NORMAL AND ABNORMAL FINDINGS FROM EXERCISE STRESS ECG VS. POST-EXERCISE ECHOCARDIOGRAPHY STUDIES IN A SERIES OF HYPERTENSIVE AND NORMOTENSIVE INDIVIDUALS

by

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Thesis submitted to the faculty of

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN EDUCATION

in

Exercise Physiology

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December, 1995

Blacksburg, Virginia

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(ABSTRACT)

The purpose of this investigation was to compare the frequencies of normal and abnormal findings from exercise electrocardioagraphy (ECG) and post-exercise echocardigraphy (ECHO) studies in a series of hypertensive and normotensive individuals who underwent diagnostic testing. Data for the ECG and ECHO variables were obtained simultaneously in association with treadmill exercise studies. Eighty consecutive cases were included in this retrospective study. Records were excluded if patients had: history of myocardial infarction; valvular heart disease; ECG evidence of abnormal Q waves, left ventricular hypertrophy (LVH) with abnormal ST/T wave pattern, or left bundle branch block (LBBB); medications that would alter blood pressure responses or ECG interpretation; technically uninterpretable records; or

failure to attain 85% of age-adjusted maximal heart rates in the exercise tests. Subjects were defined as hypertensive (HYP) if any one of the following criteria were met: 1) SBP $\geq$ 140 mmHg or DBP $\geq$ 90 mmHg; 2) current use of antihypertensive medications; or 3) history of hypertension. Normotensive subjects (NORM) were defined as absence of the above criteria. In each test, ECG data were taken at peak exercise, and ECHO data were taken immediately post-exercise (~ 45 sec). The ECG response was considered abnormal if the ST shifted $\geq$ 0.1 mV from baseline at J_{60}, while the ECHO response was considered abnormal when new or worsening of pre-existing wall motion abnormalities was observed. Chi-square analysis demonstrated that high blood pressure status significantly increased the frequency of clinically abnormal findings with ECHO ($X^2=9.15$; $p \leq 0.01$). This was not the case for exercise ECG ($X^2=2.12$; $p > 0.05$). However, there was no significant difference in the frequency of normal findings when comparing the two testing methods for both subject groups. These results indicate that resting blood pressure status may influence the rate of occurrence of abnormal *vs* normal ECG and ECHO findings; these data warrant further evaluation studies with invasive criterion measures of CAD status.

ACKNOWLEDGEMENTS

I would like to sincerely thank the following individuals for their time and effort contributed towards the completion of this project:

Dr. William G. Herbert, chairman of my committee, for your guidance, patience, and support during this project as well as throughout my graduate career. Also, thanks to Dr. Shala Davis and Dr. Don Sebolt for making the completion of this project possible.

I would also like to thank Jeff Ocel for his input and statistical knowledge along the way. Thanks to Laura Craft for her support and encouragement throughout this long process.

Finally, I would like to thank my husband, Tim, and my daughter, Taylor, as well as my very soon-to-be child and my in-laws for their patience while I finished this research. You have suffered with me as I completed my education, and I can't thank you enough. It has been a long, rough road, but now it is over.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

CHAPTER I

INTRODUCTION

Coronary artery disease (CAD) is the leading cause of death in adults in the United States (Pollock & Wilmore, 1990). The detection of CAD is key to many primary and secondary interventions designed to reduce morbidity and mortality in those with this disease. Many noninvasive screening tests have therefore been developed in order to detect CAD, such as electrocardiography, echocardiography, and thallium myocardial perfusion scintigraphy, in conjunction with exercise testing.

Treadmill exercise testing with electrocardiogram (ECG) monitoring is the most common screening tool for CAD. It is relatively simple, inexpensive, and fairly accurate in most patients. The diagnosis of myocardial ischemia is based on changes found on the electrocardiogram along with clinical symptoms exhibited by the patient during exercise (McNeer and Chaitman, 1978; Goldschlager, 1976). The sensitivity and specificity of this test have been tested extensively, and there have been many contributors to false-positive and false-negative tests found, especially among women and those patients with atypical angina (Sketch and Borer, 1975; Martin, 1972). In recent years, exercise echocardiography has gained wide acceptance in the area of CAD diagnosis and has demonstrated high sensitivity and specificity (Marwick, 1992; Crouse, 1991; Sawada, 1990; Sawada, 1989; Ryan, 1988; Oberman, 1989; Armstrong, 1986; Berberich, 1984; Robertson, 1983). It has also been shown to have equivalent accuracy to thallium perfusion imaging in detecting CAD (Quiñones, 1992; Galanti, 1991; Limacher, 1983).

Exercise echocardiography has also been used for studying hypertension, a major risk factor for CAD. Hypertension has a number of effects on the heart, including increased afterload on the left ventricle causing left ventricular hypertrophy (LVH). Previous studies have shown that silent ischemia, changes seen on the echocardiogram without clinical symptoms, is common in patients with hypertension and LVH (Pringle, 1992; Yurenev, 1990). These effects can be seen through echocardiographic measurements of regional wall motion abnormalities and systolic thickening, consistent in those patients with chronic CAD (Kraus, 1985).

STATEMENT OF THE PROBLEM

In diagnostic testing for CAD, exercise ECG has significant limitations for certain populations. The false-negative and false-positive rates for this test are 25% and 15%, consecutively. False-positive exercise ECG responses are more common in females, asymptomatic patients, hypertensives, and those with LVH (Franklin et al, 1993). Consequently, further tests must be done to adequately determine the presence of CAD, thus increasing the cost to the patient.

Since hypertension has been shown to be associated with more severe CAD, both LVH and hypertension have been studied to determine their relationship with ischemia during exercise testing. Unfortunately, the presence of LVH increases the incidence of resting ST depression, thus reducing the specificity of the exercise test (Froelicher & Umann, 1995). Patients with systemic hypertension are also more likely to be asymptomatic due to silent ischemia

(Pringle et al., 1992; Scheler et al., 1992; and Yurenev et al., 1990). Thus, hypertensive patients may also be more likely than patients with normal blood pressure to show signs of ischemia during maximal exercise, and they may also be more likely to have an inaccurate test result.

Therefore, the purpose of this investigation was to compare the frequencies of normal and abnormal findings from exercise ECG and post-exercise ECHO studies in a series of hypertensive and normotensive individuals who underwent diagnostic testing.

SIGNIFICANCE OF THE STUDY

If hypertensive subjects are more likely than normotensive subjects to have inaccurate test results for exercise ECG studies, stress echocardiography may be a better initial testing method for detecting CAD. This may decrease the rate of repeat testing procedures and therefore reduce the time involved in testing as well as the overall cost to the patient.

RESEARCH HYPOTHESES

To delineate the purpose of this study, the following null hypotheses were established by the investigator:

1. There is no difference in the occurrence of abnormal findings for normotensive or hypertensive subjects during maximal exercise observed electrocardiographically.
2. There is no difference in the occurrence of abnormal findings for normotensive or hypertensive subjects during maximal exercise observed echocardiographically.
3. There is no difference between exercise electrocardiography and exercise echocardiography in the occurrence of normal findings for normotensive or hypertensive subjects.

DELIMITATIONS

The following delimitations were incorporated into the design of this study:

1. Patients who were referred to Radford Community Hospital for stress echocardiography from January 1993 to June 1994 were included.

2. Hypertensive subjects met the following criteria: 1) systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, 2) currently taking blood pressure medication, or 3) having a past history of hypertension, denoted as a current risk factor on hospital exercise testing forms.
3. Normotensive subjects were defined as not meeting the above criteria.

LIMITATIONS

The following limitations were recognized by the investigator:

1. The results of the electrocardiographic measures during exercise testing were not unknown to the two cardiologists performing the echocardiographic measurements.
2. Angiography was not performed on the subjects after stress echocardiography to determine the clinical performance of either method of testing.
3. Optimal data for the two methods were recorded at different time intervals; ECG data was recorded at peak

exercise while ECHO data was recorded within 90 seconds of the post-exercise period, as performed by previous researchers (Berberich et al., 1984; Marwick et al, 1992; Oberman et al., 1989; Presti et al., 1987).

4. Placement of ECG lead V_2 and leads V_4-V_6 were not located in the standard position as not to overlie the acoustic echocardiographic window.

BASIC ASSUMPTIONS

The following assumptions were made by the investigator:

1. Echocardiography techniques were the same among both technicians performing testing during the study, following those standards set by the American Society of Echocardiography.
2. All subjects performed the exercise test with maximal effort.
3. Interpretations for ECG and ECHO data were done using the same techniques for both cardiologists as quantified by both the American College of Cardiology and the American Society of Echocardiography.

DEFINITIONS AND SYMBOLS

- Electrocardiography (ECG): analysis of the electrical waveforms and rhythms of the heart using ten electrodes placed on the chest.
- Echocardiography (ECHO): analysis of heart wall motion and blood flow through the use of ultrasound techniques.
- Left ventricular hypertrophy (LVH): enlargement of the muscle fibers of the left ventricle of the heart, usually associated with valvular heart disease, systemic hypertension, or cardiomyopathy.
- MET: a unit of measurement for the metabolic cost of exercise.

SUMMARY

Numerous noninvasive screening tools have been developed in order to detect coronary artery disease. The most common method is exercise electrocardiography. Stress echocardiography is becoming an increasingly popular method of detecting CAD by measuring wall motion abnormalities prior to and immediately after exercise. Since hypertensive

subjects are at increased risk of CAD and previous studies have shown that silent ischemia is common in patients with hypertension, the purpose of this study is to determine the association between resting blood pressure levels and signs of myocardial ischemia during maximal exercise observed both electrocardiographically and echocardiographically.

CHAPTER II

REVIEW OF LITERATURE

This review of literature provides research information regarding the use and diagnostic performance of both exercise electrocardiography and exercise echocardiography in the detection of coronary artery disease (CAD). In addition, this review provides data regarding the role of hypertension in ischemia and CAD. This includes research regarding those subjects with left ventricular hypertrophy (LVH). These studies provide support necessary to warrant further research in the use of echocardiography as a tool for detecting CAD in hypertensive patients.

EXERCISE ELECTROCARDIOGRAPHY

Treadmill exercise testing with electrocardiogram (ECG) monitoring is the most common screening tool for CAD. It is a relatively simple and inexpensive test, and has been found to be fairly accurate in most patients (Martin et al., 1972; Goldschlager et al., 1976; McNeer et al., 1978; and Chaitman et al., 1978). The diagnosis of myocardial ischemia and CAD is based on changes found on the ECG along with clinical symptoms exhibited by the patient during exercise.

Technique of Electrocardiography

The clinical graded exercise test is usually performed using a multiple-lead ECG system in conjunction with blood pressure monitoring. The Mason-Likar 12-lead ECG system has been a popularly used and well accepted method for monitoring during graded exercise testing (Pollock & Wilmore, 1990). This system utilizes a modified electrode placement of the limb leads at the shoulders and base of the torso. This can help eliminate most of the movement artifact found during the exercise test. Resting ECG measurements are made prior to and after the test and monitored continuously during exercise. The ECG is examined for abnormalities that might indicate exercise-induced myocardial ischemia.

ST-Segment Analysis

Although there are different means to analyze ECG results, such as R-wave amplitude and QT or QRS duration, ST segment analysis has received the most attention by researchers in the diagnosis of CAD (Froelicher & Umann, 1995; Fletcher et al., 1991). However, there is currently no agreement on the best method for ST analysis. Recently, J-point measures have been used to determine the magnitude and configuration of ST depression using the calculations for the change in ST segment/heart rate index (ΔST/HR index) and ST segment/heart rate slope (ST/HR slope). Okin et al. (1992) studied the exercise electrocardiograms of 130 patients by analyzing ST depression at both the J-point and at 60 msec after the J-point (J+60). The researchers found that J+60 measures provided higher specificity than J-point measures for both ΔST/HR index and ST/HR slope. There was no difference in sensitivity of standard criteria for either the J-point or J+60.

Computer analysis of the ST segment is now available in the routine clinical setting with the use of microprocessor technology. However, the use of these computer systems has led to problems with the precision of computer-averaged waveforms. Distortion of these waveforms can be created by noise, baseline wander, aberrant beats, and changes in conduction (Froelicher & Umann, 1995). Though they are easy to use, the cardiologists must rely on raw data to accurately depict ST segment changes. These errors were avoided in the current study by the manual analysis of the segment at J+60 in three consecutive waveforms. Those subjects with baseline wander or noise were excluded due to the technical difficulties of analysis.

Clinical Performance of Exercise Electrocardiography

Sensitivity and specificity of exercise-induced ST segment depression can be demonstrated by comparing the results of exercise testing to coronary angiography. Gianrossi et al. (1989) recently investigated the variability of the reported diagnostic accuracy of exercise ECG in 147 consecutively published reports involving 24,074 patients. Through meta analysis, the researchers found a wide variability in the sensitivity and specificity among the reports: the mean sensitivity was 68% with a range of

23% to 100%; the mean specificity was 77% with a range of 17% to 100%. When an exercise test cut point for ischemia was used of 1mm of horizontal or downsloping ST depression, a specificity of 84% and a sensitivity of 66% was found. The range for sensitivity thus became 40% for one-vessel disease and 90% for three-vessel disease. Therefore, when using the exercise ECG to predict the number of occluded coronary arteries, test sensitivity increases as more vessels are involved.

False positive tests are more likely to be found in those patients who are asymptomatic or who have atypical chest pain (Borer et al., 1975, and Froelicher et al., 1973). Additionally, the number of false positive tests can be decreased with the use of more specific criteria for an abnormal test, such as ST-segment analysis (Okin et al., 1991, and Ribisl et al., 1993).

