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Title: Major Electrocardiographic Abnormalities According to the Minnesota Coding System Among Brazilian Adults (From the ELSA-Brasil Cohort Study)

Article Type: Full Length Article

Keywords: Electrocardiography; Risk Factors; Brazil; Minnesota Code.

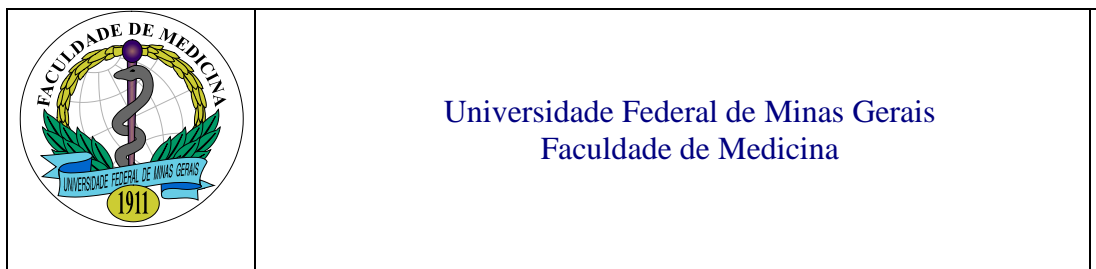
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Abstract: The electrocardiogram (ECG) is a simple and useful clinical tool; nevertheless, few studies have evaluated the prevalence of electrocardiographic abnormalities in the Latin American population. This study aims to evaluate the major electrocardiographic abnormalities according to the Minnesota coding system in Brazilian adults, stratified by sex, age, race and cardiovascular risk factors. Data from 14424 adults (45.8% men, age 35-74 years) were obtained at baseline of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil), according to standardized protocol. The ECG were obtained with the Burdick Atria 6100 machine, stored on Pyramis System, automatically coded according to the Minnesota coding system by the Glasgow University software and then manually revised. Major abnormalities were more prevalent in men than women (11.3% and 7.9%, $p < 0.001$). These differences were consistent through the different age groups, race and number of cardiovascular risk factors. Electrocardiographic major abnormalities were more prevalent in black participants for both men (black: 15.1%, mixed: 10.4%, white: 11.1%, $p = 0.001$) and women (black: 10%, mixed: 7.6%, white: 7.2%, $p = 0.004$). In conclusion, in this large sample of Brazilian adults, the prevalence of major electrocardiographic abnormalities was higher among men, the elderly, black and among people with more cardiovascular risk factors.



Belo Horizonte, December 15th, 2016.

Prof. William C. Roberts,

The Editor-in-Chief for the “American Journal of Cardiology”

Dear Sir,

You will find attached a file containing the manuscript entitled “**Major electrocardiographic abnormalities according to the Minnesota Coding System among adults: the ELSA-Brasil cohort study**” which we are submitting to be evaluated for publication.

This study is a subproject of a Brazilian multicenter cohort entitled “Brazilian Study of Adult Health – ELSA-Brazil”, which is a large cohort study in Latin America and intends to investigate the determinants of cardiovascular diseases in 15,105 participants. A conventional electrocardiogram (ECG) recording was obtained from all participants at baseline followed by automated analysis using the Glasgow software and automated coding according to the Minnesota Coding System. The major electrocardiographic abnormalities were posteriorly revised manually by myself and professor Ribeiro in order to increase accuracy.

We found that, in this Brazilian cohort, major electrocardiographic abnormalities are more prevalent in men than in women, and increase with age and with the number of cardiovascular risk factors present. We also analyzed its relationship with race and found them to be more prevalent in black participants.

So far, this is the largest cohort study in Brazil and Latin America, and race analysis in such a mixed country brings great originality to this paper.

I would like to assure you that all authors have read and approved the submission of the manuscript; the manuscript has not been published and is not being

considered for publication elsewhere, in whole or in part, in any language. There are no conflicts of interest and the study complies with current ethical considerations. No portion of the text has been copied from other material in the literature (unless in quotation marks, with citation) and I am aware that it is the authors responsibility to obtain permission for any figures or tables reproduced from any prior publications, and to cover fully any costs involved.

I look forward to hearing from you.

Yours sincerely,

Marcelo Martins Pinto Filho.

On behalf of the authors:

Marcelo M. Pinto-Filho^{a,b}, Luisa C. C. Brant^{a,b}, Murilo Foppa^{c,d}, Kaiser B. Garcia-Silva^a, Rackel Aguiar Mendes de Oliveira^a, Maria de Jesus Mendes da Fonseca^e, Sheila Alvim^f, Paulo A. Lotufo^{g,h}, José G. Millⁱ, Sandhi M. Barreto^a, Peter W. Macfarlane^j, Antonio L. P. Ribeiro^{a,b}

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January 25th, 2017

Prof. William C. Roberts,

The Editor-in-Chief for the “American Journal of Cardiology”

RE: AJC-D-16-03091

Major Electrocardiographic Abnormalities according to the Minnesota Coding System among Brazilian Adults (From the ELSA-Brasil Cohort Study)

Dear Dr. Roberts,

Thank you for your consideration and interest in our paper, which is in evaluation for publication in *the American Journal of Cardiology*. We have worked on the manuscript to improve specific points highlighted by the reviewer and have answered the questions as listed below. The modifications that we have made to the text are indicated (page, paragraph) in each answer and highlighted across the text. All the modifications that you have suggest to adequate the manuscript to the AJC requirements have been made.

Once again, we would like to thank you and the editorial board for your consideration and we hope that you find the revised manuscript suitable for publication.

Sincerely,

Antonio L. P. Ribeiro, MD, PhD

Full Professor of Internal Medicine

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Reviewer #1: This report is derived from the ongoing Brazilian Longitudinal Study of Adult Health and reports on ECG abnormalities among the 14,424 adults aged 35-74 years at baseline.

The findings that "major abnormalities" were more prevalent among men than women, the old than young, men than women and blacks than whites- are in line with studies from other countries and continents.

On the face of it, this is a straightforward archival report of adult electrocardiographic abnormalities in a section of Brazil. The description and statistical methods used are appropriate but certain things are lacking to make this a more useful contribution to the literature and these are detailed below:

Specific Major Comments:

1. First, it is indeterminate as to how the Minnesota Code patterns, reported on here, were precisely determined.

- Author's reply

The determination of the Minnesota Code patterns were made according to the reference 17 (Prineas RJ CR, Zhang ZM. The Minnesota Code Manual of Electrocardiographic Findings. Second ed. Springer L, editor. London: Springer; 2010.) which is the most often used in this kind of paper. We judged that a detailed description would imply in a more extensive manuscript and in that case could be left out without substantial prejudice. The major abnormalities are also detailed in table 3. If you feel this description should be on the manuscript we could certainly add it to the text at the expense of additional space on the manuscript. To reinforce our reference with recited it in the second paragraph at page 5.

- Manuscript changes (page 5, paragraph 2)

“The following were considered to be major abnormalities (17): major Q waves (old myocardial infarctions, MC 1-1, 1-2)...”

