



MORE THAN ONE WAY TO HIIT YOUR GOAL

High-Intensity Interval Training comes in many forms, writes exercise physiologist *Tony Boutagy*. By understanding your client's objectives you can program the most effective type for their needs.



THE QUICK READ

- HIIT can be a time-effective way to improve health, body composition and performance
- There are three main subtypes of HIIT: sprint intervals, short intervals and long intervals
- The ratios of work-to-rest vary greatly both across the three main types of HIIT, and within each subtype
- HIIT often involves stationary cycling, rowing, running or similarly simple movements that do not distract the exerciser from the intensity of effort required
- Workouts should typically be performed twice a week on a mode that can handle high work outputs without compromising good form.

Interval training refers to an intermittent style of exercise in which bouts of more intense effort are separated by periods of recovery within a single training session. The High-Intensity component of interval training can be operationally defined as training sessions where bouts of exercise are performed at an intensity higher than one could sustain for a prolonged period, of say, more than 8 minutes, interspersed with recovery periods.

One of the primary goals of interval training is the use of intermittent exercise efforts to expose the body to an accumulated intensity greater than one could sustain in a continuous bout. For example, if your best time for a 5K run was 20 minutes (4-min per km pace), then an interval training session option might involve five, 1km intervals at 3:30-min/km with 2 minutes rest, thereby accumulating 5km at a faster time than your best continuous 5km pace.

Application of this method for general fitness and sports conditioning has been recognized for around 100 years, but the last decade has seen an explosion of research into the physiological adaptations to interval training in both sports settings and in populations with cardiometabolic diseases.

Origins and history

Elite athletes seeking to improve their sports performance have used interval training, in a variety of forms, for almost a century.

Originally used by German cardiologists as part of the rehabilitation process, interval training was quickly adopted by their country's coaches in the 1930s. At a similar time in Sweden, Fartlek training was invented by the coach Gösta Holmér, which saw running training sessions punctuated with different distances varying in speed. By the mid 1930s, the Germans had formalised a structured system of interval training for track and field athletes. Within two decades, interval training was popularised by the Czech runner Emil Zátopek, who won gold medals in the 5,000m and 10,000m races, as well as the marathon, at the Helsinki Olympic games in 1952.

Thus, interval training itself is not new, being used for many decades and extensively scientifically investigated since the 1970s, initially from a performance setting and more recently for its effects on cardiometabolic health and body composition.

High-Intensity session types

As a working definition, HIIT can be broadly divided into three distinct types: Sprint Interval Training (SIT), Short Intervals; and Long Intervals.

Sprint Interval Training (SIT)

Sprint intervals are essentially repeated bouts of 'all-out' efforts with almost full recovery. Typically, work durations are between 20 seconds and up to a minute. The rest between intervals should allow for

almost complete recovery, so it is normally over 5 times longer than the actual interval duration, typically between 2 and 5 minutes. The most well-known type of SIT are Wingates, named after the Israeli institute where they were developed. A Wingate session starts at four bouts of 30 seconds with four and a half minutes active recovery between each bout. Like all work efforts in SIT sessions, the 30 seconds is performed at best possible speed, with no pacing. Although the total work performed in the session is only 2 minutes, the perception of effort is enormous, due mostly to the extremely high acidosis that is generated during the repeated all-out 30-second bouts.

Here are three examples of SIT workouts, remembering that although the duration of the interval is short, the effort required should be maximal!

Option one: 30-second bouts

Wingates: 4 x 30 seconds with 4:30 minutes rest between each bout. Add one more interval every two workouts, so that sessions 1 and 2 would be 4 x 30-second intervals; sessions 3 and 4 would have 5 intervals and sessions 5 and 6 would have 6 intervals. For the first timer performing this method, undertake the session as written. For the seasoned interval devotee, start with 6 bouts and increase to 8 over the 6 sessions.

Option two: 20-second bouts

6 x 20 seconds with 2:10 minutes recovery between each bout. Each 20-second interval commences every two and a half minutes (i.e. train for 20, recover for 2:10). For the beginner, perform as written and for the veteran, after the 6 bouts, actively recover for 4-6 minutes and perform the entire 6 bouts again.

