Predicting Aerobic Power (VO_{2max}) Using The 1-Mile Walk Test

KEYWORDS

1. Predict VO_{2max}
2. Rockport 1-mile walk test
3. Self-paced test
4. $L{\bullet}min^{-1}$
5. $mL{\bullet}kg^{-1}1min^{-1}$
6. Body weight
7. Age
8. Gender
9. HR_{peak}
10. 15-s post-exercise HR

BACKGROUND

Numerous tests have been devised and standardized for the measurement of aerobic power (VO_{2max}). Performance on these tests should be independent of strength, speed, body size, and skill, with the exception of specialized tests such as swimming, rowing, and ice skating.

The VO_{2max} test may require a continuous 3- to 5-minute "supermaximal" effort, but it usually consists of increments in effort (graded exercise) to the point where a person will no longer continue to exercise. Some researchers have perhaps imprecisely termed this end point "exhaustion.'' It should be kept in mind, however, that it is the performer who, for whatever reason, terminates the exercise. This decision is often influenced by a variety of psychologic or motivational factors that may not necessarily reflect physiologic strain.

Maximal oxygen uptake tests are usually performed (1) continuously--with no rest between work increments, or (2) discontinuously--with the subject resting several minutes between work periods.

FACTORS AFFECTING MAXIMAL AEROBIC POWER

Many factors influence the maximal oxygen uptake score. Of these, the most important are the mode of exercise and the person's heredity, state of training, body composition, gender, and age.

- **Mode of exercise**
- **Heredity**
- **State of training**
- **Gender**
- **Body composition**
- **Age**

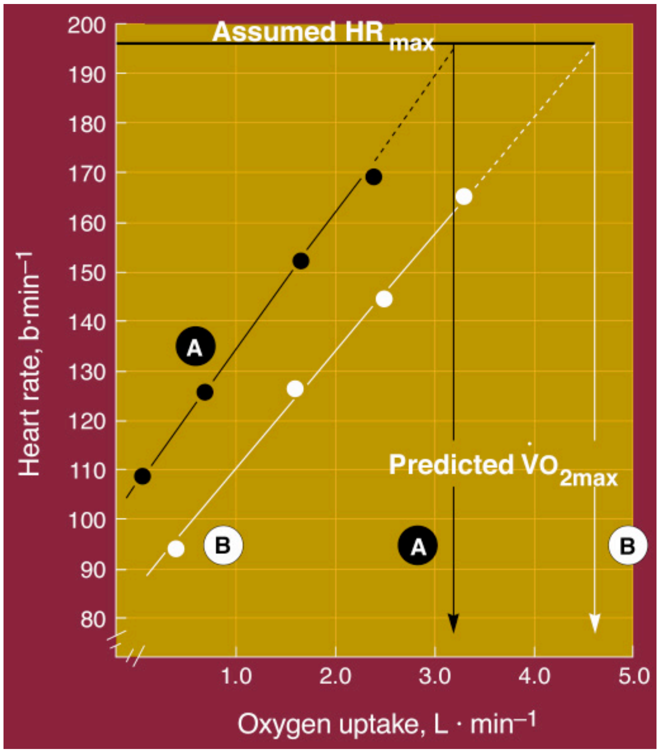
TESTS TO PREDICT VO_{2MAX}

The direct measurement of VO_{2max} requires an extensive laboratory and specialized equipment, as well as considerable motivation on the part of the subject. Consequently, these tests are not suitable for measuring large groups of untrained subjects in a field situation. In addition, such heavy exercise could pose a potential hazard to adults who are not medically cleared or who are exercised without appropriate safeguards or supervision. In view of these considerations, tests have been devised to predict the VO_{2max} from performance measures such as walking and running endurance, or from easily obtained heart rates during or immediately after exercise. The tests are easy to administer, can be used with large groups of men or women, and usually require submaximal exercise.

PREDICTIONS BASED ON HEART RATE

Common tests to predict VO_{2max} use the exercise or postexercise heart rate with a standardized regimen of submaximal exercise performed either on a bicycle, treadmill, or step test. These tests make use of the essentially linear relationship between heart rate and oxygen consumption for various intensities of light to moderately heavy exercise. The slope of this line (rate of heart rate increase) reflects the individual's aerobic fitness. The VO_{2max} can then be estimated by drawing a straight line through several submaximum points that relate heart rate and oxygen consumption (or exercise intensity) and then extending this line to some assumed maximum heart rate for the particular age group.

Figure 1 (below) illustrates the application of this "extrapolation'' procedure for trained and untrained subjects. The heart rate-oxygen consumption line was drawn from four submaximal measures during bicycle exercise. Although each person's heart rate-oxygen consumption line tends to be linear, the slope of the individual lines can differ considerably. Consequently, a person with relatively high aerobic fitness can do more work and achieve higher oxygen consumption before reaching a heart rate of 140 or 160 beats per minute than a less "fit'' person. Also, because the heart rate increases linearly with the intensity of



exercise, the person with the smallest increase in heart rate tends to have the largest work capacity and hence the highest VO_{2max}. For the two subjects illustrated in Figure 1, VO_{2max} was predicted by extrapolating the line to a heart rate of 195 beats per minute--the assumed maximum heart rate for subjects of college age.

