6-2005

Fit-To-Fight: Waist vs. Waist/Height Measurements to Determine an Individual's Fitness Level a Study in Statistical Regression and Analysis

Steven J. Swiderski

FIT-TO-FIGHT: WAIST VS. WAIST/HEIGHT MEASUREMENTS TO DETERMINE AN INDIVIDUAL'S FITNESS LEVEL - A STUDY IN STATISTICAL REGRESSION AND ANALYSIS

THESIS

Steven J. Swiderski, B.S.

Captain, USAF

AFIT/GCA/ENC/05-03

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GCA/ENC/05-03

FIT-TO-FIGHT: WAIST VS. WAIST/HEIGHT MEASUREMENTS TO DETERMINE AN INDIVIDUAL'S FITNESS LEVEL - A STUDY IN STATISTICAL REGRESSION AND ANALYSIS

THESIS

Presented to the Faculty

Department of Mathematics and Statistics

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Cost Analysis

Steven J. Swiderski, B.S.

Captain, USAF

June 2005

AFIT/GCA/ENC/05-03

FIT-TO-FIGHT: WAIST VS. WAIST/HEIGHT MEASUREMENTS TO DETERMINE AN INDIVIDUAL'S FITNESS LEVEL - A STUDY IN STATISTICAL REGRESSION AND ANALYSIS

Steven J. Swiderski, B.S.
Captain, USAF

Approved:

Dr. Edward D. White (Chairman)	date
Dr. Michael Hicks (Member)	date
Major Lisa Schmidt (Member)	date

Acknowledgements

I could not have completed this endeavor had it not been for the undying support of my wife. Her patience and understanding are limitless. I thank my daughter for reminding me when it was time to go and play, and I thank my son for reminding what is really important in life. My Family!

Steven J. Swiderski

Table of Contents

Page

List of Figures

List of Tables

Page

AFIT/GCA/ENC/05-03

Abstract

As of January 1st 2004, all Air Force members are to be tested for fitness by measuring their abdominal circumference, counting the number of sit-ups and push-ups they can accomplish, and the time it takes them to run 1 and ½ miles. The abdominal measurement is a "one-size-fits-all" fitness standard. After relying on an extensive literature review that determined there are other measures than the waist measurement to proxy an individual's fitness level, this research determines that a person's waist-to-height ratio is a better measurement than the waist measurement to estimate an individual's fitness level.

This research estimates that all of the variables used to proxy fitness (Gender, Age, Height, Waist Circumference, Waist-to-Height Ratio, Push-Ups, and Sit-Ups) are statistically significant and do represent good estimators of physical fitness. This research also determines that there is a need for separate gender scoring charts for the 1 and ½ mile run, but that these charts do not need to take age into consideration.

This research builds on the current Air Force fitness program by offering a new waist-to-height ratio scoring system. Following the original AFI's cubic trend scoring system both males and females can now be scored on one waist-to-height ratio chart. Finally, this research estimates how well the separate age and gender charts adjust raw fitness scores into points. The results suggest that the charts do adequately adjust a member's raw fitness score into fitness points.

FIT-TO-FIGHT: WAIST VS. WAIST/HEIGHT MEASUREMENTS TO DETERMINE AN INDIVIDUAL'S FITNESS LEVEL - A STUDY IN STATISTICAL REGRESSION AND ANALYSIS

I. Introduction

Problem Statement

The purpose of this research is to statistically test and determine if any statistical correlation exists between a member's fitness level and their waist, height, gender, run time, and height to waist ratio. By applying statistical techniques to the official individual scores for fitness it will be possible to determine if any of the required measurements are statistically significant. This research hopes to determine that there is a better measurement than the waist measurement to determine an individual's fitness level.

Background

The United States Air Force has implemented a new fitness policy. As of January 1st 2004, all Air Force members are to be tested for fitness by measuring the number of sit-ups and push-ups they can accomplish in one minute, the time it takes them to run 1 and ½ miles, and a waist measurement. The score any individual receives for the push-ups, crunches, and run are all scaled to take into account a members age and gender. The waist measurement however is a "one-size-fits-all" scoring system. The only scaled point difference for the waist measurement is determined by gender. For example, a 6 foot 5 inch male, weighing 240 pounds at age 55, must meet the same waist measurement standards as a 5 foot 8 inch male, weighing 135 pounds at age 18. The same "one-size-fits-all" standards hold true for female waist measurements. The goal is to statistically test if the waist measurement or a waist/height ratio is a more accurate and true indicator of an individual's fitness.

Scope and Limitations of the Study

The scope of this study will be to measure and statistically test all AFIT military personnel and students. The limitations are the degree of accuracy of the waist and height measurement and subjective counting for push-ups and crunches.

Research Question

The purpose of this research is to statistically estimate the relationship between dependent variables for fitness level and the independent variables height, gender, age, number of push-ups, number of sit-ups, 1 and ½ mile run time and waist measurement. The research question then becomes, "Is a one-size-fits-all waist measurement or a waist/height measurement ratio a better predictor of an individual's physical fitness level?"

Investigative Questions

1. Are an individual's gender, age, height, weight, waist measurement, waist-to-height ratio, push-up, and sit-up measurements good predictors for physical fitness based on the individual's 1 and ½ mile run time?

2. Can one model be used for everyone vs. using separate tables by looking at waist or waist-to-height ratios?

3. Can this research translate waist measurements into a waist-to-height ratio score table?

4. Do the separate age and gender based scoring charts accurately account for differences in age and gender?

Limitations

This research is going to be limited to analyzing AFIT Air Force military personnel and students. The data will be limited to the collection of official results from the Fit-To-Fight program (AFI 10-248). These data will be age, gender, height, weight, number of push-ups, number of sit-ups, 1 and ½ mile run time, waist measurement and official fitness scores. The scope limitation will be to determine if the independent variables are statistically significant in determining a person's fitness level and if possible how the waist/height ratio measurement can better be utilized in this analysis.

Chapter Summary

This research expands on the current Air Force fitness program (AFI 10-248). The goal is to specifically determine if the anthropometric measurements of the current program are good predictors of fitness, determine if there is a need for separate male and female fitness scoring charts, create a new abdominal circumference scoring system, and test the current age and gender charts for equity. In the following chapter an historical look at DoD fitness is review and medical studies involving different abdominal circumference proxies estimating an individual's BMI are discussed.

II. Literature Review

Chapter Overview

This chapter reviews literature that is applicable to understanding the fitness program in today's United States Air Force. The review includes a description of the physical measures used for determining an Airman's fitness, described in the Air Force's current fitness instruction (AFI 10-248), and highlights studies which prompted the use of a waist measurement. The recent need for an effective physical fitness program evolved from Department of Defense directive (1308.1) which states that individual service members must possess the stamina and strength to perform, successfully, any potential mission. The directive mandated each US military service develop a quality fitness program that improves readiness and increases combat effectiveness of their personnel.

History of Fitness in the DoD

The 20th century symbolized the beginning of a new era of fitness leaders: the Presidents of the United States. Theodore Roosevelt led the nation into the new century. Focused on fitness, he recognized the importance of exercise and physical activity, and had the power to encourage the citizens of America to be physically active. President Roosevelt's desire for physical fitness evolved out of his childhood battle with asthma, which he overcame with a rigorous exercise program. As President, he engaged in multiple forms of physical activity including hiking, horseback riding, and other outdoor endeavors. Although not all the Presidents following Roosevelt have held fitness in the same high regard, they recognized that the position required a commitment to the fitness of the Military of the United States (Karolides, 1993).

World War I

In Europe, the First World War started in August of 1914, with the entrance of the United States occurring three years later in 1917. With the United States' entry into the battle, hundreds of thousands of military personnel were drafted and trained for combat. After the war was fought and won, statistics were released from the draft with disturbing data regarding fitness levels. One out of every three drafted individuals was unfit for combat and many of those drafted were highly unfit prior to military training (Whest, 1995 and Barrow, 1998). Government legislation was passed that ordered the improvement of physical education programs within the public schools. However, the heightened interest and concern regarding low fitness levels would be short-lived as the United States entered the 1920s and the Depression.

In October of 1929, the stock market crashed, signaling the beginning of what would be a decade of economic depression. The economy failed to recover until the United States entered World War II in 1941. Along with many other aspects of life, fitness levels declined during the Depression. The gains that physical education programs made through the passage of legislation following World War I were short-lived. Funding for these programs became limited and eventually was exhausted as emphasis in the poor economy was forced to shift elsewhere (Welch, 1996 and Rice, 1958).

World War II

Throughout world history, military conflicts have had major impacts on the state of fitness. The Second World War and its aftermath in the United States would be no different. The United States entered World War II with the bombing of Pearl Harbor on December 7, 1941. With the declaration of war came the necessity to draft military personnel. However, as more men were drafted, it became clear that many of them were not fit to fight. When the war was over, it was reported that nearly half of all draftees needed to be rejected or were given non-combat positions (Rice, 1958). Nearly 900,000 of 2,000,000 men tested were rejected for military service because of mental and physical defects, and physicians estimated that of all the defects noted: "ninety percent were preventable. Moreover, even the boys who pass the examination are not vigorous enough, alert and strong enough for some of the Special Forces" (Williams, 1948:25).

1950s – Korean War

Further indications of poor physical condition among Americans came during the Korean War. Despite improvements in diet and medical care throughout the United States following World War II, nearly 50 percent of the American men attempting to enter the military service for the Korean War could not meet the minimum physical fitness test standards (Department of the Air Force, 1961:5). The era was marked by the development of an important factor influencing the modern fitness movement known as the "Minimum Muscular Fitness Tests in Children" by Kraus-Hirschland (Kraus, 1954). This study utilized the Kraus-Weber tests to measure muscular strength and flexibility in the trunk and leg muscles. It was reported that close to 60 percent of American children failed at least one of the tests. During the Cold War, these startling numbers launched political leaders into action to promote health and fitness.

When results of the Kraus-Hirschland studies were reported to President Eisenhower, he responded by holding a White House Conference in June of 1956. Out of these meetings came two important results: 1) the formation of the President's Council on Youth Fitness and 2) the appointment of the President's Citizens Advisory Committee on the Fitness of American Youth (Nieman, 1990). During the 1950s, many organizations took the initiative in educating the general public about the consequences of low fitness levels. Several agencies that have been involved in fitness promotion since the mid-1950s include the American Health Association (AHA), the American Medical Association (AMA), the American Association for Physical Education, Recreation, and Dance (AAPHERD), and the President's Council on Youth Fitness (Barrow, 1988). Additionally, the American College of Sports Medicine (ACSM) was formed in 1954, and has proved to be one of the premier organizations in the promotion of health and fitness to American society.

1960s

Presidential involvement in physical fitness was renewed in 1963. President John F. Kennedy enlarged the scope of the President’s Council on Youth Fitness. He changed its name to the President’s Council on Physical Fitness, and did much to awaken Americans to the importance of physical fitness. Kennedy spoke openly about the need for American citizens to improve their fitness levels; including writing an article in Sports Illustrated entitled "The Soft American." He said, "We are under-exercised as a nation; we look instead of play; we ride instead of walk" (Kennedy, 1960:16-17).

Kennedy prompted the federal government to become more involved in national fitness promotion and started youth pilot fitness programs. Kennedy's commitment to fitness can best be summarized when he said, "Physical fitness is the basis for all other forms of excellence" (Kennedy, 1962:12-15).

Following President Kennedy’s guidelines, Dr. Ken H. Cooper is generally credited with encouraging more Americans to exercise than any other individual in history. Cooper advocated a philosophy that shifted away from disease treatment to one of disease prevention. "It is easier to maintain good health through proper exercise, diet, and emotional balance than it is to regain it once it is lost," he said. Cooper’s book, *Aerobics*, released in 1968, sent a powerful message to the American people - to prevent the development of chronic diseases, exercise regularly and maintain high fitness levels throughout life (Cooper, 1968:36). Dr. Cooper’s message, programs and ideas based on endurance and oxygen utilization established the model from which fitness has proliferated up to modern time.

Lessons from History

The history of fitness portrays some themes that relate closely to the 21st century. There has been and still is a strong association of military and political might with physical fitness. This shows how important our leaders’ attitudes on fitness can be in regards to health and fitness especially in the military. This review of literature has encompassed nearly 100 years of exercise and fitness throughout American and military history. Understanding how out of shape Americans have been emphasizes why our military now has specified training programs and tests for compliance. The following information describes the present military physical fitness testing programs for each branch of the military.

Army

The directive that governs the Army Physical Fitness program is Field Manual 21-20, Physical Fitness Training (1998). The manual is very complete covering topics like, leadership responsibility, components of fitness, proper exercise techniques, nutrition, environmental considerations, etc. The Army program mandates vigorous, regular (3-5 times a week) physical training and directs unit commanders to lead the training. The Army also dedicates time and effort developing and training fitness experts. The Army offers a four-week training program covering all aspects of physical fitness training and how a soldier's body functions. After completing the training program, the selected individuals are called Master Fitness Trainers and they become responsible for training others in the area of fitness while helping ensure units conduct sound, safe physical fitness training. The Army physical fitness test is used to get an accurate evaluation of a soldier's fitness level and is accomplished twice each year by all Army personnel. The evaluation involves a weigh-in, push-ups, sit-ups and a two-mile run.

Navy

The Navy program is governed by Navy Instruction 6110.1E (1998). Like the Army guide to fitness, the instruction clearly states the importance of every Navy member maintaining personal fitness by participation in regular exercise. The instruction mandates that commanders aggressively support the goal of attaining and maintaining fitness by requiring a minimum of three aerobic exercise periods per week. It further stipulates the periods must be 40 minutes to allow for proper warm-up and cool-down with at least 20 minutes of continuous aerobic activity. The Navy fitness evaluation, which is conducted twice each year, includes a weigh-in, a sit and reach flexibility test (individuals must - in a sitting position with legs straight, flat on the floor, touch their toes), sit-ups (curl-ups), push-ups and a 1.5 mile run (or a 500 yard swim).

Marines

The Marine Physical Fitness Program is governed by Marine Corps Order 6100.3J Physical Fitness (1988) and Marine Corps Order 6100.10B Weight Control and Personal Appearance (1993). The Marine program is very similar to the Army and Navy Programs. The orders stress the importance of physical fitness as essential to the day-to-day effectiveness and combat readiness of the Marine Corps, as well as, an indispensable aspect of leadership. The program specifically mandates every Marine will participate in physical training at least 3 hours a week (3 exercise periods). The Marine fitness evaluation is administered twice every year. The test includes pull-ups for males (flex arm hang for females), sit-ups and a 3 mile run (1.5 mile run for females). Every Marine under the age of 46 must participate in the testing.

History of Fitness in the Air Force

This section of the literature review describes the history of the Air Force physical fitness program. The goal of looking at the past is to determine how we developed today's Air Force fitness standards and the current Air Force Instruction on Fitness (AFI 10-248).

Air Force Regulation (AFR) 50-5, published in November 1947 was the first Air Force publication regarding physical fitness. The regulation only contained three paragraphs and stated (Department of the Air Force, 1947:1): that all Air Force fitness programs were designed to:

1) Develop and maintain a high level of physical fitness in the individual so that he can perform more efficiently his assigned duties.
2) Encourage regular and healthful exercise.
3) Foster an aggressive and cooperative team spirit, increase the confidence of the individual, develop sportsmanship, and increase pride throughout participation in competitive athletics.

This AFR focused on building spirit and health, but did not focus on a standard level of fitness, provide guidance to commanders, require a test, or specify how official reports were to be kept. AFR 50-5 served as the basis for the Air Force physical fitness program from 1947 through 1959.

A comprehensive study by Balke and Ware in 1959 involving 500 male Air Force and civilian personnel concluded that (Balke, 1959:9): On the basis of the experimental findings it can be concluded that the overall state of physical fitness in the Air Force is "poor" and that the Air Force physical fitness program, as it now stands, is ineffective. In 1959 the findings from the Balke and Ware study prompted a revision to AFR 50-5. The revision directed commanders to establish physical conditioning programs, establish weight limits, and prescribe regular weekly exercise. Again the revised AFR 50-5 contained no standard program or prescribed levels of physical fitness (Department of the Air Force, 1959:1-10).

In 1961 the Air Force published Air Force Manual (AFM) 160-26, Physical Conditioning. This AFM was published to give commanders more guidance on how to establish their physical fitness programs. The manual stated (Department of the Air

Force, 1961:13): It is the commander's responsibility to see that his men are developed to a point of maximum fitness physically, psychologically, and socially so that every man can contribute fully to the Air Force mission. The manual was again written as guidance for commanders and did not specify any standard Air Force fitness level or program.

