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THE R VALUE AT VO2 MAX DURING MAXIMAL GRADED EXERCISE TREADMILL TESTS OF CORONARY ARTERY DISEASED AND NONDISEASED SUBJECTS

by

Sherry S. Williams

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
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Department of Health, Physical Education
and Recreation

Western Michigan University
Kalamazoo, Michigan
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THE R VALUE AT VO2 MAX DURING MAXIMAL GRADED EXERCISE TREADMILL TESTS OF CORONARY ARTERY DISEASED AND NONDISEASED SUBJECTS

Sherry S. Williams, M.A.

Western Michigan University, 1992

This study examined the R value at VO2 max during maximal graded treadmill exercise tests to determine if it was a reliable indicator of VO2 max and could therefore be used as a test termination criterion. The subjects in this study were 160 coronary artery diseased (CAD) patients and 170 nondiseased individuals. Data were collected from existing stress test records. The R value was also analyzed to determine if proportions of diseased and nondiseased subjects were the same. The time it took 100 CAD patients to reach VO2 max and exhaustion once R rose above 1.00 was also examined.

The findings from this study indicated that (a) the R value was not a reliable predictor of VO2 max between the values of 1.10 and 1.20, (b) the R values of the diseased and nondiseased populations were comparable, and (c) the mean additional time spent on the treadmill past VO2 max was not practically significant.

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Sherry S. Williams

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TABLE OF CONTENTS

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Table of Contents--Continued

CHAPTER

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Table of Contents--Continued

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Table of Contents--Continued

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LIST OF TABLES

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LIST OF FIGURES

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CHAPTER I

INTRODUCTION

Maximal stress testing has been used for years to assess a person's maximal oxygen consumption (VO2 max). Two populations frequently tested for VO2 max are patients who have coronary artery disease (CAD) and nondiseased individuals who wish to begin a new, rigorous exercise program.

A common time for a maximal stress test in the cardiac patient's life is just prior to participating in a structured, hospital-based, Phase II cardiac rehabilitation program. This test usually takes place 4 to 6 weeks after myocardial infarction (MI), coronary artery bypass surgery (CABG), or percutaneous transluminal coronary angioplasty (PTCA). Likewise, nondiseased subjects frequently undergo a maximal stress test prior to beginning a structured exercise program.

A wide range of guidelines for administering maximal graded exercise tests (GXT) is available. The most widely recognized of these are the guidelines set by the American College of Sports Medicine (ACSM). Within these guidelines are criteria for terminating a maximal GXT (American College, 1991). One physiological parameter,

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the respiratory exchange ratio (R), has not typically been considered a termination criterion.

The R value has been indirectly studied in the past. The results of R at the end of a maximal GXT have been reported in various studies. However, a study that focuses on the R value alone as an indicator of VO2 max and test termination has not been reported in the literature.

Statement of the Problem

The major problem in this study was to determine if the R value during a maximal GXT could be an indicator of VO2 max and a criterion for test termination. In order to determine this, retrospective data from cardiac rehabilitation patients and nondiseased subjects during maximal GXTs were analyzed. The second problem in this study was to compare the R values of CAD patients to nondiseased individuals to determine if proportions of subjects from each population were similar. It was also a subproblem of this study to report and discuss the time to VO2 max and the time to exhaustion once the R value rose above 1.00 in 100 cardiac rehabilitation patients.

Significance

Generally during a maximal GXT, VO2 max peaks and begins to drop before the patient or exercise physiologist ends the test. The time from VO2 max to test

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termination varies from person to person. In the case of CAD patients, especially Phase II entry cardiac rehabilitation patients who have just had an MI, CABG, or PTCA 4 to 6 weeks prior to testing, the additional stress as a result of the time beyond VO2 max could be dangerous. Overstressing these patients at this time could possibly precipitate another cardiac event. If the R value can be a reliable indicator of VO2 max, this extra stress could be avoided.

Although many studies have reported the R values at the end of a maximal GXT, none have looked specifically at the R value as an indicator of VO2 max. It is the intent of this study to determine if the R value can be a reliable indicator of VO2 max.

Also included in this study is a graphical display and discussion of the mean time to VO2 max and the mean time to exhaustion once the R value of 100 cardiac rehabilitation patients exceeded 1.00. This additional information would be useful to those health professionals who perform stress tests regularly. These times will aid the exercise physiologist in determining when the CAD patient has achieved a maximal effort.

Delimitations

This study was delimited to the following characteristics:

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1. All data were collected from existing stress test data on file.

2. Participants were chosen from cardiac patients at St. Joseph Mercy Hospital, Pontiac, Michigan and non-diseased subjects from The Cardiovascular Institute at Borgess Medical Center, Kalamazoo, Michigan.

3. All participants were between the ages of 21 and 79 years.

4. All tests were maximal GXTs on a treadmill.

Limitations

This investigation was limited to the following:

1. Data were collected only from subjects at Borgess Medical Center, Kalamazoo, Michigan and St. Joseph Mercy Hospital, Pontiac, Michigan. These people may not be representative of the population of nondiseased people and the population of CAD subjects.

2. Only data from maximal tests on a treadmill were used. These data may not be representative of maximal tests performed on other modes of exercise.

Assumptions

This study was conducted under the following assumptions:

1. The R value can accurately be measured by open-circuit spirometry.

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2. Each subject gave a maximal effort.

3. Medications did not affect the R value or VO2 max.

4. Each subject understood and followed directions.

5. A maximal GXT was a reliable and accurate method of measuring VO2 max.

6. All oxygen analyzing equipment was calibrated acurately.

7. Instrumentation error was minimal and random.

Hypotheses

This study was conducted to test the following hypotheses:

1. A majority of the R values of cardiac rehabilitation patients and a majority of the R values of nondiseased subjects associated with VO2 max are between or equal to 1.10 and 1.20 during a maximal graded treadmill exercise test.

2. There was no significant difference between the proportion of diseased subjects and the proportion of nondiseased subjects whose R values at VO2 max are in the range of 1.10 to 1.20.

Definitions

The following terms and their definitions are impor-

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tant to the understanding of this study:

1. Coronary Artery Bypass Graft (CABG): A surgical procedure designed to increase blood flow and oxygen delivery to ischemic cardiac tissue by bypassing the critically obstructed coronary artery with a vein from the patient's leg or the internal mammary artery (Franklin, Hollingsworth, & Borysyk, 1988).

2. Maximal Graded Treadmill Exercise Test (GXT): An exercise test using the treadmill as the mode of exercise that increases the workload every 2 to 3 min until the patient reaches his or her maximal oxygen consumption (American College, 1991).

3. Maximal Oxygen Consumption (VO2 max): The maximal rate at which oxygen can be consumed per minute; the power or capacity of the aerobic or oxygen system (Pate & Lonnett, 1988).

4. Myocardial Infarction (MI): An area of cardiac muscle tissue that dies after the cessation of blood supply through one of the coronary arteries (Pate & Lonnett, 1988).

5. Percutaneous Transluminal Coronary Angioplasty (PTCA): A surgical procedure designed to increase the lumen size of and blood flow through a partially blocked coronary artery by inserting a balloon catheter into the artery, inflating the balloon, and compressing the plaque (Franklin et al., 1988).

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6. Phase II Cardiac Rehabilitation: Exercise and lifestyle modification program administered to post-CABG, post-PTCA, and post-MI patients on an outpatient basis. ECG monitoring, emergency support, and direct professional supervision are available (American College, 1991).

7. R Category (RCAT): The subjects in this study were divided into R categories based on their R values at VO2 max. RCAT 1 represents those subjects with an R value at VO2 max less than 1.10. RCAT 2 represents those subjects with an R value at VO2 max between or equal to 1.10 and 1.20. RCAT 3 represents those subjects with an R value at VO2 max greater than 1.20.

8. Respiratory Exchange Ratio (R): The ratio of the amount of carbon dioxide (CO_2) produced by the body to the amount of oxygen (O_2) consumed by the body (VCO_2/VO_2). R is measured during exercise by the collection of expired gases using open-circuit spirometry (Pate & Lonnett, 1988).

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CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

It is a widely accepted practice in the field of cardiac rehabilitation to stress test a patient before he or she enters a Phase II cardiac rehabilitation program. It is also accepted in the field of adult fitness to either maximally or submaximally stress test a person before he or she begins a structured exercise program. Only those people given a maximal stress test are of interest in this study. The purpose of a maximal GXT is to determine VO2 max prior to engaging in a structured exercise program. VO2 max is used to write the patient's exercise prescription and also to serve as a baseline from which to improve (Wilson, 1988). VO2 max can be predicted or directly measured from a GXT. Direct measurement of VO2 max involves the collection of expired gases while the GXT is in progress.

Many physiological parameters can be determined from the collection of expired gases. For example, respiratory rate, ventilation, and oxygen consumption can all be obtained from expired gases. In particular, the respiratory exchange ratio (R) can also be obtained. R is the

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ratio of the amount of CO_2 produced by the body to the amount of O_2 consumed by the body (VCO_2/VO_2). It is the purpose of this study to examine the R value at the point of VO_2 max during maximal Phase II entry cardiac rehabilitation GXTs and maximal GXTs on nondiseased subjects to determine if there is a range of R values that indicate VO_2 max and therefore could be used as a criterion for test termination in order to avoid overstressing the subjects. In addition, 100 cardiac rehabilitation patients' mean times to VO_2 max and mean times to exhaustion once the R value exceeds 1.00 will be graphically displayed and discussed.

Respiratory Exchange Ratio

Respiratory Exchange Ratio and Respiratory Quotient

The respiratory quotient (RQ) is a measurement of expired gases that can predict the type of substrate being used for fuel during exercise. Skeletal muscle has the ability to transform chemical energy of foods into mechanical energy of muscular contraction and work. Mechanical energy, or ATP, may be generated from carbohydrate (CHO), fat, or protein. However, protein is not considered to be a significant substrate for ATP during exercise. As a result, the contribution of only CHO and fat as fuels for exercise can be determined by the col-

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lection of expired gases and is termed the nonprotein respiratory quotient (nonprotein RQ) (Whipp, 1986). When CHO is the only fuel used through the aerobic pathways, the RQ is 1.00. This is so because CHO contains hydrogen and oxygen in proper proportions to form water within the molecule. As a result, all of the oxygen consumed can be used in the oxidation of carbon. Therefore, with pure CHO, R is equal to 1.00. Similarly, when fat is the only fuel used through the aerobic pathways, the RQ has a value of 0.70. This is true because when fat is oxidized some of the oxygen combines with carbon to form carbon dioxide, but, some of the oxygen combines with hydrogen to make water. Therefore, it is expected that R will be less than 1.00.

