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Heart Rate Variability Changes in the Integrated Yoga Program: Results and Implications

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ABSTRACT

Background. Different methods are used to study cardiovascular parameters. Of these, heart rate variability (HRV) is a relevant marker for both athletes and physically active people. With regards to physical activity, yoga has become a popular form of activity in the recent years. In fact, research has indicated that yoga is a useful modality for both the management and prevention of several cardiovascular conditions. The purpose of the current study was to observe HRV dynamics in young women during a 6-month yoga intervention.

Methods. We recruited 13 women from multiple yoga studios. All participants were practicing Hatha yoga 2 times a week for 6 months. Data were collected: a) at baseline, b) 2 months after the yoga intervention, c) 4 months after the intervention and d) 6 months after the intervention. We used wireless Bluetooth electrocardiogram (ECG) recording device. ECG HRV parameters and heart rate (HR) were used for data analysis.

Results. HR dynamics showed no differences during the 6-month yoga intervention. Meanwhile, vLF parameter after relaxation and LF/HF ratio after body scan meditation significantly changed after yoga intervention. No changes were observed in LF or HF parameter dynamics.

Conclusion. Our results suggest that 6 months twice per week yoga practice influences vLF and LF/HF ratio, especially during relaxation and body scan meditation. We also suggest that healthy women could benefit from practicing body scan meditation. In conclusion, through modification of emotion reactivity, regular practice of yoga can help improve stress response and offset negative consequences associated with the stress process.

Keywords: yoga, heart rate variability, women's health, ECG, stress.

INTRODUCTION

Different methods are used to study cardiovascular parameters. Of these, heart rate variability (HRV) is a relevant marker for both athletes (Morales et al., 2013) and physically active individuals. With regards to physical activity, yoga has become a popular form of activity in the recent years (Clarke & Black, 2015). As such, researchers have investigated both physiological and psychological aspects of yoga practice (Kwok, Kwan, Auyeung, Mok, & Chan, 2017; Rocha et al., 2012). Findings from these studies have suggested that yoga practice increases parasympathetic tone and reduces depression symptoms (Chu et al., 2017). Consequently, the practice of yoga may facilitate a better quality of life due to the management of cardiovascular and psychological states and prevention of potential conditions and diseases.

Pertaining to diseases, cardiovascular conditions remain the leading causes of health impairment among women (Boardman et al., 2015; Garcia, Mulvagh, Merz, Buring, & Manson, 2016). Furthermore, cardiovascular diseases are often associated with other conditions such as migraine (Kurth et al., 2016; Willett et al., 2015). As a result, alternative and non-conventional approaches to treat cardiovascular conditions exist. Some of these include hormone therapy (Boardman et al., 2015), healthy lifestyle programs (Willett et al., 2015) and/or strength training (Shiroma et al., 2016). However, while some physical activities increase risks for developing cardiovascular diseases, others including running (Chalfoun et al., 2015), swimming, cycling or aerobics (Oja et al., 2017) reduce risks of establishing these. Of specific interest herein, practice of yoga was also recognized for reducing the risks of cardiovascular diseases (Chu, Gotink, Yeh, Goldie, & Hunink, 2014). In fact, research has indicated that yoga is a useful modality for both the management and prevention of several cardiovascular conditions (Chu, 2016).

Concerning the assessment of cardiovascular states, electrocardiogram (ECG) remains a noninvasive and reliable technique (Waechter, 2012). Most commonly measured ECG parameters include RR or JT interval as well as HRV parameters (Chu, Lin, Wu, Chang, & Lin, 2015; Rohila, 2015; Ziaukas, Alabdulgader, Vainoras, Navickas, & Ragulskis, 2017). Of these, HRV is a fluctuation between adjacent heartbeats (i.e., RR intervals) and is associated with both sympathetic and parasympathetic activities (Muralikrishnan, Balakrishnan, Balasubramanian, & Visnegarawla, 2012; Shaffer & Ginsberg, 2017). Relevant to the present study, changes in HRV during yoga practice were studied based on HRV and its relationship to both cardiovascular and neurological outcomes (Chu et al., 2015, 2017; Papp, Lindfors, Storck, & Wändell, 2013). The purpose of the current study was to observe HRV dynamics in young women during a 6-month yoga intervention.