In 1962 increased emphasis on national and military health prompted the Air Force to adopt a new fitness program. The model program was adopted from the Royal Canadian Air Force Five Basic Exercises (5BX) Plan as the new official Air force physical conditioning program. Air Force Pamphlet (AFP) 50-5-1 (5BX) for men, and AFP 50-5-2, Ten Basic Exercise Plan (XBX) for women, became the new governing regulation. The 5BX program consisted of 5 simple exercises to include 1) Forward bending to touch the floor, then straighten up and stretch backward, 2) Lying on your back sit up just far enough to see your heels, 3) Lying face down with palms under your thighs lift your head and one leg then alternate, 4) Lying face down with palms on the floor under your shoulders straighten your arms keeping your knees on the ground then raise your legs completing the push up and return to the floor, and 5) stationary running. All repetitions of the 5 exercises must be accomplished in eleven minutes.

The design was to aid in the development of the skeletal muscles, the heart, and the lungs while progressively increasing the level of difficulty until a desired level of physical fitness was achieved. The required level was to be maintained by directing exercise three times a week. AFP 50-5-1 describes the 5BX program as (The Royal Canadian Air Force 5BX Plan for Physical Fitness, 1962:4):

> Simple because it is easy to do, easy to follow. Progressive because you can develop your own personal fitness at your own rate, to your required level, without getting stiff or sore muscles. Balanced because you condition your muscles, your heart and lungs together for your daily needs. Complete because the principles of muscle and organic development are applied simultaneously and progressively. Self-measuring because it gives you clear-cut "targets for fitness" for your age and body build, along with graduated standards for checking your fitness. Convenient because you can do these exercises any place at your own convenience, without gadgets.

The 5BX program additionally established guidelines and standards, demanded specific performance levels, required an annual evaluation and written records and reports.

In 1963, Air Force representatives met with researchers from Indiana University to discuss the progress of the 5BX program. The group identified a lack of emphasis on the importance of physical activity, an excessive failure rate, and unsatisfactory testing (Air Force Military Personnel Center, 1963:1-4). The study group recommended the deletion of exercise three entirely (lying on your stomach and lifting your head and legs), altering exercise two (sitting up to see your ankles) to make it safer by keeping the knees bent, and the lowering of the required physical standards for each age group. In 1965 a revised 5BX program incorporated the recommendations from the study group.

In the late 1960's Dr. Kenneth H. Cooper, at the time an Air Force flight surgeon, was conducting extensive tests of volunteers on a treadmill. Cooper found that the total amount of energy the human body is able to produce before exhaustion (endurance capacity) is correlated very closely with the body's ability to consume oxygen (Cooper, 1968,:47). By relating oxygen consumption and body weight, Cooper proved that the ability to process and use oxygen is directly related to physical condition and can be used as a measurement of physical fitness.

In 1967 Dr. Cooper presented his aerobics plan to the Air Force Chief of Staff (Cooper, 1967:2-25). After evaluation, the USAF Aerobics Physical Fitness Program (AFP 50-56) was implemented in November of 1969. AFP 50-56 states (Department of the Air Force, 1969:2):

> The purpose of the aerobics conditioning program is to develop a higher level of fitness among airmen of all ages by providing an easily followed, interesting, and somewhat demanding program. The exercises are only those that stress the heart and lungs, thereby producing a desirable training effect. The time required for daily exercise is not excessive, but the program does require faithful participation. Many types of exercises and exercise programs have been studied, but the conclusion has invariably been that it is impossible to reach a satisfactory level of fitness without working hard at it. All of the 60-second-a-day exercise programs have proven worthless in improving the condition of the heart and lungs. Consequently, exercise programs must be both vigorous and long enough to produce a valuable conditioning response.

The program required semi-annual testing and required Air Force members to run 1.5 miles for time. There were five fitness categories (I-Very Poor, II-Poor, III-Fair, IV-good, V-Excellent) established and members were placed in one of the categories based on their age and run time.

In 1971, the Air Force published Air Force Manual 50-15, Change 3, Physical Fitness. This was a remedial conditioning program for those members that failed to achieve category III (Fair). This in essence established category III as the pass or fail level (Department of the Air Force, 1971:6).

In 1972, the Air Force physical fitness program, AFM 50-15, was replaced by Air Force Regulation (AFR) 50-49, USAF Physical Fitness and Weight Control Program (Department of the Air Force, 1972). AFR 50-49 renamed the fitness categories (I-Poor, II-Fair, III-Average, IV-Good, V-Excellent), changed required testing from semi-annually to annually, and reduced the passing level from Category III to Category II.

AFR 50-49 also exempted individuals over age 45 from the fitness requirement, and established minimum, ideal, and maximum allowable weights based on age and height.

In May 1973, the Air Force Surgeon General's office reported a large number of members reporting for physiological training were overweight and had respiratory problems. Commanders were again reminded of their responsibility for the weight and fitness of the members under their command (Susi, 1974:12).

In 1977, AFR 50-49 was changed to Air Force Regulation 35-11, Air Force Physical Fitness Program (Department of the Air Force, 1977). The new AFR made no significant changes to the pre-existing AFR.

In 1978, an Air Force study group convened to study the fitness program. They concluded that "the Air Force does not have a viable program" (Bennington, 1978:12). The study group recommended an unsupervised conditioning program during off-duty hours and an annual test for all members. According to researchers, "the study group, it appears, recommended a program which they previously concluded was not viable."

In 1979, a number of fatalities (4 to 5 on average annually) during the run test led the AF Surgeon General to recommend changes to AFR 35-11. Personnel over age 35 were tested using a 3-mile walk rather than the 1.5 mile run. This change was not popular, and by 1980, all personnel were permitted to run rather than walk for the annual fitness test.

In 1981, AFR 35-11 was changed and indicated that members could choose to walk 3-miles, run 1.5 miles, or run on a treadmill. Except for a small reduction in the standard time allowed to complete the run (in October 1989) the Cooper aerobic test remained the only Air Force measure of physical fitness until the adoption of the stationary bike test in October 1992. The run did not appear to be an accurate measure of fitness and that overexertion by some on the run led to several deaths per year.

In October 1992, the Air Force began testing with a new procedure for measuring fitness based on a cycle ergometry test. The Air Force program was governed by two Instructions, Air Force Instruction 40-501 Air Force Physical Fitness Program, and AFI 40-502 The Weight and Body Fat Management Program. Both instructions focus on the annual evaluations that are required, an annual weigh in and a cycle ergometry test. The instructions stress the importance of all Air Force members being physically fit to support the increasing and changing requirements of the Air Force mission. The instruction does not, however, mandate exercise periods but leaves the method and responsibility of achieving and maintaining physical fitness up to each individual. The annual fitness evaluation was used as an indicator of an individual's fitness level and to motivate members to participate in a year round physical conditioning program emphasizing aerobic fitness. The evaluation program involved each member completing a cycle ergometry test once a year.

It has been documented that a good measure of aerobic fitness is how well a body takes up oxygen and is able to use the oxygen. A fit person can take up and deliver oxygen very efficiently. When a body is subjected to increased aerobic workloads, oxygen uptake will increase until a maximum quantity of oxygen uptake is reached (Hunn, 2002: p. 5). When a maximum oxygen uptake level is reached the workload may increase but oxygen uptake will not. This is the point called maximal oxygen uptake or VO_2max (Mitchell and Blomquist, 1971: 1018). Maximal treadmill tests are the most accurate way to measure an individual's VO_2max. The tread mill can regulate speed and grade of the workout and requires individuals to run at increasing workloads until exhaustion. Measuring VO_2max with this test requires about 3-4 man hours, the presence of medical personnel and is very expensive (Smith and Flatten, 1997). There are a number of maximal test protocols, but about 71% of all tests administered in the United States use the Bruce protocol (Jackson and Ross, 1996: 267). The Bruce protocol VO_2max is estimated by a regression equation and is based on total treadmill time. Treadmill speed and grade are increased in 3 minute increments until the individual reaches exhaustion. The Bruce regression equation is as follows:

$$\mathbf{VO_2max = 13.30 - (0.30 \times TT) + (0.297 \times TT^2) - (0.0077 \times TT^3) + (4.2 \times CHS)}$$

TT = treadmill time   CHS = cardiac health status

The submaximal cycle ergometry test (SCET) was designed to measure how efficiently the heart and lungs work as a machine to transfer oxygen to the muscles. Submaximal tests are faster, safer and cheaper. However, submaximal test have been found to be less accurate than maximal tests (Hermansmen and Saltin, 1969: 33; Jackson and Ross, 1996: 267). Submaximal tests based on heart rate tend to estimate VO_2max only within 10-20% of maximally determined VO_2max scores (Pollock, 1994:20).

Over the last 60 years the Air Force physical fitness program has evolved from the simple three paragraph guidance in AFR 50-5 through the 5BX and XBX programs, away from the sit-ups, push-ups and run, and into the cycle ergometry test and body weight management program. Today the Air Force has placed its fitness goals on AFI 10-248 and gone back to basic measures of push-ups, sit-ups, 1 and ½ mile run, and waist measurement. This decision to go back to the basics was brought out by the Air Force Chief of Staff, General John P. Jumper. He wrote that (Callender, 2004: 70)

> "We deploy to all regions of the world," Airmen are "living in tent cities and working on flight lines in extremes of temperatures. Some of our Airmen today are operating inside Iraq, subject to attack, and could be called upon to help defend the base, a trend that will surely increase in the growing expeditionary nature of our business. The amount of energy we devote to our fitness program is not consistent with the growing demand of our warrior culture," "It's time to change that."

It should be noted that, although the new program restores the 1 and ½ mile run for most members, there are provisions for excluding some. These exclusions are basically for safety reasons and the Air Force is especially concerned about persons with cardiac problems.

Air Force Fitness in 2004

At present the physical fitness regulation governing all United States Air Force personnel is Air Force Instruction 10-248, The Air Force Fitness Program. Compliance with this instruction was mandatory as of January 1st 2004, by order of the Secretary of the Air Force. This instruction supersedes all guidance provided by AFI 40-501, Air Force Physical Fitness Program and AFI 40-502, The Weight and Body Fat Management Program. This instruction states (Department of the Air Force, 2004:1):

> All members of the Air Force must be physically fit to support the Air Force mission. Health benefits from an active lifestyle will increase productivity, optimize health, and decrease absenteeism while maintaining a higher level of readiness. The goal of the Fitness Program (FP) is to motivate all members to participate in a year-round physical conditioning program that emphasizes total fitness, to include proper aerobic conditioning, strength/flexibility training, and healthy eating. Commanders and supervisors must incorporate fitness into the AF culture to establish an environment for members to maintain physical fitness and health to meet expeditionary mission requirements and deliver a fit and ready

force. The annual fitness assessment provides commanders with a tool to assist in the determination of overall fitness of their military personnel.

AFI 10-248 requires Wing Commanders or equivalents to provide an environment that supports and motivates a healthy lifestyle through optimal fitness and nutrition. In essence the Wing Commander is to provide adequate physical fitness facilities and healthy food to all the base members. The Medical Group Commander must ensure qualified staffs provide evaluation and appropriate behavior modifications, nutrition, and fitness education for the FP. The installation's Services Commander is required to ensure adequate staff, facilities, and other resources to support fitness and sports operations on base.

Unit and Squadron Commanders must lead the fitness program. They must also provide a work environment that is supportive of nutrition and fitness by providing access to healthy foods and time to exercise during duty hours. Commanders must implement and maintain a unit/squadron PT program. Commanders must also offer a unit-based program three times a week, ensure all members are permitted up to 90 minutes of duty time for physical training three to five times weekly, administer personnel actions to members not in compliance with the standards, and appoint a unit physical training leader to conduct unit PT and fitness assessments during the body composition assessment, push-ups, sit-ups, and the 1 and ½ mile run.

AFI 10-248 specifically lays out required fitness standards for all Air Force personnel. The AF now uses a composite fitness score based on aerobic fitness, muscular strength and body composition to determine overall fitness. A composite score of 70 represents the minimum accepted health, fitness and readiness levels. To determine composite scores, age and gender-specific score charts were created and are used to calculate an individual's score. These can be found in Appendix A. Members will receive a composite score on a 0 to 100 scale based on the following maximum component scores: 50 points for aerobic fitness assessment (1.5 mile run), 30 points for body composition (abdominal circumference), 10 points for push-ups, and 10 points for crunches. The score is determined by the following formula:

$$\text{Composite Score} = \frac{\text{Total component points achieved}}{\text{Total possible Points}} \times 100$$

Component	Aerobic Fitness	Abdominal Circumference	Push-ups	Crunches
Possible Points	50	30	10	10

Table 1 – Fitness Score Components

Scoring for waivers/exemptions will be conducted only if the member has a medical profile prohibiting them from performing one or more components of the fitness assessment. Abdominal circumference will be performed on all members, unless exempted by health provider.

Examples: (Department of the Air Force, 2004:15)

1) Member exempted from push-ups: If member receives 40 points for aerobic fitness, 24 points for abdominal circumference and 8 points for crunch test; the total component points achieved equal 72. Possible points from aerobic fitness, abdominal circumference, and crunch test equal 90 points. Composite score is (72/90) X 100 = 80 points.

2) Member exempted from aerobic fitness: If member receives 21 points for abdominal circumference, 9 points for push-ups and 7 points for crunch test; the total component points achieved equal 37. Possible points from abdominal circumference, push-ups and crunch test equal 50 points. Composite score is: (37/50) X 100 = 74 points.

3) Member exempted from aerobic fitness, push-ups and crunch test: If member receives 21 points for abdominal circumference; the total component points achieved equal 21. Possible points from abdominal circumference equal 30 points. Composite score is: (21/30) X 100 = 70 points.

Composite scores represent a health-based fitness level. The four fitness levels are:

1)	Excellent. Composite score ≥ 90
2)	Good. Composite score 75 – 89.99
3)	Marginal. Composite score of 70 – 74.99
4)	Poor. Composite score < 70

Table 2 – Fitness Levels

Frequency of fitness testing is based upon a member's previous fitness score. Excellent and Good test within 12 months. Marginal score must test within 180 days. Poor must test within 90 days, but not during the first 45 days. The new AFI is 66 pages and covers who is responsible for what, and how each exercise and measurement must be performed and scored. All scores for the 1.5 mile run, sit-ups and crunches are based on the member's age and sex from the tables found in Appendix A, or by the previously presented calculations.

Clinical Studies on Fitness and Abdominal Circumference

Abdominal Circumference

This part of the literature review is not an in-depth analysis of medical terminology and scientific medical studies on visceral adiposity (abdominal and internal fat). It is being presented to provide an understanding of why the Air Force has decided to use an abdominal circumference measurement in determining an individual's level of fitness. That is, the abdominal circumference is the one test that does not take into account a member's age or height. This abdominal circumference measurement has become the "one-size-fits-all" fitness standard.

There are literally hundreds of medical studies on the relationship between an individual's abdominal circumference and how this measurement relates to their well being. The following studies support the Air Forces' decision to rely on a waist circumference measurement to determine one's health level.

A 2002 study in the *American Journal of Clinical Nutrition*, indicates that "a cross-sectional study, which supports the consistent conclusion from a large body of literature that waist circumference (WC) is at least as strong as is a body mass index (BMI) in predicting cardiovascular disease" (Lean, 2002:699). The report goes on to claim that men with a WC > 94 cm and women with a WC > 80 cm would virtually identify anyone with a BMI > 25. While a WC > 102 cm for men and > 88 cm for women would identify everyone with a BMI > 30. This study correlates well with the Air Forces decision to drop the Weight and Body Fat Management Program and rely on WC measures as a means of determining one's health.

A second study by the New York Obesity Research Center at Columbia University found that the risk of health problems increase at a waist measurement of 35 inches for women and 40 inches for men. It also indicated that health concerns begin to start at a waist measurement of 33 inches for women and 35 inches for men (Waist Management, 2003).

One final study by the Nation Institute of Health indicates that physicians are advised to determine a patient's waist circumference. A WC over 40 inches in men and 35 inches in women signifies an increased health risk in those that have a BMI of 25 to 34.9 (Pi-Sunyer, 1998:1). These studies as well as many others in the field of health and nutrition make a direct correlation to abdominal obesity and a high BMI.

Neck Circumference

There are also studies that have found other measures of the body to determine one's health. A study in the March 2003 edition of the *Nutrition Research Newsletter*, identified that neck circumference has been found to be a simple and time saving screening method that can be used to identify overweight and obese people. There was a high correlation among neck size and factors of cardiac risk. In their research it is determined that men with a neck circumference < 37 cm and women with a neck circumference < 34 cm also have low BMI's (Ben-Noun, 2003:1).

Waist-to-Hip Ratio

According to the National Institute of Diabetes and Digestive and Kidney Disease it is possible to use a waist-to-hip ratio to determine one's fitness. The Institute published that women with a waist-to-hip ratio of more than 0.80 are at increased risk of health, and men with a waist-to-hip ratio of more than 1.00 are at increased risk because of their fat distributions (Waist-to-Hip, 2004).

