# Adani Global Indology Conclave

# Raga Bhairavi in virtual reality reduces stress-related psychophysiological markers

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## Abstract

The effects of Indian classical music on psychophysiological parameters remain underexplored. This study investigated the impact of listening to *raga Bhairavi* in a virtual reality (VR) environment on anxiety, stress, depression, and heart rate variability (HRV) over six days. Forty-four participants were randomly assigned to either the **VR-raga group**, where they experienced *raga Bhairavi* via 360° video, or the **control group**, which received no exposure. HRV baselines (relax-baseline and stress-baseline) were recorded on the first day, and HRV monitoring, along with the Depression, Anxiety, and Stress Scale (DASS-21) questionnaire, was conducted on the first and sixth days. Results showed significant reductions in **DASS-21 scores** and improved **HRV parameters** in the VR-raga group, suggesting decreased physiological stress and enhanced autonomic balance. These findings support the potential of VR-based *raga Bhairavi* interventions for stress reduction and mental well-being enhancement in real-world applications.

## Problem Statement

- **Rising Mental Health Concerns -** Stress, anxiety, and depression affect millions worldwide, highlighting the need for accessible and effective interventions.
- **Potential of Music Therapy & VR -** Indian classical music, especially Raga Bhairavi, has been traditionally linked to relaxation, but its effects remain underexplored. Virtual Reality (VR) can enhance immersion, potentially increasing therapeutic benefits.


- **Bridging the Research Gap -** Limited studies combine Indian classical music with VR while **measuring both psychological (DASS-21) and physiological (HRV) stress markers**.

## Materials and Methods

**Participants -** 44 healthy adults (13 women, 31 men, mean age: 24.43 ± 4.18 years) were recruited for the study.
**Study Design -** A randomized controlled trial (RCT) with two groups: **VR-Raga** (listened to Raga Bhairavi in an immersive 360° VR environment for six days), **Control Group** (no music intervention for six days).

