ORIGINAL ARTICLE

Modulation of Heart Rate Variability in Stressed Medical Students Via Breathing Exercise

NOMAN SADIQ[1], TAHIRA SADIQ[2], WAZIR AHMED BALOCH[3], HUMAIRA FAYYAZ KHAN[4], NOOR NASIR RAJPOOT[5], SHAZIA ALI[6]
[1]*Associate Professor, Department of Physiology, Mekran Medical College, Turbat Pakistan.*
[2]*Assistant Professor, Department of Cardiology, Fazia Medical College, Islamabad Pakistan.*
[3]*Assistant Professor, Department of Anatomy, Mekran Medical College, Turbat Pakistan*
[4]*Professor, Department of Physiology, Islamic International Medical College, Rawalpindi Pakistan*
[5]*Department of Medicine, DHQ Teaching Hospital, Rawalpindi Pakistan.*
[6]*Professor, Department of Physiology, Islamic International Medical College, Rawalpindi Pakistan.*
Correspondence to Dr. Noman Sadiq, Email noman_sadiq89@yahoo.com, Mobile: +923325208023

ABSTRACT

Background: Stress in medical students is a global concern. Stress disturbs the sympathovagal balance and affects heart rate variability, a sign of healthy cardiovascular homeostasis. Various strategies have been used globally to combat stress and its effects.
Aim: To determine how blowing balloon exercise modulatesheart rate variability (HRV) in stressed medical students.
Methodology: A pretest-posttest quasi-experimental study wasconducted among stressed medical students at Islamic international medical college Rawalpindi Pakistan. Sixty students diagnosed with moderate stress were enrolled based on Depression Anxiety Stress Scale (DASS) Proforma. The study population was selected by simple random sampling via the balloting method among the stressed medical students. Study participants underwent a supervised blowing balloon exercise.Before and after a supervised blowing balloon exercise, the participants' pulmonary function tests, electrocardiograms, and DASS scores were measured. Participants' ECGs and pulmonary function tests were recorded viaPower lab (A.D. Instruments, model yam 4/25T, South Wales, Australia).
Results: Blowing balloon exercise resulted in a significant reduction of DASS score ($p<0.001$) and significant improvement in pulmonary function tests ($p<0.001$). Among Heart rate variability parameters, the participants' standard deviation of successive N-N intervals, high-frequency components, and high-frequency normalized units significantly increased ($p<0.05$) after blowing balloon exercise. Heart rate, low-frequency normalized units, and the ratio of low-frequency normalized value to high-frequency normalized value were significantly reduced ($p<0.05$) after blowing balloon exercise.
Conclusions: Blowing balloon exercise enhances medical students' heart rate variability and pulmonary function tests while reducing their stress levels. This cost-effective and easy exercise can be performed by stressed students without any time or place barrier.
Keywords: Anxiety, Breathing Exercise, Depression**,** Heart Rate Variability, Stress, Sympathovagal Balance.

INTRODUCTION

Heart rate variability (HRV) is a physiological phenomenon reflectingthe fluctuation in time intervalsamid successive heartbeats. HRV is a sign of healthy cardiac tissue and is essential for restoring cardiovascular homeostasis[1]. It allows people to respond better and adapt to various environmental and physiological conditions[2]. Reduced HRV is associated with psychopathological problems and cardiovascular diseases, including decreased cognitive function, emotional dysregulation, psychiatric disorders, hypertension, diabetic autonomic neuropathy, and sudden cardiac death[3-6].

Cardiac vagal neurons (cVPNs) originate from the dorsal vagal motor nucleus (DVMN) and nucleus ambiguous (N.A.) of the brainstem.[7]The respiratory rhythm of the body influences the Pattern of discharge of cardiac vagal neurons. These neurons receive inhibitory input from pulmonary stretch receptors during inspiration; consequently, vagal nerve activity is reduced during inspiration. While they receive powerful excitatory input from pulmonary stretch receptors during the post-inspiration state, as a consequence, vagal nerve activity is increased.[8]This cyclical oscillation of the vagal nerve activity results in heart rate variability[9].

Stress is a psychological condition that disrupts the body's internal homeostasis and directly impacts several physiological systems[10]. Review of the literature shows that 90% of medical students suffer from moderate to high level of stress[11]. The activity of the cardiac sympathetic fibre increases with stress, while that of the cardiac vagal fibre decreases[12]. Many cardiovascular disorders have poor prognostic markers, one of which is low cardiac vagal tone[13]. It is linked with childhood behavior problems, anxiety, and impulsive control disorders[14].

