

Heart Rate Variability Associated with Different Modes of Respiration during Zen Meditation

Masaki Hoshiyama^{1,2}, Asagi Hoshiyama¹

¹Meisei University, Tokyo, Japan

²The University of Tokyo, Tokyo, Japan

Abstract

To understand the effect of respiration modes on hemodynamic events elicited by deep Zen meditation during Zazen, we studied heart rate in 2 intermediate Zen meditators. The study took place over 9 sets of Zen meditations in a quiet, Zen practice hall. Each set of Zazen lasted at least for 25 minutes. The first sets were used for habituation, and the data obtained from the following eight sets were used for analysis, where 2 modes of respiration, i.e., fast inhalation followed by slow exhalation (FISE) and slow inhalation followed by fast exhalation (SIFE), were allocated alternately. Power spectrum analysis showed distinctive change in frequency components. Very low frequency (VLF) components decreased for FISE ($p=0.05$). Most notably, detrended fluctuations analysis (DFA) of HRV were around 1/2 for FISE and 0.74 for SIFE. During Zen practice, we seat ourselves in a lotus posture, practice Tanden respiration, i.e., lower abdominal breathing, and keep mind free from specific state of consciousness. We attribute the decrease of VLF components and DFA exponent in FISE to the spontaneous and passive regulation of respiratory muscles during slow exhalation, as contrasted with the active use of respiratory muscles during slow inhalation in SIFE.

1. Introduction

Zen is a traditional meditation method which utilizes unification of body, respiration and mind [1]. Though Zen has been sophisticated highly in Japan, it is spreading widely into western world today, realizing deeper meditation with minimum body movement and distraction.

While heart rate variability (HRV) during sleep and meditation has been studied in the past [2-6], there remains a lack of consensus whether heart rate during Zen practice elicit consistent HRV differences for different modes of respiration.

Research done in our laboratory aims at using the

information contained in the fluctuation response of ECG heart rate to meditational state. To achieve this goal, it is necessary to understand better the mechanisms underlying the control of hemodynamic events through reciprocal autonomic activation elicited by meditational manipulation of body, respiration and mind. Specifically, we are interested in quantifying the degree of difference between ECG interbeat interval fluctuation responses seen during Zen meditations with different modes of respiration.

2. Methods

We studied heart rate in 2 intermediate Zen meditators who had been practicing multiple years of sitting Zen meditation (Zazen). The study took place over 9 sets of Zen meditations in a quiet, Zen practice hall in Kamakura or Tokyo. Each set of Zazen lasted at least for 25 minutes.

Zazen prescribes a certain bodily posture. We sit on a cushion 5 to 15 centimeters thick that is placed on our blanket. We cross our legs so that one foot rests on the opposite thigh with the sole of our foot turned up and with our knees touching the blanket (lotus or half-lotus position). The torso should be kept straight, but it should not be strained. Except in the belly, there should be no strain anywhere. The head should be kept high with our eyes opened slightly and focused on a point about a meter away on the floor (Fig 1).

We should breath calmly and deeply through nose, usually taking 2 or 3 times as long to exhale as to inhale (FISE; fast inhalation followed by slow exhalation). We should also use lower abdominal muscles to accomplish Tanden breathing.

We should keep mind free from specific state of consciousness or distractions where 3 methods have been used for over a thousand years: concentration on breathing, so called *shikantaza* which means only to sit, and the *koan*. For beginners we use the first one by counting breaths mentally from 1 to 10 beginning with 1 again (*susokukan*), or by following the breaths, being aware only of inhalation when inhaling, and only of exhalation when exhaling (*zuisokukan*).



Figure 1. Body posture of Zazen. Left: Statue of Buddha, Right: Schematic representation of lotus position. See text.

INTERMISSION	SITTING ZEN MEDITATION ZAZEN FISE	INTERMISSION	<u>ZAZEN SIFE</u>	INTERMISSION	ZAZEN FISE	INTERMISSION	<u>ZAZEN SIFE</u>	INTERMISSION	ZAZEN FISE	INTERMISSION	ZAZEN FISE	INTERMISSION	<u>ZAZEN SIFE</u>	INTERMISSION	ZAZEN FISE
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Figure 2. Sequence of events. 9 Zazen sessions were allocated with intermission before each session. The inter-beat intervals from ECG during last 8 Zazen meditations were used for analyses, where 2 modes of respiration, i.e., FISE and SIFE, were allocated alternately. See text.

For experienced meditator we use the latter two. In *shikantaza* we directly ignore any thoughts which might arise by simply letting any thoughts in and out without sticking to them. The *koan* is logically insoluble riddle, because it contains a contradiction. Logical solutions are rejected, and experienced meditators become ‘one with *koan*’.

