ABSTRACT

Hinshelwood, Robert A. Prevalence and reproducibility of ECG-documented premature contractions (PCs) with exercise in young adults. M.S. in Physical Education, 1982. 49 pgs. (Dr. Phil Wilson)

Evaluation of exercise arrhythmias requires knowledge of distribution of such arrhythmias in a specific population. I have characterized a college-aged ($\bar{X}$ = 19 yr) population in terms of the prevalence and reproducibility of exercise PCs. Initially, 106 males (M) and 109 females (F), all Caucasian, non-smoking and clinically healthy, underwent standardized Bruce treadmill tests (T1) with continuous recording of ECG lead V5 throughout exercise and 5 min. of recovery. Thirty-one (29%) M and 21 (19%) F demonstrated PCs. These were primarily of low frequency (<6), fairly evenly distributed in terms of atrial or ventricular origin, and found throughout exercise and recovery. No heart rate threshold for PCs was evident. Males with PCs exercised longer (14:55 vs 13:55, $p \leq .01$) than M without PCs. Of the 52 subjects (Ss) with PCs on T1, 25 M and 19 F were retested (T2) within 6-119 days ($\bar{X}$ = 39 days). Eighteen (72%) M and 7 (37%) F showed PCs also on T2. Reproducibility was generally not precise in terms of frequency of PCs, but PCs were generally of the same origin and often occurred at similar exercise intensities on both tests. Females who did not reproduce PCs exercised longer (11:05 vs 10:05, $p \leq .05$) than F who did reproduce. The results show that at least occasional PCs are fairly common during exercise in clinically healthy young adults, with prevalence ($p \leq .10$) and reproducibility ($p \leq .05$) being higher in males than females. Reproducibility diminishes as one looks at specific frequencies of PCs. Individuals with six or more premature contractions during exercise are much more likely to demonstrate premature contractions during a subsequent exercise bout.

PREVALENCE AND REPRODUCIBILITY OF ECG-DOCUMENTED PREMATURE CONTRACTIONS WITH EXERCISE IN YOUNG ADULTS

A Thesis Presented

to

The Graduate Faculty

University of Wisconsin - LaCrosse

In Partial Fulfillment

of the Requirements for the

Master of Science Degree

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by

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We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

Introduction

The exercise electrocardiogram is a valuable tool to the clinician for diagnosis and prognosis with one of the important functions of the exercise electrocardiogram being the detection of cardiac arrhythmias. Arrhythmias can be of many types and can range from "rare occurrences" to quite severe perpetual problems. Arrhythmias may be considered as a possible risk factor or even symptom of advanced coronary artery disease. In order for physicians to determine the significance of observed premature contractions, the prevalence of premature contractions in the appropriate population must be known. For example, a young person who demonstrates frequent premature beats while undergoing moderate exercise warrants further evaluation. Before that evaluation could be completed, it would be helpful to know which arrhythmias are common in healthy young people.

Of further assistance to the clinician is knowledge of the reproducibility of exercise-related premature contractions. For instance, a person may develop 30 multifocal premature ventricular beats during peak exercise and the first minute of recovery on an initial exercise test. A retest might be performed to see whether these results appear again. Recurrence of arrhythmias would signify a more critical prognosis. In this case, reproducibility of the arrhythmia aids the physician in determining the probable significance of the arrhythmia.

Repeat testing of an individual who has an arrhythmia might also be a way of determining the efficacy of the treatment utilized. Knowledge of the reproducibility of arrhythmias is basic. Using the example above, it will be presumed that this person was placed on medication for control of the arrhythmia. A third exercise test could then be performed to evaluate the effectiveness of the prescribed medication. The knowledge of which premature contractions are reproducible with exercise is of value to the physician both in the prognosis and diagnosis of the premature contraction.

Knowledge of population specific prevalence and reproducibility of exercise-related premature contractions is basic to the clinician's understanding of what is abnormal for a certain population and aids in the prognosis and evaluation of any treatment that has been prescribed. To date there are no population specific data that have been obtained on the prevalence or reproducibility of ECG-documented premature contractions with exercise in young adults.

Purpose

The purpose of this study was to investigate the prevalence and reproducibility of ECG-documented premature contractions demonstrated during exercise in an apparently healthy college-age population.

Definitions

The following are definitions stating the meaning of words as they are used within this paper.

Arrhythmia. Absence of rhythm applied especially to any variation from the normal rhythm of the heartbeat (Dorland's Illustrated Medical Dictionary, 1965, p. 133).

Bruce protocol. An exercise treadmill test that involves gradual increases in speed and elevation. It is most frequently used with individuals who are asymptomatic and who have high exercise capacities. (Appendix A.)

Ectopic. "Located away from normal position." (Dorland's, p. 466).

Electrocardiogram. "A graphic tracing of the electric current produced by the contraction of the heart muscle" (Dorland's, p. 472).

Escape beat. "A condition of vagal arrhythmia in which the atrioventricular impulse becomes effective before the sino-auricular impulse" (Dorland's, p. 513).

Idiopathic. "Of unknown causation" (Dorland's, p. 723).

Master's test. An exercise test that involves stepping up and down at a predetermined height and pace. It is the earliest published standardized exercise test. (Appendix B.)

Naughton protocol. An exercise test that involves gradual increases in speed and elevation. It is most frequently used with deconditioned, symptomatic individuals. (Appendix C.)

Premature atrial contraction (PAC). An ectopic beat originating in the atria before its time.

Premature ventricular contraction (PVC). An ectopic beat originating in the ventricles before its time.

Tetralogy of Fallot. "A combination of congenital cardiac defects commonly found in adults, namely, pulmonary stenosis in the conus region, interventricular septal defect, dextroposition of the aorta so that it overrides the interventricular septum and receives venous as well as arterial blood, and right ventricular hypertrophy" (Dorland's, p. 1564).

Delimitations

These limitations were established by the author to qualify the subjects used in this study.

1. The study was restricted to 215 subjects.
2. The study was conducted in the fall and winter of the 1978-1979 school year.
3. The subjects were randomly selected from the freshman and senior classes at Oral Roberts University, but only those who passed a medical screening were accepted into the study.
4. In order to avoid any confounding of results due to population specificity, only Caucasian United States residents were included in the study.

Limitations

These restrictions were beyond the control of the author.

1. The chronological age range of the subjects was 16 to 24 years.
2. Subjects were professed non-smokers, non-drinkers (alcohol), and non-illicit drug users.

Chapter II

Review of Related Literature

The related literature is discussed in regard to (1) prevalence and (2) reproducibility of exercise-related premature contractions.

Prevalence

A considerable amount of data has been published on the prevalence of exercise-related arrhythmias. Interpretation and application of these results requires attention to the following aspects of study design or methodology: characteristics (age, sex, health status) of the sample studied, the exercise protocol, categories of arrhythmias studied and protocol for ECG recording. The interrelationship of the different aspects of design and methodology is important in understanding the results of previous studies.

