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Widened QRS-T Angle May be a Measure of Poor Ventricular Stretch during Exercise among On-Duty Firefighters

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Abstract

Background: The spatial QRS-T angle is a measure of repolarization heterogeneity and may be a predictor of poor ventricular health. It is unknown if a relationship exists between QRS-T angle and blood pressure during exercise.

Objective: The purpose of this study was to evaluate the potential relationship between QRS-T angle and blood pressure during exercise which may be indicative of ventricular stretch.

Methods: Ambulatory 12-lead 24-hour Holter ECG monitoring for QRS-T angle measurement was followed by exercise testing with blood pressure (BP) (mmHg) recordings taken pre-exercise, maximum achieved BP during exercise, and 2 minutes post-exercise. BP recovery was calculated by subtracting the maximal and 2 minute post-exercise BPs. Means (+/− standard deviation) and percentages are presented. Pearson's correlations (r) among all QRS-T angle and all BP measures were performed. One-way ANOVA was conducted on classification of QRS-T angle and all BP measures.

Results: One hundred eleven firefighters (95.5% male, mean age= 44 years) were included in this analysis. Twenty-seven percent of firefighters had either a borderline (100– 139 degrees), or widened (≥140 degrees) QRS-T angle. Although the ANOVA was not statistically significant, a near statistically significant negative correlation existed between QRS-T angle and maximum diastolic BP ($r=-0.190$, $p=0.05$), and a statistically significant relationship existed between QRS-T angle and post-exercise diastolic BP ($r=-0.261$, $p=0.008$).

Conclusions: A negative correlation existed between QRST-angle and maximal diastolic BP and post-exercise diastolic BP. Lower maximum diastolic BP during and after exercise may be a sign of poor ventricular stretch. A widened spatial QRS-T angle may represent poor ventricular stretch.

Keywords

electrocardiography; exercise; ventricular function; hypertension; firefighters

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Conflicts of interest:
None.

Introduction:

The electrocardiogram (ECG) is a simple and non-invasive tool used to assess patients at risk for cardiac events. The spatial QRS-T angle is an ECG measure of the difference in mean vectors of depolarization and repolarization (Oehler, Feldman, Henrikson & Tereshchenko, 2015). Therefore, the spatial QRS-T angle is the vector sum of the cardiac ventricular gradient, and has been postulated to represent the heterogeneity of cardiac action potential morphology (Voulgari, Pagoni, Tesfaye & Tentolouris, 2013). This heterogeneity in the action potential increases the susceptibility to arrhythmias and poor ventricular function (Voulgari & Tentolouris, 2009). With the emergence of computerized vectorcardiography, the spatial QRS-T angle may become more prevalent in clinical practice so cardiovascular nurses need to be aware of its physiological underpinnings and its associated risks (Oehler, Feldman, Henrikson & Tereshchenko, 2015). The QRS-T angle is an ECG-derived vector sum of the ventricular gradient which may represent heterogeneity in the cardiac action potential during depolarization and repolarization, and may be indicative of poor ventricular function.

A widened spatial QRS-T angle has been associated with increased risk for all-cause mortality and cardiac mortality in a recent meta-analysis (X. Zhang et al., 2015; Whang et al., 2012). Moreover, a widened spatial QRS-T angle may represent structural changes in the heart reflective of processes that contribute to left ventricular hypertrophy (LVH) confirmed by echocardiography (Gao & Yang, 2014; Man et al., 2012). LVH represents physiological adaptation to an increased cardiac work load and increased left ventricular wall stress, and hypertension is one known cause of LVH (Kahn & Bergfeldt, 2005). Hypertension acts as a stressor on the left ventricular wall stimulating myocyte hypertrophy, collagen formation and fibroblast-mediated myocardial remodeling which subsequently reduces left ventricle compliance leading to diastolic dysfunction (Kahn & Bergfeldt, 2005). The spatial QRS-T angle may be widened in patients with elevated blood pressure possibly due to structural changes in the heart reflective of LVH (Atsma et al., 2008; Dilaveris et al., 2001; Tanriverdi et al., 2018; Voulgari et al., 2006). Atsma et al. (2008) reported that elevated blood pressure among postmenopausal women led to ventricular depolarization and repolarization disturbance as measured by the spatial QRS-T angle prior to the development of LVH. Another study reported spatial QRS-T angle was associated with left ventricular performance among a group of type 2 diabetics (Voulgari et al., 2006). Furthermore, both LVH and the spatial QRS-T angle have been associated with increased susceptibility to poor cardiac outcomes (Elhendy et al., 2003; X. Zhang et al., 2015; Whang et al., 2012). Therefore, spatial QRS-T angle is a predictor of poor cardiac outcomes possibly due to poor ventricular health caused by hypertension and the development of LVH.

