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Research Article

Role of Exercise Stress Testing in Asymptomatic Patients with Coronary Risk Factors in a Tertiary Care Hospital

Monisha, S.[1], Anugraha Durairaj[2*] and Kushal R. Gowda[3]

[1]Assistant Professor, Department of General Medicine, Rajarajeshwari Medical College and Hospital, Bengaluru, Karnataka, India

[2]Associate Professor, Department of General Medicine, BGS MCH Bengaluru, Karnataka, India

[3]Senior Resident, Department of General Medicine, Rajarajeshwari Medical College and Hospital, Bengaluru, Karnataka, India

***Corresponding Author**
Dr. Anugraha Durairaj

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Abstract: Background: Cardiovascular Diseases (CVDs) are a major global health burden, with Ischemic Heart Disease (IHD) being the most prevalent form. The Treadmill Test (TMT) is a widely used non-invasive tool for detecting exercise-induced ischemia and assessing cardiovascular risk. This study evaluated the risk factors, symptoms and demographic distribution of positive TMT results. **Objectives:** (1) To estimate the risk factors associated with a positive TMT. (2) To assess the age and sex distribution of positive TMT cases. **Methods:** A hospital-based cross-sectional study was conducted over 18 months at Rajarajeshwari Medical College and Hospital, Bengaluru and included 100 adults aged 18-70 years at increased risk of IHD. Demographic variables, medical history and laboratory investigations were recorded and all participants underwent TMT to assess ischemia. Data were analyzed using SPSS version 23 and the Chi-square test. **Results:** Most participants were aged 51-60 years (32%), followed by 41-50 years (30%) and 65% were male. The prevalence of risk factors was: diabetes 98%, hypertension 94%, sedentary lifestyle 77%, smoking 74%, obesity 67%, dyslipidemia 65% and family history of cardiovascular disease 19%. The TMT was positive in 38% of participants (95% CI 29.1-47.8). Obesity was the only factor significantly associated with a positive TMT (46.3% Vs 21.2%; P = 0.015; crude odds ratio 3.2, 95% CI 1.2-8.4). Age, sex, diabetes, hypertension, smoking, sedentary lifestyle, family history and symptom category were not significantly associated with the result (all p>0.05). **Conclusion:** More than one-third of adults with coronary risk factors had a positive TMT and obesity was a significant factor significantly associated with a positive result. Comprehensive risk-factor management, particularly weight reduction and further evaluation of high-risk individuals with obesity or exertional symptoms are warranted. The study also emphasizes the need for early screening, lifestyle interventions and targeted management for reducing the burden of IHD. TMT remains a valuable, cost effective non invasive tool for risk stratification and prognosis, however Larger multicenter studies with angiographic correlation are needed.

Keywords: Ischemic Heart Disease, Treadmill Test, Risk Factors, Cardiovascular Disease, Diabetes, Hypertension, Obesity, Coronary Artery Disease

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INTRODUCTION

Cardiovascular Diseases (CVDs) are a leading cause of mortality and disability worldwide and Ischemic Heart Disease (IHD) is their most prevalent form [1]. The World Health Organization estimates that CVDs cause 17.9 million deaths each year, more than one-third of all deaths globally [2]. Low- and middle-income countries bear the greatest share of this burden, probably due to rapid urbanisation and globalisation, which have shifted the pattern from infectious diseases to non-communicable diseases as the main cause of death and disability; in India, CVDs account for a large proportion of the chronic disease burden and tend to present at younger ages than in many other regions [3-5].

India, as one of the most populous countries, accounted for 1.52 million deaths due to IHD in 2019, second only to China (1.87 million deaths). Despite improvements in high-SDI regions, India's IHD burden underscores the need for focused prevention and management strategies to address the persistent disease burden [6].

Ageing is an important contributory factor to CVD. The United Nations estimates that the population aged over 65 years will increase from 1 in 11 in 2019 to 1 in 6 by 2050 [7]. Emerging issues with social relationships, psychological distress and less than six hours of sleep a night also contribute to IHD in the current generation [8,9].

Among cardiovascular illnesses, IHD ranks as the most prevalent, [10] manifesting clinically as myocardial infarction and ischemic cardiomyopathy. More than 70% of individuals have multiple risk factors for IHD and only 2%-7% of the general population have no risk factors [11]. In addition, the costs of hospital stay and treatment contribute to disability and early mortality [2,12].