Utilization of fat and CHO varies with the exercise intensity. During submaximal exercise, a mixture of CHO and fats is used, but as the exercise period becomes longer, the percentage of fat used gradually increases. As exercise intensity increases, as it does in a GXT, nonprotein RQ also increases to demonstrate the shift of reliance on fat for fuel to the reliance on CHO for fuel. Therefore, the RQ reaches a value close to 1.00, or it can exceed 1.00 during heavy nonsteady state exercise, such as during a maximal GXT.

RQ indicates metabolism at the cellular level. Metabolism can also be measured at the lungs, in which case

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it is termed the respiratory exchange ratio (R). The calculations for both are the same (VCO_2/VO_2) (American College, 1991). In this paper, R will be used when referring to VCO_2/VO_2. The R value as it predicts the various fuels used during exercise is not of interest in this study. The focus of this paper is on the R value during heavy nonsteady state or maximal exercise.

Conditions Under Which R is Greater Than 1.00

For the most part, the R value during exercise is between 0.70 and 1.00. However, there are conditions under which the R value exceeds 1.00. Voluntary or involuntary hyperventilation results in excessive carbon dioxide loss, which pushes the R value above 1.00. The first few minutes of submaximal aerobic exercise can cause the person to exhale excess CO_2, resulting in an R value above 1.00. Most important for this study, is that during exhaustive exercise of short duration R will exceed 1.00 as a result of the buffering of lactic acid causing excessive CO_2 to be released ("Measurement of energy," 1989).

Respiratory Exchange Ratio Values at VO_2 max

The R value at VO_2 max has been indirectly examined, and the results have been published in various studies. For example, several authors agreed that during nonsteady

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state maximal exercise the R value rises above 1.00 (American College, 1991; Heinert, Serfass, & Stull, 1988; Mahon & Vaccaro, 1989; McMiken & Daniels, 1976; "Measurement of energy," 1989; Powers & Howley, 1990; Zavala, 1985).

In a study investigating the VO2 max and ventilatory threshold of 16 active male children between the ages of 10 and 14 years, the R values at VO2 max ranged from 1.10 to 1.20 on a pretest and ranged from 1.16 to 1.17 on a posttest (Mahon & Vaccaro, 1989). In another study involving 8 male collegiate runners, the R at VO2 max was found to be 1.112 $\pm$ 0.024 while running on a track and to be 1.150 $\pm$ 0.031 while running on a treadmill (McMiken & Daniels, 1976).

McMiken and Daniels, cited in Powers and Howley (1990), proposed that a VO2 max test is valid if the R value is greater than 1.15. Similarly, Heinert et al. (1988), used an R value of 1.15 as a criterion for termination of a GXT while conducting a study on 16 men to compare VO2 and stride length.

Finally, Zavala, in his 1985 book, Manual on exercise testing: A training handbook, stated:

> When R rises above 1.0 in progressive exercise, usually the subject must stop within 2-3 minutes because of increasing lactic acidosis; and when R crosses 1.1 the subject generally is within one minute of being unable to continue. R at VO2 max is 1.2 $\pm$ 0.12. (p. 43)

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To summarize, R values at VO2 max that have been indirectly studied range from 1.10 to 1.20.

Maximal Oxygen Consumption

Maximal oxygen consumption is the greatest amount of oxygen the working muscles can consume during exercise that uses large muscle groups (Powers & Howley, 1990). VO2 max is generally expressed in liters per minute (l/min) or milliliters per kilogram body weight per minute (ml/kg/min) (Pate & Lonnett, 1988). Maximal oxygen consumption can be directly measured by opencircuit spirometry during a maximal test, or it can be predicted from a maximal or submaximal test (American College, 1991). In order to obtain R values at VO2 max, direct measurement of oxygen consumption must be used.

During a maximal GXT, the subject reaches his or her VO2 max, but this value may drop before he or she voluntarily stops the test. The highest value for VO2, not the last value, is recorded as VO2 max.

Maximal Graded Treadmill Exercise Test

Exercise stress testing is widely used to assess a person's VO2 max prior to beginning an exercise program. These tests are used in both preventive and clinical settings (Lamont, 1981). In the clinical setting, stress tests are used for the purposes of diagnosis and exercise

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prescription. For a CAD patient entering a Phase II cardiac rehabilitation program, or a normal subject beginning a vigorous exercise program, a stress test is given to measure VO2 max in order to write an exercise prescription and to provide a baseline from which to improve.

A maximal treadmill test indicates that the person exercises to exhaustion on a treadmill. Each individual is different and can tolerate different intensities, therefore, certain protocols are used. Regardless of the protocol, the object of the maximal test is to stress the patient to the point of exhaustion. In order to do this, these protocols are graded. That is, the exercise physiologist increases the intensity of the work every 2 to 3 min by increasing the speed of the treadmill, increasing the grade of the treadmill, or both. This assures the exercise physiologist that the subject will want to stop within 12 to 20 min after the start of the GXT.

Phase II Cardiac Rehabilitation

Cardiac rehabilitation programs vary across the nation. Each one is different, but most of them have the same general components. Phase II takes place approximately 1 month after discharge from the hospital. Phase II is an outpatient program consisting of heart rate and rhythm monitoring by telemetry and lifestyle modification

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education (Cantwell, 1986). The patients come to the outpatient facility three times per week to exercise aerobically and attend lectures or individual educational sessions for lifestyle modification. Educational sessions focus on risk factor modification, anatomy and physiology of the heart, stress reduction, diet guidelines, smoking cessation, and exercise prescription (Papenfuss, 1985). It is extremely important to combine exercise and education to help the Phase II patient improve the quality and possibly the quantity of his or her life (Wilson, 1988). Group exercise is very helpful in motivating the patients to work hard and improve their fitness capacities.

The stress test prior to Phase II is a maximal stress test performed in a hospital or clinic (Papenfuss, 1985). This test is important for the following reasons: (a) to measure VO2 max, (b) to gather data so an exercise prescription can be written, (c) to provide a baseline from which to improve during Phase II, and (d) to provide motivation to keep improving after Phase II (Wilson, 1988).

Summary

The R value represents the VCO2 produced by the body divided by the VO2 consumed by the body during exercise. It is measured with open-circuit spirometry during a

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maximal GXT. R can rise above a value of 1.00 during short duration, exhaustive exercise due to the buffering of lactic acid producing excessive expired CO_2. The literature revealed that the R value at VO_2 max during various types of GXTs with various populations ranges from 1.10 to 1.20. The time to exhaustion has also been documented as 2-3 min once R exceeds 1.00, and 1 min once R rises above 1.10.

A study specific to the cardiac patient's R value at VO_2 max has not been done. It is important to look at this in Phase II entry patients to determine if the R value can be used as a criterion for test termination to avoid overstressing the patient. It is equally important to compare the R values at VO_2 max of nondiseased individuals and CAD patients to determine if differences between these two populations exist. It is also important to note the time to VO_2 max and the time to exhaustion once the R value rises above 1.00 so the exercise physiologist knows what to expect.

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CHAPTER III

METHODS AND PROCEDURES

One purpose of this study was to examine the R value at VO2 max to see if a majority of diseased subjects and a majority of nondiseased subjects fell into a specific range that can be utilized as a criterion for the termination of maximal GXTs. Another purpose of this study was to determine if there is a difference in the proportion of nondiseased subjects and CAD subjects whose R values at VO2 max were between or equal to 1.10 and 1.20. It was also the purpose of this study to graphically report data regarding the time to VO2 max and the time to exhaustion of 100 CAD patients once their R values exceeded 1.00. This chapter includes four sections: (1) human subjects approval, (2) subject selection, (3) data collection, and (4) statistical analysis.

Human Subjects Approval

Approval to conduct this study was required by Western Michigan University's Human Subjects Institutional Review Board (HSIRB) and St. Joseph Mercy Hospital's Institutional Review Board Research Committee. The Institute for Cardiovascular Health at Borgess Medical

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Center did not require any approval from a Review Board because all the subjects had already signed a waiver allowing their data to be used for research purposes. The appropriate forms were submitted by the principal investigator to the HSIRB and St. Joseph Mercy Hospital. After minimal changes and clarifications, both boards granted approval for this study (see Appendices A and B).

Subject Selection

The subjects in this study were people aged 21 to 79 years who had already undergone a maximal graded treadmill exercise test. The subjects were cardiac patients entering the Phase II cardiac rehabilitation program at St. Joseph Mercy Hospital in Pontiac, Michigan and nondiseased adults beginning an adult fitness program at The Institute for Cardiovascular Health at Borgess Medical Center in Kalamazoo, Michigan. The records at Borgess Medical Center were selected based on whether expired gases were directly collected during the GXT or not. Those charts without direct oxygen consumption were eliminated from the study. The records at St. Joseph Mercy Hospital were selected based on the collection of expired gases, age, and medical history. First, only patients having direct oxygen consumption were considered. Second, only patients who were 45 years of age or older were selected. Third, only Phase II cardiac

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rehabilitation entry patients with a medical history of a CABG, MI, or PTCA were considered. Data from these records remained anonymous, and the names of the individuals were never recorded.

Data Collection Procedures

All of the data were collected by the principal investigator. Data were obtained from existing charts at both institutions. The principal investigator was given access to the file cabinets containing the stress test records at each hospital and was allowed to examine the charts for desirable subjects. Data taken from the patient records included age, gender, category (CABG, MI, PTCA, multiple, or nondiseased), VO2 max, the R value at VO2 max, maximal heart rate, heart rate at VO2 max, medications, and the time to exhaustion once the R value rose above 1.00. In addition, data from 100 CAD patients' charts at St. Joseph Mercy Hospital were gathered to record the times to VO2 max once the R value rose above 1.00 and times from VO2 max to exhaustion (see Appendix C).