The first sets were used for habituation, and the data obtained from the following eight sets were used for analysis. 2 modes of respiration were (FISE; fast

inhalation followed by slow exhalation) where we took 2 or 3 times as long to exhale as to inhale and (SIFE; slow inhalation followed by fast exhalation) where we took 2 or 3 times as long to inhale as to exhale. They were allocated alternately (Fig 2). The HR was obtained from ECG recordings.

We computed the detrended fluctuations analysis (DFA) exponents [2-5] of HRV for each FISE and SIFE respiration mode during Zazen. Exponents were calculated from linear fits to log-log plots of F(n) versus n

in the regime $70 < n < 350$. We chose this fitting range to be above the regime of short-range correlations related to breathing and below the n values where statistical errors become too large due to the finite length of each Zazen session.

3. Results

ECG data were analyzed for 2 subjects to test for autonomic states during each set of Zen meditation.

Population averaged results for heart rate were not significantly different between each modes of respiration. Power spectrum analysis using Lomb method showed distinctive change in frequency components. Very low frequency (VLF; 0.003Hz to 0.04Hz, $p=0.05$) components decreased for FISE. Low frequency component (LF; 0.04Hz to 0.15Hz) and high frequency component (HF; 0.15Hz to 0.40Hz) did not show significant differences between FISE and SIFE (Fig 3).

Most notably, population averaged results for DFA

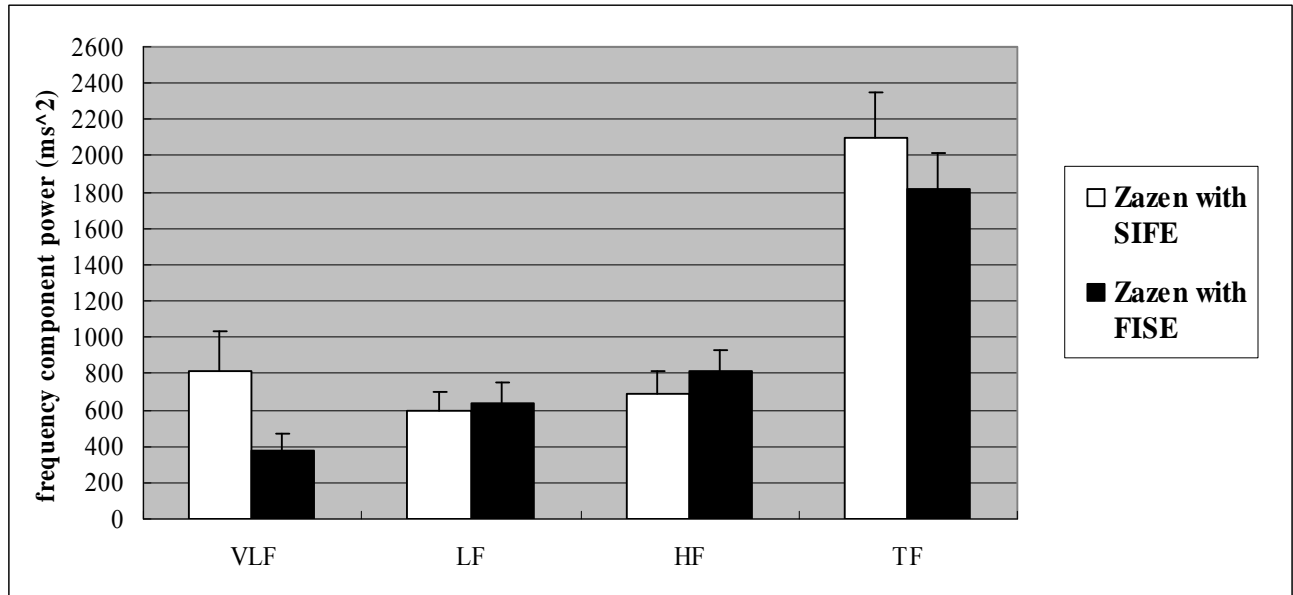


Figure 3. Frequency component power for VLF, LF, HF, TF of inter-beat intervals from ECG for Zen meditation with SIFE and FISE. Standard errors of the mean for 8 ECG segments per each group are presented as error bars.