METHODS

Participants. We recruited 13 women from multiple yoga studios. Inclusion criteria were as follows: a) women aged from 18 to 45 years, b) practicing Hatha yoga 2 times a week, c) normal blood pressure (BP) (systolic BP ≤ 130 mmHg or diastolic BP ≤ 85 mmHg), d) normal body weight: body mass index (BMI) from 18.5 to 24.9, e) in premenopausal phase, and f) normal QRS duration (< .12 ms). The exclusion criteria were as follows: a) any contraindications for physical activity, b) medication use that affects heart rate (HR) or BP c) medication use that prolongs the QT (i.e., antibiotics), antihistamines, appetite suppressants (i.e., fenfluramine), decongestants, psychotropics/antidepressants/anticonvulsants (i.e., antidepressants) d) pregnancy, e) coronary artery disease, f) resting ST-segment (segment between the S-wave and T-wave on the electrocardiogram) depression >1 mm, g) left ventricular hypertrophy, h) ST/T changes, and i) QRS complex fragmentation. There were no ectopic or missed beats in participants' ECG.

Measures were presented as means and standard deviations (mean ± *SD*). Participants' (n = 13; M_{age} 31.31 ± 6.12 years) measurements included BMI (21.47 ± 1.58 kg/m^2), systolic BP (113.46 ± 9.78 mmHg); diastolic BP (71.85 ± 7.82 mmHg), and resting HR (67.49 ± 9.01 bpm).

This study's protocol was approved by Kaunas Regional Biomedical Research Ethics Committee (BE-2-36) and adhered to the tenets of the Declaration of Helsinki. All of the risks and nature of the experiment were explained to each participants and written consent was signed by all women participating in this study.

Measures. Data were collected: a) at baseline, b) 2 months after the yoga intervention, c) 4 months after the intervention and d) 6 months after the intervention. We used wireless Bluetooth 10-lead ECG recorder M-Trace PC (M4Medical, Lublin, Poland) for ECG recording (Suligowska et al., 2018). ECG HRV parameters and HR were used for analysis. HRV power spectrum was obtained via a fast Fourier transformation (FFT) algorithm using an appropriate software program (Kaunas Load, Lithuanian University of Health Sciences, Institute of Cardiology, Lithuania; Saunoriene et al., 2019). The spectral analysis of HRV was performed using the FFT method in the following bands of frequency: vLF (0.0033–0.04 Hz), LF (0.04–0.15 Hz) and HF (0.15–0.4 Hz; Suligowska et al., 2018).

Procedures. Similarly to previous work (Yang & James, 2016), in the course of the 6-month yoga practice, cardiovascular parameters were assessed by means of ECG screenings. Screenings took place every 2 months: at baseline, 2, 4, and 6 months following the regular (2 times a week) yoga practice. Each ECG screenings took approximately 1 hour to complete for each participant. At baseline, during their first visit, participants signed the informed consent form. Next, electrodes were attached to participants' skin to prepare for ECG screening. First two electrodes were placed bilaterally under midclavicular points and other four electrodes were placed 1 cm above the left lower costal margin. Finally, the last four electrodes were placed bilaterally on participants' mid scapular region and bilaterally above mid iliac crest. Participants

