CHAPTER 2

ASSESSING AEROBIC FITNESS

CHAPTER OVERVIEW

PHYSICAL FITNESS is not only important for athletic competition, but also for good health. The components that define athletic-related fitness are the same as those used for health-related fitness; the difference is degree. The athlete develops a high level of fitness to maximize performance. For good health only a moderate level of fitness is needed. The components that define physical fitness are:

- **Aerobic fitness** is the ability to exercise at relatively high intensities for extended periods of time. Aerobic fitness is largely dependent upon, and limited by, the body's ability to deliver oxygen to the working muscles. Medical research has now defined the minimum levels of fitness needed for good health and the level required for quality, functional living in the elderly.
- **Body composition** is assessed by measuring percent body fat, which is the percentage of total body weight that is body fat. Regular exercise and proper nutrition maintain percent body fat at a level that enhances health and athletic performance. Chapter 4 outlines the methods used to assess body composition.
- The non-aerobic components of fitness are: **muscular strength**—the capacity of the muscles to generate maximal force; **muscular endurance**—the ability to exercise a muscle group for prolonged periods of time; and **flexibility**—the degree that muscle groups can be moved around joints without injury.

Aerobic fitness reduces the risk of heart disease. Chapter 3 outlines the steps needed to develop and evaluate a sound, individualized aerobic exercise program. The assessment of aerobic fitness[1] is an important element in developing and monitoring your aerobic exercise program. It is the foundation of an exercise program designed to meet your needs and be within your capacity. Periodic fitness tests monitor progress.

The general goals of Chapter 2 are to provide you with an understanding of the nature of aerobic fitness, and the tests used to assess it. The major educational outcomes of the chapter are to help you understand the following:

1. The scientific term for aerobic fitness is maximal oxygen uptake or VO2max.

1. The medical standards to consider before starting an aerobic exercise program.
2. The scientific definition and description of aerobic fitness.
3. The role of aerobic fitness on health.
4. The tests used to measure aerobic fitness.
5. The age and gender standards used to evaluate aerobic fitness.
6. The levels of aerobic fitness desirable for health promotion.
7. The influence of aging and lifestyle on aerobic fitness.

MEDICAL CONSIDERATIONS

Is it necessary for adults to have medical clearance before starting an aerobic exercise program? This is a requirement of some medically oriented adult fitness programs. For example, high risk employees who enroll in the adult fitness program at NASA/Johnson Space Center (Houston, TX) must take a treadmill stress test before starting the exercise class. For many other programs, a medical examination is not a requirement, but a fitness evaluation may be given.

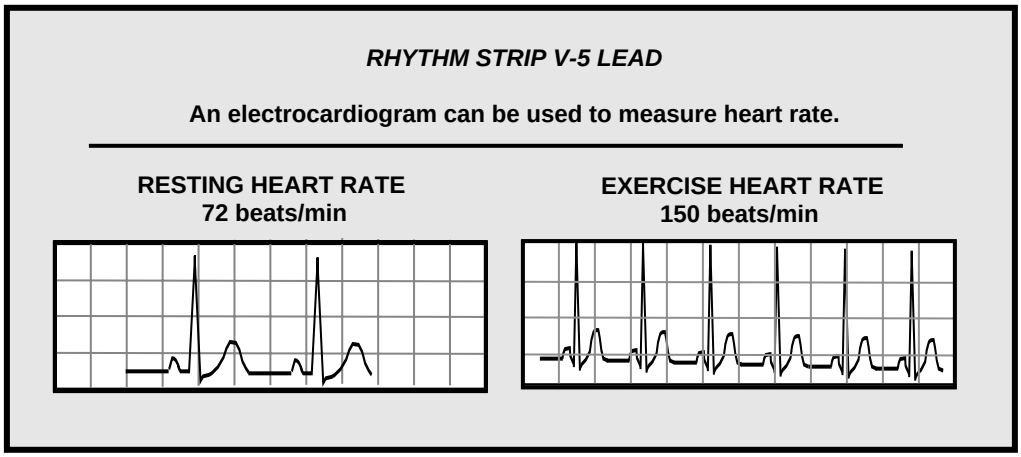
What is the difference between a fitness evaluation and a stress test? A stress test and fitness evaluation appear to provide the same information because the tests seem identical. Both tests may use either a treadmill or cycle ergometer to exercise the person. The difference is that a fitness evaluation just assesses maximal aerobic capacity (i.e., VO2max), whereas, a stress test is a diagnostic medical procedure. By examining the electrical activity of the heart under the stress of exercise (Figure 2-1), a trained physician can often detect heart disease.

Do I need a stress test? The objective of a stress test is to "stress" the heart by maximizing its work. It is neither necessary nor desirable for all adults to have a yearly stress test. The best advice can be obtained from your physician. Current medical standards show that people who fall into the following groups should consider having a stress test before starting an adult fitness program [1, 15]:

1. Sedentary men over the age of 35 years and post menopausal, sedentary women.
2. Any person who has chest pains or a history of heart disease.
3. Any person who has significant cardiovascular disease risk factors. These risk factors include:
    - A strong family history of cardiovascular disease, particularly occurring at an early age, ≤ 50 years.
    - A history of high blood pressure.
    - A history of elevated cholesterol, particularly with a low HDL-C.
    - A history of diabetes.
    - A smoker, particularly if sedentary or with other cardiovascular risk factors.
    - An abnormal resting electrocardiogram (ECG).

FIGURE 2-1.

A physician uses the exercise ECG to decide if the heart is receiving sufficient blood during exercise. If the heart muscle does not receive sufficient blood, the exercise ECG may develop an abnormal pattern that may indicate the presence of coronary artery disease. The ECG rhythm strip is also used to measure heart rate during a fitness evaluation.



PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

The Physical Activity Readiness Questionnaire (PAR-Q) is a self-report scale that is used to identify people who should seek medical clearance before starting an exercise program [1]. Answering *yes* to any of the six questions would disqualify a person from engaging in exercise without medical clearance. The questions of the PAR-Q are:

1. Has your doctor ever said you have heart trouble?
2. Do you frequently suffer from pains in your chest?
3. Do you often feel faint or have spells of severe dizziness?
4. Has a doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
5. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
6. Are you over age 65 and unaccustomed to vigorous exercise?

