EFFECTS OF BREATHING PRACTICE IN VINYASA YOGA ON HEART RATE VARIABILITY IN UNIVERSITY STUDENTS

By

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Abstract

Objective

This study investigated the effects of the breathing practice in vinyasa yoga on heart rate variability (HRV) in university students. High HRV is correlated with decreased anxiety and improved performance. It was hypothesized that HRV would increase and heart rate (HR) would decrease after yoga.

Design

Thirteen students were enrolled into a 10-week yoga program and asked to attend at least 5 yoga classes. Before and after the class, the students' HRV, and in some cases respiration rate, were measured. Each participant's measures were compared pre and post yoga sessions, and statistical differences or trends in the data were evaluated.

Setting

The study was performed in the Campus Recreational Center, University of Arizona.

Results

For students who attended 3 yoga sessions, HRV (standard deviation of inter beat intervals) significantly increased post versus pre for each session, and HRV in the low frequency range (LF power) was significantly increased after the third session compared to pre first session [1348±1468 ms^2 (SD) vs. 3796 ± 3456 ms^2, n=10]. Heart rate did not significantly change. Average respiration rate pre first session was 14.77 ± 2.54 (SD) br/min compared to 8.53 ± 2.56 after the last yoga session for which respiratory data were taken.

Conclusion

Students experience increased HRV and decreased respiration rate after yoga sessions, consistent with increased ability to handle stress.

Introduction

Heart rate variability is the variation in time intervals between heartbeats and reflects health and stress levels and sympathetic/parasympathetic balance. Maximal HRV is achieved when inhalation is associated with a marked increase in heart rate, due to decreased parasympathetic and increased sympathetic activation, and exhalation leads to a marked decrease in heart rate due to increased parasympathetic activation [1]. This process is called respiratory sinus arrhythmia (RSA), and when it is heightened, through deep, slow breathing, it promotes autonomic balance when neither the sympathetic nor parasympathetic component is dominant [2]. Autonomic balance is associated with lower stress levels and reduced risk of cardiac episodes [3]. Since improvement in autonomic balance and increased HRV lowers stress levels, this could lead to increased academic performance, benefiting students [4]. Feelings of stress and anxiety can diminish academic performance [5].

Several studies demonstrate the beneficial effects of yoga as a relaxation technique and a method to reduce stress [5-7]. Through a series of breathing practices, meditation, and poses, yoga has the ability to help practitioners manage stress. This benefit is thought to be due to improvement in eye-hand coordination, attention, relaxation, and concentration [7].

This study investigated the effects of vinyasa yoga on HRV in healthy students at the University of Arizona. Vinyasa yoga focuses on the flow of postures and on linking the breath to the movement [8]. The goal of this study was to determine whether the breathing method in yoga, practiced once a week, increases HRV based on the concept of heightened RSA. Respiratory sinus arrhythmia affects HRV because deep inhalation enhances venous return, causing the right atrium to stretch and activating receptors which signal to the brain to increase heart rate by activating the sympathetic nervous system. During exhalation venous return decreases and heart rate goes down. This coupling between breathing and HRV maximized when one breathes deeply and slowly [2]. Therefore just by controlling one's breath, one gains the ability to balance the ANS and increase HRV.

A prior study on the effect of yoga on stress and HRV showed that yoga's meditation and relaxation techniques can benefit pregnant women [9]. The HRV frequency spectrum in these women after yoga showed a decrease in sympathetic tone and an increase in parasympathetic tone, indicating an increase in balance in the autonomic nervous system. However, another study on yoga, involving only high frequency breathing, showed the opposite response [10]. If after practicing yoga, one's HRV is increased, those who suffer from anxiety, high blood pressure, emotional stress, or other stress related disorders could use yoga as a way to control their HRV adding to yoga's physical benefits.

Hypothesis

We hypothesize that HRV and autonomic balance will increase, and mean HR will decrease after yoga sessions

Methods

Human Subjects Approval

This experimental protocol was approved by the Institutional Review Board for Human Research, University of Arizona.

