

How Do They Do It?

An Introduction to Calorimetry in Research

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Calorimetry is the measurement of heat absorbed or emitted. More specifically, indirect calorimetry is the measurement of heat produced by an animal as it relates to the consumption of oxygen (O_2) and the elimination of carbon dioxide (CO_2). Scientists at Kentucky Equine Research (KER) use indirect calorimetry to answer a variety of questions, including what energy sources are used to sustain short-term and long-term exercise in horses. Horses use carbohydrates, fats, or a mixture of both to provide energy for work. By using indirect calorimetry, researchers can pinpoint what fuel is used for a specific kind of work. In addition, indirect calorimetry can also reasonably predict the exercise potential of a horse.

A respiration calorimeter is used to measure gas exchange between a horse and its surrounding atmosphere. During calorimetry, a horse wears a loose-fitting, padded face mask that is attached to a motorized air pump. The mask allows the pump to pull more air through the system than the horse requires for each breath. The normal ventilation rate of a horse is approximately 80 liters of air per minute (L/min) at rest and in excess of 1000 liters during moderate to heavy exercise. The pump pulls 10,000 L/min through the system. Suction created by the pump ensures that expired air is collected and not rebreathed by the horse, which would greatly reduce the amount of oxygen available and limit performance if it were to occur. The air in the exercise room, referred to as ambient air, is used as the control in indirect calorimetry studies.

KER conducts indirect calorimetry as horses exercise on a high speed treadmill. Particular research trials call for an incremental exercise test, which requires horses to perform at increasing speeds until maximal exertion. Other trials use longer, slower endurance-style exercise tests. Research teams can tailor exercise tests to best fit the requirements of a study.

Prior to exercise, the horse's weight is measured in kilograms. One kilogram equals 2.2

pounds. During the exercise test, the airflow rate is measured in L/min. Uptake of O_2 and expulsion of CO_2 are also recorded. These measurements can provide the following values:

- VO_2 - Liters of oxygen consumed per minute per kilogram of body weight. VO_2 is the measurement of oxygen consumption at a specific speed or workload.
- VO_{2max} - Liters of oxygen consumed per minute per kilogram of body weight when at maximal aerobic capacity (oxygen is still required in the energy production processes). VO_{2max} is the maximum amount of oxygen that can be used by the individual during intense exercise.
- VCO_2 - Liters of carbon dioxide exhaled per minute per kilogram of body weight. VCO_2 is the measurement of carbon dioxide production at a specific workload or speed.
- RQ (respiratory quotient) - This is calculated as the VCO_2 divided by VO_2 at any given speed. The resulting ratio correlates to the substrate or a mix of substrates being used as fuel. An RQ of 1.0 indicates that a horse is deriving all of its energy from carbohydrate, while an RQ of 0.70 means that the horse is using exclusively fat for energy generation.



The results from many trials using calorimetry have led KER nutritionists to advise owners, trainers, and international competitors how to better manage their horses with respect to maximizing each horse's potential.

These values are used for many different purposes throughout a research trial when assessing individual horses. VO_{2max} calculations allow the research team to evaluate the fitness of a horse and its ability to utilize oxygen for energy. As fitness progresses, the horse will be able to attain a higher speed before reaching VO_{2max} . An example of this would be a lightly trained Thoroughbred hitting maximum O_2 consumption at 25 mph, but after beginning a regular training program, the same horse would eventually be able to go 29 mph before reaching its limit. The implications to the racing world would be the difference in speed between the horse that crosses the wire first and the horse that comes in second.

Knowing the VO_{2max} of an individual horse can lead to further calculations. Certain trials require horses to run at a particular percentage of this VO_{2max} . An endurance test (typically 90 minutes) is usually performed using Arabian horses that are particularly well-suited to longer bouts of exercise. Endurance horses may be required to run at 35-40% of their VO_{2max} speed, typically between 9 and 11 mph. A Thoroughbred sprint test is run at 115% of the VO_{2max} for a two-minute peri-

od. Use of these calculations allows the treadmill speed to be adjusted to suit each horse and takes each individual's level of fitness and potential into account.