EXERCISE ECHOCARDIOGRAPHY

Echocardiography has become an increasingly popular method of detecting CAD. Since two-dimensional echocardiography allows for imaging of the heart in multiple tomographic planes, analysis of all myocardial wall segments is possible. Computer systems in echocardiography have also enabled echocardiographic images to be digitized so they can be carefully analyzed and stored on video tape. The cardiologist is able to visualize the heart chambers and blood flow frame by frame in a continuous loop format. The main advantage to using this method is that it is truly noninvasive and does not involve radiation as do other methods such as thallium testing. The equipment is also less expensive and mobile so that it may be used in the clinical setting.

Technique of Two-Dimensional Imaging

Two-dimensional imaging is the most common method of exercise echocardiography and has been used in conjunction with both cycle and treadmill exercise testing. Maurer and Nanda (1981) evaluated the use of two-dimensional echocardiography before and immediately after graded exercise testing in 48 patients. They used the technique in which the patient was imaged while lying in the left lateral decubitus position before and immediately after exercise.

They reported a success rate of 85% in obtaining diagnostic images. Limacher et al. (1983) reported an imaging success rate of 100% while patients were lying in the left lateral decubitus position. Other studies have confirmed the use of these techniques (Armstrong et al., 1986, and Ryan et al., 1988).

Oberman et al. (1989) studied the reproducibility of two dimensional echocardiography. Nineteen subjects performed a graded exercise test with echocardiographic images taken before and immediately after exercise with the patient in the left lateral decubitus position. These tests were repeated after 14 days with different observers/interpreters. Both ejection fraction and wall motion abnormalities were highly correlated between the two tests. The correlation coefficients between tests 1 and 2 were 0.92 for both pre- and post-exercise ejection fractions and 0.98 for both pre- and post-exercise wall motion scores. The researchers concluded that two dimensional exercise echocardiography provides highly reproducible quantitative measures of myocardial ischemia when compared between different observers.

Regional Wall Motion Analysis

There have been several investigations in order to develop schemes for wall motion evaluation of left ventricular myocardial ischemia. The basis of these schemes is that the coronary arteries supply specific segments of the left ventricle. Presti et al. (1988) developed a schematic representation of the left ventricular wall divided into sixteen segments in order to generate a wall motion score. Feigenbaum (1986) has also developed a diagram that has been widely used representing the relationship between the coronary arteries and the wall segments seen in the four common views in two-dimensional echocardiography: parasternal short- and long-axis and apical two- and four-chamber views.

With the use of the continuous loop technique, pre- and post-exercise images can be placed side by side and analyzed for wall motion abnormalities. The scoring system consists of the qualitative analysis of each wall segment as either normal, hypokinetic, dyskinetic, or akinetic. A wall motion score can then be calculated and used to determine the magnitude of abnormal wall motion.

Clinical Performance of Exercise Echocardiography

The advances in echocardiographic technology have led to extensive investigation of the accuracy of exercise echocardiography. Many studies have looked at its specificity and sensitivity, and it has also been compared to other techniques such as electrocardiography, thallium myocardial perfusion scintigraphy, and radionuclide ventriculography.

Marwick et al. (1992) studied the accuracy of exercise echocardiography in an unselected series of patients undergoing exercise echocardiographic testing over an 18-month period. The researchers found that this test method had a higher sensitivity than exercise electrocardiography (87 vs. 63% $p=0.01$). Exercise echocardiography also detected 68% of those subjects with single vessel disease and 96% of those subjects with multivessel disease ($p=0.01$). Crouse et al. (1991) also studied a series of patients referred for evaluation of possible CAD via exercise echocardiography and found that, compared to electrocardiography, exercise echocardiography was more sensitive (97 vs. 51%) and more specific (64 vs. 62%). They also found that exercise echocardiography was highly predictive of the extent of CAD in either one-, two-, or three-vessel disease.

Exercise echocardiography has also been compared to the accuracy of other types of screening tests. Galanti et al. (1991) studied the accuracy of exercise echocardiography in comparison with thallium scintigraphy. The researchers found that exercise echocardiography had a sensitivity of 92.6% and a specificity of 96.2% with an overall global accuracy of 94.3% as compared to thallium testing which had an overall global accuracy of 96.3%. These differences were not significant. Quiñones et al. (1992) also found that exercise echocardiography has a diagnostic accuracy comparable to thallium testing, though more abnormal regions were detected with the combination of the two methods.

HYPERTENSION

Hypertension is the most common cardiovascular disease in humans and one of the most powerful predictors of CAD (Pollock & Wilmore, 1990). Rutan et al. (1988) found in the MRFIT study that risk of premature CAD and death increases dramatically with increases in systolic and diastolic measures at rest. The risk also increases markedly when hypertension is also paired with other risk factors for CAD, such as smoking, obesity, and/or hypercholesterolemia. Hypertension is also associated with other complications such as strokes, transient ischemic attacks or small strokes, peripheral vascular disease, dissecting aortic aneurysms, nephropathy, LVH and congestive heart failure (Leon et al., 1995). Unfortunately in 95% of the cases, hypertensions idiopathic, i.e. of unknown origin (Kaplan, 1980).

Exercise Testing of Hypertensive Patients

During exercise, hypertensive patients may have increased blood pressure (BP), though the mechanism for this increase differs than the increases seen in normotensive patients. In normotensive patients, a rise in systolic BP is expected with little or no change in diastolic BP in addition to decreased vascular resistance. This is due to an increase in cardiac output with increased blood flow to the working muscle and decreased blood flow to nonworking muscles and visceral organs. In hypertension, however, both systolic and diastolic pressures are increased with an increase in vascular resistance. This is due to a decrease in cardiac output because of decreased stroke volume (Hanson & Rueckert, 1995).

Many researchers have focused their studies on blood pressure increases during maximal exercise. Smith et al. (1992) studied the pressure response of 35 normotensive and 65 hypertensive males to graded treadmill testing. These measures were compared to the presence or absence of LVH in each subject. Multiple stepwise regression revealed that pre-exercise systolic BP was the major determinant of maximal systolic BP ($r = 0.52$; $p \leq 0.0001$). However, hypertensive patients with LVH had lower increases in maximal systolic BP. This was explained by a lower maximum oxygen uptake and maximal heart rate. The presence of LVH was not found to be correlated with either pre- or post-exercise BPs. The researchers therefore concluded that exaggerated BPs were not related to LVH in normotensive or hypertensive subjects. These results have also been shown by other researchers (Irving et al., 1977, and Filipovský et al., 1992).

Fagard et al. (1991) studied 143 male hypertensive patients to determine if exercise pressure response was more predictive of mortality than pressure at rest. Each patient was followed for ten years after a progressive graded bicycle ergometer test. The researchers found that pressure at rest and during submaximal and peak exercise equally and significantly predict mortality and incidence of cardiovascular events in hypertensive men, independent of age.

Exercise Blood Pressure as Predictor of Future Hypertension

Jackson et al. (1983) looked at exercise blood pressure as a means to predict future systemic hypertension. In their study, they followed 4,856 patients over a period of two to four years after maximal exercise testing. Fifty-one percent of normotensive subjects with a hypertensive response to maximal exercise were hypertensive at rest after a two year follow-up. These subjects were matched with a group of subjects of similar age who were normotensive at rest and exercise. Only 15% of the matched subjects were found to be hypertensive at their follow-up visit. This difference was statistically significant ($p \leq 0.001$), supporting their hypothesis that exercise hypertension was a precursor of resting hypertension.

Similarly, Wilson et al. (1990) studied the exercise pressure responses of normotensive men who were at high risk of hypertension, defined by a parental history of hypertension and a high normal resting BP (systolic BP between 135-154 mmHg and diastolic BP between 85-90 mmHg). They found that those at high risk for hypertension were more likely to have an exaggerated pressure response to exercise than those subjects who were not at high risk for hypertension. They also concluded that those subjects with an exaggerated pressure response may be at highest risk for future hypertension due to an impaired capacity for exercise-induced vasodilation.

Hypertension and Indicators of Myocardial Ischemia in Exercise Testing

The presence of LVH is an important prognostic sign and an independent risk factor for sudden death, ventricular arrhythmias, and myocardial ischemia (Zarco, 1993). Since hypertension has been shown to be associated with more severe CAD, both LVH and hypertension have been studied to determine their relationship with ischemia during exercise testing. Unfortunately, the presence of LVH increases the incidence of resting ST depression, thus reducing the specificity of the exercise test. Patients who have ST-segment depression on their baseline ECG should therefore be analyzed using an additional measure of ST-segment depression, i.e., 1 mm (Froelicher & Umann, 1995). Since subjects were included in this study who had baseline ST-segment depression, a mean ST change of ≥ 1mm was used as the criteria for an ischemic response in exercise testing. In addition, those subjects who showed ECG evidence of LVH with ST-T repolarization abnormalities - the so called strain pattern - were excluded due to uninterpretable ST segments.

Recent research has shown that symptomatic and silent myocardial ischemia also occurs commonly in hypertensive patients during maximal exercise, independent of the presence of LVH or CAD (Pringle et al., 1992; Scheler et al., 1992; and Yurenev et al., 1990). This is consistent with an arising theory that angina and ischemia in hypertensive patients may, in some cases, be caused by microcirculation abnormalities instead of coronary lesions (Zarco, 1993, and Kaski, 1993). At this time, there is no screening mechanism prior to testing to determine which hypertensive patients will have exercise-induced ischemia with or without normal coronary arteries.

SUMMARY

The objective of this review was to present published findings regarding the role of ECG and echocardiography during clinical exercise testing and the changes induced in patients with hypertension. The accuracy of both testing methods was also reviewed in order to determine their differences and limitations. Previous research has shown that echocardiography is more accurate than ECG in detecting CAD, especially in single-vessel disease. Evidence also suggests that hypertensive patients are more likely to have ECG signs of ischemia during maximal exercise testing. Consequently, the possibility exists that those patients with hypertension may likely benefit from exercise echocardiography over exercise ECG due to the fact that there is a likelihood of left ventricular hypertrophy and/or ischemia. Therefore, the main purpose of the current study was to determine whether hypertensive patients are more likely to develop ischemia when compared to normotensive patients. Both exercise ECG and exercise echocardiography techniques were utilized to determine the differences, if any, in detecting ischemia.

CHAPTER III

JOURNAL MANUSCRIPT

NORMAL AND ABNORMAL FINDINGS FROM EXERCISE STRESS ECG VS. POST-EXERCISE ECHOCARDIOGRAPHY STUDIES IN A SERIES OF HYPERTENSIVE AND NORMOTENSIVE INDIVIDUALS

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ABSTRACT

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Purpose. This investigation was designed to compare the frequencies of normal and abnormal findings from exercise electrocardiography (ECG) and post-exercise echocardiography (ECHO) studies in a series of hypertensive and normotensive individuals who underwent diagnostic testing.

Methods. Eighty consecutive cases were included in this retrospective study. Subjects were defined as hypertensive (HYP) if any one of the following criteria were met: 1) SBP $\geq$ 140 mmHg or DBP $\geq$ 90 mmHg; 2) current use of antihypertensive medication; or 3) history of hypertension. Normotensive subjects (NORM) were defined as absence of the above criteria. Data for the ECG and ECHO variables were obtained simultaneously in association with treadmill exercise studies. In each test, ECG measures were taken at peak exercise while ECHO data were taken approximately 45

sec after cessation of exercise to obtain optimal images. ECG response was considered abnormal, if the ST shifted ≥ 0.1 mV from baseline at J_{60}. The 2-D ECHOs were recorded with the subject in the left lateral decubitus position, and parasternal long- and short-axis apical two and four chamber views were recorded for qualitative determination of wall motion abnormalities.

Results. Chi-square analysis demonstrated that high blood pressure status significantly increased the frequency of abnormal test results for ECHO (X^2=9.15; $p \leq 0.01$), but not for exercise ECG (X^2=2.12; $p > 0.05$). However, there was no significant difference in the frequency of normal findings when comparing the two testing methods for both subject groups.

Conclusions. These results indicate that resting blood pressure status may influence the occurrence of abnormal *vs* normal ECG and ECHO findings; these data warrant further evaluation studies with invasive criterion measures of CAD status.

Key Words: hypertension, exercise electrocardiography, exercise echocardiography.

INTRODUCTION

Treadmill exercise testing with electrocardiogram (ECG) monitoring is the most common screening tool for CAD. It is relatively simple, inexpensive, and fairly accurate in most patients. The diagnosis of myocardial ischemia is based on changes found on the electrocardiogram along with clinical symptoms exhibited by the patient during exercise[1-3]. The sensitivity and specificity of this test have been tested extensively, and there have been many contributors to false-positive and false-negative tests found, especially among women and those patients with atypical angina[4-6]. In recent years, exercise echocardiography (ECHO) has gained wide acceptance in the area of CAD diagnosis and has demonstrated high sensitivity and specificity[7-15]. It has also been shown to have equivalent accuracy to thallium perfusion imaging in detecting CAD[16-18]. Exercise ECHO has its own unique advantages. One significant advantage is the versatility of two-dimensional echocardiography. This method allows for the diagnosis of virtually all forms of cardiac disease, which may masquerade as ischemic heart disease. This includes pericardial, congenital, primary myocardial and valvular heart disease, and therefore provides a screening tool for other forms of heart disease in patients exhibiting chest pain[19]. This is a unique capability of ECHO compared to other forms of cardiac imaging. It is also noninvasive, more cost-effective, and free of any adverse side effects that might accompany other imaging techniques for detecting CAD.

Exercise echocardiography has been also been used for studying hypertension, a major risk factor for CAD. Hypertension has a number of effects on the heart, including increased afterload on the left ventricle causing left ventricular hypertrophy (LVH). Previous studies have shown that silent ischemia, changes seen on the echocardiogram without clinical symptoms, is common at rest and during daily activities in patients with hypertension and LVH[20-21]. These effects can be seen through echocardiographic measurements of regional wall motion abnormalities and systolic thickening, consistent in those patients with chronic CAD[22]. The purpose, therefore, of this investigation was to determine whether hypertensive subjects are more likely to show signs of ischemia during exercise when measured by both electrocardiography and echcoardiography.