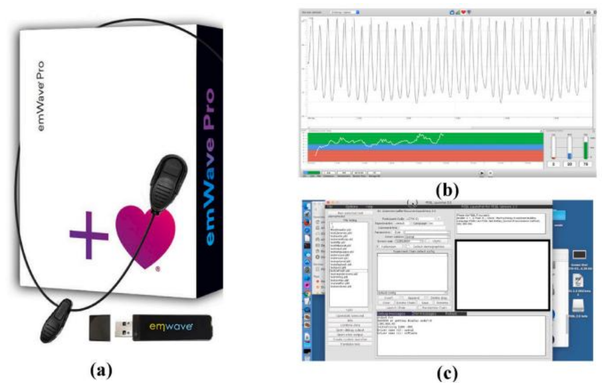


**Figure 1.** EmWave pro for HRV data acquisition

**Figure 2.** Oculus Quest 2 for VR presentation

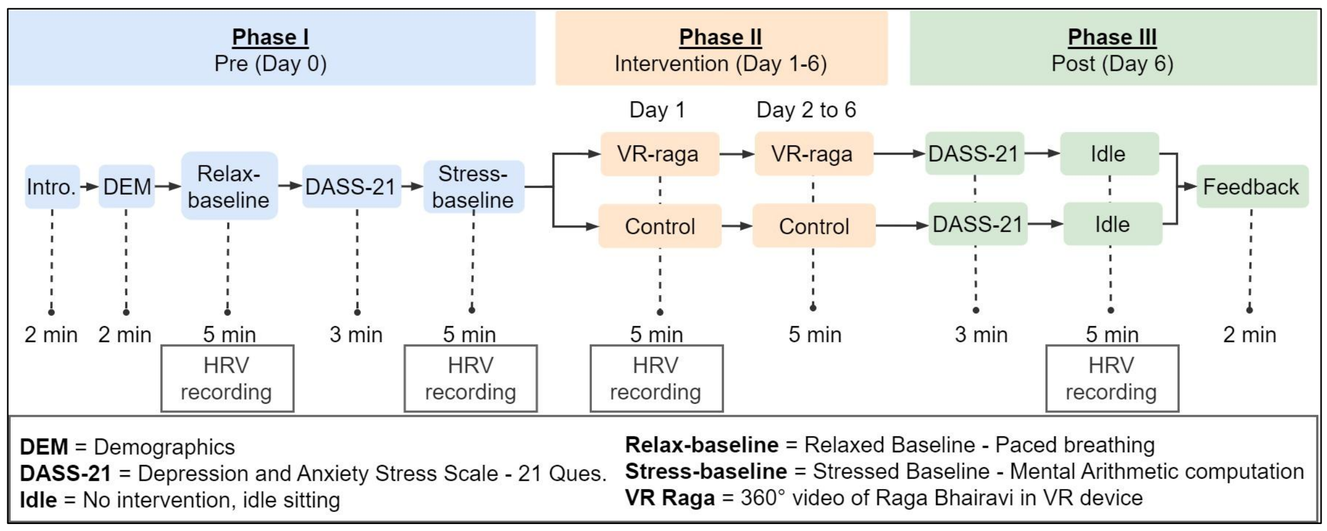


**Figure 3.** Experiment design

## Results and Discussions


**Figure 3.** Raga Bhairavi performance in a 360° VR environment. [1],[3]

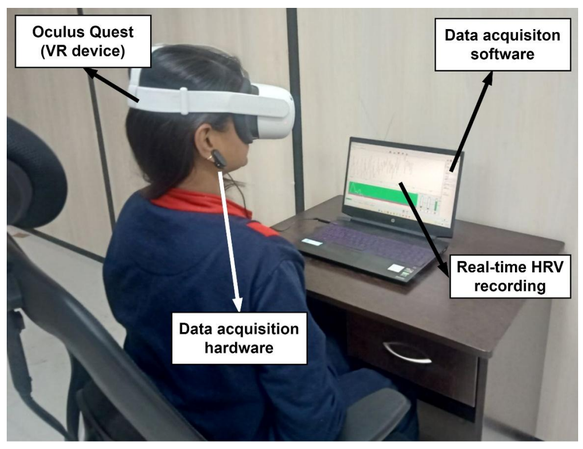


**Figure 4.** Participant under intervention. [1], [3]

**Table 1 Descriptive statistics of the DASS subscales**

| Group | DASS subscale | Pre-intervention (Mean ± SD) | Post-intervention (Mean ± SD) | Post-pre difference (Mean ± SD) |
|---|---|---|---|---|
| VR-raga | Stress | 12.36 ± 6.61 | 5.00 ± 2.74 | -7.36 ± 7.02 |
| | Anxiety | 9.55 ± 5.62 # | 3.91 ± 3.41 # | -5.64 ± 5.88 # |
| | Depression | 9.73 ± 6.88 # | 3.18 ± 3.13 # | -6.55 ± 7.26 |
| Control | Stress | 12.00 ± 8.42 # | 10.36 ± 7.45 | -1.64 ± 3.30 |
| | Anxiety | 7.00 ± 6.78 # | 6.27 ± 5.25 # | -0.73 ± 2.73 |
| | Depression | 7.45 ± 6.91 # | 6.55 ± 4.83 # | -0.91 ± 4.26 # |

**Table 2 Baseline corrected (mean ± SD) values and test statistics of the VR-raga and control groups for HRV parameters at Post-pre (day 6 - day 1)**

| HRV parameter | VR-raga (Mean ± SD) † | Control (Mean ± SD) † | t or W statistic | p-value | Effect size ($d_z$) |
|---|---|---|---|---|---|
| SDNN ↓ | 5.19 ± 24.09 | -8.44 ± 9.86 | -2.46 (42) | 0.02* | -0.74 •• |
| SDHR ↓ | 1.45 ± 3.35 | -0.7 ± 1.28 | -2.82 (42) | 0.0074* | -0.85 •• |
| HTI ↓ | 1.24 ± 5.86 | -2.08 ± 2.62 | -2.42 (42) | 0.02* | -0.73 •• |
| LF/HF ↓ | 3.5 ± 8.19 | -0.08 ± 1.39 | -2.02 (42) | 0.05* | -0.61 •• |
| RESP ↑ | 0.01 ± 0.09 | 0.03 ± 0.08 | 0.65 (42) | 0.52 | 0.2 ◦◦ |
| SD2/SD1 ↓ | 0.57 ± 1.01 | -0.06 ± 0.46 | -2.66 (42) | 0.01* | -0.8 •• |
| SampEn ↑ | -0.1 ± 0.28 | 0.02 ± 0.14 | 1.72 (42) | 0.09 | 0.52 •• |

