Age and gender differences of electrocardiographic basic values and abnormalities in general adult population; Tehran Cohort Study

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Abstract

Introduction Although several studies are available regarding baseline Electrocardiographic (ECG) parameters, major and minor ECG abnormalities, there is a big controversy regarding their age and gender differences in literature, thus we aimed to investigate any possible age or gender ECG discrepancies in general adult population. **Methods** Data of 7630 adults aged [?]35 years from Tehran Cohort Study who were registered between March 2016 to March 2019 were collected. ECG basic values, major, and minor ECG abnormalities-defined according to the Minnesota Code-were analyzed and compared between genders, and four distinct age groups. Odds ratio of having any major ECG abnormality between males, and females stratified by age, and number of cardiovascular risk factors was calculated. **Results** ECG information of 7630 participants was available. The average age was 53.6 (±12.66), and women made up 54.2% (n=4132) of subjects. The average heart rate (HR) was higher among women($p<0.0001$), while the average values of QRS duration, P wave duration, and RR intervals were higher among men($p<0.0001$). Major ECG abnormalities were observed in 2.9% of study population (with right bundle branch block, left bundle branch block, and Atrial Fibrillation being the most common) and were more prevalent among men compared to women (3.1% vs 2.7% $p=0.188$). Moreover, minor abnormalities were observed in 25.9% of study population, and again were more prevalent among men (36.4% vs 17% $p<0.001$). Prevalence of major ECG abnormalities was significantly higher in participants older than 65 years old, and participants who had [?]3 conventional cardiovascular (CV) risk factors. **Conclusion** Basic ECG values is different in male and female general population. In addition, major and minor ECG abnormalities were roughly more prevalent in male subjects. In both genders, odds of having major ECG abnormalities surges with increase in number of conventional CV risk factors and age.

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Abstract

IntroductionAlthough several studies are available regarding baseline Electrocardiographic (ECG) parameters, major and minor ECG abnormalities, there is a big controversy regarding their age and gender differences in literature, thus we aimed to investigate any possible age or gender ECG discrepancies in general adult population.

Methods Data of 7630 adults aged [?]35 years from Tehran Cohort Study who were registered between March 2016 to March 2019 were collected. ECG basic values, major, and minor ECG abnormalities-defined according to the Minnesota Code-were analyzed and compared between genders, and four distinct age groups. Odds ratio of having any major ECG abnormality between males, and females stratified by age, and number of cardiovascular risk factors was calculated.

ResultsECG information of 7630 participants was available. The average age was 53.6 ($\pm$12.66), and women made up 54.2% (n=4132) of subjects. The average heart rate (HR) was higher among women($p<0.0001$), while the average values of QRS duration, P wave duration, and RR intervals were higher among men($p<0.0001$). Major ECG abnormalities were observed in 2.9% of study population (with right bundle branch block, left bundle branch block, and Atrial Fibrillation being the most common) and were more prevalent among men compared to women (3.1% vs 2.7% p=0.188). Moreover, minor abnormalities were observed in 25.9% of study population, and again were more prevalent among men (36.4% vs 17% $p<0.001$). Prevalence of major ECG abnormalities was significantly higher in participants older than 65 years old, and participants who had [?]3 conventional cardiovascular (CV) risk factors.

ConclusionBasic ECG values is different in male and female general population. In addition, major and minor ECG abnormalities were roughly more prevalent in male subjects. In both genders, odds of having major ECG abnormalities surges with increase in number of conventional CV risk factors and age.

Keywords: Electrocardiography, ECG abnormalities, Epidemiology, Iran, Age distribution, sex distribution

Introduction

Cardiovascular diseases (CVDs)-specifically ischemic heart disease (IHD)- is one of the major leading causes of death, globally. The Global Burden of Diseases (GBD) has estimated 197 million prevalent cases, and 9.4 million IHD mortalities in 2019. In addition, GBD reported 59.7 million prevalent cases of Atrial Fibrillation (AF) and Flutter (AFL) in 2019, almost doubled compared to 1990(1). Thus, CVDs, and cardiac electrical abnormalities screening, and early diagnosis is of crucial significance in identification of high-risk cases, and development of preventive strategies for controlling the mortality rates worldwide.

Electrocardiography (ECG), is a global, inexpensive, non-invasive, and easily-accessible technique for both screening, and diagnosing heart diseases(2). The ECG has been used in a variety of contexts including; pre-employment screening(3), record tracking of symptomatic patients(4), detecting young athletes with pre-exisiting silent cardiac conditions(5). It has been shown that history of ECG abnormalities, is an independent indicator of increased risk for CVD(6, 7). Thus, ECG can be an efficient technique for assessing, controlling, and preventing CVDs.

Although several studies are available about baseline ECG parameters and major, or minor ECG abnormalities, there is a big controversy regarding sex and age differences. Some studies indicated that the ECG interpretation needs correction based on these variables(8-10). Some of the reports indicated higher median heart rates (HR) in healthy females compared to healthy males(11-13), while P wave, PQ interval, and the QRS duration (QRSd) were reported to be higher among men(11). The QT intervals was found to be longer in females, and older age was shown to be associated with comparatively wider QRSd and longer PR intervals in both genders. These discrepancies are also bolded when comparing different countries, hence, nation-wide ECG evaluation sounds necessary.

In this study we aimed to report the major and minor baseline ECG abnormalities in Tehran (the capital of Iran) general population. In addition, average ECG parameters and abnormalities will be compared in sex and age groups separately.

Material and Methods

Study design and participants

In this study, we used data from Tehran cohort study (TeCS), a prospective population-based multidisciplinary longitudinal study being conducted among adults residing in Tehran, Iran. The thorough details of this study has been published previously(14). To elaborate concisely; 4215 households, from 22 districts of Tehran were selected via systematic sampling method and enrolled in the study between March 2016 to March 2019. The inclusion criteria comprised of being a permanent resident of Tehran and having at least one member older than 35 years of age in the household. In total, 8296 individuals older than 35 years participated for cardiovascular (CV) and mental evaluation, and their personal, clinical, and para-clinical data were collected.

TeCS data collection and measurements

In TeCS several questionnaires were utilized to determine and assess the demographic characteristics, habitual risk factors, medical/medication history, psychological health, and injury occurrence among participants.

The demographic data were recorded including birthplace, ethnicity, educational level, occupation, marital status, and contact information. Regarding habitual risk factors, questionnaires focused on; smoking, drug (opioid, and non-opioid) abuse, and alcohol. In addition, a thorough medical history was recorded including previous hospital admissions, surgeries, chronic diseases, and any other comorbidities. Moreover, the medication use was obtained via documenting the name, dosage, and frequency of the medications.

Besides, fasting blood serum samples were collected for Routine biochemistry lab tests-including fasting blood sugar (FBS), total cholesterol, triglyceride (TG), blood urea nitrogen (BUN), creatinine (Cr), high-density lipoprotein (HDL), and low-density lipoprotein (LDL)- and stored in biobank. Moreover, the anthropometric, and physiologic variables including the following parameters: weight, height, waist and hip circumference, blood pressure, and HR were measured, and documented.

Resting ECG measurement

After blood samples were obtained, a 12-lead ECG was attained using a 12-channel M-TRACE ECG device (M4Medical, Lublin, Poland), according to standard methods and instructions for lead placement. A printed copy of the ECG was archived in the participants' file, and another transcript was sent to them with a report package. Also, the electronic ECG documents was saved on TeCS server. Finally, the ECG records were

reviewed and documented in ECG forms, by two expert cardiologists (P.A and K.H) and re-evaluated by the third cardiologist (M.T) in case of discrepancies.

