Applied Psychophysiology and Biofeedback, Vol. 26, No. 2, 2001

The Physiological Correlates of Kundalini Yoga Meditation: A Study of a Yoga Master

Pete Arambula,[1,2] Erik Peper,[1] Mitsumasa Kawakami,[1] and Katherine Hughes Gibney[1]

This study explores the physiological correlates of a highly practiced Kundalini Yoga meditator. Thoracic and abdominal breathing patterns, heart rate (HR), occipital parietal electroencephalograph (EEG), skin conductance level (SCL), and blood volume pulse (BVP) were monitored during prebaseline, meditation, and postbaseline periods. Visual analyses of the data showed a decrease in respiration rate during the meditation from a mean of 11 breaths/min for the pre- and 13 breaths/min for the postbaseline to a mean of 5 breaths/min during the meditation, with a predominance of abdominal/diaphragmatic breathing. There was also more alpha EEG activity during the meditation ($M = 1.71\ \mu V$) compared to the pre- ($M = .47\ \mu V$) and postbaseline ($M = .78\ \mu V$) periods, and an increase in theta EEG activity immediately following the meditation ($M = .62\ \mu V$) compared to the pre-baseline and meditative periods (each with $M = .26\ \mu V$). These findings suggest that a shift in breathing patterns may contribute to the development of alpha EEG, and those patterns need to be investigated further.

KEY WORDS: meditation; EEG; alpha; respiration; breathing.

Previous studies of the physiological correlates of meditation have been reported, although most have focused only on transcendental meditation (Corby, Roth, Zarcone Jr, & Kopell, 1978; Cusumano & Robinson, 1992; Delmonte, 1984a, 1984b; Dostalek, Faber, Krasa, & Vele, 1979; Jevning, Wallace, & Beidebach, 1992; Morse, Cohen, Furst, & Martin, 1984; Sawada & Steptoe, 1988; Stewart, 1974; Sudsuang, Chenttanez, & Veluvan, 1991; Telles, Narendran, Raghuraj, Nagarathna, & Nagendra, 1997; Travis & Wallace, 1997; Wood, 1986; Woolfolk, 1975). Only a small number centered on yogic practices, and even fewer studied individuals considered expert meditators. Because experts in yoga meditation are rarely available to researchers the subjects of such inquiries usually have practiced only a few years. For example, Becker and Shapiro (1981) and Corby et al. (1978) report on groups of "experts" who had a mean of only 4–5 years of yogic meditation practice.

[1]San Francisco State University, California.
[2]Address all correspondence to Pete Arambula, 4039 East Hayhurst Lane, Tucson, AZ 85712; email: petearambula@earthlink.net.

1090-0586/01/0600-0147$19.50/0

Research data indicate that there are varying physiological correlates associated with meditation. Some studies, for example, show increased alpha or theta electroencephalograph (EEG) activity (Becker & Shapiro, 1981; Dostalek et al., 1979; Herbert & Lehmann, 1977; Kasamatsu, Okuma, & Takenaka, 1957), whereas others show more beta or even some delta EEG present (Anad, China, & Singh, 1961; Das & Gastaut, 1957). Some studies show a decrease in heart rate (HR) and respiration rate (Bagchi & Wegner, 1957; Wegner & Bagchi, 1961), whereas others show increases or no change in these measures (Anad et al., 1961; Corby et al., 1978; Cusumano & Robinson, 1992; Dicarlo, Sparling, Hinson, Snow, & Rosskopf, 1994). Similarly, there are paradoxical data on skin conductance level (SCL); some report an increase in skin conductance (Bagchi & Wegner, 1957; Corby et al., 1978), whereas others report decreases (Jevning et al., 1992).

The dissimilarities between studies on the physiological correlates of yoga may be due to the variability of yoga practices as well as methodological flaws (Woolfolk, 1975). Woolfolk also suggests that a lack in experience of those being studied may play a role in the contradictory findings. This notion that experience may play a role in the findings in research of yoga meditation is supported by Delmonte (1984a), who found in his review of two longitudinal designs that subjects showed significant changes in alpha EEG activity only after longer periods of practicing meditation (Glueck & Stroebel, 1975; Vassiliadis, 1973). Telles et al. (1997) found significant respiratory changes in girls at a community home only after 6 months of yoga practice. These observations support the hypothesis that experience may play a role in the physiological correlates of yoga meditation. Hence, more research with individuals who are highly experienced in meditation is needed. This study is an investigation into the physiological correlates of a well-trained Kundalini Yoga meditator.

