Heart Rate Variability Associated with Walking Zen Meditation Kinhin: towards 'Contemplatio Actione'

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Abstract

To understand the effect of Zen experience on hemodynamic events elicited by deep walking Zen (Kinhin) meditation, we studied heart rate in experienced Zen meditator and beginner. The study took place over 4 sets of Kinhin meditations in a quiet, Zen practice hall. Each set of Kinhin lasted at least for 25 minutes. The first sets were used for habituation, and the data obtained from the following three sets were used for analysis. Power spectrum analysis showed distinctive change in frequency components. Very low frequency (VLF) components decreased and high frequency (HF) components increased for experienced meditator ($p=0.05$). Most notably, detrended fluctuations analysis (DFA) of HRV were around 1/2 for experienced and 0.85 for beginner. During Kinhin practice, we put our both hands on a lower chest so that we can keep our center of balance in the lower abdomen (Tanden) with lower abdominal muscle contraction, practice Tanden breathing, and keep mind free from distraction. We attribute the decrease of VLF components, increase of HF components and decrease of DFA exponent in experienced meditator to the parasympathetic stimulation, and to the minimal use of antigravity muscles in the optimal walking posture generated by Tanden located center of balance, as contrasted with the active use of antigravity muscles in the unstable posture by beginners.

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 sitting Zen (Zazen) meditation has been studied in the past [2-6], there remains a lack of consensus whether heart rate during Kinhin elicit consistent HRV features.

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 Kinhin for experienced Zen meditator and beginners.

2. Methods

We studied heart rate in 2 experienced Zen meditators who had been practicing several years of sitting Zen meditation (Zazen) and 2 beginners. The study took place over 4 sets of Kinhin meditations in a quiet, Zen practice hall in Kamakura or Tokyo. Each set of Kinhin lasted at least for 25 minutes which was preceded by specific respiratory exercise. This respiratory exercise started with fully exhaling breath as one gently bent forward. Then one inhaled breath as gently rotating head backward, followed by exhaling breath as one gently rotated head forward.

Kinhin prescribes a certain bodily posture. We put our both hands on a lower chest. We close one hand in a fist while the other hand covers the fist. The torso should be kept straight, but it should not be strained. Except in the belly, there should be minimum 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. We should also use lower abdominal muscles (LAMC; intentional lower abdominal muscle contraction) in order 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*).

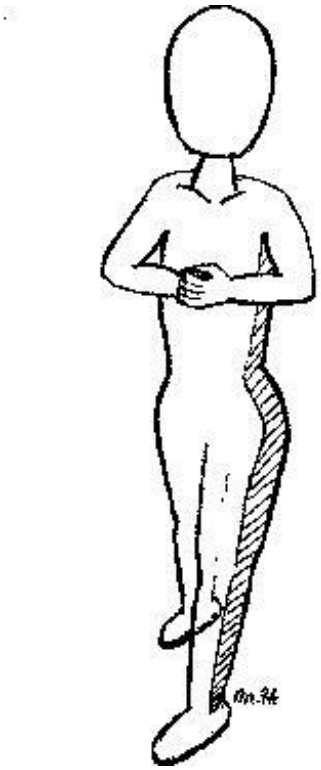

Figure 1. Bodily posture of Zen. Left: The Great Buddha of Kamakura, Right: Schematised Kinhin posture. See text.

RESPIRATORY EXERCISE	WALKING ZEN MEDITATION **KINHIN**	**INTERMISSION**	RESPIRATORY EXERCISE	WALKING ZEN MEDITATION **KINHIN**	**INTERMISSION**	RESPIRATORY EXERCISE	WALKING ZEN MEDITATION **KINHIN**	**INTERMISSION**	RESPIRATORY EXERCISE	WALKING ZEN MEDITATION **KINHIN**	**INTERMISSION**	RESPIRATORY EXERCISE

Figure 2. Sequence of events. 4 Kinhin sessions were allocated with specific respiratory exercise before and after each session. The inter-beat intervals from ECG during last 3 Kinhin meditations were used for analyses. 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 of Kinhin were used for habituation, and the data obtained from the following 3 sets were used for analysis (Fig 2). The HR was obtained from ECG recordings.