Definitions of **CV risk factors and diseases**

Current smokers were those who smoked cigarette, pipe, or hookah daily or occasionally. Former smokers were defined as participants who quit smoking at least one month before the interview. Positive alcohol consumption was defined as any use of alcoholic beverages within the preceding year. The history of diabetes mellitus (DM) was defined as a self-report of a prior DM diagnosis or taking glucose-lowering medications. Also, hyperlipidemia was defined as a prior diagnosis of hyperlipidemia or taking lipid-lowering medications. The daily total physical activity was questioned from the patients and classified as low, intermediate, and high activity according to Likert-scale questionnaire. Hypertensive patients were defined as participants with systolic blood pressure (SBP) [?]140 mmHg or diastolic blood pressure (DBP) [?]90 mmHg, or self-report of a prior hypertension diagnosis, or taking antihypertensive medications, according to 2018 ESC/ESH guideline.

Definitions of ECG abnormalities

After an ECG abnormality was diagnosed, the ECG print was reviewed by three other expert cardiologists, and ECG interpretation, and classification was done based on the Minnesota coding (MC) criteria (4, 15, 16). After that, the ECG abnormalities were classified as either, minor abnormalities; which were common and clinically irrelevant, or major abnormalities; which were clinically important and relevant.

The major ECG abnormalities comprised of AF, AFL, left bundle branch block (LBBB), right bundle branch block (RBBB), second-degree atrioventricular block (AVB), complete heart block (CHB), Wolff-Parkinson-White (WPW), supraventricular or ventricular tachycardia, and artificial pacemaker. Also, the following ECG findings, were included in minor abnormality group; sinus bradycardia, premature junctional rhythm (PJC), premature ventricular rhythm (PVC), premature atrial rhythm (PAC), First-degree AVB, Incomplete RBBB, Incomplete LBBB, left anterior fascicular hemi-block (LAFB), and left posterior fascicular hemi-block (LPFB). Additionally, ST elevation, ST depression, T wave inversion, non-pathological Q wave, fragmented QRS (f-QRS), Brugada pattern, anterior Early repolarization, and inferior/inferolateral early repolarization were also documented. Finally, left ventricular hypertrophy was defined according to Sokolow-Lyon criteria(17), also left atrial hypertrophy, left, right, or extreme right axis deviation were documented and analyzed.

Statistical analysis

Normally distributed continuous variables including age, SBP, DBP, HDL, total cholesterol, RR interval, HR, max QRSd, and P wave duration were expressed as mean with standard deviation, while TG and LDL were skewed distributed, so were described as median with 25th and 75th percentiles. Normally distributed variables were compared between males and females using an independent sample's t-test; these variables were compared between age categories using a one-way analysis of variance (ANOVA). LDL and TG were compared between sex groups and age categories using Mann-Whitney U-test and Kruskal-Wallis' test, respectively. Categorical variables, including risk factors and ECG characteristics, were compared between males and females or age categories using chi-squared or Fisher's exact test, as appropriate. The association of age categories and the number of risk factors with the persistence of major components of ECG was evaluated by applying the Logistic regression model and were reported through odds ratio (OR) with a 95% confidence interval (CI). All statistical analyses were conducted using IBM SPSS Statistics for Windows, version 23.0 (Armonk, NY: IBM Corp).

Results

Baseline characteristics, and

ECG information of 7630 participants was available. The study population's average age was 53.6 (+-12.66). 54.2% of study population were women (n=4132), and 45.8% (n=3498) were men. The prevalence of Hypertension, Dyslipidemia, DM were 27.6% (n=2099), 32.3% (n=2456), and 18% (n=1347) respec-

tively. Moreover, 14.8% (n=1123) of participants were current smokers, and former smokers made up 14.8% (n=1123) of the subjects. In addition, after the measurement of body mass index (BMI), 42% (n=3173), 21.6% (n=1633), and 8.2% (n=621) of the participants were categorized as overweight, obese, and extremely obese, respectively. Finally, 28.7% (n=2116) of recruited cases, met the US National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), criteria for metabolic syndrome, and after Framingham risk score calculation, 19.5% (n=1415) of study population were categorized as high-risk group. In Table 1, the baseline characteristics, and CV risk factors of 7630 participants in TeCS are illustrated.

ECG basic values

The mean HR was 70.6 (+-11.03) bpm, and for RR interval, QRSd, and P-wave duration the average was 870.6ms, 83.9ms, and 90.7ms respectively. In addition, the mean HR was measured significantly higher among females compared to males (72.4 vs 68.4 $p<0.001$). While the average values of the following ECG parameters were significantly higher among men compared to women; RR interval (897.8 vs 847.3 $p<0.001$), QRSd (86.8 vs 81.3 $p<0.001$), and P-wave duration (92.5 vs 89.2 $p<0.001$). The thorough details are presented in Table 2 and Table 3 illustrates the average ECG parameters, and confidence intervals in both genders of all four age groups. Also, Figure 1 demonstrates the mean ECG values in both genders of all four age groups.

ECG Abnormalities

Major ECG abnormalities were observed in 2.9% (n=221) of study population, with RBBB, LBBB, and AF being the most common. Major ECG abnormalities were more prevalent among males compared to females (3.1% vs 2.7% p=0.188). Major ECG abnormalities sorted by prevalence rate were as follows; RBBB, LBBB, AF, AFL. No cases of CHB, 2nd degree AV block were observed. In addition, the odds of having major ECG abnormalities rose with increasing numbers of CV risk factors, and age in both genders. Moreover, minor abnormalities were observed in 25.8% (n=1973) of study population and were more prevalent among men compare to women (36.3% vs 17% $p<0.001$). Table 2, and Table 3 demonstrate the prevalence of major, and minor electrocardiographic abnormalities, among males, and females, and in four pre-defined age groups of the study population.

The prevalence of ECG abnormalities in our study was estimated as follows; 15% for Sinus Bradycardia, 0.56% for both AF, and AFL, 2.28% for complete bundle branch blocks (both LBBB, and RBBB), 2.12% for premature contractions (both PVC and PAC), 2.87% for Incomplete bundle branch blocks (both incomplete LBBB, and RBBB), 0.91% for First degree AV block, and 4.94% for Left Fascicular Hemi-Blocks (both LAFB, and LPFB).

Regarding heart axis, 5.16%, 0.82%, and 0.09% of the study population had ECG patterns consistent with left, right, extreme Right QRS Axis deviation, respectively. In addition, in terms of chamber abnormalities, left ventricular hypertrophy, and left atrial hypertrophy patterns were observed in 3.19%, and 4.71% of participants, respectively.

Moreover, the prevalence of myocardial ischemic, or ischemic-like ECG changes were quantified, and 1.62% of subjects had ST segment elevation, 5.63% of individuals had ST segment depression, 0.06% of participants had T wave inversion, 21.48% of recorded ECGs had Q waves, and f-QRS was observed in 9.69% of participants. Finally, Brugada Pattern, anterior early repolarization, and inferior/inferolateral early repolarization were observed in 0.27%, 0.48%, and 1.42% of study population, respectively.

Figure 2 demonstrates the OR and the 95% confidence interval of the presence of any major ECG abnormality in both genders stratified by age, and the number CV risk factors. The reference value for the stratification of age groups is 34-45 age group, and for CV risk factors is participants with no CV risk factors. As shown in Figure 2 , the odds of having any type of major ECG abnormality increased significantly in both genders with age and the number of CV risk factors.

Discussion

Few data are available regarding ECG parameters' age, and sex-related differences, thus in this study, besides investigating the demography, and CV risk factors, the average ECG values, and ECG abnormalities in a large sample size of Tehran residents, were also analyzed. The average HR was higher among females, while the average values of QRSd, P duration, and RR intervals were higher among males. In addition, major ECG abnormalities were observed in 2.9% of study population and were more prevalent among men compared to women. Moreover, minor abnormalities were observed in 25.9% of study population, and were more prevalent among men compared to women.