If you answer *yes* to any of these questions, vigorous exercise or maximal exercise testing should be postponed and medical clearance sought. If you are not sure of your status, discuss this with your physician.

AEROBIC FITNESS - MAXIMAL OXYGEN UPTAKE

Many exercise physiologists believe aerobic fitness is the best indicator of physical fitness [3, 4, 15]. Aerobic fitness is an important indicator of a person's capacity to do activities such as jog, play tennis, shovel snow, and a host of other occupational and rec-

reational tasks. Aerobic fitness can be quantified by measuring the maximal volume of oxygen (VO2max) used during exhausting work. To measure VO2max, a person gradually increases exercise intensity to exhaustion. Computerized gas analysis equipment measures the volume of oxygen used at maximum exercise. Figure 2-2 shows the equipment used to measure VO2max.

Aerobic fitness (VO2max) is the maximum volume of oxygen a subject uses during exhaustive exercise [2, 8, 17]. It is first expressed as the total volume of oxygen used in a minute (ml/min). The more muscle mass one has, the more oxygen (ml/min) used during maximal exercise. Dividing VO2max (ml/min) by body weight expressed in kilograms adjusts for differences in body size and muscle mass. This unit of VO2max is milliliters of oxygen, per kilogram of body weight, per minute (ml/kg/min). This is the unit of measurement used to evaluate aerobic fitness [15] and will be used exclusively in this text.

In the laboratory, testing for aerobic fitness involves gradually increasing the intensity of exercise and measuring expired gases (Figure 2-2). A treadmill is commonly used to regulate exercise level, which is made more demanding by:

- Increasing treadmill speed.
- Increasing treadmill slope.
- Increasing both speed and slope.

FIGURE 2-2.

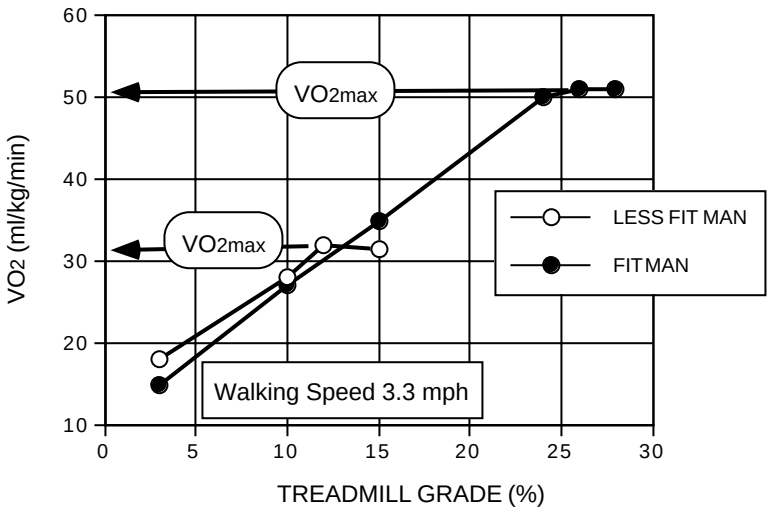
Measuring VO2max on a motor-driven treadmill. The computerized system collects the subject's expired air during exercise. In a medical setting an ECG tracing measure heart rates or, with a stress test, look for signs of cardiac ischemia, which suggests blockage in the coronary arteries. In a fitness setting exercise heart rate can be measured with a heart rate monitor.

Increasing treadmill speed forces the person to walk or run at a faster pace while increasing grade simulates walking up a hill that gets progressively steeper. The amount of oxygen used increases at a linear rate with the intensity of exercise. Figure 2-3 shows computer-generated graphs of two VO2max tests, one of a fit person and the other of someone less fit. VO2max is the point when exercise is so exhausting that the person cannot provide sufficient oxygen to meet the need demanded by the exercise intensity. At this point oxygen uptake often plateaus and the subject cannot continue.

FIGURE 2-3.

Aerobic fitness tests of an active and a sedentary man. VO2max is the point that an increase in exercise intensity does not produce an increase in oxygen consumption. This is near the level of exhaustion. Aerobic fitness increases with aerobic exercise training. Data from the Cardiopulmonary Lab, NASA, Johnson Space Center, Houston, Texas.

VO2max is your maximum aerobic fitness. A more fit person can exercise at a higher intensity.



FACTORS THAT AFFECT AEROBIC FITNESS

Age, gender, heredity, and training all influence aerobic fitness or VO2max. Typically, aerobic fitness standards adjust for gender and age. It is somewhat more difficult to separate the influence of heredity and training on aerobic fitness. Provided next is a brief discussion on these factors and how they affect aerobic fitness.

AGE

Generally, aerobic fitness declines slowly after about age 25. The typical decline in VO2max is about 0.5 ml/kg/min per year or 5 ml/kg/min per decade [5, 9, 10]. VO2max is physiologically achieved by increasing heart rate, stroke volume, and the difference in the oxygen concentration of the arterial and venous blood. In fact, VO2max is the product of these three components. Stroke volume is the volume of blood ejected with each heart beat, and the oxygen difference between arterial and venous blood measures is the volume of oxygen extracted from the blood and used by the working muscles. Since maximum heart rate decreases with age, part of the age-related decline in aerobic fitness is due to the decrease in maximum heart rate, but lifestyle can also dramatically

influence the decline in aerobic fitness with age. This important topic is addressed at the end of this chapter.

