23 (2015) 733–740

Contents lists available at ScienceDirect

Complementary Therapies in Medicine

journal homepage: www.elsevierhealth.com/journals/ctim

Music versus lifestyle on the autonomic nervous system of prehypertensives and hypertensives—a randomized control trial

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ARTICLE INFO

Article history:
Received 28 March 2015
Received in revised form 24 July 2015
Accepted 1 August 2015
Available online 5 August 2015

Keywords:
Music
Lifestyle modifications
Hypertension
Autonomic nervous system

ABSTRACT

Objectives: Ragas of Indian music are said to be beneficial in normalizing blood pressure (BP). The objective of this study was to evaluate the effect of passive listening to relaxing raga on the autonomic functions of hypertensives and prehypertensives and provide scientific evidence.
Methods: Ethical clearance was obtained from the institutional review board. A prospective, randomized controlled trial was done on hundred prehypertensives/stage I hypertensives, randomly divided into two groups ($n = 50$ in each). Group 1 received music intervention along with lifestyle modifications while Group 2 received only lifestyle modifications (according to Joint national committee VII guidelines). Group 1 listened to raga bhimpalas played on flute for 15 min daily for at least 5 days/week for 3 months. The main outcome measures were heart rate variability (HRV) (Power lab 15T, AD Instruments), BP and stress levels (State Trait anxiety inventory score). All HRV variables were log transformed for analysis. Statistical analysis was done using SPSS version 18.0 with $P < 0.05$ being considered statistically significant.
Results: Group 1 exhibited significant reduction in stress levels, diastolic BP and systolic BP decreased in Group 2 after intervention. Insignificant rise in parasympathetic parameters of HRV (SDNN, RMSSD, HF ms^2, HF nu) was seen after intervention in both the groups. We found significantly increased parasympathetic and lower sympathetic parameters (LF ms^2, LF nu, LF/HF) in Group 1 and 2 males and females of Group 2. The results suggest that females of Group 1 were least compliant with the given intervention.
Conclusions: Passive listening to Indian music along with conventional lifestyle modifications has a role in normalizing BP through autonomic function modification and thus can be used as a complementary therapy along with other lifestyle modifications.

1. Introduction

Hypertension, a multifactorial chronic disease, resulting from a complex interplay of various causative factors like the individual's genetic background, lifestyle, psycho-social factors, and exposure to various environmental toxins. Over time, this dynamic interplay leads to adverse structural and functional changes in the cardiovascular system, culminating in disease manifestation.[1,2] Among the myriad factors, psychosocial stress has been implicated to contribute significantly to hypertension.

Stress can be relieved via both pharmacological and non-pharmacological measures. The various non-pharmacological methods used recently to manage stress and high blood pressure (BP) include meditation, yoga, acupressure, biofeedback and music therapy. Combinations of the above, along with lifestyle modification modalities such as balanced nutrition, exercise and weight control would obviate the need for medications in many cases of stress-related hypertension.[3,4]

Music has long been known to reduce anxiety and minimize the need for sedatives. Thus, it holds promise for non pharmacological management of hypertension. Listening to music, offers advantages of low cost, ease of administration, better compliance

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http://dx.doi.org/10.1016/j.ctim.2015.08.003
0965-2299/

and safety. Hypertensive individuals can use music for stress reduction via active music making,[5] as well as passive listening. Time and again, studies have proven the beneficial effect of music on hypertensives.[6–10]

Cardiac autonomic regulation is studied through non-invasive measurement of Heart rate variability (HRV), beat-to-beat alteration in heart rate (HR). A decrease in HRV is a strong predictor of mortality after acute myocardial infarction.[11] In the Framingham study, all time domain and frequency domain variables of HRV were reduced in untreated hypertensive men and women.[12] Hypertensives had greater LF (low frequency) nu (normalized units) and lower HF (high frequency) nu than normotensives.[13]

Music influences both physiological and psychological health, mainly by creating a balance in the autonomic functions.[14] It has been quoted that autonomic nervous system "forms a sort of sounding-board, which every change of our consciousness, however slight, may evoke reverberations".[15] Whether music causes an increase or decrease in HR, remains a mystery.[16,17] Several studies reported that under various conditions music decreases sympathetic nervous system (SNS) and increases parasympathetic nervous system (PNS) activity as measured by HR and HRV, indicating physiological relaxation.[17–23] A few investigations revealed no difference in HR or HRV,[24,25] while others have also reported an increase in HR.[21,26]

We thus observe that there is varying literature available on the effects of music on HRV and the mechanism behind it. And, most of them have looked into acute effects of music on the heart. Very few of them have used music as an intervention and studied the effect of the same over a longer time on autonomic activity. The objective of this study was to evaluate the effect of passive listening to relaxing instrumental music (Indian) intervention on the autonomic functions of hypertensives and prehypertensives. We hypothesized that this would produce a relaxing effect on the ANS among prehypertensives and hypertensives.

