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DECREASE IN SERUM CORTISOL DURING YOGA EXERCISE IS CORRELATED WITH ALPHA WAVE ACTIVATION[1,2]

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Summary.—We examined changes in brain waves and blood levels of serum cortisol during yoga exercise in 7 yoga instructors and found that alpha waves increased and serum cortisol decreased. These two measures were negatively correlated ($r = -.83$). Comparison with a control group of nonpractitioners is desirable.

Through the course of history, human beings have come to recognize there is a connection between the mind and body. In recent years, several reports have suggested the existence of a regulatory mechanism within the immune system modulated by the psychoneurosystem (1, 7).

In terms of research done on yoga, physiological (2, 4, 36), and psychophysiological studies (29, 33) have investigated respiratory, circulatory, and metabolic systems. In addition, physiological studies investigating the meditative state achieved by people during yoga (30, 32, 34, 35) have been reported. Yoga has also been shown to have medical effects in controlling diseases, including diabetes (12, 22), hypertension (19, 20, 28), and asthma (11, 17, 25). The current knowledge concerning medical and physiological changes during yoga exercise can be summarized as follows: stabilization of the autonomic nervous system (parasympathetic dominant) (13), improvement in the thermoregulatory system (5, 6, 9), improved respiratory function (18, 21, 26), improvement in endocrine system function (13, 31), and alpha wave activation (3, 23).

As for endocrine system function, Udupa, *et al.*'s study (31) described a rise in vanillic mandelic acid excretion and a decreased excretion of 17-ketosteroids after six months of yoga exercise. On the other hand, Joseph, *et al.*

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(13) reported an increase in urinary 17-ketosteroids and monoamine oxidase excretion following three months of yoga exercise. In terms of cortisol, a slow decrease in plasma levels of cortisol has been reported after 120 min. of yoga, but the differences here were not significant between a yoga-experienced group and a yoga-inexperienced group (24). In the present study, we have examined serum cortisol levels before and after a 50-min. yoga exercise by proficient yoga instructors. We also studied the relationship between changes in serum levels of cortisol and alpha wave activity.

Method

Subjects were eight yoga instructors (4 men and 4 women). Experiments were performed from 7 a.m. to 4 p.m. in an air-conditioned room. There were 10 minutes of seated rest (rest period). During this rest period, the subjects were asked to keep their eyes open because they tended to go into a meditative state when their eyes were closed. Following the 10-min. rest were 15 min. of physical yoga exercise called Asana, 15 min. of breathing exercise called Pranayama, and then 20 min. of meditation called Soham Meditation.

Throughout rest and yoga, brain waves were continuously recorded via two disc electrodes placed on each subject's forehead (Fp_2), using the biofeedback system (Biofeedback-system produced by FUTEK ELECTRONICS Co. Ltd.), without using phonic signals. It accumulates the measured brain waves at 2-sec. intervals, dividing them into five frequency ranges (3.5–6.5 Hz theta wave, 6.5–8.5 Hz alpha wave, 8.5–11.5 Hz alpha wave, 11.5–13.5 Hz alpha wave, 13.5–30 Hz beta wave), and computes the mean frequency and appearance rate of each range's detected brain waves.

Appearance rate and average amplitude of brain waves of these five ranges in Asana, Pranayama, and Soham Meditation were calculated. For each instructor the activated frequency range(s) among the five ranges were thus obtained.

Via an indwelling heparinized catheter placed approximately 20 minutes before rest, blood samples were drawn before the beginning of Asana and after the end of Soham Meditation. Since the same results are obtained using both serum samples and plasma samples in the measurement of blood cortisol (8), the measure of serum cortisol was used throughout the experiment. The GammaCoat™[^{125}I] Cortisol Radioimmunoassay Kit (37) was used for the quantitation of serum cortisol.

The subjects were instructed to get plenty of sleep, not to drink alcohol during the 24-hr. period prior to the experiment, and not to drink any caffeinated beverages on the day of the experiment.

Results and Discussion

Brain waves at each stage of the yoga exercise (Asana, Pranayama, and

Soham Meditation) were compared statistically with those during the rest period, and the ratio of the appearance of each frequency range of brain waves to a combined total was calculated. As for the activated frequency range(s), percent alpha (8.5–11.5 Hz) time, indicating the appearance rate of alpha (8.5–11.5 Hz) waves, increased in six of the eight subjects. But, for one subject percent alpha (6.5–8.5 Hz) time increased. Furthermore, in the last subject both percent alpha (6.5–8.5 Hz) time and percent theta time increased, so the appearance rates of these two ranges were combined and calculated. Similarly, average amplitudes were combined and calculated. Thus, the appearance rate and average amplitude of their activated frequency range(s) were established for the eight subjects and analyzed together.

