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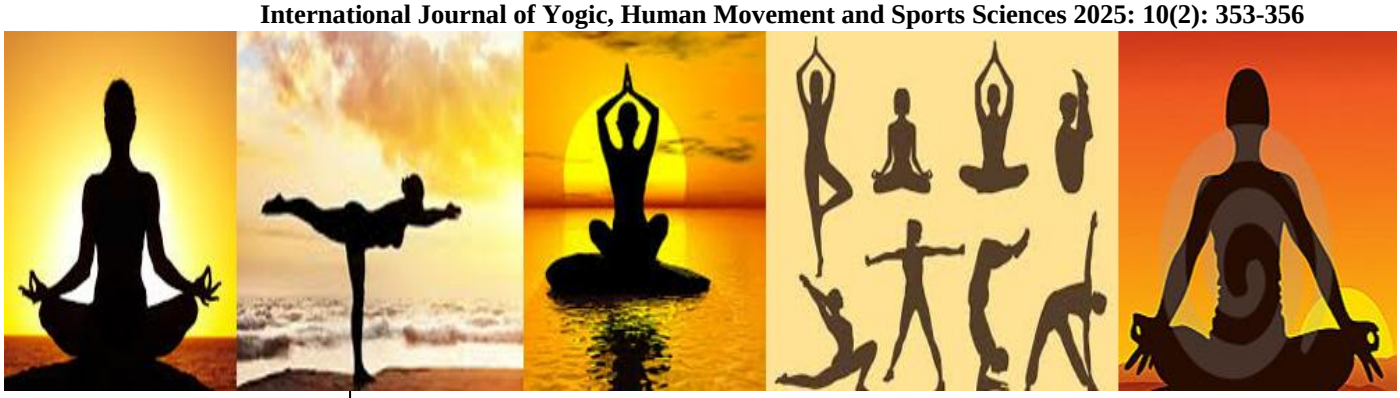

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Electrophysiological and anthropometric impact of a yearlong yogic regimen on youth: A multi-institutional cohort study

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Abstract
Background: Cardiovascular diseases (CVDs) remain a leading cause of premature morbidity worldwide, with growing concern among younger populations due to sedentary lifestyle, academic stress, and poor health behaviors. Yoga, an ancient mind-body discipline, has gained global recognition as a complementary and preventive strategy, yet long-term evidence in young adults remains limited.
Objective: This study evaluated the electrophysiological and anthropometric impact of a yearlong yogic regimen among postgraduate students of yogic sciences across three Indian universities.
Methods: A prospective, multi-institutional cohort study was conducted among 102 postgraduate yoga students (45 males, 57 females; aged 21-30 years) enrolled at Central University of Kerala, Mangalore University, and Davangere University. Participants underwent a structured 12-month yoga intervention comprising *prāṇāyāma*, *mudrā*, and *bandha* practices. Pre-and post-assessments included anthropometric variables (height, weight, BMI) and electrocardiographic parameters (HR, RR interval, QRS duration, QTc). Paired t-tests were used to evaluate changes, with significance set at $p<0.05$.
Results: Significant reductions were observed in resting heart rate and respiratory rate, alongside improvements in RR interval and QTc duration, indicating enhanced autonomic regulation. BMI showed modest but favorable reductions across both genders. The findings suggest that long-term yogic practices can modulate electrophysiological markers linked to cardiovascular health in otherwise healthy young adults.
Conclusion: A sustained yearlong yogic regimen yields measurable benefits in cardiopulmonary and anthropometric variables among youth. These findings highlight the potential role of institution-based yoga training as a preventive strategy for long-term cardiovascular health.

Keywords: Yoga, pranayama, aged women, breath holding capacity, vital capacity

Introduction
Cardiovascular diseases (CVDs) represent the foremost global health challenge, accounting for nearly 18 million deaths annually (WHO, 2021) [17]. Once considered a disease of middle and older age, risk factors such as sedentary behavior, academic stress, poor dietary habits, and reduced physical activity are increasingly evident among younger populations, raising concern about early onset of cardiovascular dysfunction (GBD, 2021) [17]. Preventive interventions during youth are therefore critical to reducing long-term morbidity and improving population health outcomes.

