

Enhancing the aerobic system and brain health to optimize athletic performance

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Heart rate monitoring | Diet | Refined carbohydrates | Fat oxidation | Body fat | Overfat | Waist-to-height ratio

Headline

The brain is the most critical organ for athletes, controlling every conscious and subconscious action. The aerobic system provides essential long-term energy for all sports activities by metabolizing fat while supporting biomechanics and other aspects of brain and body health. Aerobic and brain functions are often presumed to be working well, yet certain conditions can impair them. Notably, excess body fat, often unnoticed, is a marker for reduced aerobic and brain performance with potential downstream physical and mental injuries.

Aim

This review seeks to help clinicians, coaches, and athletes in all sports optimize the aerobic system and brain to enhance existing athletic performance. Simple evaluations and remedies are provided to help assess and monitor progress.

The Aerobic System

Humans generate energy (ATP) from a mix of glucose and fatty acids (which also produce ketones) that varies significantly with physical intensity and diet macronutrient content (1-3).

- The aerobic system incorporates red aerobic muscle fibers (Type I or slow-twitch) intertwined within most skeletal muscles that potentially burn very high amounts of fat in mitochondria for long-term energy. This influences skeletal and cardiac muscles, the brain, and many other tissues. When developed, aerobic fibers are relatively fatigue-resistant, providing long-term physical support for posture, gait, all soft tissues, joints, and bones.
- The anaerobic system's white fast-twitch Type II muscle fibers generate energy primarily from glucose, supporting short-term speed and power.

Increased aerobic function with high levels of fat burning is important in all sports activity, during rest and recovery, and can also improve health (4). For example, maximum fat burning (max fat oxidation or MFO) can also improve cardiovascular and metabolic functions, increase VO₂max, support the immune system, promote healthy aging, prevent excess stored fat, and improve performance (5-7).

Impaired aerobic function can reduce fat burning, aerobic capacity, energy production, athletic performance, and health while increasing body fat, insulin resistance (reducing glucose uptake by muscles), and physical and mental injuries (1,7,9,10). Fat burning varies significantly between ~23 and 89% of VO₂max (11).

Body fat

Normal levels of stored body fat play key roles in health and fitness, especially as an energy reserve, and for insulation, immunity, organ protection and hormone regulation, with too

much or too little fat impairing these functions. While too low body fat is associated with poor physical or mental health, this article focuses on excess body fat, a more common problem. Excess body fat content is a marker for reduced aerobic and brain function (10).

The term “overfat” refers to excess body fat that impairs health and fitness (12). The current global overfat pandemic (~80%) has not spared athletes, including those who appear fit, are not overweight or obese, or have normal body mass index (BMI). Overfat athletes (*adipositas athletica*) are not uncommon throughout sports with negative effects beginning early when overfat cells become metabolically abnormal resulting in body-wide inflammation, lowered immunity (and vitamin D uptake), and increased body weight (13).

Excess fat can be unnoticed making assessment vital. BMI can underestimate body fat, especially when considering ethnicity and gender, and misclassify ~50% of overfat individuals (14). Dual-Energy X-ray Absorptiometry (DXA) scans can accurately determine body fat percentage but are not practical for regular use; bioelectrical impedance and other devices have varying degrees of accuracy. However, the waist-to-height ratio (WHtR) is an accurate and simple home or clinic test that can assess the overfat condition (see Fig 1). It is accurate for all individuals (except young children and pregnant women) and easily performed with a flexible tape measure:

- Standing upright and relaxed, wrap a tape around your bare torso at the level of the umbilicus (belly button).
- Avoid pulling in the abdomen and keep the tape horizontal and snug to obtain a measure in centimeters or inches.
- Measure height (while barefoot).
- The WHtR = waist divided by height.
- Measures of 0.5 or above indicate overfat-*the waist should be less than half the height.*

Addressing overfat is primarily a dietary issue discussed later.

Brain Health

The brain's integral role in regulating all body activity includes aerobic function. For example, the hypothalamus constantly monitors energy levels to adjust metabolism, while the motor cortex controls the balance of muscle contraction and relaxation. Better brain function can also predict competitive behavior (15).

While motivation, visualization, relaxation and other mental approaches can help enhance sports performance, they may not be realized without better brain health. Non-traumatic brain injuries can also develop due to poor aerobic function reducing brain energy, and from mental-emotional stress due to physical injury and poor performance (10,16). Common symptoms of reduced brain health include anxiety, depression, apathy, and reduced confidence and self-esteem, with poor sleep quality a common sign.