Although the relationship between spatial QRS-T angle and LVH has been previously described, limited research has been published on spatial QRS-T angle and ventricular function during exercise which may be impaired due to underlying processes such as LVH. As mentioned, previous research suggests that adults with hypertension have widened spatial QRS-T angle possibly caused by the developing LVH (Dilaveris et al., 2001; Tanriverdi et al., 2018). However, previous studies have failed to look at this relationship during exercise testing which requires greater ventricular stretch and ventricular compliance (Dilaveris et al., 2001; Tanriverdi et al., 2018). It remains unknown how the spatial QRS-T angle, a known marker of overall cardiovascular health, relates to blood pressure before, during, and after exercise testing. It is known that in patients with LVH, left ventricle mass and ejection fraction measured using echocardiography during exercise are independent predictors of mortality (Elhendy et al., 2003). Unfortunately, only echocardiography and not ECG was used in this study limiting the associations between echocardiographic and ECG measures. Since decent left ventricular health and adequate ejection fraction are required to maintain cardiovascular fitness, exercise testing among a population at risk for LVH due to hypertension may reveal an ECG-derived measure of ventricular health and overall ventricular stretch. Applying ECG and exercise testing in a patient population in which hypertension is prevalent would help establish spatial QRS-T angle as a measurement of ventricular function and ventricular stretch. In this secondary analysis, the relation between spatial QRS-T angle and blood pressure recorded before, during, and after exercise testing and recovery from exercise was calculated to determine if spatial QRS-T is a measurement of ventricular function.

Materials and Methods:

Subjects for this secondary analysis were a part of the cross-sectional Surveying & Assessing Firefighters Fitness & Electrocardiogram (SAFFE) study conducted in Western New York, and all firefighters were eligible to participate in the study. The primary results from the SAFFE study results have been previously reported (Al-Zaiti & Carey, 2015; Carey, Al-Zaiti, Dean, Sessanna, & Finnell, 2011). Subjects included professional firefighters from seven of the 13 city firehouses. Firefighters are a unique vulnerable workforce to study because they are at a substantial increased risk for cardiac events compared to other first responders and the general public (Smith, DeBlois, Kales & Horn, 2016). Furthermore, firefighters are generally hypertensive and overweight adding to their cardiac burden (Carey, Al-Zaiti, Liao, Martin, & Butler, 2011). Given their increased cardiovascular burden, the effect size measured when evaluating spatial QRS-T angle and pre-exercise blood pressure, maximum achieved blood pressure during exercise, 2 minute post-exercise blood pressure, and blood pressure recovery may be increased using this population. Only data recorded from a 12-lead 24-hour Holter ECG monitor for QRS-T angle measurement and blood pressure recordings before, during, and after exercise testing were analyzed. For this secondary data analysis, all firefighters were included. The spatial QRS-T angle between the mean QRS and T vectors is relatively insensitive to variations in the estimates of T wave onset and offset; therefore, there was little concern of repolarization abnormalities such as in bundle branch blocks impacting QRS-T angle measurement (Z. Zhang et al., 2015).

The study was approved by the Institutional Review Board (IRB) of the State University of New York. All firefighters provided written consent after understanding the potential benefits and risks involved with this study. Self-report demographic data including age, number of years as a firefighter, ethnicity (White, Black or African American, or Other), current smoking status (yes/no), current medical diagnosis of sleep apnea (yes/no), and whether the firefighter had a pacemaker (yes/no) was collected. Afterwards, a registered nurse obtained anthropometric measures including height, weight, and abdominal circumference. Weight was recorded once using a calibrated bathroom scale. Body Mass

Index (BMI) was calculated and categorized in accordance with the Centers for Disease Control and Prevention (CDC) standard BMI range categories for adults (Calle, Thun, Petrelli, Rodriguez, & Heath, 1999).