Anderson, Lee, Campion, Amplatz, and Yuna (1972) studied 119 patients who were evaluated because of coronary insufficiency. Seventy percent of their subjects were males, with ages ranging from 12 to 65 years ($\bar{X}$ = 44). (The specific age distribution of subjects was not stated.) Using both treadmill and the Masters (1929) two-step test, overall incidence of premature contractions before, during and after exercise was 19%. Electrocardiogram recording was not continuous but occurred at 30-second intervals. ECG data obtained both before and after exercise were also included. Patients with a positive exercise test had a 3 times greater incidence of ventricular arrhythmias, with

supraventricular arrhythmias occurring only in patients with a positive exercise test. These researchers concluded that "dysrhythmias associated with exercise testing should raise the index of suspicion of underlying coronary artery disease but should not be used as a criterion for a positive test" (p. 763).

McHenry, Finch, Jordan and Corya (1972) tested 650 policemen, of whom 89 had definite or suspected cardiovascular disease. Health status was determined by a medical history, physical examination, including X rays and appropriate laboratory work. All exercise testing was performed on a treadmill using a continuous exercise protocol, with ECG being recorded continuously throughout exercise. Recovery data were not included in the results. These researchers found a greater incidence of ventricular premature complexes in the definite or suspected coronary disease subjects at every age group, although this difference was statistically significant only in the 35 to 44 age group. There was no difference between the groups at any age level in prevalence of exercise-induced supraventricular premature complexes. (Table 1) Interestingly, when PVC's occurred, they typically appeared at a heart rate of 150 beats/min. or more in the normal subjects, but at a rate below 150 beats/min. in those with definite or suspected coronary artery disease. Individuals with coronary artery disease were more likely to exhibit frequent or multifocal premature ventricular complexes or ventricular tachycardia. It was the opinion of these investigators that the unifocal ventricular premature complexes which occurred at a heart rate of 150 or greater do not necessarily indicate a pathologic state.

TABLE 1

Exercise-induced Arrhythmia Prevalence

Data of McHenry et. al. (1972)

Age Group	Total Subjects	Subjects showing any PVC's during exercise	Subjects showing any supraventricular complexes during exercise
25-34			
Normals*	266	77(29%)	17(6%)
CAD**	16	7(44%)	1(6%)
35-44			
Normals	237	81(34%)	26(11%)
CAD	46	25(54%)	3(6¢)
45-54			
Normals	58	25(43%)	8(14%)
CAD	27	13(48%)	4(15%)

*Subjects without definite or suspected coronary artery disease
**Subjects with definite or suspected coronary artery disease

Blackburn, Taylor, Hamrell, Buskirk, Nicholas, and Thoreen (1973) investigated the prevalence of exercise-induced PVC's both before and after exercise training in 196 "high risk" men aged 40 - 49. Subjects were randomly selected from "households" by a questionnaire. Risk of heart disease was assessed on the basis of serum cholesterol concentration, number of cigarettes smoked, and blood pressure level. A medical examination excluded all with suspected coronary artery disease or any other disability which would interfere with the study. The ECG was continuously monitored during a continuous treadmill exercise test to a heart rate of 150 beats/min. Treadmill tests were performed before and

after an 18-month conditioning program. In evaluating the data from the excellent adherers group (N = 25), the following results occurred. There were no statistically significant differences when comparing the frequency of premature ventricular complexes between the pre-training period submaximal test and the post-training test. However, "there is a suggestion of proportionately fewer men with premature ventricular complexes (9 vs. 4), fewer total premature ventricular complexes (24 vs. 7) and a lower average frequency per man (2.7 vs. 1.8) after the training period" (p. 447). These researchers also noted that the threshold for PVC's was raised in those who underwent an exercise conditioning program.

Jelinek and Lown (1974) performed 1000 exercise tests on 625 patients ($\bar{X}$ age = 51.8) both males and females. The population was divided into the following 3 groups: subjects with (1) proven heart disease, (2) possible heart disease, and (3) no heart disease. Coronary heart disease was present in 274 (44%) of the subjects, representing 551 of the tests. Two hundred seventy-four (58%) of the subjects had possible heart disease and accounted for 361 of the exercise tests. The remaining tests (88) were performed on 77 (12%) individuals who did not have heart disease.

Subjects were exercised on a treadmill or bicycle ergometer, using a continuous protocol, until exhaustion, symptoms, or ECG changes necessitated stopping earlier. All ECG data were continuously recorded on tape for analysis. The results were reported as they pertained to the entire subject population; therefore, individual patient subgroups were not differentiated according to arrhythmias provoked. Ventricular

ectopic activity was present during exercise or recovery in 592 of the 1000 exercise tests (59%). Atrial or junctional premature beats were observed in 262 of the 1000 tests (26%). As an additional aspect of the study 163 normal men ($\bar{X}$ age = 43) were compared to 168 coronary artery disease patients ($\bar{X}$ age = 54) in order to determine the prevalence of PVC's during exercise and recovery. The protocol was the same as described except that no cardiac medications were being taken by any subjects. Sixty-one (36.3%) of the men with coronary artery disease developed PVC's with exercise or recovery as compared to 31 (19%) of the normals. The investigators noted that more of the ectopic activity occurred during post-exercise recovery than during exercise in the coronary artery disease group, with the distribution of arrhythmias being nearly the same in exercise as in recovery for the normals.

Froelicher, Thomas, Pillow, and Lancaster (1974) performed 1,390 graded exercise tests on asymptomatic men (20 - 54 years old, $\bar{X}$ = 37.6) in the armed services to detect latent coronary artery disease. The ECG was continuously recorded on paper both during and after a maximal treadmill exercise test. Thirty-five percent of the subjects had PVC's, ranging from single to 4 or more consecutive PVC's. Forty percent of these subjects had PVC's initially during late exercise. It was found that the occurrence of PVC's was related to age, but this was not a means of identifying a high risk group apart from a positive exercise test.