Statistical Analysis

For each population, the proportion of subjects whose R values were between or equal to 1.10 and 1.20 at VO2 max was statistically analyzed using the chi-square

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goodness-of-fit statistic (Ferguson, 1976). The difference between the proportion of nondiseased subjects in RCAT 2 and the proportion of CAD subjects in RCAT 2 was calculated using the test for the significance of the difference between two independent proportions (Ferguson, 1976). Mean times for reaching VO2 max and mean times to exhaustion for 100 CAD patients once their R values rose above 1.00 were described and graphically displayed. All other statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) programs, Descriptives and Crosstabs (SPSS, Inc., 1988).

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CHAPTER IV

RESULTS AND DISCUSSION

This chapter includes the results and discussion of the proportion of subjects in the diseased group and the proportion of subjects in the nondiseased group for whom the R value at VO2 max was between or equal to 1.10 and 1.20. Also included in this chapter is the discussion of the test results concerning whether there was a significant difference between those proportions. The last item included in this chapter is a discussion and a graphical display of the mean time for reaching VO2 max and the mean time to exhaustion for 100 CAD subjects once their R values rose above 1.00.

Procedures

Statistical analyses of the raw data were performed at Western Michigan University using the SPSS programs, Descriptives and Crosstabs (SPSS, Inc., 1988). The primary research hypothesis was statistically analyzed using the chi-square goodness-of-fit test (Ferguson, 1976). The significance of the difference between two independent proportions test (Ferguson, 1976) was used to determine if there was a significant difference in the propor-

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tions whose R values fell into the range 1.10 to 1.20 between the nondiseased and the diseased subjects.

The 330 subjects in this study were first divided based on their state of health by two levels, those subjects with known CAD and those subjects who were nondiseased. Within these groups the subjects were further subdivided by gender and by R categories (RCAT). RCAT 1 represents those subjects with an R value at VO2 max less than 1.10. RCAT 2 represents those subjects with an R value at VO2 max between or equal to 1.10 and 1.20. RCAT 3 represents those subjects with an R value at VO2 max greater than 1.20. These categories were established to allow the researcher to determine if a majority of the subjects in the CAD group and a majority of the subjects in the nondiseased group had R values at VO2 max between or equal to 1.10 and 1.20.

Within the diseased group, the subjects were also identified further based on their medical history into the following categories: (a) myocardial infarction (MI), (b) coronary artery bypass graft (CABG), (c) percutaneous transluminal coronary angioplasty (PTCA), and (d) multiple, those whose records indicated two or more of the preceding conditions.

In addition, data regarding the time to reach VO2 max once the R value rose above 1.00 and the time to reach exhaustion from VO2 max on a graded treadmill exer-

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cise test were gathered on 100 CAD subjects. These data were graphically displayed and discussed.

Results

Nondiseased

Data were gathered on 170 nondiseased subjects. Their ages ranged from 21 to 70 years with a mean age of 45 years. As a whole, this group had a mean R value of 1.077 with a standard deviation of 0.130. Crosstabs data for RCATs are shown in Table 1. The Crosstabs indicated the following:

1. RCAT 1 contained 58% (n = 99) of the nondiseased subjects.

2. RCAT 2 contained 27% (n = 46) of the nondiseased subjects.

3. RCAT 3 contained 15% (n = 25) of the nondiseased subjects.

Table 1

Descriptives for Nondiseased Subjects

	Age	R Value	RCAT 1	RCAT 2	RCAT 3
Males	M = 44.662 21-70 years	M = 1.085 s = 0.131	54% n = 72	30% n = 40	16% n = 21
Females	M = 44.568 22-62 years	M = 1.048 s = 0.127	73% n = 27	16% n = 6	11% n = 4

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Males

Of the 170 nondiseased subjects, 133 were male. Their ages ranged from 21 to 70 years with a mean age of 45 years. The mean R value for this group was 1.085 with a standard deviation of 0.131. Crosstabs data for RCATs are shown in Table 1. The Crosstabs indicated the following:

1. RCAT 1 contained 54% (n = 72) of the nondiseased males.

2. RCAT 2 contained 30% (n = 40) of the nondiseased males.

3. RCAT 3 contained 16% (n = 21) of the nondiseased males.

Females

Of the 170 nondiseased subjects, 37 were female. They had a mean age of 45 years with a range of 22 to 62 years. The mean R value for the females was 1.048 with a standard deviation of 0.127. Crosstabs data for RCATs are shown in Table 1. The Crosstabs indicated the following:

1. RCAT 1 contained 73% (n = 27) of the nondiseased females.

2. RCAT 2 contained 16% (n = 6) of the nondiseased females.

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3. RCAT 3 contained 11% (n = 4) of the nondiseased females.

Diseased

Data were gathered on 160 subjects with known CAD. Their ages ranged from 45 to 79 years with a mean age of 61 years. The mean R value for this group was 1.111 with a standard deviation of 0.170. Crosstabs data for RCATs are shown in Table 2. RCATs for subdivisions by disease are also included in Table 2. Crosstabs indicated the following:

1. RCAT 1 contained 52% (n = 84) of the diseased subjects.

2. RCAT 2 contained 24% (n = 39) of the diseased subjects.

3. RCAT 3 contained 23% (n = 37) of the diseased subjects.

Males

Of the 160 diseased subjects, 130 were male. Their ages ranged from 45 to 79 years with a mean age of 60 years. The mean R value for diseased males was 1.130 with a standard deviation of 0.172. Crosstabs data for RCATs are shown in Table 2. Crosstabs indicated the following:

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Table 2

Descriptives for Diseased Subjects

	Age	R Value	RCAT 1	RCAT 2	RCAT 3
Males	*M* = 60.062 45-79 years	*M* = 1.130 *s* = 0.172	48% *n* = 62	26% *n* = 34	26% *n* = 34
Females	*M* = 62.400 45-78 years	*M* = 1.031 *s* = 0.133	73% *n* = 22	17% *n* = 5	10% *n* = 3
MI			46% *n* = 12	27% *n* = 7	27% *n* = 7
PTCA			50% *n* = 6	33% *n* = 4	17% *n* = 2
CABG			60% *n* = 24	23% *n* = 9	17% *n* = 7
Multiple			51% *n* = 42	23% *n* = 19	26% *n* = 21

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1. RCAT 1 contained 48% (n = 62) of the diseased males.

2. RCAT 2 contained 26% (n = 34) of the diseased males.

3. RCAT 3 contained 26% (n = 34) of the diseased males.

Females

There were 30 females in the diseased group. Their ages ranged from 45 to 78 years with a mean age of 62 years. The mean R value for the diseased females was 1.031 with a standard deviation of 0.133. RCATs are shown in Table 2. Crosstabs indicated the following:

1. RCAT 1 contained 73% (n = 22) of the diseased females.

2. RCAT 2 contained 17% (n = 5) of the diseased females.

3. RCAT 3 contained 10% (n = 3) of the diseased females.

Gender by Disease Categories

The diseased subjects were then examined by gender and either MI, CABG, PTCA, or multiple. Crosstabs indicated the following:

1. RCAT 1 contained 46% (n = 12) of the MI subjects. All 12 were male.

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2. RCAT 2 contained 27% ($\underline{n}$ = 7) of the MI subjects. There were 5 males and 2 females.

3. RCAT 3 contained 27% ($\underline{n}$ = 7) of the MI subjects. There were 6 males and 1 female.

4. RCAT 1 contained 60% ($\underline{n}$ = 24) of the CABG subjects. There were 14 males and 10 females.

5. RCAT 2 contained 23% ($\underline{n}$ = 9) of the CABG subjects. All of them were male.

6. RCAT 3 contained 17% ($\underline{n}$ = 7) of the CABG subjects. All of them were male.

7. RCAT 1 contained 50% ($\underline{n}$ = 6) of the PTCA subjects. There were 4 males and 2 females.

8. RCAT 2 contained 33% ($\underline{n}$ = 4) of the PTCA subjects. There were 2 males and 2 females.

9. RCAT 3 contained 17% ($\underline{n}$ = 2) of the PTCA subjects. There was 1 male and 1 female.

10. RCAT 1 contained 51% ($\underline{n}$ = 42) of the multiple subjects. There were 32 males and 10 females.

11. RCAT 2 contained 23% ($\underline{n}$ = 19) of the multiple subjects. There were 18 males and 1 female.

12. RCAT 3 contained 26% ($\underline{n}$ = 21) of the multiple subjects. There were 20 males and 1 female.

Chi-square Goodness-of-fit Test

Hypothesis 1, a majority of the R values of cardiac rehabilitation patients and a majority of the R values of

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nondiseased subjects associated with VO2 max are between or equal to 1.10 and 1.20 during a maximal graded treadmill exercise test, was tested using the chi-square goodness-of-fit test to determine if a majority of the normal subjects and a majority of the diseased subjects were in RCAT 2. The chi-square goodness-of-fit test was run with an expected proportion of 0.51 inside the range of 1.10 and 1.20 and an expected proportion of 0.49 outside this range for both nondiseased and diseased subjects. The proportion of 0.51 was chosen because this is the minimal level for a majority.

Nondiseased

The observed percentage of normals within the range of 1.10 to 1.20 was 27, and the observed percentage outside the range was 73. This resulted in $X^2(1) = 44.49$, $p < .001$. Therefore, there was a significantly larger proportion of subjects outside the 1.10 to 1.20 range.

Diseased

The observed percentage of diseased subjects within RCAT 2 was 24, and the observed percentage outside RCAT 2 was 76. This resulted in $X^2(1) = 46.67$, $p < .001$. Therefore, there was a significantly larger proportion of diseased subjects outside the 1.10 to 1.20 range.

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Difference Between Diseased and Nondiseased Within RCAT 2

Hypothesis 2, there was no significant difference between the proportion of diseased subjects and the proportion of nondiseased subjects whose R values at VO2 max are in the range of 1.10 to 1.20, was tested using the significance of the difference between two independent proportions test. This test resulted in z = 0.6229, p > .05. Therefore, it was concluded that the proportions of subjects in RCAT 2 are the same for diseased and nondiseased populations.