Blood Pressure

To determine the severity of hypertension among this sample of firefighters, resting state blood pressure was categorized in accordance with the new 2017 American Heart Association (AHA) blood pressure guidelines (Whelton et al., 2018). Firefighters were asked to sit and rest for 15 minutes prior to their blood pressure being taken by a registered nurse. A second reading was taken five minutes later with the firefighter still resting and in the sitting positon. The mean of the two blood pressures was considered the resting state blood pressure. Firefighters being treated for hypertension or that reported a diagnosis of hypertension was still considered for this study because this study was conducted prior to the release of these new guidelines. The 2017 AHA blood pressure guidelines are as followed:

Normal: Less than 120/80 mm Hg;

Elevated: Systolic between 120–129 *and* diastolic less than 80;

Stage 1: Systolic between 130–139 *or* diastolic between 80–89;

Stage 2: Systolic at least 140 *or* diastolic at least 90 mm Hg.

12-lead 24-hour Holter ECG Monitoring

This study involved the use of 12-lead H12+ Holter ECG monitors which capture continuous data for 24-hours (V3.12; Mortara Instruments, Milwaukee, WI). The 12-leads were placed in the Mason-Likar lead configuration to measure QRS-T angle (Papouchado, Walker, James & Clarke, 1987). The leads were placed on shaven and cleaned areas of the torso under the firefighters' uniforms, and monitors were securely fastened to their uniform belt. Firefighters were informed to continue their activities of daily living (i.e. eating, sleeping, exercising, etc.) with the 12-lead Holter monitor attached. High fidelity and high resolution (1000 samples per second) recordings were obtained with a frequency of 0.05 to 60 Hz. Recordings were downloaded to a computer with H-Scribe 4 software (Mortara Instrument) for ECG processing and analysis. After semi-automatic annotation was performed to delete noise and artifact, all ECGs were manually reviewed for quality assurance by a reviewer blinded to the study. High-frequency ECG waveforms like QRS-T angle can be missed with the standard upper filter setting of 60 Hz. To resolve this potential issue, the first 10-second ECG tracing of the 24-hour monitoring period was exported into a portable document format with the standard filter setting at 0.05 to 150 Hz using the ELI LINK program (Mortara Instruments) for subsequent analysis. Lastly, using Super ECG software (Mortara Instrument) the average spatial QRS-T angle from the entire 24-hour monitoring session was calculated and reported. QRS-T angle is difficult to visualize and requires calculation. Current methods of measuring the spatial QRS-T angle include the generation of X, Y, and Z axes between the QRS and T waveforms on the 12-lead ECG by using algorithms obtained from a matrix transformation (Edenbrandt & Pahlm, 1998). The mean X, Y, and Z values are calculated to obtain the mean QRS and T vectors, and the spatial QRS-T angle is calculated as the scalar product between these two vectors (Edenbrandt & Pahlm, 1998). Although this study used high fidelity computerized calculations for spatial QRS-T angle, Rautaharju and colleagues have reported a simple estimation procedure for the spatial QRS-T angle from a standard 12-lead ECG (Rautaharju, Prineas & Zhang, 2007). Lastly, LVH was also measured using the 12-lead H12+ Holter ECG monitors. LVH was determined using Cornell's Criteria (lead SV3 + lead RaVL; cutoff for LVH > 20 mm in women or > 28 mm in men). Ying Su et al. (2017) recently reported a sensitivity 22.2% and specificity 95.2% for Cornell's Criteria for LVH.

Exercise Treadmill Testing

On-duty firefighters completed a standard Bruce protocol exercise treadmill testing X-Scribe™ stress testing system (Mortara Instruments). The Bruce protocol is a maximal exercise test in which a subject works to complete exhaustion as the treadmill speed and incline increase incrementally every three minutes (Bruce, Kusumi, & Hosmer, 1973). Firefighters underwent exercise treadmill testing for as long as tolerated, even if maximum heart rate was exceeded (symptom-limited exercise). Testing was only terminated if the firefighter reported symptoms such as dyspnea or palpitations; otherwise, the exercise test was completed in about 20 minutes. Blood pressure (mmHg) was recorded 5-minutes prior to exercise treadmill testing (pre-exercise), and then at 5-minute intervals during exercise. The maximal blood pressure achieved during exercise testing was recorded based on the values recorded during these 5-minute intervals. Post-exercise blood pressure was recorded 2-minutes after exercise treadmill testing. Previous research informed us about the 2-minute cutoff (Kurl et al., 2001; Laukkanen, 2004). Recovery blood pressure was calculated by subtracting the maximal blood pressure by the 2-minute post-exercise testing blood pressure.