Participants

Participants were recruited based on their age and student status. The inclusion criteria were: a) must be between 18 and 22 years old and b) must be a current student at the University of Arizona. It was preferred, but not required that they have prior experience in yoga. The participants were recruited using email advertisements and advertisements posted at sites that students frequently visit, such as Facebook. The same script was used for both the email advertisements and social media posts. The recruitment occurred 2 weeks prior to data collection. The potential participants were informed that they were responsible for the cost of the series of yoga sessions ($25 for series) because this class was a "special fitness program" using University resources. Those who agreed were asked to sign a consent form explaining the purpose, protocol, measurements, procedure, and benefits of the study. Participants also completed a demographics form that was kept with the consent form in the locked room.

There were 14 participants recruited for this study, 2 males and 12 females. Nine of the participants were Caucasians, 2 Hispanics, 1 Asian Pacific Islander, and 1 Native American. The goal was to recruit 24 participants for the yoga class. However, only 14 were recruited by the time the class started. One participant withdrew from the study after the first class. Since this was a pilot study, it was decided to proceed with fewer students than planned.

Protocol

Subjects (n=13) registered for a yoga class, at the University of Arizona Recreational Center, that met once a week for ten weeks. The students were requested to attend at least 5 classes. Before the start of their first class, the participants were asked to complete a yoga study questionnaire to provide information about how often they attended yoga classes, if at all, and about their physical activities outside of school. The yoga performed in the class was vinyasa yoga, which entails a flow of different poses that are paired with breathing practice. The yoga instructor was certified (certification by YTT 200) and worked for the University of Arizona Recreational Center. Each yoga class was one hour long.

Data Collection

Heart rate variability data were collected from each subject before and after each class that they attended throughout the 10 weeks. For the measurements taken before the class, subjects were instructed to breath the way they usually do when at rest. For the measurements taken after the class, subjects were instructed to utilize the breathing practice that they used during the yoga class. Heart rate variability (inter beat intervals, (IBI)) and respiration were measured using the "Biograph Infiniti ProComp" device (Thought Technology, Montreal, Quebec, Canada). The "emWave 2" device (Institute of HeartMath, Boulder Creek, California) was also used to measure IBI. The parameters that were derived from IBI data were: percentage low frequency and high frequency powers, standard deviation of IBI (SDNN), root mean square of successive differences (RMSSD), HR, low frequency power (LF) and high frequency power (HF).

Before each class began, about half of the subjects had their HRV and respiration measured for five minutes with the "Biograph Infiniti ProComp" device and the other half had their HRV measured with the emWave 2. Throughout the study, each participant had their HRV and respiration measured by the Biograph Infiniti device at least once. After the class, the same subjects had their measurements repeated, using the same device, for 5 minutes.

Statistics

Paired Student t-test was used to compare the participants' measures for pre and post yoga sessions and to test for trends within each of the 5 parameters: SDNN, RMSSD, HR, LF power, and % LF power. No tests ere performed for HF power or %HF because pre and post values were almost the same. Statistical comparisons with p values of 0.05 or less were considered significant. Subjects were divided into two groups based on the number of yoga classes they attended. For the subjects who attended 3 classes, paired Student t-tests were performed on the 5 parameters for pre versus post for each class. In addition results were compared Pre Session 1 vs. Post Session 3. For the subjects who attended 4 classes, paired t-tests were performed for pre versus post for each class. In addition results were compared Pre Session 1 vs. Post Session 4. vs. Post Session 4, and Pre Session 1 vs. Post Session 4.

Results

For the 10 subjects who attended at least 3 yoga sessions, SDNN significantly increased after the first yoga session ($p<0.05$), but HR did not change [Table 1]. After the third yoga session, not only was there an increase in SDNN, and LF power and % LF also significantly increased. The long-term trend was that LF power and %LF significantly increased after the third yoga session compared to prior to the first session (baseline) [LFP: 1348 ± 1468 ms^2 [SD] vs. 3796 ± 3456 ms^2; % LF: 40.3 ± 20.5 vs. 40.3 ± 20.5].