METHODS

Subject

The subject is a male, 59 years old, Japanese Yogi with 32 years of experience practicing various forms of yoga. He is the founder and Chief Executive Director of his own school of yoga and Institute for Research of Subconscious Psychology in Fukuoko and Tokyo, Japan. The title of Yoga Samrat was bestowed upon him by the Indian Yoga Culture Federation in 1983, after demonstrating that he had reached the highest level of proficiency in his discipline. He came to the United States to participate in this research project as part of his growing interest and contribution to scientific inquiries into meditation. He used a form of Kundalini Yoga meditation for this study.

Equipment

Physiological data were collected with a FlexComp (Thought Technology, Ltd.). Abdominal and thoracic respiration patterns were recorded with strain gauges. The abdominal strain gauge was placed at the level of the umbilicus and the thoracic strain gauge was placed just below the axilla. Bipolar EEG was recorded with silver–silver chloride electrodes from occipital (O2) and parietal (P4) areas; reference was attached to the right earlobe. The EEG signal was filtered for alpha (7–13Hz) and theta (3–7Hz). Blood volume pulse (BVP) was recorded with a photoplethysmograph from the distal phalange of the right thumb. Heart rate was derived from the BVP signal.

Procedures

The subject changed into loose fitting clothing, which he uses for meditation. Sensors were then attached. While under continuous observation by a number of onlookers, he sat on a padded massage table in shidda asana (a position similar to half lotus), with eyes closed while the equipment was calibrated (the duration of this period was approximately 10 min). He then continued sitting quietly with eyes closed for a 3-min prebaseline recording. This was followed by 15 min of eyes-closed meditation, and a 3-min postbaseline period also with eyes shut.

Data Analyses

The data were visually analyzed using means from 30-s intervals of the physiological recordings.

RESULTS

There was a noticeable decrease in respiration rate during the meditation ($M = 5$) when compared to the pre- ($M = 11$ *breaths/min*) and post-baseline periods ($M = 13$ *breaths/min*), as seen in Fig. 1. The subject's abdominal breathing pattern became more pronounced during meditation. There was an increase in abdominal over thoracic breathing during meditation when compared to pre- and postbaseline periods (see Fig. 2). There was also enhanced alpha EEG activity during meditation ($M = 1.71\ \mu$V) when compared to the pre- ($M = .47\ \mu$V) and postbaselines ($M = .78\ \mu$V), and more theta EEG activity following the meditation ($M = .62\ \mu$V) when compared to the prebaseline and meditation (each with $M = .51\ \mu$V), as shown in Fig. 3. The subject reported that, when instructed to do so, he quickly entered a meditative state and remained in this state during the entire 15-min recording. There did not appear to be any notable changes in HR or BVP; therefore these data are not presented.

DISCUSSION

The decrease in respiration from 11 (prebaseline) and 13 (postbaseline) to 5 breaths/min, with continued slow breathing at 5 breaths/min during the meditation period, demonstrates significant meditative control and experience by this Yogi. It suggests a decrease in arousal that appears consistent with other findings on the physiological correlates of meditation that show a decrease in respiration. Although previous studies have reported a decrease in breathing rate, the pattern of breathing is not usually noted. In this subject there was a consistent increase in abdominal over thoracic breathing seen during the meditation period. Abdominal/diaphragmatic breathing seems to be an integral part of many relaxation techniques. Because of this, a closer examination of abdominal breathing patterns of well-trained

