ATLAS BIOFITNESS

TRAINING•NUTRITION•LONGEVITY

Metabolic Health, Exercise Physiology & VO_2 Max Testing

A PATIENT GUIDE

Metabolic syndrome • Body composition (DEXA) • GLP-1 medications

Energy systems • Cardiopulmonary exercise testing • Training zones and methods

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About this guide

This guide explains the health conditions, measurements, and exercise science behind your testing and training at Atlas BioFitness. Use it alongside your own test results. Abbreviations are spelled out the first time they appear and are collected in the glossary at the end.

It is for education only and does not replace individual advice from your physician.

PART 1 · METABOLIC HEALTH

1. Metabolic Syndrome

What is metabolic syndrome?

Metabolic syndrome is a group of health findings that together put you at higher risk for heart disease, type 2 diabetes, sleep apnea, stroke, and fatty liver. No single test diagnoses it. Instead, you have metabolic syndrome if you have **three or more** of these five conditions:

Condition	You meet this criterion if…
Large waist (central or abdominal obesity)	Men: waist over 40 inches Women: waist over 35 inches
High blood pressure (hypertension)	Top (systolic) number is 130 or higher, **or** bottom (diastolic) number is 85 or higher, or you take blood pressure medication
High blood sugar (glucose)	Fasting blood glucose is 100 milligrams per deciliter (mg/dL) or higher after nothing to eat or drink (other than water) for 8 hours, usually measured in the morning
High triglycerides	Your triglyceride level on a lipid panel is high
Low HDL ("good") cholesterol	Men: below 40 mg/dL Women: below 50 mg/dL

Triglycerides are a type of fat that circulates in your blood. They are measured on a lipid panel, a routine blood test you likely have at your annual checkup, which also measures several forms of cholesterol. HDL (high-density lipoprotein) is a "good" cholesterol. When it is low, you have a higher risk of atherosclerosis (narrowing of the arteries in your heart) and of future heart attacks.

Weight, BMI, and waist size

Body mass index (BMI), calculated from your height and weight, is the most commonly used weight measure. However, BMI is **not** part of the metabolic syndrome definition; **waist size** is. You are considered obese if your BMI is 30 or higher:

BMI	Category
30–34.9	Class I (mild) obesity
35–39.9	Class II (moderate) obesity
40 or higher	Class III (severe) obesity

BMI is less useful for children, older adults, and athletes who are heavy because they carry more muscle. Better measures include body fat percentage, or an index based on lean mass and height (lean mass ÷ height^2). See Section 2, Body Composition Analysis.

Can I have metabolic syndrome if I'm not overweight?

Yes, but it is uncommon. This is called "normal-weight metabolically obese," and it can occur in people with certain genes.

Who is more likely to have metabolic syndrome?

Metabolic syndrome is more common in people who:

- Belong to certain racial or ethnic groups
- Smoke
- Are postmenopausal
- Have low incomes
- Are physically inactive
- Eat high-carbohydrate diets

How does metabolic syndrome cause these health problems?

The current theory is **insulin resistance**: people with metabolic syndrome do not respond well to their own insulin. Insulin normally helps your tissues take up glucose (sugar) from your bloodstream. When your tissues do not respond normally, your blood glucose rises. This is why people with metabolic syndrome have higher blood glucose levels and a several-fold higher chance of developing type 2 diabetes.

What can I do to treat metabolic syndrome?

1. Lose weight.
2. Eat better, including limiting salt and drinking less alcohol.
3. Become more active with regular exercise.
4. Have your health care provider treat your high blood pressure and abnormal triglycerides or cholesterol.

What can my health care providers do?

1. Help you lose weight with a different diet, usually by having you meet with a nutritionist or dietitian.
2. Help you exercise. This almost always works best with a professional trainer experienced in helping people get fitter safely. You are also much more likely to keep exercising if you commit to working directly with a trainer for at least 2 months. There is some expense,



but it is one of the best investments you can make. A trainer will teach you both aerobic (cardio) exercise and **resistance training** (exercise machines, dumbbells, kettlebells, etc.). Several studies have shown that resistance training leads to greater improvement in the components of metabolic syndrome: waist size, weight, blood glucose, cholesterol, and triglycerides.