ECG basic values

HR

The average HR of the female participants in our study was higher compared to males, which was consistent with the findings of several previous studies(12, 13, 18-20). One large study among 486,014 Brazilians, also stated that the median HR starts decreasing with aging from the first year of life, and stabilizes between 19 to 79 years of age, at approximately 65-66bpm in males compared to 70-73bpm for women(21). Another similar study conducted among 14,424 adults also reported a significantly lower median HR of 64 for men compared to 67 for women(22).

QRSd

In contrast to HR, the average values of QRSd, P duration, and RR intervals were measured higher among men than women in our study. Similar previous studies have also reported the same gender differences, with higher QRSds among males(10-13, 19, 20).

In our study, the average QRSd in was measured significantly higher among males. We also found that, in first three age groups between ages 35 to 65, QRSd almost remained stable, while this number rose in the >65 age group in both genders, specifically among women. In contrast, Macfarlane et al. reported a progressive descent in mean QRSd of both genders(12), while Mason et al. observed stabilized mean QRSd values with increasing age(13). Moreover, Rijnbeek et al. noted, the QRSd remained almost constant for all ages(10). On the other hand, one large study found increasing values of QRSd with age, and specified that, QRSd only increased when comparing younger age groups, and it reaches a plateau in older age groups.(11) The QRSd gender discrepancy can be interpreted to be a result of comparatively smaller cardiac, and left ventricular mass in women.

P wave duration

P wave duration was also analyzed in this study, and it rose constantly by aging in both genders, and it peaked in >65 age group. Similarly, Rijnbeek et al. findings were consistent with our study, and they stated that the P durations, and PR durations were longer for men compared to women, and reported a slight, and constant increase in both values with aging (10). Other similar studies also found comparatively higher P duration, and PR interval in males, and also reported increasing P duration in older participants(13, 21-23).

RR interval

RR intervals in men, were significantly higher than women. Similar studies have also reported higher levels of RR interval among males (13). In one huge meta-analysis among 63,612 participants, Koenig et al. stated that, interestingly, although women show greater vagal parasympathetic activity compared to men, they demonstrate a higher HR, relatively decreased mean RR interval, and fewer total HR variability, and concluded that relying solely on mean HR gives us poor insight into CVD risk(24).

QRS axis deviation

Regarding QRS axis, the left deviation was the most prevalent in both groups and it rose constantly with age in both genders, particularly in >65 group. Some studies have reported similar findings to our study and signified that QRS-axis starts rotating to the left in older age groups, and almost becomes flat in horizontal position, after 70 years of age(10, 11, 23). Wu et al. found that the QRS axis degree in both

genders starts decreasing by age, and shifts to the left by ~25deg, and reaches a low of approximately 44, after 65 years old(23), while Rijnbeek found a more stark decrease, when comparing 16-19, and 80-89 age groups(10). Moreover, males had higher prevalence of QRS deviation in all age groups of this study. Consistent with our study, Mirahmadizadeh et al. measured a higher mean QRS axis degree among males, compared to females(19) while, Pinto-Filho et al. found significantly higher QRS axis degree means among women, compared to males(22). Some studies have associated the age-related left shift of QRS axis, with increasing rates of obesity, and linked it to upward shifting of diaphragm(25). In addition, one study in Japan indicated that the left axis deviation is associated with higher risk of all-cause mortalities and major CV adverse events(26).

ECG abnormalities

Generally, the older age groups had higher prevalence of following abnormalities; AF, AFL, LBBB, RBBB, sinus bradycardia, PVC, PAC, first degree AV block, incomplete RBBB, incomplete LBBB, and LAFB. Additionally, the prevalence of ECG had discrepancies when comparing genders, and most ECG abnormalities had statistically significant or non-significant higher prevalence among males including AFL, RBBB, WPW, sinus bradycardia, PVC, PAC, first degree AV block, incomplete RBBB, LAFB, and LPFB, while AF, and LBBB were more prevalent among females.

Major abnormalities

In total, by utilizing the MC criteria, major ECG abnormalities were observed in 2.9% of study population and found to be more common among men compared to women. Several other studies have reported comparatively higher prevalence of major abnormalities among men(4, 22, 27, 28), while few have stated the opposite(29). Moreover, De Bacquer et al. measured a significant sex ratio (M to F) of 1.66 in their study sample(4). Two studies conducted in the USA, the Charleston(30) and the Evans heart study(31), found a prevalence rate of approximately, 7% for major ECG findings in middle aged men free of coronary heart disease. These discrepancies in the rate of major abnormalities could be interpreted due to differences in several factors including ethnicity, sampling methods, socioeconomic states, and ECG definitions, and classifications.

In addition, the odds of having any type of major ECG changes, increased significantly in both genders, with aging and the number of CV risk factors. Our findings were consistent with several other studies that also indicated that increasing age, and CV risk factors were associated with major ECG abnormalities(22, 27). Denes et al. also signified in both males, and females the odds of major ECG abnormalities presence significantly increased with age, having 3 or more CV risk factors, and prevalent CV diseases(27). In our study the increasing numbers of CV risk factors had stronger association with the presence of major ECG abnormalities among women, while for men the aging had higher impacts. Denes et al found a significant trend, in both genders, for increasing HR, and QRSd as the quantity of CVD risk factors increased(27). Also, Yu et al. specified that, older age Independent of any other CV risk factors or gender significantly increased the odds of having AF/AFL, CHB, RBBB, PACs, PVCs, ST depression, T wave abnormalities, LAE, and left axis deviation(28).

AF, and AFL

According to the database of Global Health Data Exchange, the prevalence of AF was estimated at 0.51% of the world population, with males being affected more than females(32). Few studies are available on arrythmia prevalence in Iran, or Tehran population, and they were mostly small sampled, and reported that the AF prevalence rate was as high as 2.8%(33), while surprisingly, in our study the prevalence of AF was 0.52%, which was consistent with large multi-national studies. Moreover, the AF prevalence remained almost unchanged until 55 years of age in both genders, but it soared among women after 55, and in men after 65 years of age. Several previous studies have also reported an AF prevalence rate ranging between 0.33 to 0.95% and increasing rates with age specifically after 65 years of age(11, 22, 34-37). One study among approximately 3 million people reported that the absolute prevalence of AF in both genders was almost equal, while 60% of AF cases in >75 year-old age group belonged to women(35). Surprisingly, in our study,

the AF was more common among women however, this was statistically insignificant, while many studies have reported overall higher AF rates among males(11, 27).

Complete bundle branch blocks (both LBBB, and RBBB)

Generally, the prevalence of RBBB, was higher compared to LBBB, and RBBB was significantly more common among males, while LBBB was more observed among females. Moreover, BBBs prevalence increased significantly with age, specifically in the >65 group. Two studies conducted in northern Europe with large populations also had similar findings, and signified that RBBB was associated with aging, and it was more prevalent in males(11, 38). Also, Rodriguez et al. showed that among 13,179 Spanish workers, the complete RBBB, complete LBBB were present in 1.1, and 0.2% of the participants. One cohort study reported a prevalence of 3.2% for complete RBBB, and found that male sex and age were associated with presence of RBBB, and signified that bi-fascicular block (BFB) was significantly associated with all-cause mortalities(39). One study followed male participants for 30 years, and found a significant surge in BBBs prevalence from 1% at age 50 compared to 17% at age 80(40). Regarding LBBB, one study found that incidences of complete LBBB was 0.1, and 0.3 in >40, and >65 age groups, respectively, and reported that 71.4% of LBBB cases aged more than 65 years(41). Finally, one study of 17,489, concluded that LBBB prevalence was 0.43% for men, and 0.28% for women, and signified that LBBB's prognosis is relatively benign as few patients required pacemakers(42).