Option three: 60-second bouts

4 x 60 seconds with 4 minutes recovery between bouts. Like the Wingates in option one, add an interval every 2 sessions, so that you will perform 6 bouts on session 5 and 6. Again, like the Wingates for the advanced trainee, start with 6 bouts and progress to 8 over the same time period.

Short Intervals

Short Intervals are sessions where interval durations between 10-40 seconds are performed in blocks of 4-10 minutes, alternating the recovery duration in one of three ways: equal work-to-rest, double work-to-rest or half work-to-rest. Although similar to the work durations used in SIT sessions, the goal here is not 'all-out' but rather best sustained pace for the duration of the block. Normally, a power or speed for the interval would correspond to just below, equal to or above the power or speed you could sustain

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for your best 3-4 minutes once off (the so-called p/vVO2max). If one used a 20-second work period, then the three possible short intervals would be:

- 20-second effort, 40-second recovery (half work-to-rest)
- 20-second effort, 20-second recovery (equal work-to-rest)
- 20-second effort, 10 second recovery (double work-to-rest).

The session would be conducted as a block of 4-10 minutes, where you would perform, say, option 1 above (20 effort/40 recovery) for 6 minutes, with the goal of keeping the 20-second effort at a similar pace. After the 6 minutes was completed, you would actively rest for 2-4 minutes and repeat the 6-minute block another two times.

Using the three work-to-rest ratios above, short intervals gives us many options for program design, with the most common effort durations being intervals of 15-seconds, 20-seconds, 30-seconds and 40-seconds.

To summarise, if programming short intervals for a client, you would choose one of the 12 options above and perform repeatedly for a block of 4-10 minutes at the best sustained pace, actively recover for several minutes after the block, and repeat the block three or four more times.

Tabata short intervals

Most people have been introduced to short intervals through a more intense version known as the Tabata Method. Popular in sports like speed skating to develop the so-called 'W' (formally called 'anaerobic work capacity'), Izumi Tabata published a study in 1996 using a typical short interval method used by athletes for decades. In his work, Tabata had speed skaters perform 4 minutes of 20-second all-out sprints on a stationary bike interspersed with 10 seconds of rest, performing 7-8 lots of 20-second intervals in total. This session was performed five days a week for six weeks. At the end of the study, the speed skaters increased their VO2max (maximal oxygen uptake) by 15% and their anaerobic work capacity by 28%. It did not take long before this method became popular in the fitness industry.

The Tabata session should take approximately 20 minutes. The first ten minutes are spent warming up (see section on page 43 on structuring an ideal warm up). The next 4 minutes are spent performing the Tabata Interval: 8 bouts of 20-seconds work interspersed with 10 seconds of rest. The pace at which the 20

Short Interval work-to-rest durations

Interval Length	One-to-One (equal work-to-rest)	Two-to-One (double work-to-rest)	One-to-Two (half work-to-rest)
15-seconds	15s/15s	15s/5s (for ease)	15s/30s
20-seconds	20s/20s	20s/10s	20s/40s
30-seconds	30s/30s	30s/15s	30s/60s
40-seconds	40s/40s	40s/20s	40s/80s



seconds should be performed corresponds to your best 50-second interval pace, which can, in theory, be tested in the warm-up for each session. The final six minutes would be spent cooling down from the 4-minute bout. As this is a single 4-minute block, Tabata Intervals are performed much more intensely than traditional short intervals: Tabata uses 170% of vVO_{2max} (the minimum velocity at which VO_{2max} occurs), whereas most short interval sessions are performed around 95-120% vVO_{2max} , due to the longer duration of the blocks and sessions.

Long Intervals

Long Interval protocols are the bread and butter quality sessions of the endurance world. They involve work duration bouts of 3-8 minutes at intensities just under one's best aerobic maximum (p/vVO_{2max}), corresponding to an intensity of between 90-95% of HR_{max} , with short recovery periods of 1-2 minutes. This type of training allows one to accumulate an impressive amount of time at, or close to, VO_{2max} in the session. For this reason, Long Intervals are the primary interval of choice for endurance athletes.