We computed the detrended fluctuations analysis (DFA) exponents [2-5] of HRV for experienced meditators and beginners during Kinhin. 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 Kinhin session.

3. Results

ECG data were analyzed for 4 subjects to test for autonomic states during each set of Kinhin meditation.

Population averaged results for heart rate were not significantly different between experienced and beginners. Power spectrum analysis using Lomb method showed distinctive change in frequency components. High frequency (HF; 0.15Hz to 0.40Hz, p=0.05) components increased for experienced meditators. Very low frequency (VLF; 0.003Hz to 0.04Hz, p=0.05) components decreased for experienced meditators (Fig 3).

Most notably, population averaged results for DFA exponents of HRV differed between experienced meditators and beginners. The histograms were centered around 1/2 for experienced meditators, showing almost no correlations. DFA exponents of HRV were around

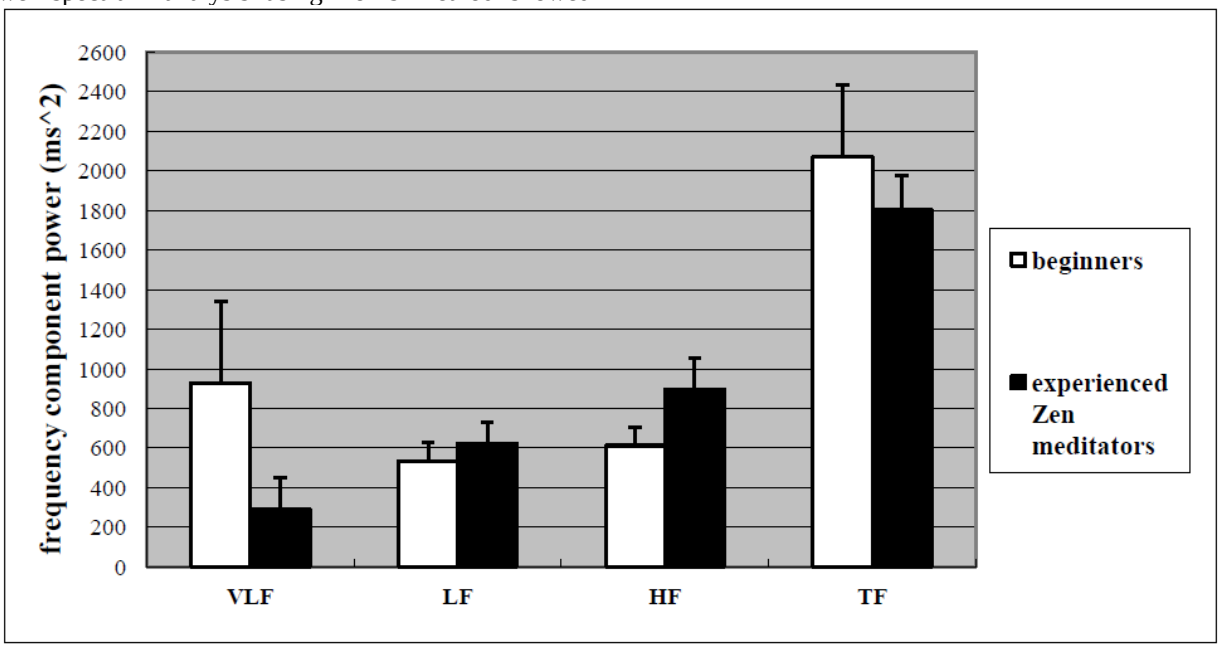

Figure 3. Frequency component power for VLF, LF, HF, TF of inter-beat intervals from ECG for beginners and experienced Zen meditators during Kinhin meditation. Standard errors of the mean for 6 ECG segments per each group are presented as error bars.