2. Methods and materials

2.1. Study design and source of subjects

After the study was ethically cleared by the institutional ethical and scientific review board a prospective open labelled randomized control trial (parallel group) was conducted. The study protocol was explained and informed consent was obtained. The subjects were informed about their rights to withdraw their participation from the study. Subjects aged 30–60 years were recruited from the out-patient department of a tertiary care hospital. BP was measured twice with a gap of 5 min in between using standard methodology and classified into prehypertensives and hypertensives based on JNC VII guidelines.[27] Subjects with stage 2 hypertension, uncontrolled hypertension, secondary hypertension, any other cardiovascular disorders, renal disorders, stroke, respiratory diseases, pregnancy, body mass index (BMI) >35 kg/m^2, epilepsy, autonomic disorders, uncontrolled diabetes, those with hearing problems, panic disorder and major psychiatric disorder were excluded from the study.

The sample size was calculated based on literature survey[6] in which a decrease of 4 mm Hg systolic BP was observed due to music intervention. Considering a mean difference of SBP as 4 mm Hg (SD = 8) with 90% power and 5% level of significance the estimated sample size was 50 per group using independent *t* test for sample size calculation. A total of 100 prehypertensives and stage 1 hypertensives were randomly assigned to two intervention arms by employing randomization process.

2.2. Randomization

The study's biostatistician (NSM) randomly placed subjects in the control or treatment group in 1:1 ratio, by permuting the total sample size into 2 arms. The first fifty numbers were allotted to the music and lifestyle intervention by tossing the coin and the next fifty into the other group (for only lifestyle intervention). No stratification for age, sex, or blood pressure range was performed. The random number indicating intervention or control was kept in an opaque and sealed envelope and the serial number of the patients were written on the top of the envelope. The envelope was opened by the research assistant (PAH) after the baseline assessment of each participant had been completed, who recruited participants to the 2 arms. After assignment to interventions, the investigators (UKK, GJ, RK, NSM) who did the outcome assessments were blinded to the interventions.

Fifty subjects assigned to one arm received music along with lifestyle intervention (Group 1). The other fifty subjects received only lifestyle intervention (Group 2). All the subjects recruited for the study were followed up as per schedule of follow up (Fig. 1).

Detailed history and sociodemographic particulars were recorded. General health examination was done after enquiring the stress levels (measured using State trait anxiety inventory—STAI), smoking and alcohol history. Disease history was enquired and the pharmacological management of hypertension was noted and continued. The subjects answered a questionnaire regarding the presence or absence of diabetes and hypertension. The hypertensives were also questioned about the non-pharamacological measures as well as medication taken by them. A few of the non-pharamacological measures enquired to control hypertension control hypertension were diet modification (high fiber diet/dietary oils, vegetable/fruit consumption), salt intake, exercise, walking, yoga, pranayama, meditation or any other measure. The anthropometric measurements, BMI and waist hip ratio (WHR) were recorded. Clinical BP was measured on recruitment and after 3 months of intervention.

2.3. Music intervention

Fifty subjects were given the musical piece on a device of their choice, based on their preference of hearing, which could increase the compliance towards the intervention. We used 22 min long instrumental (*Bansuri*) music, playing *raga* (musical scale) *Bhimpalas/Abheri*. Percussion instruments were not used. We instructed the subjects to listen to this music, preferably during the same time everyday for 3 months or beyond until follow up recordings of HRV and other physiological parameters were completed. The subjects were included for final analysis if they had heard this music for at least 15 min daily at least 5 days a week for 3 months.

2.4. Lifestyle intervention

All recruited subjects were given lifestyle modification intervention according to JNC VII guidelines. The subjects were explained orally about the modifications they should incorporate in their daily life in order to control the rise in BP along with printed handouts containing the modifications they need to follow, for their reference. The subjects were encouraged and motivated during recruitment and follow up visits to adhere to the recommendations given.

2.5. Measurement of autonomic function

Autonomic function was tested using Power lab 15 T Lab chart hardware & software (AD instruments). The studies for the assessment of HRV were carried out between 09:00 and 12.00 noon in