Prevalence of exercise-induced PVC's in both cardiac patients and normals was studied by McHenry, Morris, Kavalier, and Jordan (1976). Four hundred eighty-two male subjects were divided into 3 groups: group

1A, 141 patients (31 - 59 yr. old, $\bar{X}$ = 44) with chest pain and normal coronary arteriograms; group 1B, 144 age-matched policemen who were apparently free of coronary artery disease; group II, 197 subjects (29 - 65 yr. old, $\bar{X}$ = 48) with chest pain and arteriographically documented coronary artery disease. Appropriate medications were discontinued prior to exercise. Those patients with cardiomyopathy, valvular heart disease, heart failure or hypertension were excluded from the study. All subjects were tested on the treadmill using a continuous exercise protocol with ECG recorded continuously during exercise and recovery. Groups 1A and II were exercised to either chest pain or 85% of their predicted maximal heart rate, with three subjects being exceptions in that they had their test terminated due to episodes of ventricular tachycardia. Subjects in group II were exercise-tested to their volitional maximal heart rate. Prevalence of exercise-induced PVC's was 16% (n = 23) in group 1A, 44% (n = 64) in group 1B, and 29% (n = 57) in group II. However, when taking into account heart rate at the time of occurrence of the arrhythmia, the incidence of arrhythmias at heart rates up to 130/min. were 9, 6 and 27% respectively. Thus, these investigators found that subjects in group II exhibited more of their premature contractions at a heart rate below 130 than did subjects in either group 1A or 1B. Also, the more serious forms of ventricular arrhythmias (multifocal beats, ventricular tachycardia, etc.) were more common at submaximal heart rates in those with coronary artery disease.

In a follow-up study performed on the policemen who were evaluated by McHenry in 1972, prevalence of exercise-induced ventricular arrhythmias was determined in 543 males who had been evaluated 1 - 4 years ($\bar{X}$ =

2.9 yr.) earlier (Paris, McHenry, Jordan, and Morris, 1976). The subjects' ages ranged from 25 - 58 years. Of those subjects evaluated, 81 had definite or suspected coronary artery disease. Subjects with PVC's at rest were excluded. Each subject performed a continuous treadmill exercise test with uninterrupted ECG recording. For all groups, prevalence at test 2 was similar to that at test 1. (Table 2) The explanation given for the decreased prevalence in the 45 - 54-year-old coronary artery disease group was that 4 subjects showed PVC's at rest during test 2 and were excluded from the study. In agreement with the studies from the McHenry group, Paris et. al. found that coronary artery disease

TABLE 2

Exercise-induced Arrhythmia Prevalence

Data of Paris et. al. (1976)

Age Group	Total Subjects	Subjects showing arrhythmias during exercise in: Test 1	Test 2*
25-34			
Normals[+]	217	64(30%)	78(36%)
CAD[++]	17	8(47%)	8(47%)
35-44			
Normals	200	64(32%)	76(38%)
CAD	39	21(54%)	22(56%)
45-54			
Normals	45	16(36%)	19(42%)
CAD	25	11(44%)	8(32%)

*Test 2 was 1-4 yr. ($\bar{X}$ = 2.9 yr.) after test 1.
[+]Subjects without definite or suspected coronary artery disease
[++]Subjects with definite or suspected coronary artery disease

subjects developed more arrhythmias at a heart rate less than 150 beats/min. than did their comparative healthy group. The investigators concluded that exercise-related PVC's appear to increase with age. Those subjects with definite or suspected coronary artery disease seem to have a greater prevalence of PVC's than do their normal counterparts.

James, Kaplan, Schwartz, Chou, Sandker, and Naylor (1976), in studying the response to exercise after total surgical correction of Tetralogy of Fallot, utilized a control group of healthy subjects, primarily children. The control group consisted of 109 subjects, 68 males and 41 females (aged 5 - 42 yrs.) with no mean age given. Some of these subjects were evaluated for chest pain, fainting and/or cardiac murmur but their clinical evaluation was normal. Each of the subjects underwent a maximum bicycle exercise test in which the electrocardiogram was monitored but not continuously recorded. Not a single subject in either male or female control groups demonstrated premature ventricular or atrial contractions.

In a study performed by Udall and Ellestad (1977), 6,500 patients (80% men, 20% women) were tested to determine the predictive implications of PVC's during exercise testing. Subjects ranged in age from 21 - 80 years with the predominant number (50%) of subjects being evaluated for chest pain. Twenty-two percent of the subjects demonstrated a history of a myocardial infarction, while another 22% had hypertension, and 6% were post-cardiac surgical patients. Only 17% of the subjects were free of known or suspected coronary artery disease as determined by a comprehensive pre-test examination. Subjects were tested on a treadmill with continuous ECG recording. Premature ventricular contractions

were noted in 1,327 subjects (20.4%) either immediately before, during or immediately after exercise testing. Ominous PVC's (defined as multiform bigeminal, repetitive, or tachycardia) were observed in 201 patients (3.1%).

Sami, Kraemer, and DeBusk (1979) determined the prevalence of exercise-induced ventricular arrhythmias in men 3 to 52 weeks after myocardial infarction with 155 men ($\bar{X}$ age = 53±8 yrs.) being exercise-tested using the Naughton (1963) protocol. Continuous recording of the ECG from 3 minutes before exercise until 10 minutes into recovery was performed on all subjects. The mean prevalence rate of exercise-induced PVC's was 52%.

Ekblom, Hartley and Day (1979) studied the occurrence and reproducibility of exercise-induced PVC's in a normal population. Three hundred forty-five apparently healthy subjects (289 men, 56 women) were monitored continuously while walking/jogging in a YMCA setting. No mean age for the study population was given; however, subjects were grouped according to age. There were only 3 women and 17 men under the age of 30. Three of 17 male subjects (18%) under 30 years of age had at least 1 PVC. No women under the age of 30 exhibited a PVC while 2 of 10 (20%) at or above age 50 demonstrated at least 1 PVC. Women showed fewer premature contractions at every age than did men. "The prevalence rates of ventricular ectopy in men increased from 10% at a heart rate between 100-119 beats/min. to 50% above a heart rate of 150 beats/min." (p. 37). More premature contractions occurred during exercise than recovery. The frequency of complex arrhythmias such as multifocal and paired beats became more common as age increased. A separate group of 21 patients

with previous myocardial infarctions did not have more premature contractions than did their healthy counterparts of the same age.

Summary of Prevalence

Prevalance of PAC's

The literature reviewed shows differing prevalence rates of exercise-related premature atrial contractions in adult populations. Reported prevalance of exercise-related PAC's for a normal male population ranged from 6% in 25 - 34-year-olds to 14% in 45 - 55-year-olds using continuous monitoring (McHenry et. al., 1972). Among coronary artery disease male patients using continuous monitoring exercise-related PAC's ranged from 6% in 25 - 34-year-olds to 15% in 45 - 55-year-olds (McHenry et. al., 1972). Jelinek and Lown (1974) reported 26% of their subjects demonstrated PAC's using continuous monitoring; however, their population consisted of both normal individuals and cardiac patients. Anderson et. al., (1972) found PAC's only in their cardiac population utilizing non-continuous monitoring.

