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Effect of Diaphragmatic Breathing Exercise on Cardiovascular Parameters Following Noise Exposure in Pre Hypertensive Adults

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ABSTRACT

Objective: To explore immediate effects of breathing exercises on blood pressure; systolic (SBP) and diastolic (DBP), and heart rate (HR) of pre-hypertensive subjects after exposure to high tempo music at relatively high exposure intensity (90-dB intensity).

Methods: Thirty pre- hypertensive subjects participated. Participants were recruited from October 6 University hospital outpatients clinics, ages ranged between 30-40 years. Participants assigned into 2 groups at random; exercises and control groups. Participants were exposed to 90 dB sound for 15 minutes. Blood pressure and heart rate were measured at baseline, immediately after exposure, 5, 10, and 15 minutes post exposure. Exercises group received breathing exercises between each 2 successive measures starting at immediate post exposure and later

Results: Significant lowering of SBP, and DBP in breathing exercises group in comparison to control at 10 minutes and 15 minutes' evaluations. SBP in exercises group reached earlier to baseline means at 15 minutes evaluation, while DBP in exercises group did not reached baseline till the end of evaluations. Albeit, DBP were significantly lower than control at 10 minutes and 15 minutes evaluations. Heart rate means were non- significantly different between groups throughout all evaluations. Further, both groups reached baseline HR means at the 15 minutes evaluation.

Conclusion: Breathing exercises is helpful in controlling increment of SBP and DBP following acute exposure to noise. Further, it helps to restore baseline SBP pressure earlier than controls in pre-hypertensive participants.

Keywords: *noise, hypertension, blood pressure, heart rate*

INTRODUCTION

Noise is a form of pollution where an unwanted sound is emitted into the surroundings. The measure of noise is decibels (dB) (Kumari et al., 2015). Noise pollution is an increasing source of auditory and non-auditory problems in the modern society (Dratva et al., 2012).

The effect of noise pollution is paramount to the extent that WHO considered noise pollution as the third most dangerous source of pollution in large cities (Zamanian et al., 2013). Noise is regularly produced from different sources to which people are exposed. Noise is a form of stress that disrupt the regulation of autonomic nervous system, consequently affects cardiovascular system (Babisch, 2002) Acute exposure to noise in different forms induces changes in the autonomic nervous system (Lusk et al., 2004). A previous study of immediate effect of noise exposure over 24- hours ambulatory blood pressure (systolic and diastolic) in normotensive and hypertensive individuals showed significant increase of systolic and diastolic BP specially pronounced in hypertensive patients and proportionate to the intensity of noise exposure (Chang et al., 2015). Further, in a previous study subjects were monitored to check the effects of acute exposure to noise pollution of high pitch at noise level 90-95 dB (Lusardi P. et al., 1996). Researchers took 15 minutes measures over a period of 6 hours; 3 hours of exposure and 3 hours after exposure. They reported elevated SBP and DBP, specially marked in the first hour of exposure, but gradually go down over the following 2 hours. Heart rate continued to increase over the time of exposure and only returned to normal after 1 hour from the end of exposure time. Another investigation of the cardiovascular effects of noise pollution due to exposure to music of different styles and tempi (speed of music rhythm) and time of exposure (Bernardi et al., 2006), reported significant increase in different cardiopulmonary parameters including increased SBP, DBP, and HR especially with fast tempi as techno and rap music.

Hypertension is an important worldwide public health problem. Hypertension is known for its high frequency and serious complications. The prevalence of hypertension is estimated to be one billion people and predicted to reach as high as 1.5 billons at 2025 (Kearney et al., 2005). Consistent systolic blood pressure (SBP) between 120-139 mmHg and diastolic blood pressure of 80-89 mmHg is classified as prehypertension, and considered as first stage hypertension (Yau and Loke, 2021). Baroreflex operates to tune the function of autonomic nervous system, thus autonomic nervous system could contribute to the regulation of blood pressure and heart rate (Pavithran et al., 2010). Baroreflex lowered sensitivity associated with autonomic imbalance is seen in sustained hypertension, and is associated with elevation of peripheral resistance of blood vessels, and lowering of exercise tolerance (Joseph et al., 2005). Sympathetic overactivity, vagal withdrawal and inhibited parasympathetic activity take place in prehypertensive and hypertensive subjects exposed to noise, especially for long exposures. Sympathetic overactivity causes increase in tone of smooth muscles, elevates blood pressure and heart rate (Gowri SR and Gurushanthappa, 2016). Deep breathing exercises used as a relaxtion exercise had been suggested as a mean preventing and treating hypertension through reducing sympathetic overactivity and improving autonomic balance (Patil and Taklikar, 2015).