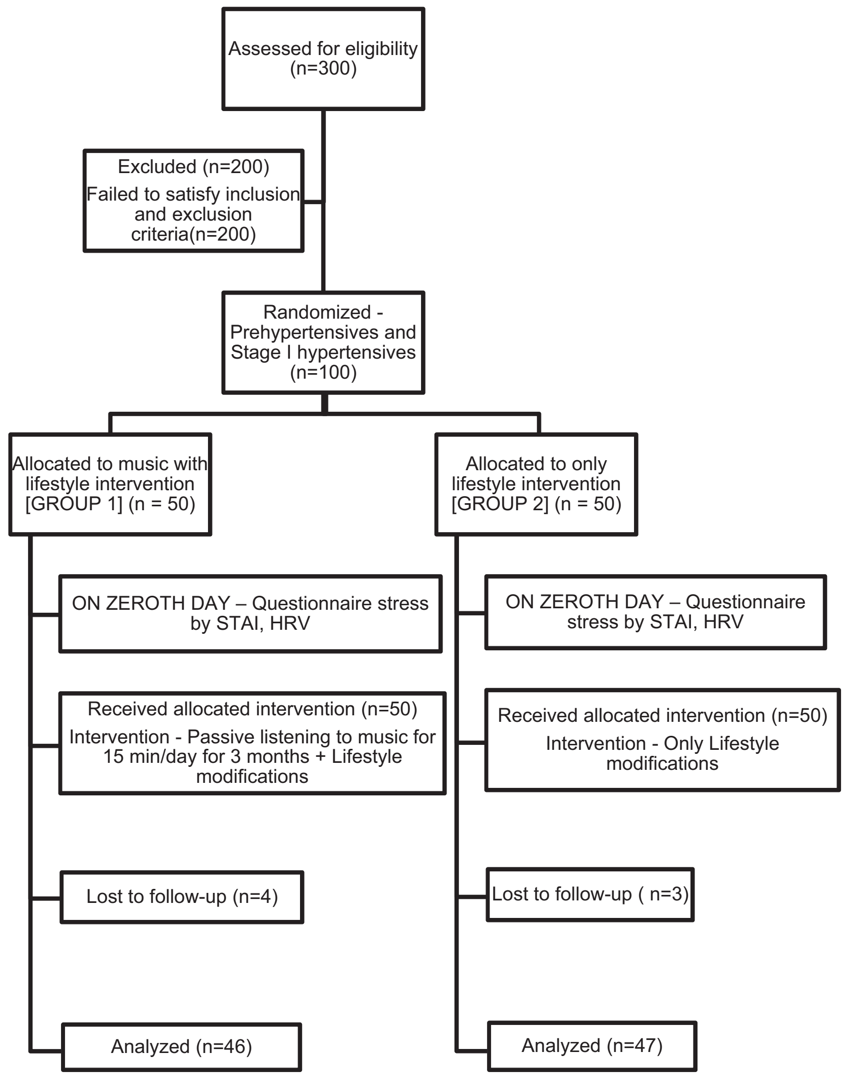

Fig. 1. Consort diagram of participant recruitment, distribution and follow up.

an isolated examination room at a stable temperature between 20 and 22 °C. The subjects were asked to relax in supine position, with their eyes closed. Movement induced artefacts were minimized by asking the subjects not to move during the recording. Subjects were asked to refrain from talking, falling asleep and intentionally altering their respiration during the recording. Participants were asked to abstain from tea, coffee about 2 h prior to the recording. They were asked to take a light breakfast and abstain from exhaustive exercise, alcohol intake and smoking for the past 24 h.[28–30] Electrocardiogram (ECG) was recorded in Lead II (sample rate of 1000 Hz) for ten minutes as it is twice the minimum window required for HRV analysis. The first 1–2 min of the data was excluded to avoid transition or adjustment effect. In this way the data used for analysis represented the resting HRV without contamination from other conditions or extraneous factors. Ectopics were excluded as they do not represent ANS activity and are not believed to contribute to HRV.[31] Analysis of HRV was done by the same investigator to avoid sources of error.

ECG was recorded twice, once at recruitment and after 3 months of intervention. Only series with more than 95% of sinus beats was used for analysis. The HRV parameters analyzed using fast Fourier transformation (FFT size: 1024) were SDNN—the standard deviation of NN intervals, RMSSD—Root square of the mean squared difference of successive NNs, NN50—number of pairs of successive NNs that differ by more than 50 ms, pNN50—proportion of NN50 divided by total number of NNs, spectral components such as Very Low Frequency (VLF), Low Frequency (LF) and High Frequency (HF) components in absolute values of power (ms^2) and in normalized units (nu), and LF/HF.

2.6. Follow up

Follow up was done by contacting them telephonically/personally on a regular basis and also monitored, weekly once (or more number of times), to ensure compliance towards the intervention. ECG for HRV and other physiological variables were recorded at the end of 3 months.

2.7. Statistical analysis

All the data were thoroughly checked for any inconsistencies and missing observations. The data was analyzed using SPSS software version 18.0. Quantitative data were expressed as mean, standard deviation (SD), minimum (Min), Maximum (Max), median and interquartile ranges. Qualitative data was expressed as percentages. To test for differences in the mean values student t test and non-parametric tests of significance were employed. Pre to post intervention outcomes within each group was assessed by paired

Student *t* test and Wilcoxon signed rank test; and between groups we used unpaired Student *t* test and Mann Whitney *U* test. Chi square and Fischer's test was applied for associations between the categorical variables. *P* value of ≤ 0.05 was considered as the level of significance.

3. Results

Out of 100 subjects recruited, 7 subjects were lost during follow up. The two groups were comparable based on age, gender, stress levels, smoking and alcohol history on recruitment. Twelve and 14% of the subjects were smokers and 22 and 32% were current alcoholics in Group 1 and Group 2 respectively. No change was observed in history for smoking and drinking during or after intervention. Disease history or drug history did not vary significantly in both the groups after intervention (Table 1).