Prevalence of PVC's

Reported prevalence of exercise test-related PVC's in normal adults ranged from 29% in 25 - 34-year-old men (McHenry et. al., 1972) to 44% in 31 - 59-year-old men (McHenry et. al., 1976). Ekblom et. al., (1979) when evaluating a normal population exercising in a recreational setting found the prevalence of PVC's to vary in that 3 of 17 (18%) male subjects under age 30 had at least 1 PVC while 45 of 90 men (50%) had produced a PVC over age 50. In women under age 30 there were no PVC's;

however, 2 of 10 (20%) women subjects over age 50 had PVC's while exercising. Prevalence of exercise test-related PVC's among cardiac patients ranged from 16% in 31 - 59-year-old men (McHenry et. al., 1976) to 52% ($\bar{X}$ age = 53 ± 8) in men 3 to 52 weeks after myocardial infarction (Sami et. al., 1979).

Prevalence of PC's: Normal Vs. CAD Subjects

Sample characteristics, the exercise protocols, and the different types of recording methods possibly account for many of the apparent discrepancies between studies. If some trends can be noted, all but one study (Ekblom et. al., 1979) found that coronary artery disease subjects exhibited more exercise arrhythmias than do their healthy counterparts of the same age (Gooch, McConnell, 1970; McHenry et. al., 1972; Jelinek, Lown, 1974; Paris et. al., 1976). Cardiac patients also develop their arrhythmias at a lower heart rate than do healthy adults (McHenry et. al., 1972; McHenry et. al., 1976; Paris et. al., 1976). In addition, the more severe types of arrhythmias appear to be most common in exercise among coronary artery disease subjects (McHenry et. al., 1972; McHenry et. al., 1976). Also, the prevalence of exercise arrhythmias appears to increase with age (Gooch, McConnell, 1970; Froelicher et. al., 1974; Paris et. al., 1976; Ekblom et. al., 1979).

Prevalence in Subjects ≤25 years

Only three studies mentioned utilized subjects under age 25 (Anderson et. al., 1972; Froelicher et. al., 1974; James et. al., 1976).

In all three studies very few subjects between the ages of 16 and 24 were evaluated. It is difficult to discern the exact number of subjects studied because only the means and ranges of the study populations were given in both the study by Anderson et. al., (1972) and James et. al., (1976). There were very few females included in any of the above-mentioned studies. James et. al., (1976) whose subjects ranged from 5 to 42 years, surprisingly found no premature contractions in any of their healthy subjects, though non-continuous monitoring may be partially responsible for this finding. Prevalence of premature contractions among young people is impossible to ascertain from the available literature because of the differences in protocol, ECG monitoring techniques and uncertainties regarding age in the study populations. In examining the previous studies there is in fact very little useful data pertaining to prevalence of exercise-related premature contractions in young people. Consequently, more age specific data is needed to determine how prevalent premature contractions are in a young population.

Reproducibility

There are two important factors to consider in interpreting the data on reproducibility of exercise-related arrhythmias. One factor is subject characteristics, i.e. age, sex, health status, and the other is the methodology that was used for determining reproducibility. The length of time between tests, intervention between tests, the exercise modality and protocol used, and the types of arrhythmias studied may affect overall reproducibility of exercise-related arrhythmias.

Gooch and McConnell (1970) studied 713 subjects (509 males, 204 females) whose ages ranged from 17 to 82. The purpose of the test was to either diagnose coronary artery disease or to evaluate their functional status with known heart disease. Subjects were tested on a treadmill to "comfortable tolerance" or to 85% of their predicted maximum heart rate, with lead V_5 being continuously monitored during exercise and 8 minutes of recovery. A subgroup of 30 were tested on a treadmill twice within a two-week period to determine reproducibility of arrhythmias. The specific sex and age of those subjects were not stated. Of the 30 subjects retested, 4 of 24 (17%) demonstrated reproducible arrhythmias. Reproducibility was not specifically defined.

Jelinek and Lown (1974) conducted exercise tests on 17 "unselected" primarily male patients who had a mean age of approximately 55 years. All were cardiac patients who were involved in a cardiac rehabilitation program during the time of the testing, with either a treadmill or bicycle ergometer being utilized. There was continuous recording of the ECG. Subjects completed two or more exercise tests within a six-month period. These investigators defined reproducibility as "the number of times the arrhythmia recurs in all the tests performed after the test that identifies the arrhythmia" (p. 511). Other researchers usually only perform two tests to determine reproducibility. Reproducibility ranged from 30% for PVC's to 50% for ventricular tachycardia.

Fabian et. al. (1974) exercise-tested 50 patients with coronary artery disease at three-month intervals, with appropriate medications being discontinued before testing. No patients with heart failure,

hypertension, intermittent claudication, rhythm or conduction disturbances, or musculoskeletal disease limiting exercise performance were included in this study. Bicycle ergometry was performed until 75% of predicted maximal aerobic power was attained or until signs, symptoms, or ECG abnormalities caused an earlier endpoint. No data were given as to age or sex of subjects, or protocol for ECG monitoring. Although the initial study group size was 50, actually only 7 patients of the 50 demonstrated arrhythmias on the first exercise test. Of the 7 patients who had arrhythmias only 1 reproduced the arrhythmia on a second exercise test.

Faris, McHenry, Jordan, and Morris (1974) as mentioned earlier, investigated the reproducibility of exercise-related arrhythmias in men aged 25 to 58 years. Eighty-one of the 543 subjects had definite or suspected coronary artery disease. A continuous treadmill exercise test to volitional maximum with continuous ECG recording was performed by each subject at 2 different sessions separated by one to four years ($\bar{X}$ = 2.9 yrs.). Reproducibility between normals and those with definite or suspected coronary artery disease differed. The percent of subjects who reproduced their arrhythmias on a second test increased with age in both groups. (Table 3) Subjects with coronary artery disease, however, were more likely to reproduce their arrhythmia as they became older than were the normal group. "Exercise-induced ventricular arrhythmias were not reproducible by type or complexity" in either group.

Shaps, Ernst, Briese, Lopez, Conde, Castellanos, and Myerburg (1977) retested 13 subjects (11 males, 2 females) with a mean age of 52 years to determine the reproducibility of exercise-induced arrhythmias

TABLE 3

Exercise-induced Arrhythmia Reproducibility

Data of Faris et. al. (1976)

Age Group (yr.)(No.)	Men with Arrhythmias on Test 1: Total No.	Without Arrhythmias on Test 2	Arrhythmias on Test 2	Men with Arrhythmias on Test 2*: Total No.	Without Arrhythmias on Test 1
25-35					
N(217)[+]	64	29(45%)	35(55%)	78[+++]	46(59%)
CAD(17)[++]	8	4(50%)	4(50%)	8	4(50%)
35-44					
N(200)	64	27(42%)	37(58%)	77	45(58%)
CAD(39)	21	5(24%)	16(76%)	26	10(39%)
45-54					
N(45)	16	6(38%)	10(62%)	21	11(52%)
CAD(25)	11	3(27%)	8(73%)	12	4(33%)

