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OBSERVATION OF PHYSIOLOGICAL CHANGES DURING TRANSCENDENTAL MEDITATION

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ABSTRACT-Techniques of yoga have been associated with alterations in physiology, but until recently there has been only haphazard and uncontrolled research. Since 1970, information has been gathered which suggests that the pratice of Transcendental Meditation (TM), a derivative of yoga, significantly affects changes in several phsiological areas. This study observed changes in breath rate and peripheral circulation before, during, and after the practice of TM. Results showed a significant decrease in breath rate and changes in circulation patterns in the hand and forehead of subjects.

For many years the various disciplines collectively called yoga have been understood to be methods of culturing the mind and body to achieve unusual states of refinement. It is commonly believed that during the various activities of yoga an accomplished practitioner can bring about voluntary control of otherwise involuntary-governed physiological parameters such as blood pressure level and heart and breath rates.

Wallace (1970) claimed that the mental state of deep rest which is experienced during transcendental meditation (tm) is so natural that it may represent an actual "fourth major state of consciousness" as different from the other three (walking, deep sleep, and dreaming) as each of them is different from the others.

Such a claim, deserves further inquiry. Several authors since Wallace have corroborated many of his findings. The research and to clarify the effect of TM on breathing and circulation.

Since the pioneering work of Brosse (1946) and Das and Gestaut (1955), there has been a rapidly increasing volume of evidence for consistent and significant physiological changes brought about by various meditation techniques. As Wallace (1970) has pointed out, however, "the problem of selection of subjects and of measuring subjects in a conventional and consistent manner is a problem which is found in most of the research on yoga". Wallace cited inconsistent results from the various early studies of O_2 consumption, as examples. Wallace's solution was to use the meditator as his own control. That procedure has since been followed by others.

Wallace's model included a 20 minute precontrol period of TM, and a 20 minute post-control period immediately following the TM. In all his work Wallace tested the difference between means of precontrol, TM and postcontrol periods using a simple t-test for significance.

Past studies of respiration

Wallace (1970), Allison (1970), Wallace, Benson and Wilson (1971) all have reported decreased O_2 consumption and decreased mean respiratory rate in studies of practitioners of TM.

Wallace found mean breath rate falling during the precontrol period from 14 breaths per minute to 13, and then during the meditation period to 10 breaths per minute. The mean breath rate remained low, at 11 breaths per minute, for 20 minutes after the meditation period.

Using thermistors suspended in front of the nostrils and mouth of a single subject, Allison found that the respiration rate was reduced and mean thermistor temperature increased during TM. He took the higher mean thermistor temperature to indicate that the volume of air passing over the thermistor had decreased; i.e., the volume of air breathed also was reduced.

Allison pointed out in his study that there is no sign of compensatory overbreathing after the meditation period. In situations where a rate decrease occured during the meditation period, no overbreathing was noted afterward, leading to the conclusion that there was "no significant CO_2 buildup."

In a study of thirty-six subjects, Wallace, Benson, and Wilson (1971) reported a decrease in mean respiration rate from 13 breaths per minute during the precontrol to 11 per minute during TM. The rate remained low at 11 breaths per minute after the meditation period.

In accordance with Allison's findings, Wallace, Benson and Wilson found the "P_{CO_2} and P_{O_2} showed no consistent or significant changes during mediatation."

Routt (1973) found that the practitioners of TM exhibit a consistently lower breath rate outside the period of meditation than do non-meditators.

Perhaps the most significant of the findings made by Wallace's orginal study is that of substantially lowered O_2 consumption. He noted a 16 percent decrease in O_2 uptake during TM from a precontrol mean of 247.9 cc per minute to a mid-meditation mean of 212.9 cc per minute. In the same study, Wallace found cardiac output to be decreased during TM by approxiamately 25 per cent. He attributed that decrease to the drop in O_2 consumption.

Study of vascular changes

Rieckert (1967), in a study involving concentration exercises (autogenic training) and TM, discovered that fingertip circulation (mainly of the skin) increased significantly during concentration whereas that of the forearm increased only slightly. TM subjects, by contrast, exhibited a threefold increase in forearm circulation with an accompanying slight decrease in fingertip circulation.