GENDER

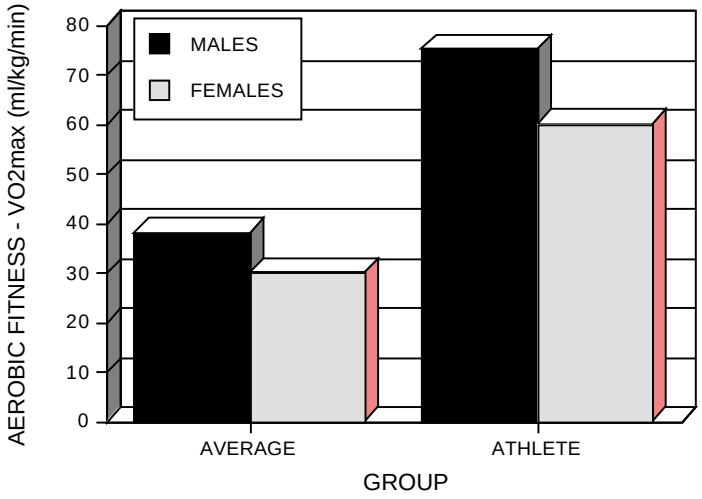
As a group, the aerobic fitness of women is about 20% lower than that of men of a similar age. This is mainly due to hormonal differences that cause women to have a lower concentration of hemoglobin in their blood and higher percent body fat. Hemoglobin is essential for oxygen transport. The normal hemoglobin level in the blood for females is approximately 13 gm%, whereas the men's value is about 15 gm%. The average percent body fat of a woman is about 6 to 8% higher than a man. For any given body weight, women have less muscle than men. These two factors account for most of the gender difference in aerobic fitness [15].

HEREDITY AND TRAINING

Figure 2-4 illustrates that the aerobic fitness of elite endurance athletes is about twice that of an average person. The most highly fit athletes tend to be distance runners and cross-country skiers. Some male athletes have a VO2max in the 80s while the female elite athletes are about 20% lower. The average aerobic fitness of an adult male is approximately 35 to 40 ml/kg/min. The high aerobic capacity of world class endurance athletes is due somewhat to heredity, but it is difficult to differentiate genetics from lifelong exercise habits. World class endurance athletes are "born" with a superior aerobic capacity, but they also must train to excel. Elite distance runners run over 100 miles per week. Genes are important, but sound aerobic exercise programs also increase aerobic fitness. Through training, previously sedentary people can increase their aerobic fitness by at least 20-30%.

FIGURE 2-4. The VO2max of elite endurance athletes is about twice the average of the normal population. Some male athletes have a VO2max in the 80s while the female elite athletes are about 20% lower.

The aerobic fitness of elite endurance athletes is about twice that of a typical person.



AEROBIC FITNESS AND HEALTH

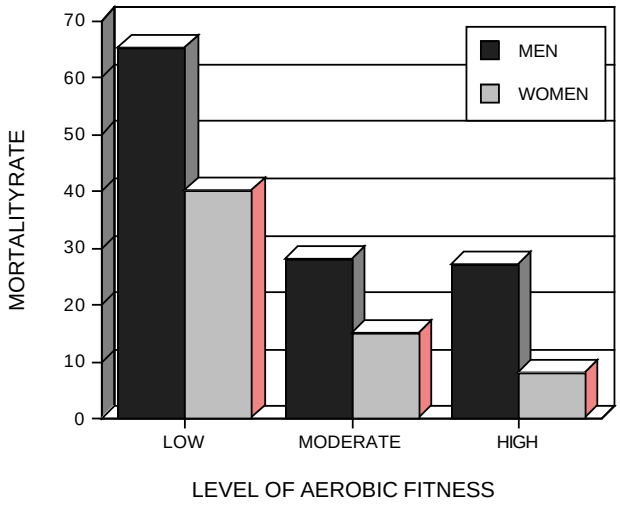
A study from the Institute for Aerobics Research in Dallas, Texas showed that low aerobic fitness predicted higher mortality rates than those who were more fit [4]. The participants of the study were healthy people who were free of diseases such as high blood pressure or diabetes. After a maximal treadmill test, the participants were followed for several years. Figure 2-5 provides a graphic summary of the study. The greatest drop in death rate was between the lowest and moderate fitness groups. The death rates of the moderate and high fitness groups were similar. This study shows the beneficial effect of a moderate level of aerobic fitness on mortality. For good health, it is not critical to be an elite athlete, rather, it is essential to be moderately fit, not a "couch potato."

Further, the researchers completed a second study and discovered that changes in fitness were related to changes in mortality risk [3]. Those who improved their aerobic fitness by moving from the low to the moderate or high categories reduced their future risk of death. Moderate fitness levels can be attained for most people who engage in regular aerobic exercise, by doing the equivalent of walking about 3 miles a day.

FIGURE 2-5.

The participants in the lowest aerobic fitness group had the highest death rates. For health purposes it is not necessary to be highly fit. The mortality rate of the moderate and highly fit groups was about the same. The high health risk occurs when you are in the low fitness group. The graph was made from published data [4].

Just a moderate level of aerobic fitness is needed to enhance health.



MEASURING AEROBIC FITNESS

The direct measurement of VO2max is exhausting, expensive and requires sophisticated equipment and personnel. Many medical facilities and exercise physiology laboratories use this method for diagnosis or research. For health and fitness assessments, several field tests provide excellent estimates of aerobic fitness. These tests are:

1. The U of H Non-exercise Test.

2. Submaximal Tests.
   - Rockport Walk Test
   - BYU Jog Test
3. Maximal Distance Run/Walk Test

U OF H NON-EXERCISE TEST

The U of H non-exercise test [9-11] is a method used to estimate aerobic fitness that does not involve actual exercise testing. The non-exercise equations are most accurate for people with an aerobic fitness below 55 ml/kg/min. The test underestimates the aerobic fitness of those over 55 ml/kg/min, but this constitutes only about 5% of all adults. The U of H test may be used with people on medications that affect heart rate, e.g., blood pressure medication. The factors used to estimate VO2max (ml/kg/min) with the U of H equations are:

1. **Gender**. Separate equations are used for men and women.
2. **Age.** Age is measured to last year, i.e., 25 years, 10 months would be 25 years.
3. **Physical Activity Rating** (PA). Figure 2-6 is the scale used to estimate physical activity. This is a global, self-rating of physical activity. Simply rate your physical activity during the past month. If several examples describe your activity, *use the highest value*. Enter the associated number in the equation.
4. **Percent body fat** (%fat). Chapter 4 gives methods for measuring percent body fat.