*Test 2 was 1 to 4 years ($\bar{X}$ = 2.9 yr.) after Test 1
[+]Subjects without definite or suspected coronary artery disease
[++]Subjects with definite or suspected coronary artery disease
[+++]Subjects who demonstrated ventricular premature complexes at rest on a new finding on Test 2 were included

after 45 minutes of rest between tests. Eight subjects had cardiac disease, while 5 were apparently free of disease. All subjects were free of arrhythmias at rest. A Bruce treadmill protocol with continuous ECG recording was utilized (Bruce et. al., 1971). Eleven of 13 subjects had some type of PVC on both exercise tests. These investigators found a "consistent decrease in the number and grade of severity of PVC's on the second test" (p. 894) as compared to the first. Since every subject had

at least one treadmill test before the study, this finding is of particular interest. An explanation given for the decrease was that there appeared to be lower rate pressure products on the second exercise test. It was concluded that "one cannot assess the effectiveness of an antiarrhythmic drug based solely on the decrease in the amount of severity of ventricular irritability between two successive exercise tests" (p. 895).

Ekblom et. al. (1979), as mentioned earlier, investigated reproducibility of ventricular ectopy in normal subjects. Reproducibility was determined in 38 male subjects; however, no age range was provided. Subjects who produced a premature ventricular beat during walking/jogging at an exercise class were continuously monitored on either a bicycle or arm ergometer. Subjects were exercised on the bicycle until a heart rate of 85% of age-estimated peak was exceeded or performed arm exercise until 70% of their estimated maximal heart rate for leg work was attained. Reproducibility of ventricular ectopy was 55% in individual subjects but increased when evaluating the percent of ventricular ectopy as a group from test one to test two. "The percent of tests in a group was almost identical on two tests for any heart rate or exercise condition" (p. 40). Only 22% of the subjects reproduced their exact number of premature ventricular beats on a retest. However, if more than 10 PVC's were found on the first test, a retest was positive in 80% of the men.

Sami et. al. (1979), as reported earlier, also observed reproducibility of ventricular premature beats in men 3 to 52 weeks after myocardial infarction. One hundred fifty-five men ($\bar{X}$ age = 53±8 yrs.) were

exercise-tested using the Naughton protocol. Continuous recording of the ECG from 3 minutes before exercise until 10 minutes into recovery was performed on all subjects. The results indicated that reproducibility was greatest at an intertest interval of 1 to 5 days. They also noted that frequency of premature ventricular complexes and heart rate at onset of the arrhythmia are more reproducible than categorical responses such as whether the arrhythmia was simple or complex in appearance.

Rozanski, Dimich, Steinfeld, and Kupersmith (1979) exercise-tested 19 children twice to evaluate arrhythmias and their reproducibility. Using the Bruce protocol, 9 boys and 10 girls aged 5 to 16 years ($\bar{X}$ = 11) with chronic idiopathic ventricular and supraventricular arrhythmias were tested twice 1 hour to 1 year apart ($\bar{X}$ = 3.1 months). The ECG was continuously recorded on paper before, during, and after exercise with recovery taking place in the supine position. As a group, performances were not statistically different between test 1 and test 2 regarding maximal heart rate achieved or total exercise time. Each child duplicated his/her arrhythmia on a second test. Many of the subjects' premature contractions disappeared at approximately the same heart rate on both tests. The authors concluded that "the effects of exercise on a variety of chronic ventricular and supraventricular arrhythmias could be rapidly assessed and, although the number of patients was not large, results were highly reproducible in all 19 children evaluated" (p. 955).

Summary of Reproducibility

Reproducibility of PCs: Normal Vs. CAD Subjects

Reported reproducibility of exercise-related arrhythmias varies from 14 (Fabian et. al., 1974) to 100 percent (Rozanski et. al., 1979), depending upon the subjects studied and the methods utilized to detect arrhythmias. Cardiac patients have demonstrated higher reproducibility than normal subjects (Faris et. al., 1974). Also, reproducibility seems to increase with age (Faris et. al., 1974). There does not appear to be any set time interval that is optimal in terms of maximizing reproducibility, although a very short time period (less than one hour) appears to significantly increase reproducibility (Shepa et. al., 1977). Continuous recording must be employed in order to properly assess reproducibility.

Reproducibility in Subjects ≤25 years

There was only one study reviewed whose subjects were under the age of 25. Both the studies performed by Gooch and McConnell (1970) and Ekblom et. al. (1979) were unclear as to their subjects' ages who were evaluated to determine reproducibility. Therefore, it is impossible in these two studies to establish what trends occurred in the under-25 age group. Rozanski et. al. (1979) consequently appears to be the only study whose subjects were younger ($\bar{X}$ = 11 yrs.). Rozanski's subjects all were evaluated because of already diagnosed idiopathic ventricular or supraventricular arrhythmias and he found 100% reproducibility.

In the 16 to 22 age group utilized for this study no appreciable evidence exists pertaining to reproducibility of premature contractions.

Chapter III

Methods

The description of procedures utilized in conducting this study is divided into four sections: (1) Subjects, (2) Testing Protocol, (3) ECG Analysis, and (4) Statistical Analysis.

Subjects

This study was conducted at Oral Roberts University (ORU) primarily during the fall semester of the 1978-1979 academic school year. Three hundred eighty-six subjects (203 females, 183 males) were randomly selected from those freshmen and seniors at ORU who met the following criteria: (a) age 16 to 22, (b) Caucasian, (c) U.S. resident. All were professed non-smokers, non-drinkers of alcoholic beverages, and non-users of illicit drugs. All subjects were asked not to consume coffee, tea, soft drink or food within 2 hours of their treadmill test. The purpose in selecting only Caucasian U.S. residents was to avoid any confounding of results due to population specificity; also, relatively few non-Caucasian or foreign residents were available for study. Of the 386 subjects selected, 215 (56%) actually participated in the study and provided data sufficient for inclusion. Age and physical characteristics are shown in Table 4.

Each subject was medically screened and approved by the university student health service for exercise with no limitations. All subjects were considered to be "healthy" and free of any known cardiovascular disease.

TABLE 4

Age, Height and Weight of Subjects ($\bar{X}$ ± SD)

	Age	Height	Weight
Males (N=106)	19.3 ± 1.8yr.	179.3 ± 6.8cm.	72.7 ± 8.9kg.
Females (N=109)	19.3 ± 1.6yr.	166.8 ± 6.7cm.	59.6 ± 8.4kg.