3. Consider glucagon-like peptide-1 (GLP-1) medications such as Wegovy, Mounjaro, and Zepbound (see Section 3).
4. Consider weight-loss surgery.
5. Treat diabetes, high blood pressure, and high cholesterol.

PART 1 · METABOLIC HEALTH

2. Body Composition Analysis

What is body composition analysis?

Your body is made up of three main types of tissue: **muscle** (lean tissue), **fat** (both overall fat and visceral fat), and **bone**. Body composition analysis measures how much of each you have.

What is fat-free mass?

Fat-free mass is everything in your body that is not fat: skin, organs, blood, muscles, bones, ligaments and tendons, and water.

What is visceral fat?

Visceral fat is fat stored around the organs in your abdomen, with some around your heart. It is different from subcutaneous fat, the fat under your skin. If you have a lot of visceral fat, you have "abdominal obesity."

Visceral fat cells are very active and release chemical messengers, including:

- **Pro-inflammatory cytokines:** tumor necrosis factor (TNF), interleukin-6 (IL-6), interleukin-1 (IL-1), and C-reactive protein (CRP)
- **Peptides (adipokines):** adiponectin, angiotensin, and resistin

Visceral fat is associated with type 2 diabetes and heart disease, including heart attacks. Normally, about 10% of your body fat is visceral fat. Because most visceral fat is in the abdomen, your waist size can predict it, which is why waist size is used to screen for metabolic syndrome.

Visceral fat on your DEXA report

A dual-energy X-ray absorptiometry (DEXA) scan measures visceral fat in the area between your lower rib cage and your pelvic bones. On the report it is called **VAT** (visceral adipose tissue). Your VAT area indicates your relative risk for heart disease and diabetes:

VAT area (cm^2)	Relative risk
10–100	Normal
100–160	Increased risk
160–300	High risk

What is the fat mass index (FMI)?

FMI is your fat mass divided by your height squared (fat mass ÷ height^2, in kg/m^2). It is better than BMI because it does not depend on your lean mass. For example, two people with identical height and weight have the same BMI. But if one is very muscular and the other is not, their FMI values will be very different: one normal, the other not. BMI also uses the same normal values for men and women, while FMI has separate normal ranges: **women 5–9 kg/m²** and **men 3–6 kg/m²**. FMI is one of the key advantages of DEXA over other methods such as bioimpedance scales.

What do "android" and "gynoid" mean?

Android refers to the waist, and **gynoid** refers to the hips. These are sometimes called the "apple" (android) and "pear" (gynoid) body shapes. People with an apple shape are more likely to have high blood pressure, heart disease, and metabolic syndrome, because this body type tends to carry more visceral fat.

The **android/gynoid (A/G) ratio** is android fat divided by gynoid fat. A ratio below 1, meaning more fat at the hips than at the waist, is better, and the lower the ratio, the better. This value is available only from a DEXA scan.

What do the percentile values mean?

Percentiles compare your values with people of the same age and sex. For example, if your total body fat percentage is at the 10th percentile, 90% of similar people have more fat than you. For fat, a lower percentile is better. For lean mass, a higher percentile is better.

Resting metabolic rate (RMR) on your DEXA report

Your RMR is how many calories your body uses while resting and very still. The RMR on a DEXA report is an **estimate**. It is not as accurate as measuring your RMR directly with an instrument that measures how much oxygen you use at rest.

What body composition tests are available?

Test	How it works and what to know
Skinfold thickness	Skinfold thickness is measured at several sites. This method was more common in the past and can be fairly accurate when performed by trained staff.
Bioelectrical impedance	Electrodes are placed on an arm and a leg, or you stand on a special scale. How easily small electrical currents pass through your body gives an estimate of body fat. Results vary with how much water you have had recently and from day to day.
CT scan or MRI	Computed tomography (CT) and magnetic resonance imaging (MRI) are rarely used because of cost.
Underwater weighing	Used before DEXA and bioimpedance were available; generally no longer offered.
DEXA scan	Originally developed to measure bone density and screen for osteoporosis (weakened bones). It is the most accurate and reproducible technique, and it measures visceral fat as well as overall body fat. It uses very low doses of X-rays, so it can be repeated periodically to track changes as you lose weight.

A DEXA scan provides information the other methods listed here do not:

- Android/gynoid fat ratio
- Trunk/limb fat ratio
- Whole-body bone density
- Visceral fat

How much radiation does a DEXA scan involve?

