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Racial Differences in the Cardiac Autonomic Function of Overweight and Obese Youth

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Abstract

Blacks experience a higher cardiovascular disease mortality rate than Whites, and racial differences in autonomic function may be one factor that contributes to cardiovascular outcomes in overweight-obese youth. This ancillary study sought to determine if there is a significant difference among cardiac autonomic measures of heart rate variability, QTc Interval duration, and Cornell voltage for left ventricular hypertrophy between 128 Black and White overweight-obese youth age 11-18 years. Univariate analysis of covariance was used to compare cardiac autonomic measures between racial groups, adjusting for age and gender. Findings indicated that participants had a similar heart rate variability measure of high frequency (p = 0.170). In addition there was no significant difference identified between racial groups for QTc Interval duration (p = 0.465) or Cornell voltage for left ventricular hypertrophy (p = 0.513). However, Black youth displayed a significantly lower heart rate variability measure of standard deviation of normal RR intervals (SDNN) in comparison to White peers (p = 0.001). Findings suggest that in Black overweight-obese, youth the risk for ventricular arrhythmias and sudden cardiac death associated with a decreased heart rate variability measure of SDNN may be increased in comparison to White peers.

Keywords: obesity, autonomic, youth, heart rate variability, QT, cardiac

Racial Differences in the Cardiac Autonomic Function of Overweight and Obese Youth

Introduction

Cardiovascular disease, a Healthy People 2020 priority,[1] is the leading cause of morbidity and mortality in the United States.[2] Although, the rates of mortality from cardiovascular disease has declined since the 1960's in all races; the rate of decline has slowed among Blacks.[3] Both young and older Blacks experience a higher cardiovascular disease mortality rate than Whites,[4] and have a disproportionately higher prevalence of being overweight.[5] Based on data from the National Health and Nutrition Examination Survey (NHANES) 2007-2008, 31.7% of youth are overweight or obese, with the highest prevalence in Black girls.[6] In addition, the prevalence of obesity drastically increased from 5-18.1% among school aged children 12-19 years between 1976-1980 and the 2007-2008 time period.[6] The increased prevalence of overweight and obese youth is associated with an increased risk for secondary health concerns. Several cardiovascular risks that can develop secondary to obesity include elevated cholesterol, abnormal glucose tolerance, and high blood pressure.[5] The treatment of obesity alone and combined with secondary health conditions is accompanied by considerable medical costs. Currently, over $129 billion dollars are spent annually on obesity and the total healthcare costs are projected to double every decade.[7]

Among the many disadvantages of obesity is dysfunction of the autonomic nervous system[8] that modulates heart rate and cardiac output.[9] It is postulated that the impaired cardiac autonomic function in overweight-obese individuals may result from the release of vasoactive substances from adipocytes that modulate sympathetic-parasympathetic balance. This alteration in autonomic function may influence several cardiac measures. These measures include heart rate variability,[10] an indirect measure of autonomic function;[11] QT Interval duration that represents ventricular depolarization and repolarization;[12] and hypertension,[13] a risk factor for left ventricular hypertrophy.[13] Each of these variables, decreased heart rate variability,[15] prolonged QT Interval duration,[16] and left ventricular hypertrophy,[17] may lead to an increased risk of ventricular arrhythmias and sudden cardiac death.

Heart Rate Variability

Heart rate variability an indicator of autonomic nervous system functioning corresponds to the normal beat-to-beat alterations of heart rate.[18] Several studies have reported age and gender differences for heart rate variability measures.[19,20] Compared to normal weight youth, obese youth exhibit lower sympathetic and parasympathetic measures of heart rate variability.[21] Individuals with decreased heart rate variability have an increased risk for ventricular arrhythmias.[22] Black youth, in comparison to Whites, have been identified to have lower heart rate variability measures.[23] In contrast to these findings, it has been noted that Black youth have a more favorable heart rate variability profile in comparison to Whites, which supports further investigation.[24]

QT Interval Duration

The QT Interval is measured from the onset of the QRS complex to the end deflection of the T wave. It has been suggested that race in general is not considered a risk factor for QT prolongation.[25] However, a study in adults suggests that the QT Interval is shorter in healthy Blacks than Whites.[26] Challenging these findings, researchers have identified contrary results but acknowledged a small sample size as a possible limitation.[27] Limited research on QT Interval duration and race has been published. In addition, no studies were identified that examined QT Interval duration in overweight-obese youth in regards to racial differences. Therefore the examination of race and QT Interval duration can provide useful findings in this population.