Received on 11-08-2022
Accepted on 22-12-2022

HRV can be used to study stress-induced sympathovagal imbalance. By determining the R-R intervals (RMSSD), a time-domain component of HRV, we can learn whether the sympathetic or parasympathetic nervous system has a greater influence on the heart rate. HRV spectral analysis can analyze beat-to-beat frequency variations in terms of H.F. and L.F. components[15]. Vagal tone regulates HRV high-frequency component. Changes in the lower frequency component of HRV reflect changes in vagal and sympathetic tone outflow. sympathovagal balance is reflected by LF/HF ratio. Stress increases LF/HF ratio and reduces the H.F. component of HRV[16]. To reduce distribution skewness, HRV LF and H.F. components are measuredin terms of normalized units.

Stress tolerance is a measure of an individual's resilience. The variance in vagal tone at the baseline explains the individual and genetic differences in the ability to cope with stress[17]. People whose HRV and vagal tone at rest are higher are thought to be more resilient, and they return more quickly to baseline after experiencing stress[18].

Individuals' stress resilience can be improved by a number of means, such as engaging in group therapy or recreational activities like cycling, jogging, or running[19]. Breathing exercises are a great way to calm and increase lung capacity immediately. Breathing exercises enhance pulmonary function test[20-21].

Breathing exercises include yoga, blowing a balloon, slow lip pursing, and other exercises.Blowing balloon therapy has been used in oral gymnastics to improve pulmonary function tests in smokers, treat obstructive sleep apnea syndrome, reduce stress in medical students, and rehabilitate stroke patients.[22-23]Respiratory muscles strengthened by the balloon-blowing exercise result in increased lung compliance and V.C., FVC, and FEV1/FVC[24]. However, the role of blowing balloon therapy in increasing heart rate variability has not yet been studied. So, the current study aims to determine the effect of blowing balloon exercise in modulation heart rate variability.

MATERIALS AND METHODS

This pretest-posttest quasi-experimental study was conducted in the power lab room at Islamic International Medical College, Rawalpindi, with the ethics review committee's consent (Number: 16/0110). All study protocols followed the Declaration of Helsinki's principles.Two hundred MBBS students of the Islamic International Medical College were given a 21-item DASS questionnaire. Students aged 18-25 with a DASS proforma score of 19-25, no oral lesions, and no history of bronchodilators were eligible. The DASS proforma was submitted by 183 students (response rate 91.5%). Out of these 183 students, 86 had stress levels deemed clinically significant (DASS score of 19–25) and were included in the study. Amid the eligible candidates, 60 students were included in the study by using the balloting method.

After informed written consent, all research participants were requested to come to the Department's Power Lab Room between 9.00 and 11.00 a.m. They were told not to consume tea or coffee. Before anything else, participants were given five minutes to sit quietly. The participants' height and weight were measured using the height and weight scale model ZT-160-NSL.Blood pressure of the participants was measured by using the mercurial sphygmomanometer model B.P-137-ST-3001. Participants were asked toremove their belts, keys, and other metal objects. There was a concerted effort to keep the room as quiet as possible. According to North American Society of Pacing Electrophysiology and American thoracic society guidelines, the Yam 4/25T power lab model recorded a ten-minute ECG and pulmonary function test of subjects seated.Recorded ECGs of participants were analysed for heart rate, Root Mean Square of the Successive R-R interval Differences (RMSSD), the low-frequency component, high-frequency component, and the ratio of low to high-frequency components normalized units using fast Fourier transform technology. Amid pulmonary function tests, tidal volume, vital capacity, forced vital capacity, forced expiratory volume in onesecond, and the ratio of forced expiratory volume in onesecond to forced vital capacity was measured.

Afterward, the subjects were instructed to blow balloons under supervision three times each week for a total of six weeks. The participants were instructed to maintain an upright posture, inhale fully, and then exhale fully into balloon mouths. With this practice, one mini-set of blowing balloon exercises was completed. The repetition of mini-sets three times results in the completion of one set. Participants completed three sets of the blowing balloon exercise in a single day. The balloons used by all participants were of the same quality. Participants were given a 2 to 3-minute rest between each set to avoid fatigue. Participants were advised to stop exercising if they felt dizzy at any point. It was stressed that Valsalva should be avoided at all costs, therefore participants were instructed to not hold their breath for longer than five seconds after exhaling. DASS score, pulmonary function tests, and electrocardiograms of study Participants were measured again after blowing balloon exercise.