Very little: about **0.001 millisievert (mSv)**, roughly the same as 3 hours of natural background radiation. For comparison:

Exam	Radiation dose
DEXA body composition scan	0.001 mSv (about 3 hours of natural background)
Chest X-ray	0.1 mSv (about 10 days of natural background)
Mammogram	0.28 mSv
CT scan of abdomen and pelvis	7.7 mSv

PART 1 · METABOLIC HEALTH

3. GLP-1 Medications

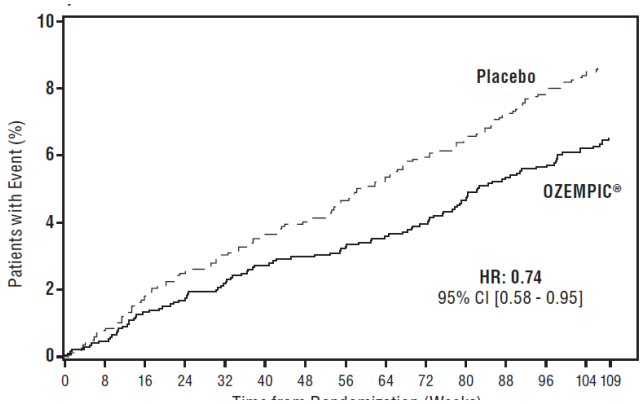
What are GLP-1 agents?

GLP-1 agents are **peptides**, short chains of amino acids. Your body uses peptides for many functions, including regulating hormones, stimulating muscle growth, and running many parts of your metabolism. GLP-1 receptors are found in many tissues, including the pancreas, stomach lining (gastric mucosa), kidney, lung, heart, skin, immune cells, and brain.

What do GLP-1 agents do?

Depending on the agent, GLP-1 medications can:

- Slow stomach emptying
- Make you feel full
- Cause your pancreas to release insulin and reduce the release of glucagon
- Slow down intestinal activity
- Lower the likelihood of a major adverse cardiac event (MACE)



Percentage of patients with a major adverse cardiac event over about two years, Ozempic (semaglutide) vs. placebo. Hazard ratio (HR) 0.74; 95% confidence interval (CI) 0.58–0.95. Figure by Marshall E. McCabe, Atlas BioFitness.

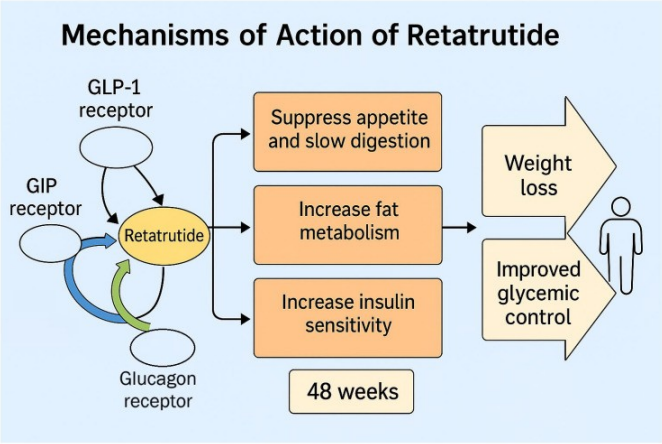
Other hormone targets: GIP and glucagon

Some newer medications act on additional receptors:

- **GIP receptor activation:** glucose-dependent insulinotropic polypeptide (GIP) increases insulin release in a glucose-dependent way.
- **Glucagon receptor activation** (retatrutide): promotes the breakdown of stored fat (lipolysis) and increases overall energy expenditure, boosting the body's calorie burning.