On page 5 of the manuscript it is stated "To improve the accuracy of the automatic coding, the Minnesota Codes (MC) related to major abnormalities were manually revised." and 2 references are given Guglin et al 2006; and Kors, 2000). The 1st of these references showed that an electrocardiograph built-in software diagnostic program (12SL) had discrepancies compared to cardiologists readings of ECGs - i.e. this is different from the current study because the human readers classification system and the computer readings were both different. The second reference (which by the way lists only the first author, of several, in the reference listing), by Kors et al. the computer program used was the 1974 version of the Novacode to derive Minnesota codes and also the MC-MEANS computer program of Kors. A selected sample of normal and abnormal records (all of which had also been visually coded in a standard manner by trained Minnesota code technicians) recorded by the NOVACODE program were compared to those of the Nova code

program and to the visual coding. There were discrepancies between all 3 coding methods. On the basis of this one experiment the study suggested multipliers for prevalence of abnormalities obtained visually to each of the 2 computer program prevalences. That is, the 2 references show that differences between specific computer readings and specific visual classifications occur. They do not show how, in the present study how "the accuracy of the automatic coding, the Minnesota Codes (MC) related to major abnormalities were manually revised " THIS DESCRIPTION IS NEEDED FOR THE PRESENT PAPER.

- Author's reply

We thank you very much for the observation. Indeed, reference 18 (by Guglin et al 2006) is inadequate and so is the affirmative that manual revision improved the accuracy of the automated reading. In electrocardiogram reading centers, manual revision is part of a routine of ECG analyses. Both the American (Wake Forest University) and Scottish (at Glasgow University) electrocardiogram reading centers, headed by Dr Prineas and Dr Macfarlane, adopt this strategy. The papers related to electrocardiogram abnormalities also often follow this strategy. The work from Bhatt H et al, 2016 (*Bhatt H, Gamboa CM, Safford MM, Soliman EZ, Glasser SP. Prevalence of Electrocardiographic Abnormalities Based on Hypertension Severity and Blood Pressure Levels: the Reasons for Geographic and Racial Differences in Stroke Study. Journal of the American Society of Hypertension 2016; Vol 10, Issue 9 707-713*) also exemplify this. Nevertheless, it is more appropriate to state that there is a difference between automated and manual reading (as stated in reference 19 by Kors et al) rather than an improvement in accuracy with manual reading. Thank you again for the observation.

- Manuscript Changes

Page 5, paragraph 2 (last sentence was suppressed, reference from Guglin 2006 was also suppressed). Added sentence marked in red color.

“The ECG intervals (PR interval and QT interval), wave durations (P and QRS) and axis (P, R and T axis) were obtained through automated analysis. QTc duration was calculated according to the Hodges formula¹⁵ and by the calculation of the QT index (QTi), calculated as $QTi = (QT/656) * (\text{heart rate} + 100)$ ¹⁶. For the Minnesota coding system, abnormalities were classified into minor and major categories¹⁷. **Major electrocardiographic abnormalities were over-read manually by a physician**¹⁸. Patients were classified according to the findings as having “any major abnormality” but also on the basis of the sum of major abnormalities.”

Page 10 (end of paragraph started at page 9) the last sentence (“The manual revision was important to guarantee the reliability of our results.”) was suppressed.

2. On page 3 speaks of the sample as including "—adults at different ages, ancestry and sociodemographic variables. The later analyses include age and

ethnicity as examined subgroups but there are no analyses (either univalent or multivariable) that include socioeconomic subdivisions. Why not?

- Author's reply: Thank you for the observation. We expect that socioeconomic subdivisions does not affect directly the electrocardiogram pattern, but mostly affects it when related to cardiovascular risk factors or race. Nevertheless, we are aware that we cannot state that with absolute certainty. Still, socioeconomic variables was not part of the objectives of our study, which aimed at evaluating cardiovascular risk factors and race. The socioeconomic implications in electrocardiographic abnormalities can be the object of future studies.
- Manuscript Changes: (end of first paragraph page 3)

The sentence "and socioeconomic conditions" was suppressed.

3. You reference the ECG recording mode but don't state it directly here. This is an ECG paper and you should include the "12-standard leads recorded simultaneously - for how many seconds?

- Author's reply: Indeed, we could have better explained in the manuscript the ECG recording methodology. The detailed process of the ECG acquisition is detailed in reference 13 (Ribeiro ALP et al., 2013).

- Manuscript changes (page 5, paragraph begun at page 4 -in red):

"Participants had their ECG recorded in the six different research centers according to a standardized protocol¹³, using the Burdick Atria 6100 machine, with a paper speed of 25mm/second and a calibration of 10mm/mV. **Digital data were acquired with simultaneous acquisition of 12 high-frequency leads (500 samples/second per channel), high-resolution thermal print in 10 seconds.** The recordings were sent to the reading center in Minas Gerais Investigation Center for automated analysis using the Glasgow software¹⁴, and automated coding according to the Minnesota Coding System."

4. In the discussion you quote rates of major abnormalities reported in other European and American studies. However, a table with the studies compared listing the #s and demographics and definitions of "major abnormality" and method of recording and method of determining Minnesota code (all missing in Discussion section comparisons) would be more easily understood.

We agree that it is important to compare our results with other studies and we tried to highlight those most representatives in the discussion text. However, to systematically review all studies and present them in table would be a task for a new study, a systematic review, which we agree would be very useful. If the reviewer and the editor agree with us, we would prefer not to add this table.

Minor comments:

1. All references should be checked for correct and complete author attribution.

Done

2. Table 3 the definition of Left ventricular hypertrophy is incomplete

- Author's reply: The definition of left Ventricular Hypertrophy was not actually given (just as the definitions for the other abnormalities were also not given). It utilizes the Minnesota Code's criteria.
- Manuscript change: We specified in tables 3 and 4 the left ventricular hypertrophy criteria utilized.

3. Table 4 - same as table 3.

Done

4. Figure 3 - all 4 panels would be better represented in one table.

Thank you for your suggestion. We feel that the graphs in figure 3 are more reader friendly, and depict well the progressive nature of electrocardiographic abnormalities with increasing age and cardiovascular risk factors. We would like, if you agree, to keep the 4 panels to represent the specific abnormalities, but are open to change it to a table, if you strongly feel it would be more didactical.

Reviewer #2: This is unique and valuable study utilizing digital ECGs in a large cohort of community-based individuals at the age of 35-74 years. The authors found ECG abnormalities more frequently present in men than women, in black vs non-black, and in older vs younger individuals. Also subjects with self-reported cardiovascular risk factors had more ECG abnormalities. There are only very few such large cohorts worldwide and the data from Brazilian cohort add significantly to this ECG epidemiology literature. Strengths of the study not only include a large cohort but most importantly the state-of-the-art ECG methodology and analyses. The analyses by race within each gender are innovative since this data are not readily available in other cohorts.

