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Original Article

Gender Differences in the Prevalence of Electrocardiogram Abnormalities in the Elderly: A Population Survey in India

Rupali Sachin Khane[1], Anil D. Surdi[2]

Abstract

Background: The health transition in India reflects the growing burden of cardiovascular diseases. It is well-known that there are significant and meaningful differences in the measured electrocardiogram (ECG) parameters between females and males. Specific to ECG diagnosis and ischemia, reports have indicated a higher number of false positive results in female patients than in male patients. This study was aimed at examining gender difference in the prevalence of ECG abnormality in older people who were free of coronary heart disease (CHD) and its associated risk factors.
Methods: This study was conducted in Solapur city using 400 apparently healthy asymptomatic subjects with an age range of 45 to 74 years. A resting 12-lead ECG was recorded in supine position in accordance with classical recommendations. The various ECG abnormalities were defined according to Minnesota code. The findings were analyzed using Chi Square test at P<0.05.
Results: Out of 400 ECGs recorded, 152 showed abnormalities. The prevalence of ECG abnormalities was significantly (P<0.001) more in males than in females. Major prevalence of ECG abnormalities in males observed were LAD, LVH, sinus bradycardia, LBBB and Q/QS patterns. There was no significant gender difference in the prevalence of other ECG abnormalities.
Conclusion: This study has outlined the overall prevalence of ECG abnormalities in males as well as in females in Solapur city. We found highly significant (P<0.001) increase in the prevalence of ECG abnormalities in males as compare to females.

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[1]Department of Physiology, D. Y. Patil Medical College, Kolhapur, Maharashtra, India.
[2]Department of Physiology, V.M. Medical College, Solapur, Maharahtra, India.

Correspondence:
Rupali Sachin Khane MD,
Department of Physiology,
D. Y. Patil Medical College,
Kolhapur, Maharashtra,
India.
Tel: +91 9890045256
Email: rupalikhane@gmail.com
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Introduction

Cardiovascular diseases accounts for approximately 12 million deaths annually and are the most common, serious, and chronic life-threatening illnesses.[1] Coronary Heart Disease (CHD) is the major contributor to the burden of premature mortality and morbidity and accounted for 85 millions disability-adjusted life years in 1990.[2] By the year 2020, CHD will still be the leading cause of death. Coronary heart disease will rise to about 140 to 160 millions, with 80% of the burden on developing countries. In India, CHD has increased in parallel with the expanding population, and will continue to increase. In 1990, approximately 25% deaths were attributable to CHD.[3] It is also noted that although the mortality from cardiovascular disease has recently been decreasing in men, it has been increasing in women.[4] Inaccurate diagnosis and ensuing management inefficiencies may contribute to the increased mortality.[5]

Accurate identification of high-risk individuals for cardiovascular disease coupled with a successful preventive approach is the preferred strategy, for the control of CVD epidemics. Therefore, the reliability of an objective measurement, such as the electrocardiogram (ECG), assumes a greater role in the evaluation of the cardiac status. In cardiac medicine, the resting ECG has proved its value as a diagnostic tool for detecting heart disease. Apart from its use in the clinical context, the ECG has been employed as a prognostic tool in apparently healthy subjects. The resting ECG permits us to suspect or diagnose a large number of cardiac disorders. As a non-invasive, less expensive and simple technique, ECG may be even more useful in developing countries like India, where resources are limited and cardiovascular diseases are rapidly emerging as a major health problem.

Several studies have shown that noninvasive cardiac stress tests have a lower diagnostic accuracy in women.[6] The lower accuracy has been attributed to lower ECG voltage, smaller size of the coronary vessels, smaller heart size, hormonal factors (premenopausal relationship with endogenous estrogen levels), breast attenuation, and functional impairment.[7,8] Specific to ECG diagnosis and ischemia, reports have indicated a higher number of false positive results in female patients than in male patients.[7] In addition, diagnostic accuracy in women also varies depending on the test administered (i.e. stress echocardiography, stress myocardial perfusion imaging, or pharmacologic or exercise electrocardiogram).[9,10] Although sensitivity and specificity vary greatly between studies, as reported values depend widely upon patient selection criteria and methodological construct, studies using cross-gender comparisons consistently report lower diagnostic accuracy in female populations.[7,9,10]

