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Hemodynamic Changes During Long Meditation

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Changes in heart rate (HR) and blood pressure (BP) in advanced male meditators during 1 hr of meditation were compared with matched control participants resting for 1 hr. Also, changes in HR and BP during 3-hr meditation were analyzed. HR was recorded continuously during meditation ($n = 38$) and the control rest ($n = 21$). BP was measured before and after the meditation ($n = 44$) and the rest ($n = 30$). During the first hour, HR declined more in the meditators than the controls ($p < .01$). Within participant variability of HR was significantly lower during meditation than rest ($p < .05$). In the second hour of meditation, HR declined further ($p = .01$). BP was unaffected by either meditation or rest. In conclusion, meditation reduced the level of HR and within participant variability of HR more than rest. HR continued to decline during the second hour of meditation.

KEY WORDS: blood pressure; heart rate; meditation; relaxation.

INTRODUCTION

High resting heart rate (HR) and blood pressure (BP) are associated with higher risks to both cardiovascular and general health (Kristal-Boneh, Silber, Harari, & Froom, 2000; Morcet, Safar, Thomas, Guize, & Benetos, 1999; Reunanen et al., 2000). HR, in particular, is often regarded as a parameter of stress. Reducing resting HR and BP yield health benefits. Therapeutic attempts to lower HR and BP have been predominantly pharmaceutical (The sixth report of the Joint National Committee, 1997). Although behavioral techniques may also reduce HR and BP, they are used infrequently in clinical practice.

Hemodynamic responses to meditation have been extensively explored (Barnes, Treiber, & Davis, 2001; Barnes, Treiber, Turner, Davis, & Strong, 1999; Delmonte, 1984; Holmes, Solomon, Cappo, & Greenberg, 1983; Schneider et al., 1995; Throll, 1982; Wallace,

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1972). Murphy's review concluded that HR at rest was on average reduced by seven (range 2–15) beats per minute (bpm) following meditation. Pollard and Ashton (1982) reported that HR descended more in meditators compared to participants using biofeedback or resting and these differences are most pronounced in the latter part of the relaxation period. A meta-analysis of effects of Transcendental Meditation (TM) suggested a nonsignificant trend towards a greater decline in HR than rest (Dillbeck, 1987). Moreover, a report of exaggerated HR oscillation during meditation challenges the notion that meditation represents an autonomically quiescent state (Peng et al., 1999).

Relaxation may reduce BP in normotensive and mildly hypertensive participants (Murphy, 1997; Patel, Marmot, & Terry, 1981). A 4 year follow-up study showed that the BP reduction was maintained long-term (Patel et al., 1985). In a study of hypertensive African Americans, 3 months of TM resulted in a mean reduction in BP of 11/6 mmHg (Alexander et al., 1996; Schneider et al., 1995). Silverberg (1990) suggested that a multifaceted approach combining relaxation techniques and physical exercise might provide additional benefits in lowering BP. The role of stress management in treating patients with elevated BP, however, remains uncertain (The sixth report of the Joint National Committee, 1997). One frequently cited review concluded that cognitive behavioral techniques did not reduce BP any more than sham techniques (Eisenberg et al., 1993). The two meditation groups included in the review did, however, show positive results. A possible limitation of the reviews, thus, may be the lack of differentiation between various relaxation techniques (Eisenberg et al., 1993; Kaplan, 1994).

Methodological problems have raised debate about the data obtained. Some of the literature on this topic is not precisely and definitively stated. The relevance of the controls included in studies has been disputed (Holmes, 1984). Reduced HR and BP have been obtained after meditation sessions of 30-min or less (Barnes et al., 1999, 2001; Holmes et al., 1983; Schneider et al., 1995). Hemodynamic responses to long meditation (LM), meditations of 1 hr or more, have not been investigated. During LM, it is likely that HR would decline initially. The point during meditation at which a steady HR would occur is not known. Many studies compare HR before and after meditation or report HR data only from sequences of meditation (Barnes et al., 1999; Pollard et al., 1982; Throll, 1982). Continuous monitoring of HR during meditation rarely has been reported. Similarly, the effect of LM on BP has not been explored. The degree to which LM may lower BP may be related to the initial BP, the quality and length of the relaxation practice, and the meditation skills of the participants. BP is more likely to be reduced in hypertensive than normotensive participants. Although a permanent decrease in BP in normotensives cannot be expected after a single session of meditation, it may occur following long-term meditation practice. Therefore, when investigating advanced meditators, effects may appear at the outset of the study as baseline differences that actually are the result of long-term practice (Solberg, Halvorsen, & Holen, 2000).

Aim of This Study

The primary aim of this study was to explore HR level, and within-participant variability of HR in advanced meditators during 1 hr of meditation as compared to matched control participants during 1 hr of rest. A secondary aim was to investigate further HR changes during a continuous meditation session of 3 hr. Additionally, BP was investigated before and after 3 hr of meditation and 1 hr of control rest.

