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Effect of specific melodic scales of Indian music in reducing state and trait anxiety: A randomized clinical trial

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Abstract

Music is an aesthetic stimulus that evokes a subjective experience in every individual involved with it. Music as a modality to reduce anxiety and stress has been researched scientifically across the world, but evidence regarding Indian musical scales (ragas) is meager. Healthy individuals were randomly divided into four groups where three groups—A (*Ahir Bhairav*), B (*Kaunsi Kanada*), and C (*Bhimpalas*)—received a music intervention (10 min) while Group D was the control group. Anxiety was scored using the State-Trait Anxiety Inventory (STAI) before and after the intervention. Data analysis was done using analysis of covariance (ANCOVA). All three scales reduced STAI scores significantly, with Scale B causing the maximum reduction in the score. After adjusting for the pre-trait scores, it was observed that age ($p = .002$) and gender ($p = .018$) affected the post-trait scores. A regression analysis on gender showed a significant association of trait scores in Group C ($p = .01$; odds ratio [OR] = 0.125). Scales A and C had more beneficial effects in females while Scale B was beneficial among males. Thus, listening to any of the three chosen Indian scales reduced anxiety. Listening to music does have therapeutic implications for anxious and stressed individuals.

Keywords

stress, relaxation, randomised controlled trials, psychophysiology, music therapy, listening, functions of music

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Music is an aesthetic stimulus that evokes a subjective experience in every individual involved with it, be it in the production of new music or a simple exercise such as listening to music. Music has been shown to reduce peri-operative and operative anxiety along with a reduction in blood pressure (BP), heart rate (HR), and the respiratory rate in gastrointestinal endoscopy (Salmore & Nelson, 2000), colonoscopy (Smolen et al., 2002), and cardiac patients (Cadigan et al., 2001). Music therapy is now commonly used in health-related areas such as pain clinics, intensive care units, peri-operative set-ups, scan waiting rooms, and pediatric units (Dileo, 2006). Newer studies emphasize the effect of different types of music in promoting relaxation and reducing anxiety and stress levels (Linnemann et al., 2015, 2016; Moola et al., 2011). Meditative classical music lowers the neuroendocrine markers of stress (Gerra et al., 1998; Möckel et al., 1994). A recent systematic review of 11 randomized trials consistently showed that music therapy (ranging from 15 to 60 min) reduced the anxiety and stress of critically ill patients (Umbrello et al., 2019).

Music may be a way to help young people reduce negative emotions (Labbé et al., 2007). Young people report that they often have a collection of favourite "tunes" that they listen to when they are feeling "stressed out" (Knobloch & Zillmann, 2002). Many correlational research studies have been conducted to determine the relationship between different genres of music and stress (Alagha & Ipradjian, 2017). Participants in bad moods often choose highly energetic, joyful music for longer periods (more than half of the time that was stipulated for the participants to listen, participants chose to listen to enjoyable music) and were more decisive in exercising their musical preferences (Knobloch & Zillmann, 2002). In one study, participants indicated that the melody was most effective and instrumentation was least effective among musical components in reducing State-Trait Anxiety Inventory (STAI) scores (Fiore, 2018). In music theory, an interval is the difference in pitch between two sounds. An octave is the interval between one musical pitch and another pitch that is double its frequency. The basic set of tones and relationships between them that are used in *ragas* are derived from the division of the octave into 12 tones that is, the chromatic scale (Bowling et al., 2012). Each interval is defined by the ratio of its fundamental frequency to the lowest tonic *(Sa)* in the scale. *Swara*/note implies a note in the successive steps of the octave (Bowling et al., 2012; Jairazbhoy, 1995). With just three notes/*swara* in one melodic scale/*raga* during Vedic times, the number increased to five and later seven notes (*Saptaswara*—represented as *Sa, Ri, Ga, Ma, Pa, Dha* and *Ni*, equivalent to *Do, Re, Mi, Fa, So, La, Ti* of western music), which is now considered ideal to produce a melodic scale/*raga* (Bowling et al., 2012; "Music of India—A Brief Outline—Part Four," 2015). A *Raga*, a musical or melodic scale, may be defined as a series of tones that, when improvised with permutations and combinations of various notes in a specific order, results in the expression of certain emotions (Jairazbhoy, 1995; Kaufmann, 1965; McNeil, 2015); see Supplementary Materials online for relevant concepts from music theory—Table S1, S2, Text S1, S2. Each melodic scale is organized as an *Aarohana* (ascending sequence of notes) and an *Avarohana* (descending sequence), is further improvised, within the framework of the scale, in vocal or instrumental performances, presenting the various aspects of the scale (e.g., sustenance of notes, elaboration, timing, ending notes, repeated notes, etc.). The "major" intervals are the *shuddh swaras* or the natural notes, namely, second, third, sixth, and seventh while the "minor" intervals are the *komal swaras* (flat) positions of the same tones. Indian music improvisation has a unique set of rules that is pre-determined yet creative, and *alaap (vistar), jor, swarakalpana, taan, tanam, neraval*, and so on, are the different parts of this improvisation. *Alaap* is a quasi-creative improvisation seen in both Carnatic and Hindustani music, where a melody is elaborated note by note, presenting the prominent phrases of the scale, usually beginning in a slow tempo, with progress to medium and faster tempi, but not bound by any rhythmic cycle ("Improvisation in Carnatic Music," n.d.; McNeil, 2017; Sadhana, 2020). It is beyond the scope of this article to describe all types of improvisations.

Table 1. *Scale Bhimpalas, Ahir Bhairav and Kaunsi Kanada*, the Names of the Notes in Hindustani Music and Western Scale.