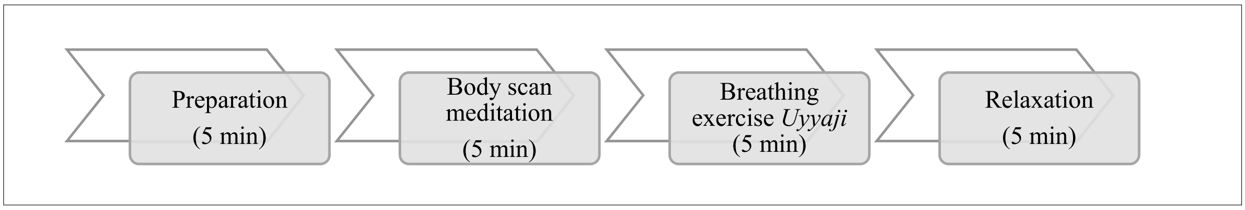

Figure 1. **ECG screening procedure**

were instructed to relax in a supine position for 20 minutes while the four phases of ECG screening were recorded: rest in preparation, body scan meditation, *Uyyaji* breathing exercise and relaxation (see Figure 1). In previous yoga research, relaxation in supine position and *Uyyaji* breathing exercise (Novakovi, Pavlovi, & Milovanovi, 2011) were commonly used as well (Bhavanani, Raj, Ramanathan, & Trakroo, 2016).

Yoga program. During a 6-month period, yoga practice was led by a certified yoga teacher (with 10 years of experience). Each practice involved a different sequence and lasted a total of 90 minutes. Each practice included 5 minutes of *pranayama* (i.e., breathing exercises), 15 minutes of warm-up, 60 minutes of *asana* (i.e., yoga pose) practice, and 10 minutes of *Savasana* (i.e., meditation/relaxation; Chu et al., 2017). Yoga poses were adapted to suit each participants' body type and individual needs. Most commonly used yoga poses included: *Sukhasana* (Easy sitting pose), *Tadasana* (Mountain pose), *Adho Mukha Svanasana* (Downward Facing Dog), *Bhujangasana* (Cobra pose), *Virabhadrasana* I, II and III (Warriors 1,2 and 3), *Trikonasana* (Triangle pose), *Vrksasana* (Tree Pose), *Marjaryasana* (Cat Pose), *Balasana* (Child's Pose) and *Savasana* (Corpse Pose). Specific emphasis was placed upon breathing and balancing movement with breath. Also, participants were instructed not to force on achieving particular poses but rather to focus on the overall practice itself.

Data analysis. Data analysis was computed using IBM SPSS Statistics 22.0 (IBM Corp., Chicago, IL, USA) and Microsoft Excel 2017. The difference between ECG screening sessions was tested using non-parametric Friedman's test because the assumption of normality was not met since the sample size was small. Values were presented as mean ± standard deviation (mean ± *SD*) and differences were considered statistically significant when values approached $p < .05$ level.

RESULTS

All participants reported a high level of commitment to the regular yoga practices as well as the ECG screenings. HR dynamics is presented in Figure 2. After rest in preparation, HR dynamics changed from 67.49 bpm at baseline to 68.05 bpm after 6 months ($\chi^2(3) = 1.34$, $p = .720$). Body scan meditation led to a decrease from HR 68.01 bpm at baseline to 66.59 bpm after 6 months of practice ($\chi^2(3) = 1.15$, $p = .764$). HR was 74.44 bpm at baseline and 70.49 bpm after 6 months following breathing exercise ($\chi^2(3) = 3.74$, $p = .291$). HR changed from 67.93 bpm at baseline to 66.50 bpm after relaxation ($\chi^2(3) = 0.79$, $p = .853$).

As seen in Figure 3, during rest in preparation, vLF parameter fluctuated from –.71 Tg(a) at baseline to –.60 Tg(a) after 6 months ($\chi^2(3) = 0.21$, $p = .976$). Body scan meditation showed different results of vLF parameter. At baseline vLF parameter was –0.33 Tg(a) and after 6 months was –0.54 Tg(a) ($\chi^2(3) = 4.81$, $p = .186$). After breathing exercise, vLF parameter reached the level of –0.38 Tg(a) at baseline while –0.36 Tg(a) after 6 months ($\chi^2(3) = 2.63$, $p = .452$). Finally, a difference was observed in vLF –0.37 Tg(a) at baseline and –0.81 Tg(a) after relaxation ($\chi^2(3) = 17.12$, $p = .001$).