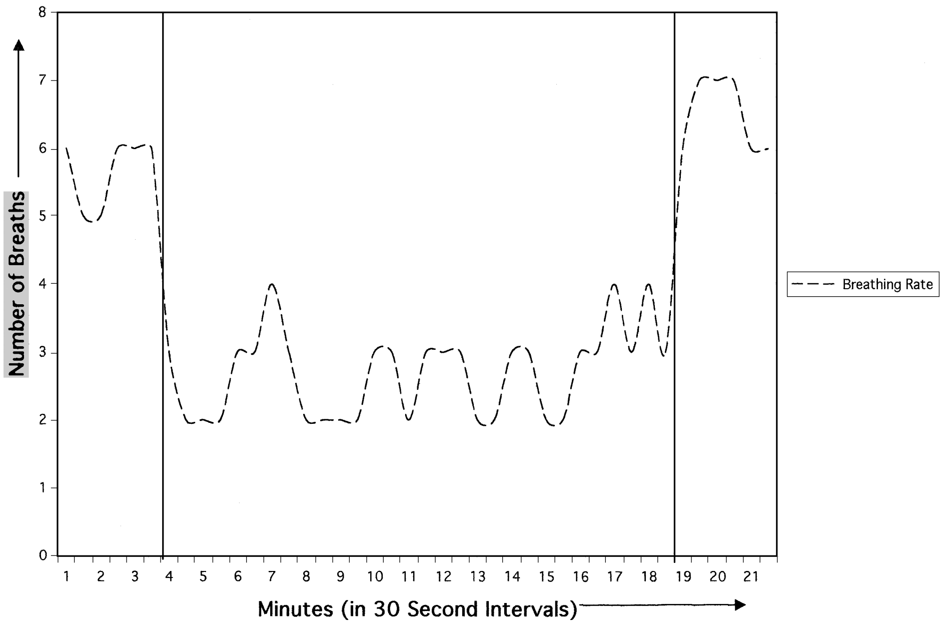

Fig. 1. Number of breaths per 30-s intervals during the pre-, meditative, and post-baseline periods.

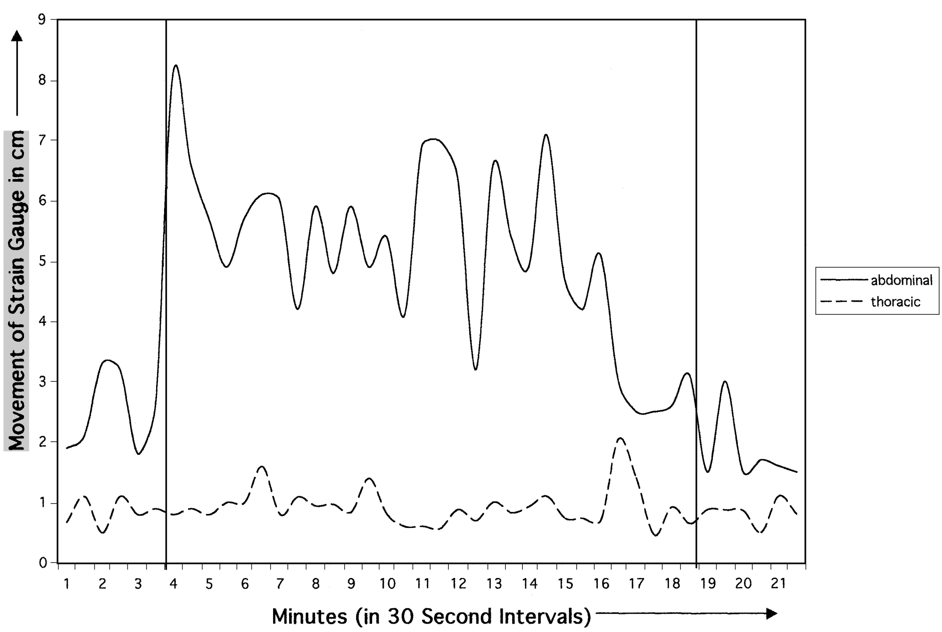

Fig. 2. Abdominal vs. Thoracic breathing patterns per 30-s intervals during the pre-, meditative, and post-baseline periods.