Compared to the rest period, the appearance rate of the activated frequency range(s) increased in Asana ($t_7 = -4.29$, $p < .005$), in Pranayama ($t_7 = -6.57$, $p < .0005$), and in Soham Meditation ($t_7 = -9.06$, $p < .0001$). An increase in the average amplitude of the activated frequency range(s) was also observed for Pranayama and for Soham Meditation ((for Asana ($t_7 = -1.87$, $p > .10$), for Pranayama ($t_7 = -3.50$, $p = .01$), for Soham Meditation ($t_7 = -2.38$, $p < .05$)).

During the yoga exercise, mean serum cortisol decreased from 11.69 μg/dl to 9.75 μg/dl ($t_7 = 2.47$, $p < .05$). A negative correlation was observed between ratio of changes in serum cortisol and changes in percent alpha (8.5–11.5 Hz in six subjects, 6.5–8.5 Hz in one subject) time (Fig. 1). Of the 8 subjects studied, one showed an increase in both theta wave and 6.5–8.5 Hz alpha wave, as described above, strongly implying a state of deep drowsiness. Thus, the score for this subject was omitted. No correlation was observed between changes in the average amplitude of the activated frequency range and ratio of changes in serum cortisol. For beta and theta frequency ranges, no correlation between ratio of changes in serum cortisol and both the percent brain wave time and the brain wave amplitude was observed.

Anand, *et al.* described an augmentation in the amplitude of alpha wave activity following yoga exercise (3). Satyanarayana, *et al.* (23) reported that over the course of 30 days of yoga exercise increases in alpha index, percent alpha time, both in occipital and prefrontal lobes were observed bilaterally, suggesting an increase in calmness. Gradual increases of both percent alpha time and alpha wave amplitude in this study agreed with these previous reports.

On the other hand, secretion of cortisol has been considered to be the mechanism underlying the stress-induced suppression of immune function. Some studies have demonstrated that serum cortisol decreased following meditation (15, 16, 27). In addition, increased plasma cortisol has been observed among women who experience an adverse life event, such as the death of a spouse (10). During this study, activation of frontal alpha wave

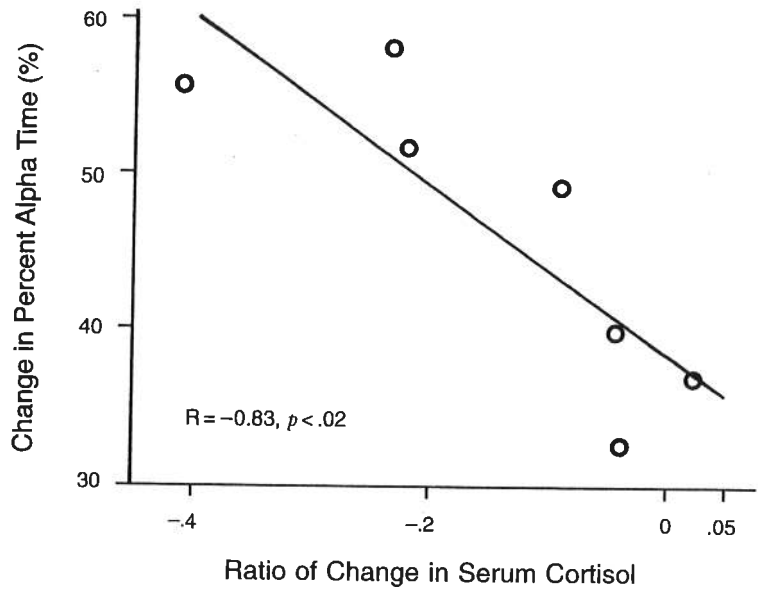

FIG. 1. Scatter plot for the ratio of change in serum cortisol and change in percent alpha time before and after yoga exercise ($N=7$)

implied the subject's mental relaxation and the decrease in serum cortisol indicated physical relaxation, suggesting a more advanced relaxation than usual. Schell, *et al.* (24) also examined the changes in plasma cortisol in a group experienced in practicing yoga (yoga group) and a group without any yoga experience in relaxation exercises (control group) during yoga exercise. The results for both groups showed a slow decrease in plasma cortisol, with cortisol in the yoga group not significantly lower than that of the controls. In the present study, as the subjects were considered to be more proficient yoga instructors, our data showed significantly decreased cortisol.

The observed negative correlation between ratio of changes in serum cortisol and changes in percent alpha time suggests the existence of a psychoneuroendocrine system related to cortisol secretion not only in stress-induced states but also in stress-free states. These two states are considered to be psychologically contrary. Therefore, stress-free states, such as occur during yoga, may be associated with increment in frontal lobe alpha wave activity, probably accompanied by a decrease in serum cortisol. The correlation between the frontal alpha wave activation and the increase of natural killer cell activity using the photic feedback system (38) has been reported, suggesting the activation of immune function with the activation of alpha rhythm (14). Although the relationship between the neuroendocrine system

and neuroimmunomodulation have not been clearly delineated, proficiency in yoga should be beneficial for both mental and physical health. Evaluations should be replicated and include a control group of nonpractitioners to sharpen comparisons of interest.

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