Svara / Note	Hindustani name	Staff note	Western interval name
	Scale Ahir Bhairav (Scale A)		
S	Shadja	C	Perfect unison
R	Komal rishab	D♭	Minor second
G	Shuddha gandhar	E	Major third
M	Shuddha madhyam	F	Perfect fourth
P	Pancham	G	Perfect fifth
D	Shuddha Dhaivat	A	Major sixth
N	Komal nishad	B♭	Minor seventh
	Scale Kaunsi Kanada (Scale B)		
S	Shadja	C	Perfect unison
R	Shuddha rishab	D	Major second
G	Komal gandhar	E♭	Minor third
M	Shuddha madhyam	F	Perfect fourth
P	Pancham	G	Perfect fifth
D	Komal Dhaivat	A♭	Minor sixth
N	Komal nishad	B♭	Minor seventh
	Scale Bhimpalas (Scale C)		
S	Shadja	C	Perfect unison
R	Shuddha rishab	D	Major second
G	Komal gandhar	E♭	Minor third
M	Shuddha madhyam	F	Perfect fourth
P	Pancham	G	Perfect fifth
D	Shuddha daivat	A	Major sixth
N	Komal nishad	B♭	Minor seventh

The "major" intervals are the *shuddh swaras* or the natural notes, namely, second, third, sixth, and seventh while the "minor" intervals are the *komal swaras* (flat) positions of the same tones.

Indian music is broadly classified into Carnatic (South Indian) and Hindustani (North Indian) music, each having its system of musical scales (*ragas*). Despite the presence of a lot of folklore in Indian music, researchers in India have barely explored the beneficial health effects of the same. A broad body of literature exists on the potential health benefits of Mozart's music and certain genres of music (Pauwels et al., 2014). Exploration of the effect of Indian music, melodic scales, scientifically on anxiety or stress is limited (Kotwal et al., 1998; Kour, 2012; Nagarajan et al., 2015; Tumuluri et al., 2017). Listening to classical Indian instrumental music has reduced psychological distress (measured using questionnaires or galvanic skin response) in lab and clinical settings (Baste & Gadkari, 2014; Joshi et al., 2017; Kotwal et al., 1998; Packyanathan et al., 2019). Settling on the conclusions drawn from the outputs of available Indian scientific literature is difficult due to extremely small sample sizes or inherent study design deficiencies (Jamali & Solanky, 2013; Joseph & Sathiyaseelan, 2014). As per the *Gandharva Veda* and *Raga Chikitsa* literature, some scales such as *Ahir Bhairav, Bhimpalas, Bhupali, Hindol, Puriya, Kaunsi Kanada*, and *Todi* have been said to normalize tension and BP (Nalapat, 2008; Raga Music Therapy, n.d.; Ragas for Health, n.d.). Of these, recordings of *Ahir Bhairav, Kaunsi Kanada*, and *Bhimpalas* were implemented for the present study. (Scales are shown in Table 1; for a detailed explanation of each scale, see Jairazbhoy, 1995; Supplementary Materials online.) These three scales were chosen as each differed from the other by one to three notes (A, D, E notes—see Table 1). In our previous study, we observed a significant reduction in state and trait anxiety (using the STAI) score among prehypertensives and hypertensives after listening to a melodic scale of Indian music, scale *Bhimpalas*, for 15 min a day, for a minimum of 5 days a week for 3 months duration (Kunikullaya et al., 2016). We did not record the short-term changes in anxiety levels, nor did we evaluate the effect of other scales on the same.

In the context of our previous findings, we found it important to understand the effect of Indian musical scales on normal healthy individuals, as a first step, before this kind of passive music intervention is extended to an appropriate patient community. The hypothesis was that listening to Indian musical scales would reduce both state and trait anxiety. The primary objective of the present study was to evaluate the effect of listening to three chosen Hindustani *ragas* (melodic scales)—*Ahir Bhairav, Kaunsi Kanada*, and *Bhimpalas*—for 10 min, on anxiety as measured using STAI. The secondary objective was to assess if a specific melodic scale had a specific effect on levels of anxiety.

Method

Ethical approval

The study protocol was approved by the institutional scientific committee on human research and ethical review board (Submission reference: MSRMC/EC/2016; Dated: 11/02/2016) as per the declaration of Helsinki. Apart from registration via an online questionnaire, where an informal informed consent to answer the online questionnaire and further participation in the study was taken, written informed consent was taken on visiting the lab. The full trial protocol can be accessed at https://clinicaltrials.gov/ct2/show/NCT02691585.

Study design and procedure

A triple-blinded, prospective, randomized controlled trial was conducted with an experimental study design adopting a completely randomized design methodology, with a total sample of 140, randomized into four intervention groups ($n = 35$ participants in each group). The four interventions were coded by a person not involved in the present study (stored as .mp3 files on a laptop, coded as A, B, C, D; Figure 1).

The basis for sample size

In a previous study (Graff et al., 2019), it was found that the change in the STAI-6 anxiety scores from before to after music intervention, was $M = 33.3$ (interquartile range [IQR] = 23.3–41.7) and $M = 30$ (IQR = 20–40), respectively. In the present study, the sample size was arrived at by considering the minimum difference of four units in the STAI score before and after the intervention, considering effect size of 0.7, power of 85%, and an alpha error of 5%, which was calculated to be 35 in each group.