Rieckert's study used a fluid-mechanical plethysmograph

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which measured gradual changes in volume within cuffs applied to finger and forearm. There were 17 concentration subjects and three TM subjects.

Wallace and Benson noted a similar, though markedly lesser increase (32 per cent) in blood flow to the forearm.

Primarily because of indications that metabolic rate is lowered by various forms of meditation, several authors have brought the autonomic nervous system into the picture (Anand, Chhina, and Singh, 1961; Wallace and Benson; and Orme-Johnson, 1973).

Specifically, they noted, lowered oxygen consumption and vascular redistribution are normally under autonomic control.

Using the plethysmograph, the pulse rate and surface capillary blood volume of the fingertip and forehead were thus continuously read and recorded.

Plethysmograph ·nsors used were fabricated from a standard type 222 self-focusing light source and either a Clairex CL903L (forehead sensor) or CL3 (fingertip sensor) cadium selenide photocell with peak spectral response in the 7350 A (red) range.

On all subjects, a plethysmograph sensor was placed on the middle finger of the right hand. In nine cases, a second sensor was attached to the forehead.

With a polar planimeter (decribed by Davis and Foote, 1940), the area of each five-minute segment of the test period was read amd recorded. This area corresponded to the total volume of blood flowing into the range of the sensor, and served as a numerical means of comparing precontrol, TM and postcontrol periods.

Respiration rate decreased

In preliminary tests, both random and fixed location sampling of two from every five minutes, produced statistically unreliable results. It was decided that the breath rate during each single minutes on all traces, a mean was calculated for the entire group during each complete period (precontrol, TM, and postcontrol). Between precontrol and TM periods, the decrease in mean breath rate for the entire group was 2.2 breaths per minute. Between TM and postcontrol periods, the mean rate showed only a slight increase of 0.3 breaths per minute (Figure 3).

With a polar planimeter, the area (square inches) of each five minute segment of all plethysmograms was determined. A group mean from all segments in each test period was then derived. Comparison of those means is made in TableI.

Table I. Main areas of five-minute plethysmogram segements from three test periods. Values correspond to blood volume in areas designated.

Precontrol mean---3.35	sq. inches
TM mean------------2.89	sq. inches
Postcontrol mean-2.70	sq. inches
RIGHT MIDDLE FINGERTIP	
Precontrol mean---2.05	sq. inches
TM mean------------2.26	sq. inches
Postcontrol mean-2.51	sq. inches

FOREHEAD

Plethysmograns form the forehead showed very little short-term fluctuation in amplitude but exhibited a gradual increase in amplitude throughout the meditation period and beyond.

Fingertip plethysmograms, however, in addition to decreasing gradually in overall amplitude throughout meditation and postcontrol periods, showed increasingly freguent and intense short segments of strongly reduced amplitude during meditation. At some points, especially in late meditation, pulse volume actually appeared to appraoch zero (Figure4).

Thought they did not disappear in the postcontrol period, such patterns decrease in frequency, especially after the subjects eyes were opened.

Respiratory and vascular changes were simultaneously and continuously recorded electro-mechanically on heat-sensitive paper traveling at a rate of 0.5 mm per second.

There were 14 subjects in this study, each being examined from one to four times. Subjects were numbered 100, 200, 300, etc., and each recorded session was numbered consecutively for each subject. Thus, for example, 501 indicated the first examination of the subject numbered 500, 603 the third examination of subject 600, and so on.

Those participanting in the study did so voluntarily. All had undergone the formal training to become practitioners of TM, and their experience ranged from six weeks to four-and-one-half years.

The test period for each session followed the model set up by Wallace as explained above, although precontrol and postcontrol periods were reduced from 20 to ten minutes each.

Upon entering the room, a subject was asked to be seated. Recording equipment was prepared and attached, requiring about 10 minutes, and the subject was asked to remain seated comfortably with eyes open and to wait further instructions (Figure 1.). After five minutes, the subject was instructed to close his eyes, but to not meditate until he was told. After five minutes, he was told, "You may begin to meditate."

After 20 minutes of meditation, the subject was asked to end the meditation according to instructions given by his TM teacher, but to remain seated. After ten minutes more, the subject was allowed to leave the room.