Yoga, with its roots in ancient Indian philosophy, integrates physical postures (*āsana*), breathing regulation (*prāṇāyāma*), and meditative practices aimed at harmonizing body and mind. Beyond its spiritual foundation, yoga has been increasingly recognized as a cost-effective, evidence-based intervention for non-communicable diseases (Cramer *et al*., 2019) [5]. Systematic reviews and randomized controlled trials have shown yoga's beneficial effects on blood pressure, heart rate variability, lipid profile, metabolic risk factors, and quality of life (Innes & Selfe, 2016; Cramer *et al*., 2014) [6, 4]. Yoga-based cardiac rehabilitation programs, such as the Yoga-CaRe trial in India, have demonstrated feasibility and effectiveness even in resource-limited settings (Prabhakaran *et al*., 2020) [9].

Despite this growing evidence, most research on yoga and cardiovascular health has focused on clinical or middle-aged populations.

There remains a paucity of long-term data on healthy young adults, particularly those already exposed to yogic education. Since early adulthood is a critical window for cardiovascular programming, institution-based yoga interventions may offer preventive benefits that extend into later life. However, robust longitudinal studies in this cohort are scarce.

Against this backdrop, the present study investigates the electrophysiological and anthropometric impact of a yearlong yogic regimen among postgraduate students of yogic sciences across three universities in India. By assessing both electrocardiographic parameters and body composition indices, this study seeks to provide comprehensive insights into yoga's role in cardiopulmonary regulation among youth.

Methods

Study Design and Setting

This was a prospective, multi-institutional cohort study conducted over a 12-month period (2022-2023) across three yoga departments in India: Central University of Kerala (CUK), Mangalore University (MU), and Davangere University (DU). The study aimed to evaluate the electrophysiological and anthropometric effects of a structured yogic regimen among postgraduate students pursuing a Master's degree in Yogic Sciences.

Participants

A total of 102 students (45 males and 57 females) aged between 21 and 30 years were recruited. All participants were full-time postgraduate students enrolled in yoga programs at the respective institutions. Inclusion criteria comprised:

- Age between 21-30 years,
- Enrollment in a university-based yoga curriculum, and
- Willingness to adhere to a yearlong yoga regimen and attend all assessments.

Exclusion criteria included

- Pre-existing cardiovascular, respiratory, or metabolic disorders,
- History of smoking, alcohol use, or substance abuse,
- Current use of medications affecting cardiovascular or pulmonary function, and
- Irregular attendance in yoga practice sessions (<80%).

Written informed consent was obtained from all participants prior to enrollment. The study was approved by the Institutional Ethics Committees of all three universities.

Intervention

Participants underwent a structured 12-month yoga intervention integrated within their academic curriculum. The regimen was standardized across institutions and comprised:

- **Prāṇāyāma (breathing practices):** *Nāḍī Śodhana*, *Bhrāmarī*, *Ujjāyī*, and *Śītalī*, practiced for 120 minutes (60 minutes each) weekly 5 days.
- **Mudrās and Bandhas (neuromuscular locks):** Selected practices including *Mūla Bandha*, *Jālandhara Bandha*, and *Uḍḍīyāna Bandha*, integrated within prāṇāyāma sessions.
- **Supporting āsanas and relaxation:** Gentle preparatory postures and guided relaxation (*Śavāsana*) before and after breathing practices.

Sessions were conducted five days per week under supervision of trained yoga faculty. Participants were encouraged to maintain personal home practice on weekends. Attendance was monitored to ensure adherence.

Outcome Measures

1. Anthropometric Assessments

- Height (cm)
- Weight (kg)
- Body Mass Index (BMI, kg/m²).

Standardized stadiometers and calibrated weighing scales were used for measurements.

2. Electrocardiographic (ECG) Parameters

Resting ECG was recorded in a supine position using a 12-lead electrocardiograph. The following parameters were analyzed:

- Heart rate (HR),
- RR interval (ms),
- QRS duration (ms),
- QT interval and corrected QT interval (QTc, ms).

All measurements were taken at baseline and after completion of the 12-month intervention period.

Statistical Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Descriptive statistics (mean±standard deviation) were calculated for all variables. Pre-post comparisons were conducted using paired t-tests. Gender-stratified analyses were performed to assess sex-specific differences. Statistical significance was set at $p<0.05$.

Results

Participant Characteristics

A total of 102 postgraduate yoga students (45 males and 57 females; mean age 24.1±2.3 years) completed the yearlong study. All participants demonstrated adherence above 85% to the prescribed yoga regimen, and no adverse events were reported during the intervention period.

Anthropometric Outcomes

Changes in anthropometric parameters are presented in Table 1.