METHODS

Patients

A retrospective design was used for subject selection. Eighty subjects who had been referred to the Heart Center at Radford Community Hospital in Virginia for treadmill exercise echocardiography testing were studied. Subjects were divided into two groups: those with normal resting blood pressures (NORM) and those with resting hypertension (HYP). Those subjects with resting hypertension met the following criteria: 1) systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, 2) currently taking blood pressure medication, or 3) having a past history of hypertension, denoted as a current risk factor on hospital exercise testing forms. Normotensive is defined as the absence of the above criteria.

Subjects were excluded who had known CAD, had taken medications the morning of the test which may have altered blood pressure responses to exercise (beta or calcium channel blockers) or which may have altered the ECG (digitalis), or who showed ST segment shift with hyperventilation ECG. In addition, those subjects who showed signs of left ventricular hypertrophy with strain, left bundle branch block, valvular stenosis or regurgitation, dyskinesis, aneurysm, known previous myocardial infarction or evidence of clinically significant Q waves > 0.04 sec were also excluded.

All subjects gave informed consent forms as per hospital policy prior to exercise testing. In accordance with hospital policy, appropriate consent was also obtained from the hospital medical director for such information to be used for statistical research.

General Protocol

Exercise testing. Treadmill exercise testing was performed on each subject using the Bruce protocol. During each 3-minute stage, a 12-lead ECG and exercising blood pressure measures were recorded while three ECG leads (II, avF, V_5) were continuously monitored. In accordance with the supervising physician, exercise test endpoints were: 1) development of limiting chest pain and/or dyspnea, 2) fatigue, or 3) subject's request to stop the test.

Electrocardiography. Resting 12-lead ECGs and blood pressure readings were performed on each subject prior to exercise testing in both the supine and standing positions. The electrodes for ECG monitoring were placed on the chest so as not to overlie the marked sites for the acoustic echocardiography window (Figure 1). Specifically, lead V_2 was placed on the sternum at the level of V_1, and leads V_4-V_6 were lowered to the 6th intercostal space.

The exercise ECG was determined by the investigator to be normal or ischemic. An ischemic response to exercise was defined as meeting one of the following criteria: 1) horizontal or downsloping ST segment depression of ≥1 mm 60 ms after the J point in a lead with a normal ST segment at rest, 2) ST segment elevation of 1 mm or more than the resting tracing 60 ms after the J point, 3) in the presence of ST depression in the resting tracing, an additional depression of 1mm or more is required. ST segment deviation was automatically calculated during the test by the computer (Q5000, Quinton Instrument Company, Bothell, Washington) as well as reviewed by the supervising physician[23]. In addition, 3 concurrent complexes were measured for ST deviation and slope 60 ms after the J-point[24].

Insert Figure 1 here

Echocardiography. Two-dimensional echocardiograms were recorded with standard commercially available equipment (Hewlett Packard Sonos 1000, Andover, Massachusetts). Parasternal long- and short-axis and apical two- and four-chamber views were recorded with the subject in the left lateral decubitus position at rest. The acoustic echocardiography window for both the parasternal and apical positions was marked on each subject's chest using a washable felt tip marker for reference. Immediately after cessation of exercise, the subject resumed the left lateral decubitus position, and the standard four views were repeated (within 90 seconds of cessation of exercise).

The echocardiography studies were digitized on-line into a quad-screen, continuous loop format for analysis (Nova Microsonics ImageVue DCR, Mahwah, New Jersey). Images were recorded on 3/4 inch VHS videotape as well as digitally on a 3½ inch floppy diskette. Data were reviewed with resting and immediate post-exercise images placed side-by-side. Images were assessed for ejection fraction, left ventricular mass, and for the presence of normal regional wall motion. Normal peak exercise shows a decrease in ventricular size with an increase in ejection fraction. Abnormal studies were defined as having regional wall motion abnormalities, such as hypokinesia, akinesia, or dyskinesia at rest or immediately after cessation of exercise as described by previous investigators[25-26]. These changes occur in conjunction with an increase in ventricular size and a decrease in ejection fraction. Ejection fraction was measured by the computer (Nova Microsonics ImageVue DCR, Mahwah, New Jersey), by calculating stroke volume and dividing by diastolic volume[19]. Left ventricular mass was defined by the investigator as normal or abnormal as recorded by the interpreting physician. The distribution of

CAD was approximated by studying the area in which the wall motion abnormalities occurred, as adopted by the American Society for Echocardiography[27] (Figure 2). Thus, the left ventricular wall was divided into 16 segments utilized to develop a wall motion score.

Insert Figure 2 here

Statistical Analysis

Independent T-tests were used for contrasting demographic data between the NORM and HYP groups. Also, chi square analysis (χ^2) was used to evaluate the distribution of normal vs abnormal clinical findings for ECG vs ECHO in the NORM and HYP groups.

RESULTS

Table 1 presents demographics and stress test characteristics for the subjects. Of the population sampled, 62.5% of subjects were hypertensive and 37.5% of subjects were normotensive. No significant differences existed between the two groups for age, gender, maximum heart rate, or METs acheived during exercise. However, resting systolic blood pressure was significantly higher for hypertensive subjects ($p \leq 0.001$) as was the presence of LVH ($p \leq 0.001$). Hypertensive subjects were also more likely to have greater than two risk factors for CAD ($p \leq 0.001$) while more normotensive subjects had no risk factors ($p \leq 0.001$).

Insert Table 1 here

Chi Square analysis indicates that the frequency of abnormal results for ECHO (Figure 3) was higher in relation to high blood pressure status, ($X^2 = 9.15$, $p \leq 0.01$), but not for ECG ($X^2 = 2.12$, $p > 0.05$) (Figure 4). In contrast, there was no significant difference in the frequency of normal findings when comparing the two testing methods for both subject groups (Figure 5). This association was not affected by gender, whereas similar numbers of male and female subjects were used in the study. Also, male subjects were analyzed separately, and no significant differences were found between male subjects and the study population for all results obtained from this investigation. Thus, study results were not subdivided for gender.

Insert Figures 3, 4, & 5 here

DISCUSSION

Since the present study demonstrated significant differences in the results obtained between ECG and ECHO techniques during exercise for both normotensive and hypertensive subjects, this suggests that the ability of these two protocols to assess ischemia is different for various patient populations. Other studies[20,21] have found that ischemia is common during maximal exercise in hypertensive patients. This finding was consistent with the data in the current study where more hypertensive subjects exhibited signs of ischemia during exercise echocardiography.

Numerous studies[28-32] have also looked at the sequence of events that occurs when there is an imbalance between myocardial oxygen supply and demand, termed the "ischemic cascade." This sequence begins with hemodynamic abnormalities and ends with clinical signs of ischemia: ST changes and angina. The onset of ventricular systolic dysfunction, seen via wall motion abnormalities, occurs prior to ST changes seen on the ECG. Thus, patients who do not exhibit ST depression may show wall motion abnormalities due to early ischemia.

In addition, the lack of ischemic results for ECG could be related to the presence of LVH. In a recent study, Otterstad[33] (1993) found that ECG criteria seriously underestimated the prevalence of LVH in hypertensive subjects when compared to ECHO studies. Additionally, Pringle et al.[20] (1992) found a sensitivity of 50% and a specificity of 70% for exercise ECG in patients with left ventricular hypertrophy due to essential hypertension. Although patients were screened in the current study for ECG strain patterns, 18 hypertensive subjects (36%) showed evidence of hypertrophy via echocardiography.

Froelicher et al.[34] (1973) has also found that when exercise testing was performed in asymptomatic patients, a positive result was not always indicative of significant CAD. This lack of specificity produced more false-positive results. In the current study, only 10% of both subject groups had chest pain during exercise. Studies evaluating the diagnostic performance of exercise ECHO suggest that this technique is more accurate when compared to exercise ECG testing. It has been demonstrated that ECHO has both a higher sensitivity and specificity in determining single- and multi-vessel coronary disease[7-8]. The present study could not confirm these conclusions in the study population, but this may account for the diagnostic differences between subject groups.

Hypertensive subjects were also more likely to have three or more risk factors for CAD. Patients with multiple risk factors are at much higher risk of having CAD than those with fewer or no risk factors. This may account, in part, to the increased number of abnormal ECHO results for hypertensive subjects.

There are also limitations to ECHO as there are with any technique. Although the optimal means of cardiac imaging is during peak exercise, this is not always feasible due to inadequate images. In order to obtain high quality images, measurements are usually made immediately post-exercise to reduce respiratory and motion artifacts. However, transient exercise-induced wall motion abnormalities may resolve quickly in the recovery period and hence be missed. Maurer and Nanda[26] (1981) found that some degree of new asynergy persisted after exercise throughout a 5-minute recovery period in patients with suspected CAD. Limacher et al.[18] (1983) also found that wall motion abnormalities produced by exercise were readily apparent for at least 90 seconds before gradually resolving in patients with suspected CAD. Recent data comparing peak imaging during upright bicycle exercise with postexercise imaging suggest that rapid recovery occurs only in a small minority of patients with less coronary occlusion[35]. Other studies have confirmed the use of post-exercise echocardiography (Armstrong et al., 1986, and Ryan et al., 1988).

Additionally, the use of multiple observers has been studied to determine the reproducibility of two dimensional echocardiography. Oberman et al. (1989) studied 19 subjects in which post-exercise echocardiography testing was repeated after 14 days with different observers/interpreters. Both ejection fraction and wall motion abnormalities were highly correlated between the two tests. The correlation coefficients between the two tests were 0.92 for both pre- and post-exercise ejection fractions and 0.98 for both pre- and post-exercise wall motion scores. Thus, the researchers concluded that two dimensional exercise echocardiography provides highly reproducible quantitative measures of myocardial ischemia when compared between different observers. The current study also utilized data obtained from two different cardiologists who adhered to those standards set by the American Society for Echocardiography for qualitative echocardiographic measurement of left ventricular wall segments.

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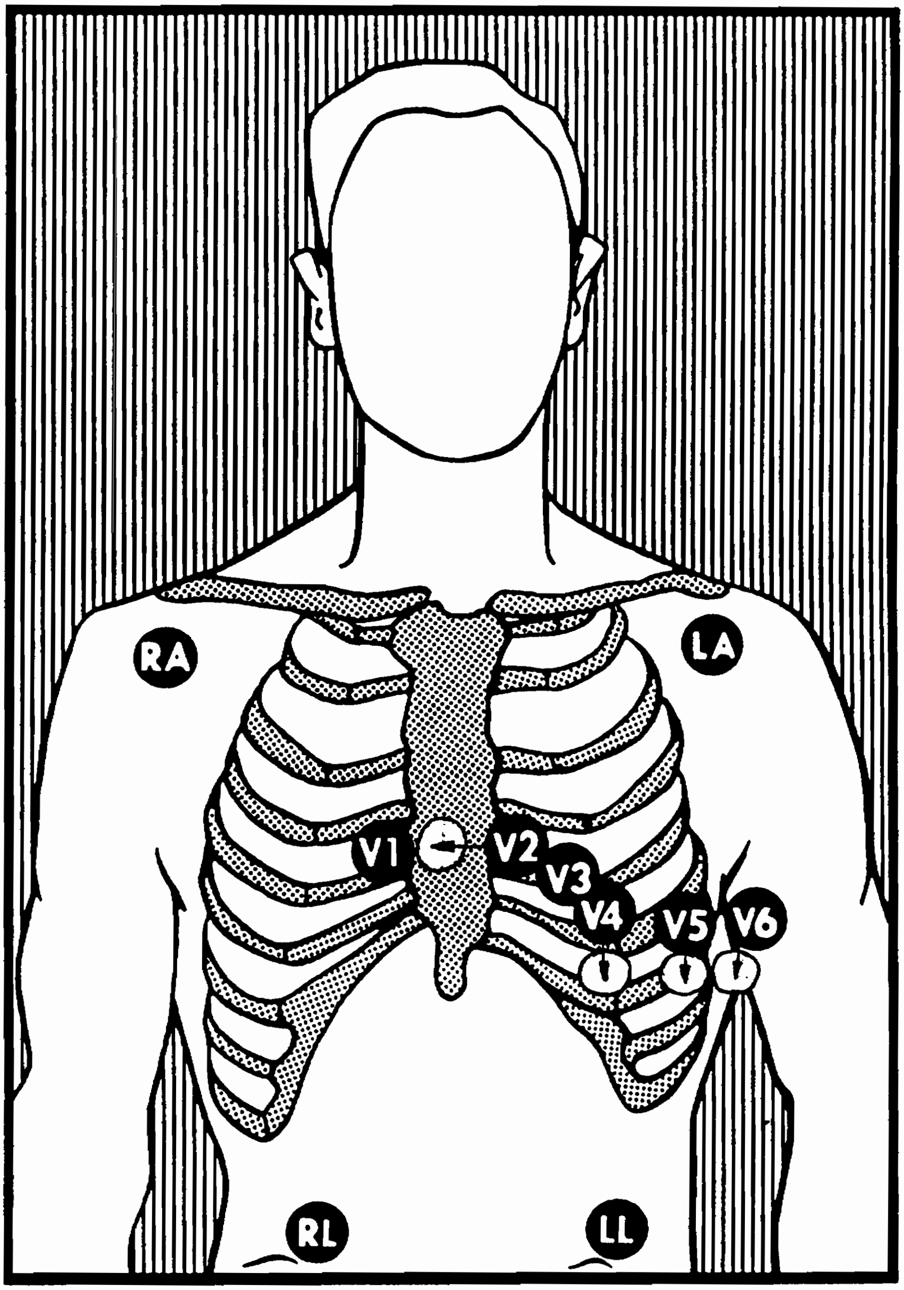

Figure 1. Modified Mason-Likar 12-lead ECG system for exercise echocardiography.

