World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Gender differences, temporal profile and outcomes of patients presenting for stress electrocardiography in southern Nigeria

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World Journal of Advanced Research and Reviews, 2024, 22(01), 1005–1013

Publication history: Received on 05 March 2024; revised on 11 April 2024; accepted on 13 April 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.22.1.0941

Abstract

Background: Exercise stress testing (EST) is a safe and cost-effective screening test for coronary artery disease (CAD) that does not require invasive procedures. Careful patient selection is essential for accurate results, but not recommended for women in their reproductive years due to a higher rate of false positives. This study aims to determine the gender difference and temporal profile of patients presenting for EST in southern Nigeria.

Method: This was a retrospective study of 102 subjects at GoodHeart Medical Consultant Hospital from October 2019 to January 2023 focused on adult patients with low or intermediate pretest symptoms referred for EST. Data on medication, smoking, alcohol, and presenting symptoms was collected.

Results: 102 subjects were studied (mean 49±16 years, 72.5% males). Most subjects (57.8%) were aged 41-60. The average duration of the EST was 9 minutes. Chest pain was the main reason for referral, and muscle fatigue was the most common reason for stopping the EST. The highest stage recorded was stage 3 (37.3%), and the lowest was stage 5 (3.9%). Over half of the subjects had a normal result, while 6.9% had ST changes and 3.9% had T wave inversion. Stress-induced ischemia was found in 7.8% and stress-induced arrhythmia in 3.9% of subjects, the study recorded a high prevalence among the males with no significant gender difference.

Conclusions: Stress ECG testing had no injuries or deaths, with over half having normal results. Ischemia and arrhythmia were rare, and muscle fatigue was the main reason for stopping.

Keywords: Stress Electrocardiography; Gender difference; Referral; GoodHeart Medical Consultant Hospital

1. Introduction

Exercise stress testing (EST) is a widely used and cost-effective noninvasive tool for evaluating suspected coronary disease and providing important cardiopulmonary information.(1) It is commonly used to assess the effects of medication and prescribe exercise for conditions such as cardiac rehabilitation, obesity, diabetes, and neuropathies. EST is typically performed on a treadmill or cycle ergometer while monitoring various factors including electrocardiography (ECG), ventilatory threshold, blood pressure, heart rate, oxygen consumption, and physical symptoms like chest pain and dyspnea (2). However, it is important to follow safe and appropriate guidelines due to the risks associated with testing in individuals with or suspected of having coronary artery disease (CAD). (3) ST-segment changes on the ECG during the treadmill test often indicate the presence of CAD and require further management (4). The American College

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of Cardiology (ACC) and American Heart Association (AHA) all recommend EST for diagnosing patients at risk of cardiovascular disease (CAD). EST can be conducted on patients who are able to exercise, regardless of age or sex.(5)

The exercise electrocardiogram (ECG) is believed to be less accurate in women compared to men due to a high prevalence of false-positive tests.(6) Controversy exists regarding gender differences in patients being evaluated for coronary artery disease (CAD), with limited resources reported.(7) The previous literature on exercise electrocardiography mainly focused on men, and there is a lack of similar studies in women. In men, treadmill test performance has a significant impact on survival, even after considering cardiac catheterization variables. However, in women, no exercise test variable independently affects survival. Exercise ST-depression and final exercise stage can be used to assess the survival of men and women separately. The 16-year survival rates based on exercise test risk classification vary between men and women with a range of 38% to 61% in men and 44% to 79% in women.(8)

The incidence of positive responses in normal women without high risk for coronary atherosclerosis is high. Abnormal exercise electrocardiograms have been found in a significant percentage of healthy women, especially in the age range of 20 to 29 and 40 to 70. (9) False positive responses, as determined by coronary arteriography, are more common in 10 of 15 women with chest pain compared to 10% of 62 men. (10) However, another study found no sex difference in sensitivity or specificity in patients evaluated for chest pain. It is suggested that the higher incidence of false positive responses in women (11) may be due to lower levels of circulating hemoglobin, resulting in a decrease in oxygen carrying capacity, (12) which can lead to women experiencing greater increase in systemic and pulmonary pressure during exercise compared to men. (13) False positive ST changes, which are more common among women, can be caused by a syndrome known as "vasoregulatory asthenia." This syndrome is typically seen in young women who often experience chest pain resembling ischemic cardiac pain. Resting ECGs of these patients often show minor ST and T abnormalities. (14) Premenopausal women may experience false-positive tests due to the digoxin-like effect of endogenous estrogen, especially during the mid-cycle when estrogen levels are highest. The accuracy of the exercise electrocardiogram in women varies greatly and is influenced by multiple factors, including exercise capacity and hormonal status. (15)The guidelines from the American College of Cardiology/American Heart Association (ACC/AHA) (16)recommend exercise testing as a first-line test for those with a normal resting 12-lead ECG and the ability to perform maximal stress.