Time From Critical R to VO2 max to Exhaustion

Data were gathered on 100 male and female CAD subjects regarding the time during a maximal treadmill stress test that it took to reach VO2 max once the R value rose above 1.00, and, from there, how long it took the subjects to reach volitional fatigue. It should be noted that during data collection, 15 subjects were found to have R values that never reached 1.00 and 4 subjects were found to have R values that never went below 1.00. These 19 subjects were excluded from further analysis of these times.

The Descriptives program for the times indicated the following.

1. The mean time to VO2 max once the R value rose

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above 1.00 was 1.960 min, or 1 min 57.6 s.

2. The mean time to exhaustion past VO2 max was 2.735 min, or 2 min 44.1 s.

3. The mean difference between VO2 max once R rose above 1.00 and volitional fatigue was 0.775 min, or 46.5 s.

4. The mean time once R rose above 1.00 to exhaustion was 4.695 min, or 4 min 41.7 s.

The mean times in minutes of reaching VO2 max and the mean times in minutes from VO2 max to exhaustion for 100 CAD subjects once their R values rose above 1.00 are displayed in Figure 1. The numbers at the various points represent the number of CAD patients at that particular time.

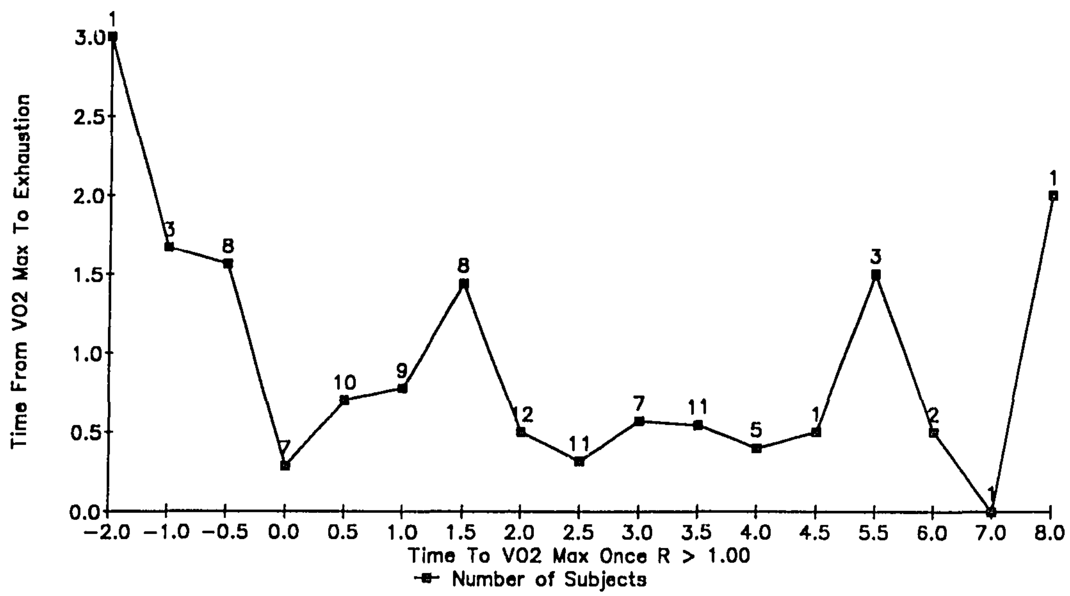

Figure 1. Time in Minutes From VO2 max to Exhaustion Once the R Value Rose Above 1.00.

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The analysis of these times indicated the following:

1. One patient achieved VO2 max 2.0 min prior to R exceeding 1.00 and remained on the treadmill an additional 3.0 min until exhaustion.

2. Three patients achieved VO2 max 1.0 min prior to R exceeding 1.00 and remained on the treadmill an additional 1.7 min until exhaustion.

3. Eight patients achieved VO2 max 0.5 min prior to R exceeding 1.00 and remained on the treadmill an additional 1.6 min until exhaustion.

4. Seven patients achieved VO2 max at the same time that R exceeded 1.00 and remained on the treadmill an additional 0.3 min until exhaustion.

5. Ten patients achieved VO2 max 0.5 min after R exceeded 1.00 and remained on the treadmill an additional 0.7 min until exhaustion.

6. Nine patients achieved VO2 max 1.0 min after R exceeded 1.00 and remained on the treadmill an additional 0.8 min until exhaustion.

7. Eight patients achieved VO2 max 1.5 min after R exceeded 1.00 and remained on the treadmill an additional 1.4 min until exhaustion.

8. Twelve patients achieved VO2 max 2.0 min after R exceeded 1.00 and remained on the treadmill an additional 0.5 min until exhaustion.

9. Eleven patients achieved VO2 max 2.5 min after

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R exceeded 1.00 and remained on the treadmill an additional 0.3 min until exhaustion.

10. Seven patients achieved VO2 max 3.0 min after R exceeded 1.00 and remained on the treadmill an additional 0.6 min until exhaustion.

11. Eleven patients achieved VO2 max 3.5 min after R exceeded 1.00 and remained on the treadmill an additional 0.6 min until exhaustion.

12. Five patients achieved VO2 max 4.0 min after R exceeded 1.00 and remained on the treadmill an additional 0.4 min until exhaustion.

13. One patient achieved VO2 max 4.5 min after R exceeded 1.00 and remained on the treadmill an additional 0.5 min until exhaustion.

14. Three patients achieved VO2 max 5.5 min after R exceeded 1.00 and remained on the treadmill an additional 1.5 min until exhaustion.

15. Two patients achieved VO2 max 6.0 min after R exceeded 1.00 and remained on the treadmill an additional 0.5 min until exhaustion.

16. One patient achieved VO2 max and exhaustion 7.0 min after R exceeded 1.00.

17. One patient achieved VO2 max 8.0 min after R exceeded 1.00 and remained on the treadmill an additional 2.0 min until exhaustion.

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Discussion

Nondiseased

The mean R value at VO2 max for nondiseased subjects fell below the hypothesized range of 1.10 to 1.20. It was found that a majority of these subjects was outside RCAT 2. In fact, over half of them were in RCAT 1, which was any R value below 1.10.

Males and Females

The mean R values at VO2 max for the nondiseased male and female categories also fell below the hypothesized range of 1.10 to 1.20. Again, neither a majority of males nor a majority of females fell into RCAT 2. Likewise, over half of the males and well over half of the females were in RCAT 1 (see Figure 2).

The R values at VO2 max for this population contradict the R values at VO2 max reported in the literature. All R values at VO2 max reported in the literature were above 1.10. This was definitely not the case with the nondiseased subjects in this study. Therefore, because a majority of nondiseased subjects was not found to have R values at VO2 max between or equal to 1.10 and 1.20, Hypothesis 1 for the nondiseased population must be rejected.

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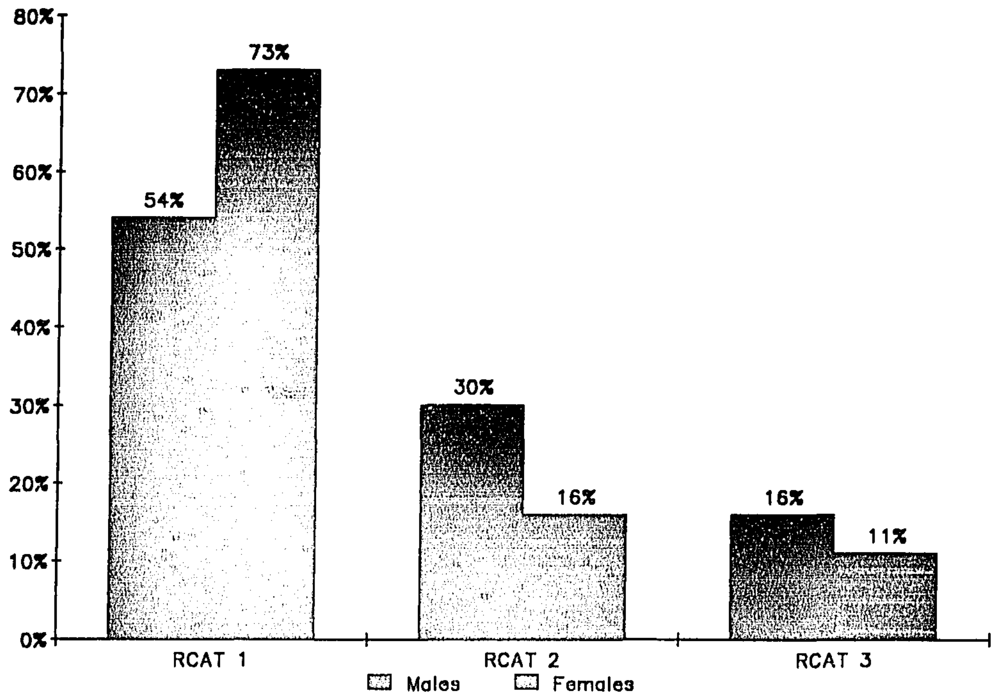

Figure 2. Percentage of Subjects in R Categories for Nondiseased Males and Females.

Diseased

The mean R value at VO2 max for the CAD subjects fell into the hypothesized range of 1.10 to 1.20. However, it was found that a majority of these subjects was outside of RCAT 2. In fact, just over half of them were in RCAT 1.

Males and Females

The mean R value at VO2 max for the diseased male and female categories fell into two separate RCATs. The males were in RCAT 2 and the females were in RCAT 1.

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However, again there was not a majority of either of these subpopulations within RCAT 2. In fact, almost half of the males and almost three-fourths of the females were in RCAT 1 (see Figure 3).

