ELECTROCARDIOGRAPHIC ABNORMALITIES AMONG MEXICAN AMERICANS: CORRELATIONS WITH DIABETES, OBESITY, AND THE METABOLIC SYNDROME

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SUMMARY

BACKGROUND—Resting ischemic electrocardiographic abnormalities have been associated with cardiovascular mortality. Simple markers of abnormal autonomic tone have also been associated with diabetes, obesity, and the metabolic syndrome in some populations. Data on these electrocardiographic abnormalities and correlations with coronary risk factors are lacking among Mexican Americans wherein these conditions are prevalent.

OBJECTIVE—This study aimed to evaluate the prevalent resting electrocardiographic abnormalities among community-dwelling Mexican Americans, and correlate these findings with coronary risk factors, particularly diabetes, obesity, and the metabolic syndrome.

METHODS—Study subjects (n=1280) were drawn from the Cameron County Hispanic Cohort comprised of community-dwelling Mexican Americans living in Brownsville, Texas at the United States-Mexico border. Ischemic electrocardiographic abnormalities were defined as presence of ST/T wave abnormalities suggestive of ischemia, abnormal Q waves, and left bundle branch block. Parameters that reflect autonomic tone, such as heart rate-corrected QT interval and resting heart rate, were also measured.

RESULTS—Ischemic electrocardiographic abnormalities were more prevalent among older persons and those with hypertension, diabetes, obesity, and the metabolic syndrome. Subjects in the highest quartiles of QTc interval and resting heart rate were also more likely to be diabetic, hypertensive, obese, or have the metabolic syndrome.

CONCLUSIONS—Among Mexican Americans, persons with diabetes, obesity, and the metabolic syndrome were more likely to have ischemic electrocardiographic abnormalities, longer QTc intervals, and higher resting heart rates. A resting electrocardiogram can play a complementary role in the comprehensive evaluation of cardiovascular risk in this minority population.

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Keywords

Electrocardiogram; Coronary Risk Factors; Minority; Health Disparity

BACKGROUND

Resting electrocardiographic (EKG) abnormalities have been associated with increased cardiovascular mortality.[1–3] Parameters that reflect abnormal autonomic tone, such as prolonged heart rate (HR)-corrected QT (QTc) interval and elevated resting HR, also have prognostic implications,[4–5] and can easily be ascertained from a resting EKG. Prolonged QTc and elevated resting HR have been associated with diabetes, obesity, and the metabolic syndrome in some populations.[6–8] However, there are few published studies that evaluate resting EKG abnormalities in non-white populations, particularly the Hispanic population, wherein these conditions are highly prevalent. Mexican Americans have been shown to have a very high prevalence of diabetes, obesity, hypertension, and the metabolic syndrome,[9–10] and yet there is a paucity of data regarding EKG abnormalities and correlations of EKG findings with coronary risk factors in this group. The United States (US) Hispanic population has almost doubled between 1990 and 2007 (9% to 15%),[11] and is projected to reach 30% by the year 2050. Of the Hispanics residing in the US, Mexican Americans represent the largest and ethnically distinct subgroup. This study aimed to evaluate the prevalent resting EKG abnormalities among community-dwelling Mexican Americans, and to correlate these findings with coronary risk factors, particularly diabetes, obesity, and the metabolic syndrome.

METHODS

Study Population

This study was approved by the Institutional Review Board of the University of Texas Health Science Center-Houston. Study subjects were drawn from the Cameron County Hispanic Cohort (CCHC) (n=1280), recruited from randomly selected city blocks according to the 2000 Census as described previously.[12] The CCHC is a homogenous community-dwelling Mexican American cohort living in Brownsville (Cameron County), Texas, a city near the mouth of the Rio Grande River at the US-Mexico border.