The male and female equations were developed with data obtained from nearly 2,000 men and women tested at the Cardio-pulmonary Laboratory, NASA/Johnson Space Center [9, 10]. A work sheet is provided in the lab section (Appendix B) that will help you use these equations to estimate your aerobic fitness. The equations for estimating VO2max with the U of H non-exercise test are:

MEN'S NON-EXERCISE EQUATION **(EQ 2-1)**

$$\text{VO2max (ml/kg/min)} = 47.34 - (0.26 \times \text{Age}) - (0.22 \times \%\text{fat}) + (3.27 \times \text{PA}) - (0.08 \times \text{PA} \times \%\text{fat})$$

WOMEN'S NON-EXERCISE EQUATION **(EQ 2-2)**

$$\text{VO2max (ml/kg/min)} = 45.63 - (0.26 \times \text{Age}) - (0.31 \times \%\text{fat}) + (2.17 \times \text{PA}) - (0.04 \times \text{PA} \times \%\text{fat})$$

FIGURE 2-6. Scale for rating physical activity for use with the U of H non-exercise test. The scale was developed for use at the Cardio-pulmonary Laboratory, NASA/Johnson Space Center, Houston, Texas.

CODE FOR PHYSICAL ACTIVITY

Use the appropriate number (0 to 7) which best describes your general ACTIVITY LEVEL for the PREVIOUS MONTH.

DO NOT PARTICIPATE REGULARLY IN PROGRAMMED RECREATION SPORT OR HEAVY PHYSICAL ACTIVITY.

0 - Avoid walking or exertion, e.g., always use elevator, drive whenever possible instead of walking.
1 - Walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration.

PARTICIPATED REGULARLY IN RECREATION OR WORK REQUIRING MODEST PHYSICAL ACTIVITY, SUCH AS GOLF, HORSEBACK RIDING, CALISTHENICS, GYMNASTICS, TABLE TENNIS, BOWLING, WEIGHT LIFTING, YARD WORK.

2 - 10 to 60 minutes per week.
3 - Over one hour per week.

PARTICIPATE REGULARLY IN HEAVY PHYSICAL EXERCISE SUCH AS RUNNING OR JOGGING, SWIMMING, CYCLING, ROWING, SKIPPING ROPE, RUNNING IN PLACE OR ENGAGING IN VIGOROUS AEROBIC ACTIVITY TYPE EXERCISE SUCH AS TENNIS, BASKETBALL OR HANDBALL.

4 -Run less then one mile per week or spend less then 30 minutes per week in comparable physical activity.
5 - Run 1 to 5 miles per week or spend 30 to 60 minutes per week in comparable physical activity.
6 -Run 5 to 10 miles per week or spend 1 to 3 hours per week in comparable physical activity.
7 -Run over 10 miles per week or spend over 3 hours per week in comparable physical activity.

INSTRUCTIONS FOR USE OF PHYSICAL ACTIVITY RATING SCALE.

Select one value that best represents your physical activity for the previous 30 days.

If you select more than one value, use the highest value.

Calculation Example - U of H Non-Exercise Method. Provided next are examples of estimating aerobic fitness for a man and woman. Assume the following data for each:

	Man	Woman
• Age	28	32
• Percent Body Fat	25%	21%
• Physical Activity Rating	3	7

MEN'S EXAMPLE

$$\text{VO2max (ml/kg/min)} = 47.34 - (0.26 \times 28) - (0.22 \times 25) + (3.27 \times 3) - (0.08 \times 25 \times 3) = 38.4$$

WOMEN'S EXAMPLE

$$\text{VO2max (ml/kg/min)} = 45.63 - (0.26 \times 32) - (0.31 \times 21) + (2.17 \times 7) - (0.04 \times 21 \times 7) = 40.1$$

SUBMAXIMAL TESTS

The Rockport walk and BYU jog tests are submaximal tests that use exercise heart rate and speed of movement to estimate aerobic fitness. Three exercise physiological principles of exercise (Figure 2-7) are the foundation of these submaximal tests. These are:

1. Heart rate (i.e., pulse rate) increases in direct proportion to the oxygen used during aerobic exercise.
2. VO2max is reached at maximum heart rate.
3. A less fit person will have a higher heart rate at any submaximal level than someone who is more aerobically fit.

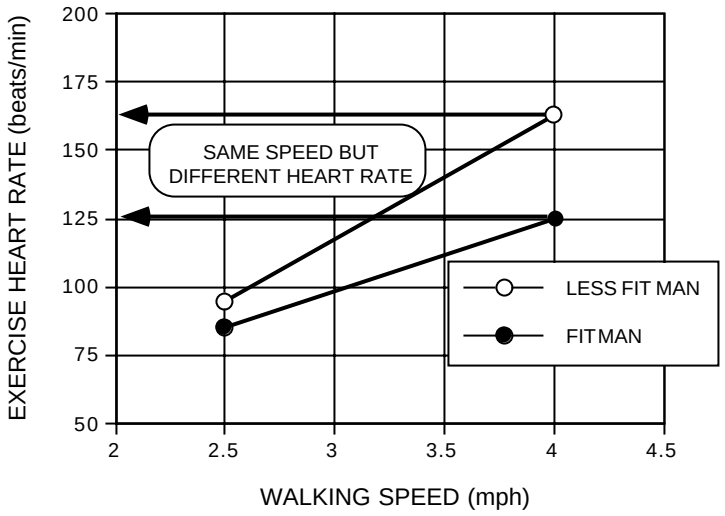
While submaximal tests commonly use a treadmill or cycle ergometer to regulate exercise level, the BYU and Rockport tests do not. All that is needed is a suitable, level space to walk or jog one mile, and a method to measure heart rate. The tests involve jogging (BYU) or walking (Rockport) at a comfortable pace for one mile followed by measuring exercise heart rate immediately upon completing the mile.

The goal of a submaximal test is to reach an exercise heart rate between about 120 and 180 beats/min. Many young, highly fit individuals cannot reach an exercise heart rate of 120 beats/min while walking. For highly fit individuals, the Rockport Walk Test is not appropriate. A better choice would be the BYU jog test. Whereas the BYU jog test was developed with young, fit college students and is not appropriate for older, less fit adults. Try both and find the test most appropriate for you.