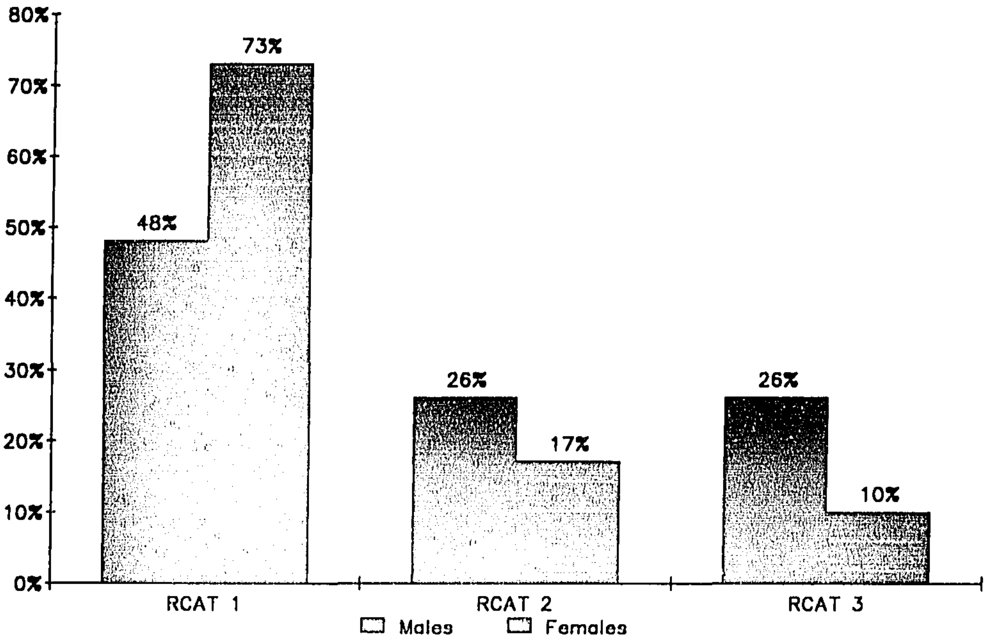

Figure 3. Percentage of Subjects in R Categories for Diseased Males and Females.

The R values at VO2 max for the CAD subjects contradict the R values for nondiseased populations found in the literature. No R values at VO2 max for CAD patients were found in the literature search to make a comparison. Nevertheless, because a majority of diseased subjects was not found to have R values at VO2 max between or equal to 1.10 and 1.20, Hypothesis 1 for the diseased population must be rejected.

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Nondiseased and Diseased

The two populations in this study consisted of subjects with known CAD and nondiseased subjects. The purpose of having these two distinct populations was to make comparisons between them and point out any differences or similarities. When examining the percentage of subjects within RCATs between these populations, it was found that they were quite similar (see Figure 4). Both populations had over half of the subjects in RCAT 1, approximately one-fourth of the subjects in RCAT 2, and the remaining subjects in RCAT 3.

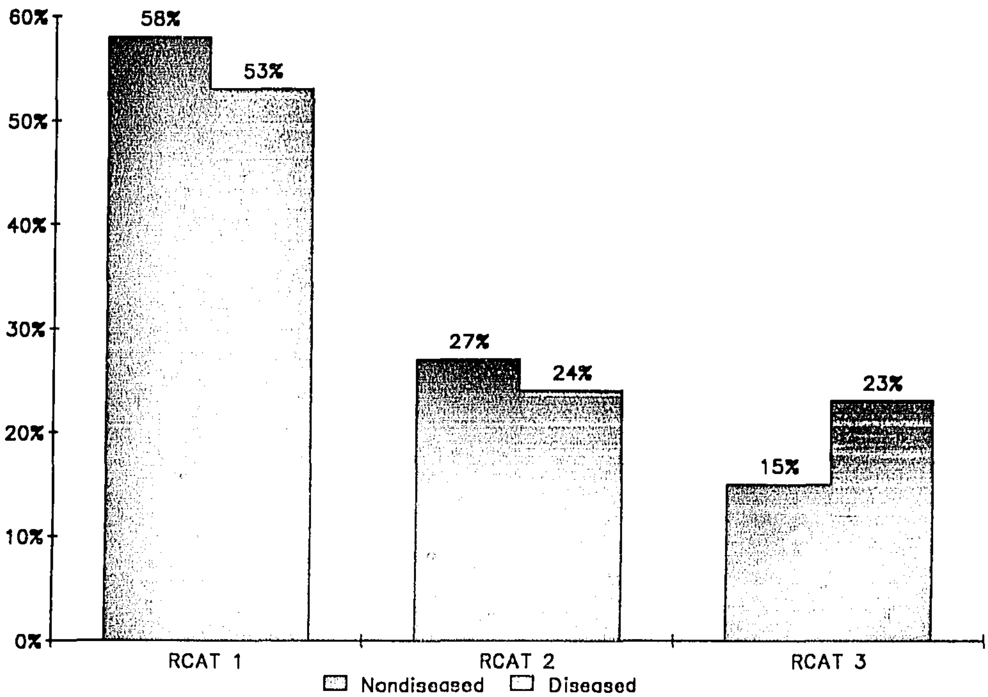

Figure 4. Percentage of Subjects in R Categories for Nondiseased and Diseased Populations.

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Males

The percentage of subjects in RCATs for the diseased males and the nondiseased males were comparable (see Figure 5). The nondiseased males had just over half of the subjects in RCAT 1, and the diseased males had just under half of the subjects in RCAT 1. Both male populations had approximately one-fourth of the subjects in RCAT 2 and the remaining subjects in RCAT 3.

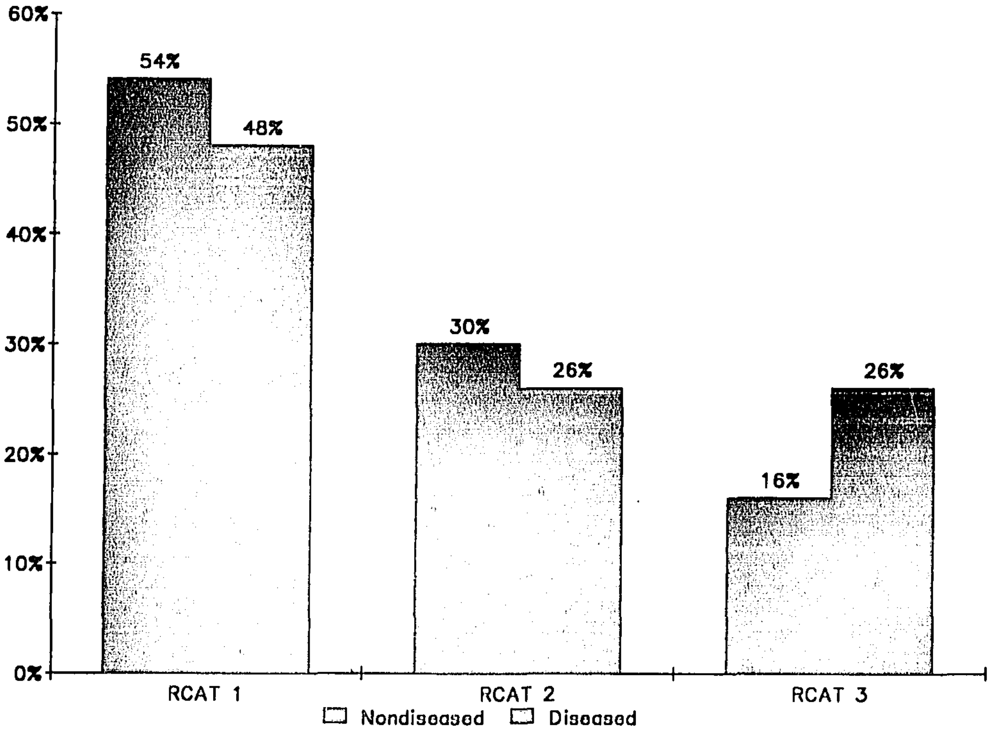

Figure 5. Percentage of Subjects in R Categories for Nondiseased and Diseased Males.

Females

The percentages of subjects in RCATs for nondiseased

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and diseased females were almost identical (see Figure 6). Both female populations had 73% in RCAT 1; nondiseased females had 16%, and diseased females had 17% in RCAT 2; and nondiseased females had 11%, and diseased females had 10% in RCAT 3.

It seems, based on the results of this study, that the R value at VO2 max does not vary greatly between diseased and nondiseased populations or between genders.

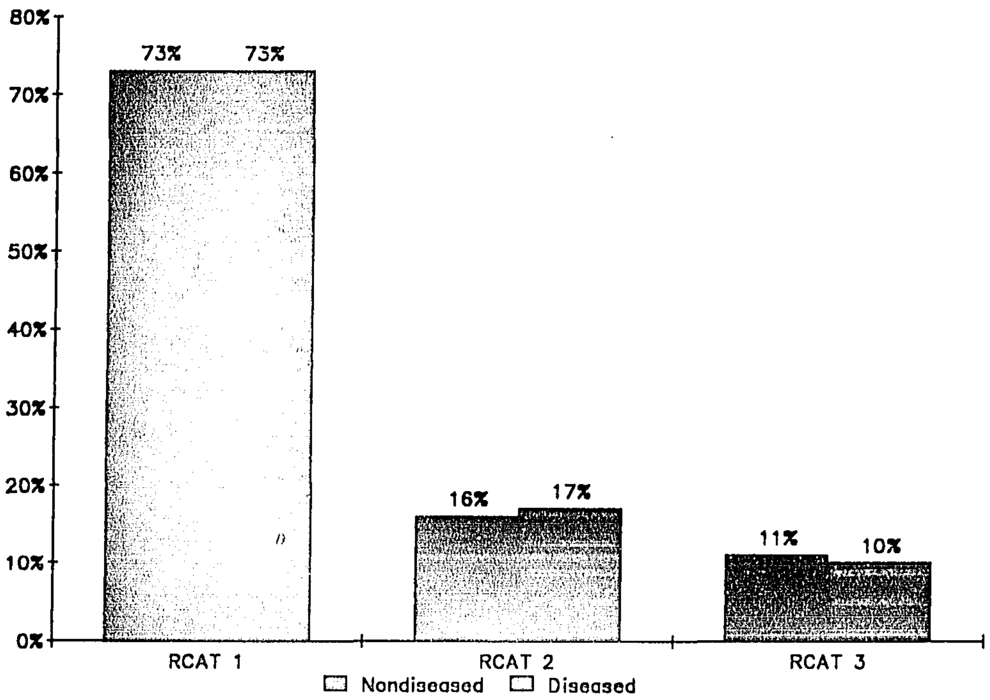

Figure 6. Percentage of Subjects in R Categories for Nondiseased and Diseased Females.

Although the R values at VO2 max in this study do not reflect those found in the literature, they do relate strongly to each other.