WPW

In total, only 4 individuals had WPW syndrome (0.05%), one male, and three females. One study of 6086 (61% male) patients with WPW, measured an overall prevalence of 0.03% with a peak of 0.06% between 20 to 24 years, and estimated the risk of mortality, and sudden death at 0.07% and 0.02% per patient-year, respectively(43). Guize et al., found higher prevalence of WPW in males, that deceased significantly with aging in both genders, and concluded that, WPW decrease may be a result ventricular pre-excitation disappearance not the increased mortality rates(44).

Minor abnormalities

The prevalence of sinus bradycardia, PVC, PAC, first degree AV block, incomplete RBBB, incomplete LBBB, and LAFB increased with age, and generally minor abnormalities were more prevalent among men compare to women. Similar studies have also investigated the prevalence of minor ECG abnormalities using the MC criteria. Yu et al. investigated 13,983 cases, and outlined that minor ECG problems were observed in 9.92% of participants, and in the 20-44, 45-59, and [?]60 age groups, the minor arrhythmia prevalence rates were 11.05, 10.82 and 14.26% in men, and 6.58, 7.85 and 14.17% in women, respectively(28). In addition, in De Bacquer et al. study the prevalence of minor ECG alterations was slightly higher among men (10.4%) compared to women (9.5%) (4). These discrepancies in minor ECG abnormalities could be due to racial differences, different ECG abnormalities definitions, and various sample sizes.

Premature contractions (PAC, and PVC)

The presence of both PVC, and PAC abnormalities increased significantly with aging, specifically in >65year old group. Both presented higher among males, with PVC being significantly more prevalent. Previous studies that used standard 12-lead ECG also reported a PVC prevalence rate ranging between 1 to 4%, while this number climaxes to 99% in studies that utilize Holter monitoring, with males being affected more than women(27, 45-47). Similarly, Amir et al, after calculating, showed a prevalence rate of 1.1% for PVC, and surprisingly, in their study the incidence of PVC was relatively higher in females(48). Moreover, Conen et al. using Holter monitoring found increasing numbers of PACs per hour with aging(47). On the other hand, significantly higher prevalence rates of PACs-using 10-second ECG-have also been reported in a Japanese cohort, at 8% among 63,197 participants aging between 40 to 79 years(49). Thus, the detection methods, age, gender, and ethnicity can be important may explain the variability of PVC, and PAC prevalence rates in different studies.

Fascicular hemi-blocks (LAFB, and LPFB)

In our study LAFB was significantly higher among men than women. In regard to the prevalence of LAFB in general population, considerable differences were observed in several studies. Krivisky et al. reported a prevalence of 1.03%(50). A prevalence of 6.2% in 3933 participants also have been reported by Rabkin et al.(51). These discrepancies can be attributed to distinguished diagnostic criteria, ethnic diversity, or different underlying pathologies. Generally, the prevalence of LAFB in the normal population according to series ranged between 0.9% to 6.2%, and according to American heart association (AHA)(52). In addition, LPFB was seen in 0.41% of our study population. Previous studies have noted that its isolated incidence is extremely rare in the general population, and specific cardiac patients, and it is mostly invariably associated with RBBB(52, 53).

First-degree AVB

In our study, first-degree AVB affected males significantly higher compared to females. Its prevalence increased with age, specifically in the >65year old age group. Similar studies have also reported higher prevalence of AVB among males and associated it with older age. Du et al. estimated an overall prevalence of 3.4% for first-degree AVB and reported that men (5.2%) were affected more than women (2.2%), and the highest prevalence was in >80year old men. They also indicated male sex, older age, taller height, higher SBP and TG, lower HDL-C, lower HR, and low physical activity as the associated independent risk factors for first-degree AVB(54). Another study, in a large population of more than 15 million people, estimated a prevalence rate of 6.84%, 0.18%, and 0.04% for first-, second- and third-degree AVB respectively. They also indicated that the AVB risk was associated with older age, male sex, lower HR, higher BMI, hypertension, DM and low HDL-C(55).

Chamber enlargement (LVH, and LAE)

In our study both LVH and LAH abnormalities, males were affected significantly higher than females, and their prevalence rates rose significantly with age. One similar study in Netherlands, reported a prevalence rate of 1% among 149,803 adult individuals, using Welch Allyn according to AHA recommendations(11). On the other hand, another study carried out among a sample of 3287 individuals, utilized M-mode echocardiography, and measured a LVH prevalence rate of 14.9%, and 9.1% for men, and women respectively. The wide discrepancies in LVH prevalence could be a result of various criteria used for its diagnosis, as Redondo et al. signified in their study that by using 17 different known LVH diagnosing criteria, the prevalence of LVH among a single population of 2564 subjects can range between 0.7% to 19.4%(56). Regarding LAH, in contrast to our study, Ou et al. found higher prevalence in women compared to men and estimated an overall prevalence of 6.43% for participants over 35 years of age(57).

ST segment, T, and Q wave alterations

The prevalence of ST elevation, ST depression, T inversion, non-pathological Q wave, and f-QRS increased with age, and were more prevalent among males except ST depression which was significantly higher among females. Previous studies had contradictory findings regarding ST depression prevalence, and its discrepancy between male, and female. One study among 959 subjects using adenosine myocardial perfusion imaging, found a total ST depression prevalence of 7.6%, which was significantly higher among women ($p < 0.001$)(58). While, van der Ende et al. reported higher prevalence of ST depression among male (0.93%), compared to females(0.86%)(11).

Regarding ST elevation, its prevalence in our study was significantly higher among men, compared to women. According to Haar et al. study, the overall prevalence of ST elevation was between 2.8% to 3.4%. They also found that the ST elevation prevalence was higher among men, compared to women, and noted that younger (<40 years) subjects had higher ST elevation prevalence compared with older individuals ([?]40 years)(59).

f-QRS was observed significantly higher among men compared to women in our study and rose significantly with aging. One large study among sudden cardiac death (SCD) victims, coronary artery disease (CAD) cases, and healthy adults in Finland, reported a higher prevalence of f-QRS among men comparing to women in general population, and associated the f-QRS prevalence with male sex, older age, previous cardiac disease

history, and severity(60). Non-pathological Q wave was also found to be higher among males, compared to females in our study.

Brugada, and early repolarization

In our study Brugada Pattern, anterior early repolarization, and inferior/inferolateral early repolarization were significantly more prevalent among males, and almost all cases of Brugada were male. The overall prevalence of inferior/inferolateral Early repolarization decreased significantly with aging, while the other two patterns mostly did not change with age. Several studies have associated early repolarization patterns with increased risk of ventricular tachycardia, and SCD(61, 62). One meta-analysis of 29 articles, measured the prevalence of early repolarization at 11.6%. they also indicated that the incidence of early repolarization was 17.0% in men and 6.2% in women and concluded that early repolarization was highly prevalent in men, blacks, and physically active individuals(63).

Brugada syndrome have also been associated with fatal arrhythmias, and SCD. One systematic review of 28 articles, estimated that the global pooled prevalence of Brugada was 0.05%, with higher prevalence among males, and preponderance among residents of Southeast Asia(64).

Conclusion

In this study of a large sample population of >35-year-old Tehran residents, ECG parameters, and major, and minor ECG abnormalities were measured, and analyzed. Our data notes that in the interpretation of basic ECG values, age, and sex should be considered. Resting HR was higher among women, while other ECG values such as P-wave, RR interval, and QRSd were higher among men. In addition, generally major, and minor ECG abnormalities were roughly more prevalent in male population. Also, the odds of having major ECG abnormalities rose with increasing numbers of CV risk factors, and age in both genders.