Diaphragmatic deep breathing (DDB) synonamly called slow abdominal breathing, or simply, deep breathing, include both descriptors in application; slow and deep. It results in increasing the contraction length of the diaphragm, decrease the respiratory rate, increases oxygen delivered to blood through increasing inhalation/exhalation volumes. DDB does not only improves hypertension physiologically, but it has been also reported to enhance hypertensionpatients' psychological health (Vasuki and Sweety, 2017)

The objectives of this study were to explore how can use of diaphragmatic breathing exercise can affect SBP and DBP, and HR in pre-hypertension adults following short time exposure to noise pollution in the form of high tempo music at relatively high exposure intensity (90-dB). Furthermore, to apply a short term follow up post exposure to check whether tested parameters reached resting values within this duration.

METHODS

This was a randomized controlled study carried out in a laboratory setting at October 6 University. Thirty pre- hypertensive volunteers participated in this study. Participants have been recruited from the out patients clinics of October 6 University hospital. Both genders participated, and mean age was 35.4 (+2.79) years and 34.5 (+3.06) years for execises and control groups respectively. During initial interview, participants were checked for pre hypertension blood pressure levels; systolic more (120 <140 mmHg), and diastolic (80<90 mmHg). Exclusion criteria were also checked, they included patients who have pulmonary diseases, renal diseases, coronary disorders, autoimmune diseases, diabetes, neuropathy and other autonomic neuropathies, or cerebrovascular diseases. Participants were then randomly assigned to exercises or control groups using a blind draw from a dark box containing group names in opaque envelops. Following group assignment, participants were given complete description of the objectives and procedures. They signed informed consent to confirm their agreement to participate in the study. Study had been ethically approved (No: P.T.REC/012/004219).

Procedures

Digital automatic blood pressure monitor (OMRON, model HEM-907, Hoofddorp, Netherlands) had been used to measure SBP, DBP, and HR. At the beginning of sessions, participants were introduced to the lab, and allowed 10 minutes period of quiet rest followed by the baseline measurement of blood pressure and heart rate. Following baseline measures noise exposure extended for 15 minutes while the participants used a head set, and checked for intensity (90dB) using sound level meter (TETSL01, total tools co, PTE, LTD, China). Immediately after noise exposure the second measure for blood pressure and heart rate was reported, followed by 3 measures after 5, 10 and 15 minutes post noise exposure.

Participants in exercises group carried out breathing exercises twice within the intervals between each of the post exposure successive evaluations. Exercises were deep breathing exercises; deep inspiration for 5 seconds and slow prolonged expiration for next 5 seconds, at a rate of 6 breaths/min (Vasuki and Sweety, 2017), rest for one minute, then apply the exercises again. On the other hand, participants in the control group rested between successive post exposure measures.

Statistical analysis has been applied using (SPSS) V.16 for windows (IBM SPSS, Chicago, IL, USA). Mixed ANOVA was applied having groups as between subjects variable and evaluation time as repeated measure for each of the three tested dependent variables; SBP, DBP, and HR. Level of significance is reported at (P< 0.05)

Statistical Analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). The mean standard deviation (SD) was used to express quantitative data. Qualitative data were expressed as frequency and percentage. The confidence interval was set to 95%, with a 5% acceptable margin of error. So, a P-value of 0.05 was considered significant.

RESULTS

Demographic data presented in table (1) showd non- significant differences between participants in both groups(P<0.05).

TABLE 1: Demographic Characteristics of participants in exercises and control groups

	Exercises group		**Control group**		
	mean	SD	mean	SD	Sig.
Age (years)	35.4	+2.79	34.5	+3.06	0.425
Weight (kg)	84.6	+6.21	85.3	+6.26	0.750
Height (cm)	166.5	+9.10	168.2	+8.03	0.599
BMI (Kg/m2)	30.6	+3.16	30.2	+2.79	0.718

*P<0.05

Outcome variables had been checked for normaility using Shapiro-wilk test and they were found normally distributed. Accordingly, parametric statitistics had been used for outcomes analysis.