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Difference Between Diseased and Nondiseased Within RCAT 2

As depicted in Figure 4, the percentage of non-diseased subjects in RCAT 2 was 27. The percentage of diseased subjects in RCAT 2 was 24. Based on the significance of the difference between two independent proportions test, it was concluded that the proportions of subjects in RCAT 2 between these two populations were the same. Therefore, Hypothesis 2 was accepted. Again, it must be mentioned that the R values at VO2 max of these two distinctly different populations are quite similar.

The R Value as a Reliable Indicator of VO2 max

This study was conducted to determine if the R value could be a reliable indicator of VO2 max. It was thought that if a range of R values could accurately indicate VO2 max, this range could be used as one of the many test termination criteria. The literature revealed a range of 1.10 to 1.20 as the reported R values at VO2 max in various nondiseased populations. Therefore, this range was specified in Hypothesis 1 and named RCAT 2. RCAT 1 was any R value below 1.10, and RCAT 3 was any value above 1.20. The data in this study did not support the literature. All of the mean R values, except for the diseased males, fell below the hypothesized range. Also,

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there was not a majority of subjects of either population in RCAT 2. As far as the scope of this study, the R value was not a reliable indicator of VO2 max within the range of 1.10 to 1.20.

After examining the data, if R were to be used as a tool to warn the exercise physiologist that the subject was getting close to exhaustion, 1.10 would be too low, because only about half of the people reached VO2 max at this value. At an R value of 1.20, approximately 80% of the subjects have reached VO2 max. Therefore, it is the author's opinion that an R value of 1.20 would be a reasonable value to use during a GXT as one of the many warning signals that the patient is about to reach exhaustion.

Time From Critical R to VO2 max to Exhaustion

Data were collected on CAD patients to report the mean time it took to reach exhaustion once R exceeded 1.00, the mean time to reach VO2 max once R exceeded 1.00, and the mean time from VO2 max to exhaustion. This subproblem is important for the exercise physiologist who performs stress tests on a regular basis. These mean times will give these health professionals an idea of what to expect during the administration of a maximal GXT on a treadmill. Zavala (1985) stated that once R rose above 1.00, the subject would stop within 2 to 3 min.

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However, the mean time for the 100 CAD subjects in this study was 4 min 41.7 s. In practical terms, this warns the exercise physiologist that once R goes above 1.00, the CAD patient will most likely complete the present stage and reach exhaustion during the next.

The mean time to reach VO2 max once R rose above 1.00 was just under 2 min, and, from that point, it took an additional mean time of 46.5 s to reach exhaustion. The additional 46.5 s is significantly longer statistically, $t(99) = -7.95$, $p > .05$, but it is the author's opinion that it is not of practical significance. Less than 1 min of additional stress past VO2 max should not put the CAD patient in danger of another cardiac event.

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CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was conducted to determine if the R value during a maximal GXT could be a reliable indicator of VO2 max and therefore a criterion for test termination. In order to determine this, retrospective data from the stress tests of 160 cardiac rehabilitation patients and 170 nondiseased individuals were analyzed. This study was also conducted to compare the R values during maximal GXTs of these two populations. A subproblem in this study was to report and discuss the time to VO2 max and the time to exhaustion once the R value rose above 1.00 in 100 cardiac rehabilitation patients.

Findings

The SPSS programs Crosstabs and Descriptives, the chi-square goodness-of-fit test, and the significance of the difference between two independent proportions test indicated the following:

1. A majority of the CAD subjects did not have R values at VO2 max between or equal to 1.10 and 1.20.

2. A majority of the nondiseased subjects did not

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have R values at VO2 max between or equal to 1.10 and 1.20.

3. The proportion of nondiseased subjects and the proportion of diseased subjects whose R values were between or equal to 1.10 and 1.20 was the same.

4. The greatest percentage of subjects within all populations and subpopulations had R values at VO2 max below 1.10.

5. The CAD patient has approximately 4 to 5 min until exhaustion once R rises above 1.00.

6. The CAD patient will reach VO2 max approximately 2 to 3 min after R rises above 1.00.

7. The CAD patient will reach fatigue approximately 45 s past VO2 max.

Conclusions

The above findings led the investigator to suggest the following conclusions:

1. The R value was not a reliable predictor of VO2 max within the range of 1.10 to 1.20.

2. Instead of using the R value as a test termination criterion, it is suggested to use it as a guideline for when the CAD patient might be close to exhaustion.

3. The percentage of subjects in RCATs 1, 2, and 3 were similar between the diseased and nondiseased populations and between genders.

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4. It is unlikely that the additional time from VO2 max to exhaustion is not of enough practical significance to put the CAD patient in danger of another cardiac event.

Recommendations

Based on the results of this study, the following are recommendations for further research:

1. A larger sample size could be observed.

2. A number of ranges of R values at VO2 max could be analyzed.

3. The nondiseased population could be subdivided by fitness levels.

4. Other factors, such as medications being taken and concomitant diseases, could be included in the analysis.

5. Subjects who had previously undergone a maximal treadmill exercise test with direct oxygen consumption could be used in order to control for the learning effect.

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Appendix A

Human Subjects Institutional Review Board Approval

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Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899

WESTERN MICHIGAN UNIVERSITY

Date: March 2, 1992

To: Sherry Williams

From: Mary Anne Bunda, Chair Mary Anne Bunda

Re: HSIRB Project Number 92-01-13

This letter will serve as confirmation that your research protocol, "The R value at VO2 max during maximal graded exercise treadmill tests of Phase II cardiac rehabilitation patients and normal subjects" has been approved after full review by the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any change in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

xc: Zabik, HPER

Approval Termination: March 2, 1993

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Appendix B

St. Joseph Mercy Hospital Chart/Data
Review Request Approval

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ST. JOSEPH
MERCY HOSPITAL
900 WOODWARD, PONTIAC, MI 48341-2985

Research Office
Box 500
(313) 858-6767

A division of Sisters of Mercy Health Corporation
A sponsored work of the Sisters of Mercy – Province of Detroit

March 17, 1992

Sherry Williams
1201 Greenwood Avenue, Apt 102
Kalamazoo, MI 48006

Dear Ms. Williams:

At the March 10, 1992 meeting of the Institutional Review Board/Research Committee, the committee unanimously voted to approve your chart review entitled: "The R Value At VO2 Max During Maximal Graded Exercise Treadmill Tests Of Phase II Cardiac Patients And Normal Subjects". It was approved for a period of one year and assigned the SJMH #92-3-1-Williams. Please refer to this number when corresponding to the Research Office.

Please also be aware that you should report to the committee concerning this project when you are completed with it or when it is scheduled to be renewed next year.

Should you wish to make any changes in your chart review, these changes must be approved by the Institutional Review Board/Research Committee prior to making any changes. In the case of revisions, the changes between the new and the old protocol should be submitted in detail and the pertinent areas of the changes highlighted to facilitate review by the Research Office and Chairman of the IRB/RC.

On behalf of the IRB/RC, I wish you well with this project.

Yours truly,

Jim Heinsimer

James Heinsimer, M.D.
On behalf of the IRB/RC

3-92:AprWillms.IRB

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Appendix C

Data Collection Sheets

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DATA COLLECTION SHEET 1

	SEX	AGE	CATEGORY	VO2 MAX/HR	R-VALUE	MHR	MED	DIS	TIME
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.									
12.									
13.									
14.									
15.									
16.									
17.									
18.									

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DATA COLLECTION SHEET 2

	VO2 TIME	EXHAUSTION
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		

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Appendix D

Raw Data

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RAW DATA CODE KEY

A = Subject Number
B = Gender
C = Age
D = Category
- 1 = Nondiseased
- 2 = MI
- 3 = CABG
- 4 = PTCA
- 5 = MI/CABG
- 6 = CABG/PTCA
- 7 = MI/PTCA
- 8 = MI/PTCA/CABG

E = VO2
F = Heart Rate at VO2 max
G = R Value
H = Maximal Heart Rate
I = Concomitant Disease
- 1 = Pulmonary Disease
- 2 = Diabetes
- 3 = Pulmonary/Diabetes

J = Time
K = Medications
- 1 = Beta Blockers
- 2 = Calcium Channel Blockers
- 3 = Analgesics
- 4 = Diuretics
- 5 = Lipid Lowering
- 6 = Anticoagulant
- 7 = Anti-inflammatory
- 8 = Nonsteroidal anti-inflammatory
- 9 = Antibiotics
- 10 = Bronchodilator
- 11 = Ulcers
- 12 = Hormones
- 13 = Vitamins/Minerals
- 14 = ACE Inhibitor
- 15 = Vasodilator
- 16 = Digitalis
- 17 = Other
- 18 = Antihypertensive
- 19 = Anti-arrythmic
- 20 = Hypoglycemic

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A	B	C	D	E	F	G	H	I	J	K----->
001	1	59	1	49.7		1.13	168			
002	1	33	1	[illegible]		1.67	190			
003	1	41	1	62.4		1.05	180			
004	1	42	1	[illegible]		1.12	173			
005	1	53	1	33.7		1.13	170			
006	1	35	1	26.5		1.04	191			
007	1	45	1	49.3		1.06	175	0	0.0	09
008	1	[illegible]	1	[illegible]		0.93	155			
009	1	54	1	53.3		0.71	193			
010	1	36	1	[illegible]		0.86	130			13
011	1	45	1	21.3		1.14	183			
012	1	44	1	40.4		1.10	190			
013	1	70	1	22.8		0.96	140			
014	1	[illegible]	1	20.7		1.16	116			01
015	1	37	1	53.4		1.00	170			
016	1	43	1	43.7		0.97	134			
017	1	47	1	62.2		1.09	168			
018	1	42	1	[illegible]		1.05	178			
019	1	44	1	49.4		1.16	172			
020	1	36	1	36.6		1.03	176			
021	1	25	1	62.3		1.11	198			13
022	1	43	1	23.1		1.07	195			
023	1	42	1	41.3		1.28	190			
024	2	[illegible]	1	42.0		1.03	135			
025	2	62	1	21.8		1.09	145			
026	1	37	1	46.5		1.30	194			
027	1	41	1	33.7		1.19	182			
028	1	30	1	72.5		0.94	190			
029	1	54	1	31.2		0.95	168			11
030	1	30	1	26.2		1.53	195			
031	1	46	1	39.2		1.12	190			
032	1	41	1	35.5		1.08	170			
033	1	49	1	52.3		1.16	175			
034	1	34	1	53.[illegible]		0.91	165			
035	1	39	1	28.4		1.11	190			
036	[illegible]	43	1	31.[illegible]		1.00	182			17
037	2	43	1	36.7		1.03	195			
038	2	41	1	32.7		1.02	178			
039	1	47	1	36.9		1.03	173			
040	1	42	1	35.5		1.04	180			03
041	2	35	1	34.1		1.04	190			
042	1	39	1	25.7		1.18	176			17
043	2	43	1	40.6		1.08	170			
044	1	38	1	57.7		0.89	180			
045	1	53	1	30.6		1.07	150			03
046	1	56	1	39.5		1.00	175			17
047	1	36	1	38.1		1.31	201			
048	1	42	1	51.3		1.31	192			
049	1	56	1	34.7		0.97	155			
050	1	43	1	46.0		1.17	130			
051	1	48	1	36.8		1.17	180			
052	1	59	1	25.4		0.95	168			10
053	2	27	1	32.1		1.02	198			17
054	2	47	1	30.1		1.20	135			
055	1	33	1	37.8		1.16	184			
056	1	37	1	54.4		0.99	179			
057	2	36	1	34.6		1.11	190			
058	1	39	1	43.6		0.99	132			17
059	2	45	1	24.3		1.19	148			01 04
060	2	37	1	33.7		0.93	170			