Left Ventricular Hypertrophy

Hypertension, a risk factor for the development of left ventricular hypertrophy, is associated with sympathovagal imbalance and vagal withdrawal.[13] Cardiovascular mortality resulting from left ventricular hypertrophy is greater in Blacks than Whites, which may be related to the higher incidence of hypertension in Blacks versus Whites.[28,29] Regardless of race, obesity in youth is associated with a clustering of cardiovascular risk factors, including hypertension.[30] Further investigation is needed to determine if race affects the development of left ventricular hypertrophy, particularly in the presence of concomitant obesity in youth, because early identification and treatment may prevent cardiac mortality.

Conceptual Framework

The conceptual basis for the examination of racial differences among cardiac autonomic measures of heart rate variability, QT Interval duration, and electrical voltage measures for left ventricular hypertrophy was developed (Figure 1). This model identifies overweight-obese youth at risk for the development of autonomic dysfunction with an increased prevalence in Black youth. The development of alterations in autonomic function in overweight-obese youth may impact cardiac function. This impairment of cardiac function may result in the development of ventricular arrhythmias and subsequent sudden cardiac death.

Purpose

Racial differences in autonomic function may be one mechanism that contributes to cardiovascular outcomes.[31] The purpose of this study is to determine if there is a significant difference between Black and White overweight-obese youth among cardiac autonomic measures of standard deviation of all RR Intervals (SDNN) and high frequency (HF) measures of heart rate variability, the corrected QT (QTc) Interval duration, and electrical voltage measures for left ventricular hypertrophy, after controlling for age and gender. It is hypothesized that Black overweight-obese youth will display lower heart rate variability, more prolonged QTc Interval duration, and higher electrical voltage measures for left ventricular hypertrophy than their White peers.

Methods

This ancillary study consisted of 128 overweight-obese youth who were aged 11 to 18 years. Institutional Review Board approval was obtained for conducting this study. In addition, written and verbal consent and assent was received from parents/legal guardians and participants respectively for the primary study that examined racial differences in glucose

metabolism, autonomic function, and lifestyle behaviors in a sample of 200 Black and White overweight and obese youth. This study differs from the primary study by further exploring racial differences among cardiac autonomic measures in overweight and obese youth using the 12-lead electrocardiogram.

Measures

During the original study, height was measured on participants without shoes, and weight was measured using a calibrated scale without shoes and excessive clothing. The height and weight measures were used to calculate body mass index [(weight (kg) / height2 (m2)] to determine if youth were overweight (≥ 85th percentile) or obese (≥ 95th percentile) according to age and gender percentiles of the Centers for Disease Control and Prevention.[32] In addition, a resting blood pressure was obtained. Heart rate variability was measured using Marquette Electronics version 5.8 Ambulatory Electrocardiogram Analysis and Editing System according to the manufacturer settings. Each heart rate variability recording contained at least 18 hours of analyzable data. Heart rate variability measures of high frequency components that reflect parasympathetic function and time domain measures of SDNN were utilized for this study.

A standard 12-lead electrocardiogram at a speed of 25mm/sec was used to measure and record the QT Interval duration and Cornell electrical voltage for left ventricular hypertrophy. The QT Interval was measured from the beginning of the QRS complex to the end deflection of the T wave in three consecutive beats and averaged. The average QTc Interval was determined according to Bazett's formula ($QTc = QT/\sqrt{RR}$), and was considered prolonged if > 0.440 sec in males and > 0.460 sec in females.[33] Cornell voltage criteria was utilized to determine left ventricular hypertrophy by measuring the S wave in lead V3 + R wave in lead aVL. Left ventricular hypertrophy was considered in males if SV3 + RaVL was > 2.8 mV and in females > 2.0 mV. With the exception of QTc Interval duration and Cornell voltage for left ventricular hypertrophy all other measures were provided from the primary study for data analysis. The QTc Interval and Cornell voltage measures were manually obtained by the primary investigator certified in electrocardiogram analysis and validated by a Pediatric Cardiologist.

Data Analysis

Univariate analysis of covariance was used to compare heart rate variability measures (SDNN and high frequency), QTc Interval duration, and Cornell voltage measures for left ventricular hypertrophy, after controlling for age and gender

between racial groups. Statistical Software for the Social Sciences version 17.0 was utilized for all statistical analysis at a significance level of 0.05.

Results

Subjects were grouped based upon self-reported race as either Black or White. Sixty percent of the sample was self reported as Black, and the remainder White; 63% were female. In addition, within our sample 4.7% of the subjects were classified as overweight and 95.3% obese according to the guidelines of the Centers for Disease Control and Prevention. Participants displayed similar measures for age, body mass index, and systolic blood pressure; however, diastolic blood pressure measures were significantly higher in Blacks in comparison to Whites (Table 1). Our study findings indicate there was no significant difference between racial groups for the heart rate variability measure of high frequency ($p = 0.170$). In addition, there was no significant difference among Black and White youth for QTc ($p = 0.465$) or Cornell voltage for left ventricular hypertrophy ($p = 0.513$). No participants were identified to have left ventricular hypertrophy based upon study criteria. However, Black youth had a significantly lower heart rate variability measure of SDNN than White peers ($p = 0.001$) (Table 2).