SPSS version 21 was used for the statistical analysis of the data. Mean plus standard deviation (mean+S.D.) was used to express the statistical outcomes of the quantitative data. The results of the balloon-blowing activity were compared to the baseline using a paired t-test. To be statistically significant, the p-value has to be under 0.05.

RESULTS

The DASS proforma was first delivered to 200 students, with 183 students returning the proforma after receiving it (response rate 91.5%). Sixty individuals were chosen by a simple random sample procedure using the balloting technique out of 86 students who fulfilled the eligibility criteria. Age of the study participants was 20.50±1.24 years (Mean±S.D) with a BMI of 21.67±3.70Kg/m^2 (Mean±S.D). Everyone who participated in the study completed all the sessions of blowing balloon exercises without missing a single session, resulting in an overall compliance rate of 100%. Six weeks of blowing balloon exercise resulted in a substantial reduction in the participants' DASS score from 21.8±2.01 to 13.41±4.29 (p-value < 0.05).

After completing the blowing balloon exercise, the indices of pulmonary function tests showed a considerable improvement. Tidal volume (milliliter's) of the participants were improved from 517.72±48.57 to 638.65±86.02 (p value<.000*). Vital Capacity (liters) of the participants were improved significantly from 3.51±0.56 to 4.83±0.77 (p value <.000*). Forced Vital Capacity (liters) of the participants were improved significantly from 3.09±0.57 to 4.45±0.78 (p value <.000*). Forced Expiratory Volume in one second (liters) of the participants were improved significantly from 2.76±0.54 to 4.13±0.77 (p value <.000*). Forced Expiratory Volume in one second / Forced Vital Capacity (%) of the participants were improved significantly from 89.36±4.54 to 92.66±4.27(p value < .000*).

As shown in table I, the participants' heart rates and the standard deviation of successive N-N intervals both increased significantly (P 0.05) as a result of the blowing balloon exercise. This was one of the time domain components of HRV that was improved. The high-frequency component of the participants' heart rate variability, as well as the high frequency normalised units, were significantly increased. This was one of the frequency domain parameters of heart rate variability. In contrast, low-frequency normalised units dropped by a significant amount after the blowing balloon exercise, as did the ratio of low-frequency normalised value to high-frequency normalised value. As can be seen in table I, there was not a discernible shift in the low-frequency component that occurred as a result of the blowing balloon exercise.

Table I: Comparison of Heart Rate Variability parameters before and after blowing balloon exercise (n=120)

Heart Rate Variability Parameter	Before Blowing Balloons Exercise (Mean±S.D)	After Blowing Balloons Exercise (Mean±S.D)	p-Value
Heart Rate (beats/min)	80.30±4.60	73.4±3.43	<0.05*
SDNN (msec)	77.21± 9.82	74.75±9.46	<0.05*
L.F. Component (ms^2)	840.69±367.47	824.53±312.72	>0.05
High Frequency Component (ms^2)	593.26±318.12	851.21±452.26	<0.05*
Low Frequency Normalized Units	61.64±15.27	52.89±15.12	<0.05*
High Frequency Normalized Units	33.25±10.52	46.22±13.37	<0.05*
LF/HF nu	2.29±1.02	1.2± 0.74	<0.05*

*p value < 0.05 is significant

DISCUSSION

Medical students often experience stress, which is a significant global issue. The autonomic nervous system's activity and outcomes are modified by stress. Breathing exercises aid in the improvement of autonomic function. This study examines heart rate variability's time and frequency components to see if the balloon-blowing exercise enhances them.

This study's findings are consistent with those of Jun, H et al., who found that elderly smokers who engaged in balloon-blowing exercise for four weeks saw improvements in V.C, FVC,FEV1, andPEF[24]. In contrast to this, our participants were stressed medical students who were otherwise healthy and didn't smoke.

V Blessy and colleagues conducted research on healthy volunteers while having them practice Bhastrika pranayama five times each day for three months. This resulted in improvements in T.V., FVC, and FEV1/FVC (p 0.02) among the study participants.[25]While V Blessy et al used a simple, forceful exhalation for their Bhastrika pranayama exercise, our study participants exhaled against resistance with a blowing balloon.