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A	B	C	D	E	F	G	H	I	J	K----->
061	1	48	1	42.7		1.16	188			
062	1	43	1	43.2		0.99	155			04
063	1	39	1	47.4		1.25	170			
064	1	23	1	31.2		1.07	194			17
065	1	49	1	19.9		1.15	170			
066	1	29	1	41.5		1.26	200			
067	2	56	1	21.5		1.23	160			09 12
068	2	59	1	25.9		1.08	170			
069	1	35	1	37.9		1.12	178			
070	1	47	1	35.8		1.21	135			
071	1	50	1	30.0		1.07	185			03 05
072	1	38	1	53.3		1.04	139			
073	2	35	1	54.2		0.99	186			
074	2	45	1	37.2		0.95	135			
075	1	32	1	47.9		1.26	201			
076	1	44	1	36.0		1.19	174			
077	1	50	1	26.3		1.08	174			
078	1	36	1	48.7		1.13	200			
079	2	47	1	26.9		1.07	168			
080	1	64	1	19.2		1.04	153			
081	1	45	1	39.4		1.30	180			
082	1	23	1	32.8		1.05	170			05 11
083	1	40	1	58.4		1.10	195			
084	1	32	1	33.9		1.22	196			
085	1	40	1	45.3		0.98	182			17
086	1	31	1	27.6		1.12	192			
087	1	47	1	49.9		1.06	172			04
088	1	47	1	32.2		1.32	150			01 04
089	1	36	1	33.0		1.04	188			
090	2	39	1	31.3		1.29	135			
091	1	65	1	27.0		1.06	160			
092	1	59	1	31.8		1.04	147			
093	1	37	1	59.2		0.97	188			
094	2	43	1	33.7		0.93	190			
095	1	21	1	41.6		1.17	190			
096	1	49	1	28.5		0.93	162			
097	2	49	1	39.7		1.03	170			
098	2	45	1	35.1		0.94	175			
099	1	44	1	35.5		1.12	174			01 04 07
100	1	40	1	34.0		1.19	194			
101	1	53	1	40.1		1.10	180			
102	2	32	1	53.6		0.79	172			
103	2	38	1	16.6		1.36	175			
104	2	22	1	40.0		1.00	194			
105	1	46	1	28.3		1.30	173			
106	2	39	1	23.2		1.22	130			03 12
107	1	39	1	44.8		1.27	180			
108	1	53	1	32.1		1.26	189			17
109	1	47	1	27.0		1.09	145			04
110	1	55	1	34.3		1.13	176			
111	1	22	1	40.5		1.16	205			
112	1	46	1	41.3		1.07	185			
113	2	46	1	27.1		1.04	165			01 12
114	2	45	1	33.3		1.11	190			12
115	2	49	1	30.2		0.92	185			
116	1	42	1	45.9		1.11	190			
117	1	63	1	24.2		0.82	148			
118	1	43	1	31.2		0.93	190			
119	1	38	1	40.3		1.16	190			
120	1	54	1	38.1		1.05	130			

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A	B	C	D	E	F	G	H	I	J	K----->
121	1	35	1	[illegible]		[illegible]	[illegible]			
122	[illegible]	43	1	41.0		[illegible]	[illegible]			
123	1	50	1	29.6		1.02	140			01
124	1	41	1	49.7		[illegible]	[illegible]			
125	1	34	1	38.4		0.87	182			12
126	1	[illegible]	1	27.3		1.05	158			
127	1	46	1	34.6		1.03	173			
128	1	45	1	[illegible]		1.00	[illegible]			
129	2	43	1	34.6		1.07	190			
130	[illegible]	59	1	[illegible]		1.02	144			
131	1	46	1	35.7		1.16	180			08 11 17
132	1	50	1	38.2		1.13	195			
133	1	43	1	38.3		1.11	169			10
134	1	23	1	39.0		0.77	130			
135	1	59	1	25.2		0.98	120			01 17
136	1	43	1	39.4		1.01	177			
137	1	40	1	62.3		0.99	171			08 11
138	1	57	1	23.1		1.15	173			
139	1	50	1	29.2		1.02	123			01
140	1	44	1	43.0		1.10	130			
141	1	38	1	48.4		1.00	198			
142	1	51	1	[illegible]		0.93	161			
143	1	43	1	42.4		1.10	177			
144	1	64	1	46.2		0.99	175			
145	2	55	1	25.3		0.95	127			
146	1	43	1	35.8		1.23	174			
147	1	42	1	34.9		1.24	200			
148	1	44	1	36.2		1.14	185			
149	1	51	1	42.4		1.19	181			
150	2	50	1	23.6		1.04	170			12
151	1	46	1	26.0		1.08	160			04 18
152	2	61	1	13.0		1.06	162			12
153	1	35	1	71.6		0.95	170			
154	1	37	1	50.7		1.01	168			
155	1	66	1	39.0		1.23	168			01 04
156	1	53	1	24.4		0.94	130			05 17
157	1	45	1	33.3		1.09	161			
158	1	59	1	43.5		0.97	160			
159	1	44	1	29.7		1.21	156			
160	1	64	1	25.3		0.33	150			17
161	1	51	1	17.1		1.13	150			04 10 12
162	1	53	1	31.9		0.93	192			
163	2	36	1	30.4		0.90	182			
164	1	42	1	61.9		1.05	190			
165	2	58	1	33.8		1.11	162			
166	1	52	1	65.2		1.01	180			
167	2	59	1	27.0		1.10	180			
168	1	54	1	28.2		0.98	149			17
169	1	43	1	34.7		0.82	180			
170	1	57	1	25.4		1.48	180			08
171	1	47	7	20.5	160	1.05	169		1.0	03 15 06 01 02
172	1	69	3	09.3	133	1.15	138		0.0	03 02 06 13
173	1	75	2	04.5	107	1.06	107	1	0.0	02 06 03 04 01 13 15
174	2	60	5	03.3	112	0.92	115	1	1.0	13 02 03 05 12
175	1	61	3	22.0	148	1.14	152	2	0.5	12 14 06 13 03
176	1	62	5	11.9	114	1.41	[illegible]		1.5	03 15 19 01
177	1	53	7	19.3	117	1.09	117		0.0	01 02 03 05
178	1	67	5	13.6	132	1.12	138		0.5	15 03 02 06 13
179	1	46	2	23.0	157	1.32	163		1.0	03 06 17 15 11
180	2	67	4	12.2	134	1.10	153		4.0	02 15 06 04