METHODS

Design

In a controlled cross-sectional comparative design advanced meditators during a period of sitting meditation were contrasted with controls resting in a sitting position. Between and within-group HR was compared before and after the 1 hr period of meditation or control rest. The term "practice period" refers to either meditation or rest. After the initial hour of meditation, participants in the meditation group continued meditating for an additional 2 hr. Thus, HR during 3 hr of continuous meditation was explored in a self-controlled design. BP was measured before and after the practice period. Because of the different time intervals the two groups were studied, only the initial BP values were compared between groups. Unique aspects of this study are the use of a lengthy meditation interval, continuous recording of HR during meditation that allowed for the determination of within-person variability of HR, and the relatively large number of advanced meditators included.

The Meditation Condition

ACEM Meditation[9] was chosen because it is well-defined and relatively widely used in Scandinavia. The practice has similarities to TM (Schneider et al., 1995) making comparisons relevant. However, differences do exist. ACEM Meditation is taught and explained in noncultic, psychophysiological terms. Practice involves a nondirected repetition of a sound ("mantra") designed for meditation. Normally, ACEM meditation is practiced 30 min twice a day. Advanced meditators occasionally practice longer. In the present study, inclusion criteria were regular meditative experience of more than 5 years and occasional practice of 3 hr meditation.

The Control Condition

During the control condition participants were instructed to sit and rest as fully as possible in any way they preferred, but were instructed to avoid talking, sleeping, or working. Leisure literature was available for those finding that reading increased their relaxation. Very few took that opportunity.

Participants

All participants were men who reported themselves as being healthy, normotensive, and employed. Mean age was 43 years (range 28–57) in both groups (*ns*).

[9]Further information of ACEM Meditation (an acronym) can be obtained from www.acem.com

Forty-four meditators were included. On average, they had practiced ACEM Meditation for 21 years (range 5–31). During 6 months before the study 43 were practicing daily and one participant practiced alternate day.

The control group consisted of 30 volunteers recruited through the company health services of three large corporations (pharmaceutical, insurance, and telecom) in Oslo. The participants had no prior experience with relaxation techniques.

Life Style

All participants completed a simple questionnaire reporting predictors of elevated BP such as overweight, physical training, and smoking (Kaplan, 1994). Mean body mass index was 24.0 ± 2 (*SD*) in the meditation group and 24.7 ± 2 in the control group (*ns*). The meditators exercised on average 1.5 times a week and the control participants 1.8 times a week (*ns*). Seven persons in the control group and none in the meditation group smoked. There were no significant differences, however, between smokers and nonsmokers in initial BP or HR declines in the control group.

Conditions Related to the Study

All participants were informed in writing about the procedures to be used to carry out measurements and gave informed consent. Participants were asked to abstain from physical exercise for 24 hr prior to the study and coffee and tea on the morning of the study. Participants were asked to travel to the study in a calm, unhurried manner so that they would not arrive in a rushed state.

Participants in the meditation group were tested at a retreat center used for long meditation. As is customary for LM, participants meditated in separate rooms. The meditators had not meditated in the morning of the study nor had they practiced LM recently. Control participants were tested at their work place sitting in a chair in a separate, quiet room with minimal disturbances. The test sites were situated close to each other. The ceiling lights were off in all of the test rooms. The lighting, thus, was similar in both groups.

The regional ethics committee approved the study.

Procedures

All tests began at 9:00 a.m. Each participant rested for 10 min before the initial measurements were made. A pulse belt was placed around the chest of each participant. Gel (Aquasonic 100) was used for optimal signal transfer. An automatic monitor (Polars Sport tester and Polar Accurex Plus, Finland) recorded HR every minute of the practice period. Cellular telephones and watches were removed to prevent electric interference. Results from the pulse watch were transferred to a computer using a data program (Polar training advisor, Finland). Skilled health personnel measured participants' BP using automatic equipment (DINAMAD XL Vital Signs Monitor). The cuff was inflated only once to minimize disturbance to the relaxation processes. Final BP measurements were conducted at the end of the practice period with participants still sitting in a relaxed position. During the measurement, no verbal communication took place.

During the meditation all participants endorsed positive signs of relaxation as previously reported (Solberg, Berglund, Engen, Ekeberg, & Loeb, 1996). After completing their 3 hr of ACEM Meditation, the meditators rated the quality of their meditation as a mean of 22 ± 12 (*SD*) on a visual analogue scale (VAS; ranged from 10 = *very pleasant* to 70 = *very unpleasant*). Thus, it is likely that the meditation condition was successful in producing the desired state.

