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Effects of Two Yoga Based Relaxation Techniques on Heart Rate Variability (HRV)

Patil Sarang and Shirley Telles AQ: 1
Swami Vivekananda Yoga Research Foundation

Heart rate variability (HRV) was studied in cyclic meditation (CM) and supine rest (SR). CM included yoga postures followed by guided relaxation. Forty-two male volunteers were assessed in CM and SR sessions of 35 minutes, where CM or SR practice was preceded and followed by 5 minutes of SR. During the yoga postures of CM and after CM, low frequency power and the low frequency to high frequency power ratio decreased, whereas high frequency power increased. Heart rate increased during the yoga postures and decreased in guided relaxation and after CM. There was no change in SR. Hence, it appeared that predominantly sympathetic activation occurred in the yoga posture phases of CM while parasympathetic dominance increased after CM.

Keywords: heart rate variability, cyclic meditation, supine rest, autonomic balance

Meditation is a specific state of consciousness characterized by deep relaxation and internalized attention (Murata, et al., 2004). Different meditation techniques and their physiological effects have been studied using a range of variables. Transcendental meditation (TM) involves mentally repeating a string of words (a *mantram*) with eyes closed and returning attention to it whenever attention wanders. In 15 college students, 30 minutes of TM practice caused a reduction in heart rate, breathing rate, and oxygen consumption and an increase in galvanic skin resistance suggesting a reduction in sympathetic arousal (Wallace, 1970). A subsequent study showed a similar trend of reduction in heart rate, total ventilation, and oxygen consumption and a greater stability of the electrodermal response (Wallace,

Patil Sarang and Shirley Telles, Swami Vivekananda Yoga Research Foundation, Bangalore, India. AQ: 6

The authors gratefully acknowledge H.R. Nagendra, who derived the CM technique from ancient yoga texts, and Ravi Kulkarni, for assistance with the statistical analysis.

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Benson, & Wilson, 1971). Based on these changes, TM came to be described as a 'wakeful hypo-metabolic physiologic state' with reductions in mass sympathetic discharge during meditation. AQ: 2

By contrast, when a study was conducted on 18 Brahmakumaris Raja yoga meditators using the self-as-control design (all subjects were studied in both meditation and nonmeditation sessions), it was found that both autonomic activation (based on a consistent increase in the heart rate) and relaxation (an increase in skin resistance and finger plethysmogram amplitude) occurred simultaneously, suggesting selective activation in different subdivisions of the sympathetic nervous system during meditation (Telles & Desiraju, 1993). Hence, a single model of sympathetic activation or overall relaxation was thought inadequate to describe the physiological effects of meditation.

Similar differential activity in the different subdivisions of the autonomic nervous system was observed during repeat meditation sessions in seven experienced "Om" meditators (Telles, Nagarathna, & Nagendra, 1995). There was a simultaneous reduction in heart rate (possibly related to increased vagal tone with reduced cardiac sympathetic activity) and finger plethysmogram amplitude (decreased sympathetic vasomotor activity).

The changes which occur during different phases of a meditation practice have also been studied. In mindfulness meditation (*Vipassana*), changes in the heart rate variability spectrum (as an indicator of the sympathovagal balance) were evaluated during different phases of meditation in 14 volunteers (Telles, Mohapatra, & Naveen, 2005). The 30 minutes of meditation practice consisted of three 10-minute phases. The first phase was for breath awareness; the next phase was for awareness of sensations from the rest of the body; and, during the last phase, the subjects were given specific philosophical concepts to think about mentally (, e.g., relating to feelings of universality and good will). A decrease in low frequency (LF) power and in the low frequency to high frequency power (LF/HF) ratio, with a trend toward an increase in high frequency (HF) power, was seen during the breath awareness phase of *Vipassana* meditation. This suggested a shift in the autonomic balance toward vagal dominance during the breath awareness phase of *Vipassana* meditation.

Hence, whether there is an overall reduction in sympathetic activity (as seen in TM) or differential activity in different subdivisions of sympathetic activity (as seen in Brahmakumaris Raja yoga meditation and in *Om* meditation) or reduced sympathetic activity in some phases of meditation (as in *Vipassana),* there is evidence that meditation is associated with reduced sympathetic activity (in some, if not all sympathetic subdivisions).