The results from the 6 subjects who attended at least 4 yoga sessions did not show any significant differences before and after their individual yoga sessions except for the fourth yoga session, although trends were seen. This was most likely due to the low number of subjects involved. However, even with this small number of subjects, significant increases in LF power and %LF were seen over the long-term (after the fourth session compared to baseline) [LFP: 1702 ±1848

ms^2 vs. 10,169 ± 6617 ms^2; %LF: 39.4 ± 25.8 vs. 81.1 ± 7.5]. Respiration rate data were collected randomly from pre and post sessions throughout the study amongst 10 of the participants. Overall, it was found that there was a significant decrease in the average respiration rate of the subjects after the last yoga session for which respiratory data were taken, where the pre-session rate was 14.77 ± 2.54 breaths/min and the post-session rate was 8.53 ± 2.56 breaths/min.

Discussion

This study analyzed students attending a yoga program to determine the effects of the breathing techniques used in yoga practice on HRV. After each yoga session, HRV increased compared to the baseline measure. These results suggest that a yoga class may reduce an individual's stress level on that given day. Therefore the hypothesis was partly supported by the data. However, mean HR did not significantly change from pre measure to post measure, or throughout the study. This result could be due to the wait time between the end of the class and the data collection (1-30 minutes) so the heart had time to return to its regular rate. Heart rate also could have increased during the class due to physical activity, which would then mask any potential decrease in heart rate due to a relaxation effect.

Another consistent result was the significant increase in LF power after yoga sessions, which was seen in subjects who attended the yoga class 3 or 4 times. This increase in LF power may be linked to the overall significant decrease in breathing rate that was observed throughout the study. Low frequency power reflects the amplitude of HRV that occurs within the frequency range 0.05-0.15 Hz. The HRV LF power is increased when one breathes at a frequency within the same range (5-7 breaths per minute) through a resonance mechanism [11]. Breathing at this frequency also enhances oscillation in blood pressure that increases baroreceptor sensitivity and allows one's blood pressure to be better modulated [11].

To determine whether the increases in HRV and LF power were sustained and amplified over time (due to a learning curve) or were limited to the effects of an individual yoga class, data from one participant, Subject 10, who came to 7 yoga sessions, are presented separately (Figure 1). This subject's SDNN gradually increased throughout the 10-week period, as did their LF power. These results support the possibility of a learning curve for some people who may have the ability to improve over time. However, the rest of the participants did not show as consistent of an increase in their HRV over time as Subject 10. A possible explanation for this apparent lack of improvement is that HRV is influenced by unpredictable, emotional events that may happen week to week, causing variability in baseline HRV. However, yoga appears to improve an individual's HRV on a given day regardless of their starting point that day.

Limitations

One limitation of this study was that the sample size was small. The low recruitment may have been due to the cost of the program. If the yoga program had been free, perhaps more people would have signed up. Secondly, there was a variable delay of data collection after each yoga session. Since there were only two people who could collect the data, some participants had to wait up to 30 minutes before their post-session data were collected. This wait time could have affected their results.

Conclusion

Overall, this pilot study provides promising results that HRV can be increased in university students after attending yoga sessions. This conclusion is based on the increase in HRV that our sample experienced, on average, after each individual session, and on the increase in LF power demonstrated after the last yoga session compared to prior to the first session. Since high HRV is correlated with a better ability to cope with stress and with improved academic performance, it would be worth conducting further studies with larger numbers of students to see whether these results are confirmed.

Conflict of Interest Statement

The authors do not have any conflicts of interest.

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References

[1] Lehrer PM, Vaschillo E, and Vaschillo B. "Resonant Frequency Biofeedback Training to Increase Cardiac Variability: Rationale and Manual for Training." *Applied Psychophysiology and Biofeedback* 2000, 25 (3): 177-191

[2] Paprika D, Gingl Z, Rudas L, Zöllei E. "Hemodynamic effects of slow breathing: Does the pattern matter beyond the rate?" *Acta Physiologica Hungarica* 2014, 101(3): 273-81

[3] Tiller W, McCraty R, and Atkinson, M. "Cardiac Coherence: A New, Noninvasive Measure of Autonomic Nervous System Order." *Alternative Therapies in Health and Medicine* 1996; 2(1): 52-66

[4] Motowidlo SJ, Packard JS, and Manning MR. "Occupational stress: Its causes and consequences for job performance." *Journal of Applied Psychology* 1986. 71(4): 618-29

[5] Kauts A and Sharma N. "Effects of yoga on academic performance in relation to stress." *International Journal of Yoga* 2009, 2(1): 39-43

[6] Markil N, Whitehurst M, Jacobs PL and Zoeller RF. "Yoga nidra relaxation increases heart rate variability and is unaffected by a prior bout of Hatha yoga." Journal of Alternative and Complementary Medicine 2011; 18(10): 953-958.