A second study found in the October 2004 issue of *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* looked at a waist-to-hip ratio as a better screening measure of cardiovascular risk factors. The goal of these researchers was to identify the best anthropometric index (BMI, waist circumference, waist-to-hip ratio, and waist-to-height ratio) in any population to predict coronary disease risk. A population-based cross-sectional study looked at 4,449 Tehranian men aged 18 to 74 years. In the 18-34 year age category the following cut-offs were estimated: BMI 24, waist-to-hip ratio 0.86, waist-to-height ratio 0.47, and waist circumference 81 cm. In the 35-54 year age category the cutoff points were 26, 0.91, 0.52, and 89 cm respectively. In the 55-74 year age category the cutoff points were 26, 0.95, 0.54, and 91 cm respectively. The results indicate the mean age of men was 41.8 +/- 15.4 years; the mean for BMI was 25.6 +/- 4.2; the mean for waist-to-hip ratios were 0.91 +/- 0.07; the mean for waist circumference were 87.7 +/- 11.7 cm; and the mean for waist-to-height ratio were 0.51 +/- 0.02. All indexes had a significant association to cardiovascular disease, but the waist-to-hip ratio had the highest correlation coefficients amongst the variables. It was concluded that waist-to-hip ratio is a better predictor of cardiovascular disease than BMI, waist circumference and waist-to-height ratios for Tehranian men (Esmaillzadeh, A., et al, 2004: 1325-1332).

Waist-to-Height Ratio

Finally there are also medical studies that use a waist-to-height ratio to determine one's health. The waist-to-height ratio is calculated by dividing waist size by the height of an individual. Some interesting waist-to-height ratios can be found on the internet. Some of the more interesting ones are:

SUBJECTS	WAIST-TO-HEIGHT RATIO
Barbie Doll	0.2500
Ken Doll	0.3600
Female College Swimmer	0.4240
Male College Swimmer	0.4280
Body Builder	0.4580
Female at increased risk	0.4920
General healthy cutoff	0.5000
Risk equivalent to BMI of 25	0.5100
Males at increased risk	0.5360
Risk equivalent to BMI of 30	0.5700
Obese	0.5770
Substantial risk increase	0.5820

Table 3 – Internet Waist/Height Ratios

In the November 2003 issue of *Public Health and the Environment*, Dr. Henry Kahn and others determined that a waist-to-height ratio is a good predictor of BMI. Regardless of sex and age, his cross-sectional, weighted sample estimated the risk factors as high if one's waist-to-height ratio was greater than 0.543 and only moderate between 0.498 and 0.543 (Kahn, 2003).

A study in the *Nippon Rinsho: Japanese Journal of Clinical Medicine* looked at various anthropometric indices (BMI, waist circumference, and waist-to-height ratio) to find a simple method for assessing the risk of metabolic syndrome. Waist-to-height ratios correlated more closely than any other index to the sum of 4 or 5 coronary risk factors. A waist-to-height index greater than 0.5000 was capable of identifying approximately all overweight individuals and also identified more individuals of normal weight as at risk than any other measure of central fat distribution. Even normal-weight subjects with a waist-to-height ratio greater than 0.5000 demonstrated significantly higher risk for 2 or more coronary risk factors than those individuals with a waist-to-height ratio less than 0.5000 (Hsieh, Shiun Dong and Takashi Muto, 2004: 1143-1149).

A study in the November 2000 issue of *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity*, determined waist-to-height ratios are a better predictor of cardiovascular disease in children than BMI. Waist-to-height ratios have been used as a proxy measure of visceral adipose tissue, mainly in adults. The objective was to validate BMI, waist circumference and waist-to-height ratio as predictors for the presence of cardiovascular risk factors in children. Their conclusions were that waist circumference and waist-to-height ratios are better predictors of cardiovascular disease in children than BMI (Savva et al, 2000: 1453 – 1458).

A second study in the November 2002 issue of *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity*, determined the optimal cut-off values of four anthropometric indices (BMI, waist circumference, waist-to-hip ratio, and waist-to-height ratio) to estimate cardiovascular disease risk factors. Data was collected on 26,359 Asian men and 29,204 Asian women with a mean age of 37. Individual body weight, height and waist circumference and a series of tests related to cardiovascular risk were assessed and their relationships were examined. Of the four indices studied, waist-to-height ratios were found to have the largest areas under the curve relative to at least one risk factor. The conclusions are that waist-to-height ratios may be a better indicator for screening overweight or obesity-related cardiovascular disease risk factors than the other three indexes (BMI, waist circumference, and waist-to-hip ratio) The optimal cut off values for overweight or obesity waist-to height ratios were 0.4800 for men and 0.4500 for women (Lin, W. Y.,et al, 2002: 1232-1238).

According to a study in the May 2003 issue of *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity*, researchers, hypothesized that the waist-to-height ratio can be used to identify subjects who are at higher metabolic risk within the normal as well as the overweight range. The researchers compared the values for BMI, waist circumference, and waist-to-height ratios for 6141 men and 2137 women at various age levels. The researchers found that for various indexes in all age groups; the gender ratio for waist-to-height was closest to 1. They determined that a single set of values for waist-to-height ratios can be used for men and women. For both men and women, the highest correlation coefficient was between waist-to-height ratio and the morbidity index for coronary risk factors. Nearly all overweight men and women (BMI ≥ 25) had waist–to-height ratios ≥ 0.5000 (98% of men and 97.5% of women). The conclusions are that waist circumference is improved by relating it to height to categorize fat distributions of different genders and ages (Hsieh, S. D., et al, 2003: 610-616).

A study in the February 2005 issue of *Preventive Medicine* looked at the superiority of the waist-to-height ratio as an anthropometric index to evaluate clustering of coronary risk factors among non-obese men and women. Researchers compared BMI, waist circumference, and waist-to-height ratios for 4,668 men and 1,853 women with a BMI < 25 as indices for estimating coronary risk factors. The researchers found that the sum of all coronary risk factors correlated positively with all the indexes, with the closest correlation found for waist-to-height ratios. Among the various proposed indexes the evaluation of risk factors were highest for a waist-to-height ratio greater than 0.5000. They concluded that waist-to-height ratio is more sensitive than BMI or waist circumference alone to evaluate coronary risk factors among non-obese men and women (Hsieh, S. D., et al, 2005: 216-220).

Chapter Summary

This literature review has covered the physical fitness history of the United States, DoD, and the history of Air Force physical fitness programs. It is presented to describe where we have been, how we got here, and where we are headed in the future, as far as physical fitness in the United States Air Force is concerned. From the turn of the century through World War I and II, the Korean War, Vietnam, Desert Storm and on into today it can be determined that physical fitness in the military, especially the Air Force, has not been a top priority.

This thesis is not specifically written to provide a complete historical record of fitness in the United States, DoD, and the Air Force. It is specifically written to look at the present Air Force Fitness Program (AFI 10-248) and statistically estimate if there is a different scoring system to estimate an individual's fitness level. This thesis will determine if the current waist measurement can be improved upon by estimating cardiovascular risk with a waist-to-height ratio. Airmen are ultimately responsible for their fitness, and they deserve to know if the standards are fair and equitable. The "one-size-fits-all" abdominal circumference measurement is what's at the heart of this research.

III. Analysis

Chapter Overview

This chapter will explain the hypothetical relationships between the anthropometric variables, the statistical procedures used to estimate and conduct this research, and the results of the statistical estimations. It begins with a list of all the variables used throughout this research and then proceeds to discuss how and where the data were collected. It goes further to discuss how the original data was scrubbed to come up with the final data set. Next graphical and summary statistics of the data are presented. The analysis measures how all the variables are related and suggestions are made as to which variables should be included in the models. The chapter then discusses the regression analysis performed to test hypotheses. Finally, interpretations of all regressions will be discussed. All statistical analysis and hypothesis testing is performed at an alpha value of 0.05.

A word of caution is in order. Data in the area of fitness scores and measurements is fragmented and comes from a variety of fitness testing personnel. All of the measurements for individual's push-ups, sit-ups, and waist measurements were measured and calculated by different individuals. One fitness tester may have different standards for counting push-ups, another tester may allow some slight hip thrust on sit-ups, and all fitness testers use a different degree of pressure and location on measuring the abdominal circumference. The one truly accurate measure of fitness is the measured time for the 1 and ½ mile run. Any findings suggested in this report should be viewed in this light.

Variable Names

Throughout the remainder of this paper there will be a number of personal fitness measurement variables presented and explained. The entire list of personal fitness variables, what they measure, and how they were calculated is relayed in Table 4.

AGE	Actual age at time of testing
FTSC	Total calculated fitness score
FTSC-WAIST	Total calculated fitness score minus points for waist measurement
HT	Height measured to the closest half of inch
PU	Number of push-ups completed in one minute
RUNS	1 and ½ mile run time converted to seconds
RUNT	1 and ½ mile run time reported in minutes and seconds
GENDER	Male =1, Female = 0
SU	Number of sit-ups completed in one minute
WAIST	Avg. abdominal circumference rounded down to nearest ½ inch
WAISTPTS	Total points scored for the abdominal measurement
WAIST/HT	Ratio of abdominal circumference to height
WT	Weight at time of testing measured to nearest ½ pound

Table 4 – Variable Descriptions

Data

To understand the regression results it is necessary to describe how the dependent and independent variables are measured and/or were created. It is also important to explain all of the transformations made to these variables. This will allow any future researcher to estimate the fitness measurement variables in the same manner. All of the personal fitness data was gathered between January 1st 2004 and October 27th 2004. It was transcribed from individual personnel information files inside the AFIT orderly room. All data points were gathered after completing the required Human Subjects Data exemption (see Appendix B). The data contained in this thesis is restricted to AFIT Air Force military members to include faculty, staff, and students. The data is reported as raw numbers of actual physical repetitions performed and measured. This data represents the number of completed repetitions not the fitness score gained for the number of exercises completed.

The original data collection process included measurements on 628 individuals. Some individuals were exempt from one or more of the required exercises or measurements due to physical limitations and/or restrictions. It was necessary to remove 36 incomplete data sets. These individuals were missing one or more fitness variables so they could not be used in the overall statistical analysis. These 36 data points comprised 5.7% of the entire original data set leaving 592 suitable data points. The most common omission was the individual's age. This measurement is required to determine an individual's total fitness score, but it was not recorded on the official fitness score sheet. It is most likely that the tester who scored the individual knew the individual's age and was able to calculate an accurate score but failed to record the age.

The following histograms and summary statistics will aid in the understanding of how all the variables were measured and what the data looks like.

Gender

The variable GENDER is simply used as a dummy variable to capture any difference in the regression results that are estimated due to an individual's gender. This variable is represented by a 1 for males, and a 0 (zero) for females. The complete data set consists of 523 males (88%) and 69 females (12%).

Age

The variable AGE is simply the age of the individual at the time the fitness test is administered. This variable is used to calculate fitness scores for the push-ups, crunches, and 1 and ½ mile run time.

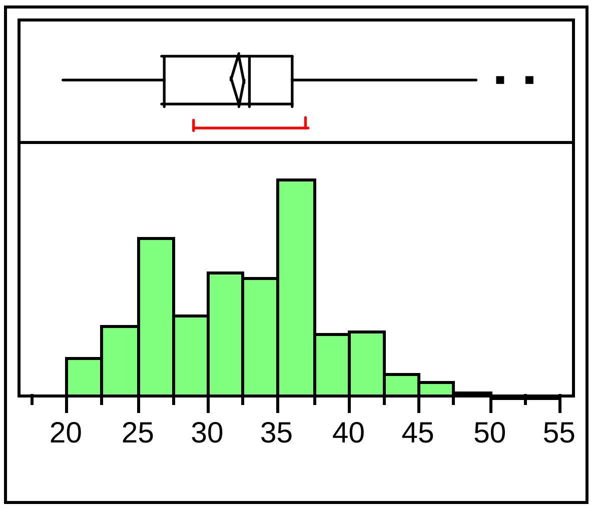

Figure 1 - AGE Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
AGE	32.2449	33.0000	6.0566	53.0000	20.0000

Table 5 – AGE Descriptive Statistics

Height (HT)

This variable is a measure of an individual's height estimated to the nearest half of an inch at the time of the fitness test.

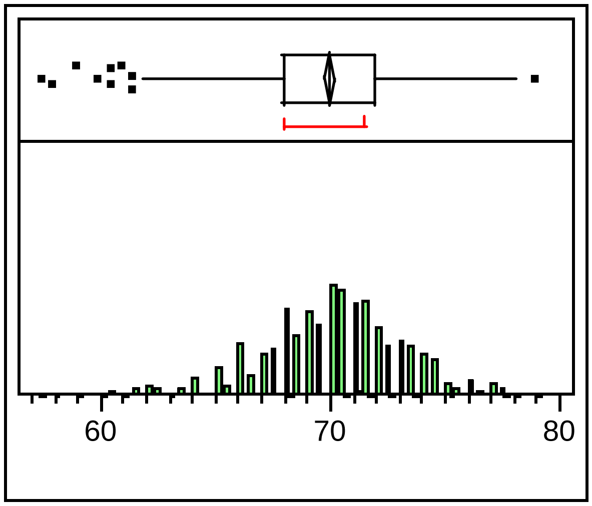

Figure 2 - Height Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
HT	70.0382	70.0000	3.1827	79.0000	57.5000

Table 6 – Height Descriptive Statistics

Weight (WT)

This variable is a measure of an individual's weight estimated to the nearest half of a pound at the time of the fitness test

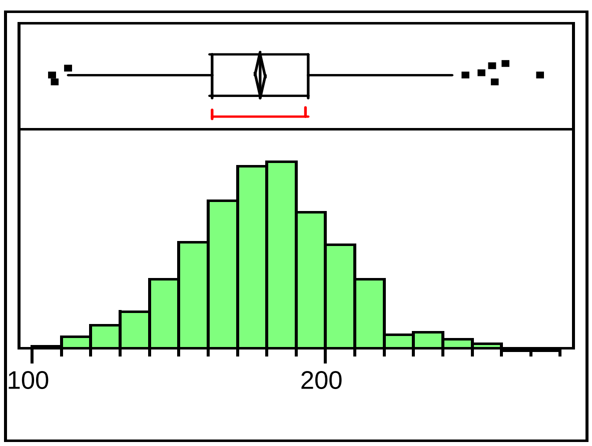

Figure 3 - Weight Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
WT	178.1725	178.0000	26.0677	274.0000	108.0000

Table 7 – Weight Descriptive Statistics

Waist

This variable is a measure of the abdominal circumference of an individual taken at the time of the fitness test. It is calculated according to AFI 10-248. The trained fitness tester must measure three times, sum these measurements, and then find the average. It is reported as the average waist measurement rounded down to the nearest half of an inch. This variable is used in calculating an individual's fitness score

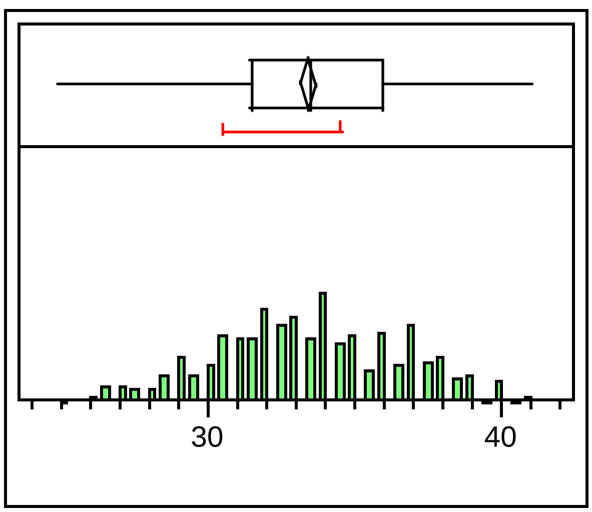

Figure 4 - Waist Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
WAIST	33.4392	33.5000	3.1348	41.0000	25.0000

Table 8 – Waist Descriptive Statistics

Waist Points (WAISTPTS)

This variable is the score given to an individual based on the individual's average waist measurement. It is calculated from the score charts located in AFI-10-248 (Appendix A). This is a one-size-fits-all score. There is no difference in the scoring based on age. The only difference being two separate charts for males and females. This calculation represents 30% of an individual's fitness score.

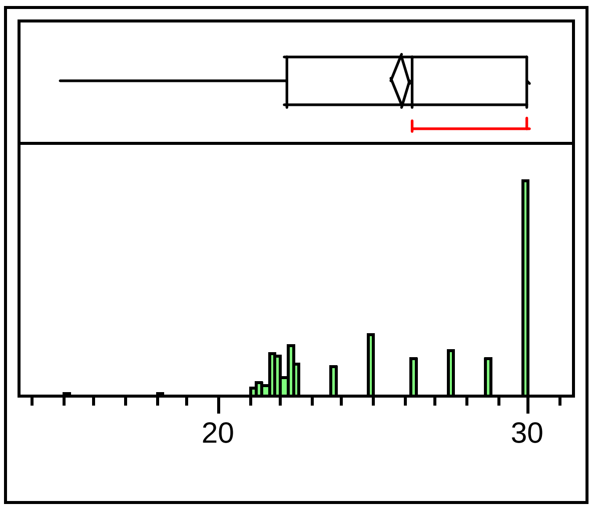

Figure 5 – Waist Points Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
WAISTPTS	25.9122	26.2500	3.5683	30.0000	15.0000

Table 9 – Waist Points Descriptive Statistics

Notice in Figure 5 that there is a large spike at 30. This is broken down as 192 of 592 (32%) individuals scored the maximum (30pts) on their WAISTPTS. A further break down indicates that 35 of the 69 females (51%) scored the maximum and 157 of the 523 Males (30%) scored the maximum on WAISTPTS.