In contrast to meditation, yoga postures (*asanas*) have been associated with increased sympathetic activity. In a study of 21 volunteers, an increase in heart rate and respiratory rate (RR) was observed during the practice of a yoga technique that included a series of 12 yoga postures practiced in sequence, known as *Surya Namaskar* (Sinha, Ray, Pathak, & Selvamurthy, 2004). In another study, in which 20 volunteers experienced in practicing the headstand (*Sirsasana*) were compared with 20 volunteers who had less experience, there was an increase in sympathetic activity in different sympathetic subdivisions such as cardiac (based on heart rate variability), sudomotor (based on skin resistance), and vasomotor (based on finger plethysmogram amplitude) in both groups of practitioners (Manjunath, & Telles, 2003).

Understanding the difference between the physiological effects of meditation and yoga postures (*asanas*) is of interest, as there exists a technique of moving meditation, which combines the practice of yoga postures with guided meditation. This has been called cyclic meditation (CM) and is based on concepts derived from an ancient yoga text, the *Mandukya Upanisad*. The practice of this technique was found to reduce oxygen consumption and breath frequency, but to increase tidal volume in 40 male volunteers (between 20 and 47 years of age), as compared to a comparable period of supine rest (SR) in the corpse posture, that is, *Shavasana* (Telles, Reddy, & Nagendra, 2000).

To extend previous research, the present study was designed to evaluate changes in heart rate variability (HRV) in CM, compared with a comparable period of SR. HRV has been widely used as a measure of vagal activation in physiological, psychological, and clinical investigations (Martinmaki, Rusko, Kooistra, Kettunen, & Saalasti, 2006), even though this measure can be influenced by extraneous factors (Grossman & Kollai, 1993; Grossman, Wilhelm, & Spoerle, 2004). In the present study, HRV was used to evaluate the changes in autonomic activity in CM and SR sessions.

METHOD

Subjects

Forty-two male volunteers participated in the study, aged 18 to 48 years (*M* = 27.1, *SD* = 6.3 years). Participants were residing at a yoga center. Male subjects alone were studied, as autonomic variables have been shown to vary with the phases of the menstrual cycle (Yildirir, Kabakci, Akgul, Tokgozoglu, & Oto, 2002). All of them were in normal health, based on a routine clinical examination. None of them were taking any medication and they did not use any other wellness strategy. The electrocardiogram (ECG) recording of all volunteers was free of extra systoles. The volunteers had experience practicing CM for more than 3 months (*M* = 15.3, *SD* = 13.3 months). The

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aims and methods of the study were explained to the meditators and all of them gave their informed consent to participate.

Design

The meditators were assessed in two separate sessions, CM and SR. For half the subjects, the CM session took place on one day, with the SR session the next day. The remaining subjects had the order of the sessions reversed. Subjects were alternately assigned to either schedule to prevent the order of the sessions influencing the outcome. The subjects were unaware about the hypothesis of the study. Recordings were made throughout a session. Each session lasted for 35 minutes, of which 22 Minutes 30 seconds were spent in the practice of either CM or SR, preceded and followed by five minutes of SR.

Assessments

The ECG was acquired using Ag/AgCl solid adhesive pregelled electrodes (Bio Protech Inc., Korea) fixed on the prominant part of the clavicle AQ: 3 on both sides to simulate Limb Lead I configuration (Thakor & Webster, 1985). These electrode positions were selected as they eliminated movement artifact. The ECG was recorded using an ambulatory ECG system (Niviqure, Bangalore, India) at the sampling rate of 1024 Hz and was analyzed offline. The data were acquired in five minute epochs in the pre, during, and post periods. The data were visually inspected offline; noise-free data were included for analysis. The R waves were detected to obtain a point event series of successive response-response intervals, from which the beat-to-beat heart series were computed. The data were analyzed with an HRV analysis program developed by the Biomedical Signal Analysis Group (Niskanen, Tarvainen, Ranta-aho, & Karjalainen, 2004).

Breath rate was assessed simultaneously with the subjects breathing ambient air while wearing a mask, using an open circuit apparatus (Oxycon Pro system, Model, 2001, Jaeger, Germany). These data were collected as part of another study (unpublished data).

