Heart Rates for Energy Expenditure

Weight loss is difficult. Not in theory – eat less and move more – but in implementation. One of the major obstacles for most people is the lack of knowledge and/or confusion surrounding caloric intake and expenditure. Most people consume more calories than they realize and burn far less calories than they expect. Knowing what (# of calories) is actually in the foods they consume is one problem and knowing how calories are referenced is another. A breakfast muffin for instance may have 400-600 kcal. While the label says 200 kcals/serving, some overlook that the label also states there are two servings per muffin. At quick glance the calories and fat presented are only half of the actual value. A similar problem occurs in the gym. The Stairclimber shows 300 kcal after a 30 minute workout. In reality, the value is only correct if the individual maintained an upright posture, did not lean on the machine, and maintained proper pace and range on the pedals; or more importantly sustained heart rates. Just like the serving and portion sizes matter in food, heart rate matters when performing continuous exercise aimed at achieving weight loss.

After 50% of VO_2max, heart rates correlate increasingly well with VO_2 at the same intensity. The chart below demonstrates the relationship between the percentage of measured heart rate and percentage of VO_2max. The percentage of heart rate max is always charted on cardio machines and the general recommendation is to train between 75-90% of HRmax, or 60-80% of VO_2max, which is explained by the number correlations below. The reason this is relevant is caloric expenditure is tied to oxygen utilization. If you know a person's VO_2 you can also determine an actual caloric expenditure by minute based on heart rates.

Percentage of HRmax	**Percentage VO_2max**
66%	50%
70%	55%
74%	60%
77%	65%
81%	70%
85%	75%
88%	80%
92%	85%

Many fitness professionals have realized by now that the Elliptical Trainer and other static modalities do not predict energy expenditure accurately and based on usage dynamics commonly over-predict the caloric expenditure – giving clients a false sense of accomplishment and frustration at the lack of results at the same time. To correct this issue the first step is identifying how many calories a person can actually expend. Walk and run tests can do this with acceptable accuracy and present viable numbers to work with for weight loss. Below are two formulas for calculating the predicted VO_2max and subsequent caloric expenditure potential. The one mile walk test best serves the less fit population, whereas the 1.5 mile run/jog test is designed for those in better shape. One caveat to both is the individual needs to perform at maximal effort and the distance must be accurate. Therefore, measuring the distance and practicing the test for pace is important for optimal validity.

One Mile Walk Test

VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$) = 132.853 - 0.0769(weight) - 0.3877(age) + 6.315(gender) - 3.2649(time) - 0.1565(HR)

- Weight is in pounds
- Age is in years
- Gender = 0 for females and 1 for males
- Time is in minutes and hundredths of minutes (ex. 13.51 = 13 minutes and 31 seconds) *divide 31 seconds by 60 seconds*
- Heart rate is in beats per minute at completion (use a 10 sec count x 6)

1.5 Mile Run Test

$$VO_2 = \text{horizontal velocity } m \cdot min^{-1} \times \frac{0.2\ ml \cdot kg^{-1} \cdot min^{-1}}{m \cdot min^{-1}} + 3.5\ ml \cdot kg^{-1} \cdot min^{-1}$$

The formula is not as complicated as it appears. Assume a 35 year old female weighing 138 lbs. ran the 1.5 mile in 12:13 min. The first thing that must be calculated is the average horizontal running velocity of the subject in meters per minute. To do this you must convert the distance run into meters and divide it by the number of minutes it took to complete the run.

Example Meter Conversion

1.5 miles = 2,413.8 meters

2,413.8 must then be divided by the time it took to complete the run in minutes (use whole numbers)

Example ($m \cdot min^{-1}$) conversion

If it took 12:00 minutes to complete the run, then 2,413.8 m / 12min = 201.15 $m \cdot min^{-1}$ (horizontal velocity)

If it took 12:13 to complete the run then the divisor would be 12.21 (12 +13/60))

Perform your conversion below:

2,413.8 meters ÷ 12.21 minutes = 198 $m \cdot min^{-1}$ (horizontal velocity)