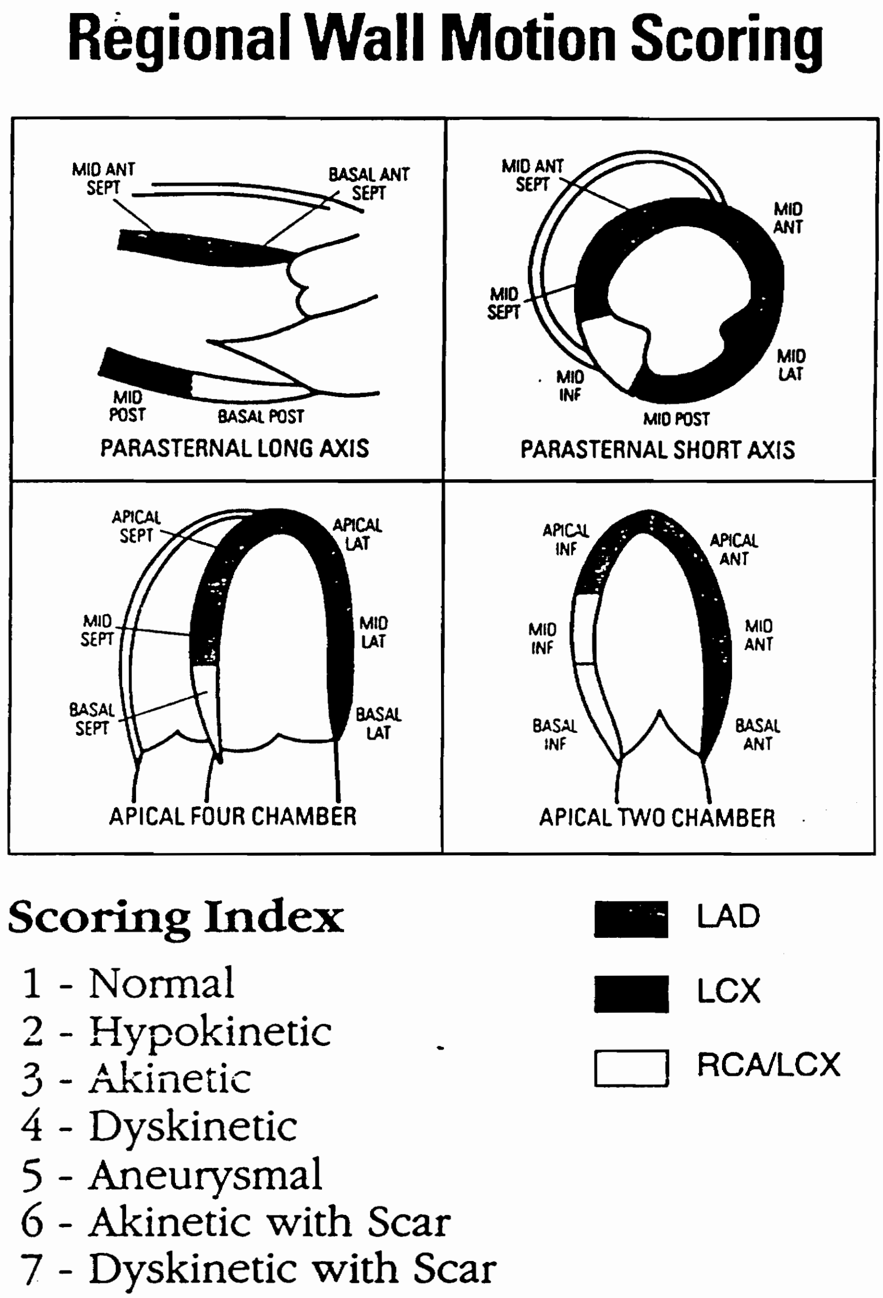

Figure 2 . Representation of left ventricular segments utilized to generate a wall motion score and coronary artery perfusion.

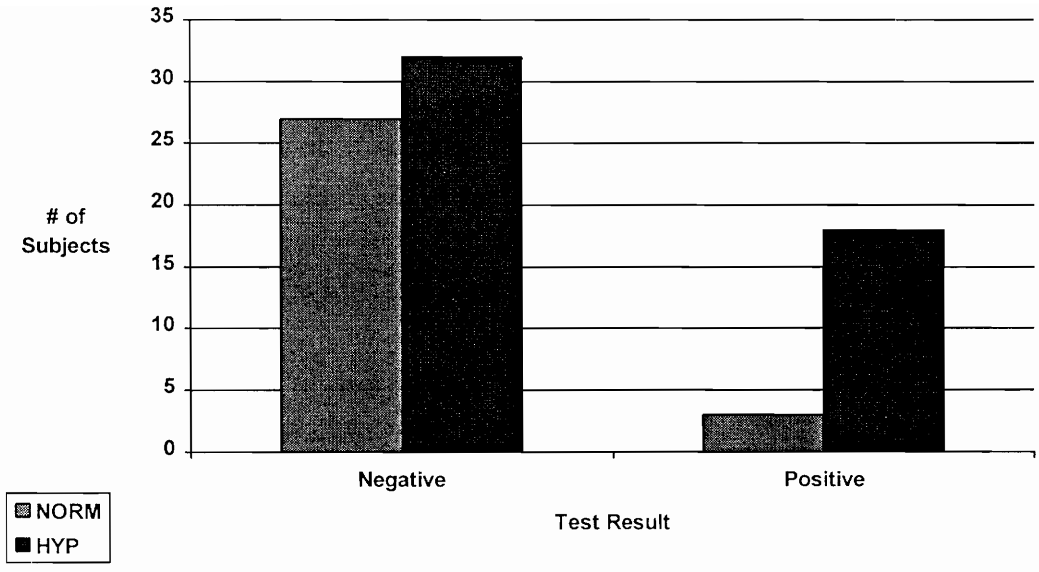

Figure 3. Distribution of echocardiography findings and hypertension among subjects.

Note. $X^2 = 9.15$, $p \leq 0.01$

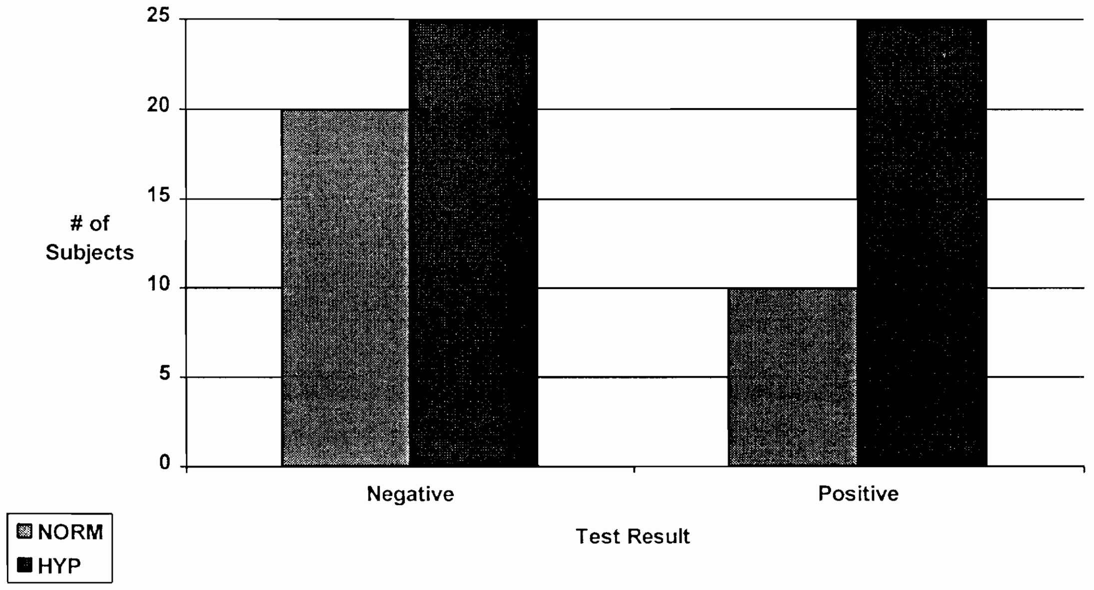

Figure 4. Distribution of electrocardiography findings and hypertension among subjects.

Note. $X^2 = 2.12$, $p > 0.05$

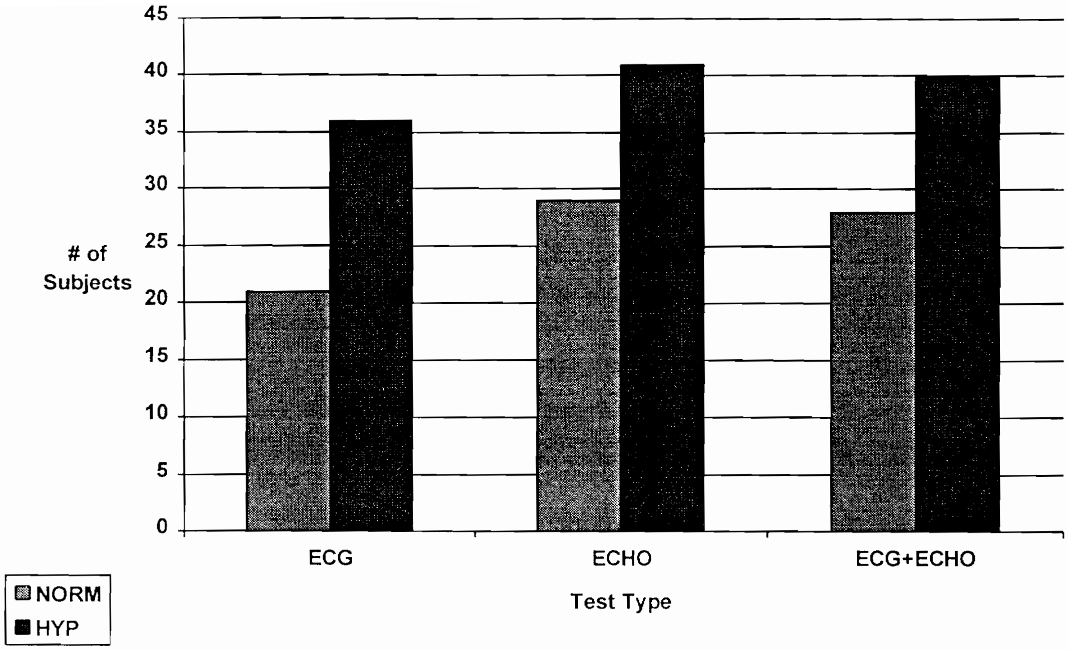

Figure 5. The association between frequency of normal results for either electrocardiography (ECG), echocardiography (ECHO), or both (ECG+ECHO) and hypertension among subjects.

Note. $X^2 = 0.34$, $p > 0.05$

Table 1. Comparison of clinical and demographic findings between normotensive and hypertensive subjects.

	NORM (n=30)		HYP (n=50)	
Age (yr)	43.1	12.2	57.4	10.7
Male/Female	21/9		24/26	
Medication:				
Antihypertensive	0 (0%)		35 (70%)	
Antianginals	0 (0%)		6 (12%)	
Other	13 (43%)		35 (70%)	
Number of CAD Risk Factors:				
None	5* (17%)		0 (0%)	
One	12 (40%)		11 (22%)	
Two	11 (37%)		13 (26%)	
Greater than Two	2 (6%)		26* (52%)	
Criteria for LVH	1 (3%)		18* (36%)	
Resting Blood Pressure (mmHg)				
Systolic	117.7	10.8	139.6*	19.2
Diastolic	80.7	6.1	86.9	8.2
Exercise Blood Pressure (mmHg)				
Systolic	162.3	21.5	190.8	29.8
Diastolic	85.7	9.4	93.9	12.8
Maximum Heart Rate (bpm)	172.3	15.3	159.5	12.6
METs Achieved	10.6	2.4	8.0	2.7
Angina during Exercise	5 (10%)		3 (10%)	
Reason For Stopping Test				
Fatigue	10 (33%)		28 (56%)	
Chest Pain	1 (3%)		0 (0%)	
Shortness of Breath	1 (3%)		4 (8%)	
Per Patient's Request	15 (50%)		14 (28%)	
Per Physician's Request	3 (10%)		4 (8%)	

Unless otherwise indicated, values are mean and standard deviation.

* $p \leq 0.001$

CHAPTER IV

SUMMARY

Hypertension is the most common cardiovascular disease and one of the most powerful predictors of CAD (Pollock & Wilmore, 1990). For this reason, a great deal of research regarding this disease has been done to determine the outcomes of cardiovascular testing. These include blood pressure response to exercise and signs of ischemia. Yet most of these studies have been done using electrocardiography (ECG) techniques.

Even with the more widespread use of exercise echocardiography (ECHO) in recent years, less research has been done utilizing this method with those more likely to have ischemic changes at rest and during exercise or left ventricular hypertrophy, such as patients with hypertension. Two-dimensional ECHO is capable of imaging the heart in multiple tomographic planes, and may therefore be a valuable tool in diagnosing CAD in hypertensive subjects. The present investigation compared the frequencies of abnormal findings from exercise ECG and post-exercise ECHO studies in normotensive and hypertensive subjects. It specifically examined the ECG ST-segment shifts at 60 ms after the J-point in addition to wall motion abnormalities exhibited on the ECHO at rest and immediately after exercise. The main research question was to determine if hypertensive subjects were more likely than normotensive subjects to show abnormal responses to exercise observed by both ECG and ECHO techniques.