Extensive family, socioeconomic, educational and personal medical histories were obtained using a directed questionnaire. Participants were asked to fast for at least 10 hours overnight before a clinic visit at the Clinical Research Unit. Anthropometric measurements obtained included height, weight, and waist circumference. The average of 3 blood pressure (BP) and HR readings taken 5 minutes apart were used. Laboratory studies performed included fasting lipid panel, hemoglobin (Hb) A1c, fasting glucose, and high sensitivity C-reactive protein (CRP). CRP levels > 10 mg/L were excluded from analysis as such high levels likely represent acute illness.[13]

The presence of hypertension was both self-reported and measured as described above. The subject was deemed to be hypertensive if the mean systolic blood pressure (SBP) was 140 mmHg or the mean diastolic blood pressure (DBP) was 90 mmHg.[14] Classification of diabetes was also both self-reported and based on measurement of HbA1c (HbA1c > 6.5) as per the latest guidelines from the American Diabetes Association.[15] Smoking status was defined as an affirmative answer to the question "Have you ever smoked > 100 cigarettes in your life?". Body mass index (BMI) was categorized according to the National Heart Lung and Blood Institute (NHLBI) criteria. Metabolic syndrome was defined according to the criteria used by the American Heart Association and NHLBI.[16]

EKG Analysis

A resting 12-lead standard supine EKG (Nihon Kohden ECG-9320, Nihon Kohden Corp., Foothill Ranch, CA) was performed. All EKGs were computer-analyzed and then manually over read and coded using the Minnesota code criteria[17] by a single cardiologist (S.Q.) to improve diagnostic accuracy. Left ventricular hypertrophy (LVH) was evaluated using both the Sokolow-Lyon and the Cornell criteria.[18–19] The QT interval was corrected for HR using the Bazett's formula using a standard HR of 60 bpm. Prolonged QTc interval was defined as QTc 460 ms. Abnormal Q/QS waves were defined as Q waves lasting greater than 0.04 seconds and greater than 1 mm in depth (code 1-1-2). ST and T wave abnormalities suggestive of ischemia were defined as horizontal or downsloping ST segments with or without T wave inversion (code 4-1-2). Ischemic T wave changes were defined as symmetric or deeply inverted T waves or biphasic T waves (codes 5–2). Ischemic EKG abnormalities were then defined as the presence of ST and T wave abnormalities suggestive of ischemia, ischemic T wave changes, abnormal Q/QS waves, and the presence of left bundle branch block (code 7-1-1).

Statistical Analysis

Data are summarized as mean and standard deviation for parametric data, or median and interquartile range (IQR) for nonparametric data. Participant demographics were stratified by gender and evaluated using univariate analysis. Student's t-test was used to compare groups for continuous parametric data, the Kruskall Wallis Test for continuous nonparametric data, and the Chi Square Test Statistic for categorical data. Multiple linear regression analysis and logistic regression analysis, for continuous and categorical data respectively, and Pearson Product Moment Correlation, were used to evaluate associations between variables. QTc intervals and HR were divided into quartiles and analyzed as categorical variables. A p value <0.05 was considered significant. All analyses were performed using SAS 9.2 TS level 1MO (SAS Institute Inc., Cary, NC).

RESULTS

Cohort Profile

Participant demographics are listed in Table 1. The median age was 43 years (range 18–93 years); 67.5% (n=865) were female. There was a high prevalence of coronary risk factors in this cohort. Approximately one in four subjects was hypertensive (23.4%), diabetic (28.8%), or a smoker (27.5%). Women were more likely to be hypertensive ($p<0.01$), with no gender difference regarding prevalence of diabetes. However, fasting glucose levels were higher among men ($p<0.001$). Mean SBP and mean DBP were also higher among men ($p<0.001$), suggestive of poorer BP and diabetes control among men. There was a very high prevalence of smoking among the male subjects, with one in two Mexican American males categorized as a smoker (50.8% versus 16.3%; $p<0.001$).

On the other hand, there was a higher prevalence of obesity among women compared to men (52.7% versus 46.5%; $p=0.04$) with more women classified as morbidly obese (8.8%) compared to men (5.3%) [$p=0.03$]. In general, the majority (82.9%) of this cohort was either overweight or obese, with a median cohort BMI of 30 (IQR 7.7); 7.6% were morbidly obese. Nearly one in two persons met criteria for the metabolic syndrome (43.4%), with a higher prevalence in women (45.4%) than in men (39.4%) [$p=0.04$].

