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Calculating Caloric Expenditure

Optimize clients' workouts by using the ACSM metabolic equations to determine exercise intensity and caloric expenditure.

A common inquiry clients often make is, "How many calories am I burning during this exercise?" How do you answer that question? Do you take an educated guess based on a client's heart rate? Do you rely on the numbers on the treadmill? You can provide a more accurate assessment by calculating exercise intensity.

In general, you can determine intensity by employing heart rate methods, such as percent heart rate maximum (%HRmax) or percent heart rate reserve; by teaching clients subjective measures, such as the rating of perceived exertion (RPE) or talk test; or by converting workload or intensity to oxygen consumption (VO_2). The last method is the most individualized and accurate one because it is based specifically on the metabolic demands of exercise (Swain & Leutholtz 2002).

Using heart rate to calculate intensity is not as accurate, because increases in heart rate are not always attributable solely to increases in exercise intensity or energy demand; heart rate can be affected by other factors, such as stress, medications, caffeine, dehydration, etc. Subjective measures also have their limitations, since it requires some experience with RPE and the talk test to monitor intensity accurately with these methods. In essence, VO_2 is the best indicator of exercise intensity because it is tied closely to energy expenditure. The higher the intensity, the more oxygen clients consume and the more calories they burn.

USING VO_2RESERVE TO CALCULATE INTENSITY

VO_2reserve (VO_2R) is the difference between VO_2max and resting VO_2. (VO_2R provides a more accurate estimate of actual exercise intensity than VO_2max precisely because it takes rest into account.) Resting VO_2 is constant for everyone and is equal to 3.5 milliliters per kilogram of body weight per minute. VO_2max is predicted from a submaximal test you administer to your client. (For a quick review of submaximal test options, refer to "Cardiorespiratory Fitness Testing," Parts I and II, in the September and November–December 2004 PFT 101 columns.) VO_2 or VO_2max can be reported in liters of oxygen consumed per minute (L/min), milliliters of oxygen consumed per minute (ml/min), or milliliters of oxygen consumed per kilogram of body weight per minute (ml/kg/min).

Once you have determined a client's VO_2max, you can calculate VO_2R by subtracting resting VO_2 (3.5 ml/kg/min) from VO_2max. When calculating VO_2R, as when calculating heart rate reserve, it is best to determine an intensity range that includes a low end and a high end. Use the low end of the range (40%–50%) for sedentary or low-fit clients and the high end (70%–85%) for fitter, more experienced exercisers. To get the target VO_2 range for an individual client, you would multiply the VO_2R by the percentages of choice and then add resting VO_2 to each number.

Here is an example:

You have a 25-year-old active client with a VO_2max of 55 ml/kg/min. For this client, you would most likely use a VO_2 range of 70%–85% and calculate as follows:

VO_2R: 55 – 3.5 = 51.5 ml/kg/min

client's low end: (51.5 × 0.70) + 3.5 = 39.55 ml/kg/min

client's high end: (51.5 × 0.80) + 3.5 = 44.7 ml/kg/min

The target VO_2 range for this individual is 39.55–44.7 ml/kg/min.

These values can now be used to calculate workloads for a variety of exercise modalities by using the ACSM metabolic equations. See "Calculations for Common Activities" on the next page.

DETERMINING CALORIC EXPENDITURE

Determining caloric expenditure from VO_2 is easy. Simply convert the client's VO_2 value to kilocalories (kcal) per minute. The VO_2 value you are using must be in liters, however, and since the VO_2 values calculated using the metabolic equations are in milliliters, you must convert them. Here's how:

1. Multiply the VO_2 value in ml/kg/min by the client's weight in kilograms. You will be left with a VO_2 value in ml/min.
2. Divide this value by 1,000 to convert VO_2 to L/min.

Once VO_2 is in liters, you can calculate how many kcal clients are expending during exercise. For every liter of oxygen consumed, approximately 5 kcal are burned, so kcal can be determined from VO_2 by using this conversion factor. Here's a quick example:

Your client is exercising at a VO_2 of 2 L/min. Multiply 2 L/min by 5 kcal/L. Your client is burning 10 kcal/min. To get total kcal burned during exercise, simply multiply 10 by the total number of minutes of exercise.

FINAL THOUGHTS

The most effective and accurate way to design an appropriate exercise intensity level and determine caloric expenditure is through the use of VO_2. However, the number of calculations required may limit use of this technique to individual clients. Other methods should be used to determine appropriate exercise intensities and calculate caloric expenditure in a group setting. In the next PFT 101 article, we will practice using VO_2R and the ACSM metabolic equations in real-life case studies.

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calculations for common activities

ACSM metabolic equations are available for five primary activities (ACSM 2000; Heyward 2002). Here we will discuss four of them: walking, running, cycling or leg ergometry, and stepping. There are two reasons to use the metabolic equations: (1) to calculate a VO_2 for a given workload or work rate and then convert VO_2 into caloric expenditure per minute, and (2) to calculate a workload or work rate intensity from a VO_2 value (Swain & Leutholtz 2002). In the equations below, VO_2 is calculated in milliliters per kilogram per minute (ml/kg/min), and 3.5 is a constant that refers to resting oxygen consumption.

Walking

VO_2 = (0.1 x speed) + (1.8 x speed x grade) + 3.5

This equation is appropriate for fairly slow speed ranges—from 1.9 to approximately 4 miles per hour (mph). Speed is calculated in meters per minute (m/min). The numbers 0.1 and 1.8 are constants that refer to the following:

0.1 = oxygen cost per meter of moving each kilogram (kg) of body weight while walking (horizontally)

1.8 = oxygen cost per meter of moving total body mass against gravity (vertically)

Running

VO_2 = (0.2 x speed) + (0.9 x speed x grade) + 3.5

This equation is appropriate for speeds greater than 5.0 mph (or 3.0 mph or greater if the subject is truly jogging). Speed is calculated in m/min. The constants refer to the following:

0.2 = oxygen cost per meter of moving each kg of body weight while running (horizontally)

0.9 = oxygen cost per meter of moving total body mass against gravity (vertically)

Cycling or Leg Ergometry

VO_2 = [1.8 (work rate) ÷ body mass in kg] + 7

This equation is appropriate for power outputs of 300–1,200 kilogram meters per minute (kgm/min) and speeds of 50–60 revolutions per minute (rpm). Since the power output that needs to be plugged into the equation is in kgm/min, and many exercise bikes measure in watts, you may need to convert watts to kgm/min (1 watt = 6 kgm/min). The constants refer to the following:

1.8 = oxygen cost of producing 1 kgm/min of power output

7 = oxygen cost of unloaded cycling plus resting oxygen consumption

Stepping

VO_2 = [0.2 (step rate)] + [1.33 x 1.8 (height in meters x step rate)] + 3.5

This equation is appropriate for stepping rates of 12–30 steps/min and for step heights ranging from 1.6 to 15.7 inches. Since the height that needs to be plugged into the equation is in meters, you must convert inches to meters (1 inch = 0.0254 meters). The constants refer to the following:

0.2 = oxygen cost of moving horizontally during stepping

1.8 = oxygen cost of moving vertically during stepping

1.33 = correction factor for positive and negative (up and down) component of stepping

Source: ACSM 2000.