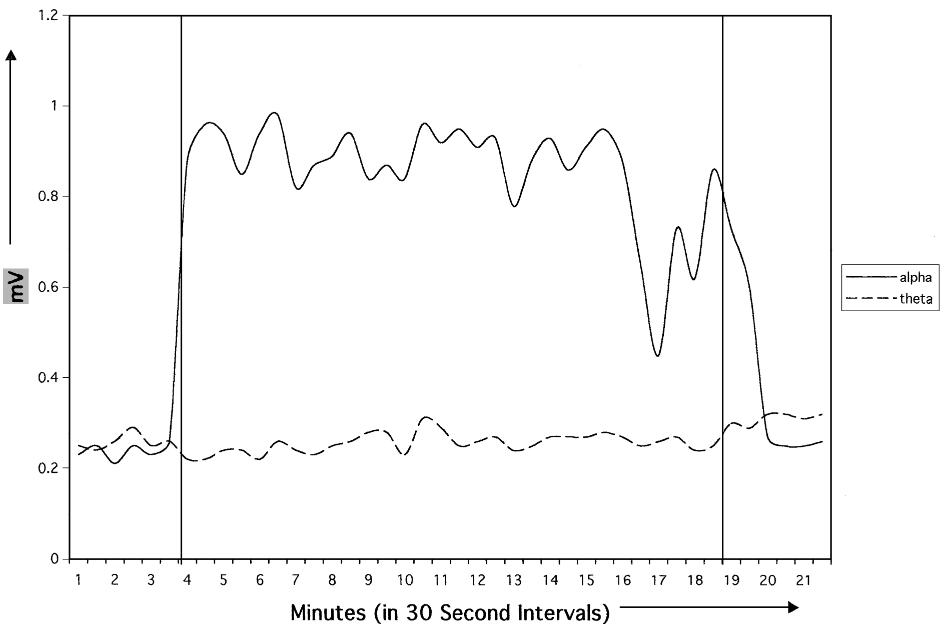

Fig. 3. Alpha and Theta EEG activity per 30-s intervals during the pre-, meditative, and post-baseline periods.

practitioners of meditation may reveal important findings. Researchers may discover, for example, that breathing plays a much more pivotal role in acquiring and maintaining a meditative state than previously thought.

There appears to be a significant increase in alpha wave production by the Yogi when he entered his meditative state, which was closely associated with the slower abdominal breathing discussed above. This production of alpha EEG is consistent with many other findings on the physiological correlates of meditation and yoga (Anad et al., 1961; Corby et al., 1978; Delmonte, 1984a; Dostalek et al., 1979; Kamatsu et al., 1957; Woolfolk, 1975). However, none have discussed the possible influence of respiration on alpha EEG production. The correlation between deep, slow, abdominal breathing and alpha EEG production suggests that this type of breathing pattern may contribute to the increase in alpha EEG as proposed by Fried (1987). A measure of metabolic rate and PCO_2 may help further our understanding of physiological processes during meditation. These findings further suggest that respiration may play an integral role in acquiring and maintaining a meditative state.

An increase in theta activity immediately following the meditation also seemed apparent in this case study. Although there are studies reporting some theta activity during meditation (Corby et al., 1978; Herbert & Lehmann, 1977; Jevning et al., 1992), there are no studies reporting on this kind of activity following a period of meditation. Because theta can be associated with pleasure, it is not surprising that it was recorded following an activity for which the subject has many years experience. One would expect an individual to continue practicing meditation for such a long period of time only if it were enjoyable to him or her.

Many of the findings here are similar to those in previous reports on the physiological correlates of meditation and yoga (Jevning et al., 1992; Morse et al., 1984; Delmonte, 1984a; Woolfolk, 1975). The uniqueness of this investigation is in the level and expertise of the subject that was studied. Examining such individuals may help to better identify the physiological correlates, and benefits of the exercise by revealing development that takes place only after achieving a high level of proficiency. This may help explain the contradictory findings surrounding the physiological correlates of meditation by creating a more accurate and complete picture of physiology during meditative practices.

Although respiration patterns have often been associated with meditation, few studies report on this data. The finding that a subject can breathe continuously at about 5 breaths/min without experiencing any air hunger or excessive arousal, with a concurrent increase in occipital alpha EEG activity, demonstrates the meditative skills of the subject. Breathing may also be one of the physiological mechanisms by which the meditation experience can easily be integrated and anchored into daily life. By refocusing on breathing during the day, the meditative state may be reestablished. Further studies comparing advanced practitioners of yoga to those who are less proficient would be desirable, as would research on larger groups of expert practitioners so that meaningful statistical analyses could be done.

REFERENCES

Anad, B. K., China, G. S., & Singh, B. (1961). Some aspects of electroencephalographic studies in yoga. *Electroencephalography and Clinical Neurophysiology, 13,* 452–456.

Bagchi, B. K., & Wegner, M. A. (1957). Electrophysiological correlates of some yogi exercises. *Electroencephalography and Clinical Neurophysiology, 7,* 132–149.

Becker, D. E., & Shapiro, D. (1981). Physiological responses to clicks during zen, yoga, and TM meditation. *Psychophysiology, 18*(6), 694–699.

