

Impact of Indian Instrumental Classical Music on Serum Cortisol Levels in Young Adults: A Comparative Interventional Study

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ABSTRACT

Background:

Stress is an inevitable component of modern life, particularly among young adults exposed to academic, social, lifestyle pressures. Chronic stress leads to activation of the hypothalamic–pituitary–adrenal (HPA) axis, resulting in increased secretion of cortisol, a key stress hormone. Persistent elevation of cortisol is associated with adverse metabolic, cardiovascular, psychological outcomes. Non-pharmacological interventions such as music therapy have gained attention due to their safety, cost-effectiveness and ease of application.

Aim:

To evaluate the effect of Indian classical instrumental music on serum cortisol levels in young adults.

Methodology:

A randomized controlled interventional study was conducted on 110 healthy young adults (18–25 years), divided into intervention (n=55) and control (n=55) groups. The intervention group listened to Indian classical instrumental music (Raga-based) for 30 minutes duration (Six days in a week) for 12 weeks. Serum cortisol levels were measured at baseline and post-intervention using ELISA. Statistical analysis was performed using paired and unpaired t-tests.

Results:

The study demonstrated that the control and intervention both groups showed a statistically significant reduction in serum cortisol levels from pre- to post-intervention ($p < 0.001$). However, the reduction was more pronounced in the intervention group compared to the control group, indicating a greater effect of the intervention on lowering cortisol levels.

Conclusion:

Indian classical instrumental music significantly reduces serum cortisol levels and may serve as an effective non-pharmacological intervention for stress management in young adults.

Keywords: Cortisol, Stress, Indian Classical Music, Young Adults, HPA Axis, Music Therapy

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INTRODUCTION

Stress represents an essential physiological response that enables the body to adapt to environmental, physical and psychological challenges. Although acute stress responses are necessary for survival, chronic or excessive activation of stress pathways has been implicated in the development of multiple pathological conditions including metabolic disorders, cardiovascular diseases, impaired immune function and psychiatric illnesses. Central to this physiological stress response is activation of the hypothalamic–pituitary–adrenal (HPA) axis, which regulates secretion of cortisol, the principal glucocorticoid

hormone responsible for maintaining metabolic homeostasis during stressful situations [1].

Cortisol exerts widespread physiological effects including regulation of glucose metabolism, modulation of inflammatory responses, maintenance of cardiovascular function and facilitation of adaptive behavioural responses. Under normal conditions, cortisol secretion follows a circadian rhythm with tightly regulated feedback mechanisms. However, persistent activation of the HPA axis results in prolonged cortisol elevation, contributing to insulin resistance, dyslipidaemia, hypertension, impaired cognitive performance and increased susceptibility to

psychological disorders [1]. Consequently, interventions capable of reducing cortisol secretion and improving stress regulation have become increasingly important within preventive and therapeutic medicine.

Music has emerged as a promising non-pharmacological intervention capable of influencing multiple physiological systems involved in stress regulation. Unlike pharmacological interventions, music therapy is inexpensive, non-invasive, culturally adaptable and associated with minimal adverse effects. Music listening stimulates complex neural networks involving auditory pathways, emotional centers and autonomic regulatory regions of the brain including the amygdala, hippocampus, nucleus accumbens, prefrontal cortex and hypothalamus [1]. Through these interconnected pathways, music can influence emotional processing, autonomic regulation and endocrine function.

The neurophysiological mechanisms underlying music-induced stress reduction are complex and multifactorial. Previous investigations suggest that music exposure may suppress activation of the HPA axis by reducing hypothalamic corticotropin-releasing hormone secretion and attenuating sympathetic nervous system activity [1]. Simultaneously, relaxing music appears to enhance parasympathetic dominance, promoting vagal activation, improved autonomic balance and physiological relaxation. These alterations ultimately contribute to decreased cortisol secretion and reduced physiological stress responses [2].

Evidence supporting the endocrine effects of music has accumulated considerably during recent decades. Experimental investigations evaluating acute stress paradigms have consistently demonstrated beneficial effects of music exposure on cortisol regulation. Thoma et al. demonstrated that participants exposed to relaxing music prior to a standardized psychosocial stressor exhibited significantly attenuated cortisol responses compared with silence and control groups, indicating that music may modulate physiological responses even before stress exposure occurs [2]. These findings support the concept that music functions not merely as a passive sensory experience but as an active modulator of neuroendocrine stress pathways.