3.1. Stress (as measured by STAI)

Prior to intervention the stress levels among both the groups was comparable. It decreased significantly after intervention in both the groups ($P \leq 0.001$) (Table 2).

3.2. Blood pressure

There was a significant drop in diastolic BP after intervention in both the groups and a drop in systolic BP in Group 2 after intervention (Table 3).

3.3. Heart rate variability

There was statistically no significant difference in the pre-intervention HRV parameters, both time domain and frequency domain, in between the two groups. After intervention, in Group 1 there was a significant decline in post intervention maximum RR interval, mean RR interval along with a significant increase in HR ($P < 0.05$). There was statistically no significant increase in mean values of SDNN (ms), RMSSD all of which are indicators of parasympathetic activity. Post intervention TP (ms^2), VLF (ms^2), LF (ms^2), LF (nu), HF (ms^2), LF/HF increased, but none of them were statistically significant. There was a non significant decrease in HF (nu) (Table 4).

In Group 2, though there was an increase in maximum RR interval but was statistically not significant. Post intervention all the time domain parameters (SDNN, RMSSD, NN50, PNN50—indicators of parasympathetic activity) increased, but was not significant. There was also increase in post intervention TP (ms^2), VLF (ms^2), LF (ms^2), LF (nu), HF (ms^2), LF/HF; none of them statistically significant. There was a decrease in HF (nu) found (statistically insignificant). This result was similar to that found in Group 1 (Table 4). After log transformation of HRV variables there was no significant difference before and after intervention in any of the parameters within the two groups (Table 5). Analysis of BP and HRV, after deletion of smokers and alcoholics did not show any significant difference between and within the groups (not shown in the tables). Similar results were found after division of the whole sample into smokers and non-smokers groups.

HRV is said to be affected by gender. Thus a subgroup analysis based on gender was done. On comparison of HRV between the two groups subdivided based on gender, the following findings were observed. Females had higher parasympathetic activity before intervention (as evidenced by higher SDNN, RMSSD, HF ms^2, HF nu and lower sympathetic parameters—LF ms^2, LF nu, LF/HF). Total power an indicator of overall autonomic function was also higher among females along with VLF ms^2.

After intervention, a statistically significant increase was seen in heart rate in Group 1 males ($P = 0.020$), decrease in HR was observed among Group 2 females ($P = 0.015$). Group 1 females showed a significant decline in HF nu ($P = 0.035$) and increase in LF/HF ($P = 0.039$) (Table 6).

Pre-intervention all females involved in the study had higher SDNN (ms), Total power (TP) (ms^2), HF power (ms^2) and HF (nu). Post intervention we found that SDNN and RMSSD (ms) showed a trend towards increase among males of both the groups and females of Group 2 [For Figs. 2–7 refer supplementary material]. Post intervention TP tended to increase among males of both the groups. Pre-intervention all females in Group 1 had lower LF power (ms^2) and lower LF (nu) than males. Post intervention LF power and HF power showed a trend towards increase among all subjects of both the groups except females of Group 1 while LF (nu) had a trend towards increase in all subjects. None of the changes seen post-intervention were statistically significant. The sympathovagal balance parameter, LF/HF, increased among all males of both the groups and females of Group 1.

None of the parameters of HRV varied significantly post intervention between males and females of both groups after log transformation. However, as seen with the raw values, after log transformation, parasympathetic indicators of HRV (SDNN, RMSSD, HF) was higher and LF (sympathetic indicator) was lower among females in both the groups.

4. Discussion

In this study we hypothesised that relaxing music would create better autonomic balance among prehypertensives and hypertensives. Lifestyle modifications recommendation as per JNC VII guidelines was given to both the groups. In addition to that Group 1 received music intervention in the form of Indian instrumental classical music heard by all the subjects for a duration of 3 months.

The music we used was Indian instrumental music played on flute for 22 min based on *raga bhimpalas*, to be heard for a minimum of 15 min/day for atleast 5 days a week for 3 months duration. *Bhimpalas/Bhimpalasi* has been suggested to normalize BP,[32,33] (along with other ragas such as *hindol*, *ahir bhairav*, *todi*, *kausi kanada*). However, there was lack of scientific evidence for substantiating the same. In this study we therefore approached this problem scientifically in order to provide an explanation by conducting stress along with BP measurements and HRV analysis among prehypertensives and hypertensives.

All the notes of *raga bhimpalas* are flat. As the elaboration of the notes of this raga progresses, it helps in human mind transition from initial nostalgic sad feeling towards heroism and triumph.[34,35] As there was very little literature available on Indian music, with regards to the most relaxing or soothing instrument, we chose flute for this study. We chose instrumental music because this type of music uses only musical components like pitch, intensity, rhythm and timbre and it does not use any verbal language (lyric). So, the effects generated would be exclusively from the musical components. The use of percussion instruments was avoided as tempo has been shown to significantly affect the heart in various ways.