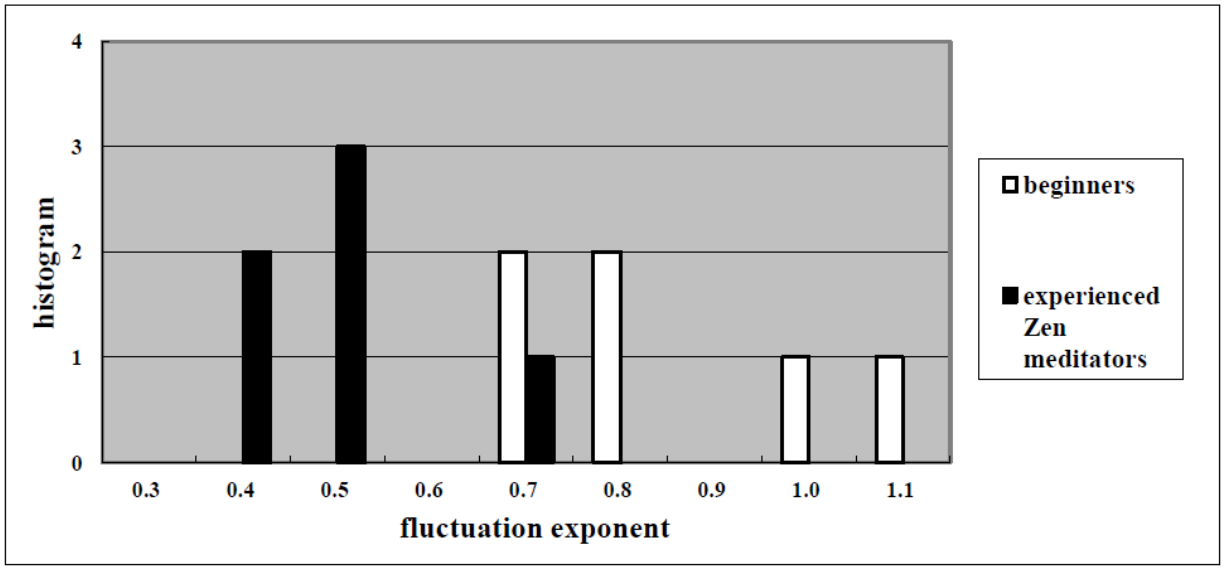

Figure 4. Histograms of DFA exponents of HRV for beginners and experienced Zen meditators during Kinhin meditation. DFA exponents were around 0.85 for beginners and around 0.5 for experienced meditators.

0.85 for beginners, implicating long-range correlations (Fig. 4).

4. Discussion and conclusions

During Kinhin practice, we put our both hands on a lower chest so that we can keep our center of balance in the lower abdomen (Tanden) with lower abdominal muscle contraction, practice Tanden breathing, i.e., lower abdominal breathing, and keep mind free from specific state of consciousness. Deep meditational state of Zen, namely Zanmai, can be accomplished after several years of Zen practice. This study was designed to elucidate the heart rate response to Zanmai during Kinhin by comparing beginners with experienced and practicing Zen meditators.

We could not find any difference in mean heart rate between beginners and experienced group. 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, HF components increased for experienced group and VLF components decreased for experienced group, which could be attributed to the response of parasympathetic neural enhancement and to the less easily distracted meditation with the minimal use of antigravity muscles in the optimal walking posture generated by Tanden located center of balance, as contrasted with the active use of antigravity muscles in the unstable posture by beginners.

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 DFA exponent in experienced meditators to the effective regulation of mind during highly sophisticated Kinhin meditation toward the edge of sleep, but not quite over it.

This result suggests the possibility of Kinhin as one step towards 'Contemplatio Actione', where we engage closely with meditation over time and allow ourselves to transform us into the images of ourselves we are created to be.

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