Interventions

Cyclic Meditation (CM)

CM lasted for 22 minutes, 30 seconds. Throughout the practice, subjects kept their eyes closed and followed instructions from an audiotape. The

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instructions emphasized carrying out the practice slowly, with awareness and relaxation. The five phases of CM consisted of the following practices.

Phase 1 (5 minutes): The practice began by repeating a verse (1 minute) from the yoga text, the *Mandukya Upanishad* (Chinmayananda, 1984); followed by isometric contraction of the muscles of the body ending with SR (1 minute, 30 seconds); slowly coming up from the left side and standing at ease, called *tadasana*, and balancing the weight on both feet, called centering (2 minute, 30 seconds).

Phase 2 (5 minutes): Then the first actual posture, bending to the right (*ardhakatichakrasana,* 1 minute, 20 seconds); a gap of 1 minute, 10 seconds in *tadasana* with instructions about relaxation and awareness; bending to the left (*ardhakaticakrasana,* 1 minute, 20 seconds); a gap of 1 minute, 10 seconds in *tadasana*.

Phase 3 (5 minutes): Forward bending (*padahastasana,* 1 minute, 20 seconds); another gap (1 minute. 10 seconds); backward bending (*ardhacakrasana*, 1 minute. 20 second); a gap of 1 minute. 10 seconds in *tadasana*.

Phase 4 (5 minutes): Slowly coming down to a supine posture for rest with instructions to relax different parts of the body in sequence.

Phase 5 (5 minutes): Supine relaxation and a prayer for 2 minutes, 30 seconds; followed by SR for 2 minutes, 30 seconds (Telles, Reddy, & Nagendra, 2000).

Supine Rest (SR)

During the 22 minutes, 30 seconds of SR, subjects lay with eyes closed in the corpse posture (*shavasana*) with their legs apart and arms away from the sides of the body. The state of SR was considered for analysis in five phases to make it comparable to the practice of CM during the CM session. However, throughout the five phases the subjects lay in the same posture.

Data Extraction

Frequency domain analysis of HRV data was carried out for 5-minute recordings in the following epochs for each session (CM and SR): pre, during 1 (D1), during 2 (D2), during 3 (D3), during 4 (D4), during 5 (D5), and post. The HRV power spectrum was obtained using Fast Fourier Transform analysis (FFT). The energy in the HRV series in the following specific frequency bands was studied: the very low frequency band (0.0–0.05 Hz), low frequency band (0.05–0.15 Hz), and high frequency band (0.15–0.50 Hz). According to guidelines, the low frequency and high frequency band values were expressed as normalized units (Task Force of the European Society of Cardiology and the North American Society of Pacing & Electrophysiology, 1996).

Data Analysis

Statistical analysis was done using SPSS (Version 10.0). Repeated measures analyses of variance (ANOVA) were performed with two Within Subjects Variables: Sessions with two levels (CM and SR), and States with seven levels (pre, D1, D2, D3, D4, D5, and post. Post hoc tests (with Bonferroni adjustment for multiple comparisons) were used to detect significant differences between mean values. AQ: 4

RESULTS

There was a significant difference between States for LF power, $F(4.03, 161.40) = 3.29$, $p < .001$, where P is corrected for sphericity violation, Huynh-Feldt É√ = .673, and in the interaction between Sessions and States, $F(5.02, 201.03) = 6.46$, $p < .001$, Huynh-Feldt É√ = .838. The significant interaction between states and sessions means that the effect of one of them is not independent of the other factor (Zar, 2005). Post hoc tests for multiple comparisons of states with their respective baseline or pre values showed a significant increase in LF power in the D2 phase (of yoga postures) compared to the pre phase ($p < .05$) for the CM, and a significant CM compared to the pre phase ($p < .001$). There was no significant change in the SR session. The comparison of the two sessions (CM and SR) at each state showed LF power was significantly higher in the D2 phase of the CM session compared to the D2 phase of the SR session ($p < .001$). The trend of change in the LF power has been shown in Figure 1A. F1

There was a significant difference between States for HF power, $F(4.33, 173.48) = 6.89$, $p < .001$, Huynh-Feldt É√ = .167, and in the interaction between Sessions and States, $F(5.71, 288.61) = 7.28$, $p < .001$, Huynh-Feldt É√ = .953. The significant interaction between states and sessions means that the effect of one of them is not independent of the other. Post hoc tests for multiple comparisons of states with their respective baseline or pre values showed a significant reduction in the D2 phase (of yoga postures) compared to the pre phase, and a significant increase after CM compared to the pre phase ($p < .001$). There was no significant change in the SR session. The comparison of the two sessions (CM and SR) at each state showed HF power