Recruitment of participants for the study

The data were collected from our campus, which has a group of institutions comprising of people from various backgrounds, including medical, dental, pharmacy, physiotherapy, and engineering. Healthy participants aged 18–30 years were invited to participate in the study via advertisements on notice boards of various institutions, social media posts, and posters. Participants who responded to the call were sent an online questionnaire via google forms, as

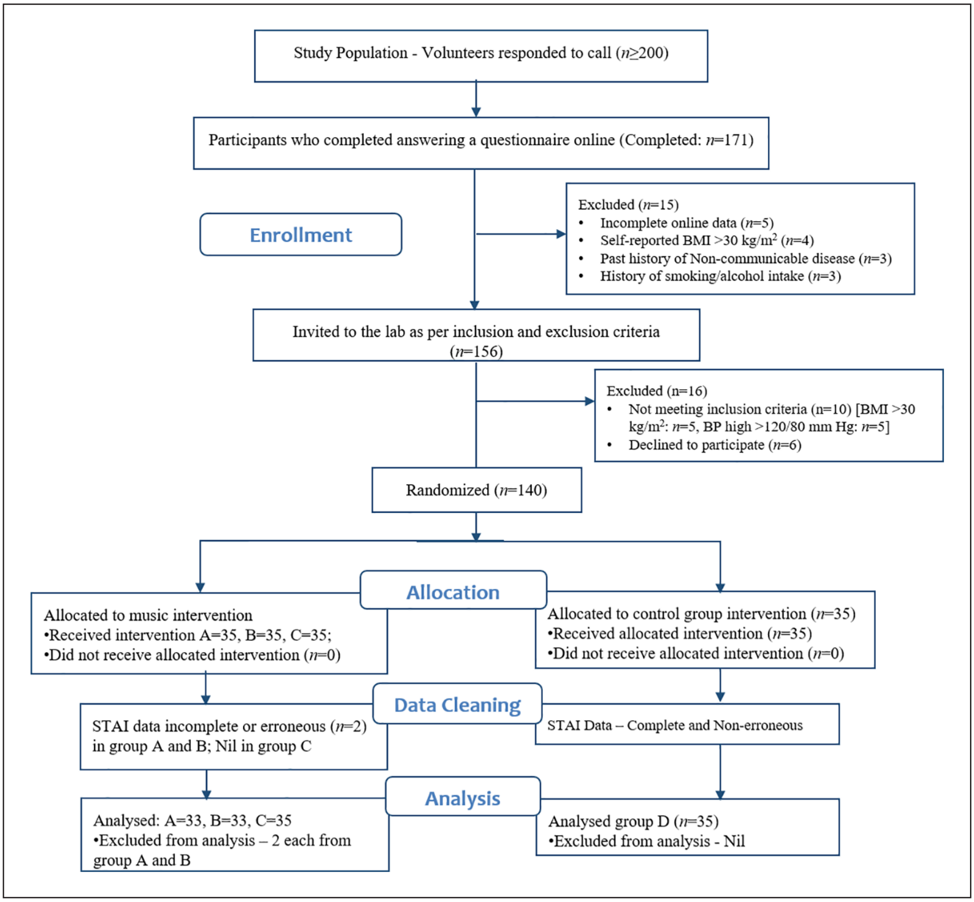

Figure 1. Consort Diagram of Participant Recruitment, Intervention and Analysis.
STAI: State-Trait Anxiety Inventory; BMI: body mass index; BP: blood pressure.

explained in (Ubrangala et al., 2020). The online questionnaire contained socio-demographic details, educational background, drug history, present or past history of non-communicable diseases if any, and family history of non-communicable disorders, smoking, and alcohol history. A few questions inquiring about the participants' preference for any type of music, previous experience with music (instrumental or vocal) were also included (Figure 1). Inclusion criteria were healthy participants, aged 18–30 years, of either gender, non-smokers, and non-alcoholics. Exclusion criteria were any medical disorder (cardiovascular, renal, respiratory, endocrine, hearing problem, psychiatric disorders, stroke, epilepsy), pregnancy, body mass index (BMI) > 30 kg/m²; intake of drugs which are known to affect the BP or autonomic status of the individual, other impairments that would prevent participants from performing the experimental procedures. The healthy cardiovascular system of the volunteers was defined by measuring BP, which confirmed their non-hypertensive state, and by measuring baseline HR, which confirmed their non-tachycardia state. A total of 150 participants who reported to the lab were given an explanation about the study, the protocol, and the cooperation expected from them. They were informed about their rights to withdraw their participation from the study. A general health check-up was done for all participants. The BMI was calculated and BP in a sitting position was measured twice after 5 min rest (Sphygmomanometer) in between and was noted (Molarius et al., 1999). Only normotensives were included as per inclusion criteria (10 more participants excluded based on lab recordings of BP and BMI).

Randomization

Recruited participants ($n = 140$) were randomized into four groups using a simple randomization technique. Random numbers were computer generated using MS Excel (4 sets of 35 each). The random number indicating intervention or control was kept in an opaque and sealed envelope and the serial number of the participants was written on the top of the envelope. The envelope was opened by the research assistant after the baseline assessment of each participant had been completed and based on the group the participants were assigned to one of the four arms (A, B, C, or D). The investigators who did the outcome assessments were blinded to the interventions.

Baseline (pre-) and post-intervention readings

Participants were asked to abstain from tea or coffee about 2 hr before the recording. All the recordings were carried out between 9:00 am and 12.00 pm in an isolated examination room at a stable temperature between 20°C and 22°C, in a noise-free atmosphere. It was ensured that no one entered the room once recordings began. After the participants responded to the pre-intervention STAI form, they were asked to lie supine and relax for about 10 min before the intervention, with their eyes closed. The music intervention with respective music as per the random group allocated was then administered. At the end of 10 min of music, the participants completed the post-intervention STAI recording, and then the participants were relieved. Pre- and post-music data analysis of anxiety levels was done.

