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Effects of Breathing Practice in Vinyasa Yoga on Heart Rate Variability in University Students- A Pilot Study

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Abstract

Objective: This pilot 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 after yoga HRV would increase and heart rate (HR) would decrease.

Design: Thirteen students were enrolled into a 10-week yoga program and asked to attend at least 3 yoga classes. Before and after each class, the students' HRV was measured. Respiration rate was measured before and after half of the classes that each student attended. 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 was greater after each session than before the session, reaching statistical significance for sessions 1 and 3. Heart rate variability in the low frequency range (LF power) significantly increased after the third session compared to baseline (before first session). Heart rate did not significantly change. Average respiration rate after the last session each student attended was significantly lower than before the session.

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

Running Head: Vinyasa Yoga and Heart Rate Variability

Keywords: Vinyasa yoga; Breathing; Heart rate variability

Introduction

Heart rate variability (HRV) is the variation in time between heartbeats produced by changes in sympathetic and parasympathetic activities. Maximal HRV is achieved when inhalation is accompanied by a marked increase in heart rate (HR), due to decreased parasympathetic and increased sympathetic activation, and exhalation results in the opposite response [1]. This coupling between breathing and HRV, respiratory sinus arrhythmia (RSA), is optimized when one breathes deeply and slowly [2]. Therefore just by controlling one's breath, one can increase HRV. High HRV is associated with lower stress levels and reduced risk of cardiac episodes [3]. Training in RSA could also lead to increased academic performance because stress and anxiety have been shown to diminish performance [4]. This outcome would be especially beneficial to university students.

One way to slow down breathing is to practice some forms of yoga. Several studies demonstrate the efficacy of yoga as a method to reduce stress through breathing practices, meditation and poses [5-7]. Vinyasa yoga focuses on the flow of postures and on linking the breath to the movement [8]. This study investigated the effects of vinyasa yoga on HRV in healthy students at the University of Arizona. The goal was to determine whether the breathing method in yoga, practiced once a week, increased HRV.

A prior study showed that the HRV frequency spectrum of pregnant women displayed decreased sympathetic and increased parasympathetic tone after yoga, indicating an improved autonomic balance [9]. However, two studies on men, using a form of yoga involving only high frequency breathing (1-2 Hz), showed the opposite response [10,11]. Thus the frequency of breathing in yoga is important regarding effects of HRV. If after practicing vinyasa yoga one's HRV increases, those suffering from emotional stress or stress related disorders could use yoga to control their HRV.

Methods

Human Subjects Approval. This pilot study was approved by the Institutional Review Board for Human Research, University of Arizona.

Participants

Participants were recruited based on their age (18-22 years) and student status. It was preferred, but not required that they have prior experience in yoga. Participants were recruited using advertisements promulgated by email and social media sites two weeks prior to data collection. Potential participants were informed that they would need to pay $25 for the yoga series because this class was a "special fitness program" using University resources. Those who agreed signed a consent form explaining the purpose, protocol, measurements, and benefits of the study and a demographics form. Fourteen participants were recruited for this study: 2 males and 12 females. Nine participants

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were Caucasian, 2 Hispanic, 1 Asian Pacific Islander, and 1 Native American. The goal was to recruit 24 participants but 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, from 6:30 – 7:30 pm, for ten weeks. Students were requested to attend at least 3 classes. Before the first class, participants completed a yoga study questionnaire to provide information about how often they attended yoga classes, if at all, and about their extracurricular physical activities. The yoga performed in the class, vinyasa yoga, 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

Before each class began, half of the subjects had their HRV (Interbeat interval, IBI) and respiration measured for 5 minutes with the "Biograph Infiniti ProComp" device (Thought Technology, Montreal, Quebec, Canada); the other half had their HRV measured with the "emWave 2" device (Institute of HeartMath, Boulder Creek, California). Throughout the study, each participant was measured with the Biograph Infiniti device before and after half of the classes that they attended. After a given class, the same subjects had their measurements repeated, using the same device, for 5 minutes. For measurements taken before the class, subjects were instructed to breathe the way they usually do when at rest. For post measurements, subjects utilized the breathing practice used during the yoga class. The parameters derived from IBI data were: standard deviation of IBI (SDNN), root mean square of successive differences (RMSSD), HR and low frequency (LF) and high frequency (HF) powers and %LF and %HF powers.

Statistics

Participants' HRV measures for pre and post yoga sessions were compared using paired Student t-test. No tests were performed for HF power or %HF because pre and post values were almost the same. Statistical comparisons with $p< 0.05$ or less were considered significant. Subjects were divided into two groups based on the number of yoga classes they attended. For both groups, paired Student t-tests were performed for pre versus post HRV measures for each class. For subjects who attended 3 classes HRV results were also compared Pre Session 1 vs. Post Session 3 and for subjects who attended 4 classes, Pre Session 1 vs. Post Session 4. Respiration rates were also compared pre and post for the last session each student attended.