Music intervention were given the music in the form of CDs or in the cell phone according to their choice. This helped in easy compliance from the subjects. Passively listening to music was chosen to have uniformity in what the subjects listened. Active making of music may not be an option for all the people.

Stress levels decreased significantly after intervention in both the groups. This could be attributed to the fact that stress reduction was part of the counselling and handouts given for all subjects in both the groups. Further music is a known stress buster.[36] Although the absolute change in stress scores was similar in both the groups,

Table 1
Percentage distribution of subjects in both the groups based on baseline parameters. A few parameters are presented as mean ± SD.

Variable	Groups for analysis	Group 1 (N = 50)	Group 2 (N = 50)	P
Age	(Years)	46.50 ± 8.5	46.88 ± 8.5	0.824
BMI (kg/m^2)	[mean ± SD]	25.93 ± 3.9	25.86 ± 3.1	0.925
WHR		0.92	0.94	0.147
Gender		M(60); F(40)	M(74); F(26)	0.137
Hypertension		P(46); A(54)	P(34); A(66)	0.221
Age at diagnosis	In years (mean ± SD)	44.87 ± 6.7	44.12 ± 7.5	0.741
Non pharmacological measures followed to control HTN	Diet modification	2	4	0.608*
	Walking	4	8	
	Exercise	2	2	
	Yoga	2	0	
	Meditation	6	0	
Measures followed to control HTN	Only non pharmacological	4	8	0.37*
	Only pharmacological	22	16	
	Both	12	6	
Diabetes Mellitus	Yes	P(10); A(90)	P(10); A(90)	1
Based on SBP (mm Hg)	Pre hypertensive	86	72	0.086
	Stage I hypertensive	14	28	

N: sample size, SD: standard deviation, BMI: body mass index, WHR: waist hip ratio, HTN: hypertension, SBP: systolic blood pressure, M: males, F: females, P: present, A: absent.
* indicates P value was calculated using Fischer's exact Test.

Table 2
Comparison of pre versus post intervention stress scores in Group 1 and Group 2.

Group	Stai scores	Pre (n = 46) Mean(SD)	Post (n = 47) Mean(SD)	Pre vs post P
1	State	31.34(10.3)	27.69(6.1)	0.001
	Trait	36.82(8.7)	30.9(5.3)	<0.001
		Pre (N = 50)	Post (N = 47)	
2	State	34.76(8.4)	30.53(5.5)	<0.001
	Trait	38.3(8.4)	33.77(5.8)	<0.001

N: sample size, SD: standard deviation.

Table 3
Comparison of pre vs post intervention blood pressure levels in Group 1 and 2.

GROUP	INT	SBP (mm Hg)			DBP (mm Hg)		
		Mean(SD)	95% CI	P	Mean(SD)	95% CI	P
Group 1 (N = 46)	PRE	130.74(8.7)	124.8–137	0.261	85.1(6.8)	81–87.3	0.004
	POST	130.02(12.2)	121–135.5		83(8.7)	77–89	
Group 2 (N = 47)	PRE	133.12(11.8)	122.8–141.3	0.015	85.24(7.3)	79.5–92	0.015
	POST	129.91(11.5)	122–136		82.58(8.0)	76–88	

N: sample size, SD: standard deviation; SBP: systolic blood pressure, DBP: diastolic blood pressure.

in terms of percentage reduction there was a 11.6% drop in state score in Group 1 subjects and 12.2% drop in Group 2. The trait score reduced by 16.1% in Group 1 and 11.8% in Group 2. Since trait score measures the persons anxiety levels over a long term basis, it can be said that music has proven to be a stress buster in this study also.

In line with this, there was a significant drop in diastolic BP in both the groups after intervention. Systolic BP reduced in both the groups, but was significant only in Group 2. The disease history and drug history did not change during the study and after intervention in both the groups. Thus the change found in BP can be exclusively attributed to the respective interventions given to both the groups.

At the time of recruitment, the two groups were comparable based on baseline HRV analysis. In Group 1 we found a significant decline in post intervention NN/RR interval. There was an insignificant rise in indicators of parasympathetic activity in Group 1. After intervention, Group 2 subjects showed a statistically insignificant increase in RR interval and parasympathetic activity indicators. After log transformation, none of the parameters showed any variation after intervention in both the groups.

Most of the studies using music intervention have shown a post intervention decrease in HRV as reviewed previously. A study using Indian instrumental music, showed parasympathetic dominance in HRV after listening to 10 min of Malkauns raga with 80% *komal swaras* i.e. minor tones (flat notes), played in the *drut gat* (faster pace) irrespective of the music knowledge of the subjects. Only musicians had parasympathetic dominance listening to *drut gat* of *yaman raga* which had no effect on non-musicians. *Alaap* (slow rendition) of either *ragas* failed to have any effect on all subjects. The authors hypothesized that *tivra swaras* (major tones) and slower renditions of Indian music fail to elicit parasympathetic response.[37] *Raga Bhimpalas* used in this study predominantly contained *komal swaras* and was delivered as *alaap*. However, we did not study the acute effect of this raga on HRV.