Declarations:

Ethics approval and consent to participate: The TeCS protocol has been granted approval by the board of research and the committee of medical ethics at Tehran University of Medical Sciences (code of ethics: IR.TUMS.MEDICINE.REC.1399.074), and all the invited participants were requested to sign a consent form on the first recruitment day.

Consent for publication: Not applicable

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interests: The authors declare that they have no competing interests.

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Authors' contributions:

AA: Data interpretation and drafting the initial manuscript. P.A. and K.H.: Concept, data collection, interpretation, and manuscript revision. E.S., M.T., and M.L.T., S.S., F.M., M.M.: Data collection, and interpretation. AO, AS: Concept, data interpretation, and subsequent revisions. AJ: Data interpretation and analysis. All the authors have read and approved the initial and final manuscript versions.

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List of abbreviations

Abbreviation	Definition
AF	Atrial Fibrillation

Abbreviation	Definition
AFL	Atrial Flutter
AVB	Atrioventricular block
BUN	Blood urea nitrogen
CHB	Complete heart block
CV	Cardiovascular
CVDs	Cardiovascular diseases
Cr	Creatinine
DBP	Diastolic blood pressure
DM	Diabetes mellitus
ECG	Electrocardiography
FBS	Fasting blood sugar
f-QRS	Fragmented-QRS
GBD	Global Burden of Diseases
HDL	High-density lipoprotein
HR	Heart rate
IHD	Ischemic heart diseases
LDL	Low-density lipoprotein
LAE	Left atrial enlargement
LAFB	Left anterior fascicular hemi-block
LBBB	left bundle branch block
LPFB	Left posterior fascicular hemi-block
LVH	Left ventricular hypertrophy
MC	Minnesota coding criteria
OR	Odds ratio
PAC	Premature atrial rhythm
PJC	Premature junctional rhythm
PVC	Premature ventricular rhythm
QRSd	QRS duration
RBBB	Right bundle branch block
SBP	Systolic blood pressure
TeCS	Tehran cohort study
TG	Triglyceride
WPW	Wolff-Parkinson-White syndrome

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Tables and figures:

Table 1 Baseline characteristics, and CV risk factors of 7630 participants

	Total (7630)	**F (4132)**	**M (3498)**	**p-value**	**35-44 (2173)**	**45-54 (2053)**	**55-64 (1796)**	**>65 (1608)**	**p-**
F	4132 (54.2%)	-	-	-	1240 (57.1%)	1120 (54.6%)	1016 (56.6%)	756 (47.0%)	<0
M	3498 (45.8%)	-	-	-	933 (42.9%)	933 (45.4%)	780 (43.4%)	852 (53.0%)	<0
Age	53.6 (12.66)	52.7 (12.23)	54.6 (13.07)	<0.001	39.1 (2.89)	49.4 (2.84)	59.1 (2.82)	72.3 (6.46)	-
HTN	2099 (27.6%)	1201 (29.1%)	898 (25.7%)	0.001	134 (6.2%)	378 (18.5%)	680 (37.9%)	907 (56.5%)	<0
Dyslipidemia	2456 (32.3%)	1428 (34.6%)	1028 (29.4%)	<0.001	319 (14.7%)	571 (27.9%)	790 (44.1%)	776 (48.3%)	<0
IFG	1931 (25.8%)	915 (22.4%)	1016 (29.8%)	<0.001	438 (20.4%)	585 (28.9%)	494 (28.2%)	414 (26.4%)	<0
DM	1347 (18%)	722 (17.7%)	625 (18.3%)	<0.001	114 (5.3%)	273 (13.5%)	458 (26.1%)	502 (32%)	<0
Current Smoker	1123 (14.8%)	202 (4.9%)	921 (26.6%)	<0.001	313 (14.5%)	316 (15.4%)	292 (16.4%)	202 (12.7%)	<0

	Total (7630)	**F (4132)**	**M (3498)**	**p-value**	**35-44 (2173)**	**45-54 (2053)**	**55-64 (1796)**	**>65 (1608)**	**p-**
Former Smoker	323 (4.3%)	36 (0.9%)	287 (8.3%)	<0.001	47 (2.2%)	63 (3.1%)	78 (4.4%)	135 (8.5%)	<0
CVD family history	713 (9.3%)	459 (11.1%)	254 (7.3%)	<0.001	210 (9.7%)	227 (11.1%)	161 (9%)	115 (7.2%)	<0
Low physical activity level	1309 (17.3%)	785 (19.1%)	524 (15.2%)	<0.001	253 (11.7%)	257 (12.6%)	302 (17%)	497 (31.3%)	<0
Intermediate physical activity level	4415 (58.4%)	2502 (60.9%)	1913 (55.4%)	<0.001	1315 (60.9%)	1205 (59.1%)	1067 (60.1%)	828 (52.2%)	<0
High physical activity level	1835 (24.3%)	820 (20%)	1015 (29.4%)	<0.001	591 (27.4%)	578 (28.3%)	405 (22.8%)	261 (16.5%)	<0
Metabolic Syndrome	2116 (28.7%)	1354 (33.9%)	762 (22.5%)	<0.001	283 (13.3%)	528 (26.5%)	671 (38.8%)	634 (41.9%)	<0
Systolic blood pressure (mmHg)	121.7 (18.88)	119.1 (19.38)	124.7 (17.82)	<0.001	111.8 (14.55)	118.9 (16.5)	126.7 (18.03)	133.2 (19.85)	<0
Diastolic blood pressure (mmHg)	80.8 (10.81)	80.8 (10.72)	80.7 (10.92)	0.570	78.1 (10.05)	81.5 (10.76)	82.4 (10.62)	81.6 (11.43)	<0
Underweight	211 (2.8%)	88 (2.2%)	123 (3.5%)	<0.001	71 (3.3%)	44 (2.2%)	41 (2.3%)	55 (3.5%)	<0
Normal	1919 (25.4%)	963 (23.6%)	956 (27.5%)	<0.001	637 (29.6%)	466 (22.8%)	394 (22.1%)	422 (26.8%)	<0
Overweight	3173 (42%)	1549 (37.9%)	1624 (46.8%)	<0.001	933 (43.3%)	862 (42.2%)	764 (42.8%)	614 (39%)	<0
Obese	1633 (21.6%)	1004 (24.6%)	629 (18.1%)	<0.001	384 (17.8%)	485 (23.7%)	414 (23.2%)	350 (22.2%)	<0
Extremely Obese	621 (8.2%)	480 (11.8%)	141 (4.1%)	<0.001	128 (5.9%)	186 (9.1%)	173 (9.7%)	134 (8.5%)	<0
LDL (mg/dl)	111 [90-134]	112 [92-137]	110 [87-132]	<0.001	110 [91-129]	116 [94-138]	114 [92-140]	105 [80-130]	<0
HDL (mg/dl)	44.8 (12.37)	49 (12.56)	39.9 (10.1)	<0.001	43.8 (11.79)	44.4 (12.6)	45.8 (12.29)	45.7 (12.83)	<0