State-Trait Anxiety Inventory (STAI)

Anxiety can be measured using different questionnaires or assessment tools that measure biomarkers of stress or anxiety. The STAI is a psychological standardized self-report questionnaire, with 40 questions, measured through four possible responses on a Likert scale. The STAI Form Y is a definitive instrument for measuring anxiety in adults (Julian, 2011; State-Trait Anxiety Inventory for Adults (STAI-AD)—Assessments, Tests Mind Garden—Mind Garden, n.d.). The STAI Y-1 scale was administered to assess the baseline level of anxiety and the change in anxiety levels after the intervention. The STAI differentiates between the temporary condition of "**s**tate anxiety" and the more general and long-standing quality of "trait anxiety," each consisting of 20 questions. STAI-S scale has questions that evaluate feelings of apprehension, tension, and worry. Here respondents indicate what they felt at a particular time (feel "right now, at this moment") in the recent past and how they would respond to a specific situation that is likely to be encountered in the future. The STAI-T scale consists questions that assess how respondents "feel generally." Patients diagnosed with depression or other psychological disorders generally have high scores. Participants required only 6 to 8 min for completing either section or less than 15 min to complete both the state and trait sections. Participants respond to each STAI item by rating themselves on a four-point scale. Hence, the range of possible scores varied between a minimum of 20 to a maximum of 80. STAI is said to have excellent internal consistency (average $\alpha > .89$), and excellent test–retest reliability (average $r = .88$) at multiple time intervals (Grös et al., 2007; Guillén-Riquelme & Buela-Casal, 2014).

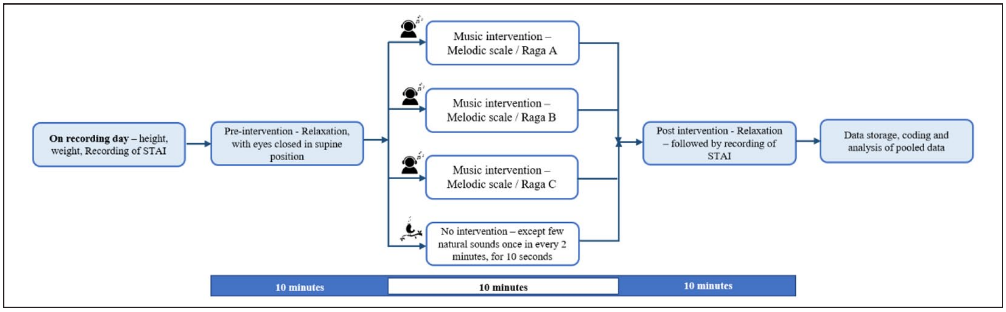

Figure 2. Intervention Protocol.

Intervention

The participants recruited for the study participants listened to the musical extracts (the intervention) through headphones (studies have previously used headphones, which is considered ideal; Idrobo-Ávila et al., 2018), connected to a laptop, at uniform volume (50%) (Figure 2).

Control group intervention. The control group (Group D) did not receive any intervention, but since the complete recording lasted for 30 to 40 min duration, it was possible for the participants to feel sleepy or fall asleep. Sleep would modify stress and anxiety levels, which would alter the objective of the present study. Furthermore, silence during the middle 10 min would not be an ideal sample to compare, when the other group received music. For these two reasons, natural sounds (birds chirping and flowing river) were played for 10 seconds for every 2 min in the 10 min (intervention phase).

Music intervention. In the music intervention, each received one of the three randomly chosen scales; Group A received Scale A (*Ahir Bhairav*), Group B received Scale B (*Kaunsi Kanada*), Group C received Scale C (*Bhimpalas*). All three scales had the perfect unison, fourth, fifth, and minor seventh (Table 1). Further *Ma* and *Sa* are the *Vadi-Samvadi* notes for all three scales. Based on the group the participant was allotted to, a particular scale was played for 10 min duration. The music used for this study was played on flute (*Bansuri*), containing *alaap* in the respective *scale*, pre-recorded by an eminent flautist. *Alaap/Vistaar* is a term given for creative improvisation, seen in both types of Indian music, where note by note elaboration is done, presenting the prominent phrases of the scale, usually beginning at a slow tempo with low notes, progressing to medium and faster tempos and higher notes, but not bound by any rhythmic cycle ("Improvisation in Carnatic Music," n.d.; McNeil, 2017; Sadhana, 2020). Participants were instructed to listen to this with eyes closed, mind relaxed, for the duration it was played.

Statistical analysis

The continuous variables such as age, BMI, STAI state and trait anxiety levels, and so on, were analysed using descriptive statistics such as mean and *SD*, minimum and maximum. The qualitative/categorical variables such as gender, education, training in music, the genre of music, duration, and so on, were analysed using frequency and percentage. The normalcy of the data was checked by applying the Kolmogorov-Smirnov Test. Baseline comparisons were carried out using a one-way analysis of variance (ANOVA). For between-group comparisons, a Kruskal

Wallis test was applied. At baseline, the categorical variables were tested for difference in proportion using Chi-Square/Fisher's exact test of significance. The STAI scores were compared between pre- and post-intervention using paired *t*-test. Analysis of covariance (ANCOVA) and multivariate forward logistic regression analysis was done to assess the effect of confounders (namely, age, gender, involvement in mind-body relaxation technique, physical activity, music training, preference to music, duration of training) after categorizing the post-trait score (dependent variable—the difference between pre and post-test scores [Categorized], independent variables—age, gender, involvement in mind-body relaxation technique, physical activity, music training, preference to music, duration of training). Apart from tabulation, data were also depicted graphically using bar diagrams and line diagrams. Data were analysed using SPSS software version 18.0 (SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0 Chicago: SPSS Inc.). A *p*-value of $\leq .05$ was considered statistically significant.

