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Original Research Article

Study of Comparative Study of ECG Changes during Various Stages of Meditation and Rest

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Abstract:

Background: Meditation is widely recognized for its beneficial effects on physical and mental health, particularly through modulation of the autonomic nervous system. Electrocardiography (ECG) provides a non-invasive method to assess cardiac electrical activity and autonomic balance. This study aims to compare ECG changes occurring during different stages of meditation with those observed during normal resting conditions.

Objectives: To evaluate and compare ECG parameters during pre-meditation rest, active meditation, deep meditation, and post-meditation rest, and to determine the influence of meditation on cardiac autonomic regulation.

Methods: A comparative observational study was conducted on healthy adult participants experienced in meditation practices. ECG recordings were obtained during four phases: baseline rest, early meditation, deep meditation, and post-meditation rest. Parameters analyzed included heart rate (HR), RR interval, PR interval, QRS duration, QT interval, and heart rate variability (HRV). Statistical analysis was performed to compare changes across different stages.

Results: Meditation was associated with a significant reduction in heart rate and an increase in RR interval compared to baseline rest. Enhanced heart rate variability was observed during deep meditation, indicating increased parasympathetic activity and reduced sympathetic influence. Minor changes in PR, QRS, and QT intervals were noted but remained within normal physiological limits. Post-meditation recordings demonstrated sustained autonomic relaxation effects compared to pre-meditation resting values.

Conclusion: Different stages of meditation produce distinct ECG changes characterized primarily by reduced heart rate and increased autonomic stability. Deep meditation showed the most pronounced effects, suggesting enhanced parasympathetic dominance and cardiovascular relaxation. These findings support the role of meditation as a beneficial practice for improving cardiac autonomic function and overall cardiovascular health.

Keywords: Meditation, Electrocardiography (ECG), Heart Rate Variability, Autonomic Nervous System, Cardiovascular Function, Relaxation Response.

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Introduction

Meditation is a mind–body practice that has been utilized for thousands of years in various cultural and spiritual traditions to promote physical, mental, and emotional well-being. In recent decades, scientific interest in meditation has increased considerably due to its potential benefits in reducing stress, anxiety, hypertension, and cardiovascular disorders. Meditation is known to influence the autonomic nervous system by enhancing parasympathetic activity and reducing sympathetic arousal, thereby producing a state of physiological relaxation. The cardiovascular system is highly responsive to autonomic modulation. Electrocardiography (ECG) is a simple, non-invasive, and reliable method for assessing cardiac electrical activity and autonomic influences on the heart. Parameters such as heart rate, RR interval, PR interval, QT interval, and heart rate variability (HRV) provide valuable information regarding autonomic balance and cardiac function. Alterations in these parameters may reflect the physiological changes occurring during meditation. Previous studies have demonstrated that meditation can reduce heart rate, improve heart rate variability, lower blood pressure, and enhance vagal tone. However, the extent and pattern of ECG changes during different stages of meditation remain incompletely understood. Most investigations have focused on comparing meditation with non-meditative states, while fewer studies have

examined the dynamic cardiovascular changes occurring throughout the various phases of meditation practice.

Understanding ECG changes during different stages of meditation may provide insights into the mechanisms through which meditation exerts its beneficial effects on cardiovascular health. Such knowledge may also contribute to the development of meditation-based interventions for stress management and prevention of cardiovascular diseases. Therefore, the present study was undertaken to compare ECG changes during various stages of meditation and resting conditions. The study aims to evaluate alterations in selected ECG parameters and assess the influence of meditation on cardiac autonomic regulation.

Materials and Methods

This comparative observational study was conducted to evaluate ECG changes during various stages of meditation and resting conditions. Department of Physiology at Darbhanga Medical College and Hospital Darbhanga Laheriasarai. Study duration of Two years. The study aimed to compare cardiovascular responses by analyzing electrocardiographic parameters recorded during rest and meditation. A total of 52 healthy adult volunteers were included in the study. Participants were recruited from meditation centers, yoga institutes, and the general population. Both male and female subjects aged between 18 and 60 years.

Inclusion Criteria

- Healthy adults aged 18–60 years.
- Individuals willing to participate in the study.
- Subjects with prior experience of meditation for at least six months.
- Participants free from known cardiovascular, respiratory, neurological, or psychiatric disorders.