Data for HRV LF parameter is presented in Figure 4. During rest in preparation, LF parameter fluctuated from 0.17 Tg(a) at baseline to 0.54 Tg(a) after 6 months ($\chi^2(3) = 2.08$, $p = .557$). Body scan meditation results of LF parameter at baseline were -.49 Tg(a) and after 6 months were –.14 Tg(a) ($\chi^2(3) = 2.72$, $p = .437$). LF parameter was –0.04 Tg(a) at baseline and 0.22 Tg(a) after 6 months following breathing exercise ($\chi^2(3) = 1.15$, $p = .764$). LF parameter fluctuated from .32 Tg(a) at baseline to 0.40 Tg(a) after relaxation ($\chi^2(3) = 0.97$, $p = .809$).

Figure 5 presents results of HRV HF parameter dynamics. HF parameter of rest in preparation showed fluctuations from –0.97 Tg(a) at baseline to

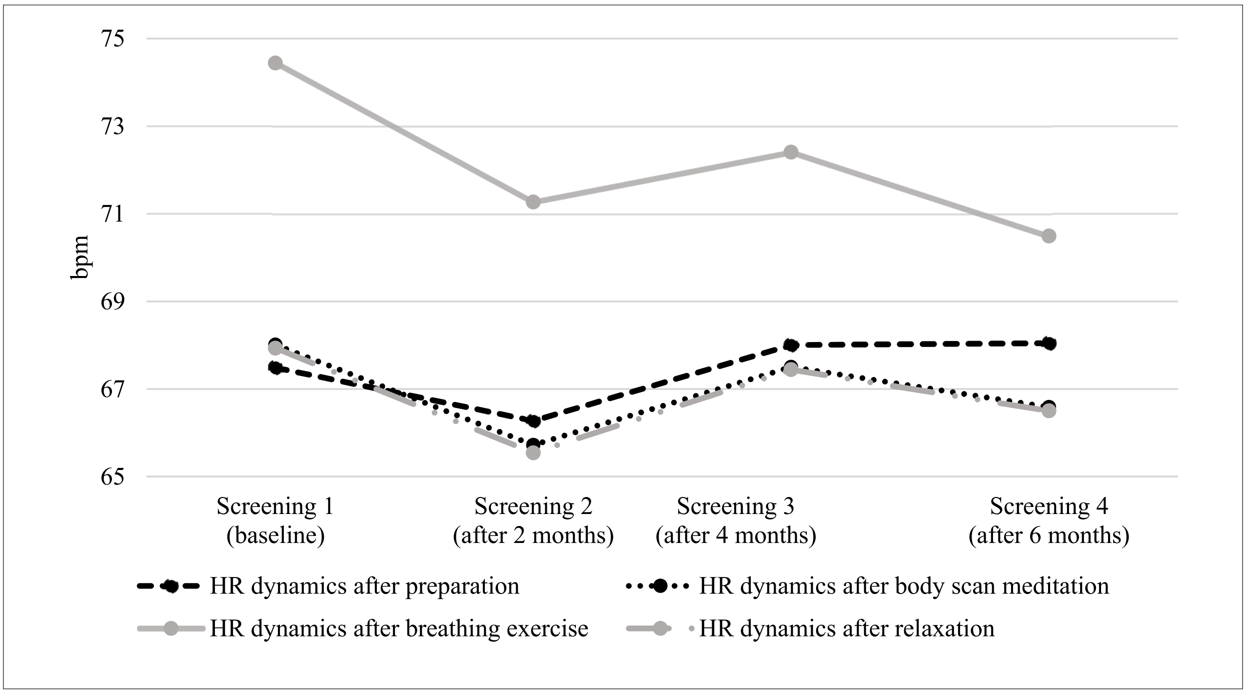

Figure 2. **HR dynamics during 6-month period**

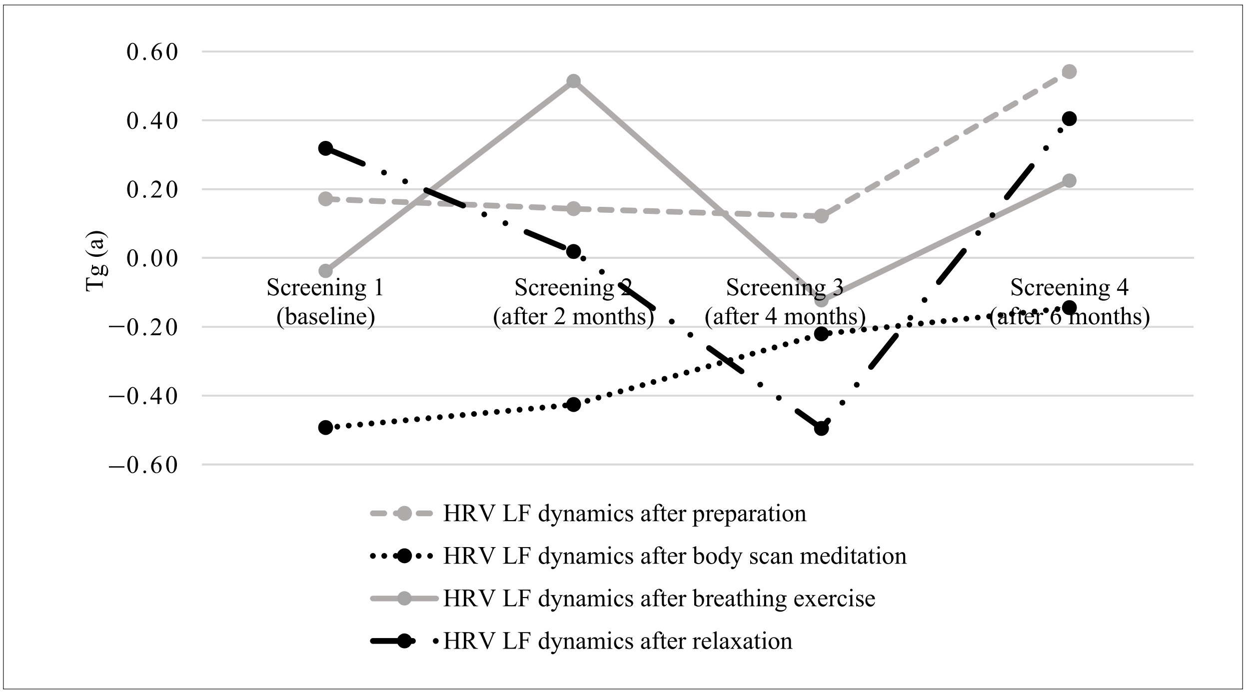

Figure 3. **HRV vLF dynamics during 6-month period**

–1.22 Tg(a) after 6 months ($\chi^2(3) = 7.43$, $p = .059$). Also, results of HF parameter at baseline were –1.13 Tg(a) and after 6 months were –1.08 Tg(a) after body scan meditation ($\chi^2(3) = 2.77$, $p = .429$). In addition to this, HF parameter differed from –1.03 Tg(a) at baseline to –0.91 Tg(a) after 6 months after breathing exercise ($\chi^2(3) = 0.98$, $p = .805$). HF parameter dynamics changed from –1.01 Tg(a) at baseline to –1.38 Tg(a) after relaxation ($\chi^2(3) = 1.62$, $p = .655$).