Although, early studies evaluating stress testing as a diagnostic tool were performed in almost exclusively male cohorts.(17,18)Until recently, the representation of women in published studies was too small to determine any gender differences in test accuracy. The underrepresentation of women, as well as the bias in selection of women when included, may be the reason for the misconceptions regarding the value of exercise stress testing in women. Nonetheless, research on exercise stress testing in women has increased in the past decade, improving our understanding of the diagnostic and prognostic value of this modality in women.(19) To the best of our knowledge, gender difference among subjects presenting for exercise electrocardiography is limited in developing country and Nigeria is not excluded from such. Hence our study aims to determine the gender difference, temporal profile and outcomes of patients presenting for EST in southern Nigeria.

2. Materials and method

We conducted a clinical examination of patients referred for exercise stress testing (EST) to GoodHeart Medical consultant hospital between October 2019 and January 2023. It was a retrospective cross-sectional study of adult patients aged (≥18 years old) and had low or intermediate pretest symptoms. Patients who were unable to conduct an exercise test or were referred for other reasons were excluded from the study. Data were collected on medication history, smoking and alcohol habits and presenting symptoms.

Hypertension was defined as systolic blood pressure > 140 mmHg, and/or diastolic blood pressure > 90 mmHg, and/or currently under antihypertensive drug treatment.(20) Body mass index (BMI) was calculated as the weight(kg) divided by height squared (m^2)(21)

The procedure was carried out according to the American Heart Association (AHA) recommendation and guidelines(22)

Data obtained was analyzed using the Statistical Package for social science (SPSS) version 20 software. Gender differences between the two groups were assessed using a chi-squared test. P value of <0.05 was considered as significant. t-test was used to calculate age differences between male and female participants.

3. Results

The population consist of 102 subjects with an average age of 49±16 years ranging from 18 to 69 years with the majority 59(57.8%) falling in the age group of 41-60 years. This is made up of 74(72.5%) males and 28(27.5%) females. The average duration for EST was 9minutes.

The study participant's baseline characteristics indicate that a small percentage of them were smokers or alcohol consumers 2.9% and 7.8% respectively and men were predominant as compared to women. Table1

In Table 2, the findings show that out of the subjects, 56(54.9%) are hypertensive, 2(1.9%) are pre-hypertensive, and 44(43.1%) have normal blood pressure. There is no significant difference between blood pressure range and gender. Additionally, 37(36.3%) of the subjects are overweight and 34(33.3%) fall under the obese class 1 category. There is a significant difference between BMI and gender, with a p-value of 0.054.

The study found that the primary reason patients visited the facility was chest pain, which was most prevalent among male subjects at 28.4%. This was followed by medical fitness at 21.6%. The majority of participants had a history of drug medication, with 74.5% reporting this. Drug medication was more common among male subjects, with a high prevalence among those on antihypertensive medication at 33.3%, while the least were on peptic ulcer disease medication at 1.9%. These findings are illustrated in Figure 1 and Figure 2.

Table 1 Baseline characteristic of study participant

Variables	Frequency (n=102)	Male	Females	P value
Gender	102(100)	74(72.5)	28(27.5)	
Age group				
<40	20(19.6)	13(12.7)	7(6.7)	
41-60	71(69.6)	52(50.9)	19(18.6)	
>60	11(10.8)	9(8.8)	2(1.9)	
Average age	49±16	49.47±9.89	48.71±25.94	0.83
History				
Smokers				
Yes	5(4.9)	5(4.9)	0(0)	
No	97(95.1)	28(27.5)	69(67.6)	
Alcohol				
Yes	8(7.8)	6(5.9)	2(1.9)	
No	94(92.2)	68(66.7)	26(25.5)	
Average duration time	9.0 minutes			

In the study, it was found that muscle fatigue was the main reason for interrupting EST, accounting for 28.4% of cases. This was followed by maximum heart rate, which accounted for 18.6% of cases among males. Among females, breathlessness was the most common reason for interrupting the EST, accounting for 7.8% of cases. Some patients experienced multiple symptoms, with muscle fatigue and maximum heart rate being the most common combination. The least common combination was breathlessness and chest pain. These findings have been presented in Table 3.

