

Association Between Elevated Resting Heart Rate and Early Atherosclerotic Changes in Young Adults

Ali Hamza Mumtaz¹, Abdul Rahman², Abdur Rehman Javed³



1. Center of Applied Molecular Biology, University of the Punjab, Lahore, Pakistan
2. Department of Anesthesia, Shaikh Zayed Hospital, Lahore, Pakistan
3. Shaikha Fatima Institute of Nursing and Health Sciences (SFINHS), Shaikh Zayed Medical Complex, Lahore, Pakistan

Corresponding author: Ali Hamza Mumtaz, Email: alihamza3700@gmail.com

ABSTRACT

Background: Elevated resting heart rate (RHR) is increasingly recognized as an early cardiovascular risk marker, yet its association with subclinical atherosclerotic changes in young adults remains underexplored. Identifying simple predictors of early vascular remodeling is essential for preventing long-term cardiovascular disease.

Objective: To evaluate the association between elevated resting heart rate and early atherosclerotic changes, assessed through carotid intima-media thickness (CIMT), in young adults aged 18–35 years.

Methods: This cross-sectional study was conducted at Shaikh Zayed Hospital, Lahore, from January 2022 to May 2023, including 80 clinically healthy young adults. Resting heart rate was measured after 10 minutes of seated rest and categorized as normal (<80 bpm) or elevated (≥ 80 bpm). Carotid ultrasonography using high-resolution B-mode imaging assessed CIMT. Demographic data, BMI, and blood pressure were recorded. Statistical analysis included independent t-tests, Pearson correlation, and logistic regression, with $p < 0.05$ considered significant.

Results: Of the 80 participants, 32 (40%) had elevated RHR. CIMT was significantly higher in the elevated RHR group (0.72 ± 0.10 mm) compared to the normal RHR group (0.57 ± 0.07 mm) ($p < 0.001$). Resting heart rate demonstrated a moderate positive correlation with CIMT ($r = 0.49$, $p < 0.001$). Logistic regression showed elevated RHR as an independent predictor of early atherosclerotic changes (AOR 3.12; 95% CI: 1.48–6.55; $p = 0.003$).

Conclusion: Elevated resting heart rate is strongly associated with increased CIMT and independently predicts early atherosclerotic changes in young adults. Routine heart rate monitoring may serve as a simple, cost-effective tool for early cardiovascular risk identification.

Keywords: Resting heart rate, early atherosclerosis, young adults, cardiovascular risk, subclinical vascular changes.



Received: 18/09/2024
Revised: 11/12/2024
Accepted: 25/12/2024
Published: 31/12/2024

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INTRODUCTION

Atherosclerosis is a progressive vascular pathology that is a chronic and continuous disease that starts at an early age and progresses silently over decades until manifesting clinical symptoms, including coronary artery disease, stroke, or peripheral vascular disease [1]. The emerging evidence shows that even in seemingly healthy adults of young age, the initial phase of atherosclerosis is present and can be identified with the help of the slightest structural alterations in the artery walls. It is thus important to know the early

signs of vascular injury to implement successful prevention measures [2].

Resting heart rate: This is a physiological parameter that can be easily measured and monitored on a regular basis, and is an indicator of the equilibrium between the sympathetic and parasympathetic parts of the autonomic nervous system [3]. An increase in RHR is a sign of sympathetic tone, a decrease in vagal activity, an increase in circulatory stress, and an increase in myocardial oxygen demand. These physiological abnormalities can over time,

add to endothelial dysfunction, inflammation, poor compliance of the vascularity and eventually to atherosclerotic formation [4].

Several longitudinal researches have found high RHR to be an independent variable predicting hypertension, metabolic syndrome, heart failure, and cardiovascular mortality. Nevertheless, most of these studies are conducted on older adult or patients with known cardiovascular risk factors. The connection between increased RHR and early structural vascular alteration in younger groups has not been highly researched, although the risk of the heart disease usually starts in young ages [5].

The Carotid intima-media thickness (CIMT) is a non-invasive and well-established ultrasonographic technique that measures early atherosclerotic changes. Greater CIMT is associated with endothelial dysfunction and forecasts cardiovascular incidents in the future. Measuring the relationship between RHR and CIMT in young adults would, therefore, be useful in the detection of clinically silent vascular injury well before the development of symptomatic disease [6].