Calculation of the RQ has proven useful when looking at substrate utilization in Thoroughbreds and Arabians. This allows the research team to assess the utilization of these fuels at different stages of exercise. Work at KER has shown that during low intensity exercise, a 90-minute trot calculated to equal 35% of the VO_{2max} , Arabians have a lower RQ and a higher concentration of free fatty acids (FFA) in their blood plasma than Thoroughbreds at all times. FFA concentration is considered proportional to the utilization of fats as a fuel source. This highlights the different abilities of breeds to utilize fuel sources from the diet; the Arabian is renowned for its endurance capabilities whereas the Thoroughbred is, by nature, a sprinter.

The procedures outlined above and the calculations that can be produced using the data will allow the researchers at KER to build a comprehensive picture of a horse's fitness, as well as potential and ability to utilize fuel sources from its diet. These are all factors that ensure that the research horses at KER are able to continue to work at their current level of intensity with little or no strain during the execution of trials. The results from many trials using calorimetry have led KER nutritionists to advise owners, trainers, and international competitors on how to better manage their horses with respect to maximizing each horse's potential. ∞

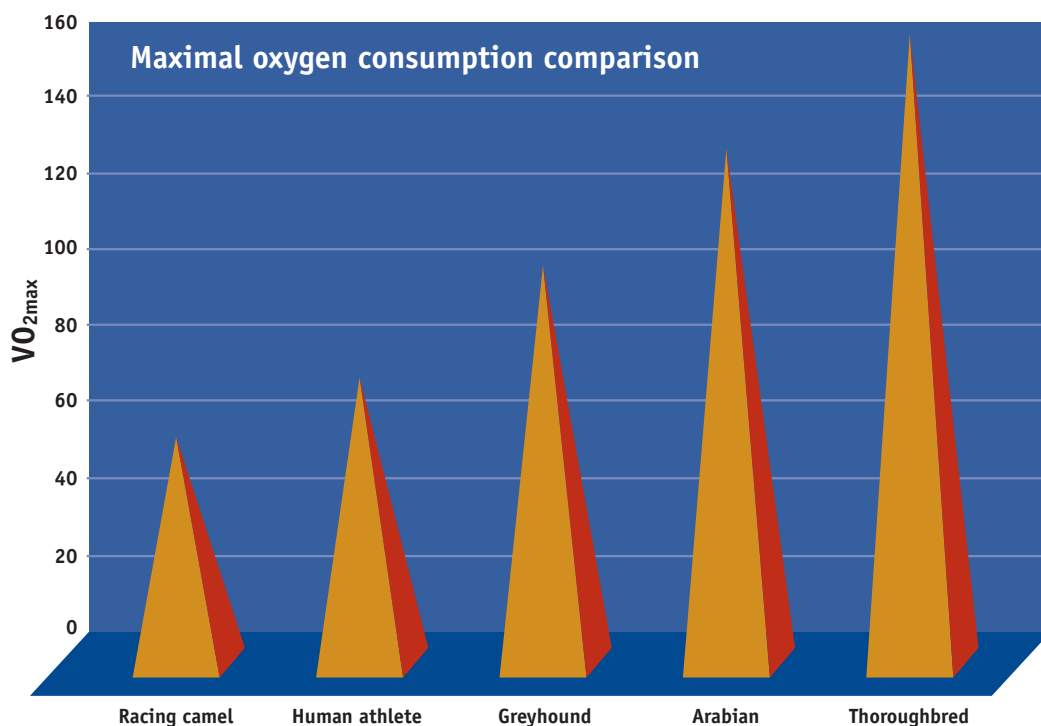


Figure 1. Thoroughbreds are far superior to human athletes in terms of VO_{2max} . The calculation of VO_{2max} allows a comparison to be made between species as the units of measurement take the individual's body weight into account.