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Original Research Article

To Assess the Effect of Music and White noise on Heart Rate Variability in Young Adults: A Comparative Study

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ABSTRACT

Background: Music and other auditory stimuli can influence emotional processing and autonomic nervous system activity. Heart rate variability (HRV) provides a non-invasive measure of autonomic regulation and may help characterize changes in sympathovagal balance in response to different auditory conditions. This study evaluated the effects of relaxant music, excitatory music, and white noise on cardiovascular parameters and HRV in healthy young adults.

Materials and Methods: This experimental study included 100 healthy adults aged 18–25 years. Following standardized pre-test restrictions and a 15-minute resting period, participants underwent 5-minute Lead II electrocardiographic recordings during four conditions: basal, relaxant music, excitatory music, and white noise. Cardiovascular parameters and time- and frequency-domain HRV indices were assessed. Repeated-measures analysis of variance was used to compare parameters across the four experimental conditions, with statistical significance set at $p<0.05$.

Results: The mean age of participants was 20.06±1.83 years. No statistically significant differences were observed across the four conditions in systolic blood pressure, diastolic blood pressure, respiratory rate, heart rate, mean RR interval, mean heart rate, RMSSD, SDSD, pRR50, or total power ($p>0.05$). In contrast, significant differences were observed in frequency-domain HRV parameters. HF power was higher during basal and relaxant music conditions (68.39±11.46 and 69.21±11.22, respectively) than during excitatory music and white noise (62.58±12.73 and 60.89±13.68, respectively; $F=11.358$, $p<0.00001$). LF power was higher during excitatory music and white noise (34.16±13.20 and 36.53±14.48) than during basal and relaxant music (28.32±11.44 and 28.08±10.68; $F=11.417$, $p<0.00001$). The LF/HF ratio also differed significantly across conditions ($F=8.900$, $p=0.00001$).

Conclusion: Auditory stimulation primarily affected frequency-domain HRV rather than cardiovascular or time-domain HRV parameters. Relaxant music was associated with a more parasympathetically predominant HRV pattern, whereas excitatory music and white noise were associated with a relative shift toward sympathetic predominance.

Keywords: Music, White noise, Heart rate variability, Autonomic nervous system, Young adults

INTRODUCTION

Music is a valuable tool for understanding human emotion, cognition, and brain function. [1] Music evokes emotional responses and stimulates the central nervous system, playing an important role in regulating sympathovagal balance. [2-5]

In modern era, stress has become a common part of modern life, even among healthy individuals. Repetitive stress can disrupt autonomic function, leading to autonomic imbalance. [2,6] Stress predominantly activates the sympathetic nervous system while suppressing parasympathetic activity, thereby contributing to sympathovagal imbalance. Persistent disruption of autonomic balance may increase the risk of several non-communicable diseases, including hypertension, diabetes mellitus, and cardiovascular diseases. [7,8] Noise, defined as unwanted sound or "wrong sound at the wrong time in wrong place," is another form of auditory stimulus that can influence physiological responses. [9] Although both noise and music consist of sound vibrations, they are perceived and processed differently, resulting in potentially distinct physiological and autonomic effects. [10]

Music can be broadly classified into classical, instrumental, folk, and popular genres based on style and cultural origin. These genres differ in tempo, rhythm, melody, and emotional content, which may produce distinct effects on autonomic nervous system activity and heart rate variability (HRV).

Auditory environments can positively or negatively influence HRV. Slow-tempo, calming classical or instrumental music generally increases heart rate variability (HRV) by enhancing parasympathetic activity, promoting relaxation, and reducing stress. In contrast, fast-tempo or loud music tends to decrease HRV by increasing sympathetic activation and physiological arousal. Thus, music influences autonomic balance in a tempo- and style-dependent manner and can serve as a useful non-pharmacological intervention for stress reduction and autonomic regulation.