The mean CRP was 3.6 ± 2.4 mg/L, which is considered to be in the high risk category for cardiovascular events.[17] Women had significantly higher levels of CRP compared to men (3.9 ± 2.4 mg/L versus 3.1 ± 2.3 mg/L; $p<0.001$). Using multiple linear regression analysis, hypertension, diabetes, metabolic syndrome, obesity, BMI, waist circumference, and HDL-

Chol were significantly associated with CRP levels after adjusting for age and gender (p<0.01).

EKG Findings

Most subjects were in normal sinus rhythm with one subject in ectopic atrial rhythm and three subjects in atrial fibrillation (prevalence of 0.2%). The prevalence of LVH was 3.6%. After controlling for age and gender, the presence of LVH was significantly associated with hypertension, metabolic syndrome, waist circumference, and BMI (p<0.05). The prevalence of an interventricular conduction delay was 3.5% (n=45) with the majority having either a nonspecific interventricular conduction delay (n=17) or a right bundle branch block (n=10). Two subjects had a left bundle branch block. Ectopic beats were seen in 1.6% (n=20) of the cohort, with the majority being isolated premature atrial complexes.

Abnormal Q waves were seen in 1.4% (n=18) of the cohort. After adjusting for other covariates, age and LDL-Chol were significantly associated with the presence of an abnormal Q wave on a resting EKG (p<0.05). Ischemic EKG abnormalities were seen in 12.7% (n=163) of the cohort. Using multivariate regression analysis, ischemic EKG abnormalities were more prevalent in older subjects, in persons with hypertension, diabetes, and the metabolic syndrome, and in those who were obese [Table 2]. Ischemic EKG abnormalities were also more prevalent in subjects with higher SBP and DBP, higher total cholesterol, larger waist circumferences, and higher BMI (p<0.01).

The mean cohort QTc interval was 408.4 ± 25.7 ms while the mean cohort HR was 66.4 ± 8.6 bpm. Only 1.3% of the cohort had prolonged QTc interval (> 460 ms) and only 0.7% had a resting HR 90 bpm (maximum mean resting HR was 100 bpm). Women had longer QTc intervals (412.5 ± 23.8 ms versus 400.1 ± 27.3 ms; p<0.001) and higher mean HR (66.9 ± 8.4 bpm versus 65.3 ± 8.9 bpm; p<0.01) compared to men. After adjusting for age and gender, subjects in the highest quartiles of QTc interval were more likely to have hypertension, obesity, the metabolic syndrome, and had higher BMI, higher HbA1c, larger waist circumference, and higher CRP levels (p<0.01) [Table 3]. Similarly, after controlling for age and gender, subjects with the highest quartiles of mean HR were more likely to have diabetes, obesity, the metabolic syndrome, and had higher BMI, higher fasting glucose and HbA1c, higher triglyceride levels, larger waist circumferences, and higher CRP levels (p<0.01) [Table 4].

DISCUSSION

This study describes the prevalent EKG abnormalities in a homogenous community-dwelling Mexican American cohort. The main finding in this study is that persons with hypertension, diabetes, obesity, and the metabolic syndrome were more likely to have ischemic electrocardiographic abnormalities, longer QTc intervals, and higher resting heart rates on a resting EKG. Studies reporting EKG abnormalities among Hispanics are scarce[20–21] and most reference data have been collected in Caucasian populations. This study contributes to the body of literature on EKG abnormalities in this large US minority population.

Resting ischemic EKG abnormalities were more prevalent among subjects with hypertension, diabetes, obesity, and the metabolic syndrome. Our findings are consistent with published literature showing similar associations in other ethnic groups;[22–26] however, to our knowledge, this study is one of few reports on these associations in a Mexican American community-dwelling cohort. The reported prevalence in our study is similar to that seen in other community-based studies such as the Persian Gulf Healthy Heart

Project,[22] as well as aggregate data from four large Belgian epidemiologic studies,[23] although it appears to be higher than that reported for Koreans.[24]