Statistical Analysis

Descriptive data are presented as means (+/− standard deviation) or percentages where appropriate. Resting state blood pressure means were used when determining hypertension classification. Bivariate correlations between QRS-T angle and all blood pressure measures were reported using Pearson's r coefficient. Spatial QRS-T angle was classified as normal (<100), borderline (100–139), and widened (≥140) (Kors et al., 2003). One-way analysis of variance (ANOVA) was conducted on classification of QRS-T angle on pre-exercise blood pressure, maximal blood pressure during exercise, post- exercise blood pressure, and recovery blood pressure. All analyses were conducted using Statistical Package for Social Sciences (SPSS version 21.0; IBM). Statistical significance was considered when $p < 0.05$.

Results:

In total, one hundred and eleven (n=111) on-duty firefighters were included in this analysis. The mean age was 43.6 (±7.7) years, and mean years as a firefighter was 15.5 years (±7.0). The mean BMI was 29.5 kg/m^2 (±4.1), and the majority were at least overweight (48.7%) if not obese (41.4%) (total= 90.1%). The mean resting state blood pressure was systolic 129.3 mmHg (±14.9) and diastolic 81.8 mmHg (± 10.6). In accordance to the new 2017 AHA guidelines, the average firefighter had stage I hypertension. Nearly 40% of the on-duty firefighters had stage I hypertension and 31.5% of firefighters had stage II hypertension (total= 71.1%) (Table 1).

The mean spatial QRS-T angle among the on-duty firefighters was 78.1 degrees (±37.3). In this sample, 73% of the on-duty firefighters had a normal spatial QRS-T angle (<100 degrees), 22% had a borderline spatial QRS-T angle (100–139 degrees), and 5% had a widened spatial QRS-T angle (≥140 degrees) (Table 1).

Blood pressure was recorded pre-exercise, maximum during exercise, post-exercise, and, additionally, blood pressure recovery was calculated. In summary for the entire sample of firefighters, the means for systolic blood pressure were: pre-exercise 130 mm Hg (±15.5), maximum during exercise 168 mm Hg (±27.5), post-exercise 152 mm Hg (±23.9), and 2-miunte recovery 18 mm Hg (±24.8). The means for diastolic blood pressure were: pre-exercise 79 mm Hg (±11.4), maximum during exercise 77 mm Hg (±13.9), post-exercise 75 mm Hg (±15.4), and 2-minute recovery 2 mm Hg (±13.4).

Next, the relationships between QRS-T angle and blood pressure were investigated. Between the three QRS-T angle groups, no statistically significant differences in the means were found for all blood pressure measures as seen in Table 2. Although the findings were not statistically significant, a trend was observed among the diastolic blood pressure measures. The group with the widened QRS-T angle had lower diastolic blood pressure compared with the normal group. The mean maximum diastolic blood pressure for the widened QRS-T angle group was 73.3 mmHg (±19.1) compared to 77.8 mmHg (±13.8) for the normal group. The mean post-exercise diastolic blood pressure for the widened QRS-T angle group was 66.1 mmHg (±21.3) compared to 76.4 mmHg (±14.6) in the normal group. Although these findings are not statistically significant, a trend was observed. Spatial QRS-T angle was nearly statistically significantly negatively correlated with maximum diastolic blood pressure ($r=-0.190$, $p=0.05$), and statistically significantly negatively correlated between spatial QRS-T angle and post-exercise diastolic blood pressure ($r= -0.261$, $p=0.008$). Pre-exercise and recovery diastolic blood pressure measurements were not statically significant as seen in Table 3. Due to the small sample size in the widened spatial QRS-T angle group ($n=6$), we combined the borderline and widened groups and compared the means, but did not find any statistical significance between the means for all blood pressure measures ($p>0.05$ for all).