Eighty consecutive cases were included in this retrospective study. Each underwent maximal treadmill exercise testing with ECG and ECHO measures taken simultaneously during testing. Further details of the methodology are included in Appendix A.

In examining the results of maximal exercise testing, a significant difference was seen between hypertensive and normotensive subjects for signs of ischemia during ECHO; that is, hypertensive subjects were more likely to have abnormal ECHO findings. These findings, however, were not duplicated for ECG results. On the other hand, normotensive subjects showed significantly more abnormal findings for the

ECG technique than for ECHO. Male subjects were also analyzed separately, and no significant differences were found between male subjects and the study population for all results obtained from this investigation. Thus, study results were not subdivided for gender.

Since the present study demonstrated significant differences in the results obtained between ECG and ECHO techniques during exercise for both normotensive and hypertensive subjects, this suggests that the ability of these two protocols to assess ischemia is different for various patient populations. Other studies have found that ischemia is common during maximal exercise in hypertensive patients (Pringle et al., 1992; Scheler et al., 1992; and Yurenev et al., 1990). This finding was consistent with the data in the current study where more hypertensive subjects exhibited signs of ischemia during exercise echocardiography.

Numerous studies have also looked at the sequence of events that occurs when there is an imbalance between myocardial oxygen supply and demand, termed the "ischemic cascade" (Hecht et al., 1994; Marwick et al., 1992;

Vassiliadis et al., 1990; Nesto and Kowalchuk, 1987; and Alam et al., 1986). This sequence begins with hemodynamic abnormalities and ends with clinical signs of ischemia: ST changes and angina. The onset of ventricular systolic dysfunction, seen via wall motion abnormalities, occurs prior to ST changes seen on the ECG. Thus, patients who do not produce ST changes may show wall motion abnormalities due to early ischemia.

In addition, the lack of ischemic results for ECG could be related to the presence of LVH. In a recent study, Otterstad (1993) found that ECG criteria seriously underestimated the prevalence of LVH in hypertensive subjects when compared to ECHO studies. Additionally, Pringle et al. (1992) found a sensitivity of 50% and a specificity of 70% for exercise ECG in patients with left ventricular hypertrophy due to essential hypertension. Although patients were screened in the current study for ECG strain patterns, 18 hypertensive subjects (36%) showed evidence of hypertrophy via echocardiography.

In addition, Froelicher et al. (1973) found that when exercise testing was performed in asymptomatic patients, a positive result was not always indicative of significant CAD. This lack of specificity produced more false-positive results. In the current study, only 10% of both subject groups had chest pain during exercise. Studies evaluating the diagnostic performance of exercise ECHO suggest that this technique is more accurate when compared to exercise ECG testing. It has been demonstrated that ECHO has both a higher sensitivity and specificity in determining single- and multi-vessel coronary disease (Marwick et al., 1992, and Crouse et al., 1991). The present study could not confirm these conclusions in the study population, but this may account for the diagnostic differences between subject groups.

Hypertensive subjects were also more likely to have three or more risk factors for CAD. Patients with multiple risk factors are at much higher risk of having CAD than those with fewer or no risk factors. This may account, in part, to the increased number of abnormal ECHO results for hypertensive subjects.

There are also limitations to ECHO as there are with any technique. Although the optimal means of cardiac imaging is during peak exercise, this is not always feasible due to inadequate images. In order to obtain high quality images, measurements are usually made immediately post-exercise to reduce respiratory and motion artifacts. However, transient exercise-induced wall motion abnormalities may resolve quickly in the recovery period and hence be missed. Maurer and Nanda (1981) found that some degree of new asynergy persisted after exercise throughout a 5-minute recovery period in patients with suspected CAD. Limacher et al. (1983) also found that wall motion abnormalities produced by exercise were readily apparent for at least 90 seconds before gradually resolving in patients with suspected CAD. Recent data comparing peak imaging during upright bicycle exercise with postexercise imaging suggest that rapid recovery occurs only in a small minority of patients with less coronary occlusion (Presti, Armstrong, and Fiegenbaum, 1987). However, whereas the overall sensitivity for the detection of CAD was 100% at peak exercise, this was reduced to 70% with postexercise imaging.

IMPLICATIONS FOR FURTHER RESEARCH

The primary objective of this study was to determine if hypertensive subjects are more likely to have abnormal results for both exercise electrocardiography and exercise echocardiography. The secondary objective was to determine if there are differences between the two techniques for determining abnormal results in both hypertensive and normotensive subjects. Although these differences were found in the present study, a comparison with angiography would be necessary to determine the accuracy of both test methods. If these test results were consistent when followed by angiography, exercise echocardiography might be preferable for determining CAD in hypertensive subjects.

Below are recommendations for further research necessary in the areas of hypertension and the evaluation of CAD via exercise electrocardiography and exercise echocardiography.

1. Since research has shown that hypertensive subjects are more likely to show signs of ischemia and therefore CAD, angiographic studies following exercise would be beneficial. In repeating the present study with

angiography, more information would be obtained to determine if exercise echocardiography would be a better test choice for determining CAD in hypertensive patients.

2. Another important question to consider is whether the modification to electrodes V_2 and V_4-V_6 cause modification to the ST-segment shifts both at rest and during exercise. The answer could likely have an effect on the accuracy of the ECG tracing during echocardiographic studies. It would therefore be beneficial to study the two techniques on different test days, followed by angiography.

3. Furthermore, few studies have evaluated the detection of exercise echocardiography in female populations. Since females are more likely to have false-negative ECG results due to single-vessel disease, exercise echocardiography might be a better alternative than standard exercise ECG tests.

4. Finally, since ischemic changes are sometimes lost from peak exercise to immediate post exercise, further

investigation is needed to evaluate the magnitude of change for echocardiography in hypertensive subjects. This includes studies utilizing upright bicycle testing with echocardiography during peak exercise in comparison to immediate post-exercise testing.

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APPENDIX A

DETAILED METHODOLOGY

METHODOLOGY

Subjects

A retrospective design was used for subject selection. Eighty subjects who had been referred to the Heart Center at Radford Community Hospital in Virginia for treadmill exercise echocardiography testing were studied. Subjects were divided into two groups: those with normal resting blood pressures (NORM) (n = 30) and those with resting hypertension (HYP) (n = 50). Those subjects with resting hypertension met the following criteria: 1) systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, 2) currently taking blood pressure medication, or 3) having a past history of hypertension, denoted as a current risk factor on hospital exercise testing forms. Normotensive is defined as the absence of the above criteria.

Subjects were excluded who had known CAD, had taken medications the morning of the test which may have altered blood pressure responses to exercise (beta or calcium channel blockers) or which may have altered the ECG (digitalis), or who showed ST segment shift with hyperventilation ECG. In addition, those subjects who showed signs of left ventricular hypertrophy with strain, left bundle branch block, valvular stenosis or regurgitation, dyskinesis, aneurysm, known previous myocardial infarction or evidence of clinically significant Q waves > 0.04 sec were also excluded.

All subjects gave informed consent forms as per hospital policy prior to exercise testing. In accordance with hospital policy, appropriate consent was also obtained from the hospital medical director for such information to be used for statistical research.

General Protocol

Exercise testing. 12-lead resting ECGs and blood pressure readings were performed on each subject prior to exercise testing in both the supine and standing positions. The electrodes for ECG monitoring were placed on the chest so as not to overlie the marked sites for the acoustic echocardiography window. Specifically, lead V_2 was placed on the sternum at the level of V_1, and leads V_4-V_6 were lowered to the 6th intercostal space.

Treadmill exercise testing was performed on each subject using the Bruce protocol. During each 3-minute stage, a 12-lead ECG and exercising blood pressure measures were recorded while three ECG leads (II, avF, V_5) were continuously monitored. In accordance with the supervising physician, exercise test endpoints were: 1) development of limiting chest pain and/or dyspnea, 2) fatigue, or 3) subject's request to stop the test.

The exercise ECG was determined by the investigator to be normal or ischemic. An ischemic response to exercise was defined as meeting one of the following criteria: 1) horizontal or downsloping ST segment depression of ≥1 mm 60 ms after the J point in a lead with a normal ST segment at rest, 2) ST segment elevation of 1 mm or more than the resting tracing 60 ms after the J point, 3) in the presence of ST depression in the resting tracing, an additional depression of 1mm or more is required. ST segment deviation was automatically calculated during the test by the computer (Q5000, Quinton Instrument Company, Bothell, Washington) as well as reviewed by the supervising physician. In addition, 3 concurrent complexes were measured for ST deviation and slope 60 ms after the J point.

Echocardiography. Two-dimensional echocardiograms were recorded with standard commercially available equipment (Hewlett Packard Sonos 1000, Andover, Massachusetts). Parasternal long- and short-axis and apical two- and four-chamber views were recorded with the subject in the left lateral decubitus position at rest. The acoustic echocardiography window for both the parasternal and apical positions was marked on each subject's chest using a washable felt tip marker for reference. Immediately after cessation of exercise, the subject resumed the left lateral decubitus position, and the standard four views were repeated (within 90 seconds of cessation of exercise), as performed by previous researchers (Berberich et al., 1984; Marwick et al, 1992; Oberman et al., 1989; Presti et al., 1987). All of the echocardiographic studies were done by either of two technicians following those guidelines set by the American Society of Echocardiography (Henry et al., 1980).

The echocardiography studies were digitized on-line into a quad-screen, continuous loop format for analysis (Nova Microsonics ImageVue DCR, Mahwah, New Jersey). Images were recorded on 3/4 inch VHS videotape as well as digitally on a 3½ inch floppy diskette. Data were reviewed with resting and immediate post-exercise images placed side-by-side. Images were assessed for ejection fraction, left ventricular mass, and for the presence of normal regional wall motion. Normal peak exercise shows a decrease in ventricular size with an increase in ejection fraction. Abnormal studies were defined as having regional wall motion abnormalities, such as hypokinesia, akinesia, or dyskinesia at rest or immediately after cessation of exercise. These changes occur in conjunction with an increase in ventricular size and a decrease in ejection fraction. Ejection fraction was measured by the computer (Nova Microsonics ImageVue DCR, Mahwah, New Jersey), by calculating stroke volume and dividing by diastolic volume. Left ventricular mass was defined by the investigator as normal or abnormal from the physician's statement.

The distribution of CAD was approximated by studying the area in which the wall motion abnormalities occurred, using those standards adopted by the American Society for Echocardiography. In general, disease of the left anterior descending artery was attributed to abnormalities in the apical, anterior, and anteroseptal regions of the heart. Involvement of the left circumflex artery was attributed to abnormalities in the lateral and posterior walls of the heart. In addition, involvement of the right coronary artery was attributed to abnormalities in the inferior and basal septal regions of the heart. The two cardiologists interpreting the results of echocardiography studies maintain clinical competence as stated by the American College of Cardiology, meeting the Level 3 requirements for echocardiography interpretation (Popp, et al., 1990).

Statistics

Independent T-tests were used for contrasting demographic data between the NORM and HYP groups. Also, chi square analysis (χ^2) was used to evaluate the distribution of normal vs abnormal clinical findings for ECG vs ECHO in the NORM and HYP groups.

APPENDIX B

INFORMED CONSENT

HEART CENTER OF THE NEW RIVER VALLEY
RADFORD COMMUNITY HOSPITAL
CARDIOLOGY SERVICES
700 RANDOLPH STREET
RADFORD, VIRGINIA 24141-2430
TELEPHONE: 703-731-2615

AUTHORIZATION
FOR
EXERCISE TOLERANCE TESTING ON THE BIKE/TREADMILL

I do hereby voluntarily consent to engage in an exercise stress test to determine the state of my heart and its circulation. The information obtained will be used to aid my physician in advising me as to the activities in which I may engage and in determining an appropriate treatment program.

I have been informed that before the beginning of this test, I will be interviewed by a physician. I will also be examined by a physician in an attempt to determine if I have any condition which would prohibit my proceeding with this test.

The test I am to undergo will be performed on a treadmill and/or exercise bike with the amount of effort increase gradually. This increase will be continued until symptoms such as fatigue, shortness of breath, or discomfort may appear which are indications for stopping the test.

I have been informed that the possibility exists of certain changes occurring during the test. These include:

1. Abnormal blood pressure,
2. Fainting,
3. Disorders of the heart beat, such as too rapid, too slow, or ineffective;
4. And, the possibility of a heart attack.

I, the undersigned, do hereby state that I have been informed and that I fully understand the above information and do hereby voluntarily sign this informed consent.

Date:____________________ Signed:____________________
Patient's Name

____
Witness

exttbktm

APPENDIX C

CONTINGENCY TABLES

CONTINGENCY TABLES

Table 2. Distribution of abnormal echocardiography findings and hypertension among subjects.

Subjects	*Result of Echocardiography* *Negative*	*Positive*	*Total*
Normotensive	27	3	30
Hypertensive	32	18	50
Total	59	21	80

Note. $X^2 = 9.15$, $p \leq 0.01$

Table 3. Distribution of abnormal electrocardiography findings and hypertension among subjects.

Subjects	*Result of Electrocardiography*		*Total*
	Negative	*Positive*	
Normotensive	20	10	30
Hypertensive	25	25	50
Total	45	35	80

Note. $X^2 = 2.12$, $p > 0.05$

Table 4. The association between frequency of normal results for either electrocardiography (ECG), echocardiography (ECHO), or both (ECG+ECHO) and hypertension among subjects.

Subjects	*ECG*	*ECHO*	*ECG+ECHO*	*Total*
Normotensive	21	29	28	78
Hypertensive	36	41	40	117
Total	57	70	68	195

Note. $X^2 = 0.34$ $p > 0.05$

APPENDIX D

MEASURES AND DEFINITIONS FOR COMPUTER DATA CODING

DEFINITIONS FOR COMPUTER DATA CODING:

(Definitions for analysis of Raw Data found in Appendix E.)