During the first decade of life, the quantitative ECG parameters in females and males are remarkably similar with regard to resting heart rate, PR interval, QRS duration, QRS voltage, T-wave amplitude, T axis, ST-segment location, QRS-T angle, QT interval, and the frequency of normal U waves.[11] There are clearly racial differences in some of these parameters, but within each racial group the ECG patterns are remarkably similar in preadolescent females and males.[12] Beginning in adolescence, the resting heart rate is somewhat faster in females than males, and the QT interval and the QTc interval become significantly longer in women than men probably as a result of female hormones.[13] However, the QRS amplitude and QRS duration become larger in males than females as a result of the male hormones and the associated increase in cardiac mass and left ventricular wall thickness.

Based on Bayes' theorem, the intrinsic value of the ECG as a valuable diagnostic tool is dependent on the prevalence of the findings in the general population. Therefore, accurate estimates of the true prevalence of ECG abnormalities from large samples are central to the interpretation of the predictive value of ECG findings. Since the introduction of the Minnesota Code,[14] several epidemiological studies have concentrated on estimating the prevalence of ECG abnormalities in a standardised way. However, most of these studies were based on population samples of men, and only a few reports contained data on women.

The objective of this study was to obtain accurate estimates of the prevalences of ECG changes in the general population, and to describe these prevalences in relation to age and sex. Moreover, it aimed at finding out gender differences in the prevalence of ECG abnormality in older people free from angina, and CHD and its associated risk factors. In contrast to previous reports from large studies where study populations were highly selected, such as life insurance candidates or air force personnel,[15] our results are derived from community based cohorts. This paper is one of the few that have reported prevalence of ECG findings in women as well as men.

Materials and Methods

Study Population

A cross-sectional survey of a random sample of the population aged ≥45 years old in the Municipal Corporation area (urban population=872478 people according to 2001 census) of Solapur was conducted. A sample size of 384 was calculated using Epi-Info software (Version 3.2) at 95% confidence level and 5% confidence interval. However, a sample size of 400 (95% confidence level and 4.9% confidence interval) was decided to include in the study. A total of 417 people were recruited considering the dropout rate of elderly subjects. Only 17 subjects were dropped out during the study. The city was divided into 98 wards and 6 zones. There were 98 wards and 6 zones in the Solapur Municipal Corporation area. North sadar bazaar zone was selected from the 6 zones of Solapur. From the updated voter list of this zone, all the members who were permanent residents and had an age of ≥45 years were selected. Using the stratified random sampling method, a list of 417 members aged ≥45 years along with their addresses was prepared. A maximum of three visits were conducted for those individuals who could not be contacted during the first visit. Necessary data were collected after obtaining informed consent. They were given the Rose angina questionnaire from the cardiovascular survey methods of World Health Organization (WHO)-1982.[14]

Selection Criteria

Apparently healthy asymptomatic subjects in the age group of 45 to 74 years were selected.

Exclusion Criteria

Subjects with the following characteristics were excluded from the study;

1- Subjects with a history of Coronary Heart Disease (CHD) characterized by; i) Positive response to Rose angina questionnaire of WHO,[5] and ii) documentary evidence of past CHD treated at home or hospital.

2- Subjects with a history of hypertension, other cardiovascular diseases, respiratory diseases, or diabetes mellitus.

3- Subjects receiving drugs that were known to interfere with cardiac or respiratory functions such as β-blockers, vasodilators, and sympathomimetic and antihypertensive drugs.
Subjects having history of chronic alcohol consumption, chronic.

4- Subjects consuming tobacco in any form.

5- Subjects with hypertension (systolic blood pressure more than 140 mm of Hg and or diastolic blood pressure more than 90 mm of Hg) or obesity.

Clinical Evaluation

All participants were interviewed for assessing demographic information, health history, personal habits including alcohol consumption and smoking, physical activity as well as Rose questionnaire for angina and intermittent claudication. The presence of angina, possible myocardial infarction or intermittent claudication was assessed by using defined Rose questionnaire criteria.[14] Direct patient interviews for a history of myocardial infarction were also employed. Subjects were also examined for pulse, blood pressure, height, weight, body-mass index. The systemic examination was included the examination of cardiovascular and respiratory system.