VO_2max conversion. The last calculation that must be performed is the one that will provide you with the subject's estimated VO_2max. Consider the above example:

$$VO_2 = \text{horizontal velocity } m \cdot min^{-1} \times \frac{0.2\ ml \cdot kg^{-1} \cdot min^{-1}}{m \cdot min^{-1}} + 3.5\ ml \cdot kg^{-1} \cdot min^{-1}$$

$$VO_2 = 198\ \cancel{m \cdot min^{-1}} \times \frac{0.2\ ml \cdot kg^{-1} \cdot min^{-1}}{\cancel{m \cdot min^{-1}}} + 3.5\ ml \cdot kg^{-1} \cdot min^{-1}$$

Less scientifically written as (198 x.2) + 3.5 = VO_2

VO_2 max = 43.1

Now at 43.5 $ml \cdot kg^{-1} \cdot min^{-1}$ the maximum oxygen use has been determined. A couple of multiplication equations later and the female's maximal oxygen consumption expressed in calories is 810 kcal/hour. So if she was able to train at 100% of her VO_2 she would be able to burn over 800 kcal/hour or 13.5 kcal/min (810 kcal ÷ 60 min). Some boot camps advertise that the class allows one to burn more than 1,000 kcal/hour - obviously an extreme exaggeration. So…assuming your client was going to train at a fitness level between 60-80% you can deduce the calories per minute accurately. Look at the example once again.

She burns 810 kcal at 100%. Which means at 60% (810 x .6) she burns 486 kcal/hour or 8 kcal/minute. At 80% she would burn 648 kcal/hour or 10.8 kcal/minute. These numbers are much more reasonable when it comes to predicting exercise related weight loss and also helps explain why it takes so long. Based on these facts if she exercised aerobically for 20 minutes at 60% of her oxygen capacity she would burn only 160 kcals (20 min x 8 kcal) or at 80% she would jump to 216 kcals; hardly enough to burn off the muffin. In fact, she would actually need about 40-45 minutes to burn off that breakfast muffin making it probably not worth the taste enjoyment.

Since not everyone is efficient with METs and not every machine has MET level buttons on them, it makes more sense to use Heart Rates. But, if you do use METs it is as simple as multiplying the VO_2max times your training percentage and dividing by 3.5.

Example $43.1\ ml \cdot kg^{-1} \cdot min^{-1} \times 60\% = 25.86 \div 3.5\ ml \cdot kg^{-1} \cdot min^{-1} = 7.3$ METs

$43.1\ ml \cdot kg^{-1} \cdot min^{-1} \times 80\% = 34.48 \div 3.5\ ml \cdot kg^{-1} \cdot min^{-1} = 9.85$ METs

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Utilizing the MET intensity button for better accuracy helps, but if you're more comfortable with Heart Rates use the Karvonen formula to establish the training zones as they correlate well with VO_2 and subsequently with the calories expended. Here we simply measure the female's resting heart rate. Let's say it is 65 beats/min. We then calculate the max heart rate 208 – (.7 x age) and since she is 35 we get 184 beats/min. Subtracting the resting from the maximal heart rate gives us the zone to work in called the heart rate reserve which should make sense since we cannot exceed max nor go below rest – so we train somewhere in the middle. When completing the calculation for the actual training zone, we'll need to add back in the resting heart rate to our calculated percentage of heart rate reserve. See example below:

183 bpm max - 65 bpm resting = 122 HRR

122 HRR x 60% + 65 bpm = 138 bpm

122 HRR x 80% + 65 bpm = 162 bpm

Based on the correlations and assumptions above if the female client gets her heart rate to 138 beats/min or works at 7.3 METs she will burn approximately 8 kcal/minute and if she gets her heart rate up to 162 beats min or 9.85 METs she will burn about 10.8 calories/minute. These values can be determined for any percentage over 50% VO_2max or 70% HRmax by simply swapping out the training intensity. The reason this is such an effective method to determine caloric expenditure is there is no way to cheat. Either you are using the oxygen as monitored by your heart rate or you are not. This forces people to be more accountable for their effort and clearly identifies when they are not doing enough to create a negative caloric balance.