Conflicting reports of cardiac functioning during the Transcendental Meditation (TM) technique have indicated a significant decrease in heart rate (5, 6) as well as no change in heart rate (1, 2) either during TM or compared to simple resting controls. In addition, cardiac output has reportedly decreased 25% during TM (5) and increased 16% (2) during the practice. Forearm blood flow has been found to decrease 9% during simple rest and increase as much as 25% during meditation (4). Jevning et al. (2) recently hypothesized a redistribution of blood flow characterized by the TM-induced hypometabolism.

The purpose of this investigation was to re-examine cardiac parameters during the Transcendental Meditation technique by measuring cardiac output, stroke volume, and heart rate using a noninvasive technique of impedance plethysmography described by Kubicek et al. (3). This was in contrast to earlier procedures which used water plethysmography (4) or catheters and dye (5, 2) which may have interrupted the otherwise natural rest or meditation procedure. By using an impedance technique it was possible to obtain a beat-by-beat assessment of aortic blood flow without anesthetization, and allow the subject to meditate or rest comfortably in a private room.

METHOD

Measures of cardiac functioning of ten subjects who had been practicing Transcendental Meditation in excess of five years was compared with ten non-meditating controls. Mean subject age was 25 years.

During testing each subject was seated comfortably in a private room. Wire connections from the subject in that room to the Biomedical Engineering Laboratory in an adjacent room permitted observation of ongoing cardiac activity without disturbing the subject.

Data collection began with ten minutes of eyes-closed rest for all subjects. Those who practiced TM were then signalled with an auditory click to begin meditating for 20 minutes and then signalled to end with a ten minute posttest rest. Nonmeditators continued resting with eyes closed for the full 40 minutes, but were signalled with an auditory click when the final ten minutes remained.

INSTRUMENTATION

Heart rate was assessed using an electrocardiogram. Cardiac output and stroke volume measurements were made using a Minnesota Impedance Cardiograph unit. This system measured changes in the electrical impedance of the thorax and provided a beat-by-beat indication of changes in blood volume (3). Instantaneous blood flow was then calculated from the impedance signal and used to determine stroke volume and cardiac output. Connection to the subject was provided by four wire mesh band electrodes placed around the subject's neck and...
abdomen. A 100 kHz, 4 mA constant current source was connected to the outside electrode and voltage changes were monitored on the inner electrodes. According to Ohm's Law, the electrical impedance is directly proportional to the measured change in voltage since the current is maintained at a fixed value.

$$\Delta Z = \frac{\Delta V}{I}$$

This relationship leads to an equation derived by Kubicek (3) for determining stroke volume from the measured impedance change:

$$S.V. = \frac{\rho L^2 \Delta Z}{Z_0^2}$$

where
- $\rho$ = electrical resistivity of blood
- $L$ = distance between the inner electrodes
- $Z_0$ = baseline impedance measurement
- $\Delta Z$ = change in impedance

RESULTS

A 2 (groups) × 3 (pre-during-posttreatments) factorial analysis of variance was performed with repeated measures on average percent change every two minutes in heart rate, stroke volume, and cardiac output.

Comparison of pre- and posttreatment means showed a small but significant ($p < .05$) increase of 6% in cardiac output during the practice of the Transcendental Meditation technique. This increase was due to a significant increase of 6% ($p < .05$) in stroke volume from a pretreatment mean value of 75.1 ml/min. There was a nonsignificant increase in heart rate ($p > .05$) of less than 1% from 73.62 beats/min.

Over the comparable 20 minute period in non-meditating controls there was a nonsignificant change of 1% in cardiac output from the initial mean of 5372.56 ml/min. Stroke volume decreased by 3% from a mean of 71.97 ml/min and heart rate increased by 2% from 74.65 beats/min. These changes in cardiac functioning measured in resting controls, although consistent, were not statistically significant ($p > .05$).

In the rest period following 20 minutes of meditation there was a continued significant ($p < .05$) elevation in cardiac output as heart rate further increased by 2% and stroke volume by 4%. A similar finding was noted during the final ten minutes of rest in the control group where heart rate increased an additional 4% and stroke volume increased 2% causing an overall increase in cardiac output.

DISCUSSION

The results of this study, using a noninvasive measurement procedure, support recent findings by Jevning and coworkers (2) who, using a dye dilution method, also found a significant increase in cardiac output during the practice of Transcendental Meditation with no significant change in heart rate. The combined increase in cardiac output and stroke volume during meditation is in contrast to simple eyes-closed rest which resulted in decreased cardiac output and stroke volume. Therefore, it appears that during the unperturbed practice of Transcendental Meditation, the physiological state differs from rest in that TM is characterized by increasing cardiovascular efficiency with a greater volume of blood pumped per heart beat.

REFERENCES

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