The maximum stage for EST was recorded in stage 3 53(52.0%) and least stage recorded were stage 5 4(3.9%). This finding was predominant among the male subject. Figure 3

ST elevation or depression and T wave inversion were more predominant among the males, more than half of the study population had normal study and a total of 9(8.7%) had ST changes while 7(6.9%) had T wave inversion, with no significant difference between the gender. Table 4

The clinical interpretation for EST findings show that 10(9.8%) had stress induced ischemia and 7(6.9%) had stress induced Arrhythmia. Table 5

Table 2 BP and BMI ranges of the study participant

Variables	Male	Female	Total	P value
BP range				0.649
Normal	31(30.4)	13(12.7)	44(43.1)	
Pre-hypertensive	2(1.9)	0(0)	2(1.9)	
Hypertensive	41(40.2)	15(14.7)	56(54.9)	
BMI range				0.054*
Normal	13(12.7)	6(5.9)	19(18.6)	
Underweight	0(0)	0(0)	0(0)	
Overweight	31(30.4)	6(5.9)	37(36.3)	
Obese C1	25(24.5)	9(8.8)	34(33.3)	
Obese C2	4(3.9)	5(4.9)	9(8.8)	
Obese C3	1(0.9)	2(1.9)	3(2.9)	

BMI=Body mass index, BP=blood pressure. P* 0.05 shows significant value. There is a significant difference between gender and BMI range of the study participant