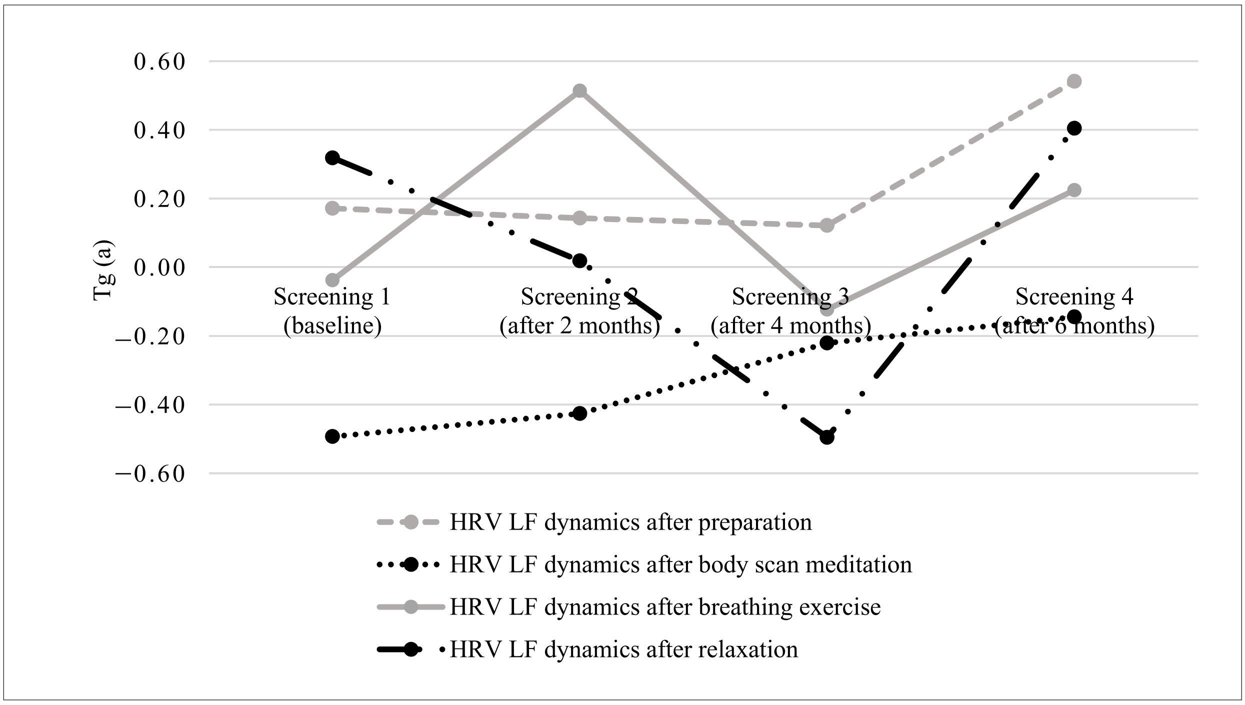

Figure 4. **HRV LF dynamics during 6-month period**

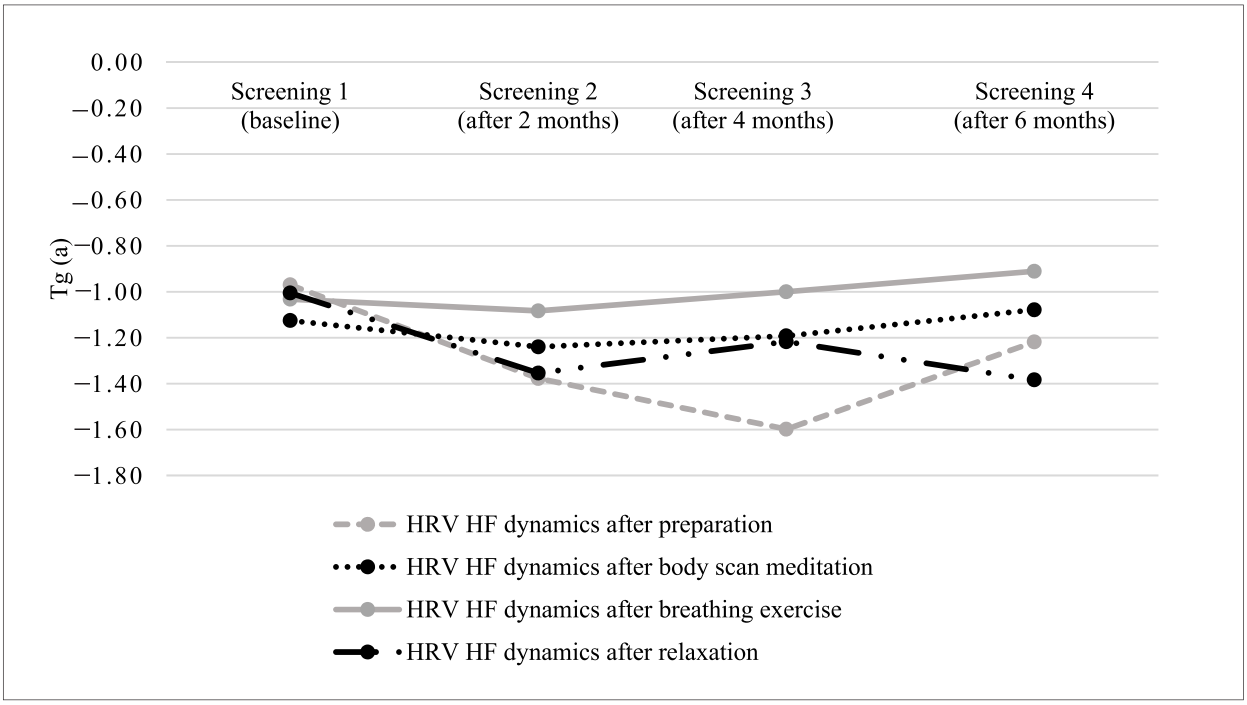

Figure 5. **HRV HF dynamics during 6-month period**

Figure 6 presents LF/HF ratio dynamics. Rest in preparation demonstrated LF/HF baseline ratio of 0.86, with a decrease to 0.66 ($\chi^2(3) = 4.58$, $p = .205$) after 6 months. Following body scan meditation LF/HF ratio changed from .70 at baseline to .63 after 6 months ($\chi^2(3) = 7.84$, $p = .049$). LF/HF ratio was 1.28 at baseline and 1.55 after 6 months following breathing exercise ($\chi^2(3) = 0.88$, $p = .831$). LF/HF ratio dynamics fluctuated from .80 at baseline to .83 after relaxation ($\chi^2(3) = 1.22$, $p = .749$).