A tiny rapid response thermistor was carefully suspended in front of the right nostril of each subject. Signals from the sensor were amplified and recorded along with other traces on a Sanborn Polygraph. Rates were calculated at a later time. A standard t-test was applied to determine the probability that the mean value from one period of the test differed significantly from that of another period. A computer program was used to test each case and to determine the means, t-ratios and p-values.

Vascular changes monitored

Unlike many plethysmorgraph models which require that light be passed through the area being studied, the model used in this work operates by reflected light (Figure 2).

The basic principle and mode of operation are as follows: Light us emitted by a self-focusing bulb and is directed into the skin of the subject. Light from the red portion of the spectrum is reflected, and its intensity is modulated by the amount of blood present. A resistive type photocell located beside the light source responds to fluctuating light intensities, and changes are registered on an amplified Wheatstone bridge. The net result of a continuing trace of those fluctuations is a record of the change in blood volume in the area studied.

Autonomic system implicated

An interesting feature of individual breath rate traces is the frequent occurence of periods of somewhat arhythmic breathing during the first few postmeditative minutes. If earlier cliams in the literature are true regarding autonomic stability, this may represent a period of adjustment of the nervous system immediately after the meditation.

Also, figure 4 indicates a dynamism in capillary blood volume at the surface of the fingertip during TM. As noted earlier, Rieckert (1967) and Wallace and Benson have noted increases in blood flow to the forearm. Rieckert also noted slight decreases as well to the fingertip.

Further research is clearly needed in this area, but it appears that TM may somehow affect control of vasoconstriction/vasodilation in various areas so as to redistribute blood. Since this is normally an autonomic function, such a conjecture would also agree with claims made by previous investigators that the autonomic system is somehow involved in meditation.

One further point is worth noting. There appears to be a correlation between periods of deep sighing and intense restriction of circulation in the fingertip. Whether such correlation has any direct relationship to meditation must remain a matter of conjecture. If there were indeed a relationship, it would serve further to implicate the autonomic system.

References

ALLISON, J. 1970. Respiratory changes during the practice of Transcendental Meditation. Lancet 7651.

ANAND, B. K., G. S. CHHINA, and BALDEV SIGH. 1961. Studies of Shri Ramanand Yogi during his stay in an airtight box. Indian Journal of Medical Research 49.

BEHANON, K. 1937. Yoga, a scientific evaluation. New York, Dover.

BENSON, H. and R.K. WALLACE. 1972. Decreased blood pressure in hypertensive subjects who practiced meditation. Circulation (Supplement II) Nos. 45 and 46.

BROSSE, T. 1946. A psycho-physiological study. Main Currents in Modern Thought. 4.

DAS, N. N., and H. GASTAUT. 1955. Electroencephalography and Clinical Neurophysiology (Supplement 6).

DEVINE, R. E. 1969. Build a psych-analyser. Popular Electronics. 30.

DAVIS, R. E. and F. S. FOOTE. 1940. Surveying, Theory and Practice. New York, McGraw-Hill.

GLUECK, B. 1974. Scientific Evaluation of Transcendental Meditation. Address to Department of Psychiatry, University of Minnesota, April, 1974.

MAHARISHI MAHESH YOGI. 1969. On the Bhagavad-Gita. Baltimore, Penguin Books.

ORME-JOHNSON, D. W. 1973. Automatic Stability and Transcendental Meditation. Psychosomatic Medicine 35.

PITTS, F. N., JR. 1969. The bio-chemistry of anxiety. Scientific American 223.

RIECKERT, H. 1967. Plethsmographische untersuchungen bei konsentrations und meditations ubugen artliche. forsche. Artliche Forsch., 21.

ROUTT, T. J. 1973 Low normal heart and respiratory rates in practitioners of Transcendental Meditation. Huxley College of Environmental Studies, Western Washington State University, Bellingham. Unpublished.