Medical Record Number (MRNUMBER): Each subject was identified using their six-digit Radford Community Hospital medical record number.

Date (DATE): The date the exercise test was performed; MM-DD-YY.

Age (AGE): The actual age in years of each subject at the time of the exercise test.

Sex (SEX): Each subject's gender was recorded; 1=male, 2=female.

History (Hx): The presenting complaint of each subject for which the exercise test was performed; 1=rule out/evaluate CAD, 2=chest pain/angina, 3=abnormal ECG, 4=shortness of breath, 5=other.

Medications: It was recorded whether each subject was regularly taking Blood Pressure Medications (BPMEDS), Antianginals (ANTIANG), and/or any other medications (OTHERMEDS); 0=no, 1=yes for each type of medication.

Hypertension risk (HTNRISK): Each subject was categorized as having (1=yes) or not having (0=no) hypertension as a risk factor for coronary heart disease by self-report of past BP readings.

Supine Blood Pressure: Each subject's blood pressure (mmHg) was measured prior to the exercise test in the supine position. (RSBPSUP) represents systolic measures, while (RDBPSUP) represents diastolic measures.

Standing Blood Pressure: Each subject's blood pressure (mmHg) was measured prior to the exercise test in the standing position. (RSBPSTA) represents systolic measures, while (RDBPSTA) represents diastolic measures.

Hypertensive Subject (HTN): Each subject was categorized into whether they were (1=yes) or were not (0=no) hypertensive by the study criteria.

Number of Risk Factors (#RF): The number of primary risk factors for CAD for each subject (0=none, 1=one, 2= two, 3=three or more).

Blood Pressure at Maximum Exercise: Each subject's blood pressure (mmHg) was measured at peak exercise during the test. (EXSBP) represents systolic measures, while (EXDBP) represents diastolic measures.

METs Achieved (METs): The maximum METs achieved by each subject at peak exercise.

Heart Rate at Maximum Exercise (EXHR): The actual heart rate in beats per minute at peak exercise.

Reason For Stopping Test (RFST): The reason for which the exercise test was stopped for each subject; 1=fatigue, 2=chest pain, 3=shortness of breath, 4=per patient request, 5=per MD request.

Resting ST Depression: The actual amount of ST depression in mm found at rest in leads V1-V6 for each subject, labeled as RV!, RV2, RV3, RV4, RV5, RV6.

Slope of ST Segment (RSLOPE): The measured slope of the ST segment from J_{60} in leads V1-V6 at rest for each subject; -1=downsloping, 0=horizontal, 1=upsloping.

Heart Axis (RAXIS): The axis of the heart was measured at rest using 1=normal, 2=LAD, 3=RAD, 4=extreme RAD. The axis was also recorded in degrees (AXISDEG).

ST Depression at Maximum Exercise: The actual amount of ST depression in mm found at maximum exercise in leads V1-V6 for each subject, labeled as EXV1, EXV2, EXV3, EXV4, EXV5, EXV6.

<u>Slope of ST segment at Maximum Exercise</u> (EXSLOPE): The measured slope of the ST segment from J_{60} for leads V1-V6 at maximum exercise for each subject; -1=downsloping, 0=horizontal, 1=upsloping.

<u>Ischemia</u> (ISCHEMIA): Whether or not ischemia was present by study criteria during exercise for each subject; 1=no, 2=yes.

<u>Chest Pain During Exercise</u> (PAIN): Whether the patient exhibited chest pain during the exercise test (0=no, 1=yes).

<u>Resting Wall Motion Abnormalities</u> (RWMA): Whether wall motion abnormalities were present at rest in any segment of the heart for each patient. Location of resting wall motion abnormalities were classified in each segment (RECHO1-RECHO16) as being present (1=yes) or not present (0=no). The following were used to define each segment:

ECHO1=mid anterior septal	ECHO9=basal septal
ECHO2=basal anterior septal	ECHO10=apical septal
ECHO3=mid posterior	ECHO11=apicallaeral
ECHO4=basal posterior	ECHO12=basal lateral

ECHO5=mid septal
ECHO6=mid inferior
ECHO7=mid lateral
ECHO8=mid anterior

ECHO13=basal inferior
ECHO14=apical inferior
ECHO15=apical anterior
ECHO16=basal anterior

Exercise Induced Wall Motion Abnormalities (EXWMA): Whether wall motion abnormalities were present at peak exercise in any segment of the heart for each patient. Location of exercise induced wall motion abnormalities were classified in each segment (EXECHO1-EXECHO16) as being present (1=yes) or not present (0=no).

Location of Wall Motion Abnormalities by Coronary Vessel: Whether wall motion abnormalities were present (0=no, 1=yes) at rest or peak exercise in the three main coronary vessels: Left Anterior Descending (LAD), Left Circumflex (LCX), and/or Right Coronary Artery (RCA).

Others (not measured for each subject): Resting Ejection Fraction (REJFRAC) as a percentage; Ejection Fraction at Peak Exercise (EXEFRAC) measured as 0=no change, 1= increase, -1=decrease from rest; Left Ventricular Mass (LVMASS) as considered 0=normal or 1=with hypertrohy.

APPENDIX E

RAW DATA

RAW DATA

(Refer to Appendix D for Coding Definitions of Raw Data.)

	MRNUMBER	DATE	AGE (yrs)	SEX	Hx	BPMEDS	ANTIANG
1	028305	06-21-93	74	1	2	1	0
2	008690	06-29-93	46	1	1	1	0
3	032077	07-22-93	62	2	2	1	0
4	021481	07-22-93	57	2	2	1	0
5	026527	08-09-93	66	2	2	1	1
6	066471	08-05-93	57	2	2	1	1
7	109543	08-05-93	60	1	2	1	0
8	048244	09-10-93	40	1	2	1	0
9	109742	08-13-93	41	1	2	0	0
10	010745	10-18-93	48	1	2	1	0
11	107524	05-26-93	67	1	2	1	1
12	104696	02-08-93	60	1	3	1	0
13	092743	05-17-93	63	2	2	1	0
14	029468	04-19-93	68	2	4	1	0
15	016434	04-14-93	74	1	5	0	0
16	006648	03-31-93	71	2	2	1	0
17	101502	03-03-93	73	2	2	1	1
18	080594	01-21-93	64	1	1	1	0
19	088561	01-14-93	56	1	3	1	0
20	092618	06-01-93	60	1	3	1	0
21	053770	07-07-93	49	2	2	1	0
22	037018	07-15-93	48	2	2	0	0
23	109328	07-29-93	36	2	2	0	0
24	076628	08-03-93	39	2	2	0	0
25	025592	08-11-93	23	1	2	0	0
26	109871	08-17-93	43	2	2	0	0
27	109811	08-20-93	55	1	1	0	0
28	038325	08-25-93	60	2	4	0	0
29	110132	08-26-93	38	1	2	0	0
30	110246	09-01-93	51	1	2	0	0
31	110486	09-03-93	49	1	2	0	0
32	051885	09-13-93	74	2	2	1	0
33	053856	09-13-93	38	1	1	0	0
34	026470	09-16-93	60	2	2	1	0
35	110931	09-22-93	32	1	2	0	0
36	111127	09-30-93	49	1	1	0	0
37	036529	10-07-93	66	2	1	0	0
38	111425	10-08-93	55	2	2	0	0
39	111475	10-12-93	57	1	3	0	0
40	041416	10-14-93	45	1	5	0	0

RAW DATA

	MRNUMBER	DATE	AGE (yrs)	SEX	Hx	BPMEDS	ANTIANG
41	017822	10-20-93	36	1	2	0	0
42	104318	01-25-93	64	2	2	0	0
43	103929	01-15-93	30	1	1	0	0
44	069859	03-21-94	69	1	2	0	0
45	013840	05-20-93	59	1	1	0	0
46	040143	01-15-93	58	2	2	0	0
47	029182	05-14-93	35	1	2	0	0
48	043104	05-07-93	50	2	1	0	0
49	022939	04-14-93	39	2	1	0	0
50	056396	03-30-93	29	1	2	0	0
51	104795	02-18-93	20	1	2	0	0
52	025316	12-29-93	43	1	2	0	0
53	065718	12-17-93	31	1	1	0	0
54	113083	12-03-93	38	2	2	0	0
55	057871	01-23-93	45	1	5	0	0
56	017475	11-10-93	29	1	5	0	0
57	111840	10-22-93	51	1	3	0	0
58	112438	11-09-93	44	1	3	0	0
59	112150	11-11-93	62	2	3	0	0
60	059180	11-12-93	53	2	3	0	0
61	112796	11-24-93	45	1	2	0	0
62	000001	11-08-93	44	1	3	0	0
63	079406	11-05-93	72	2	2	1	0
64	054669	11-02-93	54	2	2	1	1
65	111762	10-22-93	42	1	2	1	0
66	057333	12-09-93	42	1	2	0	0
67	074028	12-14-93	53	1	2	0	0
68	022502	12-20-93	59	2	2	1	0
69	049432	12-30-93	49	1	4	0	0
70	113818	01-11-94	43	1	2	1	0
71	113935	01-13-94	59	1	3	1	0
72	068958	01-14-94	60	2	3	1	0
73	011318	05-12-94	79	2	1	1	0
74	117065	05-12-94	56	1	2	1	0
75	059251	05-12-94	51	2	5	1	0
76	032982	05-13-94	47	2	2	1	0
77	095909	05-23-94	68	1	2	1	1
78	017639	05-31-94	73	2	2	0	0
79	117231	06-09-94	48	2	2	1	0
80	008717	06-14-94	62	2	1	1	0

RAW DATA

	OTHERMEDS	HTNRISK	RSBPSUP (mmHg)	RDBPSUP (mmHg)	RSBPSTA (mmHg)	RDBPSTA (mmHg)
1	1	1	130	80	140	100
2	1	1	140	80	150	78
3	1	1	140	90	146	90
4	1	1	140	80	130	85
5	1	1	150	90	120	76
6	1	1	120	88	108	84
7	0	1	150	90	180	90
8	1	1	132	90	128	92
9	1	0	106	78	128	88
10	1	1	122	88	118	82
11	0	1	146	82	156	82
12	1	1	152	80	142	90
13	1	1	130	80	124	76
14	1	1	136	96	140	96
15	1	1	160	95	180	100
16	1	0	184	102	186	100
17	1	1	140	75	140	80
18	1	1	174	82	150	95
19	0	1	128	90	124	96
20	0	0	120	80	110	85
21	1	0	98	70	92	70
22	1	1	140	80	130	90
23	0	0	110	84	112	88
24	0	0	110	80	112	82
25	0	0	110	60	110	80
26	0	0	94	70		
27	0	0	138	96	144	102
28	1	0	122	80	122	80
29	0	0	122	88	124	84
30	0	0	96	64	106	76
31	0	0	118	80	120	88
32	1	0	128	76	110	76
33	0	0	128	78	110	90
34	1	0	114	70	132	84
35	1	0	120	72	124	80
36	0	0	120	86	120	76
37	1	0	136	88	128	80
38	1	0	150	92	140	84
39	1	1	138	78	162	84
40	1	0	92	62	92	70

RAW DATA

	OTHERMEDS	HTNRISK	RSBPSUP (mmHg)	RDBPSUP (mmHg)	RSBPSTA (mmHg)	RDBPSTA (mmHg)
41	0	1	116	78	112	76
42	1	1	144	80	140	80
43	0	0	120	80	130	80
44	1	0	130	70	128	74
45	1	0	130	85	140	80
46	1	0	100	70	120	90
47	1	0	118	84	124	80
48	0	0	112	82	128	80
49	1	0	130	90	130	90
50	0	0	120	80	130	90
51	0	0	120	84	118	82
52	1	0	120	84	108	80
53	1	0	122	80	126	84
54	0	0	110	70	110	80
55	0	0	122	96	124	80
56	0	0	116	84	112	88
57	1	0	106	70	106	70
58	0	0	118	80	124	78
59	1	0	150	76	152	75
60	1	0	108	70	110	70
61	0	0	116	80	116	84
62	0	1	152	98	160	105
63	1	1	130	84	130	80
64	1	1	150	90	142	90
65	1	1	150	90	130	90
66	1	1	140	90	150	90
67	1	1	140	80	144	82
68	1	1	120	90	115	80
69	0	0	148	70	166	86
70	1	1	140	90	140	90
71	0	1	144	80	148	80
72	1	1	142	80	132	80
73	1	1	160	100	152	98
74	0	1	150	90	150	90
75	0	1	166	98	150	94
76	0	1	160	98	140	100
77	1	1	160	82	154	80
78	0	1	160	90	150	90
79	1	1	124	74	124	80
80	0	1	162	90	162	90