It should be emphasized that, HRV has been shown to increase after music intervention in some of the previous studies.[26,38] It is important to note that most researchers have done HRV during resting condition either before, during or after intervention and studied the acute changes in HRV. Also, subjects were asked to rest during music sessions or follow deep breathing exercises while listening to music. In our study we analysed HRV after three months of intervention. The instructions given to the subjects while listening to music were: (a) to listen preferably when there would be no interruptions, (b) to listen at the same time every day, (c) to relax

Table 4
Comparison of pre and post intervention HRV between the two groups.

		Group 1 pre (n = 50), post (n = 46)			Group 2 pre (n = 50), post (n = 47)		
		Mean(SD)	Median(IQR)	P	Mean(SD)	Median(IQR)	P
Max NN (ms)	Pre	939.55(212.3)	918.2(809.8–1007.2)	0.029	946.89(173.8)	921.6(861.5–1014.7)	0.958
	Post	921.07(259.6)	866.7(782.1–991.9)		939.62(185.4)	922.7(812.9–1005.3)	
Min NN (ms)	Pre	638.85(154.1)	636.5(580.9–720.9)	0.076	657.43(137.0)	647.2(562.0–724.9)	0.189
	Post	571.37(183.1)	608.5(535.9–669.6)		604.97(157.5)	634.5(600.5–682.3)	
Median NN (ms)	Pre	788.10(126.8)	776.4(705.9–849.3)	0.002	805.11(115.1)	804.3(750.4–888.7)	0.611
	Post	753.63(112.1)	739.1(667.3–828.1)		796.20(97)	800.1(716.7–853.7)	
Mean HR (BPM)	Pre	78.28(12.8)	77.1(70.2–84.5)	0.008	75.99(11)	75.1(68.1–79.9)	0.657
	Post	81.42(11.8)	80.9(72.1k89.8)		76.72(9.8)	75.2(70.2–83.9)	
SDNN (ms)	Pre	42.15(22.9)	36.8(30.0–51.5)	0.604	40.53(21.8)	33.4(27.3–48.4)	0.866
	Post	43.49(32.8)	34.0(24.3–50.5)		42.93(28.1)	34.6(25.7–54.1)	
RMSSD	Pre	34.03(28.9)	27.1(17.2k43.5)	0.373	30.43(20.6)	26.7(16.9–35.8)	0.983
	Post	35.80(39.6)	20.3(15.3–38.8)		35.38(34.7)	23.2(16.1–43.2)	
NN50	Pre	62.82(78.8)	36(6.8–84)	0.123	50.80(65.2)	24(3.5–78.0)	0.62
	Post	50.02(82.1)	22(3–55)		46.85(60.5)	14(5.0–65.0)	
pNN50	Pre	8.33(11)	4.101(0.9–12.2)	0.132	6.60(8.7)	3.2(0.5–10.2)	0.815
	Post	6.68(11.5)	2.135(0.5–7.1)		7.03(8.9)	2.1(0.6–10.5)	
TP (ms^2)	Pre	1966.47(2665.3)	1084.1(756.1–2460.1)	0.666	1763.38(2064.1)	1137.9(681.6–1812.0)	0.866
	Post	2282.10(3728.8)	944.6(515.1–2352.5)		2192.04(2817.2)	1084.7(620.6–2650.0)	
VLF (ms^2)	Pre	567.52(485.8)	412.6(291.4–770.8)	0.996	746.26(762.1)	472.9(314.6–939.7)	0.899
	Post	684.07(821.5)	368.4(234.8–742.9)		752.78(785.1)	481.6(278.9–919.0)	
LF (ms^2)	Pre	511.27(540.7)	321.2(156.9–621.0)	0.441	408.94(478.1)	235.0(124.8–402.3)	0.295
	Post	593.26(861.8)	248.2(135.1–681.6)		626.16(825.7)	255.5(149.8–849.6)	
LF (nu)	Pre	47.85(19.9)	49.2(30.8–64.4)	0.312	48.31(15)	47.5(37.0–60.9)	0.38
	Post	50.65(18.5)	47.2(37.2–61.0)		50.62(16)	50.3(36.1–64.8)	
HF (ms^2)	Pre	605.12(1010.9)	288.5(126.0–723.0)	0.544	423.93(573.0)	215.6(91.3–516.2)	0.672
	Post	728.79(1623.2)	215.2(70.5k697.3)		553.67(846.5)	195.0(93.3–534.5)	
HF (nu)	Pre	41.90(16.7)	39.7(30.5–53.0)	0.184	40.58(15)	39.5(28.7–52.3)	0.166
	Post	37.63(15.2)	43.1(24.8–49.3)		37.29(12.8)	35.4(26.6–46.2)	
LF/HF	Pre	1.64(1.6)	1.3(0.5–2.1)	0.323	1.52(1.1)	1.2(0.7–1.9)	0.465
	Post	2.06(2.2)	1.2(0.8–2.2)		1.67(1.1)	1.3(0.8–2.4)	

Note:

a) Heart rate is in Beats per minute (bpm), nu is normalized unit, ms^2 is millisecond square.
b) Values are given as mean, SD, interquartile range (IQR).
c) P value of < 0.05 is considered significant.
d) Wilcoxon signed rank test was applied to test differences in mean values for all HRV parameters to compare pre and post intervention values.

physically and mentally while listening to music. The instructions were given to achieve better compliance.