Discussion

Heart Rate Variability

The SDNN is one of the most predictive values of heart rate variability for mortality.[34] Decreased SDNN may lead to increased sympathetic modulation of the sinus node,[35] which is associated with increased fatigue and may contribute to life-threatening arrhythmias.[36] The statistically lower measures of SDNN in Blacks support findings noted in adults that minorities are more likely to have decreased SDNN than Whites. It has been postulated that the racial differences in SDNN result from possible genetic differences or daily societal stress in the minority population vs. Whites.[34] Our findings were contrary to study findings that suggest no significant difference exists in SDNN between healthy non-obese Black and White youth.[37] However, obesity within our sample differentiates from healthy Black and White subjects.

In adults it has been reported that Blacks have higher high frequency measures of heart rate variability than Whites.[38] However, there was no significant difference noted between Black and Whites for high frequency measures of heart rate variability in our study. Several factors could have contributed to our study findings. First, the engagement in more

vigorous physical activity and lower adiposity are associated with a more favorable heart rate variability profile, with higher adiposity having a more deleterious effect on heart rate variability in Black than in White youth.[24] Second, altered autonomic function has been found to be present in subjects with a family history of hypertension.[39] Within our study, family history of hypertension was not examined and this could have contributed to lower circadian fluctuations in Blacks vs. Whites. In addition, variations in age have been known to contribute to differences in heart rate variability measures. Researchers identified lower parasympathetic measures in Black youth compared to Whites but lower low frequency (LF): high frequency (HF) ratio after adjusting for age; therefore our study sought to control for this factor.[24]

QT Interval

Divergent results have been reported in regards to race for QTc Interval prolongation in Blacks and Whites. Studies were not identified that examined racial differences and QTc Interval duration in overweight-obese youth. However, in adults conflicting reports state that in Blacks versus Whites QTc Interval duration is shorter,[26] prolonged,[27] and not affected by race.[25] In our study of Black and White overweight-obese youth, no significant difference was identified for QTc Interval duration between race groups. Because obesity is one of the most common causes of QTc prolongation, the overall marked obesity throughout the sample could have contributed to this finding.[40]

Left Ventricular Hypertrophy

Blacks have an increased incidence of left ventricular hypertrophy and elevated blood pressure than Whites.[28] However, within our study no significant differences were noted between Black and White overweight-obese youth for Cornell voltage measures for left ventricular hypertrophy. Hypertension is a major risk factor for left ventricular hypertrophy.[13] Though a significant difference was noted for diastolic blood pressure measures our sample of overweight and obese youth displayed similar Cornell voltage measures. Normative standards have not been developed for overweight-obese youth for use with electrocardiogram criteria, and the use of adult standards within this study may limit the results. Although, no participants were considered to have left ventricular hypertrophy regardless of race, the literature suggests that Cornell voltage (SV3 + RaVL) is less influenced by the presence of obesity,[41] in adults. Although normative standards have not been established in youth it is important that we begin to explore electrocardiographic measures. These measures may provide useful data for the early detection of left ventricular hypertrophy and accompanying conduction defects that may lead to arrhythmias and sudden cardiac death in this high risk population.[17]

Implications for Clinical Practice

The significantly lower heart rate variability measures of SDNN in Black youth are accompanied with challenging clinical implications. Researchers have indicated that individuals with decreased heart rate variability have an increased propensity for ventricular arrhythmias.[22] Preventative screening for cardiac autonomic dysfunction with assessment of heart rate variability measures of SDNN could prove to be beneficial in overweight-obese Black youth to decrease morbidity and mortality. However, clinical practice standards for the recording duration of heart rate variability measures of SDNN have not been established.[42] Although, short term 5-minute measures may be obtained; long term 24-hour measures provide the highest cardiovascular risk prediction.[42] Long term heart rate variability measurement requires a team effort by both the heath care provider and the patient with considerable time for data collection and interpretation. Regardless of this challenge the use of 24-hour heart rate variability measurements for cardiac risk stratification in Black overweight-obese youth may prove beneficial.

The electrocardiogram is a non-invasive tool that can be used to determine QTc and Cornell voltage measures. A significant difference between racial groups for QTc or Cornell voltage measures was not identified between Black and White overweight-obese youth within our study using the electrocardiogram. However, obesity is a common cause of QTc lengthening[40] and hypertension[30] that is associated with left ventricular hypertrophy.[13] Our findings suggest that obesity may be a more independent predictor of cardiovascular illness than race alone. Therefore, healthcare providers should assess body mass index in all youth and recommend preventative weight loss measures. Two primary weight loss strategies include increasing physical activity and dietary management. Also, continued research is recommended in Black and White overweight-obese youth to determine the overall clinical relevance for QTc and Cornell voltage measures based on race.