The main GLP-1 agents

Medication	Brand names and approved uses	Average weight loss in key trials
Semaglutide (GLP-1)	**Wegovy:** chronic weight management in obesity; MASH (metabolic dysfunction-associated steatohepatitis) with moderate-to-advanced liver fibrosis, without cirrhosis; and reducing the risk of cardiovascular death, heart attack, and stroke in adults with overweight or obesity and known cardiovascular disease **Ozempic:** type 2 diabetes **Rybelsus:** type 2 diabetes	About 15% at 68 weeks (STEP-1 trial, Wegovy 2.4 mg)
Liraglutide (GLP-1)	**Saxenda:** weight loss **Victoza:** diabetes Limited use because it lasts only a short time in the body	5–7% after about a year
Tirzepatide (GLP-1 + GIP)	**Mounjaro:** type 2 diabetes **Zepbound:** chronic weight management in adults with obesity (BMI 30 or higher) or overweight (BMI 27 or higher) with at least one weight-related condition such as high blood pressure, type 2 diabetes, or high cholesterol; also obstructive sleep apnea	About 15–21% at 72 weeks, depending on dose; about 21% at the top 15 mg dose (SURMOUNT-1 trial)
Retatrutide (GLP-1 + GIP + glucagon, "triple G")	**Not yet approved** (investigational). Expected to suppress appetite, enhance lipolysis, and increase insulin sensitivity, and it may improve muscle quality	n/a



Mechanisms of action of retatrutide: activation of GLP-1, GIP, and glucagon receptors. Figure by Marshall E. McCabe, Atlas BioFitness.

What are the side effects and safety warnings?

Most side effects are mild and digestive, but these medications also carry important warnings on their FDA labels. The table below is a summary; it is not a complete list. Review the medication guide for your specific drug with your prescriber.

Issue	What to know
Digestive (GI) effects: the most common	Nausea, vomiting, diarrhea, constipation, abdominal pain, and feeling full. These are most common when you start or increase the dose and often ease over time. Severe vomiting or diarrhea can cause dehydration, which can harm the kidneys.
Muscle loss	This is a consequence of eating less and losing weight. You will lose muscle as well as fat unless you (a) eat a high-protein diet and (b) exercise: not just aerobic exercise, but resistance training with weights or cables.
Pancreatitis	Inflammation of the pancreas has been reported. Stop the medication and seek care right away for severe, persistent abdominal pain, which may spread to the back, with or without vomiting.
Gallbladder disease	Gallstones and gallbladder inflammation are more common, especially with rapid weight loss. Warning signs: pain in the upper right abdomen, fever, yellowing of the skin or eyes, or clay-colored stools.
Thyroid C-cell tumors (boxed warning)	These drugs caused thyroid C-cell tumors in rodents; whether they do in humans is unknown. Do not use them if you or a family member has had medullary thyroid carcinoma (MTC), or if you have multiple endocrine neoplasia syndrome type 2 (MEN 2). Report a neck lump or swelling, trouble swallowing, hoarseness, or shortness of breath.
Low blood sugar (hypoglycemia)	Uncommon on its own, but the risk rises when combined with insulin or a sulfonylurea (such as glipizide, glyburide, or glimepiride). The dose of those medications may need to be lowered.
Pregnancy	Not for use during pregnancy, because weight loss offers no benefit and may harm the baby. The Wegovy label advises stopping at least 2 months before a planned pregnancy. Tirzepatide can make birth-control pills less effective: use a non-oral method, or add a barrier method for 4 weeks after starting and after each dose increase.
Other label warnings	Kidney injury from dehydration, serious allergic reactions, worsening diabetic eye disease (retinopathy) in people with diabetes, a faster heart rate, and a risk of inhaling stomach contents during anesthesia or sedation (tell your care team before any procedure).

PART 2 · HOW YOUR BODY MAKES ENERGY

4. Energy Stores and Energy Systems

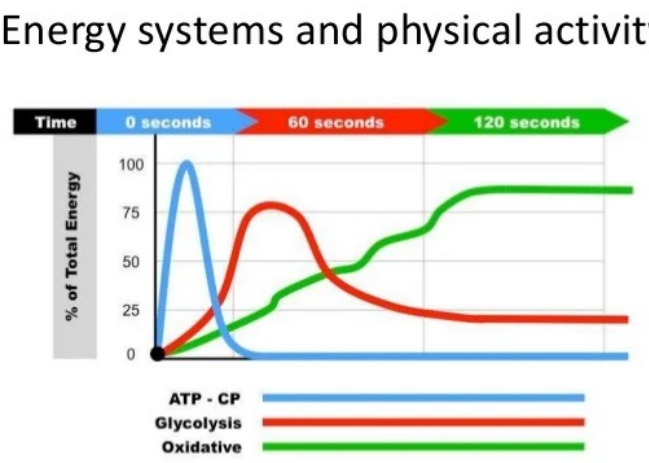
Your body makes energy for exercise in different ways depending on how strenuous the exercise is, how fit you are, and what type of stored energy is available. Your three energy systems always work together; what changes with intensity and duration is how much each one contributes. Understanding these systems matters whether you are trying to lose weight or you are an athlete trying to improve performance.

