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Letter to the Editor

Changes in heart rate variability during concentration meditation ☆

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Abstract

This study aims at investigating changes in heart rate variability (HRV) measured during meditation. The statistical and spectral measures of HRV from the RR intervals were analyzed. Results indicate that meditation may have different effects on health depending on frequency of the resonant peak that each meditator can achieve. The possible effects may concern resetting baroreflex sensitivity, increasing the parasympathetic tone, and improving efficiency of gas exchange in the lung.

Keywords: Heart rate variability; Autonomic nervous system; Meditation; Pattern recognition

1. Introduction

Originally, meditation is a spiritual practice in many religions. Nowadays, it can be practiced by anyone regardless of their religions to facilitate a greater sense of calmness or awareness. There are many types of meditation techniques. The one adopted here is concentration meditation. The terms "meditation" and "Samadhi" used throughout this paper are defined as follows. *Meditation* is a practice of concentrated focus upon the breath in order to still the mind. *Samadhi* is the state of one-pointed concentration which is a product of successful meditation. In this study, we investigate changes in heart rate variability during concentration meditation to understand more its effects on health. Finally, we discuss and compare our results with those of the other meditation techniques [1–5] such as Qigong (Chinese style), Kundalini Yoga (Indian style), and Zazen (Japanese style).

2. Materials and methods

2.1. Subjects

Thirty-five experimental subjects were recruited on a voluntary basis (mean age 33.40 years, mean weight 58.69 kg, mean height 165.63 cm). These thirty-five subjects are meditation practitioners who have experienced in achieving the Samadhi state and most of them are meditation masters. And seventy age-matched subjects who did not have any experience in meditation practice were recruited as a control group (mean age 33.56 years, mean weight 57.44 kg, mean height 162.56 cm). At the time of enrolment, all subjects were in good general health, free of any history of cardiac or vascular disease, did not follow any specific exercise routines, did not take any form of medication, and did not drink coffee or tea before meditation practices or data recording. They were non-smokers and none of them were habitual drinkers. The overall general health conditions for the meditation group and the non-meditating control group were comparable. Informed written consent was obtained from each subject after the experimental procedures had been explained.

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2.2. Data collection

RR interval data were collected from subjects by using Polar 810/810i (Polar Electro Oy, Kempele, Finland). For the meditation group, the subjects sat in a cross-legged position and kept their eyes closed as they were accustomed to doing during their meditation practice. Subjects were first instructed to sit quietly for 5 min. After that, they performed concentration meditation by focusing on the breath in order to achieve the Samadhi state. The subjects were asked to meditate everyday for about 4 weeks. The RR interval data were collected during the practices. For the control group, the subjects were also instructed to sit quietly in a cross-legged position during data recording for about 10 min per time. Totally, data were recorded 3–4 times for about 4 weeks in each subject. There are totally 1677 and 654 segments (256-second period) of RR interval data from the experimental group and the control group respectively.

2.3. Data analysis

The RR interval data were analyzed in terms of HRV parameters both in time domain and frequency domain. Then, the HRV measures in the Samadhi state and the Non-Samadhi state were compared. The spectral parameters are used to gain insight into the autonomic nervous system (ANS) response induced by meditation. We considered two measures in time domain including the mean heart rate and the autocorrelation coefficient. The spectral HRV measures for each segment were calculated by using Fast Fourier transform [6]. According to the Task Force [7], the power spectrum for short time series can be classified into 3 ranges as follows: (i) power in the very low frequency range (VLF), 0.003–0.04 Hz, (ii) power in the low frequency range (LF), 0.04–0.15 Hz, and (iii) power in the high frequency range (HF), 0.15–0.4 Hz.

2.4. Data clustering

All of the data will be classified into K groups by K-means clustering method [8]. After that, the data in each cluster are investigated to summarize the characteristics of HRV measures in the Samadhi state and compare differences to those of the Non-Samadhi state.

3. Results

We use the following features: mean heart rate, autocorrelation coefficient, normalized VLF, LF and HF power spectra, width of the highest spectral peak, and frequency of the highest spectral peak for grouping the RR interval data. By using K-means clustering algorithm and investigating data in each cluster, we can summarize that there are 3 categories of data corresponding to states of mind including Normal state, Samadhi state, and Intermediate state (meditating but cannot achieve the Samadhi state yet). The prominent feature of the Samadhi state is the appearance of the single narrow peak with high amplitude called the resonant peak. The peak may appear in the LF, HF, or VLF ranges called the LF-, HF-, and VLF-resonant peaks respectively. Results show that HRV in the Samadhi state and the Non-Samadhi state are remarkably different.

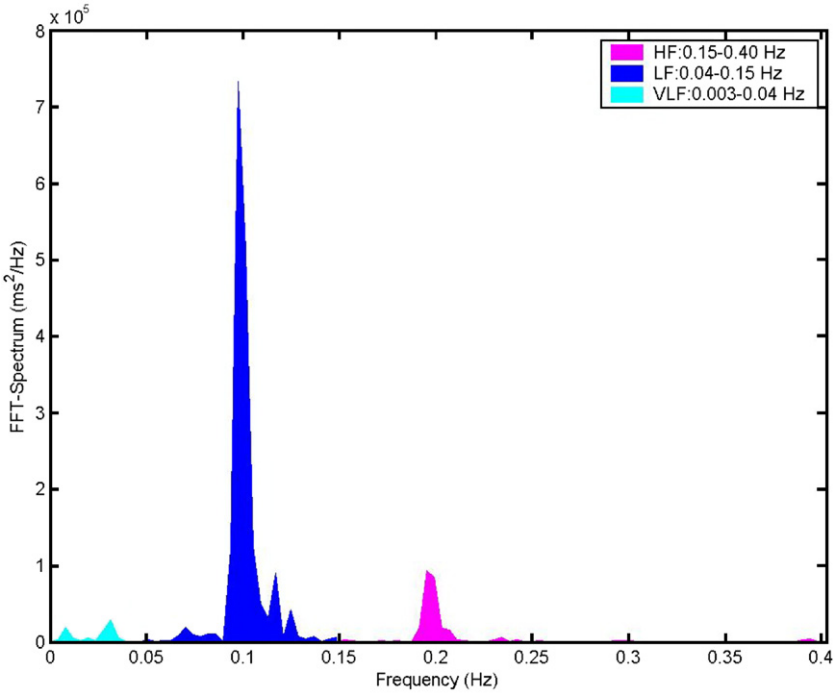

Fig. 1. Power spectrum of RR interval time series during the Samadhi State (during meditation).