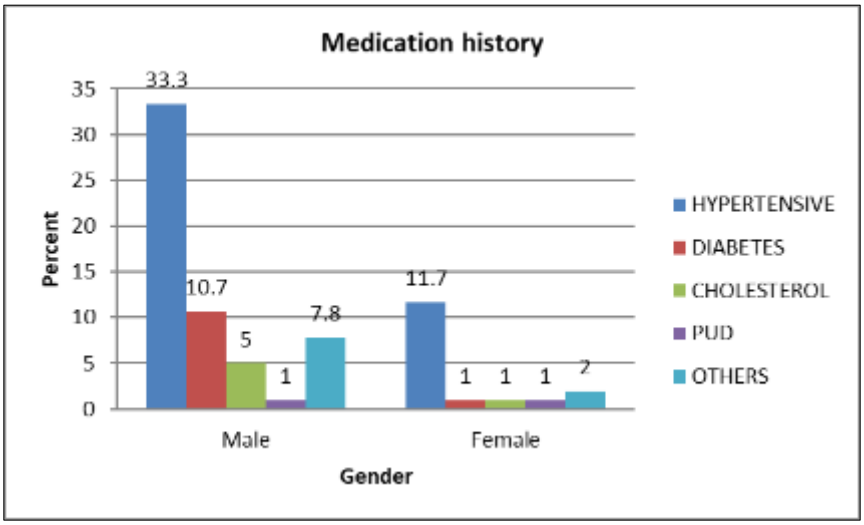

Figure 1 Medication history among gender

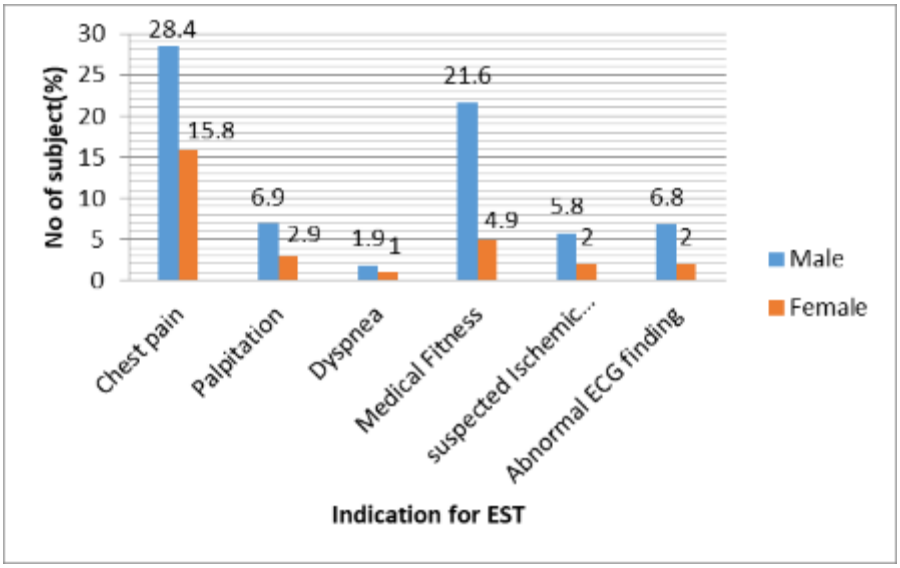

Figure 2 Symptoms at presentation for EST among gender

Table 3 Patients reason for interrupting the EST

Reason For Stopping	Total	Male	Female
Muscle fatigue	40(39.2)	29(28.4)	11(10.8)
Maximum HR age	21(24.5)	19(18.6)	2(1.9)
Breathlessness	11(10.8)	2(1.9)	8(7.8)
Chest pain	5(4.9)	2(1.9)	1(0.9)
Tachycardia	2(1.9)	2(1.9)	0(0)
Blood pressure spike	3(2.9)	2(1.9)	1(0.9)
Significant ST / T wave	4(3.9)	3(2.9)	1(0.9)
Muscle fatigue + maximum HR age	7(6.9)	4(3.9)	2(1.9)
Muscle fatigue+ chest pain	4(3.9)	3(2.9)	1(0.9)
Muscle fatigue +breathlessness	2(1.9)	1(0.9)	1(0.9)
Breathlessness + maximum HR age	2(1.9)	2(1.9)	0(0)
Breathlessness + chest pain	1(1.0)	1(1.0)	0(0)

HR= heart rate

Table 4 Prevalence of ST_T changes among subjects

ST/T Evaluation	Total	Male	Female	P value
T wave inversion and ST depression	7(6.9)	4(3.9)	3(2.9)	0.344
ST elevation	9(8.8)	7(6.9)	2(1.9)	0.766

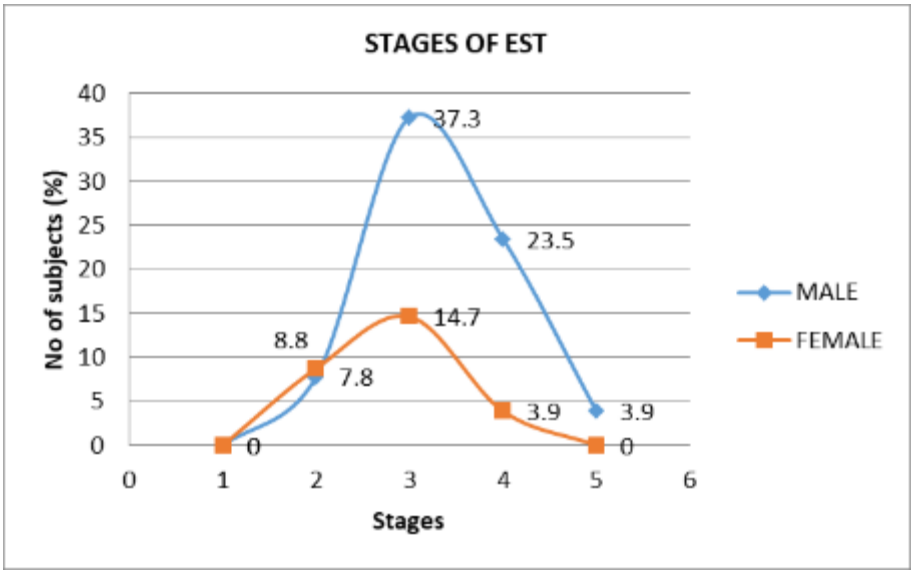

Figure 3 Stages of EST attained among the genders

Table 5 Pattern of Stress induced changes among subjects

Stress induce	Total	Male	Female	P value
Ischemia	10(9.8)	8(7.8)	2(1.9)	0.578
Arrhythmia	8(7.8)	4(3.9)	4(3.9)	0.137
Hypertension	1(1.0)	0(0)	1(1.0)	0.105
Ectopics	1(1.0)	0(0)	1(1.0)	0.102
Tachycardia	1(1.0)	1(1.0)	0(0)	0.536

4. Discussion

This is a retrospective cross-sectional study conducted at GoodHeart medical consultants hospital involving 102 subjects referred between October 2019 and January 2023. The average age of the referred patients was 49±16 years, with a higher proportion of males. Most of the subjects were aged between 41 and 60 years, and the rates of smoking and alcohol intake were low. The average duration for exercise stress testing (EST) was 9 minutes. However, the small sample size may limit the statistical power to detect differences. Additionally, patients may not accurately describe their symptoms, making it challenging to diagnose non-cardiac symptoms and cardiac-related cases. Further research is necessary to investigate the pattern of referred patients for EST.