Waist-to-Height Ratio (WAIST/HT)

This variable is a calculated variable. It was calculated by dividing an individual's waist measurement (WAIST) by the individual's height measurement (HT). WAIST/HT estimates the relationship of the waist measurement with respect to height.

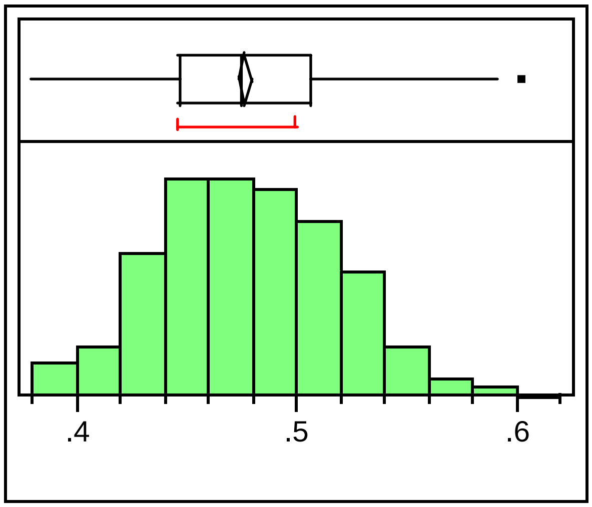

Figure 6 - Waist-to-Height Ratio Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
WAIST/HT	0.4776	0.4759	0.0409	0.6035	0.3817

Table 10 – Waist-to-Height Ratio Descriptive Statistics

Notice in Figure 6 that a large portion of this histogram falls below 0.5000. This was the number most cited in the literature review as having an increased risk of cardiovascular disease. WAIST/HT is the variable that will be used in estimating an individual's measure of cardiovascular risk.

Run Time in Seconds (RUNS)

This variable is a calculated variable. It is calculated by converting individual run times in minutes and seconds to RUNS, the individual's run time in seconds.

RUNS is being used as a proxy for the true fitness level of an individual. According to Maj. Lisa Schmidt, the Air Force surgeon general's chief of health promotion operations, "You will notice that 50 points go to aerobic fitness, because we know that's the best single indicator for overall fitness" (Callendar, 2004: p. 73).

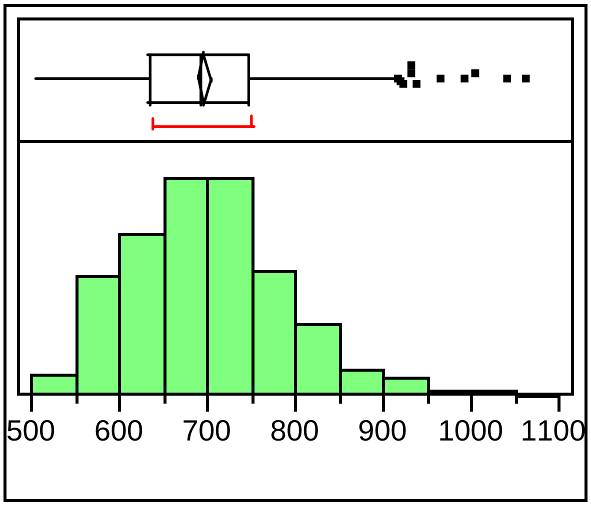

Figure 7 - Run Time in Seconds Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
RUNS	698.1757	695.0000	88.2552	1065.0000	510.0000

Table 11 – Run Time in Seconds Descriptive Statistics

Push-Ups (PU)

This variable is a measure of the number of push-ups an individual can accomplish in one minute. The push-ups are counted according to AFI-10-248. This measurement accounts for 10% of an individual's fitness score.

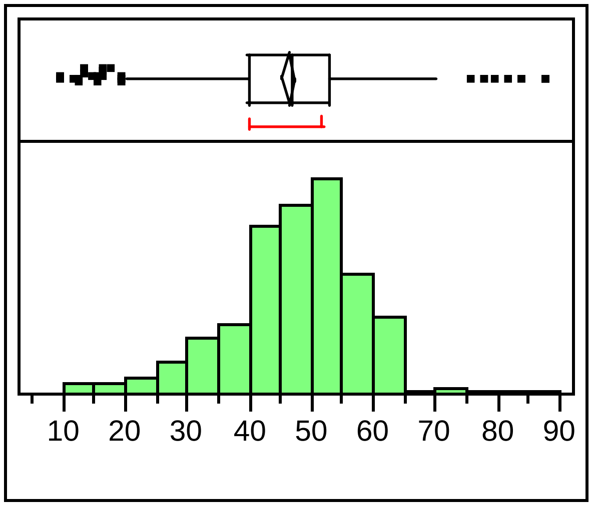

Figure 8 - Push-Ups Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
PU	46.4527	47.0000	11.3932	88.0000	10.0000

Table 12 – Push-Ups Descriptive Statistics

In Figure 8 notice the steep drop off after 50. This may be attributable to individual's stopping once they reach their maximum number required, or running out of time.

Sit-Ups (SU)

This variable is a measure of the number of sit-ups an individual can accomplish in one minute. The sit-ups are counted according to AFI-10-248. This measurement also accounts for 10% of an individual's fitness score.

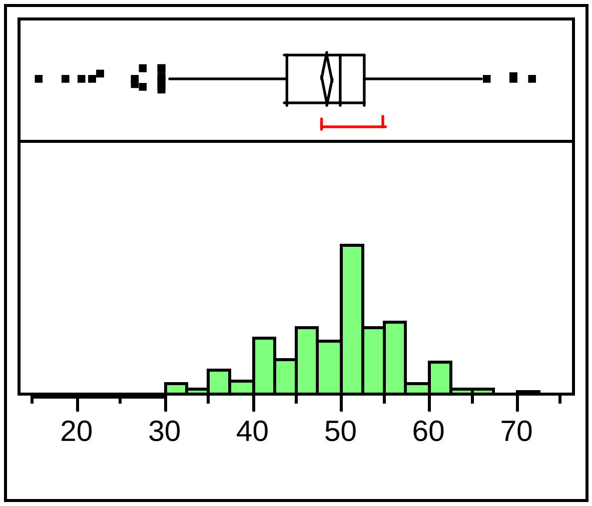

Figure 9 - Sit-Ups Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
SU	48.7027	50.0000	7.7767	72.0000	16.0000

Table 13 – Sit-Ups Descriptive Statistics

Again, in Figure 9 notice the spike at 50. This may be attributable to individual's stopping once they reach their maximum number required or running out of time.

Fitness Score (FTSC)

This variable is a measure of the total fitness level of an individual. The score can range from 0 to 100. This variable was transcribed as a pre-calculated value. The AFIT orderly room records the fitness score as a sum of all scores for each individual measurement to include WAIST, RUNT, PU, and SU. Each measurement is compared to the scoring charts found in AFI 10-248 (see Appendix A). The fitness score data accuracy is relied upon from the official AFIT orderly room calculations.

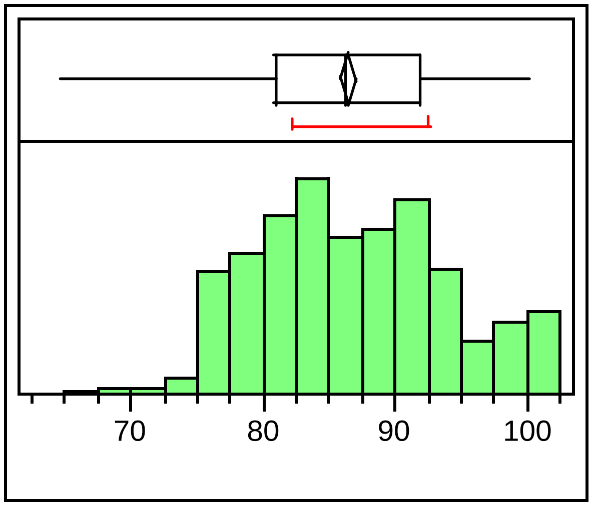

Figure 10 - Fitness Score Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
FTSC	86.5238	86.2500	7.1429	100.0000	65.0000

Table 14 – Fitness Score Descriptive Statistics

Fitness Score Minus Waist Points (FTSC-WAIST)

This variable is a calculated variable. It is a measure of an individual's fitness score minus the points received for the individual's waist measurement. This variable represents how fit an individual is regardless of their waist size. FTSC-WAIST can range between 0 and 70. This score was calculated as FTSC – WAISTPTS.

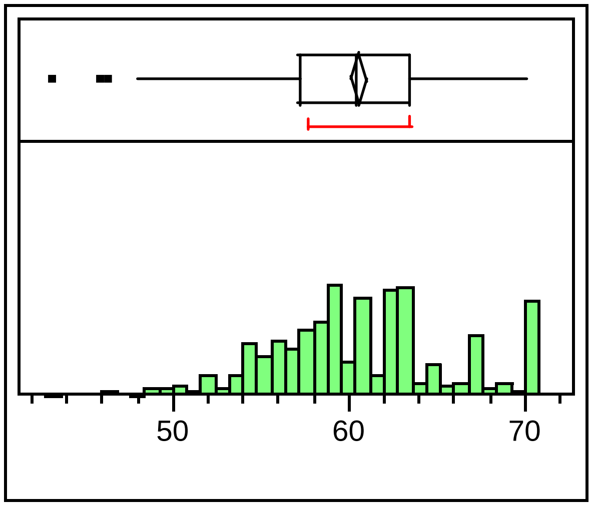

Figure 11 - Fitness Score Minus Waist Points Histogram

Variable	Mean	Median	Std Dev	Maximum	Minimum
FTSC-WAIST	60.6116	60.5000	5.0710	70.0000	43.2500

Table 15 – Fitness Score Minus Waist Points Descriptive Statistics

In Figure 11 notice the spike at 70. When WAISTPTS is removed from FTSC the total maximum fitness score becomes 70 instead of 100. The number of individuals that score the total possible fitness points (70) increase. The number of maximum fitness scores increased from 32 (5.41%) to 50 (8.45%) when based on the FTSC-WAIST scale. In essence, 17 males and 1 female maximized the PU, SU, and RUNT but failed to achieve the maximum on the WAIST measurement.

Statistical Testing of Anthropometric Predictors of Fitness

The goal of this section is to estimate the linear relationship between the dependent variable and all possible independent variables while determining if the variables are good predictors of physical fitness. A key step in successfully understanding any dependent variable is first identifying the independent variables that should be used in the theoretical model. It is important to stress that the selection of all independent variables will be based on causality and correlation analysis.

Table 16 lists all correlation coefficients between the variables. Correlation between any two variables greater than 0.500 is shaded grey. Notice that FTSC is highly correlated with a number of the variables. This is due to the fact that many of these variables are used in the calculation of FTSC. Specific correlations will be discussed later as different variables are entered into regression models.

	Correlation Coefficients, n = 592, 0.50 or greater in bold												
	SEX	*AGE*	*HT*	*WT*	*WAIST*	*WAISTPTS*	*WAIST/HT*	*RUNT*	*RUNS*	*PU*	*SU*	*FTSC*	*FTSC-WAIST*
SEX	**1.000**												
AGE	0.129	**1.000**											
HT	**0.544**	0.029	**1.000**										
WT	0.470	0.177	**0.629**	**1.000**									
WAIST	0.457	0.265	0.428	**0.854**	**1.000**								
WAISTPTS	-0.140	-0.249	-0.250	**-0.729**	**-0.887**	**1.000**							
WAIST/HT	0.220	0.279	-0.066	**0.604**	**0.872**	**-0.841**	**1.000**						
RUNT	-0.419	0.110	-0.309	0.022	0.097	-0.278	0.269	**1.000**					
RUNS	-0.421	0.114	-0.312	0.022	0.097	-0.281	0.271	**0.997**	**1.000**				
PU	0.494	-0.265	0.174	0.133	0.010	0.171	-0.074	-0.498	**-0.501**	**1.000**			
SU	0.172	-0.371	0.080	-0.021	-0.143	0.214	-0.197	-0.389	-0.391	**0.564**	**1.000**		
FTSC	-0.074	-0.112	-0.100	**-0.523**	**-0.660**	**0.746**	**-0.672**	**-0.721**	**-0.723**	0.348	0.408	**1.000**	
FTSC-WAIST	-0.006	0.017	0.035	-0.223	-0.306	0.347	-0.355	**-0.820**	**-0.821**	0.371	0.424	**0.883**	**1.000**

Table 16 – Correlation Coefficients (two-at-a-time)

Dependent Variables

In the standard vocabulary of regression the variable being studied is called the dependent variable, and sometimes referred to as an endogenous or responsive variable. The value of the dependent variable depends upon the value of the independent or exogenous variables. The dependent variable in this exploratory analysis will be the variable RUNS. This research will attempt to identify the statistically significant independent variables that best estimates an individual's fitness level via the proxy variable RUNS. Ordinary least squares regression will be used to estimate the statistical relationships. This method is appropriate because the dependent variable RUNS is reasonably continuous.

Independent Variables

The variables that determine the value of the dependent variable are commonly referred to as independent, exogenous, or predictor variables. It is from the changes in these independent variables that coefficients are estimated and a regression equation is formed. Ultimately, given known values of the independent variables it is possible to estimate a value for the associated dependent variable.

The following independent variables (GENDER, AGE, HT, WT, WAIST, WAIST/HT, PU, SU) will be individually regressed onto RUNS. The signs adjacent to the variables represent the hypothesized relationship between the dependent and independent variables. If theory leads to the expectation that the independent variable has a positive effect on the dependent variable, a plus (+) sign is used. If theory leads to the expectation that the independent variable has an inverse effect on the dependent variable, a negative (-) sign is used. If theory is unclear, a question mark (?) will be used. The theoretical or expected relationships to RUNS will be:

GENDER	-
AGE	+
HT	-
WT	+
WAIST	+
WAIST/HT	+
PU	-
SU	-

Table 17 – Independent Variable Theoretical Relationships to RUNS

It is hypothesized that GENDER will be inversely related to RUNS. If the individual is a male it is expected that RUNS will be lower. AGE is hypothesized to be positively related to RUNS. As an individual gets older their RUNS should increase. HT is hypothesized to be inversely related to RUNS. The taller an individual is the lower their RUNS should be. WT is hypothesized to be positively related to RUNS. As an individual's weight increase RUNS should increase. WAIST is hypothesized to be positively related to RUNS. As WAIST increases RUNS should increase. WAIST/HT is hypothesized to be positively related to RUNS. We assume that an individual's HT remains fixed, so the only change in this variable will be in the WAIST. Because the change in the numerator positively influences the value of the WAIST/HT ratio we assume that as WAIST increase, WAIST/HT increases; therefore RUNS increases. PU is hypothesized to be inversely related to RUNS. As PU increases it is expected that RUNS decreases. Finally, SU is hypothesized to be inversely related to RUNS. As SU increases RUNS should decrease.

Table 18 is a compilation of all independent variables and their individual statistical estimates associated with RUNS. This statistical analysis was accomplished using least squares regression and the software package JMP®.

RUNS VS. VARIABLE	ADJ R^2	COEF. ESTIMATE	T-STAT	P-VALUE (T)
GENDER	0.1757	-115.6354	-11.2700	<.0001
AGE	0.0114	1.6645	2.7900	0.0054
HT	0.0958	-8.6497	-7.9700	<.0001
WT	-0.0012	0.0753	0.5400	0.5892
WAIST	0.0078	2.7406	2.3800	0.0178
WAIST/HT	0.0719	585.0922	6.8400	<.0001
PU	0.2493	-3.8775	-14.0400	<.0001
SU	0.1517	-4.4417	-10.3300	<.0001
N = 592				

Table 18 – Individual Regression Estimates on RUNS

Waist vs. Waist/Height

By looking at the regression results in Table 18 it can be seen that all of the coefficient signs were correctly hypothesized. All of the independent variables show strong statistical significance except WT. The key independent variables to focus on in this table are WAIST and WAIST/HT. Notice WAIST/HT is a better predictor than WAIST when regressed onto RUNS. This is determined by looking at the adjusted R^2, the t-statistic and its corresponding p-value. In all cases WAIST/HT outperforms WAIST as a predictor of RUNS.

Acknowledging that WAIST/HT is a better predictor of RUNS than WAIST individually, it is important to look at how WAIST and WAIST/HT perform against other measures of fitness such as PU and SU The following regressions will look at the statistical analysis of WAIST and WAIST/HT in estimating PU and SU.

Based on the previous results it is hypothesized that WAIST/HT will be a better predictor of PU and SU than WAIST. Also, it is hypothesized that the variable WAIST and WAIST/HT will be inversely related to PU. As an individual's WAIST or WAIST/HT decreases you would expect the individual to be in better shape and PU to increase.