(*text continues on page xxx*)

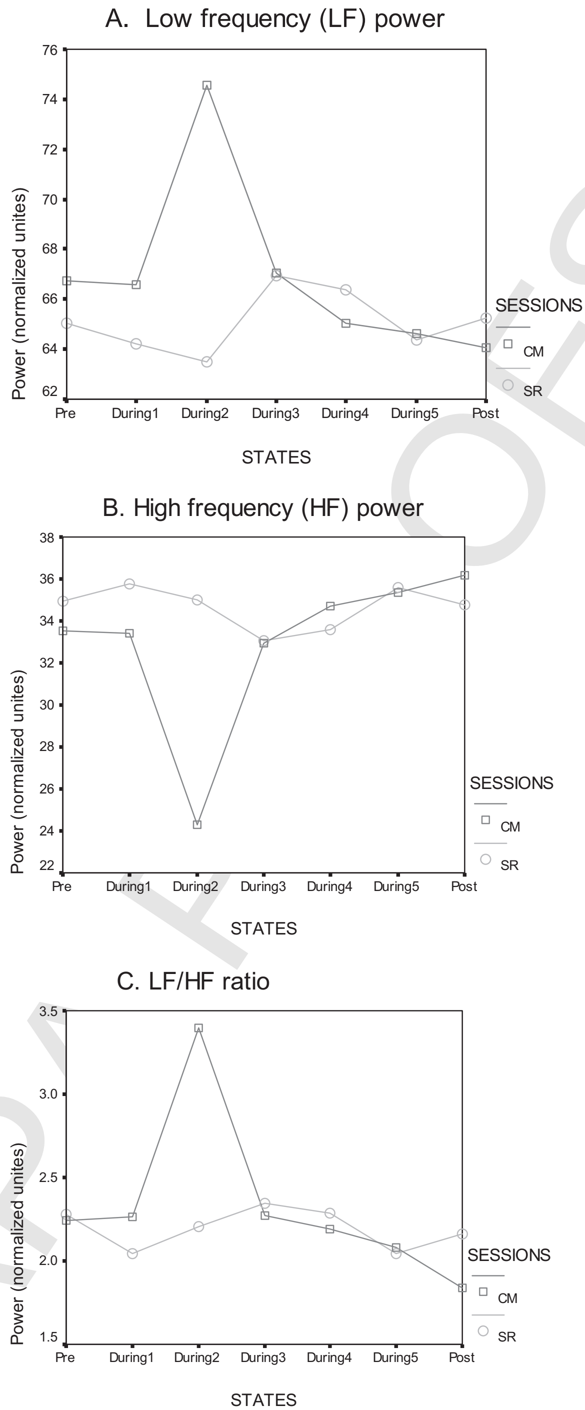

Figure 1. Changes in low frequency power (LF), high frequency power (HF), LF/HF ratio, very low frequency power (VLF), heart rate (HR), and respiratory rate in cyclic meditation (CM) and supine rest (SR) sessions.