One realizes that the investigators do not have yet long-term follow-up of the studied individuals but despite that epidemiological information regarding prevalence of specific findings is important.

- Author's reply: We kindly thank you very much for your comments.

Reviewer Suggestions

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Sayed Soliman, Wake Forest University, esoliman@wakehealth.edu

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Major Electrocardiographic Abnormalities According to the Minnesota Coding System Among Brazilian Adults (From the ELSA-Brasil Cohort Study)

Alterações eletrocardiográficas maiores pelo Código de Minnesota em adultos:

Estudo Longitudinal de Saúde do Adulto - ELSA-Brasil

Short Title: Major electrocardiographic abnormalities in adults

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ABSTRACT

The electrocardiogram (ECG) is a simple and useful clinical tool; nevertheless, few studies have evaluated the prevalence of electrocardiographic abnormalities in the Latin American population. This study aims to evaluate the major electrocardiographic abnormalities according to the Minnesota coding system in Brazilian adults, stratified by sex, age, race and cardiovascular risk factors. Data from 14424 adults (45.8% men, age 35-74 years) were obtained at baseline of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil), according to standardized protocol. The ECG were obtained with the Burdick Atria 6100 machine, stored on Pyramis System, automatically coded according to the Minnesota coding system by the Glasgow University software and then manually revised. Major abnormalities were more prevalent in men than women (11.3% and 7.9%, $p < 0.001$). These differences were consistent through the different age groups, race and number of cardiovascular risk factors. Electrocardiographic major abnormalities were more prevalent in black participants for both men (black: 15.1%, mixed: 10.4%, white: 11.1%, $p = 0.001$) and women (black: 10%, mixed: 7.6%, white: 7.2%, $p = 0.004$). In conclusion, in this large sample of Brazilian adults, the prevalence of major electrocardiographic abnormalities was higher among men, the elderly, black and among people with more cardiovascular risk factors.

Keywords: Electrocardiography; Risk Factors; Brazil; Minnesota Code.

The electrocardiogram (ECG) is an established method of cardiovascular evaluation that is widely available at low cost ¹. For decades, it has been used in large epidemiologic studies, in which many of its diagnostic and prognostic applications have been defined or confirmed ²⁻⁵. The ECG abnormalities and their relationship with cardiovascular disease (CVD) have been extensively studied in large North American and European populations, but not in Latin American countries, particularly in Brazil⁶, where high admixture since colonization, from many different ethnical backgrounds makes our population unique. The Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) is a multicenter cohort study that aims to evaluate the development of cardiovascular disease and diabetes in Brazilian adults ⁷. The study included 15105 participants recruited in six different cities, and the database offers a unique opportunity to evaluate electrocardiographic patterns and abnormalities in a large sample of adults at different ages and ancestry. The present study aims to describe the major electrocardiographic abnormalities according to the Minnesota Coding System ^{8,9} and their association with sociodemographic variables and cardiovascular risk factors.

METHODS

ELSA-Brasil recruited 15105 civil servants of both sexes aged 35 to 74 years old living in 6 Brazilian cities (Belo Horizonte, Rio de Janeiro, São Paulo, Porto Alegre, Salvador and Vitoria) and a detailed description can be found elsewhere ⁷. A conventional ECG recording was obtained from all participants at baseline (2008-2010). Participants with missing or bad quality ECG were excluded from the analysis (681 participants), resulting in a final sample of 14424 participants.

All participants in the study provided written informed consent. The ELSA-Brasil cohort study was approved by local ethics committees of the six institutions where participants were recruited and by the national ethics committee for human research.

This report is a cross-sectional descriptive study of ECGs obtained from the baseline of ELSA-Brasil cohort study. The ELSA-Brasil is an ongoing study that aims to evaluate the determinants of cardiovascular disease and diabetes in Brazilian adults. The ELSA-Brasil detailed methodology has been published elsewhere⁷. From 2008 to 2010 the participants were assessed at baseline by a standardized questionnaire, in addition to acquisition of physiologic and anthropometric data.

Hypertension was defined as a systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure (DBP) ≥ 90 mmHg or self-declared use of anti-hypertensive medication. Diabetes was defined by “known diagnosis of diabetes” or “receiving treatment for diabetes” or fasting glucose ≥ 126 mg/dl or post prandial glycaemia ≥ 200 mg/dl or glycohemoglobin $\geq 6,5\%$ ¹⁰. In this paper, presence of dyslipidemia was defined as total cholesterol ≥ 240 mg/dl, or LDL cholesterol ≥ 160 mg/dl, or HDL cholesterol ≤ 40 mg/dl, or “current use of lipid-lowering medication”¹¹. Obesity was defined as a body mass index ≥ 30 Kg/m² and smoking as “current use of tobacco”. Prevalent cardiovascular disease was defined by self-reported previous diagnosis of heart failure, coronary heart disease (previous myocardial infarction or previous coronary revascularization) and stroke.

Race was self-reported according to the Brazilian National Census (white, mixed/brown, black, Asian and indigenous).

Participants had their ECG recorded in the six different research centers according to a standardized protocol¹², using the Burdick Atria 6100 machine, with a

paper speed of 25mm/second and a calibration of 10mm/mV. Digital data were acquired with simultaneous acquisition of 12 high-frequency leads (>500 samples/second per channel), high-resolution thermal print in 10 seconds. The recordings were sent to the reading center in Minas Gerais Investigation Center for automated analysis using the Glasgow software¹³, and automated coding according to the Minnesota Coding System.

The ECG intervals (PR interval and QT interval), wave durations (P and QRS) and axis (P, R and T axis) were obtained through automated analysis. QTc duration was calculated according to the Hodges formula¹⁴ and by the calculation of the QT index (QT_i), calculated as $QT_i = (QT/656) * (\text{heart rate} + 100)$ ¹⁵. For the Minnesota coding system, abnormalities were classified into minor and major categories¹⁶. Major electrocardiographic abnormalities were over-read manually by a physician¹⁷. Patients were classified according to the findings as having “any major abnormality” but also on the basis of the sum of major abnormalities.

The following were considered to be major abnormalities¹⁶: major Q waves (old myocardial infarctions, MC 1-1, 1-2), minor Q waves plus ST-T abnormalities (possible old myocardial infarction MC 1-3 plus MC 4-1 or 4-2 or 5-1 or 5-2), major isolated ST-T abnormalities (MC 4-1 or 4-2 or 5-1 or 5-2), left ventricular hypertrophy plus ST-T abnormalities (MC 3-1 plus MC 4-1 or 4-2 or 5-1 or 5-2), intraventricular conduction abnormalities (complete/intermittent right and left bundle branch block, non-specific intraventricular block, MC 7-1 or 7-2 or 7-4), right bundle branch block plus left anterior divisional block (MC 7-8), major QT prolongation index ($QT_i \geq 116\%$), atrial fibrillation/flutter (MC 8-3), supraventricular tachycardia (MC 8-4-2), atrioventricular (AV) conduction abnormalities (second and third degree AV block, artificial pacemaker, ventricular pre-excitation such as Wolff Parkinson White syndrome, MC 6-1 or 6-2 or 6-4 or 6-8).