[7] Telles S, Nagarathna R, Vani PR, Nagendra HR. "A combination of focusing and defocusing through yoga reduces optical illusion more than focusing alone." *Indian Journal of Physiology and Pharmacology*. 41(2): 179-82, 1997.

[8] Uebelacker LA, Tremont G, Epstein-Lubow G, Gaudiano BA, Gillette T, Kalibatseva Z, and Miller IW. "Open trial of Vinyasa yoga for persistently depressed individuals: evidence of feasibility and acceptability." *Behavior Modification* 2010; 34(3): 247-264

[9] Satyapriya S, Nagendra H, Nagarathna R, and Padmalatha V. "Effect of integrated yoga on stress and heart rate variability in pregnant women." *International Journal of Gynecology and Obstetrics* 2009, 104(3): 218-222

[10] Telles S, Singh N, and Balkrishna A. "Heart rate variability changes during high frequency yoga breathing and breath awareness." *BioPsychoSocial Medicine* 2011, 5(4)

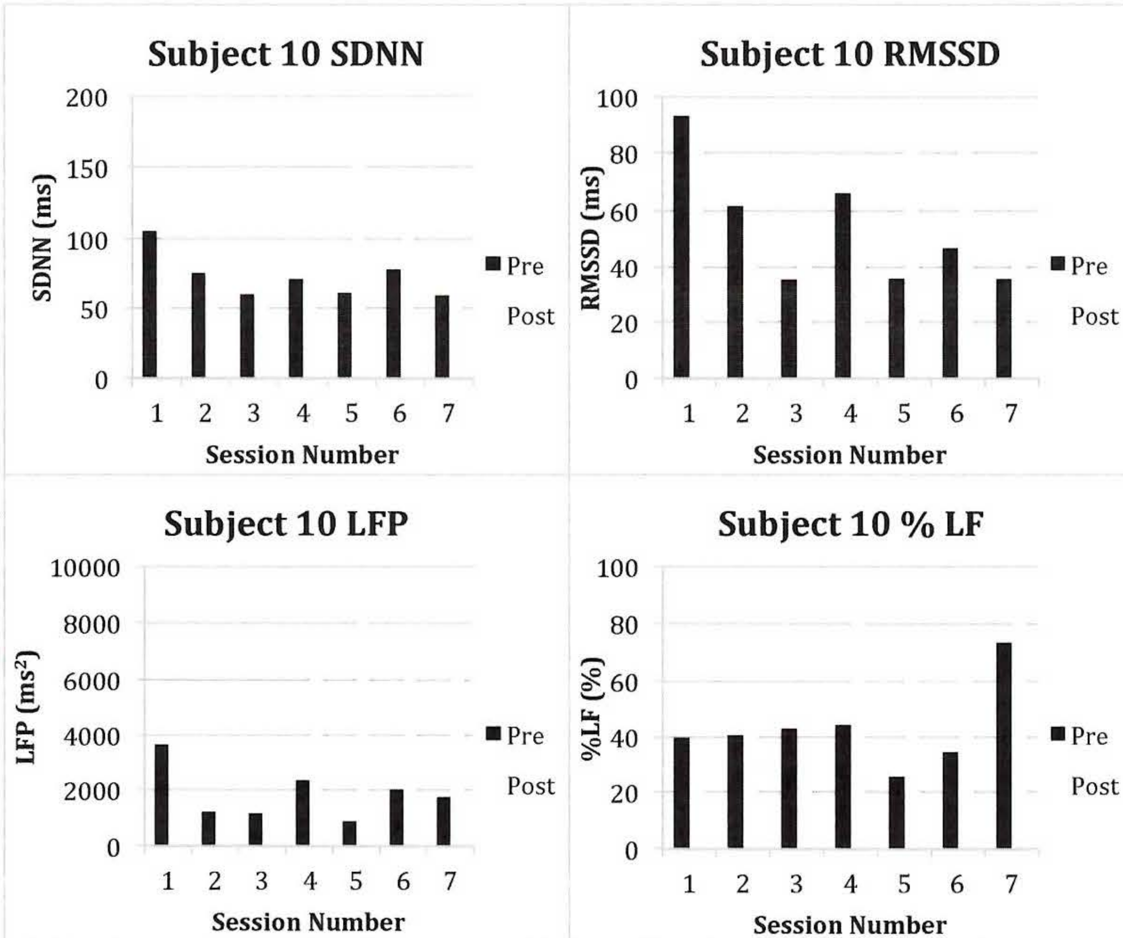
[11] Vaschillo E, Lehrer P, Rishe N, and Konstantinov M. "Heart Rate Variability Biofeedback as a Method for Assessing Baroreflex Function: A Preliminary Study of Resonance in the Cardiovascular System." *Applied Psychophysiology and Biofeedback* 2002, 27(1): 1-27