Systolic Blood pressure

Results of the current study showed significant increase in means of SBP in exercises (P< 0.001) and control (P< 0.001) groups respectively at immediate evaluation following exposure to noise compared to their baseline mean values. In exercises group, mean values continued to be significantly higher than baseline at 5- minutes (P<0.001), and 10 minutes (P= 0.005) post noise evaluations. However, at 15 minutes evaluation difference from baseline becomes non-significant (P= 0.304), which show that participants in exercises groups returned to their mean baseline values at 15 minutes following noise exposure. While in control group all three evaluations (5 minutes, 10 minutes and 15 minutes) showed significantly higher mean values (P<0.001) compared to baseline mean, which show that participants in control group have not restored mean baseline systolic blood pressure till the last evaluation in this study.

Between groups mean differences showed non-significant differences between groups throughout baseline (P=0.328), immediate post exposure (P=0.920), and 5 minutes post exposure (P=0.493) evaluations. On the other hand significantly lower mean SBP has been reported at 10 minutes (P= 0.002), and 15 minutes (P= 0.027) post exposure evaluations respectively in favour of exercise group. (Table 2, figure 1).

Diastolic blood pressure

Results of the current study showed significantly higher means of DBP at immediate post noise exposure evaluation compared to baseline values in exercises (P<0.001), and control group (P<0.001) respectively. Similarly, all means of DBP continued significantly higher than baseline through 5 minutes, 10 minutes and 15 minutes evaluation respectively in both groups (P<0.001). These results pointed out that participants in exercises and control group continued to show significantly higher mean DBP compared to baseline till the final evaluation in this study.

On the other hand, between groups comparisons showed non- significant difference between means of DBP at baseline (P=0.744), immediate post exposure (P=0.744) and 5 minutes (P=0.334) post exposure evaluations. Contrarily, means of DBP were significantly lower in exercises group than controls at 10 minutes (P= 0.003), and 15 minutes (P= 0.008) respectively. Mean DBP pointed to a much closer value to baseline in the exercises group than in the control group (Table 2, figure 2).

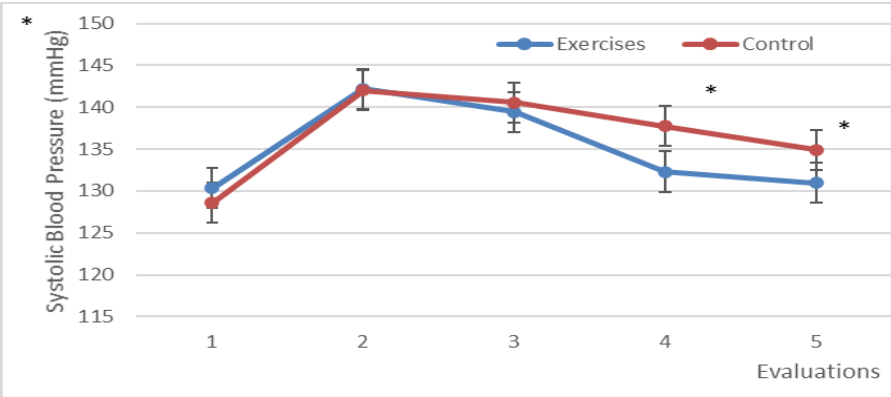
Heart Rate

Results of the current study showed significantly higher mean values of HR at immediate post exposure, and 5 minutes (P<0.001), and 10 minutes (P= 0.002) in exercises group. Likewise, in control group significantly higher mean values of HR at immediate post exposure, 5 minutes (P<0.001), and 10 minutes post exposure evaluations were found compared to baseline HR means (P<0.001). However, results showed non-significant means differences of HR in exercises (P=0.116), and control (P= 0.234) groups respectively when comparing 15 minutes post exposure to baseline evaluations. Between groups comparisons showed non- significant mean values between groups at all evaluations (Table 2, figure 3).