A descriptive analysis of the data with frequencies, means, medians of electrocardiographic variables and major abnormalities were obtained. The groups stratified according to sex, age, race and number of risk factors were compared through conventional statistical methods. For medians' comparisons, we used the Mann Whitney and Kruskal-Wallis tests and for frequencies the chi-square test. For race analyses, the Bonferroni correction was utilized to evaluate difference between groups.

We used logistic regression to evaluate the impact of black race in major electrocardiographic abnormalities. Our model included the cardiovascular risk factors previously described (dyslipidemia, diabetes, hypertension and smoking). Since there was no difference in age between race groups, this variable was not included in our model.

All analyses were made using SPSS Statistics 20 (Chicago, Illinois, USA). A two-sided p -value < 0.05 was considered statistically significant, unless stated otherwise.

RESULTS

The clinical characteristics of the participants are shown in *Table 1* and the characteristics stratified by race can be found in *Supplemental Table 1*.

The ECG parameters and measurements stratified by sex are described in *Table 2* and *Table 3* summarizes the prevalence of major abnormalities among men and women. In general those were more prevalent in men.

When stratified by self-reported race, major electrocardiographic abnormalities were more prevalent in blacks, both in men and women, mainly due to isolated major ST-T abnormalities and left ventricular hypertrophy plus ST-T abnormalities. These findings are represented in *Table 4*.

There was a clear and significant trend to increase the major abnormalities with the number of cardiovascular risk factors and in older age groups as depicted in Figures 1 and 2. All specific major abnormalities also increased with age and number of cardiovascular risk factors as summarized in Figure 3.

The odds of having any major electrocardiographic abnormality increased with age and cardiovascular risk factors as described in Figure 4. Black race was also an isolated risk factor for the presence of major cardiovascular abnormalities, with an odds ratio of 1.19 (95% confidence interval 1.02-1.38) after adjustment for cardiovascular risk factors (Hosmer and Lemeshow test 0.974). Those were mostly attributed to “left ventricular hypertrophy plus ST-T abnormalities” with an OR 9.4 (95% CI 3.9-22.7) for men and 15.9 (95% CI 5.1-49.3) for women and “major isolated ST-T abnormalities” with an OR of 2.9 (95% CI 2.2-3.9) for men and 2.5 (95% CI 1.8-3.3) for women.

The odds of having atrial flutter/fibrillation also increased with age, although, for women, the effect of age could only be seen in the higher age strata (65-74 years) with an OR of 17 (95% CI 2.1-135.9). For men aged 55-64 years the OR for AF was 18.8(95% CI 1.1-320.1) and for 65-74 years 52.3 (3.1-881.8).

DISCUSSION

This cross-sectional population-based study has provided the prevalence of major electrocardiographic abnormalities in Brazilian adults residing in six different cities. Similarly to other studies on this subject¹⁸⁻²³ our study showed that major electrocardiographic abnormalities are more prevalent in men than in women. As expected, they increase with age and with the number of cardiovascular risk factors present. It is noteworthy that our study showed that black subjects are at higher risk to

show major electrocardiographic abnormalities even after adjusting to the presence of cardiovascular risk factors.

In the analysis stratified by race, when considering the comparison between individuals who self-reported their race as white or black, our findings are also consistent with studies with smaller sample sizes from different populations. In the Reasons for Geographic and Racial Differences in Stroke Study (REGARDS), Prineas *et al.*²³ described a higher prevalence of electrocardiographic abnormalities in African-Americans men and women when compared to whites, until the age of 64 years. In the Coronary Artery Risk Development in Young Adults (CARDIA) study²⁰, Walsh III *et al* also reported the same pattern in individuals with a mean age of 45 years. In the Multi-Ethnic Study of Atherosclerosis (MESA)²¹, major electrocardiographic abnormalities were more prevalent in African-American participants with an overall prevalence of 13.4% in men and 8.4% in women.

In the present study, participants who declared themselves as blacks also had higher prevalence of major electrocardiographic abnormalities when comparing to subjects who self-declared themselves as mixed race or whites, both with similar prevalence of abnormalities. Previous studies using ECG recording in Brazil had never explored the relation of prevalent abnormalities to race, and even in a country with such a unique racial background, in which miscegenation is a relevant feature, black race was also associated with major electrocardiographic abnormalities.

The particularities regarding race described above emphasize two aspects. First, the importance of studying different populations as each has its own specificities and can add new insights to current knowledge, and second, the urgent need of studies with genetic data to clarify the reported findings.

When analyzing specific ECG abnormalities, black men and women had consistently higher prevalence of left ventricular hypertrophy and ST-T abnormalities - the main reasons for the higher prevalence of major abnormalities in participants with self-reported black race. The inaccuracy of electrocardiographic diagnosis of left ventricular hypertrophy when using the same cut-off values for different races, especially in black individuals, have already been debated by Rautaharju ¹. In our study, although left ventricular hypertrophy and ST-T changes are established risk markers for coronary disease ²⁴⁻²⁶, the prevalence of major Q wave, which reflects possible prevalent myocardial infarction, was similar among the black individuals and those who self-declared other races. These evidences raises questions if the major abnormalities related to left ventricular hypertrophy and ST-T abnormalities can be applied interchangeably for different races, and whether the present criteria for these aforementioned abnormalities hold true prognostic value for black individuals ^{22,27}. Prospective studies are needed to define if different thresholds according to race will be necessary for the diagnosis of left ventricular hypertrophy.

Regarding the findings herein described for Q waves (possible prevalent myocardial infarction), they were also comparable to other cohorts. In the Seven Countries study, Keys reported a prevalence of major Q waves in men ranging from 0.6% in Japan, to 6.0% in the United States. ^{1,3} Our findings of an intermediate prevalence (3.3% in men and 1.3% in women) are consistent with an intermediate burden of ischemic heart disease (in disability-adjusted life years) in Brazil (6,77%) when compared to Japan (5,37%) and United States (9,08%) ²⁸.

Among the limitations of our study, race data was obtained from participants' self-declaration, which may have caused inaccuracies, as already cited. However, self-declaration remains the most practical strategy for race analysis, since genetic data is

rarely available in clinical practice. Another issue to be put in perspective is that race is not to be seen only as a biological variable, since it is influenced by one's social, political and cultural background. In this context, self-declaration seems to be an appropriate approach to race analysis. Among the study's strengths the large number of participants can be highlighted, as well as the standardization in electrocardiogram acquisition and analysis.

Since ELSA-Brasil is a longitudinal study, our results will offer the opportunity for future evaluation of incident ECG abnormalities and their prognostic value. It will also enable us to evaluate the importance of race in the prognostic significance of these abnormalities.

ACKNOWLEDGEMENTS

We would like to thank all the ELSA-Brasil participants.