Heart rate variability (HRV), a non-invasive measure of autonomic nervous system (ANS) activity and homeodynamics, has received much attention in recent years in the study of cardiovascular disease, mental health, and aging. As, young adults commonly experience stress, making HRV an important marker of autonomic health.

Music and white noise are commonly used for relaxation, concentration, and sleep. However, their effects on HRV remain inadequately studied, highlighting the need for further research. Therefore, this study aimed to assess the effect of music & white noise on heart rate variability in young healthy adults.

MATERIALS & METHODS

This study was conducted in the Department of Physiology, LLRM Medical College, Meerut, after obtaining Institutional Ethics Committee approval no. SC-1/2026/1962 dated 13/03/2026. The sample size was calculated using the paired comparison of means based on the study by Dhamayanthi A. et al. [11], yielding a minimum of 76 participants after accounting for a 10% dropout rate. To improve statistical reliability, 100 healthy young adults (18–25 years) of both sexes were enrolled after obtaining written informed consent.

Healthy participants aged 18–25 years who consented to participate were included while, individuals with diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, thyroid disorders, obesity, smoking, alcohol use, medications affecting autonomic function, hearing impairment, sleep deprivation, illiteracy, or preference for both rock and classical music were excluded.

Participants were instructed to avoid heavy meals, caffeine, alcohol, and strenuous exercise for 4 hours before testing. HRV recordings were performed in a quiet, temperature-controlled environment between 9:00 AM and 1:00 PM. After 15 minutes of rest, baseline HRV was recorded using a 5-minute Lead II ECG (Neuroperfect EMG-2000 HRV system).

HRV analysis was performed according to international guidelines using time-domain (SDNN, RMSSD, pNN50, SDSD) and frequency-domain (LF, HF, LF/HF ratio, and Total Power) parameters.

The complete demographic profile including age, gender, marital status, educational level, work experience, average working hours per day, and type of work system was recorded in predesigned proforma. Weight, height, BP and HR, and HRV also recorded in proforma.

Statistical Analysis

Data were analyzed to compare cardiovascular and heart rate variability (HRV) parameters across the four experimental conditions: basal, relaxant music, excitatory music, and white noise. Continuous variables were expressed as mean ± standard deviation (SD). Differences in repeated measurements obtained from the same participants across the four experimental conditions were assessed using one-way repeated-measures analysis of variance (RM-ANOVA). The F statistic and corresponding p value were reported for each parameter. A two-sided p value <0.05 was considered indicative of statistical significance. Statistical analysis was performed using an appropriate statistical software package.

RESULT

Out of total 100 participants, the mean age was 20.06±1.83 years. The mean height, weight, and BMI were 164.23±9.28 cm, 56.77±10.65 kg, and 20.99±3.02 kg/m², respectively. Mean heart rate and respiratory rate were 69.08±8.72 bpm and 12.0±1.10 breaths/min whereas the mean systolic and diastolic blood pressures were 106.84±16.27 mmHg and 67.32±10.40 mmHg, respectively (Table 1).

Table 1: Demographic parameters of studied subjects

Parameters	Mean±SD	Range
Age (yrs)	20.06±1.83	
Height (cm)	164.23±9.28	150-187
Weight (kg)	56.77±10.65	40-87
BMI (kg/m^2)	20.99±3.02	13.84-28.74
Heart rate (bpm)	69.08±8.72	48-90
Respiratory rate (breaths/min)	12.0±1.10	10-14
Systolic BP (mmHg)	106.84 ± 16.27	80–144
Diastolic BP (mmHg)	67.32 ± 10.40	56–92

Regarding music habits, none of the participants had formal music training. Music was used as a stress reliever by 43%, while 50% enjoyed listening to music. Soft music was the most preferred genre (47%), followed by rock (40%), mixed (6%), and no preference (7%) (Table 2).