	Total (7630)	**F (4132)**	**M (3498)**	**p-value**	**35-44 (2173)**	**45-54 (2053)**	**55-64 (1796)**	**>65 (1608)**	**p-**
Total cholesterol (mg/dl)	172.5 (40.35)	177.3 (39.54)	166.8 (40.58)	<0.001	168.7 (37.08)	176.3 (39.91)	177.2 (42.45)	167.4 (41.74)	<0
TG (mg/dl)	124 [88-174]	119 [84-165]	131 [93-186]	<0.001	115 [77-170]	130 [91-182]	133 [95-181]	121 [90-165]	<0
Framingham risk score									
Low (<10%)	4446 (61.3%)	2982 (75.4%)	1464 (44.4%)	<0.001	2021 (96.8%)	1526 (77.6%)	680 (39.9%)	219 (14.7%)	<0
Intermediate (10-19%)	1392 (19.2%)	668 (16.9%)	724 (22%)	<0.001	60 (2.9%)	352 (17.9%)	584 (34.2%)	396 (26.5%)	<0
High (>20%)	1415 (19.5%)	305 (7.7%)	1110 (33.7%)	<0.001	6 (0.3%)	88 (4.5%)	442 (25.9%)	879 (58.8%)	<0

	Total (7630)	**F (4132)**	**M (3498)**	**p-value**	**35-44 (2173)**	**45-54 (2053)**	**55-64 (1796)**	**>65 (1608)**	**p-**
Notes: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**Notes**: Data are presented as number (percentage), mean ± standard deviation, or median [25th - 75th]. **Abbreviations**: F, Female; M, Male; HTN, Hypertension; IFG, Impaired fasting glucose; DM, Diabetes mellitus; CVD, Cardiovascular diseases; BMI, Body mass index; LDL, low-density lipoproteins; HDL,	**No** Da are pre sen as nu ber (pe cen age me ± da dev tio me [25 75t **Ab bre via on** Fe le; Ma HT Hy ten on IF Im rec fas glu se; DM Dia tes me tus CV Ca vas lar dis ses BM Bo ma inc LD low der lip pro ins

	Total (7630)	F (4132)	M (3498)	p-value	35-44 (2173)	45-54 (2053)	55-64 (1796)	>65 (1608)	p-

Table 2 Prevalence of major and minor electrocardiographic abnormalities by gender

ECG pattern	Total (7630)	F (4132)	F (4132)	F (4132)	M (3498)	p-Value	p-Value
Major abnormalities	**Major abnormalities**	**Major abnormalities**	**Major abnormalities**	**Major abnormalities**	**Major abnormalities**	**Major abnormalities**	**Major abnormalities**
Total	221(2.89)	221(2.89)	111(2.68 %)	110 (3.14 %)	110 (3.14 %)	110 (3.14 %)	0.188
AF	40(0.52%)	40(0.52%)	25 (0.6%)	15 (0.4%)	15 (0.4%)	15 (0.4%)	0.288
AFL	3(0.03%)	3(0.03%)	1 (0%)	2 (0.1%)	2 (0.1%)	2 (0.1%)	0.597
LBBB	73(0.95%)	73(0.95%)	47 (1.1%)	26 (0.7%)	26 (0.7%)	26 (0.7%)	0.078
RBBB	101(1.32%)	101(1.32%)	37 (0.9%)	64 (1.8%)	64 (1.8%)	64 (1.8%)	<0.001
WPW	4(0.05%)	4(0.05%)	1 (0%)	3 (0.1%)	3 (0.1%)	3 (0.1%)	0.339
Minor abnormalities	**Minor abnormalities**	**Minor abnormalities**	**Minor abnormalities**	**Minor abnormalities**	**Minor abnormalities**	**Minor abnormalities**	**Minor abnormalities**
Total	1,973 (25.84%)	1,973 (25.84%)	702 (16.98%)	1271 (36.33%)	1271 (36.33%)	1271 (36.33%)	<0.001
Sinus Bradycardia	1145(15%)	1145(15%)	412 (10.7%)	733 (22.4%)	733 (22.4%)	733 (22.4%)	<0.001
PVC	95(1.24)	95(1.24)	39 (0.9%)	56 (1.6%)	56 (1.6%)	56 (1.6%)	0.010
PAC	67(0.87)	67(0.87)	29 (0.7%)	38 (1.1%)	38 (1.1%)	38 (1.1%)	0.073
First degree AVB	70(0.91)	70(0.91)	21 (0.5%)	49 (1.4%)	49 (1.4%)	49 (1.4%)	<0.001
Incomplete RBBB	218(2.85)	218(2.85)	73 (1.8%)	145 (4.1%)	145 (4.1%)	145 (4.1%)	<0.001
Incomplete LBBB	1(0.01%)	1(0.01%)	0 (0%)	1 (0%)	1 (0%)	1 (0%)	0.458
LAFB	345(4.52)	345(4.52)	113 (2.7%)	232 (6.6%)	232 (6.6%)	232 (6.6%)	<0.001
LPFB	32(0.41)	32(0.41)	15 (0.4%)	17 (0.5%)	17 (0.5%)	17 (0.5%)	0.408
QRS axis deviation	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**
Total	464(6.08)	464(6.08)	167(2.18)	297(3.89)	297(3.89)	297(3.89)	<0.001
Left deviation	394(5.16)	394(5.16)	137 (3.3%)	257 (7.3%)	257 (7.3%)	257 (7.3%)	<0.001
Right deviation	63(0.82)	63(0.82)	29 (0.7%)	34 (1%)	34 (1%)	34 (1%)	<0.001
Extreme Right deviation	7(0.09)	7(0.09)	1 (0%)	6 (0.2%)	6 (0.2%)	6 (0.2%)	<0.001
Chamber enlargement patterns	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**

ECG pattern	Total (7630)	F (4132)	F (4132)	F (4132)	M (3498)	p-Value	p-Value
LVH	244(3.19)	244(3.19)	69(1.7%)	175(5%)	175(5%)	175(5%)	<0.001
LAE	360(4.71)	360(4.71)	108 (2.6%)	252(7.2%)	252(7.2%)	252(7.2%)	<0.001
ST segment, T, and Q wave	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**
ST segment elevation	124(1.62)	124(1.62)	55(1.3%)	69 (2%)	69 (2%)	69 (2%)	0.027
ST segment depression	430(5.63)	430(5.63)	288 (7%)	142 (4.1%)	142 (4.1%)	142 (4.1%)	<0.001
T wave inversion	5(0.06)	5(0.06)	1 (0%)	4 (0.1%)	4 (0.1%)	4 (0.1%)	0.186
Q wave	1639(21.48)	1639(21.48)	819 (19.8%)	820 (23.4%)	820 (23.4%)	820 (23.4%)	<0.001
F-QRS	740(9.69)	740(9.69)	317 (7.7%)	423 (12.1%)	423 (12.1%)	423 (12.1%)	<0.001
Brugada, and early repolarization	**Brugada, and early repolarization**	**Brugada, and early repolarization**	**Brugada, and early repolarization**	**Brugada, and early repolarization**	**Brugada, and early repolarization**	**Brugada, and early repolarization**	**Brugada, and early repolarization**
Brugada Pattern	21(0.27)	21(0.27)	1 (0%)	20 (0.6%)	20 (0.6%)	20 (0.6%)	<0.001
Anterior Early repolarization	37(0.48)	37(0.48)	4 (0.1%)	33(0.9%)	33(0.9%)	33(0.9%)	<0.001
Inferior/Inferolateral Early repolarization	119(1.42)	119(1.42)	20 (0.5%)	89 (2.5%)	89 (2.5%)	89 (2.5%)	<0.001
Sinus Arrhythmia	22(0.28)	22(0.28)	12 (0.3%)	10 (0.3%)	10 (0.3%)	10 (0.3%)	0.971
ECG values	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**
RR interval (ms)	870.6 (133.18)	870.6 (133.18)	847.3 (124.6)	897.8 (137.7)	897.8 (137.7)	897.8 (137.7)	<0.001
HR (bpm)	70.6 (11.03)	70.6 (11.03)	72.4 (10.95)	68.4 (10.73)	68.4 (10.73)	68.4 (10.73)	<0.001
QRS duration (ms)	83.9 (12.77)	83.9 (12.77)	81.3 (11.72)	86.8 (13.31)	86.8 (13.31)	86.8 (13.31)	<0.001
P-wave duration (ms)	90.7 (12.55)	90.7 (12.55)	89.2 (12.2)	92.5 (12.72)	92.5 (12.72)	92.5 (12.72)	<0.001