*Note: † The values of HRV parameters indicate the mean deviation from the stress-baseline. ↓ The mean value was lower in the control group. ↑ The mean value was higher in the control group. # Deviation from the normality. t-test (t) for normal and Wilcoxon test (W) test for non-normal data. * The p value is significant after correcting for multiple comparisons. •• Large effect; • Moderate effect; ◦◦ Small effect; ◦ Trivial effect.*

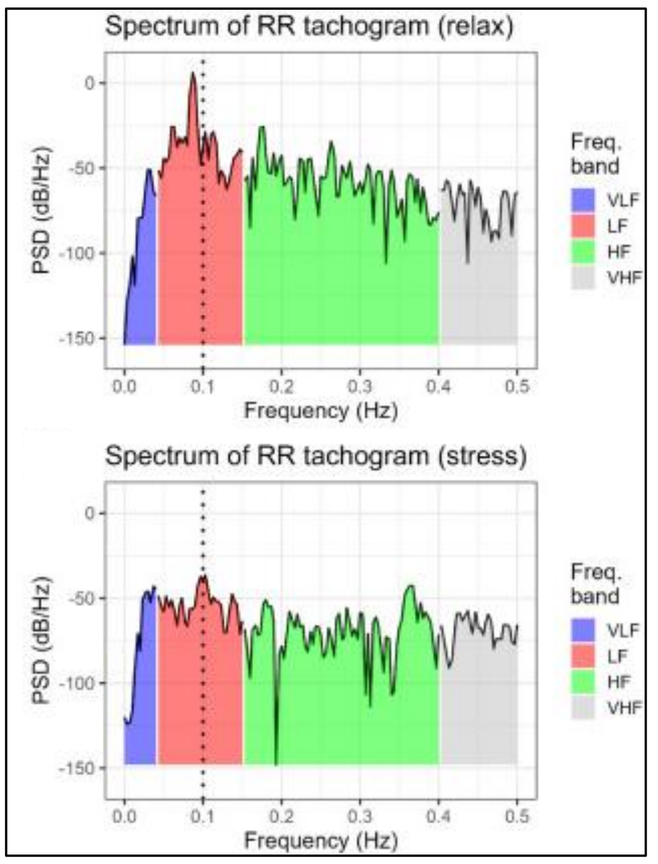


***Figure 4.*** *RR tachogram taken during relaxation (top) and stress (bottom).* [2]

## Conclusion

This study demonstrates the effectiveness of **VR-based *raga Bhairavi* therapy** in reducing **stress, anxiety, and depression**, while improving **autonomic balance** through HRV modulation. The integration of **immersive music therapy in VR** offers a **non-invasive, accessible, and engaging** mental health intervention. Its applications extend beyond clinical settings to workplaces, schools, and telemedicine platforms, making it a scalable solution. **Real-time biofeedback** could further enhance personalization, optimizing therapeutic outcomes. Future research should explore **longer interventions, diverse populations, and alternative musical genres** to expand its applicability.

## References

1. **Chand, K., Chandra, S., & Dutt, V.** (2024). *Raga Bhairavi in virtual reality reduces stress-related psychophysiological markers. Scientific Reports, 14*(1), 24816.
2. **Chand, K., Chandra, S., & Dutt, V.** (2024). *A comprehensive evaluation of linear and non-linear HRV parameters between Paced Breathing and Stressful Mental State.* Heliyon.
3. **Chandra, S., Chand, K., & Dutt, V.** (2023). *Impact of Indian Classical Raga in Immersive Environments on Human Psycho-physiological Parameters.* In *Proceedings of the 16th International Conference on Pervasive Technologies Related to Assistive Environments (PETRA).*

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