Figure Legends

Figure 1: Changes in autonomic nervous response of subject 10 over 7 sessions

Autonomic parameters were defined as follows: SDNN [standard deviation of IBI in milliseconds], RMSSD [root mean squared root of standard differences in milliseconds], HR [heart rate in beats per minute], LFP [low frequency power in milliseconds squared], and % LF [percentage low frequency power].

Figure 1:


Subject 10 SDNN
200
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SDNN (ms)
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Subject 10 RMSSD
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Subject 10 LFP
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Session Number
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Subject 10 % LF
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%LF (%)
1 2 3 4 5 6 7
Session Number
Pre
Post

Table 1: Changes in HRV in subjects who attended 3 or 4 yoga sessions

* $p < 0.05$ comparing pre-session versus post-session

N=10	SDNN	RMSSD	HR	LFP	% LF
Pre 1	62.9 ± 21.2[SD]	56.0 ± 25.6	82.8 ± 11.3	1348 ± 1468	40.3 ± 20.5
Post 1	96.7 ± 37.9*	84.8 ± 46.4	79.5 ± 11.3	3843 ± 3561	49.2 ± 22.0
Pre 2	53.2 ± 28.4	47.3 ± 24.1	84.4 ± 14.1	691 ± 624	32.4 ± 19.5
Post 2	90.4 ± 36.4	78.4 ± 36.1	77.8 ± 10.1	6701 ± 6947	59.5 ± 25.4
Pre 3	54.8 ± 22.0	44.8 ± 22.7	84.4 ± 10.6	981 ± 949	35.3 ± 20.9
Post 3	75.4 ± 33.5*	55.1 ± 34.6	82.0 ± 12.7	3796 ± 3456*	60.0 ± 23.7*
N=6	**SDNN**	**RMSSD**	**HR**	**LFP**	**% LF**
Pre 1	65.6 ± 23.2	50.2 ± 25.7	79.5 ± 12.4	1702 ± 1848	39.4 ± 25.8
Post 1	85.4 ± 56.3	96.6 ± 55.2	81.4 ± 15.4	4601 ± 4537	49.0 ± 20.2
Pre 2	61.9 ± 33.1	53.4 ± 26.5	79.3 ± 15.5	879 ± 732	34.4 ± 23.5
Post 2	99.8 ± 35.1	81.8 ± 37.6	74.3 ± 12.8	7610 ± 6183	67.8 ± 24.2
Pre 3	57.7 ± 19.8	42.1 ± 22.4	81.9 ± 10.0	1269 ± 1107	42.0 ± 25.3
Post 3	75.0 ± 27.7	47.7 ± 23.0	80.5 ± 15.7	4166 ± 3220	70.3 ± 24.4
Pre 4	75.3 ± 37.9	69.3 ± 48.0	82.3 ± 17.0	1882 ± 1240	39.0 ± 26.4
Post 4	104.7 ± 44.9	71.1 ± 35.9	76.9 ± 12.4	10169 ± 6617*	81.1 ± 7.5*