ECG pattern	**Total (7630)**	**F (4132)**	**F (4132)**	**F (4132)**	**M (3498)**	**p-Value**	**p-Value**
Notes: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS	**Notes**: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS	**Notes**: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS	**Notes**: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS	**Notes**: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS	**Notes**: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS	**Notes**: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS	**Notes**: Data are presented as number (percentage) **Abbreviations**: AF, atrial fibrillation; AFL, atrial flutter; LBBB, left bundle branch block; RBBB, Right bundle branch block; WPW, wolff-parkinson-white; PVC, Premature ventricular complex; PAC, Premature atrial complex; AVB, atrioventricular block; LAFB, left anterior fascicular block; LPFB, Left posterior fascicular block; LVH, Left ventricular hypertrophy; LAE, Left atrial enlargement; F-QRS

ECG pattern	Total (7630)	F (4132)	F (4132)	F (4132)	M (3498)	p-Value	p-Value

Table 3 Prevalence of major and minor electrocardiographic abnormalities by age groups

Age Group	Age Group			35-44	35-44			45-54	45-54				55-64	55-64	
ECG parameters	ECG parameters	Total (7630)		F (1240)	F (1240)	M (933)	M (933)	p-value	F (1120)	F (1120)	M (933)	M (933)	p-value	F (1016)	F (1016)	M (780
	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Major abnormalities	Maj
Total	Total	221 (2.89)		8 (0.6%)	8 (0.6%)	5 (0.5%)	5 (0.5%)	0.929	10 (0.9%)	10 (0.9%)	5 (0.5%)	5 (0.5%)	0.143	29 (2.9%)	29 (2.9%)	15 (1.9
AF	AF	40 (0.52%)		1 (0.1%)	1 (0.1%)	0 (0%)	0 (0%)	>0.9993	3 (0.3%)	3 (0.3%)	0 (0%)	0 (0%)	0.256	9 (0.9%)	9 (0.9%)	1 (0.1
AFL	AFL	3 (0.03%)		0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	1 (0.1%)	1 (0.1%)	0 (0%
LBBB	LBBB	73 (0.95%)		2 (0.2%)	2 (0.2%)	1 (0.1%)	1 (0.1%)	>0.9993	3 (0.3%)	3 (0.3%)	0 (0%)	0 (0%)	0.256	9 (0.9%)	9 (0.9%)	3 (0.4
RBBB	RBBB	101 (1.32%)		5 (0.4%)	5 (0.4%)	3 (0.3%)	3 (0.3%)	>0.9993	3 (0.3%)	3 (0.3%)	4 (0.4%)	4 (0.4%)	0.709	10 (1%)	10 (1%)	11 (1.4
WPW	WPW	4 (0.05%)		0 (0%)	0 (0%)	1 (0.1%)	1 (0.1%)	0.429	1 (0.1%)	1 (0.1%)	1 (0.1%)	1 (0.1%)	>0.999	0 (0%)	0 (0%)	0 (0%
	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Minor abnormalities	Min
Total	Total	1,973 (25.84%)		130 (10.5%)	130 (10.5%)	259 (27.7%)	259 (27.7%)	<0.001	168 (15%)	168 (15%)	301 (32.26%)	301 (32.26%)	<0.001	192 (18.89%)	192 (18.89%)	294 (37.6
Sinus Bradycardia	Sinus Bradycardia	1145 (15%)		86 (7.3%)	86 (7.3%)	179 (20.1%)	179 (20.1%)	<0.001	114 (11%)	114 (11%)	177 (20.2%)	177 (20.2%)	<0.001	116 (12.4%)	116 (12.4%)	177 (24.3
PVC	PVC	95 (1.24)		6 (0.5%)	6 (0.5%)	2 (0.2%)	2 (0.2%)	0.479	9 (0.8%)	9 (0.8%)	11 (1.2%)	11 (1.2%)	0.388	14 (1.4%)	14 (1.4%)	10 (1.3
PAC	PAC	67 (0.87)		3 (0.2%)	3 (0.2%)	0 (0%)	0 (0%)	0.265	3 (0.3%)	3 (0.3%)	4 (0.4%)	4 (0.4%)	0.709	6 (0.6%)	6 (0.6%)	7 (0.9
First degree AV block	First degree AV block	70 (0.91)		2 (0.2%)	2 (0.2%)	4 (0.4%)	4 (0.4%)	0.412	4 (0.4%)	4 (0.4%)	5 (0.5%)	5 (0.5%)	0.74	3 (0.3%)	3 (0.3%)	10 (1.3

Age Group	**Age Group**				**35-44**	**35-44**			**45-54**	**45-54**			**55-64**	**55-64**		
Incomplete RBBB	Incomplete RBBB	218 (2.85)			14 (1.1%)	14 (1.1%)	42 (4.5%)	42 (4.5%)	<0.001	16 (1.4%)	16 (1.4%)	49 (5.3%)	49 (5.3%)	<0.001	20 (2%)	20 (2%)	32 (4.1%
Incomplete LBBB	Incomplete LBBB	1 (0.01%)			0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	0 (0%)
LAFB	LAFB	345 (4.52)			12 (1%)	12 (1%)	23 (2.5%)	23 (2.5%)	0.006	20 (1.8%)	20 (1.8%)	52 (5.6%)	52 (5.6%)	<0.001	31 (3.1%)	31 (3.1%)	55 (7.1%
LPFB	LPFB	32 (0.41)			7 (0.6%)	7 (0.6%)	9 (1%)	9 (1%)	0.28	2 (0.2%)	2 (0.2%)	3 (0.3%)	3 (0.3%)	0.664	2 (0.2%)	2 (0.2%)	3 (0.4%
	QRS axis deviation	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**	**QRS axis deviation**
Left deviation	Left deviation	394 (5.16)			13 (1%)	13 (1%)	21 (2.3%)	21 (2.3%)	0.065	21 (1.9%)	21 (1.9%)	53 (5.7%)	53 (5.7%)	<0.001	39 (3.8%)	39 (3.8%)	61 (7.8%
Right deviation	Right deviation	63 (0.82)			17 (1.4%)	17 (1.4%)	16 (1.7%)	16 (1.7%)	0.405	3 (0.3%)	3 (0.3%)	7 (0.8%)	7 (0.8%)	<0.001	3 (0.3%)	3 (0.3%)	5 (0.6%
Extreme Right deviation	Extreme Right deviation	7 (0.09)			0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	1 (0.1%)	1 (0.1%)	0.429	1 (0.1%)	1 (0.1%)	2 (0.3%
	Chamber enlargement patterns	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**	**Chamber enlargement patterns**
LVH	LVH	244 (3.19)			8 (0.6%)	8 (0.6%)	35 (3.8%)	35 (3.8%)	<0.001	10 (0.9%)	10 (0.9%)	38 (4.1%)	38 (4.1%)	<0.001	16 (1.6%)	16 (1.6%)	38 (4.9%
LAE	LAE	360 (4.71)			3 (0.2%)	3 (0.2%)	20 (2.1%)	20 (2.1%)	<0.001	18 (1.6%)	18 (1.6%)	55 (5.9%)	55 (5.9%)	<0.001	35 (3.4%)	35 (3.4%)	72 (9.2%
	ST segment, T, and Q wave	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**	**ST segment, T, and Q wave**
ST segment elevation	ST segment elevation	124 (1.62)			5 (0.4%)	5 (0.4%)	10 (1.1%)	10 (1.1%)	0.062	5 (0.4%)	5 (0.4%)	10 (1.1%)	10 (1.1%)	0.098	11 (1.1%)	11 (1.1%)	16 (2.1%
ST segment depression	ST segment depression	430 (5.63)			47 (3.8%)	47 (3.8%)	14 (1.5%)	14 (1.5%)	0.001	53 (4.7%)	53 (4.7%)	22 (2.4%)	22 (2.4%)	0.004	77 (7.6%)	77 (7.6%)	23 (2.9%
T wave inversion	T wave inversion	5 (0.06)			0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	1 (0.1%)	1 (0.1%)	1 (0.1%