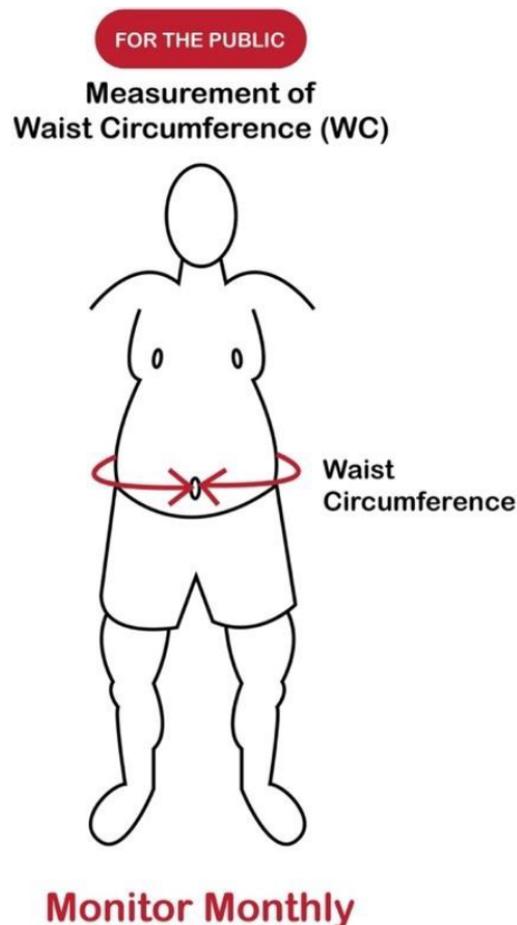


Fig. 1. Determining the waist-to-height ratio.

Remedies

Diet

Reduced aerobic and brain function is best addressed first through dietary modifications to quickly help improve metabolism. Refined carbohydrates, including sugar and most products made from flour, are primary drivers of reduced aerobic and brain health, even in relatively small amounts (10). The high consumption of these “junk foods” is a common feature of the *overtraining syndrome* (4).

Early humans relied on high levels of fat burning to develop larger brains and bodies that were very physically active, consuming a higher fat, moderate protein and low- or very-low carbohydrate diet. Today, this is accomplished by reducing or eliminating refined carbohydrates to improve fat burning, maintain healthy body fat, and increase brain function (10). Replacing junk foods with healthy items can also quickly improve nutrient status and gut microbiota (17).

This dietary transition can be accomplished immediately and safely for rapid results, albeit producing mild fatigue for a few days. Or these changes can be made slower to accommodate upcoming key competitions.

With fats providing more energy, less carbohydrate supplementation (~10-30 grams per hour) *during* competition can be used to maintain blood sugar levels (18). While this dose is much less than traditional recommendations, higher fat burning makes up the difference. This can also help the gut as high carbohydrate intake can cause stress, with nausea, bloat-

ing, diarrhea, abdominal cramps and other problems adversely affecting performance during training, competition, and recovery.

Aerobic testing and training

Given the importance of improved aerobic function, an individualized submaximal training HR theoretically associated with max fat burning (or Fatmax) and without requiring laboratory assessments was developed clinically by the author beginning in the late 1970s (7). Also called max aerobic function (MAF) HR or max aerobic HR, it can be used to 1) test aerobic function during exercise, and 2) train the aerobic system. *Aerobic progress is indicated by increased work rates at the same submax HR.* This HR is derived using the 180-formula (7). (See Table 1.)

Testing aerobic function

- While running pace is used in this example, cycling power or other easily reproducible activity can also be employed. Following a very easy *active* 12-15 minute warm up on a track or other relatively flat location, the test begins by running at a pace that maintains the max aerobic HR. Continue for a specified distance such as 5 km or 3 mi (based on fitness) recording each km or mi or total time. This is best performed at the same location, course (or equipment). The test should feel easy regardless of pace. Results vary, but generally slower paces reflect reduced aerobic function.

When dietary habits are improved (as noted above), this aerobic support can help quickly promote faster paces at the same HR often after the first month. Continued improvement should occur with ongoing training at the same max aerobic HR to further improve fat burning. (See Fig 2.)

The crucial point is that faster paces at the same max aerobic HR can also translate to improved competitive performance, i.e., faster test results are associated with faster race times or performances in other sports. It should also be noted that the test should improve over time (months and years) or temporarily plateau, but never worsen, which may indicate excess stress such as the early onset of overtraining or illness (not unlike an elevated resting HR) (4).

Training the aerobic system

- Ongoing improvement in aerobic function can be accomplished by adhering to the max aerobic HR during training—ideally for all training until substantial performance improvements are noted. Once aerobic function improves, high-intensity and or strength activities can proceed. This aerobic-only training typically is done during the “off season.” However, for those overtrained, injured, or with performance decrements, strict training of the aerobic system can commence immediately, helping to assist in recovery.

While useful for virtually all athletes, the 180-formula does not replace laboratory evaluations. As shown in Figure 3, some commonly measured laboratory relationships estimate the location of the max aerobic or MAF HR.