Autonomic dysfunction has been implicated in sudden cardiac death and is a marker of increased cardiovascular mortality in persons with and without known cardiovascular disease.[27–31] Recently, several studies have described associations of QTc interval and resting HR with diabetes, obesity, and the metabolic syndrome in other ethnic groups.[6–8, 32–33] Our study is consistent with the published literature but to our knowledge, is the first to describe these associations among Mexican Americans. Sympathetic overactivity or sympathetic imbalance seems to underlie several of the components of obesity, diabetes, and the metabolic syndrome.[34] The finding of a strong association between parameters suggestive of an abnormal autonomic tone and this "dysmetabolic" state provides support for shared pathophysiologic mechanisms to explain increased cardiovascular mortality in these patients. A strong and consistent association between autonomic neuropathy and increased risk of mortality has been shown in diabetics.[35] It has been suggested that a baseline determination of autonomic function be performed in all patients with diabetes mellitus.[35, 36] We would argue that a similar assessment of autonomic tone be performed for obese patients and patients with the metabolic syndrome. The presence of these markers of autonomic dysfunction should then alert a healthcare professional to further risk stratification or an intensification of appropriate therapies to potentially modulate autonomic function and attenuate this risk. Whether these findings translate to increased cardiovascular mortality risk in this cohort remains to be seen.

The other important finding in the study is the very high prevalence of coronary risk factors in this cohort, consistent with what has been previously described among Mexican Americans.[37] In particular, nearly one in two persons met criteria for the metabolic syndrome, and only 17% of the entire cohort had a normal BMI. The prevalence of metabolic syndrome in this homogenous Mexican American cohort (43.4%) is higher than that reported for the general American population in the National Health and Nutrition Examination Survey (NHANES) Survey and the Women's Health Study (23.4% and 24.4%, respectively).[38] Similarly, the prevalence of obesity (50.7%), and overweight and obesity combined (82.9%) in this cohort is much higher than the most recent prevalence estimates for these conditions in the US population (33.8% and 68.0%, respectively).[39]

Our study had several factors that may influence the results. This study is a cross-sectional study and we have no follow-up data to evaluate the implications of our findings on cardiovascular events and outcomes. Longitudinal data are being collected and follow-up EKGs will be analyzed to evaluate changes over time. The CCHC is a homogenous Mexican American cohort and hence, we do not have a comparison cohort. However, the findings in this study can be placed in context with the published literature regarding other ethnic groups and the general US population. A strength of this study though, is the very homogeneity of the cohort, as the US Hispanic population as a whole is actually an ethnically diverse group with varying risk profiles. We also opted to use simple EKG parameters, rather than complex computer-generated factors, because the parameters chosen are easily defined and interpreted by clinicians, with wider clinical applicability.

In summary, in this community-dwelling Mexican American cohort, persons with diabetes, hypertension, the metabolic syndrome, and obesity were more likely to have ischemic EKG changes, longer QTc intervals, and higher resting HR. The resting EKG is a simple, low-cost, and widely available cardiovascular diagnostic test which can provide a wealth of information related to coronary risk factors, as described in this study. Evaluation of latent cardiovascular disease in this high risk population would be advantageous as it may prompt clinicians to further risk stratification and/or earlier institution or intensification of

appropriate therapies. Hence, a resting EKG can play a complementary role in the comprehensive evaluation of cardiovascular risk among Mexican Americans.

Acknowledgments

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Table 1

Cohort Demographics.