Table 2: Distribution of subjects according to their interaction with music (Pretest)

Interaction	No. of subjects	Percentage
Learn any form of music	0	0
Use music as stress reliever	43	43.0
Enjoying listening of music	50	50.0
Type of music enjoyed		

Soft	47	47.0
Rock	40	40.0
Mix	6	6.0
Nil	7	7.0

The majority of participants (98%) reported being comfortable with hearing music, while 82% reported comfort with white noise after post test. A small proportion of subjects (5%) had previously heard the particular music used in the study. Additionally, 11% of participants reported being emotionally disturbed upon exposure to music (Table 3).

Table 3: Post test results among subjects

Result of exposure of music	No. of cases	Percentage
Previously hear particular music	5	5.00
Emotionally disturbed on exposure of music	11	11.00
Comfortable with hearing music	98	98.00
Comfortable with hearing white noise	82	82.00

Comparison of cardiovascular and heart rate variability parameters across the four experimental conditions showed no statistically significant differences in systolic blood pressure, diastolic blood pressure, respiratory rate, heart rate, mean RR, mean heart rate, RMSSD, SDSD, pRR50, or total power (p>0.05). In contrast, significant differences were observed in frequency-domain HRV parameters. HF power was significantly higher during the basal and relaxant conditions compared with the excitatory and white-noise conditions (F=11.358, p<0.00001). Conversely, LF power showed a significant increase during the excitatory and white-noise conditions (F=11.417, p<0.00001). The LF/HF ratio also differed significantly across conditions, increasing from 0.47±0.37 at baseline to 0.71±0.54 during white noise (F=8.900, p=0.00001), indicating a shift towards greater sympathetic predominance during the excitatory and white-noise conditions (Table 4).

Table 4: Comparison of parameters at different music and noise

Parameters	Basal Mean±SD	Relaxant Mean±SD	Excitatory Mean±SD	White Mean±SD	F ratio	ANOVA p
Systolic BP	106.84 ±16.27	107.50 ±13.0	105.70 ±11.60	106.48 ±13.25	0.3026	0.8234
Diastolic BP	67.44 ±10.35	67.34 ±9.01	66.96 ±9.17	66.56 ±11.44	0.1593	0.9236
RR	12.00 ±1.10	12.02 ±1.05	12.04 ±0.93	12.0 ±0.95	0.0357	0.9909
HR	69.16 ±8.67	71.04 ±9.71	70.49 ±10.24	70.88 ±9.18	0.8128	0.4873
MRR	698.32±305.57	707.24±289.78	750.16±239.94	743.44±233.88	0.9206	0.4308
MHR	71.49 ±9.63	72.61 ±10.86	73.11 ±10.37	73.66 ±9.56	0.8336	0.4759
RMSSD	50.52 ±26.48	48.25 ±22.71	44.47 ±19.81	45.09 ±19.31	1.6119	0.1860
SDSD	50.65 ±26.38	48.28 ±22.71	44.48 ±19.79	45.11 ±19.30	1.6731	0.1722
pRR50	29.25 ±21.57	29.93 ±21.02	26.65 ±19.77	27.20 ±19.34	0.7258	0.5370
HF	68.39 ±11.46	69.21 ±11.22	62.58 ±12.73	60.89 ±13.68	11.358	<0.00001
LF	28.32 ±11.44	28.08 ±10.68	34.16 ±13.20	36.53 ±14.48	11.417	<0.00001
LF/HF ratio	0.47 ±0.37	0.45 ±0.30	0.62 ±0.39	0.71 ±0.54	8.900	0.00001
Total power	3048.31 ±2436.77	2548.22 ±1901.20	2442.20 ±1739.81	2708.31 ±1747.77	1.7925	0.1479

DISCUSSION

The present study included healthy young adults, with a mean age of 20.06±1.83 years, mean BMI of 20.99±3.02 kg/m², heart rate of 69.08±8.72 bpm, respiratory rate of 12.0±1.10 breaths/min, and blood pressure of 106.84±16.27/67.32±10.40 mmHg. The baseline anthropometric and cardiovascular parameters indicated a physiologically stable study population. Previous studies by