Because of practical circumstances, HR was measured in 40 of the advanced meditators and in 25 volunteers of the control group. Because of technical disturbances, data from six participants were not readable and excluded from the final analyses. This yielded HR data for 38 meditators and 21 controls. BP was measured in all the 44 advanced meditators and 30 controls.

STATISTICS

Between-groups HR analyses were performed using repeated measures (ANCOVA) (Vickers & Altman, 2001). Because mean HR during the first ten minutes differed significantly between the meditators (77 ± 11) and the controls (69 ± 10), mean HR from the 11th to the 20th minutes was used as the starting point in the analyses. The endpoint for ANCOVA was the mean HR of the 50th to the 60th minute. Within-participant variability of HR (standard deviation (*SD*)) was compared using independent t-tests. Additionally in the meditators, mean HR values of every ten-minute period from the second to the third hour of meditation were compared using paired-samples t-tests. Within-group analyses of BP data were performed using paired-samples t-tests. Between-group analyses of BP data were performed using independent t-tests. The level of significance was set at 0.05.

RESULTS

Heart Rate

During the practice period there was a significantly larger decline in HR among the meditators than among the controls (ANCOVA, $p < 0.001$, $F = 71.51$, df = (2,56), $t = -5.24$, $R_2 = 0.72$). The decline was significantly larger also when applying mean HR of the 11th to the 20th minutes as baseline (ANCOVA, $p = 0.002$, $F = 100.47$, df = (2,56), $t = -3.22$, $R_2 = 0.78$). Among the meditators, mean HR declined thirteen bpm from the mean of the first ten minutes to the mean of the 50th to the 60th minute ($p < 0.001$, $t = 12.46$, df = 37), and four bpm from the mean of the 11th to the 20th minute compare to the mean of the 50th to the 60th minute ($p < 0.001$, $t = 6.19$, df = 37) (Fig. 1).

During the first ten minutes of the practice period, the mean variation (*SD*) in HR was 9.7 in the meditation group and 8 in the control group (*ns*). During the practice period HR variation declined (2.9–3.7) in the meditation group, whereas the variation remained stable (6.1–7.6) in the control group ($p < 0.05$, $2.04 < t < 2.05$, df = 57) (Fig. 2).

During the second hour of meditation, mean HR declined a further 3%, from 66 ± 9 to 64 ± 10 bpm ($p = 0.01$, $t = 2.71$, df = 37).[10] During the third hour, the average HR did not change.

[10]A HR spike at 60 min in the meditation group was iatrogenic following blood sampling. In the HR analysis of the 2nd hour of meditation, the HR data are thus smoothed out between the 60th to the 70th minute.

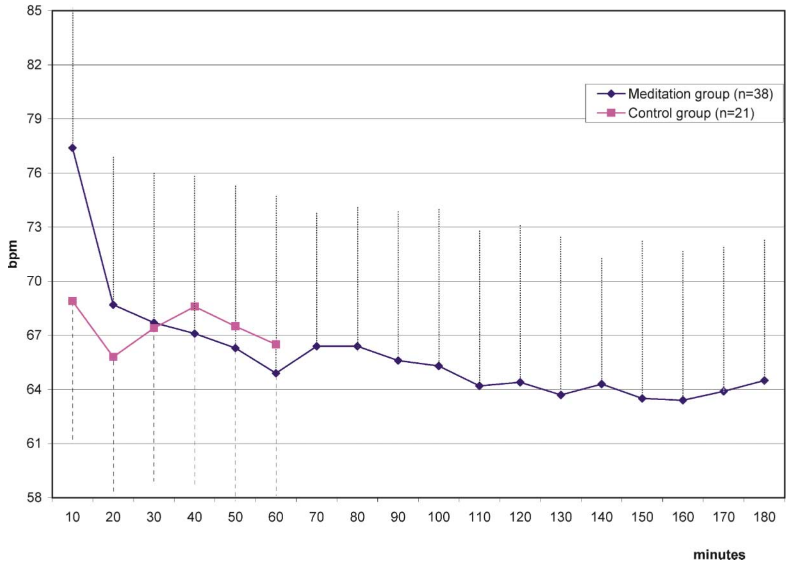

Fig. 1. Mean HR (± SEM) for successive 10-min intervals during 3 hr of meditation and 1 hr of control rest.