Both the Rockport Walk and BYU Jog tests assume that exercise heart rate is normal. There are many drugs that adversely affect the normal heart rate response. For example, blood pressure medications may lower or increase heart rate. The tests will not be accurate for people taking medications that affect heart rate. The U of H non-exercise test is more appropriate in these instances.

FIGURE 2-7. Exercise heart rate increases at a linear rate with exercise intensity, which in this example is walking speed. The exercise heart rate for the less fit person will be higher at any walking speed than the more fit person. Certain drugs may affect this relationship.

The more aerobically fit, the lower exercise heart rate for any exercise intensity, i.e, walking speed.



Measuring Exercise Heart Rate

Submaximal tests require that exercise heart rate be measured. There are electronic monitors to measure heart rate, but heart rate is more often measured with the fingers at the caroid or radial pulse. The steps to follow are given next.

1. Press gently and make sure that you do not pick up any other rhythm such as walking speed, music, or particularly breathing patterns.
2. Measure the pulse immediately after exercising. After terminating exercise, the pulse rate will gradually decrease over the first few minutes of recovery.
3. Measure the pulse for 15 seconds and multiply this value by 4 to convert to per minute (beats/min).

The accuracy of the pulse count is related to the length of time it is taken. If the pulse is taken over a very short period of time, the error of missing one beat is large. For example, if heart rate is taken over a 6-second interval, each beat represents a heart rate change of 10 beats/min, while when taking the pulse over a 15-second time period, each beat represents a heart rate change of only 4 beats/min. This is why 15 seconds is recommended. A heart rate monitor is available for use in this TIGER study.

Rockport Walk Test

The Rockport walk test [12] involves *walking* at a brisk pace for one mile. Exercise heart rate is measured immediately *after the walk*. The information needed to compute aerobic fitness with the Rockport walk test is:

- Weight measured in pounds.
- Mile walk time measured to 1/100th of a minute. Note, a walk time of 15 minutes and 20 seconds would be 15.33.

- Exercise heart rate (Ex HR) expressed in beats per minute. Exercise heart rate is measured immediately after the walk.
- Age measured to the last year.

The male and female Rockport Walk Test equations are provided next. The lab section (Appendix B) provides methods to complete these calculations.

ROCKPORT WALK TEST - MALES **(EQ 2-3)**

$$\text{VO2max (ml/kg/min)} = 139.17 - (0.08 \times \text{Weight}) - (0.39 \times \text{Age}) - (3.26 \times \text{Mile Time}) - (0.16 \times \text{ExHR})$$

ROCKPORT WALK TEST - FEMALES **(EQ 2-4)**

$$\text{VO2max (ml/kg/min)} = 132.85 - (0.08 \times \text{Weight}) - (0.39 \times \text{Age}) - (3.26 \times \text{Mile Time}) - (0.16 \times \text{ExHR})$$

The general procedures to follow to take the Rockport walk test are:

1. If you are taking medications that affect your heart rate, *do not take the test.* Inaccurate heart rate measurements substantially affect test accuracy.
2. Several electronic heart rate monitors are now commercially available, but heart rate can be accurately measured by palpation. If you do not have an electronic heart rate monitor, learn to measure exercise heart rate by palpation.
3. Practice walking the mile at a brisk, *constant* pace. You should walk fast enough to get your heart rate above 120 beats/min. If your walk pace does not bring your heart rate to this level, the test is not appropriate for you. Try the BYU Jog Test.
4. When you complete the test, calculate VO2max using the equation for men or women. The lab section (Appendix B) provides a work sheet to ease the calculation.
5. Use the standards provided in a later section this chapter to evaluate your aerobic fitness.

Calculation Example - Rockport Walk Test: Assume the following data for a man.

- Age 27 years.
- Weight 165 pounds.
- Mile walk time 15 minutes and 45 seconds, i.e., 15.75 min.
- Exercise heart rate 144 beats/min.
- Applying to these data, the man's estimated VO2max is 41.1 ml/kg/min.

$$\text{VO2max (ml/kg/min)} = 139.17 - (0.08 \times 165) - (0.39 \times 27) - (3.26 \times 15.75) - (0.16 \times 144) = 41.1$$

BYU Jog Test

The BYU Jog Test [7] is more appropriate for young, fit individuals. The test involves *jogging* at a steady pace for 1 mile. Exercise heart rate is measured immediately *after the jog*. The information needed to estimate aerobic fitness with the BYU Jog Test are:

- Weight measured in kilograms.[2]
- Mile jog time measured to 1/100th of a second.
- Exercise heart rate (Ex HR) measured immediately after the walk and expressed in beats per minute.

The male and female BYU Jog Test equations are provided next.

BYU JOG TEST - MALES **(EQ 2-5)**

$$\text{VO2max (ml/kg/min)} = 108.84 - (0.16 \times \text{Weight}) - (1.44 \times \text{Mile Time}) - (0.19 \times \text{ExHR})$$

BYU JOG TEST - FEMALES **(EQ 2-6)**

$$\text{VO2max (ml/kg/min)} = 100.50 - (0.16 \times \text{Weight}) - (1.44 \times \text{Mile Time}) - (0.19 \times \text{ExHR})$$

The test procedures to follow are listed next.

1. If you are taking medications that affect your heart rate, *do not take the test.* Inaccurate heart rate measurements substantially affect test accuracy.
2. First take a 2- to 3-minute warm-up jog.
3. The goal is to jog the 1 mile at a steady and suitable pace. Many subjects tend to run at an "all-out" rate. This is a submaximal test, it is not necessary to run the mile as fast as possible. To ensure that it is a submaximal effort, run time and exercise heart rate limits are set. These limits are:
   - Jogging pace, ≥ 8 minutes per mile for males and ≥ 9 minutes per mile for females.
   - Exercise heart rate, ≤ 180 beats/min.
4. When you complete the test, calculate VO2max using the equations for men or women. The lab section in Appendix B provides a work sheet to speed these computations.
5. Use the standards provided in a later section in this chapter to evaluate your aerobic fitness.