	Total (n=1280)	Male (n=415)	Female (n=865)	P value (Males vs. Females)
Continuous Variable	**Median (IQR)**	**Median (IQR)**	**Median (IQR)**	
Age (years)	43 (24)	43 (23)	42 (23)	0.25
Mean SBP (mmHg)	113 (20)	115 (16)	113 (21)	<0.001
Mean DBP (mmHg)	71 (12)	75 (12)	69 (12)	<0.001
Fasting Glucose (mg/dL)	97 (16)	99 (16)	96 (16)	<0.001
HbA1c	5.6 (1.4)	5.6 (1.3)	5.6 (1.4)	0.40
Total Cholesterol (mg/dL)	183 (55)	185.5 (59)	181 (54)	0.06
Triglyceride (mg/dL)	128 (107.5)	145 (134)	120 (97)	<0.001
HDL-Cholesterol (mg/dL)	46 (14)	42 (12)	47 (14)	<0.001
LDL-Cholesterol (mg/dL)	107 (42)	111 (45.2)	105.2 (39.4)	0.04
CRP (mg/dL)	2.9 (3.2)	2.4 (2.5)	3.2 (3.3)	<0.001
BMI	30 (7.7)	29.6 (6.7)	30.2 (8)	0.07
Waist Circumference (cm)	99.3 (17.3)	102 (15.6)	98 (17.7)	<0.001
Median Income (US dollars)	14,400 (14,349)	19,519 (18,000)	12876 (13200)	<0.001
Years of Education	10 (6)	12 (5)	9 (6)	<0.01
Categorical Variable	**n (%)**	**n (%)**	**n (%)**	
Diabetic	368 (28.8)	121 (29.2)	247 (28.6)	0.82
Hypertensive	299 (23.4)	77 (18.6)	222 (25.7)	<0.01
Metabolic Syndrome	552 (43.4)	163 (39.4)	389 (45.4)	0.04
Obese (BMI 30)	649 (50.7)	193 (46.5)	456 (52.7)	0.04
Morbidly Obese (BMI 40)	98 (7.6)	22 (5.3)	76 (8.8)	0.03
Smoker	352 (27.5)	211 (50.8)	141 (16.3)	<0.001
Employed	653 (51.0)	305 (73.5)	348 (40.2)	<0.001

Table 2

Ischemic EKG Abnormalities.

	Ischemic EKG (n=163)	No Ischemic EKG Abnormalities (n=1,117)	P Value	OR (95%CI)
Continuous Variable	**Median (IQR)**	**Median (IQR)**		
Age (Years)	55 (19)	41 (23)	<0.001	1.05 (1.04, 1.07)
Mean SBP	123 (27)	113 (18)	<0.001	1.03 (1.02, 1.04)
Mean DBP	75 (13)	70 (12)	<0.001	1.03 (1.02, 1.05)
Fasting Glucose (mg/dL)	103 (26)	97 (16)	<0.001	1.003 (1.000, 1.006)
HbA1c	5.9 (1.5)	5.6 (1.3)	<0.001	1.08 (1.00, 1.16)
Total Cholesterol (mg/dL)	193.5 (58)	182 (54)	<0.01	1.007 (1.003, 1.01)
Triglyceride (mg/dL)	161.5 (124)	124 (104)	<0.001	1.001 (1.000, 1.002)
HDL-Cholesterol (mg/dL)	46 (11)	46 (15)	0.66	1.003 (0.989, 1.016)
LDL-Cholesterol (mg/dL)	117.6 (43.6)	106 (42)	0.04	1.004 (0.999, 1.008)
CRP (mg/L)	3.1 (3.4)	2.9 (3.1)	0.36	1.03 (0.96, 1.12)
BMI	30.9 (6.4)	29.9 (7.8)	<0.01	1.03 (1.01, 1.05)
Waist Circumference (cm)	104 (15.5)	99 (17.1)	<0.001	1.02 (1.01, 1.03)
Categorical Variable	**n (%)**	**n (%)**		
Females	113 (68.7)	752 (67.32)	0.61	1.10 (0.75, 1.57)
Diabetic	68 (41.72)	300 (26.86)	<0.001	1.95 (1.39, 2.73)
Hypertensive	70 (42.94)	229 (20.50)	<0.001	2.92 (2.07, 4.11)
Metabolic Syndrome	99 (60.74)	453 (40.88)	<0.001	2.24 (1.60, 3.13)
Obese (BMI 30)	98 (60.12)	551 (49.33)	0.01	1.55 (1.11, 2.16)
Smoker	50 (30.67)	302 (27.04)	0.33	1.19 (0.84, 1.71)

Table 3

QTc Intervals Divided into Quartiles. P values adjusted for age and gender.