Results

A total of 140 participants' data were collected in the lab, of which data for 136 participants were found to be satisfactory and thus used for final analysis. Among the STAI forms, four participants had more than 3 missing values ($n = 2$ in A group and 2 in group B) and were excluded from the analysis.

The four groups were comparable based on all sociodemographic characteristics (Table 2). About 16 in group C (30.8%) and 14 in B (26.9%) and 11 each in groups A and D (21.2%) were

Table 2. Sociodemographic Details of Participants in the 4 Groups—Group A, B, C (Music Intervention), and D (Control Group).

Groups	A ($n = 33$)	B ($n = 33$)	C ($n = 35$)	D ($n = 35$)	*p*
Mean Age in years (*SD*)	21.1 (2.95)	20.4 (2.19)	20.2 (2.18)	21.1 (2.94)	.338
Gender					
Female	16 (20.8%)	15 (19.5%)	21 (27.3%)	25 (32.5%)	.119
Male	17 (28.8%)	18 (30.5%)	14 (23.7%)	10 (16.9%)	
Mean BMI (kg/m^2)	24.0 (4.74)	23.8 (4.19)	23.7 (4.69)	22.7 (4.28)	.642
Education					
High School, Post High School/ Intermediate	16 (27.5%)	16 (27.5%)	15 (25.8%)	11 (18.9%)	.437
Under graduation, Graduate/Post Graduate, Professional/Honours	17 (21.8%)	17 (21.8%)	20 (25.6%)	24 (30.8%)	
Training in music					
No	22 (26.2%)	19 (22.6%)	19 (22.6%)	24 (28.6%)	.55
Yes	11 (21.2%)	14 (26.9%)	16 (30.8%)	11 (21.2%)	
Genre of music training					
Indian	9 (18.8%)	12 (25.0%)	15 (31.3%)	12 (25.0%)	.92
Indian/Western	1 (25.0%)	1 (25.0%)	1 (25.0%)	1 (25.0%)	
Western	3 (50.0%)	1 (16.7%)	1 (16.7%)	1 (16.7%)	
Duration of listening to music/day					
</= 20 min	20 (32.8%)	12 (19.7%)	13 (21.3%)	16 (26.2%)	.155
20–40 min	8 (14.8%)	15 (27.8%)	14 (25.9%)	17 (31.5%)	
>/= 40 min	5 (23.8%)	6 (28.6%)	8 (38.0%)	2 (9.5%)	

BMI: body mass index.

trained in music. Participants were predominantly trained in Indian music, and the groups were comparable. The most preferred type of genre among the participants was Bollywood songs. When asked to name a few *scales* that the participants were familiar with, only about 17 individuals of the whole sample could name the *scales* such as *Anandabhairavi, Bhairav, Bhageshri, Hamsanandi, Hamsadhwani, Kalyani, Saveri*, and so on.

Pre-intervention baseline comparison of STAI-state scores was not statistically significant amongst the groups ($p = .655$), whereas the baseline value of the Pre-Trait scores showed a significant difference amongst the groups ($p < .001$). Based on the ANOVA results, the difference in mean state score (pre-state to post-state) was not significantly varying between the groups, $F(3, 132) = 2.33$, $p = .077$, but the difference in trait score (pre-trait to post-trait) was significantly varying between the groups, $F(3, 132) = 7.19$, $p < .001$. STAI scores reduced after music intervention, with maximum reduction in state score with Scale B (5.33 drop from baseline), the next being Scale C (4.45) followed by Scale A (4.09; see Table 3, Figure 3 [top]). Even for trait anxiety, Scale B showed a significant drop in trait score by 4.97, followed by Scale A (3.46), followed by Scale C (2.49; see Table 3, Figure 3 [bottom]).

Since the pre-trait scores were statistically different, ANCOVA was done to control for the baseline trait values (see the Supplementary Materials online for a list of co-variates—Table S4, Text S4). After adjusting for the pre-trait scores (Table S4), it was observed that age, $F(1) = 10.99$, $p = .002$, and gender, $F(1) = 6.05$, $p = .018$, affected the post trait scores. So, stratified analysis based on age and gender was carried out to see whether the difference in the pre-post scores was statistically significant between the groups. Age was categorized into two groups for the purpose of analysis (< and > 19 years, based on the average). Stratified analysis showed that those aged > 19 years had a higher pre-post trait score difference (stratified according to age groups). Overall, in >19 years' age group Mean, *SE* was -2.91, 1.01 ($p < .001$), versus < 19 years

Table 3. Comparison of Pre and Post STAI Score Amongst the Four Groups.

Group		*M* (*SD*)	Mean difference	*Min*	*Max*	*p* (pre-post)
State anxiety						
A	Pre	37.4 (9.62)	−4.09	25	59	.023*
	Post	33.3 (10.74)		20	56	
B	Pre	36.7 (9.12)	−5.33	24	55	.001**
	Post	31.4 (7.42)		20	49	
C	Pre	36.9, 10.10	−4.45	19	63	.003*
	Post	32.5 (9.36)		19	51	
D	Pre	34.8 (7.80)	−0.40	22	54	.724
	Post	34.4 (8.77)		20	52	
Trait anxiety						
A	Pre	43.4 (8.67)	−3.46	28	57	.001**
	Post	40.0 (8.90)		26	58	
B	Pre	43.2 (7.47)	−4.97	30	56	<.001**
	Post	38.2 (6.78)		26	54	
C	Pre	41.5 (6.87)	−2.49	30	53	.005*
	Post	39.00 (8.52)		20	53	
D	Pre	59.0 (8.13)	+1.06	47	77	.289
	Post	60.0 (9.08)		45	80	

SD: standard deviation; $^{**}p \leq 0.001$, $^{*}p \leq 0.05$ level.