TABLE 2: Comparison of mean SBP, DBP, and HR between exercises and control groups at all evaluation times

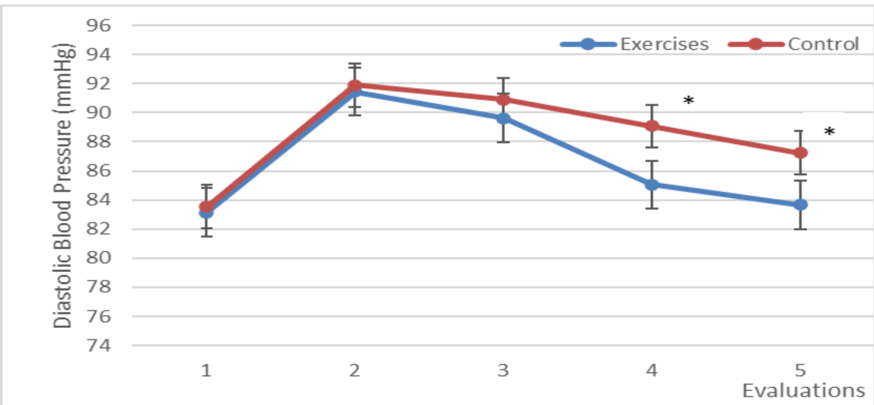
	Groups / **Time of evaluation**	**Exercises group**		**Control group**		
		Mean	**SD**	**Mean**	**SD**	**Sig.**
SBP	Baseline	130.33	4.09	128.60	5.35	0.328
	Immediate post exposure	142.16	4.21	141.99	5.10	0.920
	5- minutes post exposure	139.41	4.03	140.57	5.05	0.493
	10-minutes post exposure	132.31	3.82	137.73	4.94	0.002*
	15- minutes post exposure	130.98	4.32	134.89	4.84	0.027*
DBP	Baseline	83.13	3.68	83.53	2.92	0.744
	Immediate post exposure	91.44	4.04	91.88	3.21	0.744
	5- minutes post exposure	89.61	3.96	90.91	3.16	0.334
	10-minutes post exposure	85.04	3.76	89.06	3.09	0.003*
	15- minutes post exposure	83.67	3.71	87.23	3.03	0.008*
HR	Baseline	79.53	8.60	80.13	7.85	0.843
	Immediate post exposure	83.13	8.15	83.73	7.06	0.831
	5- minutes post exposure	81.46	8.31	82.40	7.14	0.744
	10-minutes post exposure	80.46	8.63	81.33	7.71	0.774
	15- minutes post exposure	79.80	8.47	80.33	7.88	0.860

*P<0.05



* Significant difference between groups at this evaluation time

FIGURE 1: Changes of systolic blood pressure over evaluation times in both groups



* Significant difference between groups at this evaluation time

FIGURE 2: Changes of Diastolic Blood Pressure over Evaluation Times in Both Groups

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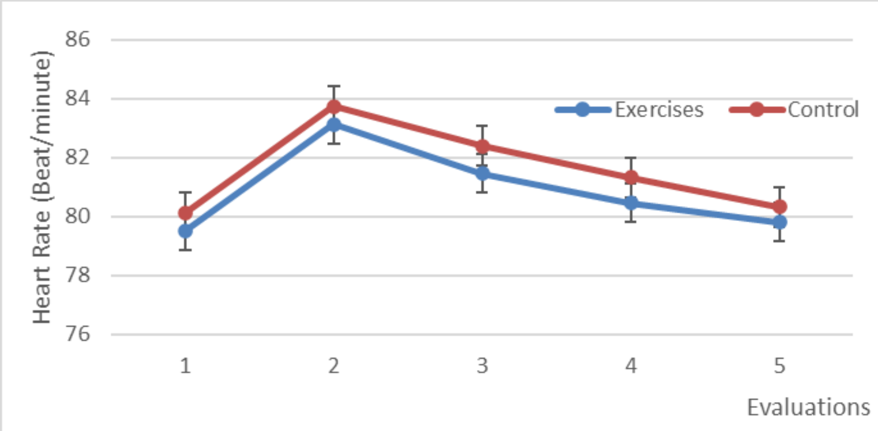

FIGURE 3: Changes of heart rate over Evaluation Times in Both Groups

DISCUSSION

Blood pressure, systolic and diastolic, and heart rate in this study followed the course previously reported of increase when noise exposure took place, then gradually decline post exposure towards baseline values, as effects of noise decline (Lusardi P. et al., 1996). Deep breathing exercises introduced during post exposure period in a check of their effects on cardiovascular parameters as SBP, DBP, and HR during this period.