Blood Pressure

Initial diastolic (but not systolic) blood pressure (DBP) was significantly lower in the meditation group than in the control group ($p < 0.05$, df $= 72$, $t = -2.15$). From before to after the practice period, mean BP changed from $129 \pm 13/77 \pm 6$ to $127 \pm 11/78 \pm 7$ mmHg in the meditation group and from $133 \pm 18/81 \pm 10$ to $131 \pm 18/79 \pm 12$ mmHg

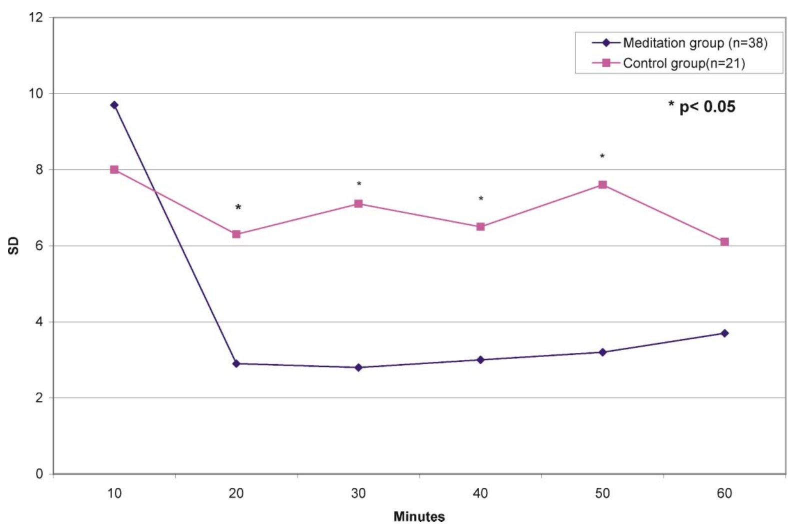

Fig. 2. Within-person variations (*SD*) of HR during 1 hr of meditation and 1 hr of control rest.

in the control group. No significant changes in BP were observed within each group during the practice period.

DISCUSSION

The main findings of this study were that HR declined considerably more in the meditators than in the controls during the 1-hr practice period. HR continued to decline slightly during the second, but not the third, of the 3-hr meditation bout. The continued decline in HR during the second hour of meditation has not been shown previously. These data suggest that the outer limit for HR reduction occurs after 2 hr of meditation. An additional finding was that meditation reduced within-person variability in HR more than control rest. No change in average BP was found from before to after the practice period in either group. This is the first study to demonstrate that 3 hr of meditation does not further reduce a low normal BP in normotensive meditators.

Initial HR was significantly higher in the meditators than in the controls, a finding that might complicate the interpretation of the data. To accommodate this difference, we choose as the starting point for ANCOVA the mean HR from both the first and the second 10-min intervals of the practice period. At the latter time, the groups' mean HR values were similar. The data then showed that meditation reduced HR more than rest, supporting the hypothesis that meditation may be superior to rest in enhancing relaxation. Our study appears to demonstrate a continuous relaxation process, in terms of HR, throughout the first two of a 3-hr meditation bout, after which an asymptotic HR level occurred. The level of HR reduction observed in this study is within the range of clinical relevance (Kristal-Boneh et al., 2000; Morcet et al., 1999; Reunanen et al., 2000) and is consistent with a previous summary of studies on HR reduction following shorter meditation (Murphy, 1997). Another study also has reported a higher baseline HR in meditators (Holmes et al., 1983). The initial difference in resting HR might indicate that the relaxing effects of meditation are accompanied by a generally higher and perhaps more adaptive tonus during nonmeditation periods.

The initially lower DBP in the advanced meditators may be a consequence of coincidence, selection, or the long-term effect of meditation on BP. The initial BP in the meditation group (129/77 mmHg) was apparently lower than in average Norwegian men aged 40–42 years (135/81 mmHg) (Wøien, Øyen, & Graff-Iversen, 1997). The initial BP in the control group (133/81 mmHg) was similar to the average BP of Norwegian men. The average HR for a Norwegian aged 40–42 years is 72 bpm (Aage Tverdal, National Health Screening Service, personal communication, 1996). These data support that the control group was representative of the wider male Norwegian population. As expected, neither 3-hr meditation nor 1 hr of seated rest significantly affected BP in these normotensive participants. A possible reason is that they had already achieved a baseline level of BP before the start of the practice period. Reduced BP is healthy only to a certain level (Hansson et al., 1998). Adolescents with high normal BP, however, have responded to TM by lowering BP both at rest and during stress (Barnes et al., 2001).

This study has limitations. Control participants ideally should have rested three hours, the same time frame as the meditation session. We considered this carefully, but rejected this prolonged rest period because we presumed that the practice period might be experienced as stressful. For the control participants, thus, 1 hr of rest was deliberately chosen as the longest time frame they would find acceptable. For practical reasons it was impossible to let the controls rest in the same place as the meditators. The responses to the meditation, as indicated by VAS, suggested that the meditation bout was adequate. Similarly, the control rest session seemed to be satisfactorily conducted. Measurements of hemodynamic variables did not appear to cause major disturbances to the meditation or the rest. The meditation and the control group differed in smoking habits. However, there were no significant differences between control smokers and nonsmokers in either initial BP or HR decreases. Miscellaneous types of meditation have influenced HR differently. Future research should explore effects of various types of meditation, including postmeditation effects more closely.

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