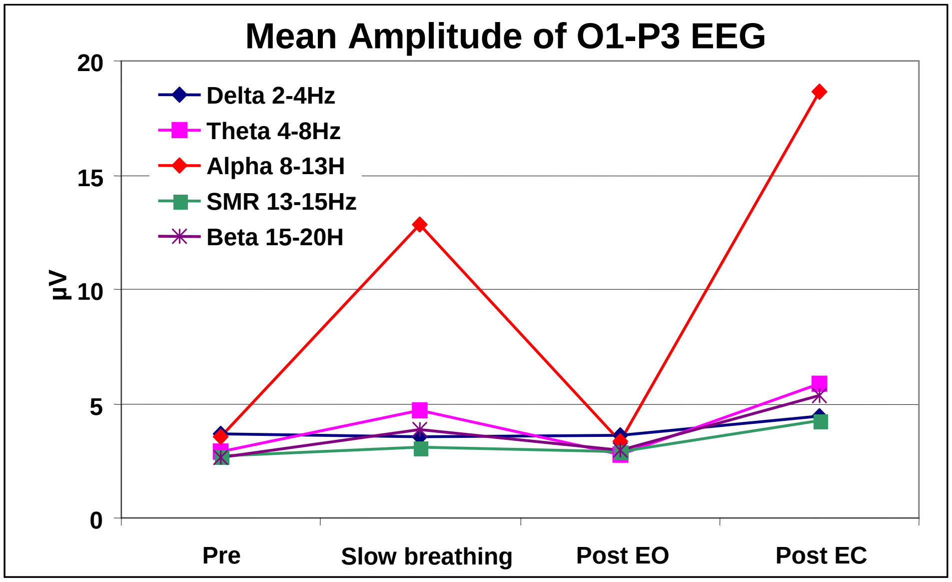

Figure 4. Mean amplitude of beta, SMR, alpha, theta and delta O1-P3 EEG across all conditions.

There was no significant change in average SpO_2 saturation from pre-baseline (95.2%; SD 0.4%), to the slow breathing condition (95.1%; SD 1.8%), to eyes open and closed post-baselines (95.6%; SD 1.0%). There was a significant increase in $ETCO_2$ (P=0.001) from pre-baseline (37.8 mm Hg; SD 1.0) to the slow breathing condition (43.7 mm Hg; SD 4.1) to eyes open and closed post-baselines (36.3 mm Hg; SD 2.0) as shown in Figure 5.

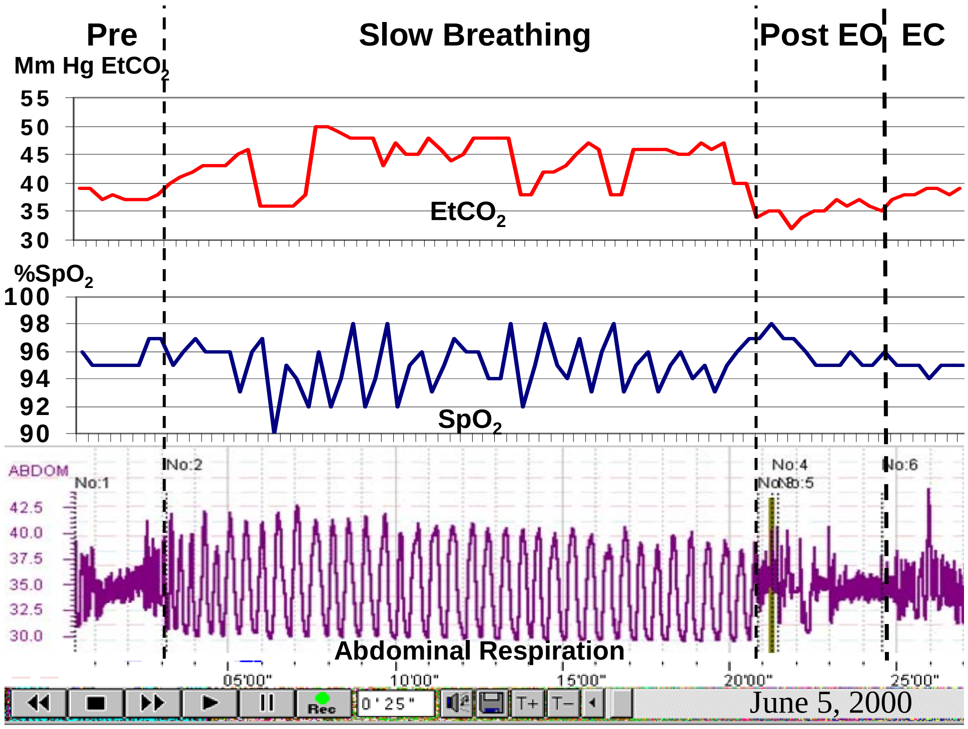

Figure 5. Abdominal respiration, $ETCO_2$ and SpO_2. Note the increase in $ETCO_2$ during the slow breathing condition.

The subject reported that slow breathing at about two breaths per minute was effortless and that he could have continued breathing at this slow rate for much longer. He reported that the sensations of his hands disappeared and that outside noises at times interfered with his mental focus.

Discussion

This study demonstrated that an experienced yogi could voluntarily lower and maintain his respiration rate to approximately 2 Brpm with minimal changes to other physiological processes. Although there was a significant increase in $ETCO_2$ during the slow breathing condition as compared to the pre- and post-baseline conditions, the mean ETC O_2 was within the normal range (Landis & Romano, 1998). The mean SpO_2 was not significantly different from the pre- and post-baseline conditions and was, also, within normal range. To maintain sufficient oxygenation level, he increased the volume of each individual breath as indicated by strain gauge recordings that may account for the absence of changes in his SPO_2 or heart rate. He breathed at approximately two breaths per minute without increasing his overall central nervous system arousal as indicated by the presence of alpha EEG while maintaining a passive attentional state.