Discussion:

This secondary analysis showed that a trend toward statistically significant negative correlation existed between spatial QRS-T angle and diastolic blood pressure during maximal exercise, and a statistically significant negative correlation existed between spatial QRS-T angle and diastolic blood pressure 2-minutes post-exercise among a sample of on-duty firefighters. Therefore, on-duty firefighters with a widened spatial QRS-T angle demonstrate lower maximal diastolic blood pressure and lower post-exercise diastolic blood pressures. This is evident in the reported means between QRS-T angle group and blood pressure measures. We conclude that a negative relation existed between spatial QRS-T angle and diastolic blood pressure due to poor underlying ventricular health. The majority of firefighters in our sample were at least overweight if not obese, and hypertensive. Obesity and hypertension may contribute to structural changes in the ventricles such as myocyte hypertrophy and cardiac remodeling which reduces ventricle stretch (Kahn & Bergfeldt, 2005). Past research has suggested that diastolic blood pressure is more closely related to left ventricular wall thickness reflecting pure pressure load (Ganau et al., 1990; Kahn & Bergfeldt, 2005). During diastole, the ventricles stretch and fill with blood to prepare for the next contraction. This process occurs more frequently with larger volumes of blood during exercise in order to meet metabolic demands. Therefore, on-duty firefighters with a widened spatial QRS-T angle demonstrated lower maximal diastolic blood pressure during exercise and lower post-exercise diastolic blood pressures possibly because of the ventricles' inability to stretch and fill with blood during diastole during higher-than-usual metabolic demands.

In our study, the spatial QRS-T angle was not associated with any measure of systolic blood pressure during exercise testing which further suggests a widened QRS-T angle is associated with ventricular stretch. LVH is a physiological adaptation to increased cardiac workload and increased left ventricular wall stress caused by hypertension (Kahn & Bergfeldt, 2005). Further, LVH reduces left ventricle compliance and is more closely related to left ventricular wall thickness contributing to poor ventricular stretch and diastolic dysfunction (Elhendy et al., 2016; Kahn & Bergfeldt, 2005). These conclusions can only be confirmed with echocardiographic data to measure left ventricular wall thickness. Only one other study associated diastolic dysfunction with spatial QRS-T angle. In a 2016 study of patients with hypertrophic cardiomyopathy and echocardiographic evidence of diastolic dysfunction with a septal or posterior wall thickness greater than 15 millimeters, a widened spatial QRS-T angle was associated with sustained ventricular arrhythmias due to poorer ventricular health (Cortex, Graw & Mestroni). Therefore, a widened spatial QRS-T angle may resemble poor ventricular stretch and overall poor ventricular health. Ventricular stretch may be poor due to the development of LVH among hypertensive populations such as firefighters. Therefore, a widened spatial QRS-T angle may resemble poor ventricular stretch associated with the progression of LVH in populations with hypertension.

Although only 3.6% of firefighters had LVH per the Cornell Voltage Criteria, the contributing factors that lead to LVH such as obesity and hypertension are evident in this workforce. It may be concluded that a widened spatial QRST-angle may indicative of structural changes in the ventricles due to obesity and hypertension. Again, echocardiography needs to confirm these hypotheses. Future prospective studies among on-duty firefighters may wish to examine spatial QRS-T angle and ventricular function using echocardiography in order to determine if decreases in ventricular stretch are associated with widened spatial QRS-T angle. It should be noted that previous research from Man and colleagues (2012) suggested that a discriminant model equation combining body surface area and spatial QRS-T angle was a more accurate approach to the diagnosis of LVH compared to conventional ECG criteria. Although our study did not take body surface area into account, this demonstrates previous research has determined the clinical usefulness of QRS-T angle for evaluating LVH. Dilaveris and colleagues (2001) demonstrated that widened spatial QRS-T angle was a marker of ventricular repolarization in a hypertensive sample of 110 patients receiving treatment. In this study, hypertension was classified as systolic BP ≥160 mm Hg or diastolic BP ≥ 95 mm Hg. Our sample of generally overweight and hypertensive on-duty firefighters also suggests a widened spatial QRS-T angle may be a marker of poorer ventricular stretch. In summary, our findings add to the body of existing evidence that a widened QRS-T angle is related to poorer ventricular stretch possibly due to LVH development.

Our study of QRS-T angle and BP measures collected before, during and after exercise testing has strengths and weaknesses. This study categorized blood pressures in accordance with the newly released new 2017 American Heart Association (AHA) blood pressure guidelines which is one of the first to do so among firefighters. These results may also be generalizable to the population at large because on-duty firefighters are overweight and hypertensive much like the general population (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016; Lacruz et al., 2015). Limitations to this study include the small coefficient values obtained from the bivariate correlations, and the small sample size of firefighters with borderline or widened QRS-T angles. Echocardiograms are necessary to determine the presence of LVH and left ventricular wall mass, which may impact diastolic function and relate to QRS-T angle. This is a significant weakness of our study. Future research may wish to include imaging data when evaluating ECG-based markers and cardiac function in order to fully evaluate the relationship between QRS-T angle and diastolic function during exercise.