Recording of Blood Pressure

Both systolic and diastolic blood pressures were measured in supine position after a rest for about 5 minutes. At least two readings of five min interval were recorded. If a blood pressure of ≥140/90 mmHg was noted, a third reading was obtained after 30 minutes. The lowest of the three measurements was taken as blood pressure.

Recording of ECG

Before recording of the *ECG*, the whole procedure was explained to the subject. The subject was asked to relax in supine position for 30 minutes. The relaxed physical and mental state of the subject was confirmed. Then, a resting 12-lead ECG was recorded in supine position, in accordance with classical recommendations on the BPL 108 ECG machine. All electrocardiograms were recorded between 9.00 am to 12.00 noon in a calm atmosphere, at a room temperature varying from 27 to 30°C. These ECGs were read and coded on the basis of Minnesota code criteria (table 1).[14]

Statistical Analysis

The data were analyzed using Chi-square test. A P value of ≤0.05 was considered statistically significant.

Results

The distribution of electrocardiographic abnormalities

Table 1: The prevalence of various electrocardiogram abnormalities in males and females participants

ECG Abnormality	Males	Females
LAD	25 (9.6%)	8 (5.7%)
Sinus Bradycardia	19 (7.30%)	11 (7.85%)
ST-T wave abnormalities	14 (5.3%)	13 (9.2%)
A. LBBB	12 (4.6%)	5 (3.5%)
B. RBBB	6 (2.3%)	4 (2.8%)
LVH	12 (4.6%)	4 (2. 8%)
Q/QS Pattern	10 (3.8%)	2 (1.42%)
VPBs	04 (1.53%)	1 (0.71%)
RVH	1 (0.3%)	0
RAD	1 (0.65%)	0
Total	104 (40%)	48 (34%)

LAD: Left axis deviation; LBBB: Left bundle branch block; RBBB: Right bundle branch block; LVH: Left ventricular hypertrophy; VPB: Ventricular premature beat; YVH: Right ventricular hypertrophy; RAD: Right axis deviation including left axis deviation, sinus bradycardia, ST-T wave abnormalities, bundle branch block, left ventricular hypertrophy, Q-QS pattern, ventricular premature beats, RVH and RAD are shown in descending order of frequency in table 2. We found that the total prevalence of ECG abnormalities in urban population of Solapur city was 38% (152/400). The prevalence of ECG abnormalities in males was significantly (P<0.001) higher than that in females.

Table 2: The Minnesota Coding used to define electrocardiogram abnormalities

ECG abnormalities	Minnesota Code
Q/QS Pattern	1-1,1-2,1-3
Left Axis Deviation (LAD)	2-1
Right Axis Deviation (RAD)	2-3
Left Ventricular Hypertrophy(LVH)	3-3
Right Ventricular Hypertrophy (RVH)	3-2
ST-T Abnormalities	4-1,4-2,5-2,5-3
Complete Left Bundle Branch Block (LBBB)	7-1-1
Complete Right Bundle Branch Block (RBBB)	7-2-1
Ventricular Premature Beats (VPBs)	8-1-2
Sinus Bradycardia	8-8

The prevalence of ECG abnormalities in males (40%) was significantly (P<0.001) more than in females (34%). The prevalence of left axis deviation was 21.7% with higher prevalence in males (9.6%) than in females (5.7%). The prevalence of sinus bradycardia was 19.4% with higher prevalence in males (7.3%) than in females (7.8%).The prevalence of ST segment and/or T wave abnormalities in the absence of bundle branch block, left ventricular hypertrophy or other conduction defects was 17.6%. Also, there was gender difference in its prevalence (5.3% in males *vs* 9.2% in females). The prevalence of bundle branch block was 17.8%; however, the incidence of left bundle branch block and right bundle branch block were11.2% and 6.6%, respectively. Moreover, the prevalence of bundle branch block was higher in males than in females.

The prevalence of left ventricular hypertrophy was 9.6%, with a higher prevalence in males (4.6%) than in females (2.8%). The prevalence of Q/QS pattern was 7.9% with a higher prevalence in males (3.8%) than in females (1.4%). The prevalence of VPBs was 3.3%, with higher prevalence in males (1.5%) than in females (0.7%). We found one ECG showing right ventricular hypertrophy and one ECG showing right axis deviation. Both of the abnormalities were found in males.

Discussion

Table 1 shows the prevalence of ECG abnormalities in male and female participants. As expected, ECG predictors of myocardial damage (left bundle branch block or Q waves) were more prevalent in men. However, the prevalence of ST-T wave abnormalities in females was more than that in males.