Four commonly performed long interval sessions are:

- 6 x 3 minutes with 2 minutes recovery
- 5 x 4 minutes with 60 seconds recovery
- 4 x 6 minutes with 2-minutes recovery
- 10 x 1 minute with 60 seconds recovery.

Although this session has an interval work bout of less than the defined duration for long intervals, the accumulated session load is similar, so most people categorise this session type as a long interval workout.

Targets of interval training

Paul Laursen and Martin Bucheit, in their marvellous and definitive textbook on interval training, *Science and Application of High-Intensity Interval Training*, recommend that interval training should be categorised into the three primary physiological targets

of each session, namely, the anaerobic, aerobic or neuromuscular systems. Based on this, Laursen and Bucheit further break these down into six subtypes of interval training:

- Type 1 targets the aerobic system only
- Type 2 elicits both an aerobic response and demands an input from the neuromuscular system
- Type 3 challenges the aerobic and anaerobic system
- Type 4 hits all three physiological targets (aerobic, anaerobic and neuromuscular)
- Type 5 turns off the oxidative system and exclusively targets the anaerobic and neuromuscular systems
- Type 6 is a neuromuscular only type of training response.

Knowing the types of each interval method allows the trainer or coach to design more specific training programs for their athletes to improve performance in a specific situation. For example, training for a marathon or Ironman triathlon would see intervals largely targeting a Type 1 response, whereas a 6-minute Strava KOM (cycle challenge) would be best trained using intervals targeting a Type 3 or 4 response.

The health benefits of HIIT

Several decades of research has shown that interval training is at least equivalent to, and in some instances more effective than, moderate intensity continuous aerobic exercise at improving markers of cardiometabolic health. HIIT has been shown to improve mitochondrial function, insulin sensitivity, glucose control, lipid metabolism and blood pressure.

Leading researcher in this field, Martin Gibala, has recently stated that there is now a considerable body of evidence suggesting that high-intensity interval training can elicit cardiometabolic health benefits comparable or superior to traditional endurance training, despite reduced time commitment. This is evidenced by a recent systematic review and meta-analyses based on 65 intervention studies that concluded, 'HIIT may serve as a time-efficient substitute or as a compliment to commonly recommended moderate intensity continuous exercise in improving cardiometabolic health'.

Gibala's team found that a single session of interval training involving 10 x 1-minute cycling bouts at 90% maximal heart rate elicited larger and longer-lasting reductions in 24-hour postprandial glycemia in obese adults, than a 30-minute bout of moderate exercise at 65% HR_{max} that was matched for total external work. Other studies have



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shown that six weeks of Wingate-based SIT induced greater reductions in whole-body fat mass and superior improvements in cardiorespiratory fitness as compared with energy-matched moderate-intensity exercise in overweight and obese women.

More recently, Gibala's team compared moderate-intensity continuous exercise with a short, time-saving interval workout. The study showed that 12 weeks of sprint interval training improved indices of cardiometabolic health similar to traditional endurance training despite a five-fold lower exercise volume and time commitment. The sprint protocol involved a total of 1 minute of 'all out' intermittent exercise set within a 10-minute time commitment (3 x 20-seconds with ~2.5 minutes rest), whereas moderate training consisted of 50 minutes of continuous exercise, and both groups trained three times per week. VO₂max increased similarly by 19% in both groups, and there were comparable improvements in insulin sensitivity as determined by intravenous glucose tolerance tests.

Modes of exercise

One of the most important considerations for HIIT is the mode of exercise being performed during the session. Given that work output is so high during the interval, a mentally challenging or technically demanding exercise mode is not recommended. Outside of specificity for sports, coaches typically recommend the use of stationary cycling, rowing, running or one of the cross-country skiing machine variations. These machines allow for true session maximal efforts with a lessened chance of sustaining an injury due to poor mechanics or technique.

Measuring the work output and training zones

There are two primary ways in which you can measure your work output for each interval session: internal or external monitoring. Internal monitoring could use a heart rate monitor or rate of perceived exertion, and external monitoring could use speed or power.

If gauging heart rate, you need to know what your maximal heart rate is and for long or short intervals you would aim to conduct the bulk of the work bouts between 90-95% of maximal heart rate. The goal of these sessions is to accumulate 10 or more minutes above 90% of HR_{max}. The heart rate monitor is less useful for sprint interval training, as these are conducted at best all-out pace, for which a heart rate response is not particularly accurate. Perceived exertion



would be a far better tool for this session type, as each bout should feel as hard as possible.

