ORIGINAL ARTICLE

Modification of Heart Rate Variability: Meditation versus Controlled Breathing Alone

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ABSTRACT

Background: Heart rate variability (HRV) is an established method to evaluate sympatho-vagal balance. Reduced HRV is a prognostic marker for fatal arrhythmias and increased mortality. Mindfulness based stress reduction (MBSR) is a well-delineated 8-week meditation program. Certain meditation practices have been shown to positively influence HRV, but the short- and long-term effects of MBSR on HRV have not been established.

Objective. It is to study the different effects of meditation and controlled breathing on HRV.

Methods: Twenty healthy volunteers were recruited from participants of a MBSR program. Continuous ECG and respiration were recorded in three phases (Resting, Controlled breathing, Meditation), with each phase lasting for 5 minutes, before and after completion of MBSR.

Time domain analysis was undertaken using standard deviation of RR intervals (SDNN) and root mean square of successive differences in adjacent RR intervals (RMSSD).

Results: After 8 weeks of MBSR, during meditation, there was no significant change in SDNN (50.9 ± 22.7 to 45.1 ± 20.7 ms, P=0.19) or RMSSD (35.0 ± 24.6 to 25.6 ± 13.1 ms, P=0.1). Compared to resting spontaneous breathing, controlled breathing was associated with significant changes in SDNN (36.9 ± 17.1 to 60.5 ± 20.4 ms, P<0.0001) and RMSSD (25.8 ± 12.6 to 34.1 ± 16.0 ms, P=0.013). Compared to meditation, controlled breathing also was associated with significant changes in SDNN (45.1 ± 20.7 to 60.5 ± 20.4 ms, P=0.001) and RMSSD (25.6 ± 13.1 to 34.1 ± 16.0 ms, P=0.0009).

Conclusion: Participation in a MBSR program did not lead to significant changes in time domain measures of HRV, either at rest or during meditation. However, controlled breathing at 6 breaths/minute produced significant improvement in HRV, compared to either resting spontaneous breathing or meditation. Although further study is warranted, controlled breathing could be a useful adjunct in management of conditions with reduced HRV, such as heart failure. (J Clin Prev Cardiol. 2014;3(1):1-4)

Keywords: autonomic nervous system; heart rate variability; MBSR; meditation; mindfulness

Introduction

Despite the intrinsic automaticity of cardiac tissue, heart rate and rhythm are to a large extent modulated on a moment-to-moment basis by the autonomic nervous system. Heart rate variability (HRV) is this beat-to-beat variation in the heart rate. In the late 1980s, it was convincingly shown that HRV was a strong and independent predictor of mortality and of arrhythmic complications after an acute myocardial infarction (1–3). Reduced HRV has also been consistently shown in heart failure patients (4).

Meditation has been used as a healing practice in Asia for more than 5000 years. Review of the literature reveals five broad categories of meditation – Mantra or transcendental meditation, Yoga, Mindfulness meditation, Tai chi and Qi gong (5). Mindfulness based stress reduction (MBSR) was developed by Jon Kabat-Zinn and colleagues at the University of Massachusetts in the early 1980s in an attempt to integrate mindfulness meditation into mainstream clinical medicine (6–7). MBSR has a standardized technique that has been described systematically in manuals, with teachers undergoing training and receiving certification and, therefore, is relatively invariant wherever and by whomever it is taught.

Certain meditation practices have been shown to positively influence HRV (8), but the short- and long-term effects of MBSR on HRV have not been established.

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We hypothesized that MBSR would have a beneficial effect on HRV.

Methods

Study objectives

- *Does MBSR lead to a change in HRV?*
- *Does meditation have any additional benefits on HRV beyond controlled breathing?*

Study design

This was a single-center, prospective, self-controlled, pre-post cohort study. Each subject acted as his/her own control. We intended to study 20 healthy volunteer subjects, and invited 22 for the first visit to allow for attrition. One subject was excluded for not completing the MBSR course, 1 subject never returned for the final visit, and 2 were excluded due to ECG artifact, giving a final N=18. This was a pilot study and consequently the sample size is arbitrary. The study protocol was approved by the University of Minnesota institutional review board, and informed consent was obtained.

Recruitment

Volunteers were recruited from among participants of the MBSR program offered by the Center for Spirituality and Healing (CSH) at the University of Minnesota. Recruitment was completed in one cycle. MBSR participants were sent a letter from the CSH inviting them to participate in the study.

Inclusion criteria

- Healthy volunteers, aged 18–80 years
- Enrolled in an MBSR program
- Able and willing to give informed consent

Exclusion criteria

- Prior participation in an MBSR program

There was no direct risk or benefits to the participants. Volunteers were reimbursed $50 per visit to cover travel costs.