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 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 pre first session (baseline) [LF power: 1348 ± 1468 ms^2 [SD] vs. 3796 ± 3456 ms^2; % LF: 40.3 ± 20.5 vs. 60.3 ± 23.7].

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 probably 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) [LF power: 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 from 10 of the participants for half of the classes each student attended. Overall, for the last yoga session for which respiration rate was monitored, respiration rate significantly decreased post versus pre-session (pre: 14.90 ± 2.15 (SD); post: 8.59 ± 2.51 breaths/min.)

Discussion

This study analyzed students attending a vinyasa yoga program to determine the effects of the breathing techniques on HRV. After each

N=10	SDNN (ms)	RMSSD (ms)	HR (bpm)	LFP (ms^2)	% 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 (ms)	RMSSD (ms)	HR (BPM)	LFP (ms^2)	% 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*

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].
All values are expressed as mean ± standard deviation (SD)
* $p < 0.05$ comparing pre-session versus post-session
** $p< 0.05$ comparing pre-session 1 versus post-session 3 or 4

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

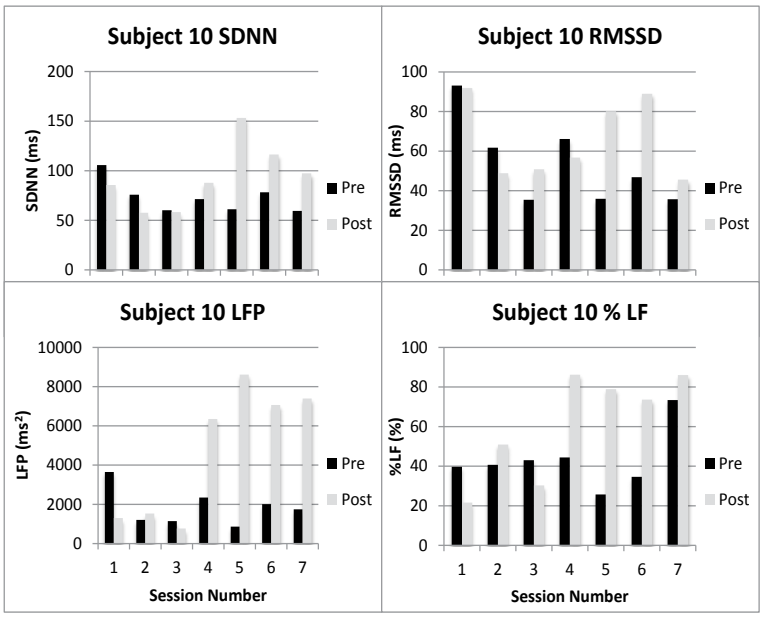

Figure 1: Changes in autonomic nervous response of subject 10 over 7 sessions
Autonomic parameters were defined as follows: SDNN [standard deviation of IBI in milliseconds], RMSSD [root mean squared root of standard differences in milliseconds], HR [heart rate in beats per minute], LFP [low frequency power in milliseconds squared], and % LF [percentage low frequency power].

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. It is possible that heart rate could have increased during the class due to physical activity, which would then mask any potential decrease in HR due to a relaxation effect.

Another consistent result was the significant increase in LF power post session, seen after the third or fourth session. This increase 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 (about 0.1 Hz or 5-7 breaths per minute) through a resonance mechanism [12]. Breathing at this frequency is beneficial because it also enhances oscillation in blood pressure, increasing baroreceptor sensitivity and allowing blood pressure to be more effectively modulated [12]. A previous yoga study showed no long-term effect on subjects' LF power but the mean respiration rate was estimated to be 0.2 Hz which would have shifted the RSA component of HRV into the HF range [13].

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 are consistent with the possibility that some people may improve over time. However, the rest of the participants did not show as consistent an increase in 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 does appear to improve an individual's HRV on a given day regardless of their starting point that day.

Limitations

The major 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 participated. Secondly, since only one device was available to measure both HRV and respiration simultaneously, only half of the students attending a given yoga session could have their respiration monitored. However, all students had their respiration rate measured before and after half of the sessions they attended.

Conclusion

Overall, this pilot study provides promising results that HRV increases in university students after attending weekly yoga sessions. This conclusion is based on the increase in HRV that students experienced, on average, after each individual session, and on the increase in LF power demonstrated after the last yoga session compared to pre 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.

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