Exclusion Criteria

- History of hypertension, ischemic heart disease, arrhythmias, or other cardiac disorders.
- Current use of medications affecting autonomic or cardiovascular function.
- Smoking, alcohol dependence, or substance abuse.
- Acute illness or inability to complete the meditation session.

Study Procedure: The study was conducted in a quiet, temperature-controlled room. Participants were advised to avoid caffeine, heavy meals, smoking, and strenuous physical activity for at least 12 hours before the recording session. After a period of acclimatization, ECG recordings were obtained using a standard 12-lead electrocardiograph during the following phases:

1. **Pre-meditation Rest (Baseline):**
    - Participants rested comfortably in a seated position with eyes closed for 10 minutes.
    - Baseline ECG parameters were recorded.
2. **Early Meditation Stage:**
    - ECG recordings were taken during the first 10 minutes of meditation practice.
3. **Deep Meditation Stage:**
    - ECG recordings were obtained during the subsequent 10–20 minutes when participants achieved a deeper meditative state.
4. **Post-meditation Rest:**
    - Following completion of meditation, participants remained seated quietly for 10 minutes.
    - ECG recordings were repeated.

Parameters Studied: The following ECG parameters were measured and analyzed:

- Heart Rate (HR)
- RR Interval
- PR Interval
- QRS Duration
- QT Interval
- Corrected QT Interval (QTc)
- Heart Rate Variability (HRV)

Data Collection: All ECG recordings were reviewed and analyzed by trained personnel using standardized methods. Mean values of ECG parameters for each study phase were recorded and tabulated.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Results were expressed as mean ± standard deviation (SD). Comparison of ECG parameters among different stages of meditation and rest was performed using repeated-measures ANOVA followed by post hoc analysis where applicable. A p-value < 0.05 was considered statistically significant.

Results

A total of 52 healthy volunteers participated in the study. ECG parameters were recorded during four phases: pre-meditation rest (baseline), early meditation, deep meditation, and post-meditation rest. The observations demonstrated significant changes in cardiac autonomic activity during meditation, particularly during the deep meditation stage.

Table 1: Distribution of Study Participants (n = 52)

Variable	Number (%)
Male	30 (57.7%)
Female	22 (42.3%)
Age 18–30 years	18 (34.6%)
Age 31–45 years	21 (40.4%)
Age 46–60 years	13 (25.0%)

Table 2: Comparison of Mean Heart Rate During Different Study Phases

Study Phase	Mean Heart Rate (beats/min)	SD
Pre-meditation Rest	76.8	6.5
Early Meditation	72.4	5.8
Deep Meditation	68.1	5.1
Post-meditation Rest	70.2	5.4

Observation: A progressive reduction in heart rate was observed during meditation, with the lowest values recorded during deep meditation. The difference was statistically significant ($p < 0.001$).

Table 3: Comparison of Mean RR Interval During Different Study Phases

Study Phase	Mean RR Interval (ms)	SD
Pre-meditation Rest	782	68
Early Meditation	829	71
Deep Meditation	881	76
Post-meditation Rest	855	72

Observation: RR interval increased significantly during meditation, reflecting a decrease in heart rate and enhanced parasympathetic activity ($p < 0.001$).

Table 4: Comparison of ECG Intervals During Different Study Phases

Parameter	Baseline	Early Meditation	Deep Meditation	Post-meditation Rest
PR Interval (ms)	158 ± 12	160 ± 11	163 ± 10	161 ± 11
QRS Duration (ms)	89 ± 7	89 ± 6	90 ± 6	89 ± 6
QT Interval (ms)	386 ± 18	394 ± 17	403 ± 16	398 ± 17
QTc Interval (ms)	412 ± 15	414 ± 14	416 ± 13	415 ± 14

Observation: Slight increases in PR and QT intervals were observed during meditation, while QRS duration remained relatively unchanged. All values remained within normal physiological limits.

Table 5: Heart Rate Variability (HRV) During Different Study Phases

Study Phase	Mean HRV (ms)	SD
Pre-meditation Rest	42.6	8.3
Early Meditation	48.7	9.1
Deep Meditation	58.9	10.2
Post-meditation Rest	53.4	9.4

Observation: HRV increased significantly during meditation, reaching maximum values during deep meditation, indicating enhanced vagal tone and improved autonomic balance ($p < 0.001$).

Summary of Findings

Heart rate decreased significantly during meditation, with the greatest reduction during deep meditation.