PU VS.				
VARIABLE	ADJ R^2	COEF. ESTIMATE	T-STAT	P-VALUE (T)
WAIST	-0.0016	0.0364	0.2400	0.8080
WAIST/HT	0.0039	-20.7204	-1.8100	0.0706
N = 592				

Table 19 – Regression Results WAIST and WAIST/HT on PU

Looking at Table 19 it is important to point out the hypothesized sign of the coefficient for WAIST was not correctly hypothesized, but also notice it is not statistically significant based on the t-statistic and p-value of t. The hypothesized relationship was correct for WAIST/HT. By looking at the regression results in table 19 it can be seen that WAIST/HT is a better predictor of PU than WAIST.

It is hypothesized that the variables WAIST and WAIST/HT will be inversely related to SU. As an individual's WAIST or WAIST/HT decreases you would expect the individual to be in better shape and SU to increase.

SU VS.				
VARIABLE	ADJ R^2	COEF. ESTIMATE	T-STAT	P-VALUE (T)
WAIST	0.0187	-0.3537	-3.5000	0.0005
WAIST/HT	0.0371	-37.4401	-4.8800	<0.0001
N = 592				

Table 20 - Regression Results WAIST and WAIST/HT on SU

It is important to note that the hypothesis that WAIST/HT would be a better predictor than WAIST for estimating PU and SU is correct. It is also important to point out the hypothesized signs of the coefficients were correctly hypothesized in the SU regression. The results from Table 19 and Table 20 prove that WAIST/HT is a better predictor of SU than WAIST. In the previous regression estimates for RUNS, PU, and SU the independent variable WAIST/HT is not only a better predictor, but it is also statistically significant, indicating that it has explanatory power.

In response to investigative question one, "Are an individual's GENDER, AGE, HT, WT, WAIST, WAIST/HT, PU, and SU measurements good predictors for physical fitness based on RUNS," all of the independent variables except WT were significant predictors of fitness. In choosing between WAIST and WAIST/HT it appears WAIST/HT is a better estimator of one's fitness based on RUNS, PU, and SU.

Creating One Fitness Scoring Model

Based on the literature review and the scoring charts from AFI 10-248 there is an expected measurable difference in an individual's fitness level based on age and gender. The previous regression results indicate that WAIST/HT is a better predictor of fitness level (RUNS, PU, and SU) than WAIST. The following least squares regressions will determine if one fitness score model can be created based on RUNS, WAIST, WAIST/HT, AGE, and GENDER.

Two regressions will be performed. The only difference in these lie in switching the WAIST and WAIST/HT variables. It is hypothesized that RUNS is inversely related to GENDER, positively related to AGE, and positively related to WAIST or WASIT/HT. Theory indicates that if GENDER is a male then RUNS should decrease. Theory also indicates that as an individual's AGE increases and as WAIST or WAIST/HT increase RUNS should increase. The regression estimates for the two previously described regression functions follow.

RUNS VS.				
VARIABLE	ADJ R^2	COEF. ESTIMATE	T-STAT	P-VALUE (T)
	0.2889			
INTERCEPT		474.2071	13.7300	<0.001
GENDER		-161.8362	-15.1000	<0.001
AGE		1.4565	2.7800	0.0056
WAIST		9.5689	8.4700	<0.001
N = 592				

Table 21 - Regression Estimates for RUNS = f(C, GENDER, AGE, WAIST)

In Table 21 notice that the hypothesized coefficient signs are as expected. All regression coefficient estimates are statistically significant based on the t-statistics and the p-value of t. This model has explanatory power. Knowing that all the statistical estimates are significant it can be said that the adjusted R^2 indicates that nearly 29% of the variation in RUNS can be explained by changes in the independent variables GENDER, AGE, and WAIST.

RUNS VS. VARIABLE	ADJ R^2	COEF. ESTIMATE	T-STAT	P-VALUE (T)
	0.3220			
INTERCEPT		412.2466	11.5400	<0.001
GENDER		-140.3342	-14.6300	<0.001
AGE		1.1543	2.2300	0.0258
WAIST/HT		780.3919	10.0300	<0.001
N = 592				

Table 22 - Regression Estimates for RUNS = f(C, GENDER, AGE, WAIST/HT)

In Table 22 the hypothesized coefficient signs are as expected. All regression coefficient estimates are also statistically significant based on the t-statistics and the p-value of t. This model has more explanatory power. It can be stated that the adjusted R^2 indicates that 32% of the variation in RUNS can be explained by changes in the independent variables GENDER, AGE, and WAIST/HT.

The results from the second regression (Table 22) show statistical improvements in comparison to the first. The most noticeable improvements are the increase in adjusted R^2 from 0.29 to 0.32 and the t-stat from 8.470 for WAIST to 10.03 for WAIST/HT. Seeing these results it can be said that using the independent variable WASIT/HT is a better predictor of an individual's RUNS

An interesting estimation from these two regressions is that as AGE increases by one year, RUNS only increase by roughly one second on average, ceteris paribus. This finding suggests that there is no need for separate AGE charts for the 1 and ½ mile run. Also, the estimation for the coefficient on GENDER shows that females run the 1 and ½ mile approximately 140 seconds slower than men, ceteris paribus. In response to investigative question two, "Can I create one model for everyone vs. using separate tables by looking at WAIST or WAIST/HT ratios," these finding suggests that there is a need to have separate scoring tables based on GENDER and the 1 and ½ mile run times.

Waist/Height Ratio Scoring Chart

The first step in creating the new WAIST/HT ratio scoring chart is to generate histograms and summary statistics for the collected data. The following charts and summary statistics for males and females will be used in creating the WAIST/HT ratio chart.

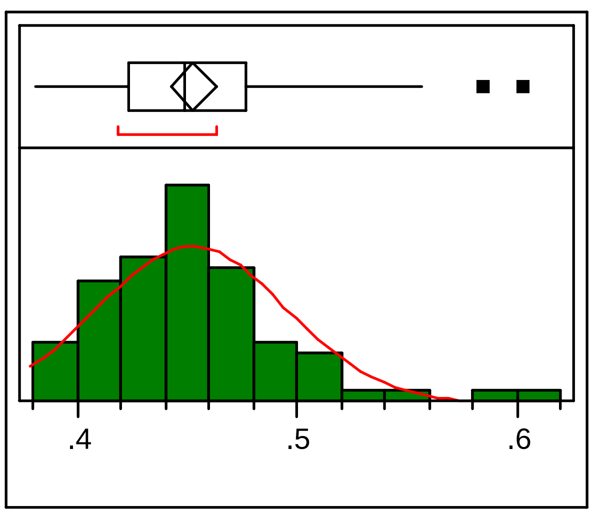

Figure 12 - Female WAIST/HT Histogram

Notice in Figure 12 that the distribution is approximately normal and centered on 0.450. The three data points to the extreme right were generated by females between 4' 10" and 5' 2", with waist circumferences from 34.5" to 36", and weighing from 160 to 218 pounds. Also, nearly 90% of the data points fall below 0.500 the cutoff for increased risk of cardiovascular disease, which was determined in the literature review.

Variable	Mean	Median	Std Dev	Maximum	Minimum
WAIST/HT	0.4528	0.4485	0.0428	0.6035	0.3817

Table 23 – Female WAIST/HT Descriptive Statistics

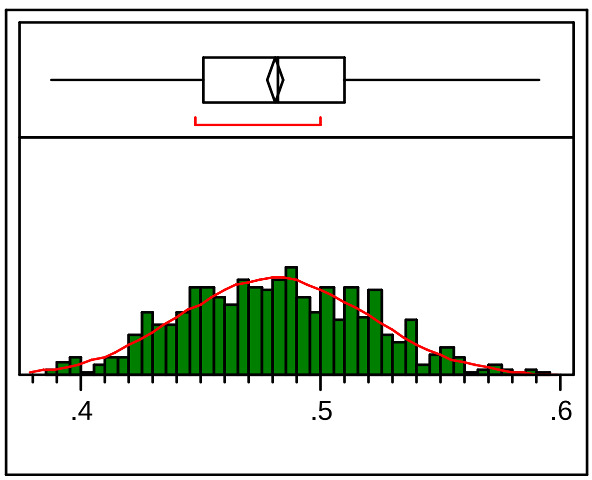

Figure 13 - Male WAIST/HT Histogram

In Figure 13 the histogram is normally distributed and centered on 0.480. Nearly 75% of the data points fall below 0.500 the cutoff for increased cardiovascular risk.

Variable	Mean	Median	Std Dev	Maximum	Minimum
WAIST/HT	0.4808	0.4818	0.0395	0.5913	0.3878

Table 24 – Male WAIST/HT Descriptive Statistics

Table 25 is a summary of the female, male, and combined WAIST/HT ratio summary statistics. In Table 25 it is important to point out that the maximum WAIST/HT ratio for females is 0.6035 and the minimum is 0.3817 with a mean of 0.4528. These numbers are very comparable to the summary statistics for males. The maximum WAIST/HT ratio for males is 0.5913, the minimum is 0.3878, and the mean is 0.4808.

Variable	Mean	Median	Std Dev	Maximum	Minimum
Female WAIST/HT	0.4528	0.4485	0.0428	0.6035	0.3817
Male WAIST/HT	0.4808	0.4818	0.0395	0.5913	0.3878
Combined WAIST/HT	0.4776	0.4759	0.0409	0.6035	0.3817

Table 25 – Female/Male/Combined WAIST/HT Descriptive Statistics

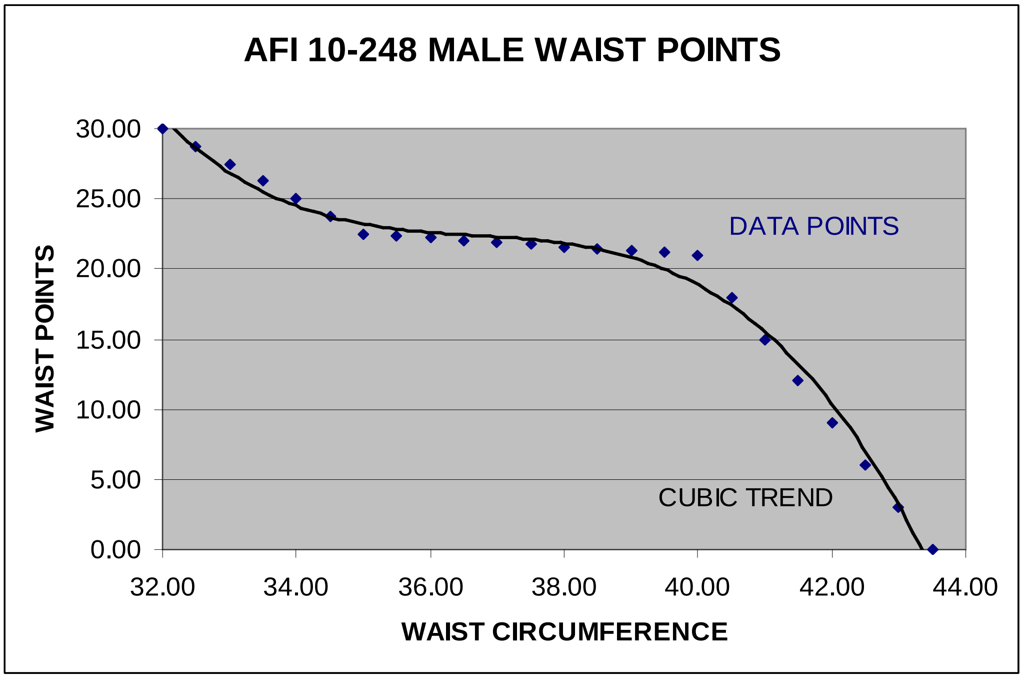

Figure 14 - (AFI 10-248) Male Waist Points Graph

Figure 14 depicts the original waist point's chart for males. Notice that a male receives the maximum of 30 points for a waist measurement of 32 inches and zero points at 43.5 inches.

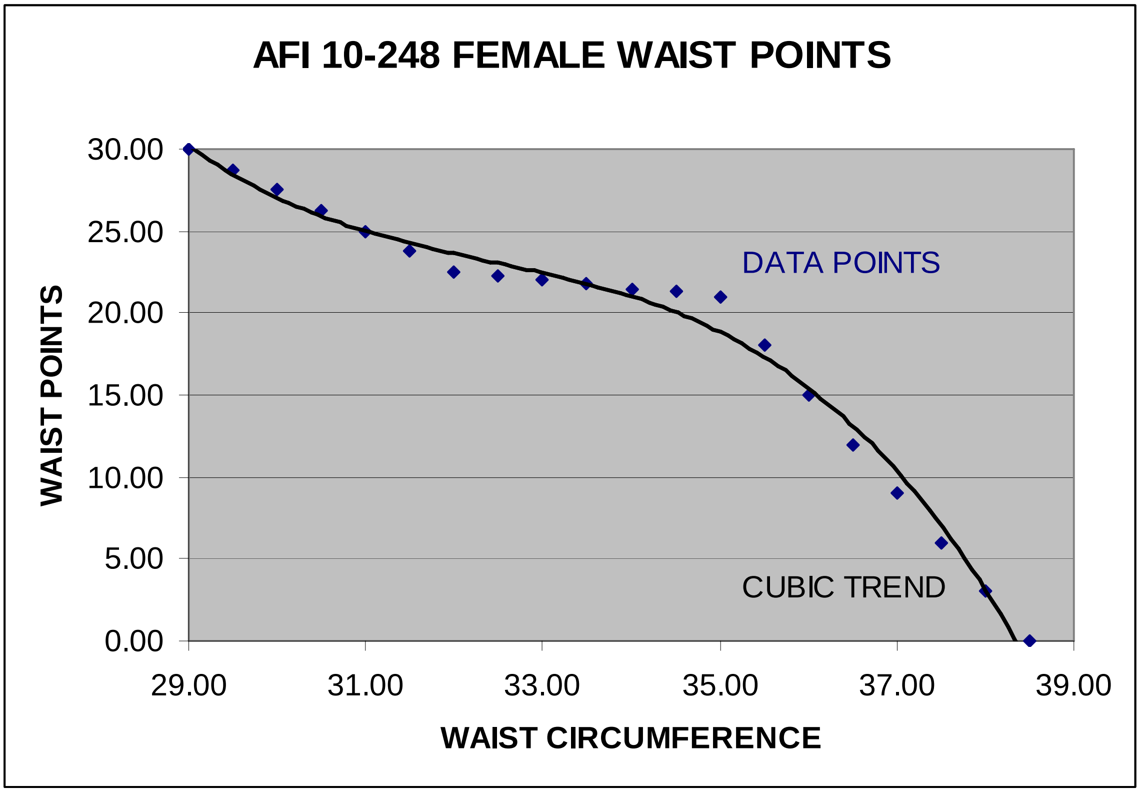

Figure 15 - (AFI 10-248) Female Waist Points Graph

Figure 15 depicts the original waist point's chart for females. Notice that a female receives the maximum of 30 points for a waist measurement of 29 inches and zero points at 38.5 inches. In creating the new male/female WAIST/HT ratio chart it is important to recognize that the original male and female waist scoring charts were created mimicking a cubic trend. The goal is to follow that pattern and create one chart for both genders given the available data.

Table 26 is the proposed scoring chart for males and females based on their height-to-waist ratio. There is no exact point system. There is no one-size-fits-all waist-to-height ratio that perfectly predicts an individual's degree of cardiovascular risk. Table 26 is based on a sample of 592 individuals and is proposed as a solution to what members feel is an unfair waist measurement system.

WAIST/HT		POINTS
< 0.460		30.00
0.460		29.00
0.470		27.00
0.480		24.00
0.490		21.00
0.500		18.50
0.510		16.50
0.520		15.50
0.530		15.00
0.540		14.50
0.550		13.50
0.560		11.50
0.570		9.00
0.580		6.00
0.590		3.00
0.600		1.00
> 0.600		0.00

Table 26 - Male/Female Proposed WAIST/HT Ratio Point Scale

In Table 26 an individual receives the maximum of 30 points for a WAIST/HT ratio less than 0.460, and zero point for a WAIST/HT ratio greater than 0.600. The goal of this scoring system is to encourage individuals to decrease their WAIST/HT ratio to acceptable levels.