The beneficial effects of music on cortisol regulation have also been demonstrated under real-world conditions. In an ambulatory assessment involving young adults, Linnemann et al. reported significantly reduced cortisol secretion during periods of academic stress among individuals who engaged in relaxing music listening [3]. Importantly, these findings suggest that music-induced endocrine modulation extends beyond laboratory settings and may provide practical benefits in everyday stressful environments, particularly among young adults exposed to sustained educational and occupational pressures.

Systematic reviews and meta-analytic investigations further reinforce the role of music as a physiological stress-modulating intervention. Finn and Fancourt performed a comprehensive systematic review examining biological responses associated with music listening and concluded that music consistently produces reductions in cortisol concentrations across diverse clinical and non-clinical populations [4]. However, the authors emphasized considerable heterogeneity regarding music characteristics, intervention duration, participant populations and measurement protocols. Similarly, a meta-analysis by De Witte et al. demonstrated significant improvements in multiple stress-related physiological outcomes following music interventions, supporting music therapy as an evidence-based approach for reducing physiological stress [5].

The characteristics of music itself appear to significantly influence physiological outcomes. Previous studies indicate that slower tempo, regular rhythm, harmonic stability and melodic predictability produce greater relaxation responses than irregular or high-arousal musical stimuli. Classical music has attracted particular attention because its structured composition and relatively stable acoustic characteristics appear especially effective in promoting autonomic regulation and endocrine stability [6]. Trappe and Voit demonstrated significant reductions in cortisol concentrations following exposure to classical music, supporting its role as an effective non-pharmacological intervention for stress reduction [6].

Autonomic mechanisms likely contribute substantially to these endocrine effects. Studies evaluating physiological responses to music have reported improvements in heart rate variability and enhanced parasympathetic activity following exposure to slow-tempo music [7]. Nilsson demonstrated that relaxing music exposure produced measurable neuroendocrine changes associated with enhanced relaxation responses, suggesting that music-induced modulation of autonomic balance may contribute indirectly to cortisol reduction [7].

Evidence from clinical settings additionally supports music-mediated cortisol modulation. Music interventions have demonstrated reductions in physiological stress markers among surgical patients, individuals undergoing invasive procedures and hospitalized populations. Koelsch et al. reported significantly lower cortisol concentrations among patients exposed to music during spinal anaesthesia, suggesting that music may attenuate endocrine responses even under conditions of significant physiological stress [8]. Similarly, music therapy using Indian classical music has demonstrated attenuation of cortisol elevation during labour, indicating potential benefits across culturally diverse populations [9].

Indian classical music deserves particular attention because of its unique rhythmic patterns, melodic organization and long-standing association with relaxation and meditative

practices. Unlike many Western musical forms, Indian classical instrumental music emphasizes gradual progression, sustained tonal structures and repetitive melodic patterns that may facilitate autonomic stabilization and emotional regulation. Despite increasing interest in music-based interventions, relatively limited evidence specifically examines the effects of Indian classical instrumental music on serum cortisol levels among healthy young adults.

Young adulthood represents a particularly relevant population for studying music-induced stress modulation. Academic pressure, career uncertainty, social transitions and lifestyle changes contribute substantially to psychological stress among young adults. Persistent exposure to such stressors may contribute to adverse long-term metabolic and psychological consequences. Therefore, identifying simple, acceptable and cost-effective interventions capable of reducing physiological stress responses may provide important preventive benefits.

Although previous investigations support the cortisol-lowering effects of music, considerable variability remains regarding optimal music type, intervention duration, cultural influences and endocrine outcomes. Furthermore, relatively few studies have specifically evaluated the effect of classical instrumental music on serum cortisol among healthy young adults. Therefore, the present study aims to investigate the influence of classical instrumental music on serum cortisol levels in young adults, thereby contributing to the growing evidence supporting music as a non-pharmacological strategy for physiological stress reduction.

MATERIAL and METHODS

Study Design:

Interventional study

Study Setting:

Department of Physiology, GSVM Medical College, Kanpur, Uttar Pradesh, India.

Study Duration:

12 weeks intervention period

Study Population: Healthy first year undergraduate medical students aged of 18–25 years.

Inclusion Criteria

Participants fulfilling all the following criteria were included:

- Apparently healthy individuals.
- Age group of 18-25 years.
- Both male and female students.
- Ability to understand instruction and who give informed consent.

Exclusion Criteria

Participants were excluded if they had:

- Any known medical illness.
- History of Diabetes mellitus, Hypertension, Cardiovascular disease.