There was a significant increase in occipital parietal alpha activity by the subject during the slow breathing condition. However, the increase in alpha EEG was similar to the eyes closed post-baseline condition. Most likely, the increase in alpha EEG during slow breathing was due to his eye closure. Nevertheless, the predominant alpha activity, consistent with many other reports on the physiological correlates of meditation and yoga, implies that he was not distracted from his internal focus nor was he activated by thoughts or external stimuli. Possibly the slight increase in SCL without having any spontaneous large responses again supports the yogic beliefs that breath control minimizes reactivity to stressors. At the same time, there was no increase in Delta EEG activity that would have indicated increased sleepiness or anoxia. Consequently, this supports the concept that if subjects are highly skilled, they can voluntarily alter their physiological systems through conscious control.

The subject demonstrated that he could breathe continuously and effortlessly at about 2 Brpm without compromising oxygen saturation. The slow breathing rate was significantly less than his normal rate during all baseline conditions. It was also significantly different from his breathing rate and respiratory sinus arrhythmia (RSA) reported in a previous study (Arambula, Peper, Kawakami, & Gibney, 2001). In that earlier study he breathed at about 6 Brpm during meditation with spontaneous phase-locked RSA as shown in Figure 6.

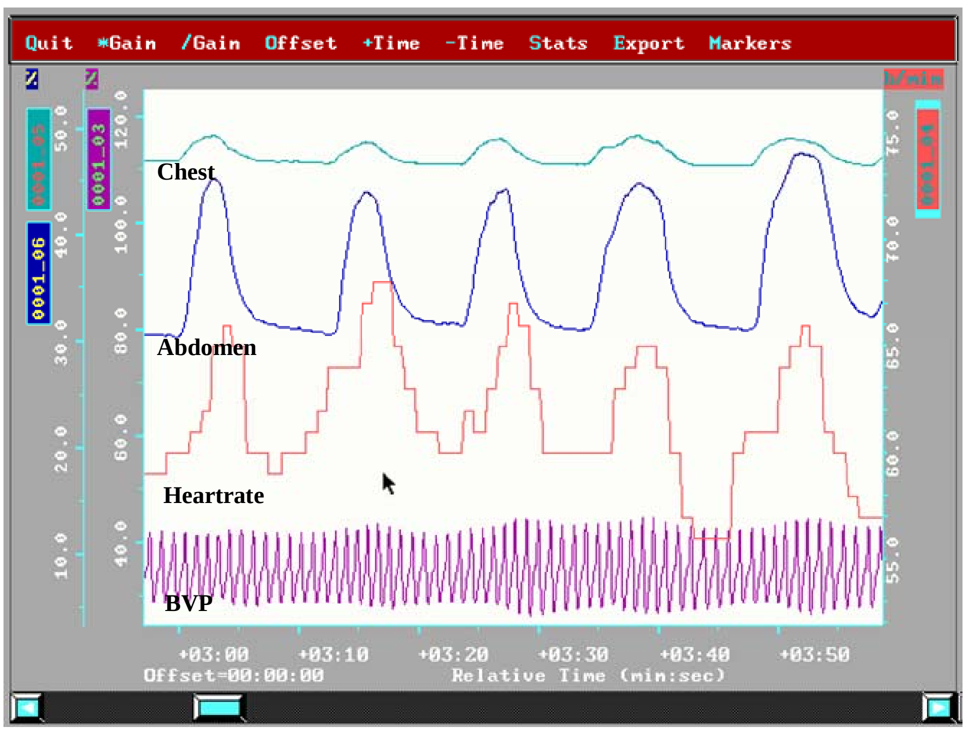

Figure 6. Representative 1 minute physiological recording during the subject's normal meditation. In this previous study, he breathed spontaneously at about 6 Brpm with a significantly increased phase-locked RSA (From: Arambula, Peper, Kawakami & Gibney, 2001).

Yoga masters report that voluntary control over breathing provides them with evidence of internal mastery, which is integral to meditation. The mental process focuses upon control of the three phases of breathing: inhaling and exhaling through the nose, and holding the breath. We propose that through breath control, individuals may experience a shift in beliefs and understanding of the fundamental mind-body interconnectedness. This shift in belief give the person a deep sense of confidence that many things are possible, even though the culture may imply otherwise. The subject's slowing of the respiratory rate through voluntary control resulted in quieting of the mind and emotions as indicated by the continued alpha EEG and absence of spontaneous skin conductance responses. In this process of breath control, the person learns to inhibit automatic reactions to internal and external stimuli. He can observe and evaluate the appropriateness of a reaction before responding, thereby increasing control. Having the ability to be an observer and/or to maintain passive awareness has implications for health and well-being, since it appears to act as a global desensitization process that inhibits escalating arousal triggered by thoughts and emotions.

According to Yogic traditions, control of breath is indispensable in deepening one's consciousness and health. It is an approach to meditation, a path towards enlightenment, and an effective process for cultivating intuition, contemplation and creativity (Green & Green, 1977). Breathing is one of the bridges between the mind/body and the physiological mechanism by which the meditative experience can be taught and integrated into daily life. Consequently, slow breathing helps to encourage a regenerative state. We suggest that systematic studies be conducted on training patients in slow breathing as complementary treatment strategies for conditions such as asthma, panic, hypertension, coronary heart disease and stress-related disorders.

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