Enhanced pulmonary function tests are associated with increased HRV. A literature review shows that several pulmonary function parameters, for example, FEV1 and FVC, are significantly correlated with enhanced vagal activity i.e. HRV[26-27]**.** The current study showed that blowing balloon exercise increased pulmonary function tests and improved heart rate variability parameters towards parasympathetic dominance. This study's findings support those of Cheng et al, who concluded that bicycling exercise improved H.F. components (absolute and normalized), reduced L.F. components (absolute and normalized), improved LF/HF ratio, and improved pulmonary function tests[27]**.**

Our study also supports the findings of Tulppo et al, which concluded that exercise training (treadmill) for four weeks enhances H.F. component and reduces heart rate and LF/HF ratio, indicating that exercise resulted in the shift of autonomic balance towards parasympathetic dominance[28]**.** However, Cheng et al. and Tulppo M et al also reported that bicycling exercise and treadmill exercise reduces L.F. component of heart rate variability, which was not reduced due to blowing balloon exercise done by our participants. Review of the literature shows that exercises like treadmill and bicycling alter the sympathovagal balance towards parasympathetic dominance by reducing sympathetic activity. In contrast to these studies, the blowing balloon exercise alters sympathovagal balance towards parasympathetic dominance by enhancing parasympathetic activity. Blowing balloon increases the afferent cardiac vagal nerve fibers activity via stimulating slow adapting pulmonary stretch receptors, which might be the possible reason why the L.F. component of HRV was not reduced as a result of blowing balloon exercise.

Poyhonen et al conducted a study to investigate the effect of respiratory patterns on HRV and concluded that voluntary increase in tidal volume enhances the H.F. component of HRV, indicating vagal dominance[29]**.** Blowing balloon exercise conducted in our study also significantly improved tidal volume and H.F. component of HRV.

Hepburnet al mentioned in their study that respiratory training for six weeks by using "Hepburn Heart and Lung Exerciser" (HHALE) increased pulmonary function tests (FVC, FEV1), H.F. component of HRV, and a decrease in heart rate, LF/HF ratio of HRV[30]**.** Our study is in line with this study as blowing balloon also increases pulmonary function tests and alters HRV parameters towards parasympathetic dominance. HHALE increases resistance to airflow and ventilation depth. Increased depth of respiration favors parasympathetic dominance. Blowing balloon exercise also increased airflow resistance, which increased depth of respiration and parasympathetic nerve activity.

CONCLUSION

According to our findings, blowing balloons exercise increases heart rate variability and pulmonary function tests in medical students while decreasing their stress level.