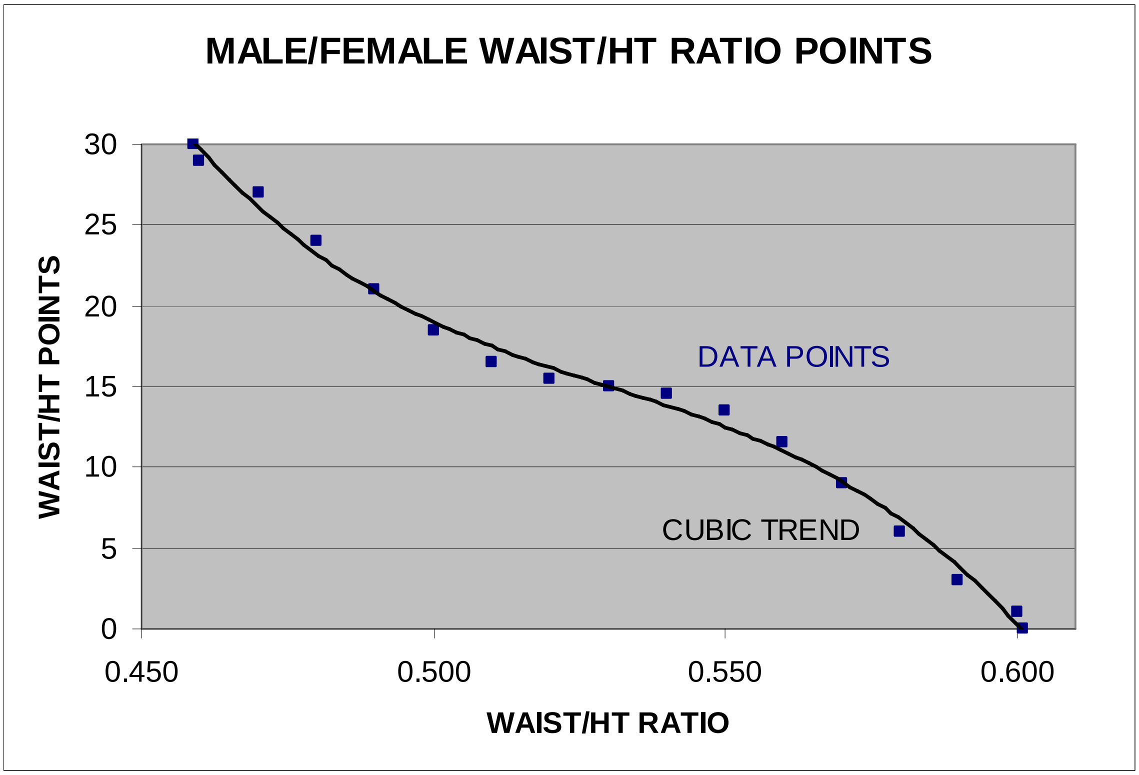

Figure 16 – Male/Female WAIST/HT Ratio Points Graph

Figure 16 is a graphical representation of the proposed scoring chart for the WAIST/HT ratio point system. Notice that this graph follows the cubic trend that was proposed in the original male and female waist score charts. In response to investigative question three, "Can this research translate WAIST measurements into a WAIST/HT ratio score table," the summary WAIST/HT statistics and the literature review suggests an equitable table can be built.

Scoring Chart Equity

The charts from AFI 10-248 (see Appendix A) are scaled to account for differences based on age and gender. These charts adjust the completed exercise raw scores into fitness scores for various age groups and gender. The current charts will be tested by using simple linear regression and ANOVA analysis to determine if they correctly adjust raw fitness scores based on an individual's age and gender. The expectation is that across all age groups and genders there will be no statistical difference in their mean total fitness scores.

The first step in determining gender equity will be to run a regression with FTSC as the dependent variable and GENDER as the independent variable. It is hypothesized that the independent variable GENDER will not be statistically significant.

FTSC VS.				
VARIABLE	ADJ R^2	COEF. ESTIMATE	T-STAT	P-VALUE (T)
GENDER	0.0039	-1.6480	-1.8000	0.0716
N = 592				

Table 27 - Regression Results GENDER on FTSC

By looking at Table 27 it can be seen that the independent variable GENDER is not statistically significant. Based on these results it appears the gender tables accurately adjust fitness scores based on GENDER.

To determine equity in the scoring tables based on age it is necessary to perform ANOVA analysis. All data was separated into the respective age groups. It is hypothesized that the individual age groups will not be statistically significant and there will be no difference in their means for FTSC.

FTSC VS. VARIABLE	COEF. ESTIMATE	T-STAT	P-VALUE (T)	MEAN
Under 25				88.4417
Age Group[25 - 29]	0.7076	0.7400	0.4585	86.5659
Age Group[30 - 34]	0.5846	0.6100	0.5399	86.4428
Age Group[35 - 39]	0.5936	0.6300	0.5259	86.4518
Age Group[40 - 44]	-1.2111	-1.0400	0.2990	84.6471
Age Group[45 - 49]	0.4751	0.2500	0.8045	86.3333
Age Group[50 - 54]	-3.7332	-0.8600	0.3894	82.125
N = 592				

Table 28 – ANOVA Analysis AGE Groups on FTSC

In Table 28 notice that all of the age groups are not statistically significant. The means test also shows that the largest difference in mean FTSC is between the age group (under 25) and the age group (50-54). The difference is 6 points. The result of a least squares means Tukey test revealed that there is no statistical difference in the age groups means. Based on these results it appears the age tables accurately adjust fitness scores based on AGE.

The same ANOVA tests were performed using FTSC-WAIST as the dependent variable. This test will determine if there is a statistical difference in the age groups when the scores for the WAIST measurement are removed. It is hypothesized that the age group variables will not be statistically significant.

FTSC-WAIST VS. VARIABLE	COEF. ESTIMATE	T-STAT	P-VALUE (T)	MEAN
Under 25				60.7152
Age Group[25 - 29]	-0.7711	-1.1400	0.2568	59.9362
Age Group[30 - 34]	0.2581	0.3800	0.7039	60.9654
Age Group[35 - 39]	0.2202	0.3300	0.7410	60.9275
Age Group[40 - 44]	-0.6756	-0.8100	0.4158	60.0317
Age Group[45 - 49]	1.2927	0.9500	0.3444	62.0000
Age Group[50 - 54]	-0.3323	-0.1100	0.9143	60.3750
N = 592				

Table 29 - ANOVA Analysis AGE Groups on FTSC-WAIST

Table 29 shows the results of the statistical analysis. Again, all of the age groups are not statistically significant. The means test shows that the largest difference in mean FTSC-WAIST is between the age group (25-29) and the age group (45-49). This difference is only 2 points. It might be said that when WAIST scores are removed from fitness scores younger individuals mean scores are more in line with older age groups. Apparently younger people have smaller waists. In general, mean fitness scores are closer with the WAIST score removed.

Based on the results in Tables 27, 28, and 29 it appears the original tables in AFI 10-248 (see Appendix A) accurately adjust FTSC based on an individual's gender and age. In response to investigative question four, "Do the separate age and gender based scoring charts accurately account for differences in age and gender," the statistical analysis suggests the charts do account for differences in age and gender.

Chapter Summary

This chapter began with a visual and statistical description of all the anthropometric variables collected for this research. Correlation of all the variables (two-at-a-time) were shown and discussed. Using simple linear regression all of the variables were regressed onto RUNS (one-at-a-time) and found to be correctly hypothesized and statistically significant. The variable WT was found to be not significant. This confirms investigative question one. The anthropometric variables are good estimators of an individual's fitness based on RUNS. This analysis also determined that WAIST/HT is a better predictor than WAIST in estimating and individual's 1 and ½ mile run time.

In response to investigative question two, the research determined that there is a need for separate scoring charts based on gender. Females do run the 1 and ½ mile slower than males, ceteris paribus. But, Age does not appear to be a factor when completing the 1 and ½ mile run.

Furthermore, an analysis of the WAIST/HT ratios determined that investigative question three can be accomplished. Relying on the literature review and the summary statistics for WAIST/HT a scoring chart was presented for consideration in future changes to AFI 10-248.

Finally, using simple linear regression and ANOVA analysis it was determined that the age and gender scoring charts do account for differences in age and gender. This confirms investigative question four. There does appear to be equity in how the tables adjust raw fitness scores to calculate an individual's FTSC. The next chapter will summarize this research process, make suggestions on how these findings may be used, and present some suggestions for future research.

IV. Conclusions

Chapter Overview

This chapter reviews the research that has been conducted in studying the new Air Force fitness program, AFI 10-248, and summarizes the findings of the three previous chapters. It begins with a restatement of the problem and what limitations the research is faced with. It highlights the main points from the literature review and summarizes the findings from all of the statistical analysis. The chapter concludes by providing possible future research projects and discusses a few changes that could be made to the current Air Force fitness program.

Restatement of the Problem

The United States Air Force implemented a new fitness policy. All members are to be tested by measuring the number of sit-ups and push-ups they can accomplish, the time it takes them to run 1 and ½ miles, and a waist measurement. The scores for each exercise are converted to points based on age and gender charts. The waist measurement however is a "one-size-fits-all" scoring system. The goal is to statistically test if the waist measurement or a waist/height ratio is a more accurate and true indicator of an individual's fitness. This research determines that there is a better measurement than the waist measurement to determine an individual's fitness level.

Limitations

The main limitations of this study are the degree of accuracy of the waist and height measurement and subjective counting for push-ups and crunches. The waist data is collected by measuring the abdominal circumference three times, summing these three waist measurements and then finding the average. The average is then rounded down to the nearest half of an inch. The height measurement is simply rounded to the nearest half of an inch. In addition, each fitness score tester has subjective measures by which to count the number of push-ups and sit-ups. These facts should be taken into consideration with this report.

Review of Literature

The literature review covers the physical fitness history of the United States, DoD, and the history of Air Force physical fitness programs. It could be said that from the turn of the century through World War I, World War II, the Korean War, and through today many Americans could not meet the minimum physical fitness test standards required to enter military service. The recent need for an effective physical fitness program evolved from Department of Defense directive (1308.1) which states that individual service members must possess the stamina and strength to perform, successfully, any potential mission.

The literature review covers over 50 years of Air Force fitness. It begins with Air Force Regulation (AFR) 50-5 which served as the basis for the Air Force physical fitness program from 1947 through 1959. It further discusses the Air Forces numerous changes to the fitness program to include the 5BX and XBX programs adopted from the Royal Canadian Air Force. It goes further to discuss the Air Force aerobics program from the late 1960s and all of its changes resulting from numerous deaths on the 1 and 1/12 mile run. In 1992 the Air Force began testing with a new procedure for measuring fitness based on a cycle ergometry test which estimated an individual's VO_2max score. This test has been the standard until today. The literature review then describes the current Air Force fitness program and discusses what is to be tested, how it's to be tested, and who is responsible for making sure individuals pass the test.

The literature review concludes by looking at a number of anthropometric studies that utilize some form of a waist measurement to estimate an individual's BMI. These studies include abdominal measurements, neck circumference, waist-to-hip ratios and waist-to-height ratios.

Review of Analysis

All of the findings in this study were estimated using simple linear regression and means testing through ANOVA analysis. Investigative question one asks: "Are an individual's GENDER, AGE, HT, WT, WAIST, WAIST/HT, PU, and SU measurements good predictors for physical fitness based on RUNS?" The findings indicate all of the independent variables except WT were significant. Also, according to the statistical analysis WAIST/HT is a better estimator of one's fitness based on RUNS, PU, and SU. These findings suggest utilizing a waist-to-height ratio vs. the waist measurement in future Air Force fitness instructions.

In response to investigative question two, "Can I create one model for everyone vs. using separate tables by looking at WAIST or WAIST/HT ratios," the findings indicate that there is a need to have separate scoring tables based on GENDER but not age. As AGE increases by one year, RUNS only increase by roughly one second on average. These results indicate there is a need to have separate gender scoring charts for the 1 and ½ mile run, but they may not need to be broken down by age.

In response to investigative question three, “Can this research translate WAIST measurements into a WAIST/HT ratio score table,” the summary WAIST/HT statistics and the literature review suggest a WAIST/HT ratio table can be built. Following the AFI’s original cubic points trend a scoring table is provided that both genders can use.

In response to investigative question four, “Do the separate age and gender based scoring charts accurately account for differences in age and gender,” the statistical analysis suggests the charts do adjust raw scores for differences in age and gender. In the regression analysis of GENDER on FTSC it was determined that GENDER is not significant. Also, in the ANOVA analysis of age groups and FTSC it was determined that no specific age group’s mean FTSC was statistically different. Finally, the results did appear to show that younger individuals have smaller waists.

Possible Follow-on Theses

The database used in this research is by no means complete. Other measures of physical fitness such as BMI, cycle ergometry scores, neck and hip measurements could be added. The larger the database, the more useful it will become in other fitness related research. Some possible related areas of research include:

- Allow data to build by adding new data points and perform same statistical tests with a larger sample.
- Gather additional data to include the individual’s BMI, cycle ergometry score, neck and hip circumference. Test these proxies for cardiac risk against push-ups, sit-ups, the run, and the waist measurement to determine if they are good measures of fitness.
- Look at the data from geographically separated bases. Possibly use Peterson, Wright Patterson, and Hickam AFB to test for differences in mean scores based on confounders like altitude or weather conditions.

- Compare individual's fitness scores and raw scores over time to see if there is any improvement brought about by participation in the new fitness program.

- Find a random sample of civilians to test and compare their scores with Air Force members to determine the degree of difference in physical fitness.

Recommendations

The first recommendation is to completely remove the waist score from the scoring of the fitness test. Base an individual's fitness score on their fitness level and not on their cardiovascular risk level. Rely on the proven BMI tests to determine an individual's cardiovascular risk.

Secondly, measure waist and height to the nearest 1/4 or 1/8 inch. Do not solely round down. This will allow for a more accurate WAIST/HT ratio and possible improvement to the WAIST/HT scoring chart.

According to the statistical results there is no need to take age into consideration for the 1 and ½ mile run, but it is important to account for gender. Create only two charts that apply to all ages of males and females. The best proxy for fitness level is the 1 and ½ mile run. One age chart would encourage older individuals to stay or get into shape.

Do not discourage individuals from doing push-ups and sit-ups. The one minute time limit and known scoring charts appear to be discouraging members from strengthening their arms and abs. Possibly allow extra points to be added to the final score for superior fitness. If fitness scores are going to be added to performance report this could encourage individuals to work harder.

The final recommendation is to seriously review the current waist scoring charts for males and females. This research discovered that 35 of the 69 females (51%) scored the maximum and only 157 of the 523 Males (30%) scored the maximum on waist points. As in the previous recommendation, future performance reports may include fitness results and the current tables heavily favor females for waist circumference. One solution may be to use hip measurements for females or rely on one chart for males and females which scores by waist-to-height ratios.

Appendix A

AFI 10-248 Age and Gender Specific Score Charts

Males Under 25

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤9:36	≥54	50.00
9:37-9:48	53	47.50
9:49-10:12	51-52	45.00
10:13-10:36	49-50	43.50
10:37-11:06	47-48	42.00
11:07-11:36	45-46	40.50
11:37-12:12	43-44	39.00
12:13-12:54	41-42	37.50
12:55-13:36	39-40	36.00
13:37-14:24	37-38	34.00
14:25-14:54	36	32.00
14:55-15:18	35	30.00
15:19-15:48	34	27.00
15:49-16:24	33	24.00
16:25-16:54	32	21.00
16:55-17:36	31	18.00
17:37-18:12	30	15.00
18:13-18:54	29	12.00
18:55-19:42	28	9.00
19:43-20:36	27	6.00
20:37-21:30	26	3.00
>21:30	<26	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points
≥62	10.00
61	9.75
60	9.50
59	9.25
57-58	9.00
52-56	8.75
49-51	8.50
45-48	8.25
41-44	8.00
37-40	7.75
33-36	7.50
30-32	7.40
27-29	7.30
24-26	7.20
21-23	7.10
19-20	7.00
17-18	6.00
15-16	5.00
14	4.00
12-13	3.00
10-11	2.00
8-9	1.00
<8	0.00

1 minute Crunch (# Reps)	Component Points
≥55	10.00
53-54	9.50
52	9.00
50-51	8.75
48-49	8.50
46-47	8.25
44-45	8.00
42-43	7.75
40-41	7.50
38-39	7.40
36-37	7.30
35	7.20
33-34	7.10
32	7.00
30-31	6.00
28-29	4.00
27	2.00
<27	0.00

Males 25-29

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤9:36	≥54	50.00
9:37-9:48	53	47.50
9:49-10:12	51-52	45.00
10:13-10:36	49-50	43.50
10:37-11:06	47-48	42.00
11:07-11:36	45-46	40.50
11:37-12:12	43-44	39.00
12:13-12:54	41-42	37.50
12:55-13:36	39-40	36.00
13:37-14:24	37-38	34.00
14:25-14:54	36	32.00
14:55-15:18	35	30.00
15:19-15:48	34	27.00
15:49-16:24	33	24.00
16:25-16:54	32	21.00
16:55-17:36	31	18.00
17:37-18:12	30	15.00
18:13-18:54	29	12.00
18:55-19:42	28	9.00
19:43-20:36	27	6.00
20:37-21:30	26	3.00
>21:30	<26	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points
≥57	10.00
56	9.75
55	9.50
54	9.25
52-53	9.00
48-51	8.75
45-47	8.50
41-44	8.25
37-40	8.00
34-36	7.75
30-33	7.50
27-29	7.40
25-26	7.30
23-24	7.20
20-22	7.10
17-19	7.00
15-16	6.00
13-14	5.00
11-12	4.00
10	3.00
9	2.00
7-8	1.00
<7	0.00

1 minute Crunch (# Reps)	Component Points
≥53	10.00
51-52	9.50
50	9.00
48-49	8.75
46-47	8.50
44-45	8.25
42-43	8.00
40-41	7.75
38-39	7.50
36-37	7.40
34-35	7.30
33	7.20
31-32	7.10
30	7.00
28-29	6.00
27	4.00
25-26	2.00
<25	0.00

Appendix A (cont.)