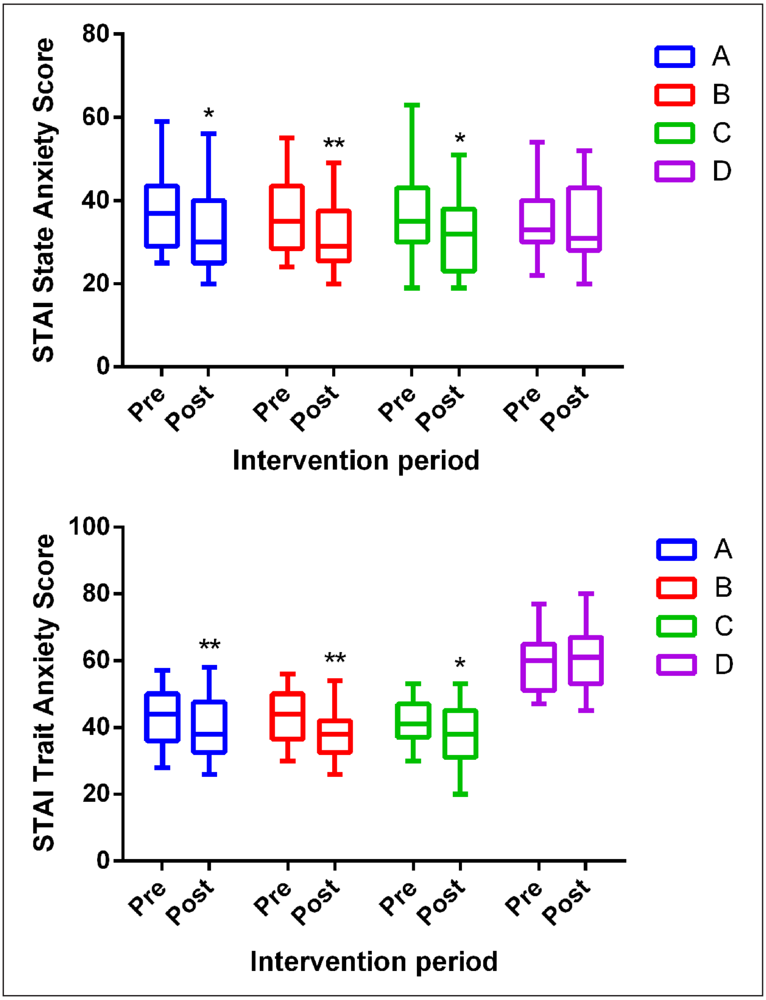

Figure 3. Actual Mean Change in STAI State (Top) and Trait (Bottom) Scores Pre and Post Intervention Between the Four Groups (**$p \leq 0.001$, *$p \leq 0.05$ level).

where mean difference was 2.14, 0.57 (p=.086). Further post-hoc analysis of those aged > 19 years showed that the highest mean differences (p < .05) were between Groups B and D (mean difference [MD] = 11.93, SD = 2.25), Groups B and C (MD = 9.7, SD = 2.61), and Groups B and A (MD = 6.13, SD = 2.28; see Table S5 in Supplementary Materials online). Similarly, the gender-based stratified analysis showed that there was a statistically significant difference in the overall mean difference of trait scores from pre to post. Among males it was MD = 2.22 (SD = 6.12), p = .006, while among females it was MD = 2.56 (SD = 5.87), p = .012. On post-hoc analysis it was observed that the maximum mean difference (p < .05) was seen between males of Groups B and D (MD = 7.8, SD = 2.21), Groups B and C (MD = 4.93, SD = 2.0), and groups A and D (MD = 5.07, SD = 2.24). Among females, the mean difference was greater (p < .05) for groups A (MD = 4.74, SD = 1.78), B (MD = 4.89, SD = 1.81), and C (MD = 4.32, SD = 1.64) than control group D (see Table S5 in Supplementary Materials online). Further multivariate forward logistic regression analysis based on age categories, gender against categorized mean differences of trait scores, it was observed that females had a higher mean

Table 4. Paired Sample Tests of Mean Difference of Pre and Post Trait Scores Between Males and Females.

Gender	STAI	Pre	Post	Mean differences	*SE*	95% CI		*t*	*p*
		M (*SD*)	*M* (*SD*)			Lower	Upper		
Males	State	38.2, 10.7	35.0, 9.48	3.14	9.73	0.35	5.94	2.26	.028
	Trait	43.8, 7.86	40.6, 8.96	3.14	5.79	1.48	4.81	3.80	<.001
Females	State	35.9, 8.25	29.9, 8.30	6.02	7.71	3.87	8.16	5.63	<.001
	Trait	41.6, 7.40	37.6, 6.91	4.06	5.33	2.57	5.54	5.49	<.001

CI: confidence interval; STAI: State-Trait Anxiety Inventory; *SE*: standard error.
The table shows the results of all groups combined.

difference than males in Group C ($p = .012$; $OR = 0.125$). On combined analysis of A, B, and C groups, categorized based on gender, STAI scores reduced after intervention irrespective of gender, but females had a higher reduction (higher mean difference) than males (Table 4).