Testing Protocol

Each subject underwent a treadmill test using the Bruce protocol (Bruce, 1971) with continuous recording of the exercise and recovery ECG (lead V_5). Treadmills were calibrated for each elevation before testing and speed was calibrated during each test. A 7-lead Hewlett Packard 1500 B ECG machine was used for monitoring along with a Hewlett Packard 7803 B single-channel scope. Prior to exercise and after at least 30 seconds of quiet standing, a rhythm strip was recorded for approximately 12 seconds with the subject standing. A second rhythm strip was recorded after approximately 30 seconds of hyperventilation. Most subjects' heart rates returned to within 10 beats/min. of prehyperventilation level by the beginning of the treadmill test. Each subject then exercised to a voluntary maximum effort; if this could not be achieved, the data were not used in the study. Immediately upon cessation of exercise, test duration was noted and the subject assumed a supine position for recovery. Heart rate was measured each minute during exercise, at test termination, and at the 1st, 3rd, and 5th minute of recovery using a standard ECG ruler. Blood pressure was measured during the

third minute of each stage as long as the subject was walking and at the 1st, 3rd, and 5th minute in recovery. The treadmill test protocol for this study was complete after 5 minutes of recovery.

ECG Analysis

Each ECG was reviewed by an American College of Sports Medicine Certified Preventive/Rehabilitative Exercise Test Technologist and all premature beats were noted and identified. Premature contractions were identified as either ventricular or supraventricular in origin. Criteria used for identification of a PAC were: (1) premature in appearance, (2) P wave which differed from sinus node initiated contraction, (3) QRS pattern consistent with sinus node initiated contraction, (4) compensatory pause when next conducted beat is originated at the sinus node. Criteria used for identification of a PVC were: (1) premature in appearance, (2) no existing P wave, (3) QRS width being $\geq$.12 seconds, (4) compensatory pause when next conducted contraction is initiated by the sinus node. Premature contractions were also characterized according to the number of premature contractions observed during exercise and recovery (1-5, 6-10, 11 or more). Lastly, premature contractions were divided into 3 categories: (1) early exercise, defined as $\leq$90% of maximal attained heart rate, (2) peak exercise, defined as >90% of maximal attained heart rate, and (3) recovery. In instances where there was question as to identification of an arrhythmia, a cardiologist was consulted. The cardiologist also reviewed each test in which signs, symptoms or ECG changes were noted during exercise or recovery. Those subjects (N = 52) who displayed premature beats during the treadmill test

were asked to return for another treadmill test. Forty-four subjects (85%) returned for a second test. The mean time interval between test 1 and test 2 was 39 days (range = 6-119 days). Twenty of the subjects (45%) were retested within 30 days. Subjects exhibiting minor sinus arrhythmias during exercise were not noted in the results section. It was felt that these arrhythmias were probably due to changes in rate of respiration and/or nervousness.

Statistical Analysis

The statistical treatment of the data included the means ($\bar{X}$) and standard deviations (SD) of all pertinent variables. The independent T test was used to determine statistical differences between groups.

Chapter IV

The results and discussion sections will each be presented in 2 parts: (1) prevalence and (2) reproducibility of exercise-related premature contractions.

Results

Prevalence

Of the total of 217 subjects, 31 of 106 males (29%) and 21 of 109 (19%) females had some type of premature contraction during the exercise test. There were 3 subjects who had arrhythmias other than premature beats: two had Wenkebach Phenomenon in recovery and one had an escape beat during early exercise. Two subjects displayed short runs of paroxysmal atrial tachycardia which ended after 5 successive ectopic atrial beats. Serious arrhythmias such as ventricular tachycardia or pairs of premature ventricular contractions did not occur during exercise or recovery in any subjects (Table 5). As can be seen in Table 5, most of the premature beats observed were of a total number of 5 or less for both males and females. Only 9 males (29%) and 2 females (9%) displayed more than 5 premature beats during the entire exercise test. Premature contractions were scattered throughout early exercise, peak exercise and recovery. There did not appear to be any trends in terms of type of premature beats exhibited except that female subjects produced more premature atrial contractions than premature ventricular contractions.

TABLE 5

Prevalence of Premature Contractions with Exercise

Total Number of Premature Contractions	Number of Subjects with the Indicated Arrhythmia															
	Early Exercise*				Peak Exercise**				Recovery				During Exercise or Recovery			
	PAC only	PVC only	Both	Any Arr.	PAC only	PVC only	Both	Any Arr.	PAC only	PVC only	Both	Any Arr.	PAC only	PVC only	Both	Any Arr.
Males (n=31)																
1-5	2	8	0	10	4	4	0	8	5	3	1	9	7	11	4	22
6-10	0	1	0	1	1	0	0	1	1	2	0	3	2	2	0	4
11 or more	3	0	0	3	2	0	0	2	4	1	0	5	4	0	1	5
Females (n=21)																
1-5	4	0	0	4	2	6	0	8	10	1	0	11	12	5	2	19
6-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 or more	1	1	0	2	0	1	0	1	1	1	0	2	1	1	0	2

*Early exercise is ≤90% of maximal attained heart rate.
**Peak exercise is>90% of maximal attained heart rate.

The 2 females that had 11 or more premature beats had 22 premature atrial beats and 78 ventricular contractions respectively, occurring throughout the protocol. The premature ventricular contractions were unifocal in appearance and there were only 2 pairs of premature atrial beats demonstrated. The 5 men with 11 or more premature beats during the test averaged 54 premature beats (range 15-114), 14 of which were ventricular. There were no couplets of premature contractions and the premature ventricular contractions appeared to be unifocal.

The females with premature beats did not differ significantly from the females without premature beats in terms of height, weight, total treadmill time or peak heart rate attained (Table 6). The males with premature beats did not differ significantly from the males without premature beats in terms of height and weight, but the groups differed in terms of total treadmill time and peak heart rate. Males with premature beats exercised longer on the treadmill (14:55 vs. 13:55, $p \leq .01$), yet their peak heart rates were lower than their male counterparts without premature contractions. Thus, as a group, the males who demonstrated premature beats with exercise were at a higher cardiorespiratory fitness level than those with no premature beats. However, the latter group was hardly "unfit"; a mean treadmill time of 13:55 (13.5 METS) is considered average for persons of that age. It is possible that just the increased amount of time that the subjects with arrhythmias were under monitoring accounted for the increase in premature contractions.

TABLE 6

Comparison of Subjects with and without Arrhythmias on Selected Parameters

Males	With Premature Contractions N=31	Without Premature Contractions N=75
	$\bar{X}$ ± SD	$\bar{X}$ ± SD
Height	179 ± 7cm.	179 ± 7cm.
Weight	70 ± 8kg.	73 ± 9kg.
Total Treadmill Time	14:55 ± 1:30*	13:55 ± 1:30*
Peak Heart Rate	192 ± 7	194 ± 8
Females	**With Premature Contractions N=21**	**Without Premature Contractions N=88**
	$\bar{X}$ ± SD	$\bar{X}$ ± SD
Height	167 ± 7cm.	167 ± 7cm.
Weight	62 ± 9kg.	59 ± 8kg.
Total Treadmill Time	10:45 ± 1:20	10:45 ± 1:05
Peak Heart Rate	188 ± 9	189 ± 8

*$p \leq .01$.