Music is said to be in synchrony with a person's mood causing a psychological response that leads to physiological changes regardless of whether the person is in activated or calm state.[26] This might have resulted in the above findings of statistically insignificant reduction of HRV among music intervention subjects in this study.

Prior to intervention parasympathetic indicators of HRV were high among females. This finding is similar to most of the previous studies where females have been shown to have higher levels of parasympathetic activity.[39–41] After intervention males of both the groups (SDNN, RMSSD, HF power, Total power) and females of Group 2 (RMSSD) had higher parasympathetic activity. Females in Group 1, on the other hand, showed a decrease in post-intervention SDNN, Total power, HF power unlike females in Group 2. RMSSD (ms) was much higher among the females involved in the study than males which persisted after the intervention. Further, all subjects showed a trend towards increase in LF (nu), LF/HF and decrease in HF (nu). However, as mentioned previously, none of the changes seen after intervention were statistically significant. Thus, HRV showed a trend towards increase among females of Group 1 leading us to infer that the males of both the groups and females of Group 2 were more compliant with the respective interventions than Group 1 females. It could also due to this fact that systolic BP reduced only in Group 2.

On subgroup analysis of BP based on gender there was a significant drop in BP among males. Diastolic BP decreased in males of both the groups where as systolic BP reduced significantly only in Group 2 males. Females of both the groups had a drop in BP but none of them was statistically significant.

Table 5
Comparison of pre and post intervention HRV after log 10 transformation between the two groups.

	Group 1 (n = 46)					Group 2 (n = 47)				
	Pre		Post			Pre		Post		
	Mean	SD	Mean	SD	P	Mean	SD	Mean	SD	P
SDNN	1.57	0.23	1.56	0.24	0.792	1.56	0.20	1.56	0.25	0.907
RMSSD	1.43	0.31	1.40	0.35	0.607	1.41	0.26	1.42	0.32	0.866
TP	3.07	0.49	3.06	0.47	0.935	3.05	0.40	3.08	0.48	0.751
VLF	2.63	0.39	2.63	0.40	0.939	2.70	0.38	2.68	0.44	0.816
LF	2.47	0.57	2.48	0.49	0.887	2.40	0.42	2.49	0.53	0.340
HF	2.41	0.63	2.34	0.67	0.581	2.32	0.56	2.36	0.60	0.714

Table 6
Comparison of pre and post intervention HRV between males and females.

	Group 1 males			Group 2 males		
	Pre (n = 30) Mean(SD)	Post (n = 28) Mean(SD)	P	Pre (n = 37) Mean(SD)	Post (n = 35) Mean(SD)	P
Mean HR (BPM)	75.61(10.4)	79.20(12.4)	0.020	74.29(11.7)	76.69(10.8)	0.555
SDNN (ms)	41.30(20.1)	45.39(32.7)	1.000	38.56(20.0)	40.53(23.9)	0.987
RMSSD	31.71(31.1)	34.80(39.5)	0.649	28.34(15.1)	32.05(24.9)	0.831
NN50	47.30(63.5)	53.54(88.6)	0.776	51.27(66.5)	51.09(68.0)	0.668
pNN50	6.84(10.5)	7.48(12.9)	0.699	6.77(9.1)	7.49(9.9)	0.993
TP (ms^2)	1926.51(2955.6)	2540.31(4319.3)	0.964	1466.77(1321.6)	2032.85(2310.3)	0.743
VLF (ms^2)	535.33(358.6)	757.30(782.2)	0.374	668.56(607.7)	732.12(742.5)	0.756
LF (ms^2)	573.05(569.4)	712.18(1018.6)	0.452	381.22(421.7)	627.17(866.5)	0.376
LF (nu)	55.70(18.4)	56.71(18.6)	0.785	49.90(15.1)	52.44(15.9)	0.471
HF (ms^2)	534.27(1127.1)	821.77(1986.9)	0.802	346.57(377.1)	495.73(667.3)	0.756
HF (nu)	36.47(15.5)	36.07(15.7)	0.964	39.72(16.0)	35.74(13.1)	0.154
LF/HF	2.14(1.9)	2.53(2.6)	0.982	1.63(1.1)	1.81(1.1)	0.461
	Group 1 females			Group 2 females		
	Pre (n = 20) Mean(SD)	Post (n = 18) Mean(SD)	P	Pre (n = 13) Mean(SD)	Post (n = 12) Mean(SD)	P
Mean HR (BPM)	82.28(15.1)	84.88(10.3)	0.133	80.83(7.0)	76.79(6.6)	0.015
SDNN (ms)	43.43(27.2)	40.55(33.7)	0.396	46.16(26.2)	49.92(38.1)	0.754
RMSSD	37.52(25.7)	37.37(40.9)	0.500	36.37(31.7)	45.08(54.4)	0.638
NN50	86.10(94.4)	44.56(72.9)	0.070	49.46(64.1)	34.50(27.9)	0.859
pNN50	10.57(11.6)	5.44(9.3)	0.098	6.12(7.8)	5.67(5.2)	0.657
TP (ms^2)	2026.41(2231.9)	1880.45(2625.3)	0.472	2607.59(3333.8)	2656.33(4046.7)	0.937
VLF (ms^2)	615.81(638.9)	570.14(889.9)	0.327	967.42(1091.8)	813.05(931.7)	0.480
LF (ms^2)	418.59(493.9)	408.27(508.6)	0.528	487.84(625.2)	623.21(728.1)	0.480
LF (nu)	36.07(16.2)	41.23(14.2)	0.157	43.76(14.1)	45.31(15.6)	0.814
HF (ms^2)	711.40(822.9)	584.16(817.3)	0.420	644.14(918.3)	722.64(1256.2)	0.754
HF (nu)	50.05(15.2)	40.07(14.4)	0.035	43.00(11.7)	41.84(11.1)	0.814
LF/HF	0.88(0.7)	1.34(1.1)	0.039	1.18(0.8)	1.23(0.7)	0.937