The American Heart Association [13] cites that at least 68% of people aged 65 or older with diabetes die from some form of heart disease and 16% die of stroke. Adults with diabetes are two to four times more likely to die from heart disease than adults without diabetes. Kannel *et al.* [14] were among the first to demonstrate the higher risk of CVD in women with diabetes compared with men with diabetes, using data from the Framingham Heart Study [14].

In 2021, high systolic blood pressure remained the leading risk factor, responsible for 10.8 million cardiovascular deaths and 209 million Disability-Adjusted Life Years (DALYs) [15].

Dietary risks, including excessive sodium intake and low consumption of fruits, vegetables and whole grains, accounted for 6.58 million cardiovascular deaths and 142 million DALYs. Public health initiatives, such as sodium reduction and promotion of Mediterranean diets, have been effective but remain limited in reach [15].

High Low-Density Lipoprotein Cholesterol (LDL-C) led to 3.81 million deaths and 86.3 million DALYs, highlighting the importance of lipid-lowering therapies such as statins and innovative approaches such as PCSK9 inhibitors. Air pollution, encompassing ambient particulate matter and household pollution from solid fuels, caused 4.75 million cardiovascular deaths and 62.5 million DALYs. Global initiatives targeting clean energy and air quality improvements are critical to mitigate this risk. Tobacco use contributed to 3.01 million cardiovascular deaths and 59.6 million DALYs, with strategies such as taxation, advertising bans and cessation programs showing measurable reductions in smoking prevalence. These factors underscore the urgent need for scalable and cost-effective interventions to address the global burden of cardiovascular diseases [15]. Atherosclerosis, an inflammatory arterial disease characterized by lipid deposition, is the principal pathological process underlying IHD [16]. Its development is driven by non-modifiable factors (age, sex, family history) and by modifiable factors, including hypertension, diabetes mellitus, dyslipidemia, smoking, obesity and physical inactivity [17]. The incidence of IHD is expected to keep rising with the growing prevalence of obesity, diabetes and metabolic syndrome and with population ageing [15]. Understanding these risk factors is essential for early diagnosis and management; however, their presence alone does not confirm Coronary Artery Disease (CAD), which calls for reliable methods to assess the functional and ischemic burden.

Exercise stress electrocardiography, commonly performed as the Treadmill Test (TMT), records the 12-lead Electrocardiogram (ECG), heart rate, blood pressure and symptoms during graded exercise. It can detect exercise-induced ischemia, stratify risk and inform prognosis. Current ACC/AHA guidance recommends exercise ECG as the initial diagnostic test in patients at intermediate pre-test probability of CAD who can exercise and have an interpretable resting ECG [18,19] and the 2019 European Society of Cardiology guidelines on chronic coronary syndromes likewise base test selection on pre-test probability [20]. Despite these recommendations, imaging-based stress testing is often used as the first-line strategy. The TMT has an average sensitivity of about 68% and specificity of about 77%, which vary with pre-test probability and it remains the least costly provocative non-invasive test [21].

The role of TMT in people with coronary risk factors who have few or no symptoms is debated. In asymptomatic individuals with a low pre-test probability, false-positive results are common and routine screening is not advised, [21] whereas in the Framingham Offspring cohort, exercise-test variables added prognostic information to risk scores in asymptomatic men [22]. Indian data on the risk factors and symptoms that accompany a positive TMT remain limited [23,24]. The present study therefore evaluated the risk factors, presenting symptoms and age and sex distribution associated with a positive TMT in adults with coronary risk factors.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based, cross-sectional study conducted over 18 months in the Departments of General Medicine and Cardiology, Rajarajeshwari Medical College and Hospital, Bengaluru, India.

Ethical Approval and Informed Consent

The study was approved by the Institutional Ethics Committee before commencement. Written informed consent was obtained from all participants before enrolment and participant confidentiality was maintained.

Study Population

A total of 100 adults aged 18-70 years with an increased risk of developing IHD were enrolled. The risk factors of interest were hypertension, diabetes mellitus, smoking, hyperlipidemia, obesity and sedentary lifestyle. All 100 participants underwent TMT and all were included in the analysis.

Sample Size

The sample size was estimated for a cross-sectional prevalence study using the formula:

$$n = Z^2 * p(1-p)/d^2$$

where:

- Z is the standard normal deviate for the chosen confidence level (1.96 for 95%)
- p is the expected proportion of participants with a positive TMT
- d is the absolute precision

Taking p = 0.34 from a previous study of TMT positivity in patients with diabetes [24], a 95% confidence level and an absolute precision of 10% (d = 0.10), n = $(1.96)^2 \times 0.34 \times 0.66/(0.10)^2$ = 86.2, i.e., 87 participants. Allowing for approximately 15% of tests being incomplete or inconclusive (87×1.15 ≈ 100), a sample of 100 participants was enrolled.