4. Discussion

The resonant peak is the prominent characteristic of the Samadhi state. There are three types of the resonant peak. Each type may reflect different effects on health. Referring to the physiological explanation of spectral components, we may expect benefits of meditation in the sections that follow.

4.1. LF-resonant peak

For most cases, the LF power was increased during the Samadhi state. In particular, the "coherent mode" [9] appeared, i.e., there is a narrowed-band with high amplitude peak at around 0.1 Hz as an example shown in Fig. 1. But, for the Non-Samadhi state, the LF power was relatively low and there were several spectral peaks spreading throughout the VLF and LF ranges as shown in Fig. 2. This result is consistent with the results from Peng et al.'s work investigating Qigong meditation and Kundalini Yoga [1], and Lehrer et al.'s work investigating Zazen meditation [2]. The coherence means synchronization among diverse physiological oscillatory systems, e.g., heart rhythm, respiratory rhythm, and blood pressure rhythm [9]. From the physiological point of view, the coherence has the benefit for resetting of baroreceptor sensitivity which is involved in short-term blood pressure control [10].

4.2. HF-resonant peak

For some cases, the resonant peak appeared in the HF range during the Samadhi state. This phenomenon was not discovered before in the previous studies. However, it partially agreed with the results from Lee et al.'s work [3], and Takahashi et al.'s work [5]. They also revealed that the HF power was increased during meditation. The resonant peak in the HF range means that HRV is synchronized to the respiratory rhythm [10]. The HF power is primarily modulated by the parasympathetic system [7]. Therefore, the result in this case indicates that meditation can increase parasympathetic tone. And HRV in synchrony with respiration may also have a positive influence on gas exchange, i.e., improving efficiency of gas exchange in the lung [11].

4.3. VLF-resonant peak

Results revealed that it was possible to exhibit the resonant peak in the VLF range during the Samadhi state. But it is the rare case. Only one of the subjects participating in this study could induce the VLF-resonant peak. This phenomenon was accompanied with very slow heart rate (average 49.42 bpm). The subject also reported that he felt warm during meditation. Lehrer et al. [2] also reported that one subject in their study felt increased warmth during performing Zazen meditation. However, the physiological explanation of the VLF component is not well established. There is some evidence that it is related to thermoregulation [12], and humoral regulatory. These issues still need further investigation.

5. Conclusions

Our study revealed that heart rate variability during concentration meditation was changed from the normal state in a systematic way. During meditation, the power spectrum of

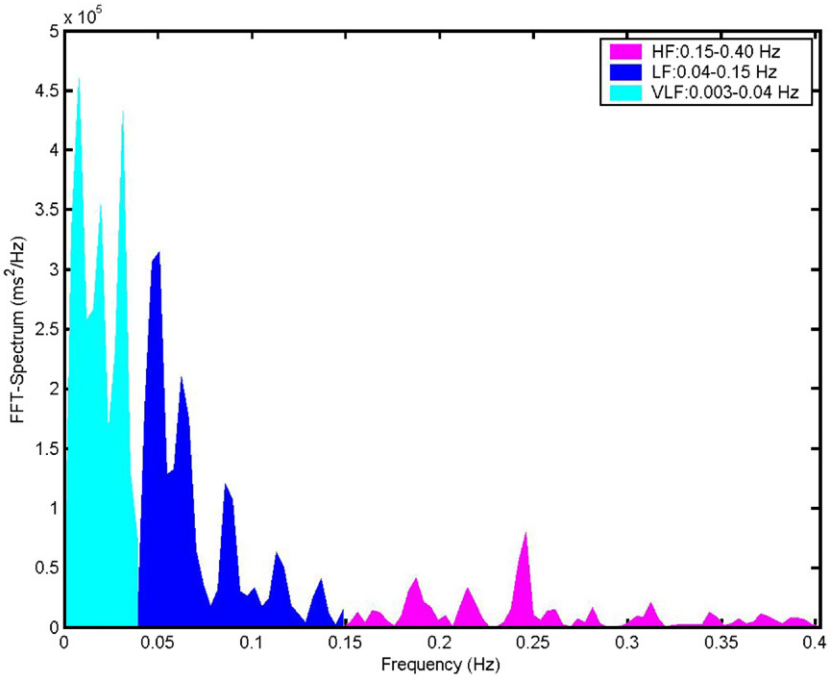

Fig. 2. Power spectrum of RR interval time series during ordinary quiet sitting.

the RR time series signal tends to shift towards a specific location of frequency to form the resonant peak. When the meditator can achieve the Samadhi state, the resonant peak will appear in the LF, HF or VLF ranges. Based on the physiological explanation of spectral components, it indicates that meditation may have the following health benefits: resetting baroreflex sensitivity, increasing parasympathetic tone and improving efficiency of gas exchange in the lung. It also can establish the unique VLF oscillation, but the physiological explanation of the VLF component is not clear now.

Acknowledgments

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