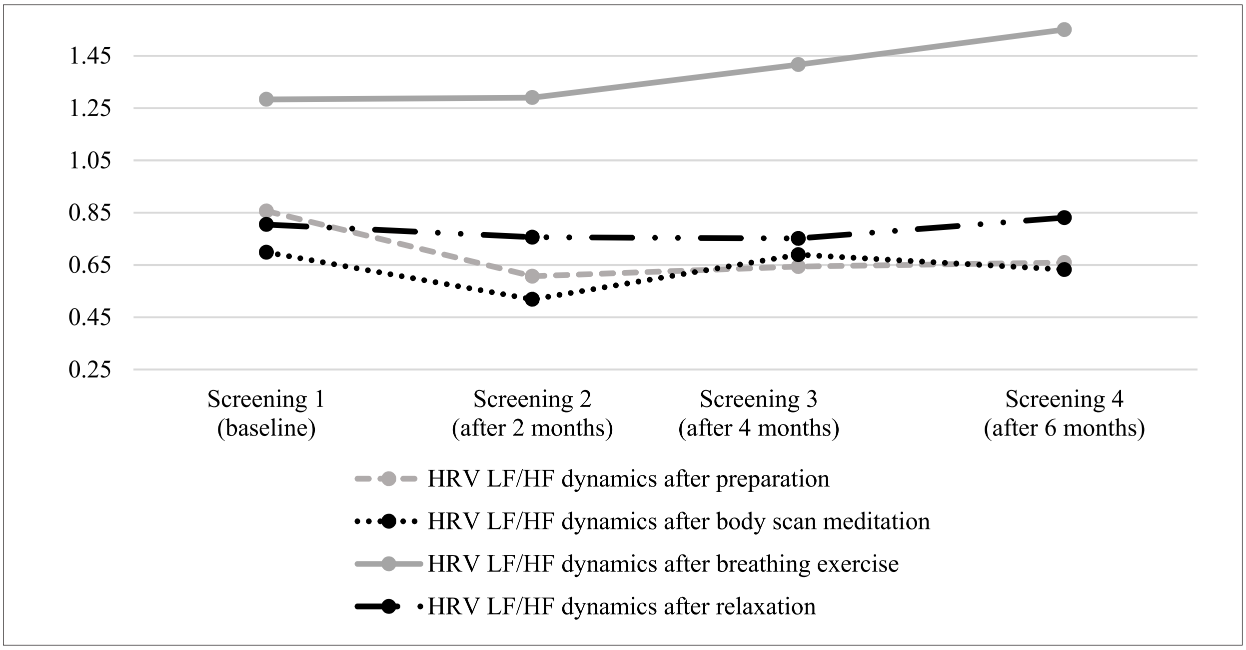

Figure 6. **HRV LF/HF dynamics during 6-month period**

DISCUSSION

The present findings reflect the combined effects of low intensity exercise with meditation and breath control that are typically intertwined in yoga practice (Benvenutti et al., 2017). The main finding of this study revealed that vLF differed in relaxation and LF/HF ratio changed in body scan meditation after 6 months in comparison to baseline. While there were changes with regards to HR, vLF, LF, HF, LF/HF ratio, after rest in preparation, body scan meditation, breathing exercise and relaxation significant changes were only present in body scan meditation and relaxation.

These findings are at least partially consistent with the previous ones suggesting that HRV parameters (i.e., HF, LF, and LF/HF) do not differ between individuals practicing yoga and control groups (Chu et al., 2015). Specifically, in the course of an 8-week yoga program practiced twice a week, 60 minutes per session, there was no significant improvement in HRV (Chu et al., 2015). Therefore, this is one of the first studies to reveal that a 6-month yoga practice can lead to changes in vLF and LF/HF ratio. Some of previous work has used the LF/HF ratio to quantify the degree of sympathovagal balance (Rosenberg, Chanwimalueang, Adjei, & Jaffer, 2017) while some others have used the vLF band to indicate sympathovagal balance (Usui & Nishida, 2017). Earlier studies have also shown that voluntary breathing exercises with varying frequency, depth, and pauses can help modulate cardiovascular sympathovagal oscillations (Novak et al., 1993; Subbalakshmi, Basha, & Ramesh, 2009). To that end, it is also important to note that positive reactions may emerge since LF/HF is sensitive to psychological stress and was previously was used as a marker in a number of studies (Malliani et al., 1997; Montano et al., 1994; Rådmark, Sidorchuk, & Osika, 2019).

Contrary to our findings, some of the previous work examining the LF/HF ratio releveled significant decreases in the ratio in the course of a SKY (*Sudarshan Kriya*) program. A SKY program involves slow *Ujjayi* breathing (diaphragmatic breathing) with inhalatory and exhalatory pauses, followed by fast-paced *Bhastrika pranayama* (rapid breathing) and cyclic rhythmic breathings. The breathings in a SKY program occur in slow, medium, and fast frequencies (Bhaskar, Kharya, Deepak, & Kochupillai, 2017).