Conclusions:

In this secondary analysis of on-duty firefighters, obesity and hypertension are prevalent medical conditions increasing cardiac burden and placing firefighters at greater risk for LVH. A negative correlation existed between the spatial QRS-T angle and maximal diastolic blood pressure during exercise, and between the spatial QRS-T angle and 2-minutes post-exercise. We conclude that a negative relation existed between spatial QRS-T angle and diastolic blood pressure during and after exercise may be due to poor underlying poor ventricular stretch.

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Table 1.

Descriptive Characteristics of On-Duty Firefighters, n=111

Physiological Measure	**% (n)**
Male	95.5 (106)
Female	4.5 (5)
White	81.1 (90)
Black or African American	13.5 (15)
Other	5.4 (6)
Current Smoker	11.7 (13)
Waist Circumference greater than 100cm	55.9 (62)
Sleep Apnea	4.5 (5)
Pacemaker	0.9 (1)
Normal Weight (BMI 18.5–24.9)	9.9 (11)
Overweight (BMI 25–29.9)	48.7 (54)
Obese Class I (BMI 30–34.9)	34.2 (38)
Obese Class II (BMI 35–39.9)	4.5 (5)
Obese Class III (BMI ≥40)	2.7 (3)
Normal Blood Pressure (<120/80 mmHg)	23.4 (26)
Elevated Blood Pressure (systolic 120–129 *and* diastolic <80 mmHg)	5.4 (6)
Stage I Hypertension (systolic 130–139 *or* diastolic 80–89 mmHg)	39.6 (44)
Stage II Hypertension (≥140 *or* diastolic ≥90 mm Hg)	31.5 (35)
Normal QRS-T Angle (<100 degrees)	73.0 (81)
Borderline QRS-T Angle (100–139 degrees)	21.6 (24)
Widened QRS-T Angle (≥140 degrees)	5.4 (6)
LLH (per Cornell’s Criteria)	3.6 (4)

Table 2.

One-Way ANOVA between QRS-T angle Group & Blood Pressure, n=111

Blood Pressure Measure	**Group**	**Mean (±SD)**	**ANOVA p-value**
Pre-Exercise Systolic	Normal	129.4 (±15.8)	0.872
	Borderline	131.4 (±16.2)	
	Widened	130.5 (±11.4)	
Maximum Exercise Systolic	Normal	169.6 (±28.2)	0.101
	Borderline	158.1 (±24.6)	
	Widened	181.0 (±20.4)	
Post-Exercise Systolic	Normal	152.0 (±24.0)	0.524
	Borderline	148.9 (±17.8)	
	Widened	161.3 (±37.8)	
2-minute Recovery Systolic	Normal	20.2 (±25.8)	0.439
	Borderline	12.4 (±21.3)	
	Widened	19.7 (±24.7)	
Pre-Exercise Diastolic	Normal	79.4 (±11.0)	0.126
	Borderline	80.4 (±12.0)	
	Widened	70.0 (±13.3)	
Maximum Exercise Diastolic	Normal	77.8 (±13.8)	0.635
	Borderline	75.5 (±13.2)	
	Widened	73.3 (±19.1)	
Post-Exercise Systolic	Normal	76.4 (±14.5)	0.263
	Borderline	73.6 (±16.7)	
	Widened	66.2 (±21.3)	
2-minute Recovery Diastolic	Normal	0.8 (±13.0)	0.473
	Borderline	3.0 (±15.6)	
	Widened	7.2 (±13.4)	

Table 3.

Pearson’s *r* Relations between Spatial QRS-T Angle & BP Measures, n=111

		Pre-Exercise Diastolic BP	**Maximum Exercise Diastolic BP**	**Post-Exercise Diastolic BP**	**Diastolic Blood Pressure Recovery**
QRS-T angle at the initial ECG	Pearson (r)	−0.007	−0.190	−0.261	0.119
	Sig. (2-tailed)	0.944	0.05 *	0.008 **	0.242

** Correlation is significant at the 0.01 level

* Correlation is near significant at the 0.05 level