BYU Calculation Example: Assume the following data for a woman.

- Weight 75.1 kilograms (165 pounds)
- Mile walk time 6 minutes and 20 seconds, i.e., 6.33
- Exercise heart rate 164 beats/min.

2. Weight in kilograms = Weight in Pounds x 0.455.

• Applying these data to the woman's equation, her VO2max is 48.2 ml/kg/min.

$$\text{VO2max (ml/kg/min)} = 100.50 - (0.16 \times 75.1) - (1.44 \times 6.33) - (0.19 \times 164) = 48.2$$

DISTANCE RUN/WALK TESTS

Running performance is an excellent indicator of aerobic fitness. The most popular test is the 1.5 mile run/walk test.The rules to follow when taking this test are:

1. The goal of the 1.5 mile test is to cover the distance as fast as possible. You may walk, jog, or use a combination of both. Ideally, you should be exhausted after the test. Traveling too fast is exhausting, but if you travel too slowly, VO2max will not be reached. You should practice your walking/jogging pace before taking the test.
2. Use Table 2-1 to convert your run/walk performance to an estimated VO2max.
3. Use the standards provided in a later section this chapter to evaluate your aerobic fitness.

It is important to remember that a timed distance run/walk test *is a maximal* test. It has all the attendant risks of a maximal exercise test, and the added risk of being unsupervised. Maximal exercise tests should not be given to sedentary people or those at high risk for cardiovascular disease without prior medical clearance. If you are not certain, check Chapter 1 and the medical consideration section provided at the beginning of this chapter.

TABLE 2-1. Aerobic Fitness (VO2max ml/kg/min) for the 1.5 mile run time in minutes and seconds.*

1.5-MILE TIME MIN:SEC	VO2max (ml/kg/min)	1.5-MILE TIME MIN:SEC	VO2max (ml/kg/min)	1.5-MILE TIME MIN:SEC	VO2max (ml/kg/min)
23:59	20	14:47	37	9:07	54
24:15	21	14:20	38	8:56	54
23:33	22	13:53	39	8:45	56
22:51	23	13:27	40	8:35	57
22:11	24	13:03	41	8:27	58
21:31	25	12:39	42	8:19	59
20:52	26	12:16	43	8:12	60
20:14	27	11:54	44	8:06	61
19:37	28	11:33	45	8:01	62
19:01	28	11:13	46	7:57	63
18:26	30	10:54	47	7:54	64
17:52	31	10:36	48	7:52	65
17:19	32	10:19	49	7:50	66
16:47	33	10:03	50	7:48	67
16:15	34	9:47	51	7:46	68
15:45	35	9:33	52	7:45	69
15:16	36	9:20	53	7:44	70

*Use the listed time that is closest to your run/walk time.

EVALUATING YOUR AEROBIC FITNESS

As previously discussed, aerobic fitness is dependent upon many factors such as gender, age, lifestyle, and heredity. The method most commonly used to evaluate aerobic fitness is by using norms adjusted for age and gender. Table 2-2 lists aerobic fitness standards for evaluating aerobic fitness of men and women of various age groups [8].While the norms given in Table 2-2 describe the aerobic fitness of adults, the levels are not suitable for adult health promotion. The research published by Blair and associates [4] gives the first scientific data defining the level of aerobic fitness needed for health. They showed that the aerobic fitness health promotion threshold was 32 ml/kg/min for women and 35 ml/kg/min for men (Figure 2-8). The mortality rate of men and women with the lowest level of aerobic fitness was four times higher than the rate of those who exceeded these levels. However, there was no added advantage in terms of mortality to have fitness levels beyond these threshold levels. As we will show in the next section of this chapter, aerobic fitness declines with age and the 35 and 32 levels were for men and women at age 45. Since most who will use this text are college-age students, your health promotion aerobic fitness level is above the 32 and 35 ml/kg/min level.

High levels of aerobic fitness are not needed for good health, but very low levels are dangerous.

FIGURE 2-8.

Curves of the relationship between aerobic fitness and health show that the curves level off at 32 ml/kg/min for women and 35 ml/kg/min for men. These values define the threshold level of fitness needed for health promotion (i.e., reduced mortality) for 45-year-old men and women. Graph made from published data [4].

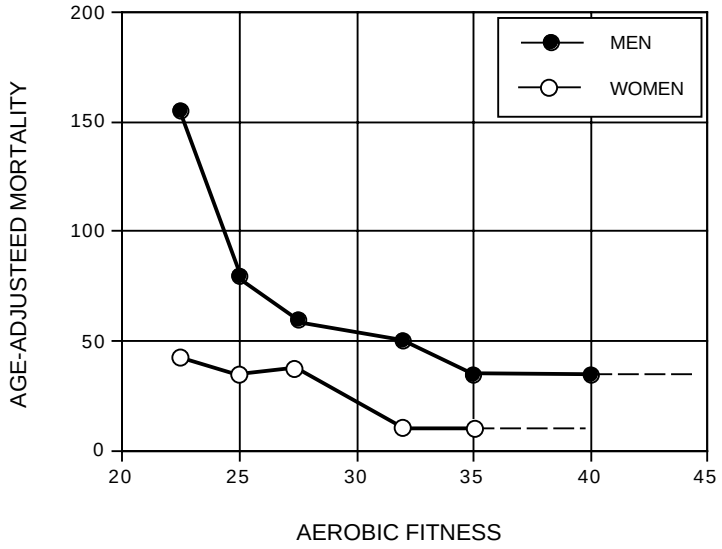


Table 2-3 lists aerobic fitness suitable for health promotion, accounting for the age-related decline in aerobic fitness. Given is the value you would need to be to have an aerobic capacity of 35 or 32 ml/kg/min at age 45 years, assuming you maintain your current level of exercise and percent body fat. As you will learn in the next section of this chapter, changing your exercise habits and percent body fat can dramatically affect the rate that aerobic fitness changes as you age.

TABLE 2-2. Aerobic fitness standards (VO2max ml/kg/min) for men and women published by the American College of Sports Medicine [8].