An external monitoring approach to interval training would be a percentage of peak aerobic speed, velocity or power. An easy field test for this would be measuring your best speed, velocity or power over 4 minutes. This corresponds quite nicely to one's aerobic maximum, when measured with an incremental test to exhaustion. From here, one can set an appropriate speed, velocity or power based on a percentage below, on or above VO₂max. For example, as an avid cyclist, my power over 4 minutes is ~500W. If performing long intervals, I would aim to conduct my 6 x 3-minute intervals at ~88% of 500W (440W). For short intervals, I would go above this by around ~20%, and a session of 6 x 20-seconds with 40 seconds rest would be held at ~600W. For sprint interval training I would aim to hit in excess of 800W (~170%).

Interval training for sporting performance vs. health

Research has shown that the time commitment for improving cardiometabolic health using interval training is relatively small, ranging from 10-30 minutes per workout. However, in well-trained individuals, as one might expect, the volume/duration of interval sessions appear to be greater. The majority of studies show that for short or long interval sessions, the greatest improvements in VO₂max are seen with the sessions that accumulate more than 10 minutes of work above 90% HR_{max}. This normally equates to interval session duration of 40-60 minutes, including the warm ups and cool downs.

Warm ups for intervals

Warming up for an interval workout is a special art. You have to consider taking yourself from a state of rest, up to the power, speed or heart rate demands that the first interval will impose on you. If you fail to do this, the consequences for the session will be severe! Therefore 5-10 minutes is required to warm up the aerobic, anaerobic and neuromuscular systems. As a general rule, spend the first 5 minutes incrementally increasing the heart rate until you spend a minute, at minute six of the warm up, at around 90% of maximum. Over the next few minutes, perform several sprints between 6-10 seconds to recruit the anaerobic and neuromuscular pathways. Recover for a minute, and then perform your first interval.



How many interval workouts per week and per program?

For the goals of health and body composition, HIIT sessions are recommended to be performed twice per week. For performance, a twice-a-week approach might be used initially, however, recent data suggest that a block periodised organisation of training might be more beneficial. Here, interval sessions would be performed each day of the week to overload the fitness capacity of the individual. This 'hell week' would then be followed by three lighter weeks, where one HIIT session would be performed each week. Due to the intensive nature of this 4-week block method, it is only recommended for serious endurance athletes.

Training-nutrition interaction and the train low philosophy

Since the recent advent of techniques able to measure the molecular response to exercise, scientists have discovered that performing HIIT with differing amounts of carbohydrate stored in the muscle can alter the physiological response to the session.

These discoveries have led to a paradigm of training and nutrition called Train Low in which sessions are either deliberately conducted with low carbohydrate stores in the muscle; with normal carbohydrate levels but with carbohydrate-deficient meals consumed afterwards; or in the afternoon followed by a low carbohydrate dinner and going to bed with low muscle glycogen (recover low and sleep low respectively).

This change in thinking around fuelling for training is based on numerous studies showing greater muscle adaptation to sessions performed when the working muscles are deprived of carbohydrate during or after training. This makes sense, as training is stress and training without a major muscle fuel is even greater stress. Of course, these recommendations are for training blocks and not for performance, as it is beyond dispute that performance is enhanced with adequate glycogen stores.

Wrapping up HIIT

HIIT can improve your health, body composition and performance. In some instances, it is more time effective than traditional endurance exercise, while still imparting the benefits of longer duration, higher volume sessions. HIIT can be broadly categorised into three subtypes:

sprint intervals, in which the sprints are performed at your best 'all-out' pace with almost full recovery; short intervals; and long intervals, both of which are performed around your best sustained aerobic pace or power. Workouts are typically performed twice a week using a mode of exercise that can handle high work outputs without fear of technical failure.

With the majority of the population having enormous demands on their time, finding the opportunity to exercise can be difficult. For those that can manage the intense nature of the bouts, HIIT has become an extremely attractive option, as the time commitment is low and the benefits are huge. **N**

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