De Bacquer et al.[16] found that the prevalence of left axis deviation in men was 4.8% and in women was 2.5%, and was age-dependent. Apart from the influence of age and sex, a positive association with obesity was seen. Assantachai et al.[17] found that left axis deviation was the most common electrocardiographic abnormality found among older men with a prevalence of 4.1%, which was significantly higher than that in older women. Dhanunjaya et al.[18] found that the prevalence of left axis deviation was 17% with its incidence being higher in males (31%) than in females (13%). Our findings are in agreement with those of De Bacquer and colleagues. Mihalick,[19,20] and Fisch attributed this change to greater freedom of motion of the heart within the thorax in the elderly subjects. The freedom of motion was due to the anatomical changes such as progressive development of kyphoscoliosis with increasing AP diameter, lowering of the diaphragm due to pulmonary emphysema, loss of the elasticity and increased resistivity of the tissues surrounding the heart, and elongation of the aorta.

Zerkiebel et al.[21,22] found that men had a lower heart rate than women, younger men had lower a heart rate than older men. They attributed the inverse relation of heart rate to age to a higher level of physical activity by young men than by older men. Moreover, the lower heart rate in men compared to that in women may be explained by the same phenomenon. Our findings agree with the findings of the above studies with respect to gender difference.

The ST segment is more labile with a greater degree of nonspecific ST-segment deviation in women than in men. In the absence of cardiovascular disease, these differences remain significant between sexes throughout adulthood. The greater liability and dynamicity of ST segment deviation in women than in men adds to the difficulty in accurately diagnosing subtle ischemic related ECG changes in women.[23]The higher prevalence of ST-T wave abnormalities in old aged women can be explained by the role of estrogen in these women.[23] Campbell et al.[24] observed a prevalence of 15% for ST-T wave abnormalities, especially T wave flattening, which was more common in women than in men. Oopik et al.[25] observed that ST-T wave abnormalities were present more in women than in men (5.3% vs 3.8% P<0.02). Lakkireddy,[18] observed that in centenarians the incidence of ST depression was 3% in men and 12% in women, while the prevalence of T wave abnormalities was 11% in men and 8% in women.

Greenland et al.[26] found that the significantly higher prevalence of ST-T wave abnormalities in middle aged women (2.0%) was significantly (P<0.001) higher than in men (0.8%). In the study of Assantachai[17] et al, the evidence of ST-T wave abnormality was found in 4% of males and 6.1% of females. Chadha,[15] found a higher prevalence of ST-T wave abnormalities in women (64.3/1000) as compared to men (39.0/1000). Zerkiebel et al.[21] noted a higher prevalence of ST segment and T wave abnormality in women than in men. De Bacqueret al.[16] in their study found no gender difference in the prevalence of ST change (2.6% in women vs 2.3% in men) and T wave abnormalities being (7.6% in women vs 6.5% in men). Our findings are in agreement with those of the above studies regarding gender difference.

De Bacquer et al.[16] found that the incidence of bundle branch block was 1.6% in men and 0.8% in women. They also showed an equal evidence for left bundle branch block in both males and females, and asignificant sex difference for right bundle branch block. Assantachai et al.[17] found a higher prevalence of bundle branch block in men (3.6%) than in women (1.3%). Lakkireddy,[18] also observed a higher prevalence of bundle branch block in males than in females. They observed the prevalence of right bundle branch block to be 8% in men and 4% in women, while the prevalence of left bundle branch block to be 11% in males and 10% in females.

Oopik et al.[25] observed an increasing prevalence of bundle branch block with an increasing age. They also showed that the prevalence of bundle branch block was higher in men (4.2%) than in women (2%). Campbell et al, found that the prevalence of complete left bundle branch block was 1.4% in 31 subjects and that of complete right bundle branch block was 1.9% in 40 subjects. Our findings are in agreement with those of De Bacquer, Assantachai, Lakkireddy, Oopik, and Campbell. These studies explained that part of the gender difference that might be simply due to longer depolarization time in men than in women as a result of increased ventricular mass in men than in women.