Laederach-Hofmann et al. [12] reported increased sympathetic activity and reduced vagal tone in overweight and obese individuals. The absence of obesity in the present study minimizes the potential confounding effect of obesity-related autonomic alterations on the findings. Maintaining normal baseline physiological parameters is essential in HRV research because abnormal cardiovascular conditions, such as hypertension or tachycardia, may significantly influence autonomic nervous system activity. [13,14]

The present study showed that music was a familiar and commonly used means of relaxation among participants, with 43% using music as a stress reliever and 50% reporting that they enjoyed listening to music. A preference for soft music (47%) over rock (40%) may show a liking for calmer sounds, though personal taste still shapes emotional and physical reactions. This is consistent with Groarke et al. [15] who found that individuals commonly select music as a strategy for stress recovery, with self-selected music being valued as a recovery activity.

The high level of participants comfort with music (98%) indicates good acceptability of the musical intervention, whereas the lower comfort with white noise (82%) suggests that non-musical auditory stimuli may be less universally preferred. Only 5% had previously heard the study music, minimizing the influence of familiarity. However, 11% experienced emotional disturbance, highlighting the variable emotional and autonomic responses to music based on individual preferences and musical characteristics. Similar systematic review emphasized that the effects of music on stress and autonomic function vary according to genre, tempo, listener preference, and selection of music. [16,17]

We observed, no significant differences in systolic blood pressure, diastolic blood pressure, respiratory rate, heart rate, mean RR, mean heart rate, RMSSD, SDSD, HR, pRR50, or total power across basal, relaxant music, excitatory music, and white-noise conditions ($p>0.05$). However, time-domain indices RMSSD and SDSD showed a gradual numerical reduction from basal to excitatory music and white noise, but these changes did not reach statistical significance which shows that acute auditory stimulation in healthy young adults may not produce sufficiently large changes in conventional cardiovascular or time-domain HRV measures, despite producing alterations in autonomic balance.

The most important finding in this study was the significant alteration in frequency-domain HRV parameters. HF power was significantly higher during the basal (68.39±11.46) and relaxant music (69.21±11.22) conditions than during excitatory music (62.58±12.73) and white noise (60.89±13.68), with $F=11.358$ and $p<0.00001$. Conversely, LF power increased from 28.32±11.44 at baseline and 28.08±10.68 during relaxant music to 34.16±13.20 during excitatory music and 36.53±14.48 during white noise ($F=11.417$, $p<0.00001$). Consequently, the LF/HF ratio increased significantly from 0.47±0.37 and 0.45±0.30 during basal and relaxant conditions to 0.62±0.39 during excitatory music and 0.71±0.54 during white noise ($F=8.900$, $p=0.00001$). Our results aligns with study by Dhamayanthi A. et al. [11] who reported higher LF values during white noise (359.04±388.79) than basal (297.41±234.78), classical music (226.36±252.62), and rock music (244.56±234.93), with significant differences between classical music and white noise ($p=0.007$) and rock music and white noise ($p=0.029$). Similarly, Lee et al. [18] found that increasing white-noise intensity significantly increased LF and LF/HF ratio, suggesting greater sympathetic activation, while HF remained unchanged. We emphasize that faster or more stimulating auditory patterns tend to be associated with greater physiological arousal, whereas slower and more pleasant music is more likely to facilitate parasympathetic regulation.

CONCLUSION

We concluded that auditory stimuli primarily influenced the autonomic frequency-domain components rather than resting cardiovascular variables or time-domain HRV indices. The significant reduction in HF accompanied by increases in LF and LF/HF ratio during excitatory music and white noise suggests a relative shift away from parasympathetic dominance, whereas the relaxant music condition maintained the most favorable autonomic profile, characterized by higher HF and lower LF/HF ratio.

Declaration

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