Low awareness, limitation of healthcare, and the misconception that heart disease mainly affects older people make early cardiovascular risk assessment a forgotten issue in most low- and middle-income countries, such as Pakistan. The search of simple inexpensive indicators like RHR would be worthy in identifying young adults with higher chances of atherosclerosis [7].

Hence, this paper will test the hypothesis that high resting heart rate is linked to early atherosclerotic alterations assessed by CIMT among young adults under the age of 35 years. This knowledge can help prevent and detect cardiovascular disease among young people earlier [8].

MATERIALS AND METHODS

The setting of the present cross-sectional clinical study was Shanghai Zayed Hospital, Lahore, specifically at the Outpatient Department and Radiology Unit, during a timeframe spanning between January 2022 and May 2023. A consecutive sampling method was used to sample 80 young adults between the ages of 18 and 35 years. Patients who came and presented themselves to a normal check-up or general examination were welcome to join. Only healthy individuals in the targeted age group were eligible provided they were not known to have chronic conditions and were not on drugs that could slow the heart rate including beta-blockers or calcium channel blockers. The exclusion criteria included a diagnosis of hypertension, diabetes mellitus, thyroid diseases, dyslipidemia, chronic kidney disease, autoimmune diseases, acute infection, cardiovascular history, reported arrhythmias, smoking or substance use, and pregnancy and lactation in female participants. The candidates were screened properly before enrollment to ensure consistency of eligibility.

The Institutional Review Board (IRB) of Shaikh Zayed Postgraduate Medical Institute (SZPGMI), Shaikh Zayed Hospital, Lahore, provided ethical approval of the study under reference number SZH/IRB/2022/0843 dated 05 January 2022. All participants provided written informed consent and were assured confidentiality, anonymity, and withdrawal at any time without any impact on their clinical care. The research followed the ethical principles as stipulated in the declaration of Helsinki.

The resting heart rate was taken under a standardized situation, with a validated automated digital sphygmomanometer (Omron 8. All participants were requested to take a ten-minute rest in a seated position under a comfortable environment of no noise and temperature control. Two readings on the heart rate were taken after a span of five minutes and the mean of the two readings was assumed to be the final resting heart rate. Participants were divided into two groups on the basis of the measured values into those who had normal resting heart rate (less than 80 beats per minute), and those with high resting heart rate (not less than 80 beats per minute).

The assessment of early atherosclerotic alterations was done by measuring the carotid intima-media thickness (CIMT) on the basis of the high-resolution ultrasonography (B mode) examined in the Radiology Department. All measurements were done with a linear transducer whose frequency range was between 7 and 12 MHz. The ultrasonographic tests were conducted by an expert radiologist who was blinded to the clinical information of the subjects in order to reduce the influence of observer bias. The CIMT was assessed at the distant wall in the common carotid artery about one centimeter above the carotid bulb. Each side was measured three times and the average of the CIMT was determined in millimeters. The values of 0.65 mm and higher were regarded as the sign of early atherosclerotic alterations, which was stipulated by the international standards.

Moreover, along with CIMT and resting heart rate, demographic and clinical factors such as age, gender, body mass index, blood pressure, and short medical and lifestyle history were collected. BMI was calculated by measuring the height and weight using standardized equipment and the blood pressure measured as per the guidelines of the American Heart Association using a calibrated digital sphygmomanometer. All the data obtained were drafted in a structured proforma which was designed to be used in this research.

The SPSS version 26 was used to analyze data. Means and standard deviation of continuous variables were used as descriptive statistics and frequencies of percentages of categorical variables. The independent samples t-test was used to check the similarities in means of CIMTs between the normal and the high resting heart rate groups. Pearson correlation coefficient was used to determine the correlation between CIMT and the resting heart rate. Also, binary

logistic regression analysis was undertaken to establish whether high resting heart rate was an independent predictor of early atherosclerotic changes on controlling potential confounders. All the statistical tests had a p-value of less than 0.05 as the level of significance.