FITNESS	MEN - AGE IN YEARS					WOMEN - AGE IN YEARS				
STANDARD	20-29	30-39	40-49	50-59	≥60	20-29	30-39	40-49	50-59	≥60
Excellent	>51	>48	>46	>42	>40	>42	>39	>37	>33	>33
Good	49-51	46-48	44-46	40-42	38-40	40-42	37-39	35-37	31-33	31-33
Average	42-48	39-45	37-43	33-39	31-37	33-39	31-36	29-34	25-30	25-30
Fair	39-41	36-38	34-36	30-32	28-30	30-32	28-30	26-28	22-24	22-24
Poor	<39	<36	<34	<30	<28	<30	<28	<26	<22	<22

TABLE 2-3. Age-adjusted aerobic fitness standards for health promotion.*

AGE	VO2max (ml/kg/min)	
IN YEARS	MEN	WOMEN
20	40	38
25	39	36
30	38	35
35	37	34
40	36	33
45	35	32
50	34	31
55	32	29
60	31	28
65 and Over	30	27

*Standards developed from data [9, 10] and personal communication with S. Blair, September 30, 1993.

AGING AND AEROBIC FITNESS

Adequate aerobic fitness is important for not only maintaining health, but also the quality of life as we age. As in most developed countries, the American population is aging. By the year 2000, the American population will grow to 270 million, and the population will be older. In 1975, the age of 50% of Americans was 29 years or younger. In the year 2000, this will increase to 36 years. By the year 2000, 35 million people will be over the age of 65, representing 13% of the total population. In 1950, only 8% of Americans were over age 65. The population of the oldest old, those over age 85, will have increased by 30%, totalling 4.6 million by the year 2000.

The last thing that a typical college student thinks about is aging, but research shows that the lifestyle maintained during adult life affects aerobic fitness. The principal lifestyle factors that affect the decline in aerobic fitness with age are exercise habits and percent

body fat [5, 9, 10]. Compared to active individuals, those who remain sedentary during their adult years not only accumulate body fat, but also lose their aerobic fitness at a faster rate. Aerobic fitness is not only a risk factor for many adult degenerative diseases, but also a determinant of quality of life. Many elderly, low fit individuals have difficulty meeting the energy demands required by daily functional and recreational tasks.

LIFESTYLE AND AEROBIC FITNESS

Maximum aerobic fitness decreases with age. Research [5, 9, 10] suggests that the decline in aerobic fitness is not just due to biological aging, but also lifestyle. We discovered that 50% of the yearly decline in aerobic fitness could be predicted by changes in physical activity and body composition [9, 10]. Those who became sedentary and increased their percent body fat lost their aerobic fitness at a faster rate than those who remained active and maintained a desirable level of body composition. Figure 2-9 shows this effect with men. Provided is the average aerobic fitness of men at age 25 and 65 years. Also provided is the expected aerobic fitness at age 65 for three different lifestyles, which are:

- **Highly active** (7 on NASA activity scale) and very lean, 15%.
- **Moderately activ**e (5 on NASA activity scale) and optimal percent body fat level (20%).
- **Sedentary** (0 on NASA activity scale) and high percent body fat level (30%).

At age 65, the *average* loss in aerobic fitness was 41%. The men who remained highly active and stayed very lean maintained a higher percentage of the aerobic fitness they had at age 20. The loss in aerobic fitness would only be 17%. In contrast, those who led a sedentary life and accumulated a high level of body fat would have a reduction in VO2max of 53%. While leading a highly active lifestyle is not likely a realistic option for many, maintaining a moderately active lifestyle and optimal percent body fat level is an effective method of maintaining fitness as you age. The expected rate of decline of those who remain moderately active and maintain an optimal percent body fat is about 10% less than the average decline, or about a 32% reduction. We found nearly identical results with women [10].

FIGURE 2-9.

Changes in aerobic fitness that can be expected for men from age 20 to age 65. Provided are the average aerobic fitness values that can be expected at age 65 for different lifestyles. Given is the percentage of aerobic fitness lost from age 20 to 65 for each.

Lifestyle factors affect the rate at which men lose aerobic fitness.

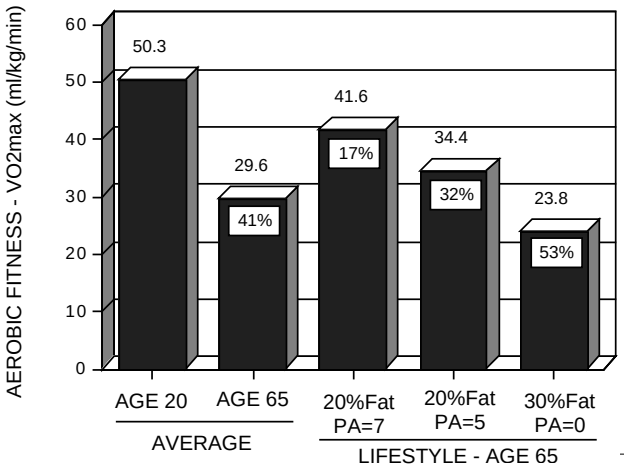
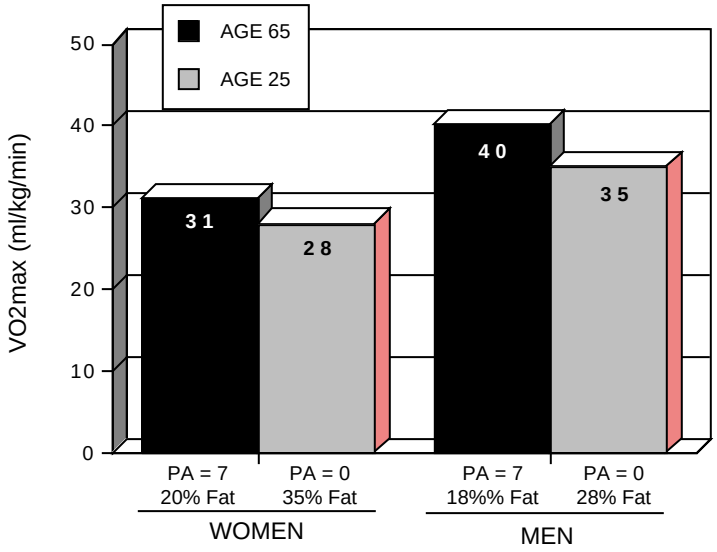


FIGURE 2-10. Estimated aerobic fitness from women and men at age 25 and 65 who differ in level of physical activity and percent body fat. Graph made from published data [9,10].