FUNDING

The ELSA-Brasil baseline study was supported by the Brazilian Ministries of Health and of Science and Technology (grants 01060010.00RS, 01060212.00BA, 01060300.00ES, 01060278.00MG, 01060115.00SP, and 01060071.00RJ). PAL, JGM, SMB e ALPR are supported by research grant from CNPq. A.L.P.R. is also supported by a research grant (Pesquisador Mineiro) from FAPEMIG, the research agency of the State of Minas Gerais, Brazil.

DISCLOSURES

None

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FIGURE LEGENDS

Figure 1: Relationship between cardiovascular risk factors and the prevalence of major electrocardiographic abnormalities stratified by sex.

* $p < 0.01$ for both men and women

Figure 2: Prevalence of major electrocardiographic abnormalities by age group stratified by sex.

* $p < 0.01$ for both men and women

Figure 3: Specific major electrocardiographic abnormalities stratified by age groups and sum of cardiovascular risk factors.

*($p < 0.001$ for all variables, except for left ventricular hypertrophy plus major ST-T abnormalities and left bundle branch block in men by age groups, $p = 0.624$ and 0.039 respectively).

Figure 4: Odds ratio for the presence of any major electrocardiographic abnormality in men and women stratified by race, age and cardiovascular risk factors.

*Represented by their calculated odds ratio and the 95% confidence interval (the reference parameters for age group is “34-45” years and for cardiovascular risk factors is “no cardiovascular risk factors”).

Table 1: Characteristics of the Brazilian Longitudinal Study of Adult Health participants with valid electrocardiogram at baseline (n= 14424).

Characteristics	Men (45,8%)	Women(54,2%)
Age (years)	52±9	52±9
Age group (years)		
35-44	22.2%	21.2%
45-54	38.8%	39.3%
55-64	27.3%	29.4%
65-74	11.7%	10.1%
Race*		
Black	13.9%	18.3%
Mixed race	30.3%	27.1%
White	52.6%	50.9%
Asian/Yellow	1.9%	2.9%
Indigenous	1.3%	0.8%
Heart rate (bpm)	64±10	67±9
Systolic blood pressure (mmHg)	127±17	118±17
Diastolic blood pressure (mmHg)	79±11	74±10
Body mass index (kg/m ²)	27.0±4	27.1±5
Fasting glucose (mg/dl)	117±34	108±27
Low-density lipoprotein cholesterol (mg/dl)	131±34	131±34
High-density lipoprotein cholesterol (mg/dl)	51±15	62±15
Total Cholesterol (mg/dl)	213±45	217±41
Hypertension	40.3%	32.5%
Diabetes Mellitus	23.6%	16.7%
Hypercholesterolemia	47.4%	51.6%
Obesity	20.6%	24.8%
Present smoking	14.3%	12.1%
Prevalent cardiovascular Disease	8.4%	5.4%

bpm = beats per minute. Values are frequencies or means and standard deviations.

*Those who did not declare race were excluded from race analysis. Less frequent race were also excluded (Asian/yellow and indigenous).

Table 2: Eletrocardiographic interval and measurements in Brazilian Longitudinal Study of Adult Health participants.

Variables*	Men (45,8%) (n=6608)	Women (54,2%) (n=7816)	P
Heart Rate (bpm)	63(57-70)	66(60-72)	<0.001
PR interval (ms)	164(148-180)	158(144-174)	<0.001
QRS duration (ms)	94(86-100)	86(80-92)	<0.001
P axis (degrees)	54(36-64)	56(41-65)	<0.001
QRS axis (degrees)	33(4-57)	41(17-59)	<0.001
T axis (degrees)	39(18-55)	45(29-58)	<0.001
P duration (ms)	112(104-120)	108(100-116)	<0.001
QTc interval (Hodges) (ms)	412(401-424)	422(410-434)	<0.001

bpm = beats per minute; ms = milliseconds.

*Represented by the median and the first to third interquartile range.

Table 3. Prevalence of major electrocardiogram abnormalities by sex

Major Minnesota Code Abnormalities	Men (n=6608)	Women (n=7816)	P
Major Q-wave abnormalities	221(3.3%)	122(1.3%)	<0.001
Minor Q-wave plus major ST-T abnormalities	23(0.3%)	13(0.2%)	0.029
Major isolated ST-T abnormalities	257(3.9%)	305(3.9%)	0.968
Left ventricular hypertrophy* with major ST-T abnormalities	44(0.7%)	25(0.3%)	0.003
Complete/intermittent left bundle branch block	36(0.5%)	33(0.4%)	0.288
Complete/intermittent right bundle branch block	174(2.6%)	63(0.8%)	<0.001
Nonspecific intraventricular conduction delay.	69(1.0%)	17(0.2%)	<0.001
Complete/intermittent right bundle branch block with left anterior hemiblock	3(<0.01%)	0	0.096
Major atrioventricular conduction abnormalities	0	0	
Atrial fibrillation/flutter	30(0.5%)	18(0.2%)	0.020
Major QT prolongation index (QT index \geq 116%)	49(0.7%)	130(1.7%)	<0.001
Artificial pacemaker	5(0.1%)	3(<0.01%)	0.343
Pre excitation	4(0.1%)	3(<0.01%)	0.547
Supraventricular Tachycardia	0	0	
Second or third degree atrioventricular block	0	0	
Any major electrocardiographic abnormality	748(11.3%)	617(7.9%)	<0.001

*according to Minnesota Code criteria.

Table 4: Prevalence of major electrocardiographic abnormalities by race in men and women.

Major Minnesota Code Abnormalities	Men (n=6528)			P**	Difference
	Black (1) (n=904)	Mixed (2) (n=1943)	White (3) (n=3454)		
Major Q-wave abnormalities	3.1 (%)	2.6 (%)	3.9 (%)	0.039	2≠3
Minor Q-wave plus major ST-T abnormalities	0.7 (%)	0.2 (%)	0.3 (%)	0.139	
Major isolated ST-T abnormalities	8.3 (%)	4.1 (%)	2.7 (%)	<0.001	1≠2≠3
Left ventricular hypertrophy* with major ST-T abnormalities	1.9 (%)	1.0 (%)	0.2 (%)	<0.001	3≠(1=2)
Complete/intermittent left bundle branch block	0.6 (%)	0.4 (%)	0.6 (%)	0.709	
Complete/intermittent right bundle branch block	2.2 (%)	2.0 (%)	3.1 (%)	0.038	
Nonspecific intraventricular conduction delay	1.0 (%)	1.0 (%)	0.9 (%)	0.931	
Atrial fibrillation/flutter	0.3 (%)	0.4 (%)	0.6 (%)	0.422	
Major QT prolongation index (QTindex ≥116%)	0.6 (%)	0.6 (%)	0.8 (%)	0.427	
Any major electrocardiographic abnormality	14.5 (%)	10.2 (%)	11.0 (%)	0.003	1≠(2=3)
Major Minnesota Code Abnormalities	Women (n=7766)			P**	Difference
	Black (1) (n=1399)	Mixed (2) (n=2101)	White (3) (n=3948)		
Major Q-wave abnormalities	1.1 (%)	1.3 (%)	1.8 (%)	0.080	
Minor Q-wave plus major ST-T abnormalities	0.2 (%)	0.2 (%)	0.1 (%)	0.227	
Major isolated ST-T abnormalities	7.0 (%)	4.0 (%)	2.7 (%)	<0.001	1≠2≠3
Left ventricular hypertrophy* with major ST-T abnormalities	0.9 (%)	0.3 (%)	0.1 (%)	<0.001	3≠1
Complete/intermittent left bundle branch block	0.4 (%)	0.3 (%)	0.5 (%)	0.556	
Complete/intermittent right bundle branch block	0.7 (%)	0.8 (%)	0.8 (%)	0.966	
Nonspecific intraventricular conduction delay	0.1 (%)	0.1 (%)	0.3 (%)	0.202	
Atrial fibrillation/flutter	0.3 (%)	0.2 (%)	0.2 (%)	0.846	
Major QT prolongation index (QT index ≥116%)	2.1 (%)	1.6 (%)	1.5 (%)	0.352	
Any major electrocardiographic abnormality	10.4 (%)	7.4 (%)	7.0 (%)	<0.001	1≠(2=3)