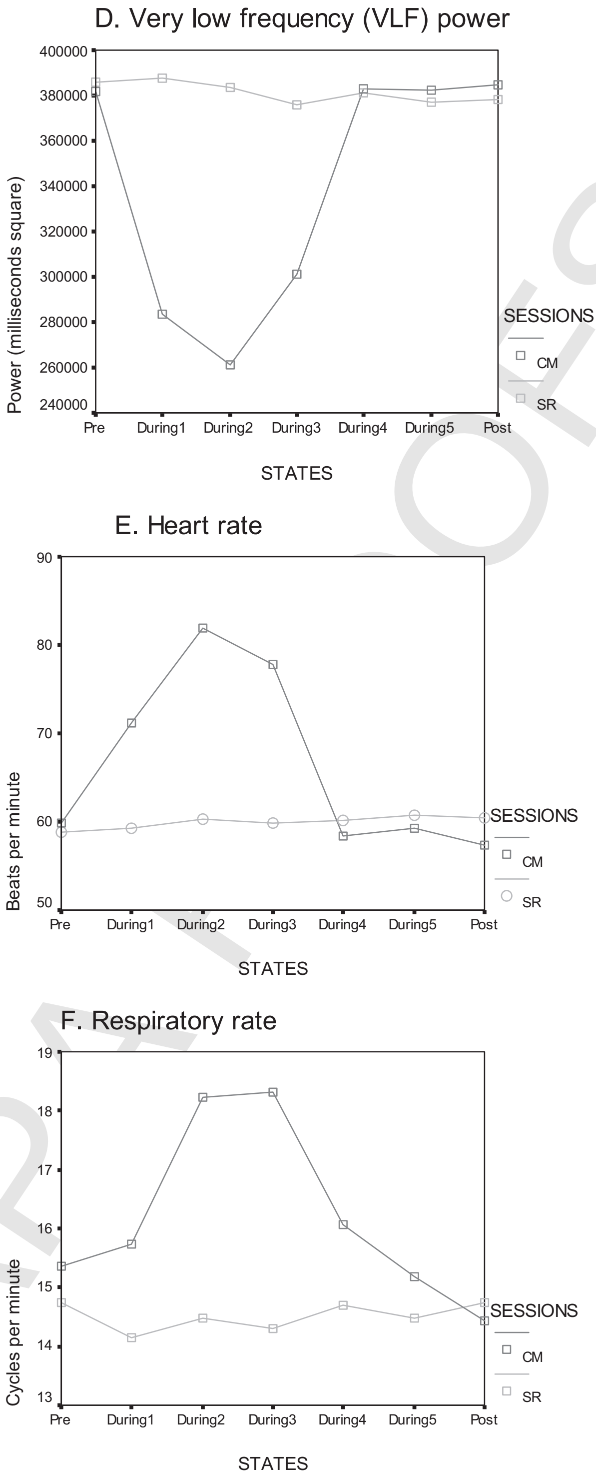

Figure 1. (*Continued*)

was significantly lower in the D2 phase of the CM session compared to the D2 phase of the SR session ($p < .001$). The trend of change in the HF power has been shown in Figure 1B.

There was a significant difference between States for LF/HF ratio, $F(4.52, 180.85) = 10.86$, $p < .001$, Huynh-Feldt É√ = .167, and in the interaction between Sessions and States, $F(5.25, 210.27) = 9.16$, $p < .001$, Huynh-Feldt É√ = .876. The significant interaction between states and sessions means that the effect of one of them is not independent of the other. Post hoc tests for multiple comparisons of states against their respective baseline or pre values showed a significant increase in the LF/HF ratio in the D2 phase (of yoga postures) compared to the pre phase and a decrease after CM compared to the pre phase ($p < .001$). There was no significant change in the SR session. The comparison of the two sessions (CM and SR) at each state showed the LF/HF ratio was significantly higher in the D2 phase of the CM session compared to the D2 phase of the SR session ($p < .001$) and was significantly lower after the CM session when compared to after the SR session ($p < .05$). The trend of change in the LF/HF rate is shown in Figure 1C.

For very low frequency (VLF) power there were significant differences between Sessions, $F(1, 41 = 25.32$, $p < .001$, Huynh-Feldt É√ = 1.00; States, $F(3.93, 157.18) = 36.59$, $p < .001$, Huynh-Feldt É√ = .591; and the interaction between Sessions and States, $F(3.21, 141.16) = 37.88$, $p < .001$, Huynh-Feldt É√ = .536. Post hoc tests for multiple comparisons of states with their respective baseline or pre values showed a significant decrease in VLF power in the D1, D2, and D3 phases ($p < .001$) compared to the pre phase for the CM session ($p < .001$). There was no significant change in the SR session. The comparison of the two sessions (CM and SR) at each state showed that VLF power was significantly lower in the D1, D2, and D3 phases of the CM session compared to the respective phases of the SR session ($p <$ .001). The trend of change in VLF power has been shown in Figure 1D.