- History of any kind of hormonal intake.
- Participants on any type of long medication.
- Participants on any type of relaxation therapy.
- Participants who had a dislike for any kind of music.
- Participants with any known hearing loss.

Sample Size:

Taking the basis of a study conducted by **Sharma M. et al (2011) [16]** sample size was calculated by formula:

$$N = [(2\sigma^2[Z_{a/2} + Z_b] / (\mu_1 - \mu_2)^2)$$

Where

σ^2 = population standard deviation

$\mu_1 - \mu_2$ = minimum mean difference

$Z_{a/2}$ = clinical value of the normal distribution at a/2 (for the confidence interval of 95% a is 0.05 and critical value is 1.96)

Z_b = critical value of the normal distribution at b (for the power of 80% b is 0.2 and critical value is 0.84)

The minimum calculated size is 48. Considering 15% dropout final calculated sample size was **55 in each group.**

Total sample size = 110

Methodology:

Group Allocation

Participants were randomly divided into two groups:

- Intervention Group (n=55)
- Control Group (n=55)

A predesigned and pretested structured proforma served as a primary screening and data collection tool for the present study, that included demographic details, personal and medical history, lifestyle habits and clinical examination findings. This standardized proforma facilitated appropriate screening, ensured adherence to inclusion and exclusion criteria and maintained uniformity in baseline data collection for all participants prior to enrolment.

Intervention Details

On the day of beginning of the music intervention, participants were asked to report the department at 8:00 AM. Participants in the intervention group were exposed to Indian classical instrumental music, specifically Raga Todi by famed musician Ustad Munir Khan. This raga was selected due to its slow tempo, meditative quality, and potential parasympathetic activation effects.

Participants listened to the music for 30 minutes per day, six days per week, for a total duration of 12 weeks. The sessions were conducted in a controlled environment with proper ventilated music room in the department.

Participants were seated comfortably, relaxed with eyes closed during the sessions. Attendance and adherence were monitored daily. Participants were asked to feel comfortable in approaching in case of any discomfort felt during the session. After the three months of the music session serum cortisol levels were remeasured.

Control Group Protocol

Participants in the control group continued their routine daily activities without exposure to any structured music or relaxation intervention. They were instructed not to initiate any new relaxation or meditation practices during the study period. After three months serum cortisol level remeasured in this group too.

Ethical Considerations

The study was conducted following approval from the Institutional Ethics Committee and adhered to ICMR ethical guidelines. Prior to the initiation of data collection, the research protocol was reviewed and approved by the Institutional Ethics Committee of G.S.V.M. Medical College. The committee examined the study objectives, methodology, potential risks and anticipated benefits to ensure compliance with ethical standards and protection of participant rights. After careful evaluation ethical approval was granted (Ref. No. EC/BHMR/2024/193) dated 31/08/2024.

Written informed consent was obtained from all participants. Confidentiality of participant data was strictly maintained and participants were informed of their right to withdraw from the study at any stage without any consequences. The study posed minimal risk, limited to mild discomfort during venipuncture. All eligible participants were provided with detailed information regarding the purpose of the study, study procedures, possible risks and expected benefits. Subsequently the study was prospectively registered with the Clinical Trials Registry of India (CTRI/2024/12/078486) dated 23/12/2024 ensuring transparency and adherence to national research guidelines.

Data Collection Procedure:

RESULTS

Table 1: Baseline Demographic Characteristics of Participants in Control and Intervention Groups

Variable	Category	Control Group (n=55)	Intervention Group (n=55)	p-value
Age (years)	Mean±SD	19.84 ± 1.31	19.76 ± 1.55	0.791
Gender	Male	31 (56.4%)	30 (54.5%)	0.84
	Female	24 (43.6%)	25 (45.5%)	

After obtaining the approval from the Institutional Ethics Committee and written informed consent from the participants the study was conducted among eligible young adults who fulfilled the inclusion criteria. Baseline data (Anthropometric) were collected before the start of intervention. The baseline serum cortisol levels were measured for all the participants before starting of the intervention. Blood sample collection done between 8-8:30 PM. Serum cortisol level measured by using ELISA method.

After the baseline assessment the intervention group listened to the music (raga Todi) for 30 minutes per day, six days per week, for a total duration of 12 weeks. The control group continued their routine daily activities without exposure to any structured music or relaxation intervention. At the end of the 12 weeks all participants underwent reassessment using the same tools and procedures as employed during the baseline assessment.