For an accurate interpretation of the current findings, two limitations should be considered: (a) first, despite statistical significance our conclusions are not applicable to menopausal women or women with specific conditions such as those with high levels of anxiety and stress and/or with chronic respiratory diseases including chronic nasal congestion or obstruction Therefore, our results should be generalized with caution, (b) additional studies with alternative yoga poses or varying protocols are needed to advance the knowledge on the acute cardiovascular effects of these poses by measuring not only HR, vLF, LF, HF, LF/HF ratio, but also additional ECG parameters, for instance including ST amplitude, QRS, and JT intervals. Hence, the current findings do not speak to the outcomes of one specific yoga method (i.e., *Surya Namaskar, Kapalabhati* breathing exercise) but rather a combination of different methods.

CONCLUSIONS

The purpose of the current study was to investigate HRV dynamics in young women during a 6-month yoga intervention. Specifically, this remains among the first attempts to explore the cardiovascular dynamics during a long-term (6-month) twice per week yoga practice assessed at 2-months intervals. Our results suggest that 6 months twice per week yoga practice can help affect the vLF and LF/HF ratio, especially while performing relaxation and body scan meditation components.

From a practical standpoint, our findings suggest that healthy women could benefit from practicing body scan meditation as the meditation seems to increases the effect of HF parameter that in turn helps decrease LF/HF ratio as a stronger influence of the parasympathetic nervous system. This said, it is important to note that the parasympathetic nervous system gets activated once individuals are at rest (Ming et al., 2019). The latter is especially important with regards to coping with stress and resilience in the course of stressful situations. In conclusion, then, through modification of emotional reactivity, regular practice of yoga can help improve stress response and offset negative consequences associated with the stress process.

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