For heart rate (HR) there were significant differences between Sessions, $F(1, 41) = 83.37$, $p < .001$, Huynh-Feldt É√ = .167; States, $F(3.61, 144.60) = 138.93$, $p < .001$, Huynh-Feldt É√ = .167; and the interaction between Sessions and States, $F(3.40, 136.05) = 136.66$, $p < .001$, Huynh-Feldt É√ = .567. Post hoc tests for multiple comparisons of states against their respective baseline or pre values showed a significant increase in HR in the D1, D2, and D3 phases ($p < .001$) compared to the pre values for the CM session, whereas it was significantly reduced after CM compared to the pre phase ($p < .001$). There was no significant change in the SR session. The comparison of the two sessions (CM and SR) at each state showed that HR was significantly higher in the D1, D2, and D3 phases of the CM session compared to the respective phases of the SR session ($p < .001$) and was significantly lower after the CM session compared to after the SR session ($p < .001$). The trend of change in the heart rate is shown in Figure 1E.

Table 1. LF Power, HF Power, LF/HF Ratio, VLF Power, HR, and RR in CM and SR Sessions

		Phases	
Variables	Sessions	Pre	During1
LF (n.u.)	CM	66.71 ± 9.05	66.57 ± 9.54
	SR	65.06 ± 12.44	64.19 ± 10.9
HF (n.u.)	CM	33.53 ± 9.00	33.43 ± 9.54
	SR	34.94 ± 12.44	35.76 ± 10.01
LF/HF ratio	CM	2.22 ± 0.90	2.23 ± 0.88
	SR	2.27 ± 1.30	2.05 ± 0.95
VLF (ms^2)	CM	381,836.78 ± 76,315.70	283,394.49*** ± 66,898.74
	SR	386,165.22 ± 79,165.36	387,836.10 ± 86,180.09
HR bpm	CM	59.79 ± 6.18	71.19*** ± 7.97
	SR	58.89 ± 5.98	59.26 ± 6.30
RR cpm	CM	15.35 ± 2.41	15.73 ± 2.89
	SR	14.75 ± 2.46	14.14 ± 2.72

Note. Values are group means ± *SD*s. LF = low frequency; HF = high frequency; VLF = very low frequency; HR = heart rate; RR = respiratory rate; CM = cyclic meditation; SR = supine rest.
$^{*}p < 0.05$. $^{***}p < 0.001$. (post-hoc tests with Bonferroni adjustment, compared with respective pre values)

For RR there were significant differences between Sessions, $F(1, 41) = 36.23$, $p < .001$, Huynh-Feldt É√ = 1.00; States, $F(3.86, 154.49) = 28.90$, $p < .001$, Huynh-Feldt É√ = .644; and the interaction between Sessions and States, $F(3.93, 157.18) = 36.11$, $p < .001$, Huynh-Feldt É√ = .655. Post hoc tests for multiple comparisons of states against their respective baseline or pre values showed a significant increase in the RR in the D2, D3, ($p < .001$), and D4 phases ($p < .05$), compared to the pre phase for the CM session and a decrease after the CM compared to the pre phase ($p < .001$). There was no significant change in the SR session. The comparison of the two sessions (CM and SR) at each state showed that RR was significantly higher during D1, D2, D3, D4 ($p < .001$), and D5 ($p < .05$) phases of the CM session, compared to the respective phases of the SR session The trend of change in the LF power is shown in Figure 1F. The group mean values and *SD*s of LF power, HF power, LF/HF ratio, VLF power, HR, and RR are given in Table 1.

DISCUSSION

The present study evaluated changes in HRV before, during, and after the practice of CM compared to a comparable period of SR (*Shavasana*). The practice of CM was considered in five phases, of which the first three included the actual practice of yoga postures, while the fourth and fifth phases consisted of guided relaxation.

Phases		
During3	During4	During5
75.70* ± 7.30	67.04 ± 8.41	65.70 ± 10.09
64.79 ± 12.80	66.91 ± 10.80	66.39 ± 10.20
24.28*** ± 7.30	32.95 ± 8.41	34.30 ± 10.09
34.99 ± 12.72	33.08 ± 10.80	33.60 ± 10.20
3.45*** ± 1.19	2.26 ± 0.93	2.19 ± 1.00
2.20 ± 1.03	2.35 ± 1.05	2.27 ± 1.02
261,083.76*** ± 57,685.64	301,392.98*** ± 57,311.10	382,935.27 ± 69,370.48
383,616.00 ± 86,377.02	376,016.73 ± 85,184.72	381,002.95 ± 86,870.62
81.95*** ± 9.21	77.73*** ± 7.91	58.36 ± 6.40
60.24 ± 6.28	59.86 ± 6.29	60.11 ± 6.40
18.21*** ± 3.40	18.31*** ± 3.51	16.07* ± 2.31
14.47 ± 2.97	14.29 ± 2.93	14.69 ± 2.58

