High Intensity Interval Training (HIIT) vs. High Volume Training (HVT)

The fitness industry is seeing a surge of interest in high-intensity interval training (HIIT), a burst-and-recover cycle that can offer a viable alternative to continuous aerobic exercise.

HIIT, which pairs quick bouts of high-energy exercise with low-effort rest intervals, is not exactly a new idea. As early as 1912, the Finnish Olympic long-distance runner Hannes Kolehmainen was using interval training in his workouts (Billat 2001). As our knowledge of HIIT has increased, exercise scientists have demonstrated that HIIT can boost the performance of competitive athletes; improve the health of recreational exercisers; and provide the benefits of continuous-endurance training with fewer workouts.

The standard way to improve cardiovascular fitness is to increase the volume of exercise—for example, with longer runs or bike rides, or more time on an aerobic machine. HIIT is intriguing because, according to current research, it can yield a broad range of physiological gains, often in less time than high-volume continuous exercise (Daussin et al. 2008).

With that in mind, this article will discuss the body’s cardiovascular, skeletal-muscle and metabolic adaptations to HIIT and compare them with the body’s responses to continuous endurance exercise. (Continuous aerobic training is defined as exercising—running, cycling, swimming, etc.—for more than 20 minutes at a steady intensity.) Also included here are research-based examples of HIIT and continuous endurance training.

Cardiovascular Physiology 101: Basic Responses and Adaptations of Aerobic Training
Before we can compare HIIT and continuous endurance training, it’s important to review how the body’s cardiovascular system adapts to an aerobic workout. During aerobic exercise, heart performance is based on heart rate, stroke volume (the amount of blood pumped per beat) and heart contractility (the forcefulness of each heart contraction). These variables increase blood flow and oxygen supply to meet the demands of exercising muscles.

The contraction of the skeletal muscle also boosts the flow of venous blood returning to the heart, which increases ventricle blood filling (called the preload). This elevated preload contributes to the heart’s enhanced stroke volume during exercise, and this in turn is a major determinant of aerobic performance (Joyner & Coyle 2008).

Progressive increases in endurance training trigger adaptations in the heart muscle structure: heart muscle thickens, and the left ventricle expands, improving heart function during exercise. Consistent endurance exercise—such as 30–60 minutes of continuous running or cycling 3–7 days a week—causes a long list of cardiovascular adaptations and responses (see Figure 1).

HIIT vs. Continuous Endurance Exercise: HIIT vs. Continuous Endurance Exercise: Cardiovascular Adaptations
Recent research shows that the cardiovascular adaptations that occur with HIIT are similar, and in some cases superior, to those that occur with continuous endurance training (Helgerud et al. 2007; Wisløff, Ellingsen & Kemi 2009). Helgerud et al. showed that 4 repetitions of 4-minute runs at 90%–95% of heart rate maximum (HRmax) followed by 3 minutes of active recovery at 70% HRmax performed 3 days per week for 8 weeks resulted in a 10% greater improvement in stroke volume than did long, slow distance training 3 days per week for 8 weeks (total oxygen consumption was similar in both protocols).

Another study (Slørdahl et al. 2004) demonstrated that high-intensity aerobic training at 90%–95% of maximal oxygen consumption (VO2max) increased left-ventricle heart mass by 12% and cardiac contractility by 13%—improvements comparable to those observed with continuous aerobic exercise.

VO2max is considered the body’s upper limit for consuming, distributing and using oxygen for energy production. Commonly called maximal aerobic capacity, VO2max is a good predictor of exercise performance.
Improving cardiovascular function increases the body’s VO2max. Some research suggests that HIIT is better than endurance training for improving VO2max.

Daussin et al. (2008) measured VO2max responses among men and women who participated in an 8-week HIIT program and a continuous cardiovascular training program. VO2max increases were higher in the HIIT program (15%) than they were in the continuous training program (9%).

Improving cardiovascular function and increasing VO2max are major goals of patients with cardiovascular disease, which is why some cardiac rehabilitation centers are beginning to include interval training for heart disease patients (Bartels, Bourne & Dwyer 2010). Although traditional low-intensity exercise produces similar gains, improvements from interval training happen in a shorter time, with fewer sessions.

**HIIT vs. Continuous Endurance Exercise: HIIT vs. Continuous Endurance Exercise: Skeletal-Muscle Adaptations**

An increase in the size and number of mitochondria (the “energy factory” of a cell) is becoming a hallmark adaptation with HIIT (Gibala 2009). The increase in mitochondria density, as scientists call it, has been thought for many years to occur only from chronic endurance training.