RESULTS

A total of 80 young adults aged between 18-35 years were included in the study with a mean age of 26.1 ± 4.5. The number of participants was 45 (56.3) and 35 (43.7) (3.4:1) males and females, respectively. On categorization by resting heart rate (RHR) 48 people (60 percent)

demonstrated normal RHR (less than 80 bpm), and 32 other people (40 percent) demonstrated high RHR (more than 80 bpm). In the normal RHR group, the proportion of 28 males (58.3) to 20 females (41.7) was found to be statistically similar according to gender ($p = 0.64$) since the elevated RHR group had 17 males (53.1) and 15 females (46.9). Baseline data showed that subjects were similar in age and BMI but those in the high RHR were significantly older and showed both increased systolic and diastolic blood pressure values. More importantly, the average carotid intima-media thickness (CIMT) was significantly more significant in the individuals with increased RHR than in normal RHR. A summary of these results is presented in Table 1.

Table 1. Baseline Characteristics of Study Participants According to Resting Heart Rate (N = 80)

Variable	Total (N=80)	Normal RHR <80 bpm (n=48)	Elevated RHR ≥80 bpm (n=32)	p-value
Age (years)	26.1 ± 4.5	25.7 ± 4.3	26.8 ± 4.8	0.32
Gender				
Male	45 (56.3%)	28 (58.3%)	17 (53.1%)	0.64
Female	35 (43.7%)	20 (41.7%)	15 (46.9%)	
BMI (kg/m ²)	24.8 ± 3.4	24.3 ± 3.2	25.5 ± 3.6	0.11
Systolic BP (mmHg)	118.9 ± 10.8	116.2 ± 10.1	123.2 ± 11.3	0.01*
Diastolic BP (mmHg)	77.8 ± 7.1	75.6 ± 6.4	81.0 ± 7.3	0.004*
Mean CIMT (mm)	0.63 ± 0.11	0.57 ± 0.07	0.72 ± 0.10	<0.001*

*Statistically significant at $p < 0.05$

Table 2. Logistic Regression Analysis for Predicting Early Atherosclerotic Changes

Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Elevated RHR (≥80 bpm)	3.12	1.48–6.55	0.003*
Systolic BP (mmHg)	1.04	1.01–1.07	0.02*
BMI (kg/m ²)	1.08	0.97–1.21	0.15
Age (years)	1.02	0.95–1.09	0.51

Statistically significant at $p < 0.05$

As evidenced by the values in Table 1, the demographic variables did not differ remarkably between the two groups, but the individuals with high RHR experience much higher systolic and diastolic blood pressure as well as a much larger mean CIMT. The difference in CIMT was significantly pronounced ($p < 0.001$), which means that the process of arterial wall thickening appeared earlier in people with high RHR. In order to extend to the connection between heart rate and vascular alterations, the correlation analysis of Pearson was applied, which showed a moderate but significant positive correlation between rest heart rate and CIMT ($r = 0.49$, $p < 0.001$). This correlation indicates that the greater the heart rate is, the greater the thickness of the arteries.

In order to establish whether an increase in resting heart rate was an independent predictor of early atherosclerotic changes, logistic regression analysis was done by using elevated CIMT (0.65 mm or higher) as a dependent variable. The increased RHR was still a strong independent predictor after correcting the possible confounding factors such as age, BMI and systolic blood pressure. The logistic regression analysis revealed that the participants that had a high RHR were at an increased risk of having early atherosclerotic changes by over 3 times

(AOR 3.12, 95% CI: 1.486.55), and the systolic blood pressure was also found to be a significant predictive variable. BMI and age were however not significant predictors. Table 2 shows the results of the regression.

Combined, the results indicate that high resting heart rate is closely linked with high blood pressure as well as premature thickening of carotid arterial walls. The high-risk correlation between RHR and CIMT as well as triple odds of atherosclerotic changes in adults with high levels of RHR demonstrate the clinical significance of resting heart rate as a predictor of vascular risks in young adults. The balance between the two groups in terms of gender further confirms the validity of the relationship as gender cannot be considered as a confounding factor. On the whole, the findings provide a clear evidence that high resting heart rate is an independent and an early indicator of subclinical atherosclerosis in young people who otherwise seem to be clinically well.

DISCUSSION

This study has shown a significant and evident association between increased resting heart rate and premature atherosclerotic alterations in young adults aged 18-35 years.