LF power and the LF/HF ratio increased in the second phase of CM and was reduced after the practice by comparison with the baseline (pre phase). In contrast, HF power was reduced in the second phase and increased after the practice of CM, compared to the pre phase. HR showed an increase in the first three phases of CM and was reduced in the fifth phase with a further reduction after the practice of CM. In the SR session, there was no significant change in the LF power, HF power, LF/HF ratio, and HR.

The LF band of the HRV is mainly related to sympathetic modulation when expressed in normalized units (Task Force of the European Society of Cardiology and the North American Society of Pacing & Electrophysiology, 1996), and efferent vagal activity is a major contributor to the HF band. The LF/HF ratio is correlated with sympathovagal balance (Malliani, Pagani, Lombardi, & Cerutti, 1991).

CM is a moving meditation technique in which physical postures are interspersed with SR (Telles, Reddy, & Nagendra, 2000). The second phase of CM practice consists of a sideward bending posture (*ardhakatichakrasana*) and a forward bending posture (*padahastasana).* The increase in LF power and LF/HF ratio and reduction in HF power during this phase of CM suggests sympathetic activation and decreased cardiac vagal (i.e., parasympathetic) tone. These results are similar to the changes observed during the practice of an inverted posture known as the headstand or *Sirsasana* (Manjunath & Telles, 2003), which also resulted in changes suggestive of sympathetic activation. However, changes in autonomic tone are not the only factors that can vary LF.

Table 1. (*Continued*)

Variables	Sessions	Phases	
		During5	Post
LF (n.u.)	CM	64.65 ± 10.18	64.04*** ± 8.89
	SR	64.38 ± 9.99	65.25 ± 11.14
HF (n.u.)	CM	35.35 ± 10.18	36.18*** ± 8.64
	SR	35.61 ± 9.99	34.75 ± 11.14
LF/HF ratio	CM	2.08 ± 0.94	1.88*** ± 0.80
	SR	2.04 ± 0.89	2.16 ± 0.94
VLF (ms^2)	CM	382,453.83 ± 76,046.83	384,493.17 ± 82,098.71
	SR	377,139.39 ± 85,073.20	378,404.29 ± 85,180.11
HR bpm	CM	59.32 ± 5.32	57.42*** ± 5.61
	SR	60.80 ± 7.08	60.51 ± 6.74
RR cpm	CM	15.19 ± 2.14	14.42*** ± 2.33
	SR	14.47 ± 2.54	14.74 ± 2.66

Respiratory sinus arrhythmia (RSA) is a commonly employed noninvasive measure of cardiac vagal control (Wilhelm, Grossman, & Coyle, 2004). Respiratory variables such as tidal volume and breath rate have been shown to change with no change in tonic vagal activity. Hence, concurrent monitoring of respiration and physical activity are considered likely to enhance HRV accuracy to predict autonomic control. This is supported by acute increases in low frequency and total spectrum HRV and in vagal baroreflex gain, corrected with slow breathing during biofeedback periods (Lehrer, et al., 2003). It was earlier shown that biofeedback training to increase the amplitude of respiratory sinus arrhythmia maximally increases the amplitude of heart rate oscillations only at approximately 0.1 Hz. (Lehrer, Vaschillo, & Vaschillo, 2000). To achieve this, breathing is slowed to a point at which resonance occurs between respiratory-induced oscillations and oscillations that naturally occur at this rate. In the present study, changes in LF and HF power were correlated with changes in breath rate (monitored simultaneously). Breath rate increased significantly during the second, third, and fourth phases of CM and decreased after CM. The increase in breath rate during the practice of yoga postures (second and third phase) was more than during guided relaxation (fourth phase). This suggests that the shift to LF activity in the second phase of CM resulted from changes in autonomic balance and was not due to a change in breath rate to the low-frequency range.