- RR interval increased progressively throughout meditation.
- PR and QT intervals showed mild prolongation but remained within normal limits.
- QRS duration exhibited minimal variation across study phases.
- Heart rate variability increased significantly during meditation, suggesting enhanced parasympathetic dominance.
- Post-meditation recordings indicated persistence of relaxation effects even after cessation of meditation.

These findings suggest that meditation induces favorable autonomic and cardiovascular changes, with the most pronounced effects occurring during the deep meditation stage.

Discussion

The present study was conducted to evaluate and compare ECG changes during various stages of

meditation and rest in 52 healthy adult participants. The findings demonstrated significant alterations in cardiovascular parameters during meditation, particularly during the deep meditation stage, indicating enhanced parasympathetic activity and reduced sympathetic influence on the heart. One of the most notable observations in the present study was the significant reduction in heart rate during meditation. The mean heart rate decreased progressively from the baseline resting state to the deep meditation stage. This finding is consistent with previous studies that have reported a reduction in heart rate during meditation due to increased vagal tone and decreased sympathetic nervous system activity. The slowing of heart rate reflects a state of physiological relaxation and reduced metabolic demand.

The RR interval showed a corresponding increase during meditation, with maximum values observed during deep meditation. Since the RR interval is inversely related to heart rate, this finding further supports the presence of enhanced parasympathetic dominance during meditation. Similar observations have been reported by researchers investigating the cardiovascular effects of mindfulness meditation, transcendental meditation, and yogic practices.

In the present study, slight increases in PR interval and QT interval were observed during meditation. These changes may be attributed to reduced sympathetic stimulation and increased vagal influence on cardiac conduction pathways. However, all measured values remained within normal physiological limits, indicating that meditation produces adaptive rather than pathological changes in cardiac electrical activity. QRS duration showed minimal variation throughout the study phases, suggesting that ventricular depolarization remains largely unaffected by meditation. Heart rate variability (HRV), an important indicator of autonomic nervous system function, increased significantly during meditation, with the highest values recorded during deep meditation. Increased HRV is generally associated with improved autonomic balance, enhanced cardiovascular adaptability, and reduced stress. The observed increase in HRV in this study is in agreement with earlier reports demonstrating that meditation enhances parasympathetic activity and promotes cardiovascular stability. The persistence of lower heart rate and higher HRV values during the post-meditation resting period suggests that the beneficial effects of meditation may continue beyond the actual meditation session. This sustained autonomic modulation may contribute to the long-term cardiovascular benefits associated with regular meditation practice, including improved blood pressure regulation, reduced stress levels, and decreased risk of cardiovascular disease.

The findings of the present study are comparable with those reported by researchers such as Herbert Benson, who described the "relaxation response" characterized by reduced heart rate and decreased physiological arousal during meditation. Similar observations have also been documented in studies evaluating mindfulness-based and yogic meditation techniques. Despite the valuable findings, the study has certain limitations. The sample size was relatively small, and participants were drawn from a limited geographic area. Variations in meditation techniques, duration of practice, and individual experience levels may also have influenced the results. Future studies involving larger populations, advanced ECG analyses, and long-term follow-up are recommended to further elucidate the cardiovascular effects of meditation.

Overall, the present study demonstrates that meditation produces significant beneficial changes in ECG parameters, particularly reductions in heart rate, increases in RR interval, and enhancement of heart rate variability. These findings support the role of meditation as an effective non-pharmacological intervention for improving autonomic regulation and promoting cardiovascular health.

Conclusion

The present study demonstrates that meditation produces significant and favorable changes in electrocardiographic parameters, reflecting improved autonomic nervous system regulation and cardiovascular function. A progressive reduction in heart rate and a corresponding increase in RR interval were observed during meditation, with the most pronounced effects occurring during the deep meditation stage. Heart rate variability showed a significant increase during meditation, indicating enhanced parasympathetic activity and improved autonomic balance. Minor changes in PR and QT intervals were noted; however, all values remained within normal physiological limits, suggesting that meditation induces beneficial physiological adaptations without adverse effects on cardiac conduction. The persistence of these changes during the post-meditation resting period further suggests that the cardiovascular benefits of meditation extend beyond the actual practice session. These findings support the use of meditation as a simple, safe, and effective non-pharmacological approach for stress reduction, autonomic regulation, and promotion of cardiovascular health.

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