Inclusion Criteria

Participants aged 18-70 years, willing to provide informed consent and judged to be at increased risk of developing IHD on the basis of the risk factors of interest listed above.

Exclusion Criteria:

- Recent complicated myocardial infarction
- Unstable angina
- Uncontrolled ventricular or atrial arrhythmia
- Third-degree atrioventricular block without a pacemaker
- Acute congestive cardiac failure
- Severe aortic stenosis
- Suspected aortic aneurysm
- Active or suspected myocarditis
- Endocarditis or pericarditis
- Intracardiac tumors
- Recent pulmonary or systemic embolization
- Osteoarthritis or severe joint disorders
- Chronic liver disease or chronic kidney disease
- Recent stroke (ischemic or hemorrhagic)

Exercise Stress Testing

A 12-lead ECG was recorded before, during and after exercise on a treadmill using the Bruce protocol, with trained personnel monitoring heart rate, blood pressure, ECG and symptoms throughout [25,26].

The test was stopped immediately if significant ST-segment elevation (>1 mm) was seen in leads without pre-existing Q waves from a prior myocardial infarction, or if severe symptoms such as angina, ataxia, dizziness, or near-syncope developed. It was also stopped if systolic blood pressure dropped by >10 mm Hg from baseline when accompanied by other evidence of ischemia (e.g., chest pain or ST depression) and it was terminated if dangerous arrhythmias were evident.

The endpoint was achievement of the target heart rate, calculated as 85% of the maximum predicted heart rate (MPHR), where MPHR = 220-age.

The TMT was considered positive if there was >1 mm ST depression below baseline, slow upsloping ST depression, or ST elevation on exertion. It was considered negative if the participant completed the protocol and achieved the target heart rate without symptoms or ECG changes of ischemia and inconclusive if the test could not be completed for any of the reasons mentioned above.

Study Assessments

After consent, each participant underwent a detailed medical history, general examination (pulse, blood pressure, respiratory rate, temperature), systemic examination (cardiovascular, abdominal, central nervous and respiratory systems) and relevant laboratory investigations, including fasting and postprandial blood glucose and glycated hemoglobin (HbA1c). Demographic data, Body Mass Index (BMI), presenting symptoms (effort angina, atypical chest pain, dyspnea on exertion, other symptoms, or asymptomatic) and the presence of diabetes, hypertension, smoking, obesity (BMI >30 kg/m^2), sedentary lifestyle (6 or more hours of daily sitting or reclining, or low energy expenditure of about 1.5 metabolic equivalents or less), dyslipidemia (total cholesterol >240 mg/dL, LDL >160 mg/dL, HDL <40 mg/dL for men and <50 mg/dL for women, or triglycerides >200 mg/dL) and family history of cardiovascular disease were recorded on a structured proforma. The total number of risk factors per participant was tallied.

Statistical Analysis

Data were analyzed using SPSS version 23 and MS Excel. Categorical variables are presented as frequencies and percentages and continuous variables as mean ± Standard Deviation (SD). The association between each categorical variable and the TMT result (positive or negative) was assessed using the Chi-square test. Exact P values are reported and a p value <0.05 was considered statistically significant. Ninety-five percent Confidence Intervals (CIs) for proportions were calculated using the Wilson score method and the crude Odds Ratio (OR) with its 95% CI was calculated from the 2×2 table using the logit (Woolf) method.

RESULTS

Baseline Characteristics

Participants were predominantly aged 51-60 years (32%), followed by 41-50 years (30%), as depicted in Table 1. Of the 100 participants, 65% were male and 35% were female. The mean BMI was 27.98±4.20 kg/m^2. Mean glycemic parameters were fasting blood glucose 145.08±50.04 mg/dL, postprandial blood glucose 230.34±76.03 mg/dL and HbA1c 7.84±2.02%. Mean systolic and diastolic blood pressures were 134.16±18.88 mmHg and 83.72±9.45 mmHg, respectively (Table 1).