MBSR

The program consists of an 8-week intervention with weekly classes that last 2–3 hours (9). There is a daylong intensive meditation session between the sixth and seventh sessions. MBSR participants are expected to learn the skills of meditation assisted by the instructor and guided by a series of audiotapes for home practice. Participants also complete 20–30-minute sessions at home, at least 6 days a week for 8 weeks.

Visits

The study involved two visits, before and after completion of the MBSR program. Each visit lasted for about an hour, and included identical procedures. The first visit could be anytime up to a month before starting the program, and the second visit could be anytime up to a month after finishing the program. Subjects were required to attend at least 6–8 sessions plus the all-day session to be considered to have completed the course, and be eligible for the second visit.

Procedure

After a brief period to help acclimatize, three phases of data were recorded during each session, with each phase lasting for 5 minutes. ECG and respiration were recorded continuously throughout each phase. Subjects were given an introduction about the three phases, and told to follow instructions as played in their headphones.

Phase 1. Resting served as baseline, wherein the subject was asked to breathe spontaneously. There were no audio cues.

Phase 2. Controlled respiration involved audio cues (asking to breathe in and out) to control the respiratory rate at a fixed interval of 6 breaths/minute.

Phase 3. Meditation involved self-guided sitting meditation. Subjects were assisted with an audio recording from the MBSR program material, helping to focus on the present moment and breathing spontaneously.

Data collection

Data collection was done in a standard clinical exam room while sitting upright comfortably in a chair. For ECG recordings, electrodes were placed in standard fashion to obtain a single lead II tracing (BIOPAC MP 150 System Electrical Bioimpedance Amplifier, EBI 100C manufactured by Biopac® Systems, Goleta, CA). A chest band was used for measurement of respiratory rate (BIOPAC RSP100C amplifier with the TSD201 connector manufactured by Biopac® Systems, Goleta, CA). Volunteers wore noise reduction headphones (Logitech UE 6000, manufactured by Logitech, Switzerland). All equipment used is commercially available and approved for human use by the appropriate safety standards organizations.

Data from the above equipment were acquired using BIOPAC MP 150 System Data Acquisition unit (MP 150 ACE) and AcqKnowledge 4.2.0 software manufactured by Biopac® Systems, Goleta, CA. EKG was sampled at 8 Hz and automated software was used to label QRS complexes, which was manually verified to confirm correct labeling. All RR intervals from premature ventricular contractions (PVCs) and the following post-PVC beat were rejected. Segments with ECG artifact were reviewed, and QRS complexes manually located and labeled as best as possible. Despite this, two subjects were excluded due to ECG artifact. Respiratory rate was manually counted from the acquired signal. All data was verified by two independent readers (PSN, KP).

Endpoints

Time domain analysis was undertaken using standard deviation of RR intervals (SDNN) and root mean square of successive differences in adjacent RR intervals (RMSSD). This was in accordance with a task force document of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (now the Heart Rhythm Society) that recommends SDNN and RMSSD as the preferred variables for short-term 5-minute recordings (10).

Primary endpoint

- Change in HRV during meditation (phase 3) after completion of MBSR

Secondary endpoints

- Change in HRV between controlled respiration (phase 2) and meditation (phase 3) after completion of MBSR
- Change in HRV between controlled respiration (phase 2) and baseline spontaneous breathing (phase 1) after completion of MBSR

Statistical analysis

Continuous data are reported as mean and standard deviation (SD), and means between different time points compared with paired t-tests. A significance level of $P<0.05$ was considered significantly different. Data analyses were performed using Stata software version 13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX).

Results

There was a fairly equal gender distribution, with 10 females and 8 males. After 8 weeks of MBSR, during meditation, there was no significant change in SDNN (50.9 ± 22.7 to 45.1 ± 20.7 ms, P=0.19) or RMSSD (35.0 ± 24.6 to 25.6 ± 13.1 ms, P=0.1) (Table 1). Compared to resting spontaneous breathing, controlled breathing was associated with significant changes in SDNN (36.9 ± 17.1 to 60.5 ± 20.4 ms, P<0.0001) and RMSSD (25.8 ± 12.6 to 34.1 ± 16.0 ms, P=0.013). Compared to meditation, controlled breathing also was associated

Table 1. Time domain analysis – before and after MBSR program (n=18)

Variables	Pre-MBSR			Post-MBSR			P-value*	
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	a	b
Mean HR (beats/min)	69.2 ± 9.4	70.1 ± 8.9	68.9 ± 8.5	68.6 ± 8.6	69.2 ± 8.0	69.1 ± 8.1	0.94	0.80
RR (breaths/min)	12.0 ± 3.1	6.2 ± 0.2	9.8 ± 2.9	11.9 ± 3.8	6.4 ± 1.1	10.1 ± 3.8	0.46	0.0007
SDNN (ms)	37.8 ± 13.0	61.9 ± 24.4	50.9 ± 22.7	36.9 ± 17.1	60.5 ± 20.4	45.1 ± 20.7	0.19	0.0018
RMSSD (ms)	28.2 ± 14.3	34.8 ± 16.9	35.0 ± 24.6	25.8 ± 12.6	34.1 ± 16.0	25.6 ± 13.1	0.098	0.0009

*Comparisons
a – Post phase 3 vs. pre phase 3 (meditation)
b – Post phase 3 vs. post phase 2 (post MBSR meditation vs. controlled respiration)

with significant changes in SDNN (45.1 ± 20.7 to 60.5 ± 20.4 ms, P=0.001) and RMSSD (25.6 ± 13.1 to 34.1 ± 16.0 ms, P=0.0009).