*According to Minnesota Code criteria.

**The p values, when reached statistical significance (<0.05), were readjusted among each group by the Bonferroni correction, and were considered to have significance when < 0.0166 for each category.

Figure 1
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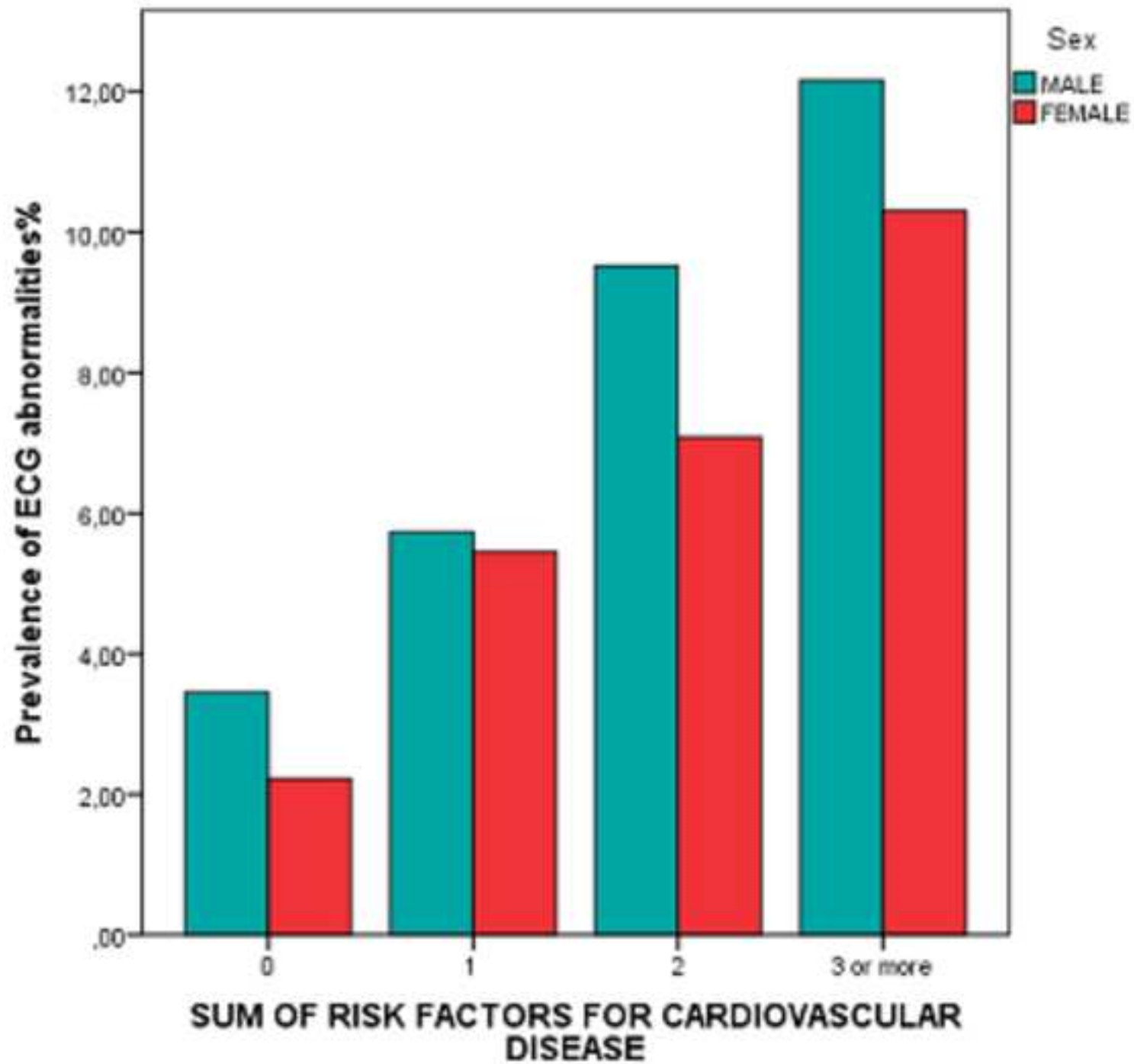