The higher prevalence in males (4.6%) than in females (2.8%) can be a result of the male hormones and the associated increase in cardiac mass and left ventricular wall thickness. Decreased QRS amplitudes in women may be explained in part by the increased spatial separation of myocardium from precordial electrodes attributable to breast tissue.[27] The aging process, which causes cardiac muscle hypertrophy mainly the left ventricular hypertrophy in elderly subjects, could be the basis for the increasing prevalence of left ventricular hypertrophy with the advancing age.[28]

Campbell et al.[24] observed possible left ventricular hypertophy in 4% of subjects without significant age or sex differences, but probable left ventricular hypertrophy pattern were more frequent in women than in men, and its frequency increased with increased age. Oopik et al.[25] reported that the prevalence of left ventricular hypertrophy was higher in 55-64 years age range, and the prevalence were equal in both sexes. De Bacquer et al.[16] estimated the prevalence of left ventricular hypertrophy to be 0.7% in men and 0.5% in women.

The higher prevalence of Q/QS pattern in males can be attributed to the high physical activity in males than in females leading to more cardiac overload and development of myocardial infraction. [22] Campbell et al.[24] showed the prevalence of Q/QS abnormalities in 6 to 10% of records. They found them more common in men than in women. Oopik et al.[25] found that definite or possible myocardial infarction (defined by Q/QS pattern according to Minnesota Code) was present in 6.5% of the participants. They also found that definite myocardial infarction was less common in women than in men, but possible infarction was equally prevalent among men and women.

Tervahauta et al.[29] De Bacquer, et al.[16] and Zerkiebel et al, [21] detected “old myocardial infarction” (as defined by Q/QS pattern according to Minnesota Code) to occur more in men than in women, and “old myocardial infarction possible” to occur more in men (6.1%) than in women (3%). They also showed that that it was much more prevalent in men aged more than 45 years than in younger ones. Chadha,[30] found higher prevalence of MI (as defined by Q/QS pattern according to Minnesota Code.) in men (17.4/1000) than in women (11.5/1000). Our findings are in agreement with all these studies. Two other community-based studies, conducted in India for estimating the prevalence of CHD, also supports our findings. The study showed that CHD occurs a decade earlier in India than in developed countries. The peak of occurrence of the disease was in the age range of 51-60 years. The prevalence (per 1000 population) of 30 years old and above were 65.4 in males and 47.8 in females in the study of Urban Chandigadh, and 22.8 in males and 17.8 in females in the study of Rural Haryana.

Mihalick,[19] Zerkiebel,[21] and Lakkireddy et al.[18] observed that the prevalence of ventricular premature beats were more prevalent in males than in females. We found one ECG showing right ventricular hypertrophy and one ECG showing right axis deviation. It was present in male subjects, but not in females. Campbell et al.[24] found the prevalence of right ventricular hypertrophy to be 1.4% in men and 0.3% in women.

Conclusion

The present study was carried out in 400 apparently healthy asymptomatic subjects with an age range of 45-74 years selected from the urban population of Solapur City. All the subjects were screened for gender difference in the prevalence of various ECG abnormalities by recording resting 12-lead electrocardiogram. The ECGs were coded and classified as abnormal according to Minnesota code.

The study found that in urban population of Solapur City the overall prevalence of ECG abnormalities was 38% (152/400). It also found that various ECG abnormalities in decreasing order of frequency were LAD, sinus bradycardia, bundle branch block, ST-T wave abnormalities, left ventricular hypertrophy, Q/QS pattern, ventricular premature beats, right ventricular hypertrophy and RAD. Moreover, it showed a significantly higher prevalence of ECG abnormalities in males than in females in urban population of Solapur City.

The differences that exist between healthy men and women in various ECG parameters probably reflect the interplay of anatomic, structural, hormonal, autonomic, and genetic factors. We know that the frequency and incidence of many cardiac diseases are different based on gender and age of the subjects.

The sex- and age-based ECG standards should be used or should be taken into consideration in the interpretation of the clinical significance of various ECG abnormalities in both sexes to avoid false positive or negative results. One could easily and accurately approach towards correct diagnosis with reliability on the basis of ECG. This is the most important clinical implication of this study. Therefore, there is a necessity of more epidemiological and supportive research program on regional basis in a vast developing country like India, where there are extreme diversities in socioeconomic patterns, dietary habits and life styles. More similar studies are necessary and helpful to define total burden of CHD, and to determine risk factors in various population.

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Conflict of Interest: None declared

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