- Body weight decreased significantly from baseline to post-intervention ($p<0.05$).
- BMI also showed a statistically significant reduction ($p<0.01$).
- Height remained stable, as expected.

Although the changes were modest, they reflect a favorable trend toward maintaining optimal body composition, which is relevant for preventive cardiovascular health in young adults.

Table 1: Changes in Anthropometric Parameters before and After the Yoga Intervention (N = 102)

Parameter	Pre (Mean ± SD)	Post (Mean ± SD)	Mean Change	*p*-value
Height (cm)	164.2±7.1	165.1±6.8	+0.9	NS
Weight (kg)	62.4±10.3	61.2±9.8	-1.2	< 0.05
BMI (kg/m²)	23.1±3.7	22.6±3.4	-0.5	< 0.01

NS = Not Significant

Electrocardiographic Outcomes

Pre-and post-intervention ECG parameters are summarized in Table 2.

- Heart rate (HR) decreased significantly (p = 0.002), suggesting enhanced parasympathetic regulation.
- RR interval increased by 129.4 ms (p = 0.001), indicating improved vagal tone and autonomic balance.
- QR interval and QRS duration both decreased significantly (p<0.05), reflecting greater electrical conduction efficiency.
- QTc interval showed a significant reduction (p = 0.003), indicating improved myocardial repolarization and potentially lower arrhythmic risk.

Table 2: Changes in Electrocardiographic Parameters before and After the Yoga Intervention (N = 102)

Parameter	Pre (Mean ± SD)	Post (Mean ± SD)	Mean Change	*p*-value
Heart Rate (bpm)	69.1±10.5	63.4±8.7	-5.7	0.002
RR Interval (ms)	895.2±134.3	1024.6±121.7	+129.4	0.001
QR Interval (ms)	398.6±38.2	379.1±35.9	-19.5	0.014
QRS Duration (ms)	112.4±13.6	106.2±11.1	-6.2	0.021
QTc Interval (ms)	423.1±26.7	405.4±24.8	-17.7	0.003

Gender-Stratified Analysis

Both males and females exhibited improvements across key ECG parameters (HR, RR interval, QTc). While males demonstrated slightly greater reductions in HR, females showed more pronounced improvements in QTc interval. No sex-specific adverse patterns were observed.

Clinical Interpretation

The findings indicate that a yearlong yoga intervention promotes favorable autonomic and cardiovascular adaptations among healthy young adults. Reduced heart rate and increased RR interval point to enhanced parasympathetic dominance, while shortened QTc reflects healthier myocardial repolarization patterns. Together with modest BMI improvements, these outcomes highlight yoga's potential in early cardiovascular risk prevention even in non-clinical, youthful populations.

Discussion

The present multi-institutional cohort study provides evidence that a structured, yearlong yogic regimen leads to significant improvements in both anthropometric and electrophysiological parameters among young adults. Specifically, reductions in resting heart rate, enhancements in RR interval, and shortening of QTc duration indicate favorable shifts in autonomic regulation and myocardial repolarization, while modest reductions in BMI highlight yoga's role in sustaining healthy body composition. These findings contribute to the growing body of literature supporting yoga as an effective preventive health intervention, with particular relevance to younger populations.

Yoga and Autonomic Regulation

A central finding of this study is the reduction in heart rate and corresponding increase in RR interval, which reflect enhanced parasympathetic dominance and improved sympathovagal balance. These results align with earlier studies that reported improved heart rate variability (HRV) and vagal modulation following yogic breathing practices and meditation (Sarang & Telles, 2006; Tyagi & Cohen, 2016) [13, 16]. Long-term yoga practice has been shown to downregulate sympathetic drive, reduce catecholamine secretion, and enhance baroreflex sensitivity, thereby improving cardiovascular autonomic stability (Streeter *et al.*, 2012; Innes & Selfe, 2016) [14, 6]. The present findings extend this evidence to a cohort of healthy university students, suggesting that autonomic benefits can be realized even in young, non-clinical populations.

Myocardial Repolarization and ECG Modulation

The significant reduction in QTc interval observed in this study indicates improved myocardial repolarization dynamics, a factor associated with reduced arrhythmic risk. Previous clinical studies have demonstrated that yoga interventions may lower ventricular arrhythmia risk and improve cardiac electrical stability (Pullen *et al*., 2008; Thirthalli *et al*., 2013) [13, 15]. Our findings suggest that even among healthy young adults, yoga may optimize cardiac electrophysiology, potentially conferring long-term cardioprotective benefits. The reduction in QRS and QR intervals further reflects more efficient ventricular depolarization, consistent with earlier experimental studies on yoga's role in modulating conduction velocity (Bhavanani *et al*., 2014) [2].