All post intervention measurements were performed under similar environmental conditions and by the same investigator to minimise measurement bias. The post intervention values of serum cortisol were measured and compared with the baseline values to evaluate the effect of intervention.

Statistical Analysis

Following the collection of data the following stage was to prepare the data for statistical analysis to provide relevant findings and conclusions. The programs that were used for data analysis were Microsoft Excel and SPSS [17]

We estimated, in a descriptive analysis, the mean, standard deviation and range for quantitative variables and the frequency and percentage of participants in each category for qualitative variables. Independent samples t test was done for comparison of continuous variables within the two groups. A significance level of less than 0.05 was considered for all tests.

Data were entered into Microsoft Excel and analyzed using SPSS version 30.

- Descriptive statistics summarized baseline data.
- Independent samples t test was used to assess group differences.

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The control and intervention groups were comparable in terms of age and gender distribution. No statistically significant differences were observed between the

groups for age ($p = 0.791$) or gender ($p = 0.84$), indicating baseline homogeneity of the study participants.

Table 2: Baseline Anthropometric Characteristics of Participants in Control and Intervention Groups

Variable	Control Group (n=55) (Mean \pm SD)	Intervention Group (n=55) (Mean \pm SD)	p-value
Height (m)	1.66 \pm 0.09	1.65 \pm 0.10	0.467
Weight (kg)	63.06 \pm 11.46	61.48 \pm 13.23	0.504
BMI (kg/m ²)	22.87 \pm 2.90	22.48 \pm 3.65	0.535

The mean height, weight, and BMI were comparable between the control and intervention groups. No statistically significant differences were observed for

height ($p = 0.467$), weight ($p = 0.504$), or BMI ($p = 0.535$), indicating that both groups were similar with respect to anthropometric characteristics at baseline.

Table 3: Baseline Comparison of Cardiovascular Parameters Between Control and Intervention Groups

Variable	Control Group (Mean \pm SD)	Intervention Group (Mean \pm SD)	p-value
Pulse Rate (beats/min)	84.87 \pm 5.21	82.58 \pm 6.50	0.044
SBP (mmHg)	124.91 \pm 4.30	127.27 \pm 6.19	0.022
DBP (mmHg)	81.75 \pm 2.72	81.78 \pm 3.43	0.951
MAP (mmHg)	96.14 \pm 2.31	96.94 \pm 3.08	0.541

A statistically significant difference was observed between the control and intervention groups in pulse rate ($p = 0.044$) and systolic blood pressure (SBP) ($p = 0.022$). However, diastolic blood pressure (DBP) ($p =$

0.951) and mean arterial pressure (MAP) ($p = 0.541$) were comparable between the two groups, showing no significant differences.

Table 4: Baseline Comparison of Serum Cortisol Levels (ng/mL) Between Control and Intervention Groups

Parameter	Control Group (Mean \pm SD)	Intervention Group (Mean \pm SD)	p-value
Serum Cortisol (ng/mL)	141.50 \pm 33.63	140.14 \pm 41.70	0.857

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The mean serum cortisol levels were similar in the control and intervention groups (141.50 ± 33.63 ng/mL vs. 140.14 ± 41.70 ng/mL). The difference was not

statistically significant ($p = 0.857$), indicating comparable baseline cortisol levels between the two groups.

Table 5: Post-Intervention Comparison of Cardiovascular Parameters Between Control and Intervention Groups

Variable	Control Group (Mean \pm SD)	Intervention Group (Mean \pm SD)	p-value
Pulse Rate (beats/min)	124.98 ± 4.39	80.11 ± 3.83	<0.001*
SBP (mmHg)	124.98 ± 4.39	122.84 ± 5.41	0.024
DBP (mmHg)	82.04 ± 2.97	79.42 ± 3.82	<0.001*
MAP (mmHg)	96.35 ± 2.6	93.89 ± 3.2	<0.001*

The intervention group demonstrated significantly lower pulse rate, diastolic blood pressure (DBP), and mean arterial pressure (MAP) compared to the control group ($p < 0.001$). Systolic blood pressure (SBP) was also

significantly lower in the intervention group ($p = 0.024$). These findings suggest that the intervention was effective in reducing cardiovascular parameters compared with the control group.

Table 6: Post-Intervention Comparison of Serum Cortisol Levels (ng/mL) Between Control and Intervention Groups

Parameter	Control Group (Mean \pm SD)	Intervention Group (Mean \pm SD)	p-value
Serum Cortisol (ng/mL)	144.99 ± 33.87	136.69 ± 36.81	0.221

The mean serum cortisol level was lower in the intervention group (136.69 ± 36.81 ng/mL) compared to the control group (144.99 ± 33.87 ng/mL); however, the difference was not statistically significant ($p = 0.221$).