Discussion

Even though there is a body of evidence documenting the effects of meditation on heart rate and blood pressure, HRV is generally considered to be a more robust method to evaluate the complex autonomic modulation of cardiopulmonary dynamics and to assess the impact of interventions on these dynamics.

Participation in an MBSR program did not lead to significant changes in time domain measures of HRV, either at rest or during meditation. Prior reports have shown improvements in HRV even during a non-meditative state in experienced zen masters (11). However, participants in our study were novice meditators, and had only a few weeks to hone their skills. It is likely that much more practice is needed to induce changes in HRV.

Since a big part of mindfulness meditation involves focusing on one's breath, and respiration is known to impact HRV, we wanted to see whether there is any additional effect on HRV with meditation as compared to controlled breathing alone. However, controlled breathing at 6 breaths/minute produced significant improvement in HRV, compared to either resting spontaneous breathing or meditation. Although further study is warranted, controlled breathing could be a useful adjunct in management of conditions with reduced HRV, such as heart failure.

Limitations

There are some limitations to our study. The sample size is small, and hence the results should be hypothesis generating and serve to spur further research in this field. The lack of a control group introduces the potential for confounding. This was a highly motivated cohort, introducing the potential for selection bias. MBSR is an amalgam of different meditation techniques, though the main focus in still on mindfulness.

Conclusion

Participation in a MBSR program did not lead to significant changes in time domain measures of HRV, either at rest or during meditation. However, controlled breathing at 6 breaths/minute produced significant improvement in HRV, compared to either resting spontaneous breathing or meditation. Although further study is warranted, controlled breathing could be a useful adjunct in management of conditions with reduced HRV, such as heart failure.

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References

1. Lombardi F, Sandrone G, Pernpruner S, Sala R, Garimoldi M, Cerutti S, Baselli G, Pagani M, Malliani A. Heart rate variability as an index of sympathovagal interaction after acute myocardial infarction. Am J Cardiol. 1987;60:1239–45.
2. Bigger JT, Jr, Fleiss JL, Steinman RC, Rolnitzky LM, Kleiger RE, Rottman JN. Frequency domain measures of heart period variability and mortality after myocardial infarction. Circulation. 1992;85:164–71.
3. Odemuyiwa O, Malik M, Farrell T, Bashir Y, Poloniecki J, Camm J. Comparison of the predictive characteristics of heart rate variability index and left ventricular ejection fraction for all-cause mortality, arrhythmic events and sudden death after acute myocardial infarction. Am J Cardiol. 1991;68:434–9.
4. Casolo G, Balli E, Taddei T, Amuhasi J, Gori C. Decreased spontaneous heart rate variability in congestive heart failure. Am J Cardiol. 1989;64:1162–7.
5. Ospina MB, Bond K, Karkhaneh M, Tjosvold L, Vandermeer B, Liang Y, Bialy L, Hooton N, Buscemi N, Dryden DM, Klassen TP. Meditation practices for health: state of the research. Evidence report/ technology assessment no. 155 (prepared by the University of Alberta. Evidence-based practice center under contract no. 290-02-0023). AHRQ publication no. 07-E010. Rockville, MD: Agency for healthcare research and quality. June 2007.
6. Ludwig DS, Kabat-Zinn J. Mindfulness in medicine. JAMA. 2008;300:1350–2.
7. Kabat-Zinn J. Full Catastrophe Living: Using the Wisdom of Your Body and Mind to Face Stress, Pain, and Illness. New York: Dell publishing; 1990.
8. Peng CK, Henry IC, Mietus JE, Hausdorff JM, Khalsa G, Benson H, Goldberger AL. Heart rate dynamics during three forms of meditation. Int J Cardiol. 2004;95:19–27.
9. MBSR program [Internet]. Available from: http://www.csh.umn.edu/programs/Mindfulness_Based_Stress_Reduction_MBSR/MBSRMeditations/MBSRMeditations.html
10. Heart rate variability: Standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Circulation. 1996;93:1043–65.
11. Peng CK, Mietus JE, Liu Y, Khalsa G, Douglas PS, Benson H, Goldberger AL. Exaggerated heart rate oscillations during two meditation techniques. Int J Cardiol. 1999;70:101–7.