Males 30-34

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤9:48	≥53	50.00
9:49-10:12	51-52	47.50
10:13-10:24	50	45.00
10:25-10:54	48-49	43.50
10:55-11:24	46-47	42.00
11:25-11:54	44-45	40.50
11:55-12:30	42-43	39.00
12:31-12:54	41	37.50
12:55-13:36	39-40	36.00
13:37-14:24	37-38	34.00
14:25-14:54	36	32.00
14:55-15:18	35	30.00
15:19-15:48	34	27.00
15:49-16:24	33	24.00
16:25-16:54	32	21.00
16:55-17:36	31	18.00
17:37-18:12	30	15.00
18:13-18:54	29	12.00
18:55-19:42	28	9.00
19:43-20:36	27	6.00
20:37-21:30	26	3.00
>21:30	<26	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥52	10.00	≥51	10.00
50-51	9.75	49-50	9.50
49	9.50	48	9.00
48	9.25	46-47	8.75
46-47	9.00	44-45	8.50
43-45	8.75	42-43	8.25
40-42	8.50	40-41	8.00
36-39	8.25	38-39	7.75
33-35	8.00	36-37	7.50
30-32	7.75	34-35	7.40
27-29	7.50	33	7.30
24-26	7.40	31-32	7.20
22-23	7.30	30	7.10
20-21	7.20	28-29	7.00
17-19	7.10	26-27	6.00
15-16	7.00	25	4.00
13-14	6.00	23-24	2.00
12	5.00	<23	0.00
10-11	4.00		
8-9	3.00		
7	2.00		
5-6	1.00		
<5	0.00		

Males 35-39

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤9:48	≥53	50.00
9:49-10:12	51-52	47.50
10:13-10:24	50	45.00
10:25-10:54	48-49	43.50
10:55-11:24	46-47	42.00
11:25-11:54	44-45	40.50
11:55-12:30	42-43	39.00
12:31-12:54	41	37.50
12:55-13:36	39-40	36.00
13:37-14:24	37-38	34.00
14:25-14:54	36	32.00
14:55-15:18	35	30.00
15:19-15:48	34	27.00
15:49-16:24	33	24.00
16:25-16:54	32	21.00
16:55-17:36	31	18.00
17:37-18:12	30	15.00
18:13-18:54	29	12.00
18:55-19:42	28	9.00
19:43-20:36	27	6.00
20:37-21:30	26	3.00
>21:30	<26	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥46	10.00	≥49	10.00
45	9.75	47-48	9.50
44	9.50	46	9.00
42-43	9.25	44-45	8.75
41	9.00	42-43	8.50
38-40	8.75	40-41	8.25
35-37	8.50	38-39	8.00
32-34	8.25	36-37	7.75
30-31	8.00	34-35	7.50
27-29	7.75	32-33	7.40
24-26	7.50	30-31	7.30
21-23	7.40	29	7.20
19-20	7.30	27-28	7.10
17-18	7.20	25-26	7.00
15-16	7.10	23-24	6.00
13-14	7.00	22	4.00
11-12	6.00	20-21	2.00
9-10	5.00	<20	0.00
8	4.00		
6-7	3.00		
5	2.00		
3-4	1.00		
<3	0.00		

Appendix A (cont.)

Males 40-44

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤10:24	≥50	50.00
10:25-10:36	49	47.50
10:37-10:54	48	45.00
10:55-11:24	46-47	43.50
11:25-11:54	44-45	42.00
11:55-12:30	42-43	40.50
12:31-13:12	40-41	39.00
13:13-13:36	39	37.50
13:37-14:24	37-38	36.00
14:25-15:18	35-36	34.00
15:19-15:48	34	32.00
15:49-16:24	33	30.00
16:25-16:54	32	27.00
16:55-17:36	31	24.00
17:37-18:12	30	21.00
18:13-18:54	29	18.00
18:55-19:42	28	15.00
19:43-20:36	27	12.00
20:37-21:30	26	9.00
21:31-22:30	25	6.00
22:31-23:36	24	3.00
>23:36	<24	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points
≥40	10.00
39	9.75
38	9.50
37	9.25
36	9.00
33-35	8.75
31-32	8.50
28-30	8.25
26-27	8.00
23-25	7.75
21-22	7.50
18-20	7.40
16-17	7.30
14-15	7.20
12-13	7.10
10-11	7.00
8-9	6.00
7	5.00
6	4.00
4-5	3.00
3	2.00
1-2	1.00
<1	0.00

1 minute Crunch (# Reps)	Component Points
≥47	10.00
45-46	9.50
43-44	9.00
41-42	8.75
39-40	8.50
37-38	8.25
35-36	8.00
33-34	7.75
31-32	7.50
29-30	7.40
27-28	7.30
26	7.20
24-25	7.10
22-23	7.00
20-21	6.00
19	4.00
17-18	2.00
<17	0.00

Males 45-49

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤10:24	≥50	50.00
10:25-10:36	49	47.50
10:37-10:54	48	45.00
10:55-11:24	46-47	43.50
11:25-11:54	44-45	42.00
11:55-12:30	42-43	40.50
12:31-13:12	40-41	39.00
13:13-13:36	39	37.50
13:37-14:24	37-38	36.00
14:25-15:18	35-36	34.00
15:19-15:48	34	32.00
15:49-16:24	33	30.00
16:25-16:54	32	27.00
16:55-17:36	31	24.00
17:37-18:12	30	21.00
18:13-18:54	29	18.00
18:55-19:42	28	15.00
19:43-20:36	27	12.00
20:37-21:30	26	9.00
21:31-22:30	25	6.00
22:31-23:36	24	3.00
>23:36	<24	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points
≥40	10.00
39	9.75
37-38	9.50
35-36	9.25
33-34	9.00
30-32	8.75
27-29	8.50
25-26	8.25
22-24	8.00
20-21	7.75
18-19	7.50
16-17	7.40
14-15	7.30
12-13	7.20
10-11	7.10
9	7.00
7-8	6.00
6	5.00
5	4.00
4	3.00
2-3	2.00
1	1.00
0	0.00

1 minute Crunch (# Reps)	Component Points
≥45	10.00
43-44	9.50
41-42	9.00
39-40	8.75
37-38	8.50
35-36	8.25
33-34	8.00
31-32	7.75
29-30	7.50
27-28	7.40
25-26	7.30
24	7.20
22-23	7.10
20-21	7.00
18-19	6.00
17	4.00
15-16	2.00
<15	0.00

Appendix A (cont.)

Males 50-54

Aerobic Fitness		
1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤11:06	≥47	50.00
11:07-11:24	46	47.50
11:25-11:36	45	45.00
11:37-12:12	43-44	43.50
12:13-12:54	41-42	42.00
12:55-13:36	39-40	40.50
13:37-14:24	37-38	39.00
14:25-15:18	35-36	37.50
15:19-15:48	34	36.00
15:49-16:54	32-33	34.00
16:55-17:36	31	32.00
17:37-18:12	30	30.00
18:13-18:54	29	27.00
18:55-19:42	28	24.00
19:43-20:36	27	21.00
20:37-21:30	26	18.00
21:31-22:30	25	15.00
22:31-23:36	24	12.00
23:37-24:48	23	9.00
24:49-26:06	22	6.00
26:07-27:36	21	3.00
>27:36	<21	0.00

Body Composition	
Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness			
1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥39	10.00	≥43	10.00
37-38	9.75	41-42	9.50
35-36	9.50	39-40	9.00
32-34	9.25	37-38	8.75
30-31	9.00	35-36	8.50
27-29	8.75	32-34	8.25
25-26	8.50	30-31	8.00
22-24	8.25	28-29	7.75
20-21	8.00	26-27	7.50
17-19	7.75	24-25	7.40
15-16	7.50	22-23	7.30
13-14	7.40	21	7.20
12	7.30	19-20	7.10
10-11	7.20	17-18	7.00
9	7.10	15-16	6.00
7-8	7.00	14	4.00
6	6.00	12-13	2.00
5	5.00	<12	0.00
4	4.00		
3	3.00		
2	2.00		
1	1.00		
0	0.00		

Males 55+

Aerobic Fitness		
1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤11:06	≥47	50.00
11:07-11:24	46	47.50
11:25-11:36	45	45.00
11:37-12:12	43-44	43.50
12:13-12:54	41-42	42.00
12:55-13:36	39-40	40.50
13:37-14:24	37-38	39.00
14:25-15:18	35-36	37.50
15:19-15:48	34	36.00
15:49-16:54	32-33	34.00
16:55-17:36	31	32.00
17:37-18:12	30	30.00
18:13-18:54	29	27.00
18:55-19:42	28	24.00
19:43-20:36	27	21.00
20:37-21:30	26	18.00
21:31-22:30	25	15.00
22:31-23:36	24	12.00
23:37-24:48	23	9.00
24:49-26:06	22	6.00
26:07-27:36	21	3.00
>27:36	<21	0.00

Body Composition	
Abdominal Circumference (inches)	Component Points
<32.5	30.00
32.50	28.75
33.00	27.50
33.50	26.25
34.00	25.00
34.50	23.75
35.00	22.50
35.50	22.35
36.00	22.20
36.50	22.05
37.00	21.90
37.50	21.75
38.00	21.60
38.50	21.45
39.00	21.30
39.50	21.25
40.00	21.00
40.50	18.00
41.00	15.00
41.50	12.00
42.00	9.00
42.50	6.00
43.00	3.00
>43.00	0.00

Muscle Fitness			
1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥35	10.00	≥41	10.00
33-34	9.75	39-40	9.50
31-32	9.50	37-38	9.00
29-30	9.25	34-36	8.75
28	9.00	32-33	8.50
26-27	8.75	30-31	8.25
24-25	8.50	27-29	8.00
21-23	8.25	25-26	7.75
19-20	8.00	23-24	7.50
17-18	7.75	21-22	7.40
15-16	7.50	20	7.30
13-14	7.40	18-19	7.20
11-12	7.30	16-17	7.10
10	7.20	15	7.00
8-9	7.10	13-14	6.00
6-7	7.00	12	4.00
5	6.00	10-11	2.00
4	5.00	<10	0.00
3	4.00		
2	3.00		
1	2.00		
0	0.00		

Appendix A (cont.)

Females Under 25

Aerobic Fitness		
1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤11:06	≥47	50.00
11:07-11:36	45-46	47.50
11:37-11:54	44	45.00
11:55-12:30	42-43	43.50
12:31-13:12	40-41	42.00
13:13-14:00	38-39	40.50
14:01-14:54	36-37	39.00
14:55-15:18	35	37.50
15:19-15:48	34	36.00
15:49-16:24	33	34.00
16:25-16:54	32	32.00
16:55-17:36	31	30.00
17:37-18:12	30	27.00
18:13-18:54	29	24.00
18:55-19:42	28	21.00
19:43-20:36	27	18.00
20:37-21:30	26	15.00
21:31-22:30	25	12.00
22:31-23:36	24	9.00
23:37-24:48	23	6.00
24:49-26:06	22	3.00
>26:06	<22	0.00

Body Composition	
Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness			
1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥42	10.00	≥51	10.00
41	9.75	50	9.50
40	9.50	49	9.00
38-39	9.25	46-48	8.75
37	9.00	44-45	8.50
34-36	8.75	42-43	8.25
31-33	8.50	40-41	8.00
27-30	8.25	37-39	7.75
24-26	8.00	35-36	7.50
21-23	7.75	33-34	7.40
18-20	7.50	30-32	7.30
16-17	7.40	28-29	7.20
14-15	7.30	26-27	7.10
12-13	7.20	24-25	7.00
10-11	7.10	22-23	6.00
9	7.00	20-21	4.00
8	6.00	18-19	2.00
7	5.00	<18	0.00
6	4.00		
5	3.00		
4	2.00		
3	1.00		
<3	0.00		

Females 25-29

Aerobic Fitness		
1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤11:24	≥46	50.00
11:25-11:36	45	47.50
11:37-11:54	44	45.00
11:55-12:30	42-43	43.50
12:31-13:12	40-41	42.00
13:13-14:00	38-39	40.50
14:01-14:54	36-37	39.00
14:55-15:18	35	37.50
15:19-15:48	34	36.00
15:49-16:24	33	34.00
16:25-16:54	32	32.00
16:55-17:36	31	30.00
17:37-18:12	30	27.00
18:13-18:54	29	24.00
18:55-19:42	28	21.00
19:43-20:36	27	18.00
20:37-21:30	26	15.00
21:31-22:30	25	12.00
22:31-23:36	24	9.00
23:37-24:48	23	6.00
24:49-26:06	22	3.00
>26:06	21	0.00

Body Composition	
Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness			
1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥41	10.00	≥47	10.00
40	9.75	46	9.50
38-39	9.50	45	9.00
36-37	9.25	42-44	8.75
35	9.00	40-41	8.50
31-34	8.75	38-39	8.25
28-30	8.50	36-37	8.00
25-27	8.25	34-35	7.75
22-24	8.00	31-33	7.50
19-21	7.75	29-30	7.40
16-18	7.50	27-28	7.30
14-15	7.40	25-26	7.20
13	7.30	23-24	7.10
11-12	7.20	21-22	7.00
10	7.10	19-20	6.00
8-9	7.00	17-18	4.00
7	6.00	15-16	2.00
6	5.00	<15	0.00
5	4.00		
4	3.00		
3	2.00		
2	1.00		
<2	0.00		

Appendix A (cont.)

Females 30-34

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤11:54	≥44	50.00
11:55-12:30	42-43	47.50
12:31-12:54	41	45.00
12:55-13:12	40	43.50
13:13-13:36	39	42.00
13:37-14:24	37-38	40.50
14:25-14:54	36	39.00
14:55-15:18	35	37.50
15:19-15:48	34	36.00
15:49-16:24	33	34.00
16:25-16:54	32	32.00
16:55-17:36	31	30.00
17:37-18:12	30	27.00
18:13-18:54	29	24.00
18:55-19:42	28	21.00
19:43-20:36	27	18.00
20:37-21:30	26	15.00
21:31-22:30	25	12.00
22:31-23:36	24	9.00
23:37-24:48	23	6.00
24:49-26:06	22	3.00
>26:06	<22	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points
≥40	10.00
39	9.75
37-38	9.50
35-36	9.25
33-34	9.00
29-32	8.75
26-28	8.50
23-25	8.25
20-22	8.00
17-19	7.75
14-16	7.50
12-13	7.40
11	7.30
10	7.20
9	7.10
7-8	7.00
6	6.00
5	5.00
4	4.00
3	3.00
2	2.00
1	1.00
0	0.00

1 minute Crunch (# Reps)	Component Points
≥42	10.00
41	9.50
40	9.00
37-39	8.75
35-36	8.50
33-34	8.25
31-32	8.00
29-30	7.75
27-28	7.50
25-26	7.40
23-24	7.30
22	7.20
20-21	7.10
18-19	7.00
16-17	6.00
13-15	4.00
11-12	2.00
<11	0.00

Females 35-39

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤11:54	≥44	50.00
11:55-12:30	42-43	47.50
12:31-12:54	41	45.00
12:55-13:12	40	43.50
13:13-13:36	39	42.00
13:37-14:24	37-38	40.50
14:25-14:54	36	39.00
14:55-15:18	35	37.50
15:19-15:48	34	36.00
15:49-16:24	33	34.00
16:25-16:54	32	32.00
16:55-17:36	31	30.00
17:37-18:12	30	27.00
18:13-18:54	29	24.00
18:55-19:42	28	21.00
19:43-20:36	27	18.00
20:37-21:30	26	15.00
21:31-22:30	25	12.00
22:31-23:36	24	9.00
23:37-24:48	23	6.00
24:49-26:06	22	3.00
>26:06	<22	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points
≥30	10.00
29	9.75
28	9.50
27	9.25
26	9.00
23-25	8.75
21-22	8.50
19-20	8.25
17-18	8.00
15-16	7.75
13-14	7.50
11-12	7.40
10	7.30
9	7.20
8	7.10
6-7	7.00
4-5	6.00
3	4.00
1-2	2.00
<1	0.00

1 minute Crunch (# Reps)	Component Points
≥40	10.00
38-39	9.50
37	9.00
35-36	8.75
33-34	8.50
31-32	8.25
29-30	8.00
27-28	7.75
25-26	7.50
23-24	7.40
21-22	7.30
20	7.20
18-19	7.10
16-17	7.00
14-15	6.00
12-13	4.00
9-11	2.00
<9	0.00

Appendix A (cont.)