Corby, J. C., Roth, W. T., Zarcone Jr, V. P., & Kopell, B. S. (1978). Psychophysiological correlates of tantric yoga meditation. *Archives of General Psychiatry, 35,* 571–577.

Cusumano, J. A., & Robinson, S. E. (1992). The short term psychophysiological effects of hatha yoga and progressive relaxation on female Japanese students. *Applied Psychology: An International Review, 42*(1), 77–90.

Das, N. N., & Gastaut, H. (1957). Variations de l'activite electrique du cerveau du coeur et des muscles quelletiques au cours de la meditation et de l'extase yogique. *Electroencephalgraphy and Clinical Neurophysiology, 6,* 211–219.

Delmonte, M. M. (1984a). Electrocortical activity and related phenomena associated with meditation practice: A literature Review. *International Journal of Neurosciences, 24,* 217–231.

Delmonte, M. M. (1984b). Physiological concomitants of meditation practice. *International Journal of Psychosomatics, 31*(4), 23–26.

DiCarlo, L. J., Sparling, P. B., Hinson, B. T., Snow, T. K., & Rosskopf, L. B. (1994). Cardiovascular, metabolic, and perceptual responses to hatha yoga standing poses. *Medicine Exercise Nutrition Health, 4,* 107–112.

Dostalek, C., Faber, J., Krasa, H., & Vele, F. (1979). Meditational yoga exercises in EEG and EMG. *Ceskoslovenska Psychologie, 23*(1), 61–65.

Fried, R. (1987). *The hyperventilation syndrome: Research and clinical treatment*. Baltimore and London: The John Hopkins University Press.

Glueck, B., & Stroebel, C. (1975). Biofeedback and meditation in the treatment of psychiatric illnesses. *Comprehensive Psychiatry, 16,* 303–321.

Hebert, R., & Lehmann, D. (1977). Theta bursts: An EEG pattern in normal subjects practicing the transcendental meditation technique. *Electroencephalgraphy and Clinical Neurophysiology, 42,* 397–405.

Jevning, R., Wallace, R. K., & Beidebach, M. (1992). The physiology of meditation: A review. A wakeful Hypometabolic integrated response. *Neuroscience and Biobehavioral Reviews, 16,* 415–424.

Kasamatsu, A., Okuma, T., & Takenaka, S. (1957). The EEG of zen and yoga practitioners. *Electroencephalography and Clinical Neurophysiology, 9,* 51–52.

Morse, D. R., Cohen, L. C., Furst, M. L., & Martin, J. S. (1984). A physiological evaluation of the yoga concept of respiratory control of autonomic nervous system activity. *International Journal of Neurosciences, 31,* 3–19.

Sawada, Y., & Steptoe, A. (1988). The effects of brief meditation training on cardiovascular stress responses. *Journal of Psychophysiology, 24,* 249–257.

Stewart, R. A. C. (1974). States of human realization: Some physiological and psychological correlates. *Psychologia*, *17,* 126–134.

Sudsuang, R., Chenttanez, V., & Veluvan, K. (1991). Effect of Buddhist meditation on serum cortisol and total protein levels, blood pressure, pulse rate, lung volume, and reaction time. *Physiology and Behavior*, *50,* 543–548.

Telles, S., Narendran, S., Raghuraj, P., Nagarathna, R., & Nagendra, H. R. (1997). Comparison of changes in autonomic and respiratory parameters of girls after yoga and games at a community home. *Perceptual and Motor Skills*, *84,* 251–257.

Travis, F., & Wallace, R. K. (1997). Autonomic patterns during respiratory suspensions: Possible markers of transcendental markers. *Psychophysiology*, *34,* 39–46.

Vassiliadis (1973). *Longitudinal and physiological changes of TM practice*. Paper presented at APA convention, Montreal.

Wegner, M. A. & Bagchi, B. K. (1961). Studies of autonomic functions in practitioners of yoga in India. *Behavioral Science*, *6,* 312–323.

Wood, C. J. (1986). Evaluation of meditation and relaxation on physiological response during the performance of fine motor and gross motor tasks. *Perceptual and Motor Skills*, *62,* 91–98.

Woolfolk, R. L. (1975). Psychophysiological correlates of meditation. *Archives of General Psychiatry*, *32,* 1326–1333.