Conclusion

Although the direct relationship for decreased heart rate variability measure of SDNN in Black overweight-obese youth is unknown, our study findings are consistent with adult study findings within Blacks and Whites. Although heart rate variability analysis has not been widely accepted for clinical use,[42] it is important for healthcare providers to be aware that decreased SDNN may identify individuals at risk for the development of ventricular arrhythmias.[36] Our findings suggest that in Black overweight-obese youth, the risk for ventricular arrhythmias may be increased due to the decreased SDNN. Obesity is a major health risk that contributes to many cardiovascular alterations. Although no differences were identified

for the heart rate variability measure of high frequency, the QTc Interval duration, or Cornell voltage for left ventricular hypertrophy, additional research examining a more varied weight group and the identification of normative standards for electrocardiogram measurement of left ventricular hypertrophy is warranted in this population to determine with more distinction the role of race on cardiac autonomic function.

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Table 1. Comparison of Racial Demographics Based on Analysis of Variance

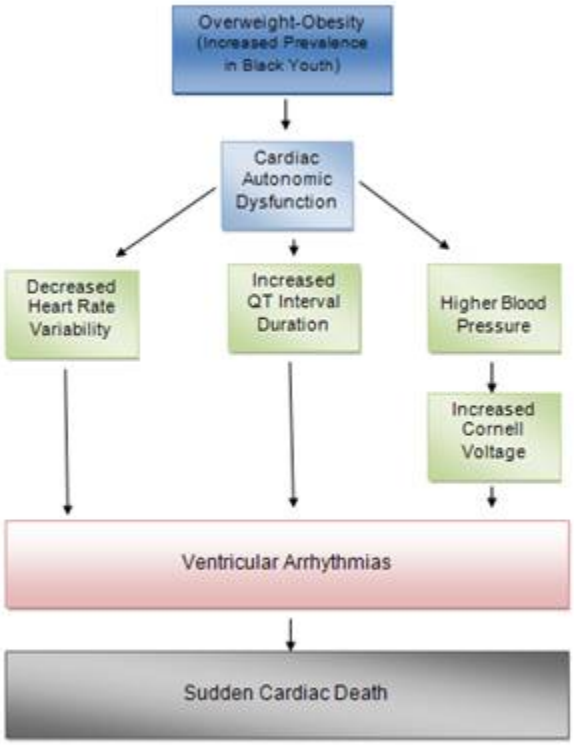
Measures	Black (n=77)	White (n=51)	p
Age (years)	14.22 ± 1.95	14.47 ± 1.86	0.473
BMI [(weight (kg) / height2 (m2)]	37.56 ± 8.06	36.61 ± 6.32	0.478
BMI percentile	98.48 ± 1.67	98.31 ± 2.47	0.637
Systolic BP (mm/Hg)	123.64 ± 14.06	123.59 ± 12.20	0.980
Diastolic BP (mm/Hg)	70.61 ± 8.75	67.75 ± 7.49	0.051*
Note. Data expressed as mean ± standard deviation. BMI = Body Mass Index; BP = Blood Pressure; *p ≤ 0.05			

Note. Data expressed as mean ± standard deviation. BMI = Body Mass Index; BP = Blood Pressure; *p ≤ 0.05

Table 2. Racial Differences for Adjusted Means of Cardiac Autonomic Measures Based on Univariate Analysis of Covariance

Measures	Black (n=77)	White (n=51)	p
Heart Rate Variability			
SDNN (ms)	128.62 ± 35.16	154.51 ± 41.30	0.001*
HF (ms2)	5.96 ± 0.89	6.63 ± 3.44	0.170
QTc (sec)	0.407 ± 0.038	0.410 ± 0.029	0.465
Cornell Voltage (mV)	0.863 ± 0.332	0.860 ± 0.387	0.513
Note. The covariance included age and gender. Data expressed as adjusted mean ± standard deviation. HF = High Frequency; QTc = Corrected QT; SDNN = Standard deviation of all normal RR Intervals; *p ≤ 0.05			

Figure 1. Conceptual Model of Overweight-Obesity and Cardiac Autonomic Function in Youth


Overweight-Obesity (Increased Prevalence in Black Youth)
Cardiac Autonomic Dysfunction
Decreased Heart Rate Variability
Increased QT Interval Duration
Higher Blood Pressure
Increased Cornell Voltage
Ventricular Arrhythmias
Sudden Cardiac Death