The decrease in the LF power and the LF/HF ratio after the practice of CM suggests a shift toward vagal dominance. This is similar to HRV changes following a low velocity, low impact technique involving movements, called Wai Tan Kung. Wai Tan Kung is a traditional Taiwanese conditioning exercise. The effect of Wai Tan Kung was studied on autonomic nervous modulation in elderly volunteers (Lu & Kuo, 2003). The immediate effect of practicing Wai Tan Kung was to enhance vagal modulation and to suppress sympathetic modulation.

In the present study, VLF power decreased during the first, second, and third phases of CM, which involved practicing yoga postures. VLF power accounts for more than 90% of the total power in the 24-hour heart rate power spectrum, but the physiological mechanisms for VLF power have not been identified (Hadase, et al., 2004). VLF power in part reflects thermoregulatory mechanisms, fluctuation in activity of the renin-angiotensin system, and the function of peripheral chemoreceptors (Malliani, Pagani, Lombardi, & Cerutti, 1991; Parati, Saul, Di Rieuzo, & Mancia, 1995). Also, both the respiratory pattern and level of physical activity modulate VLF power (Bernadi, Valle, Coco, Calciati, & Sleight, 1996; Mortara, et al., 1997). In summary, the physiological mechanisms for VLF power are not fully understood (although this measure is currently considered to be a possible predictor of cardiac events in patients with cardiac disease; Hadase, et al., 2004). Hence, in the present study, there was no attempt to discuss the physiological significance of changes in VLF power during CM.

The increase in HR while practicing yoga postures during CM is not unexpected. The reduction in HR in the fifth phase of CM with a further decrease after the practice of CM suggests that the practice was followed by a period of parasympathetic dominance based on the HRV and heart rate. Changes in the HR during yogic practices are well known (Telles, et al., 2004). The present results, suggesting a shift toward parasympathetic dominance after the practice of CM, are compatible with those of an earlier study on the effects of CM, which showed a reduction in RR and oxygen consumption immediately after the practice of CM to a greater degree than after SR (Telles, Reddy & Nagendra, 2000).

The exact mechanism by which CM brings about a state of relaxation needs to be understood. It may be related to the fact that CM practice includes yoga postures (which involve stretching) and guided relaxation. When a body-mind training program, which included meditative stretching and guided relaxation, was practiced by persons with chronic toxic encephalopathy for eight weeks, they showed improved physical and mental relaxation as indicated by lower electromyograph activity, higher alpha percentage, and reduced state anxiety (Engel & Andersen, 2000).

When attempting to understand HRV changes that have occurred during CM, it is important to understand the factors involved in the practice. During CM, yoga postures are practiced with awareness, relaxation, and instructions to breathe normally. During the practice of a sitting yoga posture (*virasana*) there was an increased metabolic rate and increased sympathetic activity, which suggested that this practice is a "form of mild exercise" (Rai & Ram, 1973). Similarly the yoga postures may have caused an increase in LF power, as the immediate effect of (mild) exercise (Mourot, Bouhaddi, Tordi, Rouillon, & Regnard, 2004). The decrease in LF power and LF/HF ratio after CM to a lower level than the pre value and the value after the SR session suggests that the combination of yoga postures followed by guided relaxation is effective in modifying LF activity. Guided relaxation has been shown to be more effective in reducing physiological arousal than a control session of SR (Sakakibara, Takeuchi, & Hayano, 1994). Specifically yoga based guided relaxation (as used in CM) decreased LF power and increased HF power, a pattern that did not occur during a period of SR of the same duration (Vempati & Telles, 2002). Guided relaxation has several components, such as visual imagery and muscle relaxation that may contribute to the effect. However, the exact mechanism is not known. CM also includes awareness of the breath and of other sensations in the body. Zen meditation, in which deep relaxation and increased internalized attention coexist, increasing HF power, and decreasing the LF/HF ratio during the meditation (Murata, et al., 2004). Also, during the breath awareness phase of *Vipassana* mindfulness meditation, there was a decrease in the LF/HF ratio (Telles, Mohapatra, & Naveen, 2005). Hence, the changes (decrease in LF power, LF/HF ratio) after CM may be related to the effects of imagery and muscle relaxation (during guided relaxation) and of awareness (throughout CM practice). The fact that the change occurred after CM (and not during the phases of guided relaxation) suggests that it is the combination of yoga postures followed by guided relaxation that is effective. However, further studies are required to understand the exact mechanisms involved.

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