	QTc1 <395ms	QTc2 >395– <409ms	QTc3 >409– <422ms	QTc4 >422ms	P Value (QTc4 vs. QTc1)	OR (95% CI) QTc4 vs. QTc1
Continuous Variable	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)		
Mean SBP	112 (17)	112.5 (20)	115 (19)	117 (24)	<0.001	1.02 (1.00, 1.03)
Mean DBP	71 (12)	71 (13)	71 (12)	71 (13)	0.82	1.02 (1.00, 1.04)
Fasting Glucose (mg/dL)	96 (13)	97 (16.5)	99 (17)	100 (22)	<0.01	1.003 (1.00, 1.007)
HbA1c	5.4 (1.1)	5.6 (1.2)	5.6 (1.5)	5.8 (1.4)	<0.01	1.11 (1.01, 1.22)
CRP (<10 mg/L)	2.5 (2.5)	3 (3.5)	3.1 (3.3)	3.2 (3.1)	<0.001	1.12 (1.03, 1.22)
BMI	28.5 (6.8)	30 (8.3)	30.4 (7.9)	31 (7.4)	<0.001	1.06 (1.04, 1.09)
Waist Circumference (cm)	97.1 (17)	98 (18.9)	100 (15.3)	10.25 (17.1)	<0.001	1.03 (1.02, 1.05)
Categorical Variable	n (%)	n (%)	n (%)	n (%)		**OR (95%CI)**
Diabetic	75 (23.4)	84 (25.9)	106 (31.4)	103 (34.7)	<0.01	1.24 (0.84, 1.83)
Hypertensive	49 (15.3)	63 (19.4)	76 (22.5)	111 (37.4)	<0.001	1.65 (1.06, 2.57)
Metabolic Syndrome	98 (30.8)	130 (40.8)	171 (50.7)	153 (51.5)	<0.001	1.69 (1.18, 2.42)
Obese (BMI >30)	131 (40.8)	162 (50.0)	182 (53.9)	174 (58.6)	<0.001	1.89 (1.34, 2.66)
Smoker	105 (32.7)	88 (27.2)	78 (23.1)	81 (27.3)	0.14	1.42 (0.95, 2.13)

Table 4

Mean Resting Heart Rate Divided into Quartiles. P values adjusted for age and gender.

Continuous Variable	MeanHR1 60.5bpm Median (IQR)	MeanHR2 >60.5– 65.5bpm Median (IQR)	MeanHR3 >65.5– 72bpm Median (IQR)	MeanHR4 >72bpm Median (IQR)	P Value MeanHR4 vs. MeanHR1	OR (95%CI) MeanHR4 vs. MeanHR1
Mean SBP	114 (22)	113 (19)	113 (17)	115 (21)	0.23	1.01 (1.00, 1.03)
Mean DBP	69 (12)	71 (12)	71 (14)	73 (13)	<0.001	1.04 (1.03, 1.06)
Fasting Glucose (mg/dL)	97 (14)	97 (15)	96 (17)	100 (29)	<0.01	1.012 (1.007, 1.016)
HbA1c	5.5 (1.1)	5.6 (1.2)	5.6 (1.4)	5.9 (1.8)	<0.001	1.26 (1.15, 1.39)
Triglyceride (mg/dL)	120.5 (100)	126.5 (99)	129 (112)	138 (112)	<0.01	1.002 (1.001, 1.003)
CRP (<=10 mg/L)	2.7 (2.7)	2.8 (3.1)	3.1 (3.1)	3.4 (3.7)	<0.01	1.15 (1.07, 1.24)
BMI	28.7 (7.1)	30.2 (7.4)	29.9 (7.2)	31.4 (9.1)	<0.001	1.06 (1.04, 1.09)
Waist Circumference (cm)	97.8 (16.8)	98.9 (16.2)	99.1 (16.3)	102.2 (20.3)	<0.001	1.03 (1.02, 1.05)
Categorical Variable	**n (%)**	**n (%)**	**n (%)**	**n (%)**		**OR (95%CI)**
Diabetic	75 (21.9)	87 (27.6)	95 (29.3)	111 (37.1)	<0.001	2.44 (1.69, 3.51)
Hypertensive	76 (22.2)	70 (22.2)	67 (20.7)	86 (28.8)	0.07	1.72 (1.14, 2.58)
Metabolic Syndrome	118 (34.6)	119 (37.8)	159 (49.5)	156 (53.1)	<0.001	2.38 (1.70, 3.33)
Obese (BMI>=30)	145 (42.4)	165 (52.4)	160 (49.4)	179 (59.9)	<0.001	2.02 (1.47, 2.77)
Smoker	110 (32.2)	88 (27.9)	75 (23.2)	79 (26.4)	0.12	0.89 (0.62, 1.29)