The accuracy of predicting VO_{2max} from submaximal exercise heart rate is limited by the following assumptions:

1. Linearity of the heart rate-oxygen consumption (exercise intensity) relationship. This assumption is met to a large degree, especially for various intensities of light to moderate exercise. In some subjects, the heart rate-oxygen consumption line curves or asymptotes at the heavier work loads in a direction that indicates a larger than expected increase in oxygen consumption per unit increase in heart rate. The oxygen consumption actually increases more than would be predicted through linear extrapolation of the heart rate-oxygen consumption line. Thus, the predicted VO_{2max} in these subjects would be underestimated.
2. Similar maximum heart rates for all subjects. The standard deviation is approximately $\pm$10 beats per minute about the average maximum heart rate of individuals of the same age. Therefore, the VO_{2max} of a person with an actual maximum heart rate of 185 beats per minute would be overestimated if the heart rate-oxygen consumption line were extrapolated to 195 or 200 beats per minute. The opposite would be true for a subject with an actual maximum heart rate of 210 beats per minute. Maximum heart rate also decreases with age. Unless this age effect is considered, older subjects will be consistently overestimated by assuming a maximum heart rate of 195 beats per minute, which is the appropriate heart rate maximum for 25-year-olds.
3. Assumed constant economy or mechanical efficiency. In cases in which submaximal oxygen consumption is not measured, but is instead estimated from work load, the predicted VO_{2max} may be in error by the magnitude of variability in mechanical efficiency. A subject with poor mechanical efficiency (oxygen consumption at submaximal work higher than assumed) will be underestimated in terms of VO_{2max}, because heart rate will be elevated due to the added oxygen cost of the inefficient exercise. The variation among individuals in oxygen consumption during walking, stepping, or cycling does not usually exceed +-6%. In addition, seemingly small

modifications in test procedures can have profound effects on the metabolic cost of exercise. Allowing individuals to support themselves with the treadmill handrails, for example, can reduce the oxygen cost of exercise by as much as 30%.

4. Day-to-day variation in heart rate. Even under highly standardized conditions, the variation in submaximal heart rate is about +-5 beats per minute with day-to-day testing at the same exercise load.

Within the framework of these limitations, the VO_{2max} predicted from submaximal heart rate is generally within 10 to 20% of the person's actual value. Clearly, this is not acceptable accuracy for research purposes. These tests, however, are well-suited for purposes of screening and classification in terms of aerobic fitness. Recently, this technique has been successfully applied in estimating aerobic capacity during pregnancy.

WALKING TESTS

With interest in "fitness walking'' reaching a zenith in the 1980s, walking tests to predict VO_{2max} were developed. In a study on a large sample of males and females the following equation emerged to predict VO_{2max} from walking speed and other variables:

The Rockport Walking Test is a simple, self-paced test to predict aerobic power (VO_{2max}). The test is ideal for use with large groups of subjects but can also be used for individuals.

Equations

Equation #1 - Predicts VO_{2max} in $L{\bullet}min^{-1}$ as follows:

$$\mathbf{VO_{2max}\ (L{\bullet}min^{-1}) = 6.9652 + (0.0091 \times \mathit{W})\ (0.0257 \times \mathit{A}) + (0.5955 \times \mathit{G})\ (0.224 \times \mathit{T1})\ (0.0115 \times \mathit{HR_{peak}})}$$

Equation #2 - Predicts VO_{2max} in $mL{\bullet}kg^{-1}{\bullet}min^{-1}$ as follows:

$$\mathbf{VO_{2max}\ (mL{\bullet}kg^{-1}{\bullet}min^{-1}) = 132.853\ \ (0.0769 \times \mathit{W})\ (0.3877 \times \mathit{A}) + (6.315 \times \mathit{G})\ (3.2649 \times \mathit{T1})\ (0.1565 \times \mathit{HR_{peak}})}$$

where:

- W = body weight in pounds

- A = age in years
- G = gender; 0 = female, 1 = male
- T1 = time for the 1-mile track walk expressed as minutes and hundredths of a minute
- HR_{peak} = Peak heart rate in b•min-1 at the end of the last one-quarter mile (measured as a 15-s pulse immediately after the walk times 4 to convert to b•min^{-1}).

The Test

The test consists of individuals walking 1 mile as fast as possible, without jogging or running. The following instructions should be followed:

- On a measured track, walk 1 mile as fast as possible; walk on the inside lane when using a standard multi-lane track. The test can be administered outdoors on a track or indoors on a treadmill and will give similar results.
- When finished, record the time of the walk to the nearest minute and hundredth minute.
- Measure the 15-second immediate post-exercise pulse rate following the walk.
- Use the appropriate equation (see above) to predict VO_{2max}.

For most individuals, the predicted VO_{2max} ranges within 0.335 L•min^{-1} (±4.4 mL•kg^{-1}•min^{-1}) of the actual VO_{2max}. This prediction method applies to a large segment of the general population and can be used for elderly subjects if they are accustomed to walking.

Example

Predict VO_{2max} (mL•kg^{-1}•min^{-1}) from the following data:

- gender = female
- age = 30 y
- body weight = 155.5 lb
- T1 = 13.56 min
- HR_{peak} = 145 b•min^{-1}.

Substituting the above values in equation #2.

VO_{2max} (mL•kg^{-1}•min^{-1}) = 132.853 (0.0769 x *155.5*) (0.3877 x *30.0*) + (6.315 x *0*) (3.2649 x *13.56*) (0.1565 x *145*)

= 132.853 (11.96) (11.63) + (0) (44.27) (22.69)

= 42.3 mL•kg^{-1}•min^{-1}

Assignment

1. Compute your aerobic power (VO_{2max}) in both L•min^{-1} and mL•kg^{-1}•min^{-1}) using the formula given above. Show all your work.

2. Compare and contrast your data to the average for your age and gender found in your text or the references. Explain why you think your VO_{2max} is higher or lower than the average.

3. Devise a prescription to improve your aerobic power, if necessary. Be specific with respect to mode, duration, frequency and intensity of exercise required.

4. Discuss whether your exercise Rx is sufficient to complement your weight management goals determined from your previous assignment.

5. Discuss what you discovered in this lab experience. How might this affect the way you think about physical activity and weight control as you become older.

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