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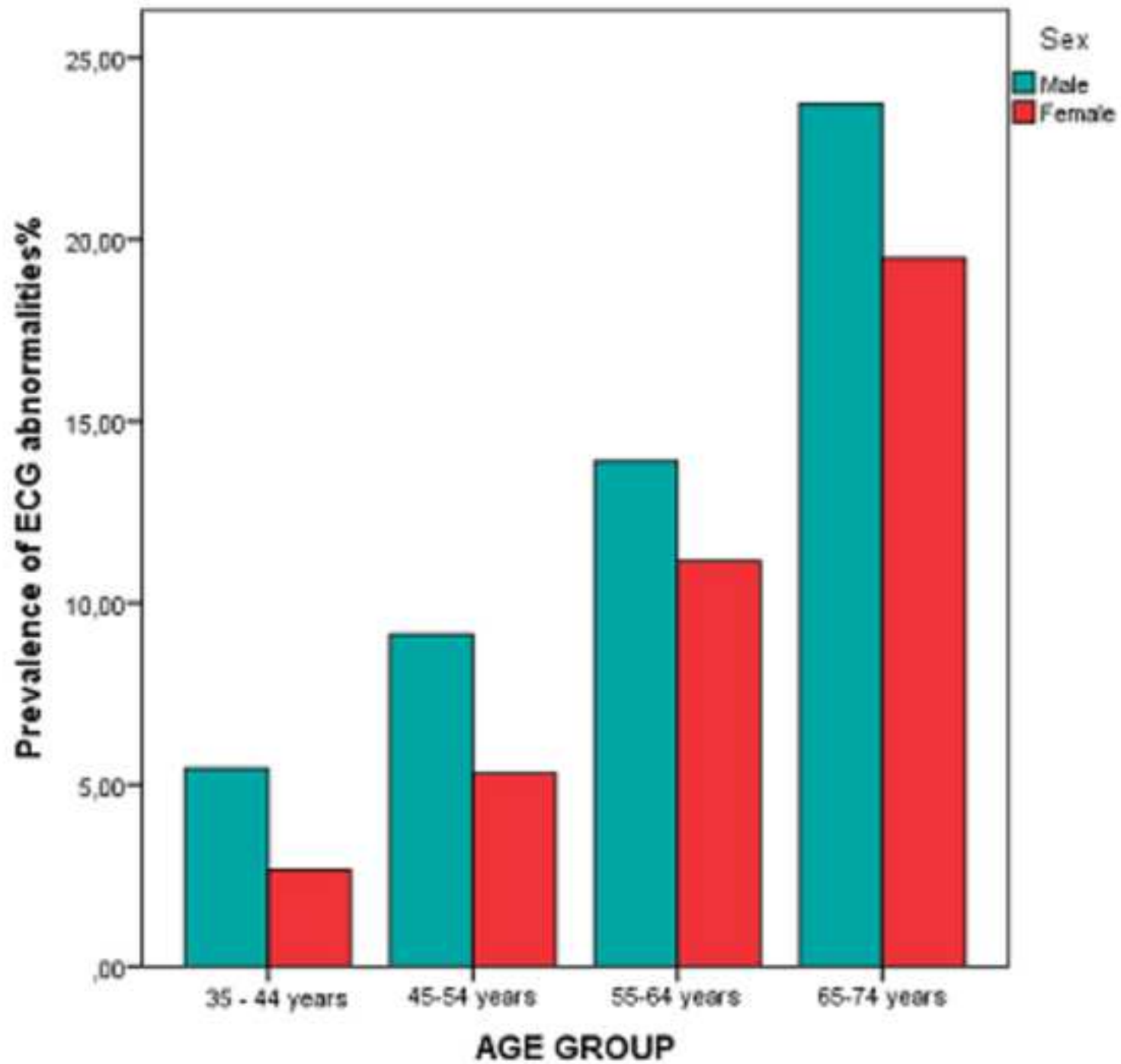