Females of Groups A (state score, $p < .001$) and C (Trait score, $p < .001$) had a significant reduction in STAI scores. In group B, trait scores reduced significantly in both males ($p = .003$) and females ($p = .008$) while state scores reduced significantly only in males ($p = .006$). In group A, trait scores reduced significantly in both males ($p = .015$) and females ($p = .026$; see Table S6 and Figure S3 in Supplementary Materials online).

Discussion, conclusion, and implications

In this study, for the first time, three different scales of Indian classical music in the form of three Hindustani *ragas*/scales were tested for their effect on objective anxiety measurements among healthy young individuals. In this study, all three music intervention groups experienced a significant drop in anxiety levels (state and trait) after listening to Indian music for 10 min. Maximum reduction in the state score was in Group B with scale *Kaunsi Kanada* (5.33 drop from baseline), the next being in Group C with scale *Bhimpalas* (4.45) followed by group A with scale *Ahir Bhairav* (4.09). Even in trait anxiety, Scale B showed a maximum drop in trait score of 4.97, followed by Scale A (3.46), then Scale C (2.49). Music is said to influence stress-related cognitive processes and, as a consequence, result in physiological responses (Thoma et al., 2013). A recent systematic review and meta-analysis have shown that music was significantly effective in reducing stress both physiologically ($d = 0.380$) and psychologically ($d = 0.545$; de Witte et al., 2020). A reduction in anxiety after listening to music is the most consistent finding reported in the field and laboratory-based studies (Ghasemi et al., 2017; Labbé et al., 2007; Ventura et al., 2012). A reduction in trait and state anxiety was observed in a previous study after listening to the scale *Bhimpalas* for 15 min a day, for a minimum of 5 days a week for 3 months among prehypertensives and hypertensives (Kunikullaya et al., 2015, 2016).

In the current study, gender was one of the most important factors influencing the pre-trait scores and pre-post trait mean differences scores. Females had a higher overall reduction in anxiety scores (overall in the three intervention groups). In Groups A and B, trait scores reduced significantly irrespective of the gender while state scores reduced significantly in males of Group B ($p = .006$). Females of Groups A (state score, $p < .001$) and C (State score, $p = .003$; Trait score, $p < .001$) had a significant reduction in scores. This points towards gender-specific effects of music on anxiety. Furthermore, a unique effect is caused by the musical components of each melodic scale.

The gender difference could reflect a difference in the way that males and females process and predict musical structure (Thorpe et al., 2012). Females are said to have higher level of bilateral functioning compared to asymmetrical laterality in males (Koelsch et al., 2005; Koelsch, Grossmann, et al., 2003; Koelsch, Maess, et al., 2003). Listening to music has been shown to reduce cortisol in women, but increase alpha-amylase in men (Thoma et al., 2013; Wuttke-Linnemann et al., 2019). The mechanism of the psychological and neuroendocrine effects seen in females follows the proposed pattern of "tend-and-befriend" with females' responses being marked. While tending means nurturing the self and protecting oneself, befriending is socializing, creating, and maintaining (Taylor et al., 2000). Women are said to use music specifically for relaxation while creativity (activation and stimulation) is the motivation for men to choose music (North, 2010; Wuttke-Linnemann et al., 2019). In a study where musical compositions were analysed, songs that sounded sad and romanticized and had a lot of emotion were categorized as being from a female composer. "Passionate, grounded, very delicate, [a] lot of attention" to detail were a few other words used to describe female composers (Edvenson, 2017; Sergeant & Himonides, 2016). The current study results are in line with existing literature, in which females have shown better anxiety reduction with music listening than men. Additionally, each scale showed gender-specific effects in that females had a maximal significant reduction in state anxiety with scale *Ahir Bhairav*, and state and trait anxiety with scale *Bhimpalas*, while among males scale *Kaunsi Kanada* caused the maximal reduction in state and trait anxiety. This may be attributed to the musical components or features.