Conflict of interest: Nil

REFERENCES

1. Souza HCD, Philbois SV, Veiga AC, Aguilar BA. Heart Rate Variability and Cardiovascular Fitness: What We Know so Far. Vasc Health Risk Manag. 2021;17:701-711.
2. Nolan RP, Kamath MV, Floras J.S. et al. Heart rate variability biofeedback as a behavioral neurocardiac intervention to enhance vagal heart rate control. Am Heart J. 2005; 149(6): 1137-48..
3. Lin IM, Fan SY, Yen CF et al. Heart rate variability biofeedback increased autonomic activation and improved symptoms of depression and insomnia among patients with major depressive disorder. Clin Psychopharmacol Neurosci. 2019; 17(2): 222-31.
4. Koichubekov BK, Sorokina MA, Laryushina YM, Turgunova LG, Korshukov IV. Nonlinear analyses of heart rate variability in hypertension. In Annals de Cardiologieetd'Angéiologie. 2018; 67(3):174-79.
5. Benichou T, Pereira B, Mermillod M et al.Heart rate variability in type 2 diabetes mellitus: A systematic review and meta-analysis. PloS one. 2018;13(4): e0195166.
6. Sessa F, Anna V, Messina G et al. Heart rate variability as a predictive factor for sudden cardiac death. Aging. 2018;10(2):166-72.
7. Gourine AV, Machhada A, Trapp S, Spyer KM. Cardiac vagal preganglionic neurones: An update. AutonNeurosci. 2016; 199: 24-38.
8. Dergacheva O, Griffioen KJ, Neff RA, Mendelowitz D. Respiratory modulation of premotor cardiac vagal neurons in the brainstem. RespirPhysiolNeurobiol. 2010; 174(1-2): 102-10.
9. Appelhans BM, Luecken LJ. Heart rate variability as an index of regulated emotional responding. Rev Gen Psychol. 2006; 10(3): 229-40.
10. Pinto VN, Wasnik S, Joshi SM, Velankar DH. Medical students' perceptions of stress factors affecting their academic performance, perceived stress, and stress management techniques. Int J Community Med Public Health. 2018; 5: 191-96.
11. Jahangeer SMA, Hasnain N, Tariq MT, Jamil A, Zia SY, Amir W. Frequency and Association of Stress Levels with Modes of Commuting Among Medical Students of a Developing Country. Malays J Med Sci. 2021; 28(4): 113-122.
12. Kim HG, Cheon EJ, Bai DS, Lee YH, Koo BH. Stress and heart rate variability: a meta-analysis and review of the literature. Psychiatry Investig. 2018;15(3):235-45.
13. Geisler FC, Kubiak T, Siewert K, Weber H. Cardiac vagal tone is associated with social engagement and self-regulation. Biol Psychol. 2013;93(2):279-86.
14. Graziano P, Derefinko K. Cardiac vagal control and children's adaptive functioning: A meta-analysis. Biol Psychol.2013; 94(1):22-37.
15. Thayer JF, Åhs F, Fredrikson M, Sollers JJ 3rd, Wager TD. A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. NeurosciBiobehav Rev. 2012; 36(2): 747-56.
16. Sadiq N, Raziq H, Tahir M, Rajpoot NN. Effect of psychological stress on time and frequency domain parameters of heart rate variability in undergraduate medical students. J Fatima Jinnah Med Univ. 2019; 13(1): 34-37.
17. Carnevali L, Koenig J, Sgoifo A, Ottaviani C. Autonomic and brain morphological predictors of stress resilience. Front Neurosci. 2018;12: 228.
18. Perna G, Riva A, Defillo A et al. Heart rate variability: Can it serve as a marker of mental health resilience?.J Affect Disord. 2020; 263: 754-61.
19. An E, Nolty AA, Amano SS et al. Heart rate variability as an index of resilience. Mil. Med. 2020; 185(3-4): 363-69.
20. Shiralkar MT, Harris TB, Eddins-Folensbee FF, Coverdale JH. A systematic review of stress-management programs for medical students. Acad Psychiatry. 2013; 37(3):158-64.
21. Sharma VK, Trakroo M, Subramaniam V et al. Effect of fast and slow pranayama on perceived stress and cardiovascular parameters in young health-care students. Int J Yoga. 2013;6(2):104-10.
22. Sadiq N, Khan HF, Siddiqui A. Blowing balloons, a novel way for reducing stress and improving pulmonary function tests. J Islam Int Med Coll. 2018;13(2):66-70.
23. Guimaraes KC, Drager LF, Genta PR, Marcondes BF, Lorenzi-Filho G. Effects of oropharyngeal exercises on patients with moderate obstructive sleep apnea syndrome. Am J RespirCrit Care Med. 2009;179(10):962-66.
24. Jun HJ, Kim KJ, Nam KW, Kim CH. Effects of breathing exercises on lung capacity and muscle activities of elderly smokers. J Phys Ther Sci. 2016;28(6):1681-85.
25. Blessy V, Sayyad R, Yadav PK, Kar SK. Effect of breathing exercises on pulmonary function tests in healthy adults. J Clin Biomed Sci. 2014; 4: 226-29.
26. Bianchim MS, Sperandio EF, Martinhao GS et al. Correlation between heart rate variability and pulmonary function adjusted by confounding factors in healthy adults. Braz J Med Biol Res. 2016;49;1-7.
27. Cheng ST, Wu YK, Yang MC et al. Pulmonary rehabilitation improves heart rate variability at peak exercise, exercise capacity, and health-related quality of life in chronic obstructive pulmonary disease. Heart & Lung. 2014; 43(3): 249-55.
28. Tulppo MP, Hautala AJ, Makikallio TH et al. Effects of aerobic training on heart rate dynamics in sedentary subjects. J Appl Physiol. 2003; 95(1): 364-72.
29. Poyhonen M, Syvaoja S, Hartikainen J, Ruokonen E, Takala J. The effect of carbon dioxide, respiratory rate, and tidal volume on human heart rate variability. ActaAnaesthesiologicaScandinavica. 2004; 48(1): 93-101.
30. Hepburn H, Fletcher J, Rosengarten TH, Coote JH. Cardiac vagal tone, exercise performance, and the effect of respiratory training. Eur J Appl Physiol. 2005; 94(5): 681-89.