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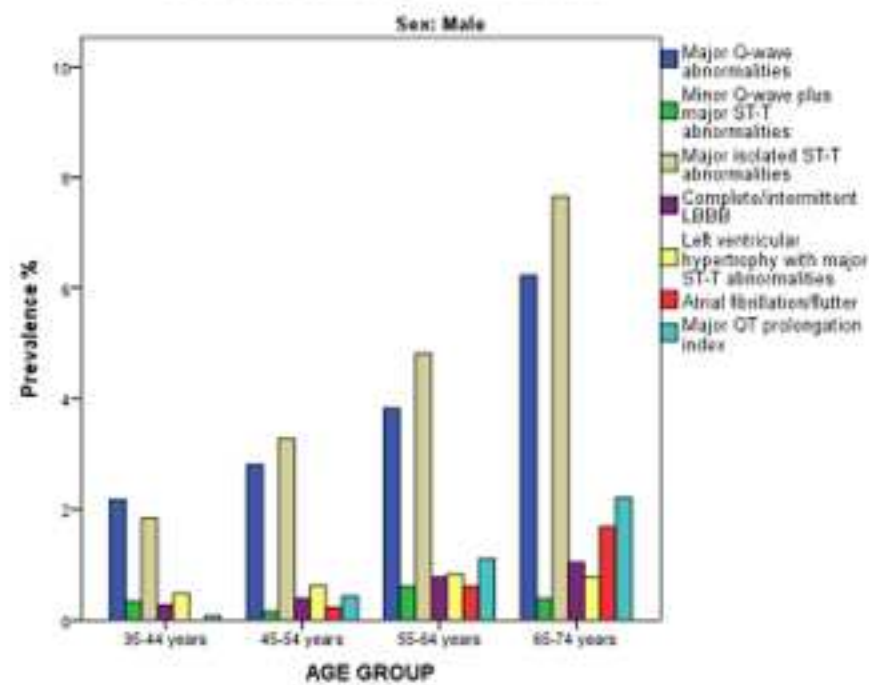
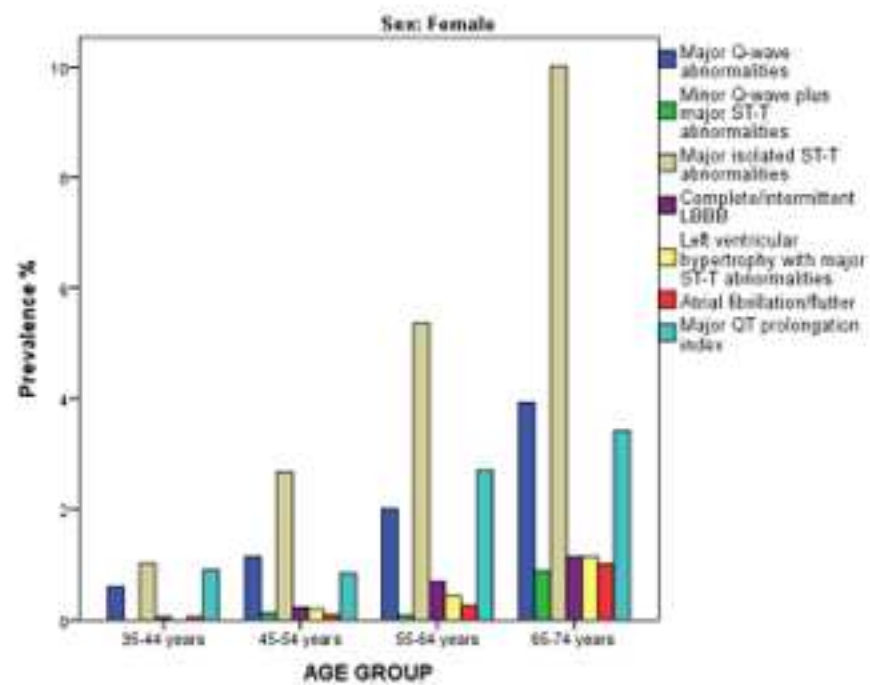
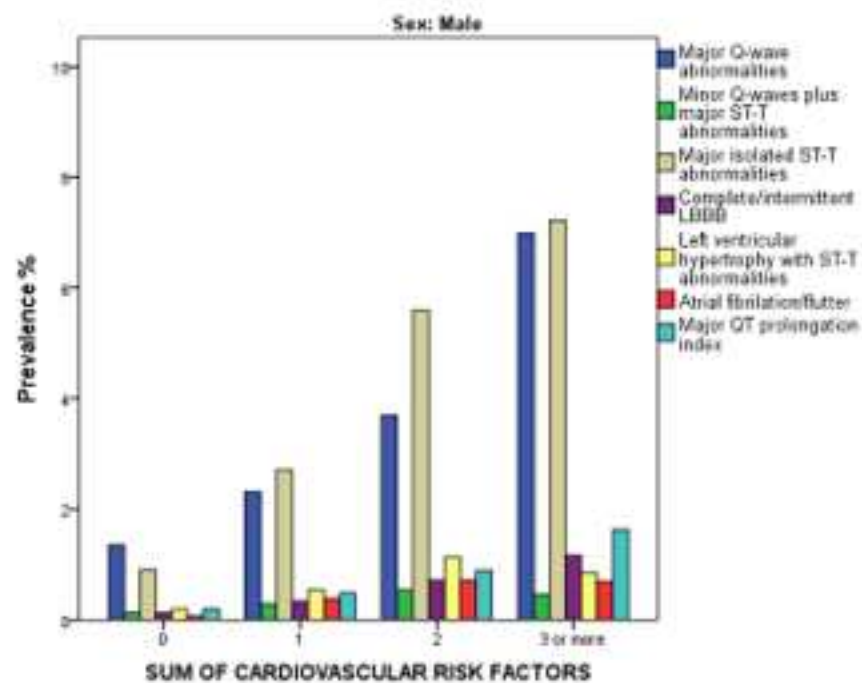
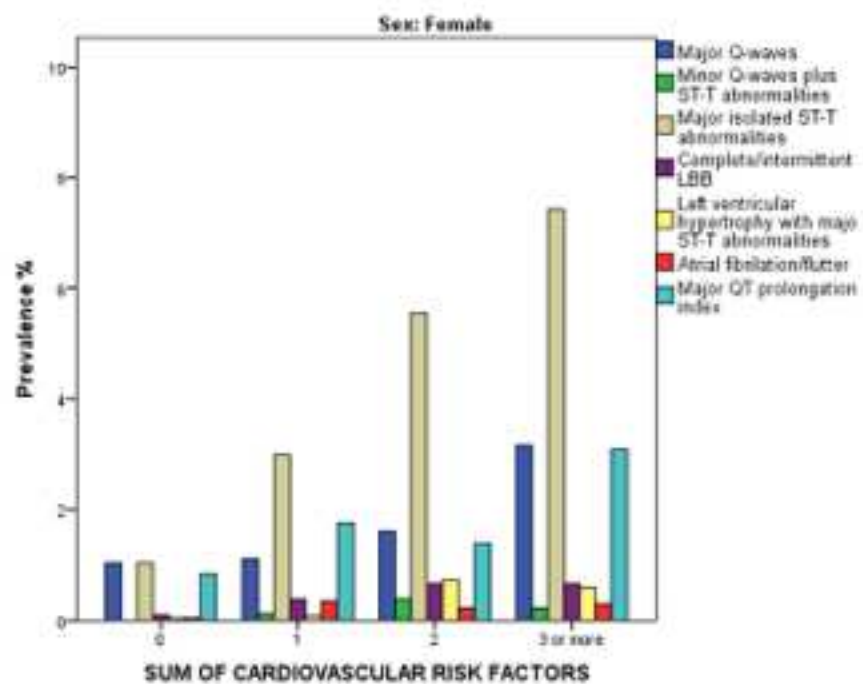
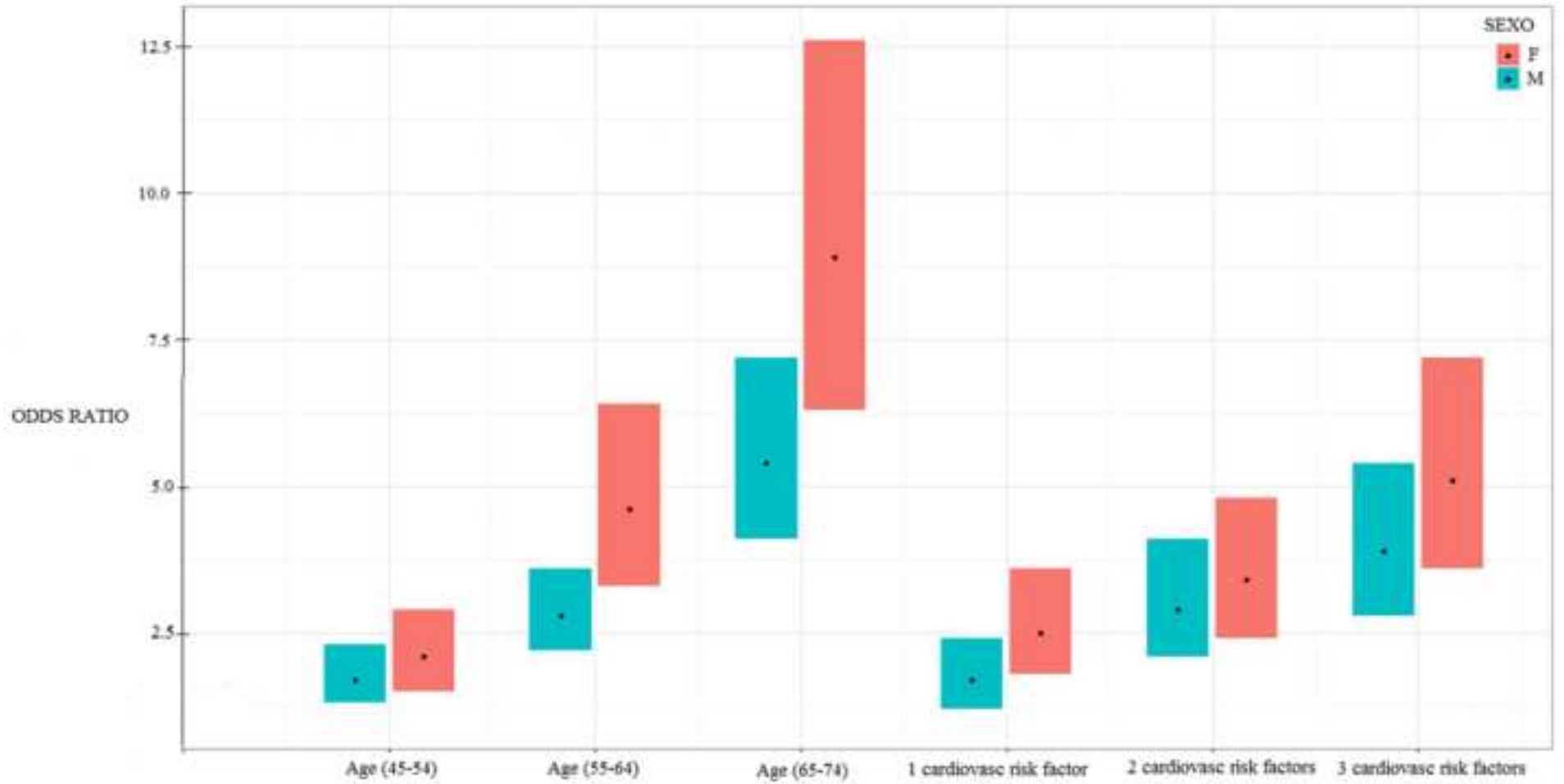


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