Table 1: Baseline Characteristics of Participants (n = 100)

Characteristic	Category/parameter	n (%) or mean ± SD
Age group (years)	21-30	2 (2.0)
	31-40	27 (27.0)
	41-50	30 (30.0)
	51-60	32 (32.0)
	>60	9 (9.0)
Sex	Male	65 (65.0)
	Female	35 (35.0)
Clinical and laboratory parameters	BMI (kg/m^2)	27.98±4.20
	FBS (mg/dL)	145.08±50.04
	PPBS (mg/dL)	230.34±76.03
	HbA1c (%)	7.84±2.02
	Systolic BP (mmHg)	134.16±18.88
	Diastolic BP (mmHg)	83.72±9.45

BMI: Body Mass Index, FBS: Fasting Blood Sugar, PPBS: Postprandial Blood Sugar, HbA1c: Glycated Hemoglobin, BP: Blood Pressure, SD: Standard Deviation. Values are n (%) for categorical variables and mean ± SD for continuous variables

Table 2: Prevalence of Coronary Risk Factors and Presenting Symptoms (n = 100)

Variable	Category	n (%)
Coronary risk factors	Diabetes mellitus	98 (98.0)
	Hypertension	94 (94.0)
	Diabetes and hypertension	93 (93.0)
	Sedentary lifestyle	77 (77.0)
	Smoking	74 (74.0)
	Obesity	67 (67.0)
	Dyslipidemia	65 (65.0)
	Family history of CVD	19 (19.0)
Number of risk factors per participant	2	3 (3.0)
	3	26 (26.0)
	4	34 (34.0)
	5	32 (32.0)
	6	5 (5.0)

CVD: Cardiovascular Disease

Table 3: Association of Demographic Factors, Risk Factors and Symptoms with TMT Result (n = 100)

Variable	Category	TMT positive, n (%)	TMT negative, n (%)	p value
Age group (years)	21-30	0 (0.0)	2 (100.0)	0.438
	31-40	10 (37.0)	17 (63.0)	
	41-50	15 (50.0)	15 (50.0)	
	51-60	10 (31.3)	22 (68.8)	
	>60	3 (33.3)	6 (66.7)	
Sex	Female	17 (48.6)	18 (51.4)	0.110
	Male	21 (32.3)	44 (67.7)	
Diabetes mellitus	Yes	37 (37.8)	61 (62.2)	0.724
	No	1 (50.0)	1 (50.0)	
Hypertension	Yes	35 (37.2)	59 (62.8)	0.532
	No	3 (50.0)	3 (50.0)	
Diabetes and hypertension	Yes	35 (37.6)	58 (62.4)	0.784
	No	3 (42.9)	4 (57.1)	
Smoking	Yes	31 (41.9)	43 (58.1)	0.176
	No	7 (26.9)	19 (73.1)	
Obesity	Yes	31 (46.3)	36 (53.7)	0.015*
	No	7 (21.2)	26 (78.8)	
Sedentary lifestyle	Yes	33 (42.9)	44 (57.1)	0.067
	No	5 (21.7)	18 (78.3)	
Family history of CVD	Yes	9 (47.4)	10 (52.6)	0.350
	No	29 (35.8)	52 (64.2)	

TMT: Treadmill Test, CVD: Cardiovascular Disease. Percentages are row percentages (% of each category). P values by Chi-square test. *Statistically significant ($p<0.05$)

Prevalence of Risk Factors and Symptoms

Diabetes mellitus (98%), hypertension (94%) and their coexistence (93%) were nearly universal. Sedentary lifestyle (77%), smoking (74%), obesity (67%) and dyslipidemia (65%) were also common, whereas a family history of cardiovascular disease was reported by 19%. Most participants had three (26%), four (34%), or five (32%) risk factors; 3% had two and 5% had six risk factors (Table 2).

Subject Disposition

Among the 100 enrolled participants who underwent TMT and were analyzed, the TMT was positive in 38 (38%; 95% CI 29.1-47.8%) and negative in 62 (62%); none was inconclusive.

Association of Demographic and Risk Factors with TMT Result

Positive TMT results were most frequent in the 41-50-year group (15 of 30; 50%) and least frequent in the 21-30-year group (0 of 2; 0%), but the association with age was not significant (p = 0.438). Positivity was numerically higher in females (48.6%) than in males (32.3%; p = 0.110). Diabetes (p = 0.724), hypertension (p = 0.532), coexisting diabetes and hypertension (p = 0.784), smoking (p = 0.176) and family history (p = 0.350) were not significantly associated with a positive TMT.

Obesity was significantly associated with a positive TMT: 46.3% of obese participants (31 of 67) had a positive test compared with 21.2% of non-obese participants (7 of 33; p = 0.015), a crude odds ratio of 3.2 (95% CI 1.2-8.4). Sedentary participants also had higher positivity (42.9% Vs 21.7%), but this did not reach significance (p = 0.067) (Table 3).

