

The relaxation effect of prolonged expiratory breathing

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Abstract

This study was performed to confirm that autonomic nervous activity is affected by breathing speed. I hypothesized that prolonged expiratory breathing would promote parasympathetic dominance, whereas rapid breathing would promote sympathetic dominance. Ten healthy men, ages 21-28 years old, were instructed to perform prolonged expiratory breathing (6 seconds expiration, 4 seconds inspiration) after spontaneous breathing and rapid breathing (1 second expiration, 1 second inspiration) after spontaneous breathing; changes in high frequency (HF) and low frequency (LF)/HF of heart rate variability (HRV) were measured during each type of breathing. During prolonged expiratory breathing, parasympathetic nervous function was significantly activated. Conversely, during rapid breathing, parasympathetic nervous function was significantly suppressed. The HRV method assessing sympathetic and parasympathetic modulation in this study is an indirect, non-invasive method with clear limitations. The use of additional techniques should be considered to clarify the relationships between the breathing speed and the mind.

Introduction

The health promoting effects of slow breathing, as involved in yoga, have been known in the Orient for many years. Several methods of low breathing have been conveyed to the West, eliciting much attention and research.¹ However, sufficient medical research regarding the physiological significance of slow breathing has not been performed; thus, it is necessary to confirm that this modified breathing is beneficial to health.

The physiological effects of slow respiration are broad and complex, centered on the cardiovascular system. High frequency (HF) and low frequency (LF)/HF calculated from heart rate variability (HRV) represent parasympathetic nervous activity and sympathovagal balance to the heart, respectively.¹ There is data to support the association between parasympathetic nervous activity and the HF component of HRV, but the LF component seems to be influenced both by parasympathetic and sympathetic nervous activity.² Although these do not necessarily represent the autonomic nervous activity of the whole

body, the use of additional techniques should be considered.

This study was undertaken to confirm the influence of slow and rapid breathing on autonomic nervous function, as a foundation for future research on the mind. In future experiments, the use of additional techniques to examine the state of the mind is needed.

Materials and Methods

Participant recruitment and ethical considerations

This experiment was conducted with the approval of the Ethics Committee of Mie University Graduate School of Medicine. Eligible participants were excluded if they reported a history of smoking or cardiovascular disease. Enrolled participants comprised 10 healthy men, ages 21 to 28; informed consent was obtained from all participants.

Breathing technique

For rapid breathing, participants were instructed to breathe with 1 second expiration and 1 second inspiration. For prolonged expiratory breathing, participants were instructed to breathe with 6 seconds expiration and 4 seconds inspiration. The participants were instructed so that expiration duration became 6 seconds by taking a conscious one second for each of the start of breath, belly, lower abdomen, head, hand, and feet. Inspiration naturally became 4 seconds if it did not force. It was necessary to learn its feeling. Participants practiced and mastered this breathing technique for several days. Rapid breathing was able to be done by repeating expiration and inspiration, with a little exercise.

Laboratory environment

The study was performed between 14:00 and 16:00 in an air-conditioned room maintained at 20-23°C and 40-60% humidity. The room luminance was 300 lux. Each subject sat on a soft chair.

Electrocardiogram measurement

Electrocardiograms were measured using CheckMyheart (TRYTECH Co., Ltd.). Measurements were conducted for 5-minute periods. During each measurement period, the participants were asked to keep their eyes closed. Electrocardiogram data were analyzed by power spectrum analysis of frequency according to the principle of maximum entropy using associated software, and low frequency (LF; 0.04 to 0.15 Hz) and high frequency (HF; 0.15 to 0.4 Hz) components were calculated. The HF and LF/HF values were used as indices of parasympathetic nervous activity and sympathovagal balance, respectively.

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Study procedure

In Experiment 1, participants performed spontaneous breathing for 10 minutes and electrocardiogram measurement was performed for the latter half (for 5 minutes). Subsequently, prolonged expiratory breathing was performed for 10 minutes, and electrocardiogram measurement was performed for the latter half (for 5 minutes).

Experiment 2 was conducted on a separate day from Experiment 1. In Experiment 2, after 5-minute electrocardiogram measurements during spontaneous breathing, rapid breathing was performed for 10 minutes, and electrocardiogram measurement was performed for the latter half (for 5 minutes).

Statistical analysis

For statistical analysis, I utilized Student's t-test. P-values <0.05 were considered to be significant.

Results

The results of Experiment 1, involving prolonged expiratory breathing, are shown in Table 1. Prolonged expiratory breathing significantly increased HF and significantly reduced LF/HF.

The results of Experiment 2, involving

Table 1. Changes in autonomic nervous activity after rapid breathing.

	Spontaneous breathing	Rapid breathing
HF	35.87±2.32	32.12±2.41*
LF/HF	1.50±0.22	2.27±0.27*

HF; high frequency, LF; low frequency. *P<0.01 vs. spontaneous breathing.

Table 2. Changes in autonomic nervous activity after prolonged expiration.

	Spontaneous breathing	Prolonged breathing
HF	36.88±1.94	43.08±1.52*
LF/HF	1.53±0.29	1.08±0.23*

HF; high frequency, LF; low frequency. *P<0.01 vs. spontaneous breathing.

rapid breathing, are shown in Table 2. Rapid breathing significantly decreased HF and significantly increased LF/HF.

Discussion

Decreasing breathing frequency reportedly suppresses sympathetic nervous activity and activates parasympathetic nervous activity.^{2,3} Further, the activity of the vagus nerve is enhanced by 8 breaths per minute, compared with 12 or 16 breaths per minute; 8 breaths per minute shifts the balance to parasympathetic nervous activity.⁴ Although the relationship between breathing frequency and autonomic function has been thus reported, the increase in lung volume during inspiration activates pulmonary vagal afferents that reflexly inhibit sympathetic nerve discharge.⁴ Therefore, whether prolonged expiration is effective for relaxation is unknown unless we consider non-invasive or invasive techniques other than HRV. Excessive extension of expiration may increase the perception of stress. A breathing technique that comprises 4 seconds expiration and 2 seconds inspiration has been reported as effective, based on its load on the cardiovascular system.⁵ I con-

firmed in preliminary experiments that there is no tension (*i.e.*, stiffness), even when expiration is set to 6 seconds; in this study, I used a breathing technique of 6 seconds expiration and 4 seconds inspiration.

I conducted an experiment of rapid breathing as a contrast with prolonged inspiration. I planned to shorten only expiration while keeping inspiration for 4 seconds, but I set it to 1 second for both expiration and inspiration so that breathing rhythm can be easily adjusted. Although it is a model at the time of tension, it is sometimes shortened only by expiration at the time of tension and further experiments are needed. During rapid breathing, chest respiration solely uses the intercostal muscles; therefore, no diaphragm is used. One known cause of relaxation by prolonged expiration is that the movement of the diaphragm serves as a stimulus to the parasympathetic nerve.⁶

In this study, we found that prolonging expiration acts on parasympathetic dominance over the heart with HRV as an indirect, non-invasive method. It is a goal to use the prolonged expiration to stabilize the mind, and in future experiments, the use of additional techniques to examine the state of the mind is needed.

Conclusions

Using HRV as an index, this study showed that moderately prolonged expiration results in parasympathetic dominance, whereas rapid breathing leads to sympathetic dominance. Using HRV as an index, this study showed that moderately prolonged expiration results in parasympathetic dominance, whereas leads to sympathetic dominance. Further research is needed to show that prolonging expiration is beneficial for the stability of the mind.

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