Though atherosclerosis is conventionally regarded as a disease occurring later in life, the current study presents powerful evidence that subclinical vascular alterations could occur much earlier, and are highly driven by such parameters of physiological condition as resting heart rate [7-10]. The study revealed that participants whose RHR was high exhibited much greater systolic and diastolic blood pressure which is indicative of the sympathetic nervous system to be active and thereby accelerate endothelial injury, oxidative stress and stiffening of the arteries. These physiological activities are likely to explain the increased carotid intima-media of the higher RHR group [11].

The positive relation between RHR and CIMT, which occurs in this study, reinforces the current understanding of the emerging usefulness of heart rate as a cardiovascular risk factor. High RHR is a sign of increased sympathetic activity and decreased vagal tone, both of which result in increased catecholamine levels, elevated myocardial workload, and chronic cardiac-related hemodynamic stress on the arterial walls. The combined effect here is that early atherosclerotic remodelling is encouraged even in healthy individuals [12]. This association is further supported by the logistic regression results that indicated that the high resting heart rate was an independent predictor of early atherosclerotic changes with the risk more than tripled after the higher ages, BMI, and systolic blood pressure. This autonomy emphasizes the role of monitoring heart rate to the extent of non-conventional risk determiners, especially in primary cardiovascular testing [13].

In line with other research studies performed in an older population, the study has been able to extrapolate the usefulness of the resting heart rate to younger groups of people in which early changes in the vessels can start silently in adulthood. The fact that there are no substantial differences between BMI and age of the normal and high RHR groups indicates that the relationship between RHR and CIMT is not merely an expression of anthropometric differences but a substantive physiological correlation. The rather equal gender representation in both groups eliminates gender as a confounding factor and therefore enhances validity of the results [14,15].

The implications of these results on the general population are immense. The young adults also fail to request cardiovascular assessment unless they are symptomatic, although increased resting heart rate, which is a cheap and readily available clinical finding, can be an early indicator of subclinical atherosclerosis [12,13]. Early detection of those with high RHR gives a chance to implement timely lifestyle changes which include physical exercises, stress, eating habits and body mass index. Given the continuing growth in the prevalence of cardiovascular disease in low- and middle-income economies like those in Pakistan, the inclusion of resting heart rate within standard screening schemes could provide a viable approach in the

reduction of the long-term risk of cardiovascular disease [16].

Irrespective of the power of findings, the study has a few flaws. The cross-sectional structure makes it impossible to draw conclusions about causality and longitudinal studies would be needed to find out whether high RHR is a good predictor of clinically significant cardiovascular events in the long run [17]. Moreover, whereas carotid intima-media thickness is a validated surrogate endpoint of early atherosclerosis, flow-mediated dilation and arterial stiffness indices as well as inflammatory biomarkers were not evaluated. However, the research gives strong preliminary data to confirm the position of increased heart rate as an early sign of changes in the vasculature in young adults [18].

CONCLUSION

The research proves that high resting heart rate has strong correlations with early atherosclerotic alterations in young adults, based on the high carotid intima-media thickness. Persons with increased RHR exhibited greater blood pressure and increased vascular wall thickening and even after confounding variables were controlled the index of RHR continued to remain a predictor of early atherosclerosis. These results identify resting heart rate as a cheap, simple and clinically useful early-screening indicator of identifying youth at high-cardiovascular-risk. Regular measurement of heart rate during prevention health examination and promotion of lifestyle change to those already affected could help decrease the burden of cardiovascular disease in the future. It is also suggested that longitudinal studies should be conducted in order to investigate the effect of high resting heart rate on cardiovascular outcomes in the long-term.

Conflict of Interest: The authors report no conflicts of interest.

Funding: No external funding was received for this study.

Acknowledgments: We gratefully acknowledge our colleagues and all study participants for their valuable contribution.

Authors' contributions: All authors contributed equally, all read and approved the final version of the manuscript.

Data Availability Statement: The data used in this study are available upon reasonable request from the corresponding author, subject to ethical and institutional guidelines.

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This Article May be cited As: Mumtaz A.H, Rahman A, Javed AR. Association between elevated resting heart rate and early atherosclerotic changes in young adults: Resting heart rate and early atherosclerosis. *Dev Med Life Sci.* 2024;1(10). doi:10.69750/dmls.01.010.039

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