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A	B	C	D	E	F	G	H	I	J	K----->							
181	1	64	5	17.0	101	1.26	104		0.5	02	15	04	02	06	16		
182	1	54	5	19.4	133	1.05	144	2	0.5	01	06	15	02				
183	1	60	7	17.7	138	0.96	160	2	3.0	01	20						
184	1	61	3	14.1	150	1.15	160		0.0	03	16	02	15				
185	2	65	4	10.2	113	0.73	114		1.5	15	01	04	05	02	08		
186	1	60	4	26.1	117	0.93	119		0.5	01	[illegible]	15					
187	1	52	4	25.4	165	1.17	173		1.0	17	02	06	15	05			
188	1	74	6	13.3	113	1.09	118		0.0	02	03	06	13	16	08	19	11
189	1	61	5	20.4	143	1.07	143		0.0	15	06	03					
190	1	72	5	12.5	133	0.93	136		1.0	16	03	15	10	03	13		
191	2	76	3	09.2	087	0.98	088		0.5	01	02	15					
192	1	71	4	11.2	108	1.15	113	1	0.5	01	02	06	17	16	11	10	04
193	2	57	3	14.5	152	1.05	152	1	0.0	03	02	20	17				
194	2	55	2	13.0	137	1.20	137		0.0	03	01						
195	2	75	3	07.2	126	1.07	128	2	0.5	03	12	02	15				
196	1	60	3	19.4	141	0.93	141		0.0	03							
197	1	56	5	35.6	152	0.90	156		0.5	03	02	19					
198	1	51	3	17.4	089	1.31	092		0.5	03	01						
199	1	64	8	17.9	143	1.47	143		0.0	17	19	06	03				
200	1	50	4	33.0	152	1.10	152		0.0	15	03	07					
201	1	53	3	29.3	165	0.97	165	1	0.0	03	05						
202	1	52	7	13.6	115	0.91	115		0.0	08	11	06	03				
203	1	72	2	13.2	144	1.02	151		1.0	05	02	15	03				
204	1	54	3	12.9	121	1.11	132	1	2.0	13	15	02	06				
205	2	56	2	10.8	113	1.28	113		0.0	01	03	05	15				
206	1	54	7	21.1	152	0.96	152		0.0	15	03	11	04				
207	1	55	2	26.3	158	1.20	158		0.0	15	02	06	03				
208	1	46	2	23.6	144	1.12	156		1.5	01	02	03	15				
209	1	70	7	10.7	117	1.41	117		0.0	16	13						
210	2	43	3	14.5	133	0.85	142		1.5	02	03	13					
211	1	57	5	20.8	129	0.79	138		1.0	03	15						
212	2	45	3	14.3	147	1.01	159		2.0	03							
213	1	78	5	13.6	125	1.18	130	1	1.5	03	13	06	17	05			
214	1	50	2	25.2	159	1.30	159		0.0	02	03	11					
215	1	52	3	22.5	153	1.30	163		1.0	03							
216	1	65	3	17.7	135	0.91	140		0.5	02	03	13	14				
217	1	65	3	18.3	133	0.91	145		2.0	03	02	14	17				
218	1	72	5	15.7	126	1.27	126		0.0	03	19	15	17	03	02	04	
219	1	59	5	13.2	149	1.02	153		0.5	03	16						
220	2	68	3	20.9	143	1.05	143		0.0	16	06	01					
221	1	51	3	17.4	143	1.05	143		0.0	03							
222	1	71	5	14.5	151	1.17	151	2	0.0	03	17	06	04	05			
223	1	72	5	18.4	153	1.14	153		0.0	02	15	03	06	11			
224	1	61	3	17.6	158	1.19	163		0.5								
225	1	56	3	21.4	167	1.44	171		0.5	03	15	10					
226	1	48	6	28.8	141	1.19	146		0.5	01	03						
227	1	57	2	22.4	152	1.26	160		1.0	15	02	17					
228	1	61	3	17.2	148	1.40	143		0.0	16	03	06					
229	1	55	5	12.7	135	1.13	135		0.5	16	03	13					
230	1	60	2	22.3	136	1.01	142		0.5	03	15	01	19				
231	1	73	5	10.4	130	1.44	136	2	1.5	03	08						
232	1	65	6	18.0	141	0.92	141		0.0	03							
233	1	73	3	17.4	123	0.95	123		0.0	01	03	06	11	17			
234	1	46	3	22.0	155	1.22	158		0.5	01	03						
235	2	68	3	09.4	124	1.01	124		0.0	02	15	13	17				
236	1	59	2	11.3	138	1.22	142		0.5								
237	1	47	7	21.1	148	1.21	148		0.0	03	15	02					
238	1	72	2	19.6	145	1.12	145		0.5	06	02	08	16				
239	1	76	5	09.7	111	1.05	137		3.5	06	03						
240	1	50	3	16.1	136	1.01	152	1	1.5	03	15						

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A	B	C	D	E	F	G	H	I	J	K----->									
241	1	66	5	15.3	150	1.14	150		0.0	03	06	15							
242	1	63	5	16.5	131	1.16	131	2	0.0	06	15	05	02	04					
243	1	52	7	14.0	123	1.75	123		0.0	01	02	03							
244	1	47	7	28.9	150	1.20	150		1.0	02	03								
245	1	50	2	19.4	152	1.11	160		1.0	03	15	16							
246	1	57	5	15.7	104	0.94	107		2.0	03	01	17							
247	1	64	5	33.7	166	1.18	166		0.0	03	02	15							
248	1	57	4	12.8	130	0.98	130		0.0	03	15	05	08	11	17				
249	1	51	2	27.0	160	1.29	160		0.0	03	01								
250	1	58	5	11.3	103	0.99	103	2	0.0	03	01	15	17	08					
251	1	56	5	16.2	128	1.32	128		0.0	06	01	03	13						
252	1	47	3	14.3	146	1.19	146		0.0	06	15	02							
253	1	60	3	12.6	090	1.34	090	1	0.5	06	01	15	13	16					
254	1	55	7	15.8	145	1.05	145		0.0	03	11	17	13	04					
255	1	61	5	13.7	134	1.04	140	2	1.0	03	05	16	17	14					
256	1	73	3	14.2	131	0.90	131		0.0	03	02	17	06						
257	1	56	5	20.0	150	1.36	150		0.0	15	01	03	13	02					
258	2	76	5	04.3	126	0.75	126	2	0.0	15	16	14	02	05	13	11	10	06	04
259	1	53	4	15.2	147	1.04	155	2	0.5	15	03	02	11						
260	1	60	3	13.3	145	0.94	145		0.0	03	16	06	19	02	13				
261	1	50	2	20.2	163	1.29	174		1.0	03	02	06	15						
262	1	70	5	12.4	141	0.95	148		1.5	11	19	04	16	13					
263	1	54	6	17.2	109	1.46	117		1.5	03	01	15	02						
264	1	43	5	17.7	134	1.35	134		0.0	02	01	03	15	11					
265	1	53	7	16.6	127	1.16	127		0.0	03	02	15	01						
266	1	58	5	07.3	143	1.71	143		0.5	03	02	06	15						
267	1	52	6	20.2	148	1.24	148		0.0	01	03	06	02						
268	1	72	5	11.7	122	1.14	128		1.5	03	19	13	16	06	15				
269	1	47	3	24.1	120	1.19	120		0.0	01	02	05	03	15	16				
270	2	52	3	04.1	117	0.92	118		0.5	15	06	03	12	16					
271	2	66	3	09.7	099	1.05	101		0.5	03	01	15							
272	1	73	5	07.7	105	1.09	112		5.0	03	06	19							
273	1	56	5	12.0	131	1.10	134		0.5	03	11	10	17	02	15				
274	1	55	3	13.9	136	1.23	136		0.0	03	02	15							
275	1	55	7	21.5	129	0.95	145	1	1.0	15	02	03	01	04					
276	1	67	5	10.7	109	1.00	113		1.0	03	06	02							
277	1	58	3	15.6	146	1.15	157		2.0	16	13	03							
278	1	65	3	15.0	148	0.87	148		0.5	19	17	06							
279	2	78	8	03.0	101	1.12	103		0.5	03	01	15	13	02					
280	1	53	5	12.6	137	1.37	149		1.5	03	06								
281	1	63	5	11.7	105	1.04	111	2	1.0	03	06	15	01	02					
282	1	69	5	12.5	120	1.01	129	1	0.5	02	01	16							
283	2	47	7	16.2	158	1.31	158	1	0.0	16	06	15	02	11	17				
284	1	70	3	15.4	148	1.21	148		0.0	03	15								
285	1	70	3	12.7	105	0.97	107		1.0	03	19	06	16						
286	1	73	5	28.1	103	0.85	106		1.5	19	04	02	16	06					
287	1	68	2	20.6	152	1.22	152		0.0	03	06	02							
288	1	71	3	14.1	149	1.17	149		0.0	16	06								
289	1	48	7	19.2	120	0.99	126		1.5	03	02	05	06	01	11	15	12		
290	1	56	7	14.1	138	0.97	138	1	0.0	02	15	17							
291	2	52	8	14.4	105	1.01	105		0.0	03	02	06	12						
292	2	45	7	20.5	129	1.06	141		0.5	02	01	03	11	15					
293	2	56	4	13.0	133	1.22	135	1	1.0	02	15	03	08	17					
294	1	62	5	08.6	117	1.19	117		0.0	03	19	04	16	06	15				
295	2	68	2	06.7	148	1.16	148	3	0.0	03	15	02	12	10					
296	2	70	5	16.2	136	1.05	146		1.0	03	06	15							
297	1	62	2	22.7	120	0.98	120	2	0.0	03	02	20							
298	1	52	3	15.5	090	1.06	090		0.0	15	06	16	17	19					
299	1	53	5	19.6	155	1.14	155		0.0	03	06								
300	1	75	3	15.2	138	0.97	141		1.0	03	15	06	17						

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A	B	C	D	E	F	G	H	I	J	K----->							
301	1	61	3	13.5	139	1.01	139		0.0	06	03	16	19	02			
302	1	57	5	11.7	117	1.00	117		0.0	16	15	02	13				
303	1	54	3	12.5	125	0.84	130		0.5	01	06	16	04	03			
304	1	62	3	10.9	130	1.06	130		0.0	03	16	02	15	17			
305	1	71	5	14.6	111	1.17	113		0.5	01	05	19	03	16			
306	1	66	3	11.8	103	1.03	104	3	2.0	03	15	15	01	13	04	12	10
307	1	54	2	13.6	127	1.06	127		0.0	01	06						
308	1	73	3	11.4	129	1.02	129		0.0	15	17	06	02	03			
309	1	45	3	24.3	163	1.10	163	3	0.0	13	12	03	15	06			
310	1	66	3	14.5	109	1.03	114		1.5	14	16	03	19	17			
311	1	54	6	11.1	120	1.72	120		0.0	03	15	17	02	01	06		
312	1	55	6	13.0	073	1.00	073		0.0	01	03	06					
313	1	79	6	15.0	128	1.06	128	1	0.0	03	15	16	13				
314	1	58	4	07.9	125	1.03	123		0.5	15	01	02	11	05			
315	2	63	3	06.6	095	1.07	102	1	1.0	15	02	03	01				
316	1	63	2	03.6	117	0.95	117	3	0.0	15	02	06	03				
317	1	56	2	20.5	146	1.09	158	3	1.0	03	17	04	08	11	06	16	02
318	1	72	5	17.6	134	1.06	133		0.5	15	05	06	01	19			
319	1	55	5	24.3	154	1.25	154		0.0	03	15	02	06	05			
320	1	52	4	12.0	133	1.06	133		0.5	02	03	15					
321	2	72	5	09.2	125	0.97	129		1.0	03	06	04	02	13			
322	1	43	5	14.1	136	1.10	136		0.0	03	01	02					
323	2	55	7	20.6	153	0.93	163		1.5	03	01	11	12				
324	1	45	3	17.5	113	0.90	120	2	1.5	15	01	05	02				
325	1	70	5	05.2	081	1.09	081	2	0.0	17	04	03	11	16	15		
326	1	55	5	19.7	130	1.17	130		0.0	16	06	13	09				
327	1	77	5	10.1	134	1.35	134		0.0	02	19	03	16	15	10	13	
328	1	62	5	14.7	125	0.91	125		0.0	11	02	06	03				
329	2	65	4	12.9	131	1.00	131		0.5	15	02	03	12				
330	1	50	4	24.6	129	1.33	144		1.5	03	02	04	15	17			

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