Table 1. The 180-Formula

1. Subtract your age from 180.
2. Modify this number by choosing one category below that best applies to you:
 - a. If you have or are recovering from a major illness (including any operation or hospital stay), are in rehabilitation, have been prescribed any regular medication, or are chronically overtrained, subtract an additional 10.
 - b. If you are injured, have regressed or not improved in training (such as poor MAF tests) or competition, get more than two colds, flu or other infections per year, have seasonal allergies or asthma, are overfat, are acutely overtraining, or if you have been inconsistent, just beginning or returning to exercise, subtract an additional 5.
 - c. If you have been training consistently (at least four times weekly) for up to 2 years without any of the problems mentioned in (a) or (b), no modification is necessary (use 180 minus age as your MAF HR).
 - d. If you have been training for more than 2 years without any of the problems listed above, have made progress in your MAF tests, and have improved competitively, add 5.

The resulting HR is the high end of the HR range with the low being 10 beats below. For example, (a) 40-year old in category (b) would have an exercise range of 125–135 bpm. Users can self-select any intensity within this range.

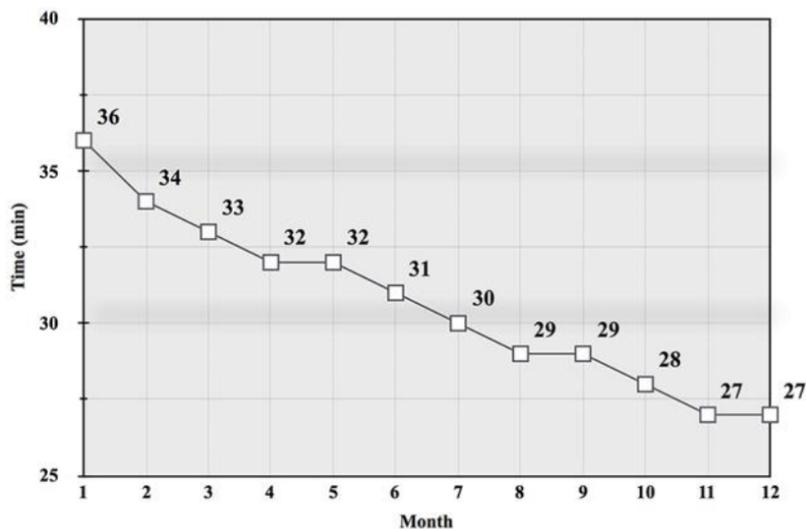


Fig. 2. Graph from a 35 year-old experienced male runner’s monthly MAF HR test results (total time in min, rounded) obtained from the 180-formula and performed on a flat 5 km road course during 12 months of aerobic-only training

MAF HR, maximum aerobic function heart rate; AerT, aerobic threshold; VT1, first ventilatory threshold; LT, lactate threshold; MLSS, maximal lactate steady state; FTP/S, functional threshold power/speed; VT2, second ventilatory threshold; AT, anaerobic threshold; RER, respiratory exchange ratio; VO₂max, maximal oxygen uptake

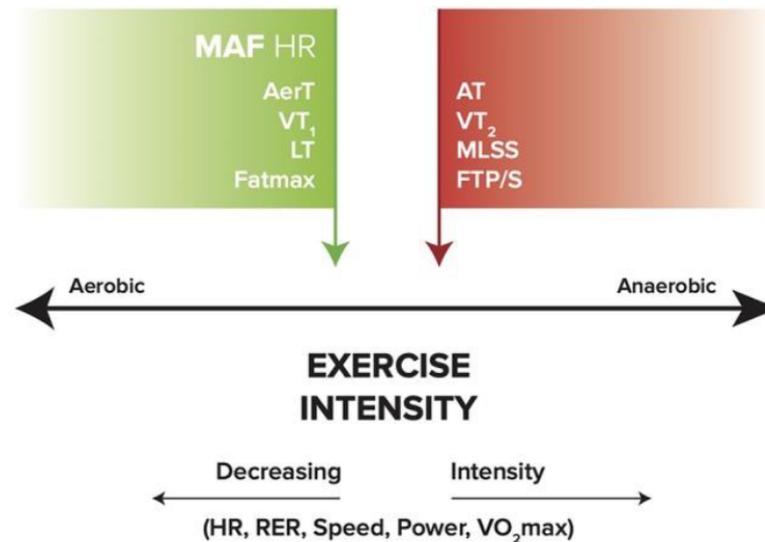


Fig. 3. Some general laboratory measures and relationships between aerobic (MAF HR, AerT, VT1, LT, and Fatmax), anaerobic (MLSS, FTP/S, VT2, and AT), and exercise intensity (HR, RER, speed, power, and VO₂max). Green arrow indicates increased fat burning and red arrow indicates reduced fat burning. Measures of Fatmax, AerT, and VT1 appear to be generally associated with max fat burning and a low to moderate level of exercise intensity. Theoretically, the HR determined by the 180-formula (MAF HR) is associated with these same measures (3,7).

Practical Applications

Along with regular health care, athletic evaluation and ongoing monitoring of the aerobic system and brain is essential:

- Perform the WHtR every 1-2 months.
- Perform the max aerobic HR test every 1-2 months.
- Employ an aerobic-only training period during the off season or when necessary to develop the aerobic system.
- Assess diet quality regularly.

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