Females 40-44

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤12:30	≥42	50.00
12:31-12:54	41	47.50
12:55-13:12	40	45.00
13:13-14:00	38-39	43.50
14:01-14:54	36-37	42.00
14:55-15:48	34-35	40.50
15:49-16:24	33	39.00
16:25-16:54	32	37.50
16:55-17:36	31	36.00
17:37-18:12	30	34.00
18:13-18:54	29	32.00
18:55-19:42	28	30.00
19:43-20:36	27	27.00
20:37-21:30	26	24.00
21:31-22:30	25	21.00
22:31-23:36	24	18.00
23:37-24:48	23	15.00
24:49-26:06	22	12.00
26:07-27:36	21	9.00
27:37-29:18	20	6.00
29:19-31:12	19	3.00
>31:12	<19	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥20	10.00	≥38	10.00
19	9.50	36-37	9.50
18	9.00	34-35	9.00
16-17	8.75	32-33	8.75
15	8.50	30-31	8.50
14	8.25	28-29	8.25
13	8.00	26-27	8.00
12	7.75	24-25	7.75
11	7.50	22-23	7.50
9-10	7.40	20-21	7.40
8	7.30	18-19	7.30
7	7.20	17	7.20
6	7.10	15-16	7.10
5	7.00	13-14	7.00
3-4	6.00	11-12	6.00
2	4.00	9-10	4.00
1	2.00	7-8	2.00
0	0.00	<7	0.00

Females 45-49

Aerobic Fitness

1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤12:30	≥42	50.00
12:31-12:54	41	47.50
12:55-13:12	40	45.00
13:13-14:00	38-39	43.50
14:01-14:54	36-37	42.00
14:55-15:48	34-35	40.50
15:49-16:24	33	39.00
16:25-16:54	32	37.50
16:55-17:36	31	36.00
17:37-18:12	30	34.00
18:13-18:54	29	32.00
18:55-19:42	28	30.00
19:43-20:36	27	27.00
20:37-21:30	26	24.00
21:31-22:30	25	21.00
22:31-23:36	24	18.00
23:37-24:48	23	15.00
24:49-26:06	22	12.00
26:07-27:36	21	9.00
27:37-29:18	20	6.00
29:19-31:12	19	3.00
>31:12	<19	0.00

Body Composition

Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness

1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥18	10.00	≥34	10.00
17	9.50	33	9.50
16	9.00	32	9.00
14-15	8.75	30-31	8.75
13	8.50	28-29	8.50
12	8.25	26-27	8.25
11	8.00	24-25	8.00
10	7.75	22-23	7.75
9	7.50	20-21	7.50
8	7.40	18-19	7.40
7	7.30	16-17	7.30
6	7.20	14-15	7.20
5	7.10	12-13	7.10
4	7.00	10-11	7.00
3	6.00	8-9	6.00
2	4.00	7	4.00
1	2.00	6	2.00
0	0.00	<6	0.00

Appendix A (cont.)

Females 50-54

Aerobic Fitness		
1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤14:24	≥37	50.00
14:25-14:54	36	47.50
14:55-15:18	35	45.00
15:19-16:24	33-34	43.50
16:25-16:54	32	42.00
16:55-17:36	31	40.50
17:37-18:12	30	39.00
18:13-18:54	29	37.50
18:55-19:42	28	36.00
19:43-20:36	27	34.00
20:37-21:30	26	32.00
21:31-22:30	25	30.00
22:31-23:36	24	27.00
23:37-24:48	23	24.00
24:49-26:06	22	21.00
26:07-27:36	21	18.00
27:37-29:18	20	15.00
29:19-31:12	19	12.00
31:13-33:18	18	9.00
33:19-35:48	17	6.00
35:49-38:36	16	3.00
>38:36	<16	0.00

Body Composition	
Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness			
1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥16	10.00	≥30	10.00
15	9.50	29	9.00
14	9.00	27-28	8.75
13	8.75	25-26	8.50
12	8.50	23-24	8.25
11	8.25	21-22	8.00
10	8.00	19-20	7.75
9	7.75	17-18	7.50
8	7.50	15-16	7.40
7	7.40	13-14	7.30
6	7.30	11-12	7.20
5	7.20	9-10	7.10
4	7.10	7-8	7.00
3	7.00	5-6	6.00
2	6.00	3-4	4.00
1	3.00	1-2	2.00
<1	0.00	<1	0.00

Females 55+

Aerobic Fitness		
1.5-Mile Run Time (min.)	Bike Test (VO_2)	Component Points
≤14:24	≥37	50.00
14:25-14:54	36	47.50
14:55-15:18	35	45.00
15:19-16:24	33-34	43.50
16:25-16:54	32	42.00
16:55-17:36	31	40.50
17:37-18:12	30	39.00
18:13-18:54	29	37.50
18:55-19:42	28	36.00
19:43-20:36	27	34.00
20:37-21:30	26	32.00
21:31-22:30	25	30.00
22:31-23:36	24	27.00
23:37-24:48	23	24.00
24:49-26:06	22	21.00
26:07-27:36	21	18.00
27:37-29:18	20	15.00
29:19-31:12	19	12.00
31:13-33:18	18	9.00
33:19-35:48	17	6.00
35:49-38:36	16	3.00
>38:36	<16	0.00

Body Composition	
Abdominal Circumference (inches)	Component Points
<29.5	30.00
29.50	28.75
30.00	27.50
30.50	26.25
31.00	25.00
31.50	23.75
32.00	22.50
32.50	22.30
33.00	22.00
33.50	21.80
34.00	21.50
34.50	21.30
35.00	21.00
35.50	18.00
36.00	15.00
36.50	12.00
37.00	9.00
37.50	6.00
38.00	3.00
>38.00	0.00

Muscle Fitness			
1 minute Push-up (# Reps)	Component Points	1 minute Crunch (# Reps)	Component Points
≥14	10.00	≥27	10.00
13	9.50	26	9.50
12	9.00	25	9.00
10-11	8.50	23-24	8.75
9	8.00	21-22	8.50
7-8	7.50	19-20	8.25
6	7.40	18	8.00
5	7.30	16-17	7.75
4	7.20	14-15	7.50
3	7.10	12-13	7.40
2	7.00	10-11	7.30
1	6.00	8-9	7.20
<1	0.00	6-7	7.10
		4-5	7.00
		3	6.00
		2	4.00
		1	2.00
		<1	0.00

Appendix B

Exemption From Human Experimentation Requirements

DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

8 September 2004

MEMORANDUM FOR AFIT/ENV
ATTN: DR. Edward D. White III

FROM: AFRL/HEH

SUBJECT: Approval for the Use of Volunteers in Demonstrations

1. Human experimentation as described in Protocol 04-56-E, "A Study in Statistical Regression and Analysis", may begin.

2. In accordance with AFI 40-402, this protocol was reviewed and approved by the Wright Site Institutional Review Board (WSIRB) on 30 August 2004, the AFRL Chief of Aerospace Medicine on 8 September 2004.

3. Please notify the undersigned of any changes in procedures prior to their implementation. A judgment will be made at that time whether or not a complete WSIRB review is necessary.

Signed 8 September 2004
HELEN JENNINGS
Human Use Administrator

Bibliography

Air Force Military Personnel Center, Department of the Air force. *Conference Report of Meeting Between United States Air force and Indiana University Personnel Regarding the USAF Physical Fitness Program.* Randolph AFB TX, 21 November 1963

Balke, Bruno, and Ray W Ware, Captain, USAF. *The Present Status of Physical Fitness in the Air Force.* Unpublished research report No. 59-67. School of Aviation Medicine, Randolph AFB TX, May 1959 (AD 036235).

Barrow, H.M. and Brown, J.P. *Man and Movement: Principles of Physical Education. 4th Ed*. Philadelphia: Lea & Febiger, 1988.

Ben-Noun, L. and A. Labor. "Relationship of neck circumference to cardiovascular risk factors," *Obesity Research*, 11:226-231 (January 2003).

Bennington, Raymond O., Lieutenant Colonel, USAF. *Report of TDY Travel for the Purpose of Participating in the AF Physical Fitness Study Group*. Unpublished travel report, Air Force Military Personnel Center, Randolph AFB TX, 5 October 1978.

Callender, Bruce D. "Jumper to Airmen: Get in Shape," *Air Force Magazine*, p70 (January 2004).

Cooper, Kenneth H. *The proposed United States Air Force Physical Fitness Program.* Untitled research report, unnumbered, Aerospace Medical Laboratory, Wilford Hall USAF Hospital, Lackland AFB TX, May 1967.

Cooper, Kenneth H. *Aerobics*. New York: Bantam Books, 1968.

Department of Defense. *Department of Defense Directive on Physical Fitness and Weight Control Programs*. DoD Directive 1308.1. Washington: GPO, 1981.

Department of the Air Force. *Training-Physical Conditioning.* AFR 50-5. Washington: GPO, 13 November 1947.

Department of the Air Force. *Training-Physical Conditioning*. AFR 50-5. Washington: GPO, 27 April 1959.

Department of the Air Force. *Physical Conditioning.* AFM 160-26. Washington: GPO, 8 June 1961.

Department of the Air Force. *USAF Aerobics Physical Fitness Program (Male)*. AFP 50-56. Washington: GPO, 1 November 1969.

Department of the Air Force. *Physical Fitness*. AFM 50-15, Change 3. Washington: GPO, February 1971.

Department of the Air Force. *USAF Physical Fitness and Weight Control Program*. AFR 50-49. Washington: GPO, 21 July 1972.

Department of the Air Force. *Air Force Physical Fitness Program*. AFR 35-11, Immediate Message Change 79-1. Washington: GPO, 23 September 1977.

Department of the Air Force. *The Weight and Body Fat Management Program.* AFI 40-502. Washington: HQ AFMOA/SGOP, 1994

Department of the Air Force. *The Air Force Physical Fitness Program.* AFI 40-501. Washington: HQ AFMOA/SGOP, 1998

Department of the Air Force. *The Air Force Fitness Program.* AFI 10-248. Washington: HQ USAF/SGO, 1 January 2004.

Department of the Army. *Physical Fitness Training.* FM 21-20. Washington: Headquarters US Army, 1998

Department of the Navy. *OPNAV INSTRUCTION 6110.1E.* Washington: Naval Military Personnel Command, 1998.

Esmaillzadeh, A. and others. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity*, 1325-1332 (2004).

Hermansmen, Lars and Bengt Saltin. "Oxygen uptake during maximal treadmill and bicycle exercise," *Journal of Applied Physiology*, 26: 31-37 (1969).

Hsieh, S. D., H. Yoshinaga, and T. Muto. "Waist-to-height ratio, a simple and practical index for assessing central fat distribution and metabolic risk in Japanese men and women," *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity*, 27: 610-616 (May 2003).

Hsieh, Shiun Dong and Takashi Muto. "A simple and practical index for assessing the risk of metabolic syndrome during routine health checkups," *Nippon Rinsho, Japanese Journal of Clinical Medicine*, 62: 1143-1149 (June 2004).

Hsieh, Shiun Dong and Takashi Muto. “The superiority of waist-to-height ratio as an anthropometric index to evaluate clustering of coronary risk factors among non-obese men and women,” *Preventive Medicine*, 40: 216-220 (February 2005).

Hunn, Heather M. *Factors Influencing the Air Force Cycle Ergometry Fitness Assessment*. MS thesis, AFIT/GLM/ENV/01M-02. School of Engineering and Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, March 2001.

Jackson, Andrew S. and Robert M. Ross. "Methods and limitations of assessing functional work capacity objectively," *Journal of Back and Musculoskeletal Rehabilitation,* 6: 265-276 (1996).

JMP® Version 5.0, (Academic), CD-ROM. Computer Software. SAS Institute Inc., Cary NC, 2002.

Kahn, Henry S. and Yiling J. Cheng. “Waist-to-height ratio (WHtR) is as useful as BMI percentiles for predicting risk identification,” *Public Health and the Environment*, 4204.0: (November 9 2003).

Karolides, N.J. and Karolides, M. *Focus on Fitness*. Santa Barbara, CA: ABC-CLIO, 1993.

Kennedy, John F. “The Soft American,” *Sports Illustrated*, 16-17 (December 1960).

Kennedy, John F. “The Vigor we Need,” *Sports Illustrated*, 17: 12-15 (1962).

Kraus, H. and Hirschland, R. “Minimum muscular fitness tests in school children,” *Research Quarterly*. 25:178, (1954).

Lean, Michael J. and Thang S. Han. “Waist Worries,” *American journal of Clinical Nutrition*, 76: 699-700 (2002).

Lin, W-Y., L-T Lee, C-Y Chen, H. Lo, H-H Hsia, I-L Liu, R-S Lin, W-Y Shau, and K-C Huang. “Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan,” *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association For the Study of Obesity*, 26: 1232-1238 (September 2002).

Mitchell, Jere H. and Gunnar Blomquist. "Maximal oxygen uptake," *New England Journal of Medicine,* 284: 1018-1022 (1971)

Nash, W. *Military Science and Tactics and Physical Education.* New York: AMS Press, Inc. 1972.

Nieman, D.C. *Fitness and Sports Medicine: An Introduction*. Palo Alto CA: Bull Publishing Co., 1990.

Pi-Sunyer, F. Xavier. "Statement on first federal obesity clinical guidelines," *National Institute of Health*, NHLBI Communications Office, (June 1998).

Pollock, Michael L. and others. *The cross-validation of the United States Air Force submaximal cycle ergometry test to estimate aerobic capacity*. Crew Systems Directorate, Crew Technology Division, Brooks AFB TX, June 1994 (ADA284005).

Rice, E.A. and others. *A Brief History of Physical Education*. New York: The Ronald Press Co., 1958.

Royal Canadian Air Force. *5BX Plan for physical Fitness*. AFP 50-5-1. Ottawa: Queen's Printer and Controller of Stationary, 1962.

Savva, S. C. M. Tornaritis, M. Savva, Y. Kourides, A. Panagi, N. Silikiotou, C. Georgiou, and A. Kafatos. "Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index," *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association For the Study of Obesity*, 24: 1453-1458 (November 2000).

Smith, T. G.and F. P. Flatten. *Air Force Fitness Program Talking Paper*. HSC/YAM (1997).

Susi, Ronald A., Major, USAF. *Aerobics: Fact or Fiction?* Unpublished research report, No. 2654-74, Air Command and Staff College, Maxwell AFB AL, May 1974.

United States Marine Corps. *Marine Corps Order 6100.3J.* Washington: Headquarters United States Marine Corps, 1988.

United States Marine Corps. *Marine Corps Order 6100.10B.* Washington: Headquarters United States Marine Corps, 1993.

"Waist management: Gauging your risk," *Consumer Reports*, (August 2003)

"Waist-to-Hip Ratio," *National Institute of Diabetes and Digestive and Kidney Disease*, Http://www.stayinginshape.com/4trover/libv/d18.shtml. 30 July 2004.

Welch, P.D. *History of American Physical Education and Sport (2nd ed.)*. Springfield IL: Charles C. Thomas, 1996.

Whest, D.A., and Bucher, C.A. *Foundations of Physical Education and Sport*. St. Louis MO: Mosby, 1995.

Williams, Jesse F. *The Principles of Physical Education*. Philadelphia: Saunders and Company, 1948.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 074-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
14-06-2005	**Master's Thesis**	Jan 2004 – Jun 2005

4. TITLE AND SUBTITLE

Fit-To-Fight: Waist vs. Waist/Height Measurements to Determine An Individual's Fitness Level - A Study In Statistical Regression and Analysis

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Swiderski, Steven J., Captain, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way, Building 641
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT/GCA/ENC/05-03

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Air Force members are to be tested for fitness by measuring their abdominal circumference, counting the number of sit-ups and push-ups they can accomplish, and the time it takes them to run 1 and ½ miles. The abdominal measurement is a "one-size-fits-all" fitness standard. This research determines that a person's waist-to-height ratio is a better measurement than the waist measurement to estimate an individual's fitness level. This research estimates that all of the variables used to proxy fitness (Gender, Age, Height, Waist Circumference, Waist-to-Height Ratio, Push-Ups, and Sit-Ups) are statistically significant and do represent good estimators of physical fitness. This research also determines that there is a need for separate gender scoring charts for the 1 and ½ mile run, but that these charts do not need to take age into consideration. This research builds on the current Air Force fitness program by offering a new waist-to-height ratio scoring system. Both males and females can now be scored on one waist-to-height ratio chart. Finally, this research estimates how well the separate age and gender charts adjust raw fitness scores into points. The results suggest that the charts do adequately adjust a member's raw fitness score into fitness points.

15. SUBJECT TERMS

Air Force Fitness Test, Abdominal Circumference, Sit-Ups, Push-Ups, 1 and ½ mile Run, one-size-fits-all, Fitness Score, Gender, Age, Height, Waist Circumference, Waist-to-Height Ratio, Neck Circumference, Waist-to-Hip Ratio, Linear Regression, ANOVA Analysis, AFI 10-248, Fit-to-Fight, Cubic Trend Scoring System, Anthropometric, VO_2max, Bruce Protocol, Cycle Erogometry, Body Mass Index, BMI, Physical Fitness

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Dr. Edward D. White
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	UU	91	(937) 255-3636, ext 4540; e-mail: Edward.White@afit.edu

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18