Reproducibility

Of the 52 subjects with premature contractions on their first test, 25 males (86%) and 19 females (91%) returned for a retest. All subjects were retested between 6-119 days ($\bar{X}$ = 39 days). Of those retested 18 males (72%) and 7 females (37%) who had at least one premature contraction on test one displayed at least 1 premature contraction

on test two (Table 7). Reproducibility was generally not precise in regard to frequency from test 1 to test 2. However, every subject who had 6 or more premature contractions on test 1 displayed at least 1 premature contraction on test 2, although not necessarily at the same point of the test protocol. Premature contractions on test 2 were generally

TABLE 7

Reproducibility of Premature Contractions

Using Selected Parameters

	Males		Females	
	T_1	T_2	T_1	T_2
I. Any Premature Contraction	25	18(72%)	19	7(37%)
A. ≤90% of Peak H.R.	14	5	11	3
1. 1-5 Premature Beats	10	1	10	2
2. 6-10 Premature Beats	3	0	0	0
3. 11 or More Premature Beats	1	0	1	0
B. >90% of Peak H.R.	6	5	5	1
1. 1-5 Premature Beats	5	2	5	0
2. 6-10 Premature Beats	1	0	0	0
3. 11 or More Premature Beats	0	0	0	0
C. Both ≤90% and >90% of Peak H.R.	5	2	3	1
1. 1-5 Premature Beats	2	0	2	0
2. 6-10 Premature Beats	0	0	0	0
3. 11 or More Premature Beats	3	1	1	1
II. Supraventricular Only	12	7(58%)	12	4(33%)
A. ≤90% of Peak H.R.	5	3	10	3
1. 1-5 Premature Beats	4	1	9	2
2. 6-10 Premature Beats	1	0	0	0
3. 11 or More Premature Beats	0	0	1	0
B. >90% of Peak H.R.	3	2	1	1
1. 1-5 Premature Beats	2	1	1	0
2. 6-10 Premature Beats	1	0	0	0
3. 11 or More Premature Beats	0	0	0	0
C. Both ≤90% and >90% Peak H.R.	4	2	1	0
1. 1-5 Premature Beats	1	0	1	0
2. 6-10 Premature Beats	0	0	0	0
3. 11 or More Premature Beats	3	1	0	0

III. Ventricular Only	10	5(50%)	6	1(17%)
A. ≤90% of Peak H.R.	6	2	1	0
1. 1-5 Premature Beats	4	0	1	0
2. 6-10 Premature Beats	2	0	0	0
3. 11 or More Premature Beats	0	0	0	0
B. >90% of Peak H.R.	3	3	4	0
1. 1-5 Premature Beats	3	1	4	0
2. 6-10 Premature Beats	0	0	0	0
3. 11 or More Premature Beats	0	0	0	0
C. Both ≤90% and >90% of Peak H.R.	1	0	1	1
1. 1-5 Premature Beats	1	0	0	0
2. 6-10 Premature Beats	0	0	0	0
3. 11 or More Premature Beats	0	0	1	1
IV. Supraventricular and Ventricular	3	0	1	0
A. ≤90% of Peak H.R.	2	0	0	0
1. 1-5 Premature Beats	2	0	0	0
2. 6-10 Premature Beats	0	0	0	0
3. 11 or More Premature Beats	0	0	0	0
B. >90% of Peak H.R.	0	0	0	0
1. 1-5 Premature Beats	0	0	0	0
2. 6-10 Premature Beats	0	0	0	0
3. 11 or More Premature Beats	0	0	0	0
C. Both ≤90% and >90% of Peak H.R.	1	0	1	0
1. 1-5 Premature Beats	0	0	1	0
2. 6-10 Premature Beats	0	0	0	0
3. 11 or More Premature Beats	1	0	0	0

of the same origin and often occurred at similar exercise intensities on both tests. As can be seen in Table 7, the more specific the categories as to heart rate and type of premature contraction, the less the rate of reproducibility. Reproducibility was defined as anyone demonstrating at least one premature contraction on both the first and second exercise test.

Table 4 compares subjects with and without reproducible arrhythmias to examine if certain parameters distinguish between these groups (Table 8). The only difference that is statistically significant is that females who did not have reproducible arrhythmias exercised longer

TABLE 8

Comparison of Subjects with and without

Reproducible[+] Arrhythmias on Selected Parameters

	Males		Females	
	With Reproducible Arr. (n=10) $\bar{X}$ ± SD	Without Reproducible Arr. (n=7) $\bar{X}$ ± SD	With Reproducible Arr. (n=7) $\bar{X}$ ± SD	Without Reproducible Arr. (n=12) $\bar{X}$ ± SD
Height (cm)*	179 ± 7	178 ± 7	172 ± 7	164 ± 6
Weight (kg)*	71 ± 9	68 ± 5	68 ± 10	57 ± 4
Treadmill Time:				
Test 1	15:05 ± 1:45	14:30 ± 1:10	10:05 ± 0:40	11:05 ± 1:25**
Test 2	15:05 ± 2:00	14:20 ± 1:15	10:30 ± 0:50	11:10 ± 1:30
Met Capacity (Estimated):				
Test 1	15.5	15.0	10.0	11.0
Test 2	15.5	15.0	10.5	11.0
Peak H.R.				
Test 1	191 ± 8	191 ± 3	186 ± 11	187 ± 8
Test 2	192 ± 9	190 ± 6	187 ± 10	190 ± 9

*Height and weight only taken at test 1

**$p \leq .05$

[+]Reproducible arrhythmias will be defined as anyone demonstrating at least one premature contraction on both the first and second exercise test.

on the treadmill during test 1 ($p \leq .05$) than did females who had reproducible arrhythmias. Since treadmill times were not statistically different on test 2 the importance of this is questionable. Using the parameters of height, weight, treadmill time, and peak heart rate, no trends are evident in order to differentiate subjects with and without reproducing arrhythmias.