We have reviewed studies which have shown increased or decreased HRV previously. The type of music, familiarity and their liking towards the given piece of music can also affect the physiological response[21,42–46]. Heart rate increased when participants listened to music they liked.[47]

The strengths of this study was that this is the first time that a randomized trial of Indian music intervention was given to stage I hypertensives and prehypertensives, the study sample has been larger as compared to many other previous studies. Also, the music used in our study was exclusively recorded for this study after looking into the drawbacks in previous literature (e.g.: presence of percussion and lyrics in music, researcher selected music, basis for the *raga* or the instrument used). Subjects from both sexes with homogenous age group were selected and then randomly allotted into two groups. Previous literature has shown that music intervention is beneficial in normalizing BP among hypertensives. However, the mechanisms involved in this reduction have not been explored fully. Hence, we have studied the autonomic variations by doing HRV analysis. The dropout rate was minimal.

Music can thus be included as an adjunct therapy along with JNC VII recommendations. Nonetheless, there are multitudes of causative factors/biomarkers of hypertension, not all of them have been explored here. Hence a study, where biomarkers are tested, will help in finding the aetiology of BP variations better. What is still to be achieved is an investigation of effect of Indian music on hypertension on a large population and its impact on other stress related disorders.

4.1. Study limitations

Short term HRV analysis and BP before, during and immediately after the music intervention was not done on a single day to study the acute effects of music. HF power is affected by respiratory sinus arrhythmia. Though respiratory rate was controlled (12–16 breaths/min) it was not analysed and adjusted for while analysing HRV. Choice of music was not given to the subjects; as previous literature has shown a significant effect after using familiar rather than unfamiliar music intervention. Personal preference has been shown to increase the sense of control, from the act of selecting music, which in itself can reduce psychological and physical stress[48]. Choice of music being given to the subject will lead to many different types of music being heard, which by itself forms a confounding factor and reduce the uniformity of the intervention being given. The level of music sound pressure (in decibels) was not measured. Music intervention combined with slow guided breathing exercises might have been a better intervention as shown by many previous studies rather than only passive listening to music[9,49]. The involvement of subjects in the respective interventions was not checked objectively, i.e., how much a subject got involved in the music while listening to the same; though compliance check was done during the three months of intervention. Probably a laboratory setting where the intervention is given could have been better to get more reliable results. Abel et al. had observed different cardiovascular responses in laboratory versus natural settings.[50]

5. Conclusions

The results of this study further emphasize the fact that even passive listening to Indian music along with conventional lifestyle modifications does have a role in normalizing blood pressure, particularly diastolic BP. We found higher parasympathetic activity after music intervention. One of the results of music could be achieving a better autonomic balance. Thus, music can be included as an adjunct or complementary therapy along with JNC VII recommendations. There is however, a need for long durational studies (6 months to 1 year) as the parasympathetic activity had started to increase in the course of three months during the study.

Conflict of interest

None declared.

Funding

This research was supported by non-communicable diseases division, Indian Council for Medical Research, New Delhi, Government of India [Grant number—2010-13440].

Acknowledgments

The authors acknowledge Indian Council of Medical Research (ICMR), New Delhi for funding the project and Vidhwan Pravin Godhkhindi for the musical piece. We also wish to thank all the participants of this study for volunteering and cooperation.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ctim.2015.08.003

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