The smoking rates in men were higher (4.9%) compared to non-smoking women. Among men, 7.8% consumed alcohol, which was lower than women. The prevalence of obesity in men decreased across three classes (C1-C3), while it increased in women, especially in C2 and C3. Despite a higher sample size of male subjects, obesity was more prevalent in women, with a significant proportion observed (0.05) using chi-square analysis. This contrasts with a previous study where obesity increased in men and remained high in women.(21) In terms of blood pressure, 54.9% of the subjects were hypertensive, 1.9% were pre-hypertensive, and 43.1% had normal blood pressure. Men had a higher prevalence of these blood pressure ranges compared to women, with no significant difference between the BP ranges and gender.

Our study found that more male subjects than female subjects were referred for exercise stress testing due to initial presenting symptoms. Chest pain was the main reason for referral, accounting for 28.4% of cases. However, previous studies have shown that women presenting with chest pain have different clinical presentations, diagnostic test performance, and prevalence of coronary artery disease compared to men. These differences affect pretest likelihood,

referral patterns, and diagnostic ability of tests. The lack of available data on noninvasive diagnosis of chest pain in women adds to the challenge of evaluating them. (23)

The majority of participants in the study had a history of drug medication, with 74.5% reporting this. This was more common among male subjects, particularly those on antihypertensive medication (33.3%). The least common medication reported was for peptic ulcer disease (1.9%). Muscle fatigue was the most common reason for interrupting the exercise stress test (EST), accounting for 28.4% of participants. Among males, the second most common reason was reaching maximum heart rate (18.6%), while among females, breathlessness was more predominant (7.8%). Some patients experienced more than two symptoms, with muscle fatigue and maximum heart rate being the most common combination, and breathlessness and chest pain being the least common combination.

The study found that the maximum stage reached during exercise stress testing (EST) was stage 3 for 53 individuals (52.0%), while the least stage reached was stage 5 for 4 individuals (3.9%), with a higher prevalence among males. It has been reported that healthy, well-trained individuals can complete the Bruce protocol in a maximum of 27 minutes, whereas the average middle-aged adult typically takes 8-10 minutes. Exercise duration is a significant indicator of functional capacity and is a strong predictor of mortality and cardiac events in patients with cardiovascular diseases. Functional capacity tends to be lower in women compared to men and decreases with age, but exercise duration remains a valuable prognostic factor even after adjusting for age and sex. In patients with coronary artery disease (CAD), exercise duration has been shown to be useful for risk stratification. (24, 25)

The study found that ST elevation or depression and T wave inversion were more common in males, while more than half of the study population had normal results. T wave inversion was present in 7 individuals, accounting for 3.9% of males and 2.9% of females, while ST changes were present in 9 individuals, with a higher percentage in males than females. This is similar to the previous studies. (21,26,27) In a study of symptomatic men and women undergoing exercise ECG and subsequent angiography, the positive predictive value of ST-segment depression with exercise testing was lower in women than in men. (28) This may be due to several factors, including baseline ST- and T-wave changes in women, the effects of estrogen on ST-segment changes, and false positive tests in menstruating (29,30) and postmenopausal women taking oral estrogen (31). In larger and more recent studies of asymptomatic women, ST-segment depression appears to be less common than previously reported. (25, 26)

The clinical interpretation of EST findings revealed that 9.8% had stress-induced ischemia and 6.9% had stress-induced arrhythmia. Obese individuals showed higher rates of ST-changes, T-wave inversion, ischemic, and arrhythmia ECG findings compared to those with other BMI ranges, consistent with a previous study. (21)

Stress induce hypertension was observed among the female subjects with a prevalent of 1(1.0%). A study has shown that discontinuation of drugs that reduce heart rate and blood pressure such as β-blockers, days before the test can help in accuracy of EST results. (2) Various medical conditions, including orthopedic, lung, and neurologic diseases, as well as deconditioning or prolonged bedrest, can affect EST interpretation. Also, factors like drug history, abnormal resting ECG, and left ventricular hypertrophy should be taken into consideration. (34)

5. Conclusions

There was not any injury or mortality during stress ECG testing with over half of the subjects having normal study. Stress induced ischemia and arrhythmia was still uncommon. Muscle fatigue was the most common reason for interrupting the stress ECG which shows that typical angina is of low rate. Stress ECG is safe in our environment, and should be regularly carried out collecting and evaluating an accurate patient medical history is important as it can impact both test results and information gathered during EST.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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