RAW DATA

	HTN	#RF	EXSBP (mmHg)	EXDBP (mmHg)	METs	EXHR (bpm)	RFST	RV1 (mm)	RV2 (mm)
1	1	3	210	100	7.4	146	1	0	0
2	1	2	226	80	10.0	160	1	0	0
3	1	3	150	90	7.0	136	1	0	0
4	1	3	180	90	9.0	170	1	0.5	0
5	1	3	184	110	7.0	170	5	0	0
6	1	1	158	94	7.0	143	4	0	0
7	1	3	210	100	7.4	170	3	1	0
8	1	3	168	84	12.5	164	4	0	1
9	0	2	205	105	15.0	178	1	0	0.5
10	1	3	156	96	10.0	161	1	0	0
11	1	3	178	86	7.4	160	4	0	0
12	1	2	198	88	10.0	169	1	0	1
13	1	3	220	138	7.0	157	1	0	0
14	1	3	194	114	7.0	154	1	0	0
15	1	1	240	130	2.0	151	5	0.5	2
16	1	1	256	110	4.7	152	1	0	0
17	1	3	180	80	4.7	132	1	0	0
18	1	3	210	100	10.0	147	1	0	0
19	1	3	162	96	10.0	172	1	0	1.5
20	1	2	150	90	12.5	165	1	0.5	0.5
21	1	3	170	80	4.7	160	1	0	1
22	1	2	182	98	10.0	179	4	0	0
23	0	1	138	96	11.7	186	5	0	0
24	0	1	142	86	7.0	168	4	0	0
25	0	2	164	100	12.5	205	4	1.5	2.5
26	0	1	148	82	10.0	174	4	0	0
27	1	3	220	108	12.5	169	5	0	1
28	0	1	168	84	7.0	167	4	0	0
29	0	1	182	90	12.5	167	5	0	0.5
30	0	1	156	90	12.5	180	4	0.5	0
31	0	1	162	90	12.5	165	4	0	0
32	1	2	156	80	9.4	162	5	0	0
33	0	2	180	98	10.0	182	5	0	0
34	1	1	202	90	10.0	139	4	0	0
35	0	0	142	82	10.0	199	1	0.5	0
36	0	2	152	86	10.0	161	4	0	0
37	0	2	184	98	7.0	148	1	0	0
38	1	3	160	80	7.0	168	1	0	0
39	1	3	190	90	12.5	162	1	0	0
40	0	1	144	90	12.5	168	4	0	0

RAW DATA

	HTN	#RF	EXSBP (mmHg)	EXDBP (mmHg)	METs	EXHR (bpm)	RFST	RV1 (mm)	RV2 (mm)
41	1	2	150	80	12.5	173	1	0	0.5
42	1	3	218	90	4.7	140	1	0	0.5
43	0	0	175	85	12.5	185	1	0	2.5
44	0	2	200	74	7.4	139	4	0	0
45	0	1	170	65	10.0	146	4	0.5	0
46	0	0	140	80	10.0	161	1	0	0.5
47	0	3	204	72	10.0	197	1	0	0.5
48	0	1	164	86	9.4	176	2	0	1
49	1	3	140	90	7.0	181	1	0	0
50	0	1	150	90	10.0	183	4	1	3
51	0	1	170	72	10.0	181	3	0.5	3
52	0	2	180	80	10.0	155	4	0.5	0.5
53	0	2	148	76	10.0	182	4	0	0.5
54	0	0	122	82	7.0	181	4	0	0.5
55	1	2	178	78	12.5	185	1	0	0.5
56	0	0	158	76	17.5	178	4	0	1
57	0	3	154	90	10.0	160	1	0	0
58	0	2	188	98	12.5	169	1	0	0.5
59	1	1	182	78	7.0	158	1	0.5	0.5
60	0	2	130	78	9.4	172	1	0	0
61	0	2	148	90	12.5	157	1	0	0
62	1	1	220	98	10.0	180	1	1	1.5
63	1	2	210	100	7.0	150	4	0.5	1
64	1	2	200	100	4.7	149	4	0	0
65	1	3	192	92	7.4	158	1	0	0
66	1	3	240	100	12.5	183	1	0.5	0.5
67	1	2	150	70	4.9	143	1	1	0.5
68	1	3	150	96	7.0	158	4	0	0
69	1	3	214	80	7.4	150	4	0.5	1
70	1	3	198	86	9.4	178	4	0.5	0.5
71	1	3	180	80	10.0	160	1	0.5	0.5
72	1	2	152	88	4.7	142	4	0	0
73	1	1	190	104	4.7	160	4	0	0
74	1	3	230	90	7.0	155	3	0.5	0.5
75	1	2	260	104	7.0	160	3	0	0
76	1	1	160	100	4.7	150	3	0	0
77	1	1	200	102	9.4	165	4	0	0
78	1	1	200	102	7.0	160	4	0	0
79	1	2	210	90	10.0	168	4	0	0.5
80	1	1	206	96	4.7	152	1	0	0

RAW DATA

	RV3 (mm)	RV4 (mm)	RV5 (mm)	RV6 (mm)	RSLOPE	RAXIS	AXISDEG (°)
1	0	0	0	0	0	1	30
2	0	0	0	0	0	1	90
3	-0.5	-0.5	-1	-0.5	-1	1	90
4	0.5	0	0	0	1	1	0
5	-0.5	-0.5	-0.5	-0.5	0	1	90
6	0	0	0	0	0	1	60
7	1	0.5	0	0	0	1	90
8	0	0	0	0	1	1	90
9	0	0	0	0	0	1	90
10	1	1	0	0	1	1	90
11	0	0	0	0	0	2	-60
12	1.5	0	0	0	1	1	90
13	0	0	0	0	0	1	0
14	0	0	0	0	0	1	60
15	2	1	0	0	1	1	90
16	0.5	0.5	0	0	1	1	-30
17	0	0	0	0	0	1	90
18	1	0.5	0	0	1	1	60
19	1	1	0.5	0	1	1	90
20	1	0.5	0	0	1	1	60
21	0.5	0	0	0	0	1	90
22	0	0	0	0	0	1	90
23	0.5	0	0	0	1	1	90
24	0	0	0	0	0	1	90
25	0.5	0.5	0	0	1	1	90
26	0	0	0	0	0	1	0
27	0	0	0	0	0	1	90
28	0	0	0	0	0	1	90
29	0.5	0.5	0.5	0	1	1	0
30	0	0	0	0	0	1	90
31	0	0	0	0	0	1	60
32	0	0	0	0	0	2	-60
33	1	1	0.5	0.5	1	1	60
34	0	0.5	0	0	1	2	-60
35	1	0.5	0.5	0	1	1	-30
36	1.5	0.5	1	0.5	1	1	90
37	0	0	0	0	0	1	90
38	0	0	0	0	1	1	90
39	0	0	0	0	1	1	90
40	1.5	1	0.5	0.5	1	1	90

RAW DATA

	RV3 (mm)	RV4 (mm)	RV5 (mm)	RV6 (mm)	RSLOPE	RAXIS	AXISDEG (°)
41	0.5	0	0	0	1	1	90
42	0.5	0	0	0	1	1	30
43	1	0.5	0.5	0	1	1	90
44	-1	-1	-1	-1	0	1	90
45	0	0	0	0	0	1	90
46	0.5	1	0	0	1	1	90
47	0.5	0.5	0	0	1	1	90
48	0	0	0	0	0	1	90
49	0	0	0	0	1	1	90
50	2	1	0.5	0.5	1	1	60
51	1	0.5	0.5	0.5	1	1	90
52	0.5	0.5	0.5	0.5	1	1	-30
53	1	0.5	1	0.5	1	3	120
54	0.5	0	0	0	1	1	90
55	1	0.5	0	0	1	1	30
56	2	1	0.5	0.5	1	1	90
57	0.5	0	0	0	0	1	90
58	0.5	0.5	0	0	1	1	60
59	0.5	0	0.5	0.5	1	1	60
60	0.5	0	0	0	0	1	60
61	0	0	0	0	0	1	60
62	1	0.5	0	0	1	1	90
63	0	0	0	0	0	1	90
64	0	0	-0.5	-0.5	0	1	60
65	0	0	0	0	0	3	180
66	1	0	0	-0.5	1	1	90
67	0	-0.5	-0.5	-0.5	0	1	-30
68	0	0	0	0	0	1	90
69	0	0	-0.5	-1	0	1	60
70	1	0.5	0	0	1	1	90
71	1	0	0	0	0	1	60
72	0	0	0	0	0	1	90
73	-0.5	-0.5	-0.5	-0.5	0	1	60
74	0.5	0	0	0	1	1	0
75	1	1	0.5	0	1	1	-30
76	0	0	0	0	1	1	90
77	0	0	0	0	0	1	60
78	0	0	0	0	0	1	60
79	0	0	0	0	1	1	90
80	0	0	0	0	0	1	90

RAW DATA

	EXV1 (mm)	EXV2 (mm)	EXV3 (mm)	EXV4 (mm)	EXV5 (mm)	EXV6 (mm)	EXSLOPE
1	0	0	0	0	0	0	-1
2	1	0	0	-0.5	-1.0	-1	1
3	1	0	-0.5	-1.5	-1.5	-1.5	1
4	1.5	0.5	1	0.5	-1.5	-2	1
5	0	0	-1	-1.5	-1.5	-1	0
6	0.5	0	0	0	0	0	1
7	1	0.5	2	-1	-1	-1.5	1
8	0	1	-0.5	0	-0.5	-0.5	1
9	0	0	-1.5	-1	-1	-1	0
10	0	0	0	-1	-1	-1	1
11	0	0.5	0.5	0.5	-0.5	0	1
12	1	1.5	1	-2	-2	-1	1
13	0	0	0	0	-1	-1	1
14	0	-1	-0.5	-0.5	-1	-1	1
15	1	1	-0.5	-1	-1.5	-1.5	1
16	0	0	0	0	0	0	1
17	0	0	0	0	-0.5	-0.5	1
18	0	0.5	0	0	0	0	1
19	0	1.5	1.5	1.5	0.5	0	1
20	0	0	0	0	-0.5	-0.5	1
21	0.5	0.5	0.5	0.5	0	0	1
22	0	0.5	0	-0.5	-1	-1	1
23	0	0	0.5	0	-1	-1	0
24	0	0.5	0	-0.5	-1	-1	1
25	1.5	3	0	0	-0.5	-0.5	1
26	0	0	0	-1	-1	-1	1
27	0	0.5	0	-0.5	-0.5	-0.5	1
28	0	0	-1	-1.5	-1.5	-1.5	1
29	0	1	1	1	1	1	1
30	1	0	0	-1.5	-1.5	-1	0
31	0	0	0	0	0	0	1
32	0	0	-1	-1	-1	-1	0
33	0	0	1	0.5	0	0	1
34	0	0.5	0.5	0	-0.5	-0.5	1
35	0.5	-0.5	1.5	0	0	0	1
36	1	0.5	1.5	0	0.5	0	1
37	0	0.5	-0.5	-1.5	-2	-1.5	0
38	0.5	0	-1.5	-2	-2	-1.5	0
39	0	0	-1.5	-1.5	-1	-1	1
40	0	0	1.5	0	0	0	1

RAW DATA

	EXV1 (mm)	EXV2 (mm)	EXV3 (mm)	EXV4 (mm)	EXV5 (mm)	EXV6 (mm)	EXSLOPE
41	0	1.5	1.5	0	-0.5	-0.5	1
42	0.5	0.5	0.5	0.5	-0.5	-0.5	1
43	1	6	2	2	1	2	1
44	0	0.5	-1.5	-2	-2	-2	-1
45	0.5	0.5	0	-1	-1	-1	-1
46	0	0	0	0	-0.5	-0.5	1
47	0.5	0.5	1	0	-0.5	-0.5	1
48	0.5	0	-1.5	-1.5	-1.5	-1.5	0
49	0	-0.5	-1	-1	-1	-1	1
50	0.5	1.5	1.5	1	1	1	1
51	0.5	3.5	2	1	0.5	0.5	1
52	0.5	0	0.5	0.5	0.5	0.5	1
53	0	-0.5	1	1	1.5	1	1
54	0	0.5	0	-0.5	-0.5	-0.5	1
55	0.5	1	1	0.5	0.5	0	1
56	0	3	3	4	2	1	1
57	0	0	0	-0.5	-0.5	-0.5	1
58	0	0	-0.5	-1.5	-2	-1	0
59	1	1	1.5	1	0.5	0	1
60	0	0	0.5	0	0	-0.5	1
61	0	0	1	1	0	0	0
62	1	1.5	1	-1.5	-2	-2	0
63	1	1	1	-0.5	-1	-1	1
64	0.5	0.5	0	-1	-1	-1	1
65	0.5	0	-1	-1	-1.5	-1.5	0
66	0.5	0	0.5	-0.5	-1	-1	1
67	0	0	-2	-1.5	-1	-1	0
68	0	0	-1	-2	-2	-2.5	0
69	1	1	-0.5	-0.5	-1	-1	0
70	1	1	1	-1	-2	-2	0
71	1	1.5	0.5	0.5	-0.5	-0.5	1
72	0	0	0	-1	-1	-1	0
73	0	0	0	0	-0.5	-0.5	1
74	0	0	1	-0.5	0	0	1
75	0	0	0	0	0	0	1
76	0	0	-0.5	-0.5	-1	-1	1
77	0	0	1	0.5	0	0	1
78	0	0	-0.5	-0.5	-0.5	-0.5	1
79	0	0.5	1	0	0	0	1
80	0	0	0	0	0	0	1

RAW DATA

	ISCH	PAIN	RWMA	RECHO1	RECHO2	RECHO3	RECHO4
1	1	1	1	0	0	0	0
2	2	0	0	0	0	0	0
3	2	0	0	0	0	0	0
4	2	0	0	0	0	0	0
5	2	1	0	0	0	0	0
6	1	0	0	0	0	0	0
7	1	0	0	0	0	0	0
8	1	0	0	0	0	0	0
9	1	0	0	0	0	0	0
10	2	0	1	0	0	1	0
11	1	0	0	0	0	0	0
12	2	0	0	0	0	0	0
13	2	1	1	0	0	0	1
14	2	0	0	0	0	0	0
15	2	0	0	0	0	0	0
16	1	0	1	0	0	0	1
17	1	0	0	0	0	0	0
18	1	0	1	1	0	0	0
19	1	0	0	0	0	0	0
20	1	0	0	0	0	0	0
21	1	0	0	0	0	0	0
22	2	0	0	0	0	0	0
23	2	1	0	0	0	0	0
24	2	0	0	0	0	0	0
25	1	0	0	0	0	0	0
26	2	0	0	0	0	0	0
27	1	0	0	0	0	0	0
28	2	0	0	0	0	0	0
29	1	0	0	0	0	0	0
30	2	0	1	0	0	0	0
31	1	0	0	0	0	0	0
32	2	0	0	0	0	0	0
33	1	0	0	0	0	0	0
34	1	0	0	0	0	0	0
35	1	0	0	0	0	0	0
36	1	0	0	0	0	0	0
37	2	1	0	0	0	0	0
38	2	0	1	0	0	0	1
39	2	0	0	0	0	0	0
40	1	0	0	0	0	0	0