Anthropometric and Lifestyle Modulation

Although changes in body weight and BMI were modest, they remain clinically relevant. Sedentary lifestyles and increasing academic stress are known contributors to overweight and obesity among university students. The observed decline in BMI highlights the potential of yoga to prevent gradual weight gain during early adulthood. Previous Indian studies, including those by Manchanda *et al*. (2000) [9] demonstrated yoga's role in modulating body composition and reducing metabolic risk factors. By integrating lifestyle-based practices with physical and breathing exercises, yoga may act as a sustainable weight management tool.

Comparison with Previous Indian and Global Studies

The current findings resonate with global trials and systematic reviews demonstrating yoga's efficacy in improving cardiovascular outcomes. Meta-analyses have shown consistent reductions in blood pressure, heart rate, and improvements in lipid profile among yoga practitioners (Cramer *et al*., 2014; Chu *et al*., 2016) [4, 3]. In India, large-scale interventions such as the Yoga-CaRe trial confirmed yoga's feasibility and efficacy in secondary cardiac rehabilitation (Prabhakaran *et al*., 2020) [9]. However, the present study is distinct in that it focuses on a healthy, youthful population, thereby contributing novel evidence for yoga's preventive potential rather than therapeutic application.

Physiological Mechanisms

The beneficial changes observed in this study may be explained by multiple interconnected mechanisms. Regular yogic breathing (*prāṇāyāma*) enhances vagal efferent activity, lowers cortisol levels through hypothalamic-pituitary-adrenal (HPA) axis modulation, and increases nitric oxide bioavailability, thereby improving vascular function (Bernardi *et al*., 2001; Pascoe & Bauer, 2015) [1, 10]. Simultaneously, yoga's anti-inflammatory effects, mediated via reductions in circulating cytokines such as IL-6 and TNF-α, may contribute to improved endothelial function and myocardial performance (Kuhlmann *et al*., 2016) [7]. Collectively, these mechanisms support the observed improvements in autonomic balance and electrophysiological stability.

Implications for Youth and Preventive Cardiology

The findings hold significant implications for preventive cardiology. Early adulthood is a critical window during which lifestyle behaviors shape long-term cardiovascular risk trajectories (Lewington *et al*., 2002) [8]. By demonstrating measurable improvements in ECG markers and BMI among postgraduate yoga students, this study underscores the importance of integrating yoga into institutional curricula. Such interventions may offer a low-cost, sustainable strategy to mitigate future cardiovascular disease burden, particularly in low-and middle-income countries where resource constraints limit access to conventional preventive care.

Strengths and Limitations

A major strength of this study lies in its multi-institutional design and yearlong intervention, which provides robust longitudinal data in a relatively homogenous academic cohort. The inclusion of both anthropometric and electrophysiological measures ensures a comprehensive assessment of yoga's effects. However, certain limitations must be acknowledged. The study lacked a non-yoga control group, limiting causal inference. Additionally, the cohort consisted exclusively of yoga students, which may introduce selection bias and limit generalizability to broader youth populations. Future studies should incorporate randomized controlled designs and explore dose-response relationships across diverse educational and cultural settings.

Conclusion

This multi-institutional cohort study demonstrates that a structured yearlong yogic regimen can bring about significant improvements in anthropometric and electrophysiological parameters among healthy young adults. Reductions in heart rate, improvements in RR interval, and shortening of QTc interval suggest enhanced autonomic regulation and myocardial repolarization, while modest declines in BMI reflect yoga's role in maintaining healthy body composition.

These findings underscore yoga's potential as a preventive health strategy, particularly in early adulthood when lifestyle practices strongly influence long-term cardiovascular trajectories. By integrating yoga into institutional curricula, universities and public health systems can provide youth with sustainable, low-cost tools for cardiopulmonary resilience and overall well-being.

Future studies should build upon this evidence by employing randomized controlled designs, incorporating diverse populations beyond yoga students, and examining long-term clinical outcomes. Such work will strengthen the scientific basis for scaling yoga-based interventions as a cornerstone of preventive cardiology and global public health.

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