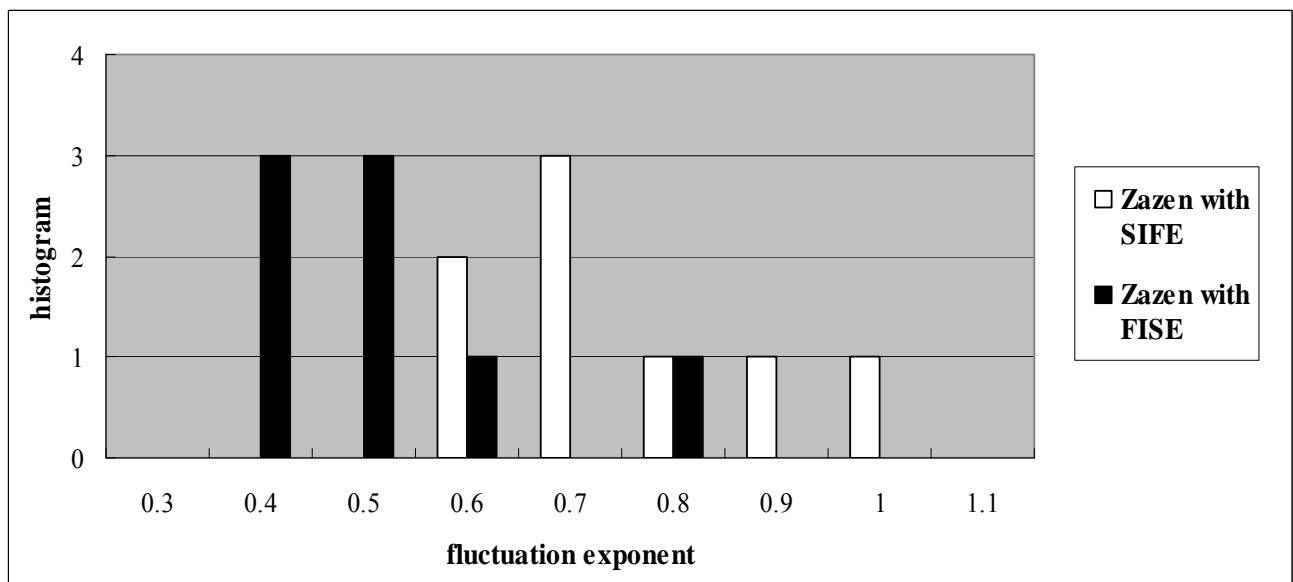


Figure 4. Histograms of DFA exponents of HRV for Zen meditation with SIFE and FISE. DFA exponents were around 0.74 for SIFE and around 0.5 for FISE.

exponents of HRV differed between FISE and SIFE. The histograms were centered around 1/2 for FISE, showing almost no correlations. DFA exponents of HRV were around 0.74 for SIFE, implicating long-range correlations (Fig. 4).

4. Discussion and conclusions

During Zen practice, we seat ourselves in a lotus posture, practice Tanden respiration, i.e., lower abdominal breathing, and keep mind free from specific state of consciousness. FISE mode of respiration has been recommended in order to accomplish deep meditative state of Zen, namely Zanmai. This study was designed to elucidate the heart rate response to respiration modes by comparing FISE and SIFE during Zen meditation.

We could not find any difference in mean heart rate between FISE and SIFE. Significant differences exist between the two groups in frequency components of the heart rate power spectrum. High frequency component is around the frequency of respiration, because it corresponds to respiratory sinus arrhythmia. Parasympathetic nervous system can transfer as high as 1Hz where respiratory sinus arrhythmia is transferred, but sympathetic nervous system cannot transfer fluctuations higher than 0.15Hz. High frequency component is modulated by parasympathetic nervous system, but not by sympathetic nervous system [7,8]. Mayer wave [9] in arterial blood pressure reflect itself to heart rate through arterial baroreflex which generates low frequency component of the heart rate variability [10,11]. Recently this low frequency component has also been found in heart rate fluctuations under the artificial heart control suggesting central origin of this autonomic nervous rhythm [12]. Since the low frequency component is within the transferable frequency of sympathetic nervous system, this component is modulated by both sympathetic and parasympathetic nervous system. As mentioned above, VLF components decreased for FISE modes, which could be attributed to the less easily distracted meditation.

In the previous sleep studies, DFA exponent of HRV decreased from 0.8 to around 1/2 when they fall into light sleep from awake [13,14]. We attribute the decrease of VLF components and DFA exponent in FISE to the spontaneous and passive regulation of respiratory muscles during slow exhalation, as contrasted with the active use of respiratory muscles during slow inhalation in SIFE, hence to the effective regulation of mind during sophisticated Zen meditation toward the edge of sleep, but not quite over it.

This result suggests the possibility of HRV as a handy and quantitative evaluator for Zen meditation.

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Address for correspondence.

Masaki Hoshiyama, M.D., Ph.D.
Omachi 1-9-12, Kamakura, Kanagawa, Japan
M.Hoshiyama@gmail.com