Age Group	Age Group				35-44	35-44			45-54	45-54			55-64	55-64		
Q wave	Q wave	1639 (21.48)			160 (12.9%)	160 (12.9%)	206 (22.1%)	206 (22.1%)	<0.001	237 (21.2%)	237 (21.2%)	203 (21.8%)	203 (21.8%)	0.743	218 (21.5%)	218 (21.5%)	186 (23.8
f-QRS	f-QRS	740 (9.69)			58 (4.7%)	58 (4.7%)	76 (8.1%)	76 (8.1%)	0.001	73 (6.5%)	73 (6.5%)	97 (10.4%)	97 (10.4%)	0.001	87 (8.6%)	87 (8.6%)	100 (12.8
	Brugada and early repolarization	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**	**Brugada and early repolarization**
Brugada Pattern	Brugada Pattern	21 (0.27)			0 (0%)	0 (0%)	6 (0.7%)	6 (0.7%)	0.006	0 (0%)	0 (0%)	4 (0.4%)	4 (0.4%)	0.042	0 (0%)	0 (0%)	5 (0.7%
Anterior Early repolarization	Anterior Early repolarization	37 (0.48)			1 (0.1%)	1 (0.1%)	8 (0.9%)	8 (0.9%)	<0.001	0 (0%)	0 (0%)	5 (0.5%)	5 (0.5%)	<0.001	3 (0.3%)	3 (0.3%)	13 (1.7%
Inferior/lateral Early repolarization	Inferior/lateral Early repolarization	106 (1.42)			6 (0.5%)	6 (0.5%)	43 (4.6%)	43 (4.6%)	<0.001	8 (0.7%)	8 (0.7%)	26 (2.8%)	26 (2.8%)	<0.001	4 (0.4%)	4 (0.4%)	12 (1.5%
	ECG values	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**	**ECG values**
RR interval (ms)	RR Interval (ms)	870.6 (133.18)			833.6 (117.39)	833.6 (117.39)	890 (132.93)	890 (132.93)	<0.001	849 (122.44)	849 (122.44)	890.7 (128.09)	890.7 (128.09)	<0.001	858.7 (126.26)	858.7 (126.26)	904.5 (142
Heart Rate	Heart Rate	70.6 (11.03)			73.4 (10.67)	73.4 (10.67)	68.9 (10.25)	68.9 (10.25)	<0.001	72.2 (10.67)	72.2 (10.67)	68.8 (9.97)	68.8 (9.97)	<0.001	71.4 (10.82)	71.4 (10.82)	68 (10.8
QRS duration (ms)	QRS duration (ms)	83.9 (12.77)			80.9 (9.64)	80.9 (9.64)	86.9 (10.02)	86.9 (10.02)	<0.001	80.5 (9.38)	80.5 (9.38)	86.3 (10.37)	86.3 (10.37)	<0.001	80.8 (11.95)	80.8 (11.95)	85.5 (12.5
P-wave duration (ms)	P-wave duration (ms)	90.7 (12.55)			87.2 (11.12)	87.2 (11.12)	90.2 (11.5)	90.2 (11.5)	<0.001	88.9 (11.51)	88.9 (11.51)	92 (12.01)	92 (12.01)	<0.001	90.5 (12.59)	90.5 (12.59)	93.7 (13.2

Age Group	**Age Group**					**35-44**	**35-44**					**45-54**	**45-54**					**55-64**	**55-64**
	Notes: Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-	**Notes:** Data are presented as number (percentage) **Abbreviations:** AF, atrial fibrillation; AFL, atrial flutter; LBBB, Left Bundle Branch Block; RBBB, Right Bundle Branch Block; PVC, Premature Ventricular Complex; PAC, Premature Atrial Complex; LAFB, Left An-

Age Group	Age Group	35-44	35-44	45-54	45-54	55-64	55-64

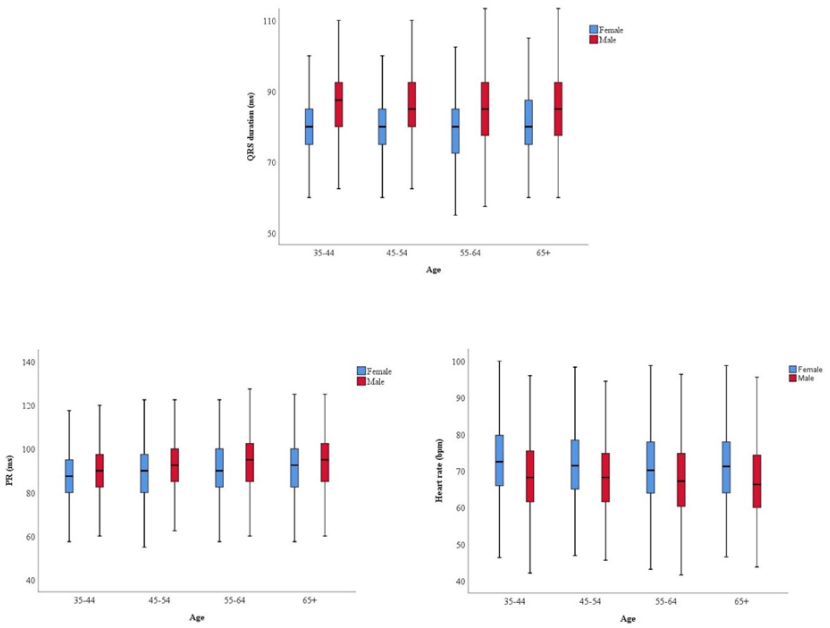

Figure 1 Average ECG basic values in Tehran general population, stratified by age and gender

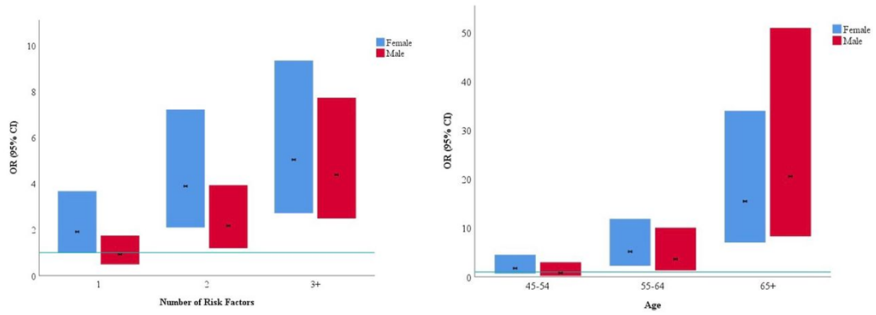

Figure 2 - OR of having any major ECG abnormality among males, and females stratified by age, and CV risk factors. The Bars illustrate the measured OR, and the 95% confidence interval. The reference value for age group is 34 to 45 age group, and for CV risk factors is participants with no conventional CV risk factors.