It is difficult to conclusively comment about the exact causes for the change observed with this particular type of music. In Indian music, multiple scales are generated from a single heptatonic scale (Hindustani-*thaat; Carnatic-Melakartha ragas*). The scale *Kaunsi Kanada*, containing three minor tones, belongs to the *Bhairavi Thaat* (Phrygian mode) which is known to have a devotional and compassionate effect ("Raga Kaunsi Kanada—A Midnight Conversation," 2016). The three minor tones present in the scale point towards the production of sadness as an emotion, as per available literature (Bowling et al., 2012; Mathur et al., 2015; Parncutt, 2014). But, in the current study, we observed a significant reduction in state and trait anxiety for the scale. *Bhimpalas* in contrast belongs to the *Kapi thaat* (Dorian mode), with two major and two minor tones, which bring about the mood of spring (Agarwala, 1966; Chib, 2004). Listening to this scale also reduced anxiety but to a lesser extent than *Kaunsi Kanada*. The melodic scale *Ahir Bhairav* belongs to the *Bhairav thaat* (Double Harmonic) and is said to create a pensive mood initially followed by a deep unconditional romantic feeling (Nandyala, 2013). *Ahir Bhairav* caused the least reduction in state anxiety in the current study, though statistically significant. The *komal re* (minor second) is the best predictor of negative valence (Mathur et al., 2015). The only scale that had this note was *Ahir Bhairav*. However, females had a maximal significant reduction in state anxiety with scale *Ahir Bhairav.* Bowling et al. (2012) observed that melodies that are positive/excitatory had more major intervals (>200 cents) while negative/subdued *ragas* have more minor intervals. Recently, it was shown that scales with major intervals (*shuddh Re* and *shuddh Ga*) were rated as "calm" while those with minor intervals (*komal re* and *komal dha*) were rated as "sad" using Hindustani music scales (Mathur et al., 2015). Though sadness is generally taken as a negative emotion, in an aesthetic context, sadness is associated with some degree of pleasure (Eerola et al., 2018). This is because it is harmless (perceived as non-threatening), aesthetically pleasing and thus the listeners are left with emotions such as awe, transcendence, and chills (pleasurable experience). The emphasis given to the notes (*pakar*, *vadi*, and *samvadi*) varies with each scale and so the melody, where each note is presented at different frequency of occurrences (Mathur et al., 2015), also plays a role in the emotions generated. Recent studies also highlight the usage of pentatonic scales in calming the mind plausibly due to the reduction of dissonant intervals in the scale with only five notes (Pugh-Kitingan, 2017; Ranger et al., 2018; Wu et al., 2013). Note that in the current study, lyrics and percussion were absent. All musical pieces were in a slow tempo without any particular rhythm. The music was played with a *Bansuri* (and drone instrument in the background), set at scale “E” the frequency of which was 329.36 Hz—Note Sa (fundamental note). Neither the emotions nor the personalities of participants were recorded. It may be observed that a multitude of conditions might have caused the reduction in anxiety with listening to the specific scale. Thus, the combination of notes in a natural setting of music (music heard as it is, without separation of its components) along with the notes that are particular to specific scales might have caused the reduction in anxiety seen with individual scales. A constant recording (real-time) of anxiety via subjective measures along with simultaneous recording of physiological measures during listening to each individual scale must be planned, in order to correlate variations in the individual features of music against anxiety levels. This may help us to derive conclusive remarks about the probable causes of the change in anxiety observed on listening to particular scales.

The strengths of the study are that, to the best of our knowledge, for the first time three Indian melodic scales/*ragas* have been systematically and scientifically studied, with a triple-blinded randomized study design, among normal healthy individuals, on a short-term basis. All parameters were free from measurement errors as the recordings were performed by a single, well-trained, but blinded research assistant (reducing observer’s error) along with validation from the PI (who was also blinded) for accuracy of the data collected. Participants of both genders with homogenous age groups were compared. Anxiety was measured using reliable and well-validated questionnaires. The music used was composed of pure *alaap* against a drone instrument. The control group was well matched and the intervention received by the control group was also standardized. The sample size was calculated based on prior research, with appropriate power, and was adequate to show measurable, significant effects of the intervention. Thus, the evidence obtained is scientifically authentic.

The study did have a few limitations. First, the choice of music was not given to the participants. Previous studies show that music has a better effect, especially for pain, when it is self-chosen (Huang et al., 2010; Mitchell et al., 2006; Parente, 1976; Roy et al., 2008; Villarreal et al., 2012). However, one study has shown that experimenter-chosen music is better than self-chosen music (Pelletier, 2004) while another study showed that the choice of music did not matter (Thaut & Davis, 1993). Active music-making has shown to be a better anxiety and stress reliever compared to passive listening to music (de Witte et al., 2020). Participants’ actual experiences or the emotions generated by the music given were not captured. A community-based approach or home-based setting (facilitating more comfort to the participant) would have been better to conduct a long-duration or long-term intervention. Ten minutes may be too short a duration for us to expect a physiological change that will persist and benefit an individual over the long term. Though all participants were clinically normal, laboratory measurements of their blood parameters were not conducted to conclusively say that everyone was healthy. Further extraction of the musical components through music retrieval software and its correlation with the anxiety scores may further elaborate on the cause and effect of the observed response.

Conclusion

For the first time, through this study, we have shown the short-term effect of Indian music on anxiety, during the first exposure to a tune, among young healthy individuals, in a systematic fashion. Listening to 10 min of a north Indian Hindustani classical musical scale reduced state and trait scores. Gender-specific changes in anxiety were noted with the scales *Bhimpalas* and *Ahir Bhairav* causing the maximal reduction in anxiety scores among females and the scale *Kaunsi Kanada* causing a maximal reduction in state and trait anxiety among males. Nevertheless, *Kaunsi Kanada* seemed to have the best effect on subjective anxiety. The effect observed may be attributed to the melody heard as a whole with enough attention to cause a significant change in anxiety levels. Future studies should try to evaluate the musical components and their correlation to the psychological and physiological responses during listening to different genres, scales of music. Music medicine (listening to music) does have therapeutic implications for anxious individuals.

Author note

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Authors declaration

All authors of this manuscript have approved the final version of the manuscript. All persons designated as authors qualify for authorship, and all those who qualify for authorship are listed. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The authors acknowledge that they did not have any financial interest or benefit arising from the direct applications of this research.

Author contributions

Conceptualization, funding acquisition—U.K.K.; data curation—U.K.K. and R.K.; formal analysis—R.K. and N.S.M.; investigation—U.K.K. and V.J.; methodology—U.K.K., R.K. and V.J.; project administration—U.K.K., V.J., G.J., N.S.M., and R.K.; resources—U.K.K. and V.J.; software—U.K.K., R.K., and N.S.M.; supervision—U.K.K., V.J., G.J., and V.S.P.; validation—R.K. and N.S.M.; writing original draft—U.K.K. and G.J.; review and editing—G.J., R.K., N.S.M., and V.S.P. All authors have approved the final version of the manuscript and agree to be accountable for all aspects of the work. All persons designated as authors qualify for authorship, and all those who qualify for authorship are listed.

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Data availability statement

The project data will be made available on request to the authors.

Supplemental material

Supplemental material for this article is available online.

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