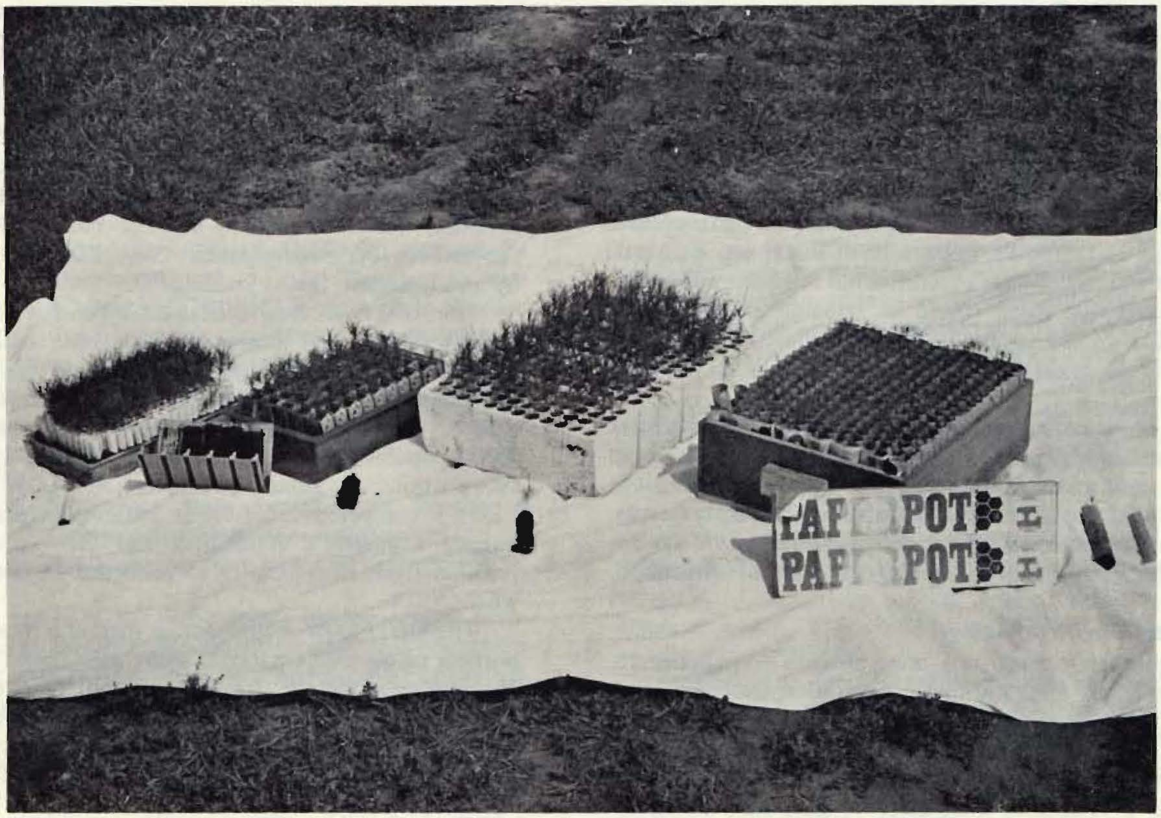
WALLACE, R. K. 1970. The physiological effects of Transcendental Meditation: A proposed fourth major state of consciousness. Ph. D. Thesis. University of California, Los Angeles.

WALLACE, R. K., and H. BENSON. 1972. The physiology of meditation. Scientific American 226.

WALLACE, R. K., and H. BENSON, and A. F. WILSON. 1971. A wakeful hypometabolic phsiological state. American Journal of Physiology 221.

ERRATA

EDITOR'S NOTE: - During the changeover to a new printing arrangement for the JOURNAL, a mishap in handling of a photograph made it impossible to print the picture illustrating different seedling tree planting methods as described in an article by Alvin A. Alm, associate professor at the University of Minnesota Cloquet forestry center. The illustation omitted from the previous JOURNAL issue (Volume 41,1975) is reproduced below.



The figure illustrates containerized seedling systems described in the article "Status of Containerized Forest Seedling Research in Minnesota", which appeared in the 1975 issue of the JOURNAL. From left to right are tubelings, book planters, BC/CFS (British Columbia/Canadian Forest Service) styrofoam blocks, and paper pots. The tubeling (small 3", open-ended plastic tube) system has largely been replaced with the other three. The book planters and BC/CFS styrofoam blocks are essentially "containerless concepts" wherein a soil plug with a growing seedling in it is planted. The paper pot system consists of a flat package which opens in accordian fashion. The individual pots have a double layer of paper bound together with water soluble glue. Upon watering, the glue dissolves, separating the individual pots at time of planting. The paper disintegrates about six months after being planted in the field.