Discussion

Prevalence

Overall prevalence of 29% for males and 19% for females is comparable to other related studies. Anderson et. al. (1972) found lower prevalence of premature contractions (19%); however, there was no continuous monitoring of the ECG, data on males and females were combined, and the study population was considerably older in age. McHenry et. al. (1972), using continuous monitoring, studied a population of 25 - 34-year-old normal men with 29% having PVC's and 6% with PAC's during exercise only. In a follow-up study using the same population, the prevalence of PVC's was evaluated in 25 - 34-year-old men in two exercise tests 1 to 4 years apart (Faris et. al., 1976). Prevalence was 30% and 36%, respectively, when using continuous monitoring. Froelicher et. al. (1974), using continuous monitoring, studied 1,390 male subjects with a wide range of ages (20 - 54 yrs.). The prevalence of PVC's induced by exercise testing alone was 35%. The control population studied by James et. al. (1976) was somewhat similar in age to this present study's population in terms of the age of the subjects. The control population consisted of 109 healthy subjects, 68 females and 41 males (ages 5 - 42 yrs.), who were not continuously monitored during exercise on the ECG. No premature contraction of any type was observed, which is in contrast to what would be expected in light of the previous studies. Non-continuous monitoring may be the explanation for this discrepancy.

Reproducibility

In this population 18 males (72%) demonstrated at least one premature contraction on both the first and second exercise test as compared to 7 females (37%). This result is interesting in light of several other studies. Gooch and McConnell (1970) studied a subgroup of patients who were part of a larger group of 713 subjects (509 males, 204 females) whose ages ranged from 17 to 82 years. Subjects were cardiac patients or suspected cardiac patients who were continuously monitored on lead V_5. Reproducibility was not defined specifically in this study; however, it was stated that 4 of 24 subjects (17%) had reproducible arrhythmias.

Ekblom et. al. (1979) studied 38 healthy male subjects whose ages were not given. Subjects who produced a PVC while walking/jogging in an exercise class were continuously monitored on either a bicycle or arm ergometer to determine if the arrhythmia was reproducible. While subjects were not maximally tested, PVC's appeared during exercise testing in 55% of those subjects who demonstrated PVC's while walking/jogging.

Faris et al. (1976) utilized 543 subjects, (25 - 58 yrs.), 81 of which had definite or suspected coronary artery disease. Continuous monitoring was used to determine reproducibility of arrhythmias, with reproducibility not specifically defined. The investigators found 55% reproducibility in males 25 to 35 years of age and generally found that as age increased, so did reproducibility.

Sheps et. al. (1977) twice exercise-tested 13 subjects (11 males, 2 females) with a mean age of 52 years. Eight subjects had cardiac

disease while 5 did not. Subjects were retested after only 45 minutes of rest. Continuous monitoring was used during the testing. Eleven of 13 subjects (85%) had some type of PVC on both tests. A consistent decrease in number and severity of PVC's on the second test was also noted.

Since the previous studies are quite different in their methodologies and population characteristics, a close comparison between this study and others is difficult. However, in general, it can be said that males in this study displayed premature contractions during test 1 and test 2 at a higher rate (72%) than would be expected for their age and health status. This result in a healthy population should lessen the importance of infrequent premature contractions even if they are reproducible.

The finding that individuals with six or more premature contractions during exercise are much more likely to demonstrate premature contractions during a second exercise bout is of interest. Should this result be verified in subsequent studies, it will allow the physician who desires to treat a serious arrhythmia the opportunity to assess the efficacy of the treatment through repeat exercise testing.

The data for females cannot be compared to other studies because of the lack of data relative to this population. The difference in the reproducibility percentage between males and females cannot be explained. Perhaps future study will offer an answer to this discrepancy.

Chapter V

Conclusions

The purpose of this study was to investigate the prevalence and reproducibility of ECG-documented premature contractions with exercise in an apparently healthy college age population. Prevalence of premature contractions was determined by randomly selecting freshmen and senior male and female students at Oral Roberts University to undergo Bruce protocol treadmill tests. The reproducibility of premature contractions was determined by having those students who exhibited premature contractions on the initial treadmill test return for a subsequent treadmill test.

The following are conclusions based upon the results of this study.

1. Occasional premature contractions are fairly common during exercise in clinically healthy young adults.

2. Prevalence and reproducibility of exercise premature contractions are higher in males than in females.

3. Reproducibility of premature contractions diminishes as one examines specific frequencies of premature contractions.

4. Individuals with six or more premature contractions during exercise are much more likely to demonstrate premature contractions during a subsequent exercise bout.

5. No relationship was found between time of occurrence of premature contraction and specific heart rate or met level.

Recommendations

The following recommendations are given as a guide for further research.

1. Additional subjects need to be evaluated in this same age group in order to verify the results given.

2. A follow-up study should be performed in order to determine whether prevalence or reproducibility changes over time.

3. In addition, the subjects from this study should be followed to determine if those subjects with arrhythmias have an increased likelihood of developing more serious arrhythmias with increasing age.

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APPENDIX

APPENDIX A

APPENDIX A

Bruce Protocol

Time	Stage	Speed	Grade	Mets	
				Male	Female
0- 3min	I	1.7	10	2- 5	1- 4
4- 6	II	2.5	12	5- 8	4- 7
7- 9	III	3.4	14	8-10	7-10
10-12	IV	4.2	16	10-13	10-13
13-15	V	5.0	18	13-16	13-15

APPENDIX B

APPENDIX B

Standard Exercise for the Master's Test

Standard Number of Ascents for Men

Weight	Age in Years												
(lb)	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
40- 49	34	36											
50- 59	33	35	32										
60- 69	31	33	31										
70- 79	28	32	30										
80- 89	26	30	29	29	29	28	27	27	26	25	25	24	23
90- 99	24	29	28	28	28	27	27	26	25	25	24	23	22
100-109	22	27	27	28	28	27	26	25	25	24	23	22	22
110-119	20	26	26	27	27	26	25	25	24	23	23	22	21
120-129	18	24	25	26	27	26	25	24	23	23	22	21	20
130-139	16	23	24	25	26	25	24	23	23	22	21	20	20
140-149		21	23	24	25	24	24	23	22	21	20	20	19
150-159		20	22	24	25	24	23	22	21	20	20	19	18
160-169		18	21	23	24	23	22	22	21	20	19	18	18
170-179			20	22	23	23	22	21	20	19	18	18	17
180-189			19	21	23	22	21	20	19	19	18	17	16
190-199			18	20	22	21	21	20	19	18	17	16	15
200-209				19	21	21	20	19	18	17	16	16	15
210-219				18	21	20	19	18	17	17	16	15	14
220-229				17	20	20	19	18	17	16	15	14	13

(Ellestad, 1975 p. 285)

APPENDIX C

APPENDIX C

Naughton Protocol

Stage	Duration (min)	Speed (mph & m/min)	Grade	Mets
I	2	1.0 26.8	0	1.77
II	2	2.0 53.6	0	2.53
III	2	2.0 53.6	3.5	3.50
IV	2	2.0 53.6	7.0	4.46
V	2	2.0 53.6	10.5	5.43
VI	2	2.0 53.6	14.0	6.39
VII	2	2.0 53.6	17.5	7.36
Recovery	2	1.0 26.8	0	1.77
	2	1.0 26.8	0	1.77
	2	1.0 26.8	0	1.77
	Sitting			