During aerobic exercise, mitochondria use oxygen to manufacture high levels of ATP (adenosine triphosphate, the energy molecule of the cell) through the breakdown of carbohydrates and fat. As mitochondrial density increases, more energy becomes available to working muscles, producing greater force for a longer duration (allowing an athlete to run longer at a higher intensity, for example).

In a 6-week training study, Burgomaster et al. (2008) showed similar increases in levels of oxidative enzymes (proteins in mitochondria that accelerate biological reactions to liberate ATP) among subjects who performed a HIIT program consisting of four to six 30-second maximal cycling sprints (followed by 4.5-minute recovery bouts) 3 days per week and subjects who completed 40–60 minutes of steady cycling at 65% VO2max 5 days per week. An increase in mitochondrial oxidative enzymes leads to more effective fat and carbohydrate breakdown for fuel.

Related work by MacDougall et al. (1998) demonstrated higher levels of the oxidative enzymes citrate synthase (36%), malate dehydrogenase (29%) and succinate dehydrogenase (65%) in the skeletal muscle of healthy male undergraduate students engaging in 7 weeks of HIIT cycling sprints. Three days per week, subjects performed four to ten 30-second maximal cycling sprints followed by 4-minute recovery intervals. The higher levels of mitochondrial enzymes seen among the subjects led to improved skeletal-muscle metabolic function.

There has been a spike of current research explaining the complex molecular pathways that lead to increased mitochondrial density. HIIT can cause physiological changes that mirror the results of traditional endurance training, but the HIIT changes are accomplished through different message-signaling pathways (see Figure 2).

In this model, calcium–calmodulin kinase (CaMK) and adenosine monophosphate kinase (AMPK) are signaling pathways that activate peroxisome proliferator-activated receptor-g coactivator-1α (PGC-1α). PGC-1α is like a “master switch” that is believed to be involved in promoting the development of the skeletal-muscle functions shown in the figure. High-volume training appears more likely to operate through the CaMK pathway, whereas high intensity appears more likely to signal via the AMPK pathway.

**HIIT vs. Continuous Endurance Exercise: Metabolic Adaptations**

Increasing mitochondrial density can be considered a skeletal-muscle and metabolic adaptation. One focal point of interest for metabolic adaptations is the metabolism of fat for fuel during exercise. Because of the nature of high-intensity exercise, its effectiveness for burning fat has been closely examined. Perry et al. (2008) showed that fat oxidation, or fat burning, was significantly higher and carbohydrate oxidation (burning) significantly lower after 6 weeks of interval training.
Similarly, but in as little as 2 weeks, Talanian et al. (2007) showed a significant shift in fatty acid oxidation with HIIT. Horowitz and Klein (2000) reported that an increase in fatty acid oxidation was a noteworthy adaptation observed with continuous endurance exercise.

Another metabolic benefit of HIIT is excess post-exercise oxygen consumption (EPOC). After an exercise session, oxygen consumption (and thus caloric expenditure) remains elevated as the working muscle cells restore physiological and metabolic factors in the cell to pre-exercise levels. This translates into higher and longer calorie burning after exercise has stopped.

In their review article, LaForgia, Withers and Gore (2006) noted that exercise-intensity studies indicate higher EPOC values with HIIT training than with continuous aerobic training.

Final Verdict: And the Winner of the Battle of the Aerobic Titans is . . .

The major goals of most endurance exercise programs are to improve cardiovascular, metabolic and skeletal-muscle function in the body. For years, continuous aerobic exercise has been the chosen method for achieving these goals. However, research shows that HIIT leads to similar and, in some cases, better improvements in less time for some physiological markers. Incorporating HIIT (with appropriate intensity and frequency) into your clients’ cardiovascular training gives them a time-efficient way to reach their goals.

And since both HIIT and continuous aerobic exercise programs improve all of these meaningful physiological and metabolic functions of the human body, incorporating a balance of both programs in clients’ training is clearly the “win-win” approach for successful cardiovascular exercise improvement and performance. Go HIIT and go endurance!

Figure 1. Cardiovascular Responses And Adaptations To Endurance Training

Source: Joyner and Coyle 2008; Pavlik et al. 2010.
Figure 2. Signaling Pathways Of Continuous Endurance Training And HIIT

Source: Laursen 2010.