The aerobic fitness of 65 year olds can be higher than 25 year olds.

QUALITY OF LIFE

While a suitable level of aerobic fitness is needed for health promotion, the quality of life is also important. A goal of aging is not just living longer and dying later, but also what Shephard [16] terms a "quality-adjusted lifesaving." For many elderly this is the capacity to function independently, which is partly dependent upon their aerobic capacity.

Older Americans tend to be inactive. Over 40% of people over age 65 report no leisure time physical activity. Less than one-third participate in regular moderate physical activity, such as walking and gardening regularly, and less than 10% engage routinely in vigorous physical activity. In the National Health Interview Survey [6, 13], nearly 40% of men and women over age 65 reported activity-dependent limitations. Data from the National Institute on Aging [6, 13] found that many adults over age 65 cannot do common physical tasks. As many as 51% could not do heavy housework and up to 33% could not walk a half-mile. Although some of this disability is due to chronic health problems such as arthritis, emphysema, and cardiovascular disease, it is also due, in part, to low levels of aerobic fitness. To a large degree, low aerobic fitness levels of the elderly can be traced to their adult sedentary lifestyle.The capacity to do many different living and recreational activities is dependent upon aerobic capacity. Independent living is the capacity to carry on many normal tasks such as climbing stairs, gardening, mowing the grass and participating in enjoyable recreational activities.

Maintaining an active lifestyle enhances quality of life. The levels of aerobic fitness defined by the American Medical Association for independent living are:

- **Severe Impairment** - 15 ml/kg/min
- **Moderate Impairment** - 20 ml/kg/min

The aerobic fitness of physically active men and women in the 50s and 60s exceeds that of overweight, sedentary individuals in their 20s. Figure 2-10 shows this with data from our NASA research [9, 10]. Shown is the expected aerobic fitness of 65-year-old men and women who were active (7 on NASA PA scale) and lean, and 25-year olds who were sedentary (0 on NASA PA scale) and overweight. Many older individuals are more aerobically fit than young, college graduates.

Examples of the data shown in Figure 2-10 are constantly documented by aerobic athletic performances of master athletes. A story taken from an Austin, Texas newspaper about a man who competed in the physically demanding United States Rowing Masters Regatta illustrates the value of physical activity and the positive influence on the quality of life.

> There's an up-and-coming Californian named John Adams whom Cam Jones thinks is a pretty fair rower. In fact, it was Jones who talked Adams into trying competitive rowing, despite knowing full well he might be recruiting someone who could beat him some day. "He's just started, but I can tell he's going to be very good," Jones said. "One thing in his favor is he's a gung-ho youngster." John Adams is 76. Cam Jones can smile tolerantly at Adams' youthful exuberance, because in this instance, youth isn't wasted on the young. Jones is 81, going on 31....
>
> ...Relatively speaking, Jones is a rowing neophyte himself. He took up the sport about 12 years ago after retiring from his own plastics business in California. "...I got into it because I enjoy the motion. I enjoy the rhythmic motion and having everything just right. You get the full use of all the muscles in your body, too, so it's a good exercise sport. I keep threatening to retire, but then I'll get a call from the guys in Philly or somewhere asking me to be on their eight in a race somewhere," he said. "I love to do it, so what do I do? It's more than just the exercise. It's opened up a brand new set of goals for me." Like fending off the challenges of all those up-and-coming 70-year-old whippersnappers.

SUMMARY

Assessing aerobic fitness is the first step in designing a sound exercise program. Aerobic fitness is a major component of physical fitness. The most accurate way to measure aerobic fitness is in the laboratory, but other tests that are easy to administer also provide good estimates of aerobic fitness. These tests include:

1. U of H non-exercise test.
2. Rockport walk test.
3. BYU jog test.
4. Distance walk/run tests.

The aerobic fitness or VO2max of women is about 80% of men; this is mostly due to body composition and blood hemoglobin differences. Aerobic fitness also declines with age. Aerobic fitness standards are based on age and gender. Medical research has documented that a threshold level of aerobic fitness is needed for health promotion. The aerobic fitness health promotion standards at age 45 are 32 ml/kg/min for women and 35 ml/kg/min. These values are higher for younger college students.

While an average aerobic fitness declines at a rate of about 4-5 ml/kg/min per decade, research shows that lifestyle, namely exercise habits and body composition, may account for about 50% of the decline. Maintaining an active lifestyle and suitable body composition slows the rate aerobic fitness declines with age. In fact, many older, active, lean individuals can outperform younger, sedentary individuals with a high percent body fat. A suitable level of aerobic fitness is essential for quality of life while we age. The minimum level of aerobic fitness needed for independent living is 15-20 ml/kg/min. This low level can be easily exceeded by maintaining a moderately active lifestyle during adulthood. Adequate levels of aerobic fitness are important for both quantity and quality of life.

STUDY QUESTIONS

These study questions can help you find if you have mastered the information in this chapter.

1. What is the most accurate method of assessing aerobic fitness? What methods can you use to test yourself?

2. Why is VO2max expressed per kilogram of body weight?

3. What types of individuals should have a medically supervised exercise stress test before starting an exercise program?

4. What is the PAR-Q? What is your status on the PAR-Q?

5. What is the scientific definition of VO2max and what type of individuals have the highest levels of aerobic fitness?

6. What is the influence of age and gender on aerobic fitness?

7. What is the difference between normative and health-promotion aerobic fitness standards? What is your health-promotion standard?

8. It is well documented that aerobic fitness declines with age. What lifestyle factors affect the decline in aerobic fitness with age?

9. What are the minimum levels of aerobic fitness needed for functional, independent living?

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