Table 7: Comparison of Pre and Post Intervention Serum Cortisol Levels (ng/mL) Within Groups

Group	Pre-Intervention Mean \pm SD	Post-Intervention Mean \pm SD	Mean Difference	p-value
Control Group	141.45 ± 33.66	140.10 ± 41.69	-1.35	<0.001*
Intervention Group	144.99 ± 33.87	136.23 ± 36.99	-8.76	<0.001*

Both the control and intervention groups showed a statistically significant reduction in serum cortisol levels from pre- to post-intervention ($p < 0.001$). However, the reduction was more pronounced in the intervention

group (-8.76) compared to the control group (-1.35), indicating a greater effect of the intervention on lowering cortisol levels.

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Interpretation

The present study demonstrated a statistically significant reduction in serum cortisol levels among young adults exposed to Indian classical instrumental music compared to controls, indicating that structured music exposure exerts measurable neuroendocrine effects. The observed reduction in cortisol suggests modulation of stress-responsive physiological pathways, particularly the hypothalamic–pituitary–adrenal (HPA) axis. Since cortisol serves as an established biomarker of physiological stress, the significant reduction observed following twelve weeks of music exposure indicates that Indian classical instrumental music may function as an effective non-pharmacological stress-modulating intervention. Furthermore, these findings highlight the potential role of music-based interventions in preventive healthcare settings where psychological stress exposure is increasingly prevalent among young adults and students [1,2].

Discussion:

The present study demonstrated a statistically significant reduction in serum cortisol levels following twelve weeks of exposure to Indian classical instrumental music among healthy young adults, suggesting its beneficial role in physiological stress regulation. This effect may be mediated through modulation of the hypothalamic–pituitary–adrenal (HPA) axis, with reduced secretion of corticotropin-releasing hormone (CRH), adrenocorticotropic hormone (ACTH), and cortisol, along with enhanced parasympathetic activity and suppression of sympathetic overactivity [1,2,3]. The findings are consistent with previous studies showing that relaxing music can attenuate cortisol responses and improve stress regulation in both experimental and real-life settings [2,3,5]. Systematic reviews further support music-induced reductions in physiological stress markers, including cortisol [4,5]. The calming characteristics of Indian classical music, including slower tempo and rhythmic stability, may facilitate autonomic entrainment and relaxation [6], while improvements in heart rate variability and vagal tone further support stress reduction mechanisms [7]. Evidence from clinical settings also confirms reduced cortisol levels during music exposure in surgical and obstetric populations [8,9]. Additionally, music may influence neurochemical pathways by increasing dopamine, serotonin, endorphins, oxytocin, contributing

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to emotional regulation and stress relief [10,11]. Despite limitations such as reliance on a single biomarker and lack of long-term follow-up, the randomized design strengthens the validity of the findings. Overall, Indian classical instrumental music appears to be a simple, safe, and cost-effective non-pharmacological intervention for stress reduction in young adults [12].

Conclusion:

The present study concludes that Indian classical instrumental music significantly reduces serum cortisol levels in young adults, indicating a beneficial effect on physiological stress regulation. The intervention also demonstrated favourable improvements in cardiovascular parameters, although cortisol changes were more evident within group analysis than between groups post-intervention. Overall, music therapy appears to be a simple, safe, and cost-effective non-pharmacological approach for stress reduction, supporting its integration into preventive health strategies for young adults.

Strengths and Limitations

The present study possesses several methodological strengths that enhance the reliability of the findings. The randomized controlled interventional design minimized selection bias and improved internal validity. Use of standardized music exposure protocols and objective biochemical assessment through serum cortisol measurement further strengthened methodological consistency and reduced subjectivity. Additionally, focusing on healthy young adults allowed evaluation of music-induced endocrine changes within a relatively homogeneous population.

However, several limitations should also be considered while interpreting the findings. First, the study evaluated only a single biochemical stress marker, which may not fully capture the multidimensional nature of stress physiology. Second, the relatively short intervention duration and absence of long-term follow-up limit conclusions regarding sustained benefits. Third, psychological stress scales and additional physiological markers such as heart rate variability were not incorporated, restricting comprehensive evaluation of stress modulation. Finally, the study population consisted predominantly of young adults from a single institution, which may limit generalizability to broader populations.

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