RAW DATA

	ISCH	PAIN	RWMA	RECHO1	RECHO2	RECHO3	RECHO4
41	1	0	0	0	0	0	0
42	1	0	0	0	0	0	0
43	1	0	0	0	0	0	0
44	2	0	1	0	0	0	1
45	2	0	0	0	0	0	0
46	1	0	0	0	0	0	0
47	1	0	0	0	0	0	0
48	2	1	0	0	0	0	0
49	2	0	0	0	0	0	0
50	1	0	0	0	0	0	0
51	1	0	0	0	0	0	0
52	1	0	0	0	0	0	0
53	1	0	0	0	0	0	0
54	1	0	0	0	0	0	0
55	1	0	0	0	0	0	0
56	1	0	1	0	0	0	0
57	1	0	0	0	0	0	0
58	2	0	0	0	0	0	0
59	1	0	0	0	0	0	0
60	1	0	0	0	0	0	0
61	1	0	0	0	0	0	0
62	2	0	0	0	0	0	0
63	2	0	0	0	0	0	0
64	2	0	0	0	0	0	0
65	2	0	0	0	0	0	0
66	2	0	0	0	0	0	0
67	2	1	1	0	0	0	0
68	2	1	1	0	0	0	0
69	1	0	1	0	0	0	1
70	2	0	0	0	0	0	0
71	1	0	0	0	0	0	0
72	2	0	0	0	0	0	0
73	1	0	1	0	0	0	0
74	1	0	1	0	0	0	0
75	1	0	0	0	0	0	0
76	2	0	0	0	0	0	0
77	1	0	1	0	0	0	1
78	2	0	0	0	0	0	0
79	1	0	0	0	0	0	0
80	1	0	0	0	0	0	0

RAW DATA

	RECHO5	RECHO6	RECHO7	RECHO8	RECHO9	RECHO10
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	1	0	1	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	1	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0

RAW DATA

	RECHO5	RECHO6	RECHO7	RECHO8	RECHO9	RECHO10
41	0	0	0	0	0	0
42	0	0	0	0	0	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	0	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	1	0	0	0	0
57	0	0	0	0	0	0
58	0	0	0	0	0	0
59	0	0	0	0	0	0
60	0	0	0	0	0	0
61	0	0	0	0	0	0
62	0	0	0	0	0	0
63	0	0	0	0	0	0
64	0	0	0	0	0	0
65	0	0	0	0	0	0
66	0	0	0	0	0	0
67	0	0	1	1	0	0
68	0	0	0	0	0	0
69	0	0	0	0	0	0
70	0	0	0	0	0	0
71	0	0	0	0	0	0
72	0	0	0	0	0	0
73	0	1	0	0	0	0
74	0	0	0	1	0	1
75	0	0	0	0	0	0
76	0	0	0	0	0	0
77	0	0	0	0	0	0
78	0	0	0	0	0	0
79	0	0	0	0	0	0
80	0	0	0	0	0	0

RAW DATA

	RECHO11	RECHO12	RECHO13	RECHO14	RECHO15	RECHO16
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0

RAW DATA

	RECHO11	RECHO12	RECHO13	RECHO14	RECHO15	RECHO16
41	0	0	0	0	0	0
42	0	0	0	0	0	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	0	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	0	0	0	0	0
57	0	0	0	0	0	0
58	0	0	0	0	0	0
59	0	0	0	0	0	0
60	0	0	0	0	0	0
61	0	0	0	0	0	0
62	0	0	0	0	0	0
63	0	0	0	0	0	0
64	0	0	0	0	0	0
65	0	0	0	0	0	0
66	0	0	0	0	0	0
67	0	0	0	0	0	0
68	0	0	0	0	1	0
69	0	0	0	0	0	0
70	0	0	0	0	0	0
71	0	0	0	0	0	0
72	0	0	0	0	0	0
73	0	0	0	0	0	0
74	0	0	0	0	1	0
75	0	0	0	0	0	0
76	0	0	0	0	0	0
77	0	0	0	0	0	0
78	0	0	0	0	0	0
79	0	0	0	0	0	0
80	0	0	0	0	0	0

RAW DATA

	EXWMA	EXECHO1	EXECHO2	EXECHO3	EXECHO4	EXECHO5
1	2	1	1	0	0	0
2	2	0	0	0	0	0
3	2	0	0	0	0	0
4	1	0	0	0	0	0
5	2	0	0	1	0	0
6	2	1	0	0	0	1
7	1	0	0	0	0	0
8	1	0	0	0	0	0
9	1	0	0	0	0	0
10	1	0	0	0	0	0
11	2	1	0	0	0	0
12	1	0	0	0	0	0
13	2	0	0	0	0	0
14	1	0	0	0	0	0
15	2	0	0	0	0	0
16	1	0	0	0	0	0
17	1	0	0	0	0	0
18	1	0	0	0	0	0
19	1	0	0	0	0	0
20	1	0	0	0	0	0
21	1	0	0	0	0	0
22	1	0	0	0	0	0
23	1	0	0	0	0	0
24	1	0	0	0	0	0
25	1	0	0	0	0	0
26	1	0	0	0	0	0
27	1	0	0	0	0	0
28	1	0	0	0	0	0
29	1	0	0	0	0	0
30	1	0	0	0	0	0
31	2	0	0	0	0	0
32	1	0	0	0	0	0
33	1	0	0	0	0	0
34	1	0	0	0	0	0
35	1	0	0	0	0	0
36	1	0	0	0	0	0
37	2	0	0	0	0	0
38	2	1	0	0	0	0
39	1	0	0	0	0	0
40	1	0	0	0	0	0

RAW DATA

	EXWMA	EXECHO1	EXECHO2	EXECHO3	EXECHO4	EXECHO5
41	1	0	0	0	0	0
42	2	0	0	0	0	0
43	1	0	0	0	1	0
44	2	0	0	0	0	0
45	1	0	0	0	0	0
46	1	0	0	0	0	0
47	1	0	0	0	0	0
48	1	0	0	0	0	0
49	1	0	0	0	0	0
50	1	0	0	0	0	0
51	1	0	0	0	0	0
52	1	0	0	0	0	0
53	1	0	0	0	0	0
54	1	0	0	0	0	0
55	1	0	0	0	0	0
56	1	0	0	0	0	0
57	1	0	0	0	0	0
58	1	0	0	0	0	0
59	1	0	0	0	0	0
60	1	0	0	0	0	0
61	1	0	0	0	0	0
62	1	0	0	0	0	0
63	1	0	0	0	0	0
64	1	0	0	0	0	0
65	2	0	0	0	0	0
66	2	0	0	0	0	0
67	2	1	0	0	0	0
68	2	0	0	0	0	0
69	2	0	0	0	0	0
70	1	0	0	0	0	0
71	1	0	0	0	0	0
72	1	0	0	0	0	0
73	2	1	1	0	0	0
74	2	1	0	0	0	0
75	1	0	0	0	0	0
76	1	0	0	0	0	0
77	2	0	0	0	0	0
78	1	0	0	0	0	0
79	1	0	0	0	0	0
80	1	0	0	0	0	0

RAW DATA

	EXECHO6	EXECHO7	EXECHO8	EXECHO9	EXECHO10	EXECHO11
1	0	0	1	0	1	1
2	0	1	1	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	1	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	1	0	0	0
12	0	0	0	0	0	0
13	0	0	0	1	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	1	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	1	0	0	1	0	0
38	0	0	1	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0

RAW DATA

	EXECHO6	EXECHO7	EXECHO8	EXECHO9	EXECHO10	EXECHO11
41	0	0	0	0	0	0
42	0	1	1	0	1	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	0	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	0	0	0	0	0
57	0	0	0	0	0	0
58	0	0	0	0	0	0
59	0	0	0	0	0	0
60	0	0	0	0	0	0
61	0	0	0	0	0	0
62	0	0	0	0	0	0
63	0	0	0	0	0	0
64	0	0	0	0	0	0
65	0	0	1	0	0	0
66	1	0	0	1	0	0
67	1	1	1	0	0	1
68	0	0	1	0	0	0
69	0	0	0	0	0	0
70	0	0	0	0	0	0
71	0	0	0	0	0	0
72	0	0	0	0	0	0
73	1	0	0	0	0	0
74	0	0	0	0	1	0
75	0	0	0	0	0	0
76	0	0	0	0	0	0
77	0	0	0	0	0	0
78	0	0	0	0	0	0
79	0	0	0	0	0	0
80	0	0	0	0	0	0

RAW DATA

	EXECHO12	EXECHO13	EXECHO14	EXECHO15	EXECHO16
1	0	1	1	1	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	1	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	0	0	0	0	0
31	0	0	0	0	0
32	0	0	0	0	0
33	0	0	0	0	0
34	0	0	0	0	0
35	0	0	0	0	0
36	0	0	0	0	0
37	1	1	1	0	0
38	0	0	0	1	1
39	0	0	0	0	0
40	0	0	0	0	0

RAW DATA

	EXECHO12	EXECHO13	EXECHO14	EXECHO15	EXECHO16
41	0	0	0	0	0
42	0	0	0	1	0
43	0	0	0	0	0
44	1	0	0	0	0
45	0	0	0	0	0
46	0	0	0	0	0
47	0	0	0	0	0
48	0	0	0	0	0
49	0	0	0	0	0
50	0	0	0	0	0
51	0	0	0	0	0
52	0	0	0	0	0
53	0	0	0	0	0
54	0	0	0	0	0
55	0	0	0	0	0
56	0	0	0	0	0
57	0	0	0	0	0
58	0	0	0	0	0
59	0	0	0	0	0
60	0	0	0	0	0
61	0	0	0	0	0
62	0	0	0	0	0
63	0	0	0	0	0
64	0	0	0	0	0
65	0	0	0	0	1
66	0	0	0	0	0
67	1	1	1	1	1
68	0	0	0	1	0
69	0	0	0	0	0
70	0	0	0	0	0
71	0	0	0	0	0
72	0	0	0	0	0
73	0	0	0	0	0
74	0	0	0	1	0
75	0	0	0	0	0
76	0	0	0	0	0
77	0	0	0	1	0
78	0	0	0	0	0
79	0	0	0	0	0
80	0	0	0	0	0

RAW DATA

	LAD	LCX	RCA	REJFRAC (%)	EXEFRAC (%)	LVMASS
1	1	1	1	65	1	1
2	1	0	0	60	1	1
3	0	0	1			0
4	0	0	0			1
5	0	1	1			1
6	1	0	0			0
7	0	0	0	55	1	0
8	0	0	0	55	1	0
9	0	0	0	55	1	0
10	0	1	0			0
11	1	0	0			0
12	0	0	0	55	1	0
13	0	0	1	60	1	1
14	0	0	0	65	1	1
15	1	0	0	60	1	1
16	0	0	1	65	1	1
17	0	0	0	55	1	1
18	1	0	0	50	1	0
19	0	0	0	55	1	0
20	0	0	0	55	1	0
21	0	0	0	55	1	0
22	0	0	0			0
23	0	0	0	55	1	0
24	0	0	0		1	0
25	0	0	0		1	0
26	0	0	0		1	0
27	0	0	0	55	1	1
28	0	0	0	55	1	0
29	0	0	0	60	1	0
30	0	0	1		1	0
31	1	0	0	55	1	0
32	0	0	0	55	1	0
33	0	0	0	55	1	0
34	0	0	0		1	0
35	0	0	0	55	1	0
36	0	0	0		1	0
37	1	1	1	65	-1	1
38	1	0	0	70	0	1
39	0	0	0	55	1	0
40	0	0	0		1	0

RAW DATA

	LAD	LCX	RCA	REJFRAC (%)	EXEFRAC (%)	LVMASS
41	0	0	0	55	1	0
42	1	1	0	60	1	1
43	0	0	0	55	1	0
44	0	1	1	60	1	0
45	0	0	0		1	0
46	0	0	0	55	1	0
47	0	0	0	55	1	0
48	0	0	0		1	0
49	0	0	0	55	1	0
50	0	0	0	60	1	0
51	0	0	0	55	1	0
52	0	0	0		1	0
53	0	0	0		1	0
54	0	0	0		1	0
55	0	0	0	55	1	0
56	0	0	1		1	0
57	0	0	0	55	1	0
58	0	0	0	55	1	0
59	0	0	0	55	1	0
60	0	0	0	55	1	0
61	0	0	0	55	1	0
62	0	0	0	55	1	0
63	0	0	0		1	0
64	0	0	0		1	1
65	1	0	0	60	-1	1
66	0	0	1	60	1	0
67	1	1	1	40	-1	1
68	1	0	0			0
69	0	0	1			0
70	0	0	0		1	0
71	0	0	0	55	1	0
72	0	0	0		1	0
73	1	0	1		1	0
74	1	0	0	60	1	1
75	0	0	0	55	1	0
76	0	0	0		1	1
77	1	0	0		1	0
78	0	0	0		1	1
79	0	0	0		1	0
80	0	0	0		1	0

VITA

Wendy Rogister Downey was born in Norfolk, Virginia in 1968. She went to school at Virginia Tech where she earned Bachelors degrees in both Exercise Science and Health Education. Since 1991, she has worked at Radford Community Hospital as an exercise physiologist in both Wellness and Cardiac Rehabilitation. She is currently pursuing a Masters degree in cardiac rehabilitation while she and her husband, Tim, are raising their daughter, Taylor, and expecting a second child late this year.