This study outcome showed statistically significant reduced SBP, and DBP in exercises group compared to control group at 10 and 15 minutes post exposure evaluations. With SBP equivaling baseline at 15 minutes post exposure evaluation. Besides, the mean DBP, that did not reach baseline mean values in breathing exercises group at 15 minutes evaluation, was 0.54 mmHg higher than baseline; which is well below the minimum clinical important difference (MCID) for DBP of 2 mmHg previously reported in literature (Kelley et al., 2021). Increased HR was found to be significant following noise exposure in both groups, and decreased gradually post exposure until reaching baseline means at 15 minutes post exposure in both groups. However, both groups were non-significantly different from each other at all evaluation times.

Diaphragmatic deep breathing stimulatory effect on parasympathetic nervous system has a possible psychological effect in prehypertensive and hypertensive participants (Ma et al., 2017, Elliott et al., 2004), thus reversing the effect of noise exposure. Noise as stressors, induces the release of stress hormones, and the sympathetic tone remains elevated above its resting level. Accordingly, negative emotions are induced as a sequele of prolonged exposure to stressors (Chen et al., 2016). Therefore, diaphragmatic deep breathing in slow and deep application with prolonged expiration possibly reduces symapathetic tone, which lead the subject to less psychological stress (Lehrer and Gevirtz, 2014), thus reversing the effect of noise exposure. A further explaintion of the effect of deep breathing exercises is the increase in lung inflation and lower respiratory rate, stimulating slowly adapting pulmonary stretch receptors. This physiological reflex modulation provides sensory input to the medulla that is used in integration with information from arterial baroreceptors to control hypertension (Narkiewicz et al., 2006). Also, with slow deep breathing, by physiological neural modulation of the activity of respiratory centers, results in enhanced vagal tone due to released activity of cardiovagal centers, with blood pressure and heart rate reduction in consequence (Pal and Velkumary, 2004).

This result is partly in parallel with a study that proved a significant reduction in all the blood pressure parameters in the prehypertensive experimental group exercised using deep breathing exercises. They applied exercises for 10 minutes, two sessions per day for 10 days, showing a remarkable reduction in SBP by 12.9 mmHg in participants without antihypertensive medication (Amandeep et al., 2015). Likewise, a study testing the effects of slow breathing exercises on hypertension patients, at a rate of 6 cycles per minute, reported reduction of blood pressure. They attributed their results to increased vagal tone, and decreased sympathetic activation, adjusting the disrupted autonomic balance (Joseph et al., 2005). Likewise, Mourya M. et al has observed that diaphragmatic deep breathing at 6 or ≤10 breaths per minute for 15 minutes twice daily over 3 months, could reduce SBP and DBP in hypertensive participants through a series of physiological changes that tunes sympathetic and parasympathetic activity, and baroreflex sensitivity, thus results in arteriolar dilation (Mourya et al., 2009). Further Vasuki G. et al concluded that blood pressure decreased in their experimental group of pre-hypertensive and hypertensive patinets applying deep diaphragmatic breathing when compared with the control group at 4, 8 and 12 weeks (Vasuki and Sweety, 2017).

The difference between previous studies and the current one is the participants exposure to noise stress. Besides, the difference in duration of application of breathing exercises. With the exception of Joseph et al. (2005) who studied the effects of single application of deep breathing exercises on baroreflex and blood pressure, the other studies conducted programs of various durations implementing breathing exercises.

Studies that pointed out the effect of diaphragmatic deep breathing on HR in prehypertensive and hypertensive patinets included two studies that reported reduction of HR by 2–4 beats per min over a 2- or 4-weeks intervention (Harneet, 2014, Sundaram et al., 2012). On the contrary current study did not detect that diaphragmatic deep breathing exercise lowers HR more than controls, or reach baseline after noise exposure faster than controls. This is likely due to short single application of deep breathing exercises.

CONCLUSIONS

Diaphragmatic deep breathing exercises are recommended to be applied after noise exposure as a mean of lowering of blood pressure, but not HR, in prehypertensive participants exposed to noise. Future research of longer follow up duration is recommended to follow up diastolic blood pressure until it reach to baseline.

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No funding was received.

CONFLICT OF INTEREST

None

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None

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