DISCUSSION

In this cross-sectional study of 100 adults with coronary risk factors, nearly two in five (38%) had a positive TMT. Participants carried a heavy burden of modifiable risk factors, namely diabetes (98%), hypertension (94%), sedentary lifestyle (77%), smoking (74%) and obesity (67%) and 71% had four or more concurrent risk factors.

The cohort was predominantly middle-aged (41-60 years, 62%) and male (65%). Acharya *et al*. [23], studying 50 patients with coronary risk factors in Ahmedabad, reported the highest proportion of positive tests at 41-50 years and a higher positivity in men (71.4%) than in women (33.3%). In our sample, positivity was highest at 41-50 years (50.0%) but was numerically higher in women (48.6% Vs 32.3%), with no significant difference by age or sex. Gupta *et al*. [24] studied 150 patients with diabetes who were older (most aged 60-74 years) and predominantly female and reported an overall TMT positivity of 34%, comparable to the 38% observed here.

However, without angiographic or imaging confirmation, true and false positives cannot be distinguished here. In asymptomatic people with a low pre-test probability, false positives cause anxiety and costly, potentially invasive follow-up and routine TMT is not advised [21]. A cross-sectional study from Northeast Brazil found that 78% of TMT referrals were inappropriate, mostly in patients with low pre-test probability [27]. Our participants, by contrast, had a high burden of risk factors and therefore a higher pre-test probability. In such patients, exercise capacity, heart-rate recovery and failure to achieve the target heart rate add information beyond ST-segment depression [22,28]. The Duke treadmill score, which combines ST deviation, angina and exercise duration, has been validated for diagnosis and prognosis in symptomatic patients [29]. Importantly, imaging offers greater diagnostic and prognostic value than exercise ECG in higher-risk groups such as those with diabetes or poor functional capacity [28]. Because 98% of our participants had diabetes and because the sensitivity of exercise ECG is imperfect, [21,30] a negative TMT in this population should not be taken as excluding CAD.

Obesity was the single factor significantly associated with a positive TMT (46.3% Vs 21.2%; p = 0.015; crude odds ratio 3.2,95% CI 1.2-8.4). Acharya *et al*. [23] likewise reported a high proportion of positive tests among obese participants. Obesity may also influence exercise performance and the choice of treadmill protocol [31]. Our data cannot establish whether obesity acts independently or as a marker of clustered metabolic risk, because no multivariable analysis was performed.

The absence of association with diabetes, hypertension, smoking and sedentary lifestyle contrasts with earlier reports. Acharya *et al*. [23] noted high proportions of positive tests among hypertensive, diabetic-hypertensive and smoking participants and Gupta *et al*. [24] linked a positive test to hypertension, longer duration of hypertension, smoking, alcohol use and raised cholesterol. Several explanations are plausible. Near-universal exposure to diabetes (98%) and hypertension (94%) left almost no comparison group (only 2 and 6 participants without these conditions, respectively); the sample was small; and the duration and control of risk factors, which may matter more than their presence alone, were not analyzed. Sedentary lifestyle showed a numerical trend (42.9% Vs 21.7%; p = 0.067) that merits evaluation in a larger sample. Diabetes is an established independent risk factor for CAD [23] and consensus statements recommend exercise testing in selected symptomatic and asymptomatic people with diabetes who meet specific criteria, including sedentary individuals planning more strenuous exercise [32,33].

Limitations

This study has limitations. The sample was small and drawn from a single center, limiting external validity. The cross-sectional design precluded follow-up of long-term cardiovascular outcomes in participants with positive tests. Selection of participants on the basis of high risk, with a very high prevalence of diabetes and hypertension, introduces selection

bias. TMT results were not corroborated with coronary angiography or other imaging. Several comparison cells were small, making Chi-square estimates unstable and no multivariable analysis was performed.

CONCLUSION

In adults with coronary risk factors, more than one-third had a positive TMT and obesity was significantly associated with a positive result, whereas age, sex, diabetes, hypertension, smoking, sedentary lifestyle, family history and symptom category were not. These findings underscore the importance of comprehensive risk-factor management, particularly weight reduction and of further diagnostic evaluation in high-risk individuals with obesity or exertional symptoms. Early screening, risk factor prevention and targeted management for IHD are definitely warranted. Larger, multicenter studies with angiographic correlation and follow-up are needed.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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