Your three energy stores

1. **Carbohydrate** (glucose and glycogen): the easiest for your muscles to use and the most readily available. But we do not store much of it.
2. **Fat:** harder to use. It can take your body 20 minutes or so to mobilize fat for energy.
3. **Protein:** we do not want to use this, because we want to keep our muscles.

Your three energy systems

System	Fuel and oxygen	How long it lasts
Phosphagen system (ATP-PC system)	Uses adenosine triphosphate (ATP) already stored in your muscles. Once that ATP is used, phosphocreatine (PC, creatine phosphate) is used to make more. Does not require oxygen.	Rapid energy, but only for about 10 seconds of all-out effort (10–15 seconds)
Glycolytic system (fast glycolysis)	Breaks down carbohydrate (glucose, and glycogen, the storage form of glucose) quickly, without needing oxygen, producing lactate. It runs alongside the other systems and takes the lead in hard efforts lasting from seconds to a couple of minutes.	15 seconds to 2 minutes
Oxidative system (aerobic system)	Uses oxygen along with fat, carbohydrate, or muscle protein to generate energy.	Takes 3–5 minutes to ramp up, then lasts a long time, which is why it is best to warm up before exercising



How each energy system (ATP-PC, glycolytic, and oxidative) contributes to total energy over the first 2 minutes of activity. Figure by Marshall E. McCabe, Atlas BioFitness.

Aerobic and anaerobic metabolism

Aerobic metabolism requires oxygen; **anaerobic** metabolism does not directly require oxygen. Most of the time, you combine oxygen (O_2) with stored energy and produce carbon dioxide (CO_2). You breathe in air that is 21% oxygen and 0% CO_2, and you breathe out air with less oxygen (you cannot remove all of it) plus CO_2.

- **Aerobic:** uses fat or carbohydrate. Burning fat produces about 7 molecules of CO_2 for every 10 molecules of O_2; burning carbohydrate produces 1 molecule of CO_2 for every molecule of O_2.
- **Anaerobic:** uses carbohydrate; no oxygen is immediately required.

Carbohydrate and fat are burned through different chemical reactions. Which one you use depends on several factors, including exercise intensity and how much oxygen your lungs and heart can deliver to your muscles. As exercise gets harder, you use more carbohydrate and produce lactate faster. When lactate builds up, your body buffers the accompanying acid with bicarbonate, which releases extra CO_2 that you breathe out. You are always producing CO_2, but anaerobic metabolism does not require O_2.

The respiratory exchange ratio: reading your fuel mix

The ratio of CO_2 produced to O_2 used tells us which fuel you are burning. Inside the cells it is called the **respiratory quotient (RQ)**. Measured from your breath during a CPET, it is called the **respiratory exchange ratio (RER)**. Pure fat burning gives 0.7 (7/10), and pure carbohydrate burning gives 1.0 (10/10).

During exercise you are almost always burning a mix of both, so a value of exactly 0.7 is not a typical training-zone value. Your RER is about 0.80 or below in Zone 1. It rises steadily through Zones 2, 3, and 4 as you burn more carbohydrate, and it rises above 1.0 in Zone 5 (above VT2). Above 1.0, you are breathing out extra CO_2 released as your body buffers acid. See the zone tables in Section 7.

How does my body use fat?

Fat tissue is made of cells that contain fat droplets. The fat in these droplets is stored as **triglycerides**, three fatty acids joined to a glycerol molecule. This is the same substance measured in your blood on a lipid panel.

When your body needs energy from fat, epinephrine (adrenaline) circulates and signals your fat cells to increase a messenger called cyclic adenosine monophosphate (cyclic AMP). Cyclic AMP activates enzymes, adipose triglyceride lipase (ATGL) and hormone-sensitive lipase (HSL), that break each triglyceride into three free fatty acids and glycerol. The glycerol travels to the liver and is turned into glucose. The free fatty acids are carried in the bloodstream by a protein called albumin to tissues such as muscle. Inside muscle cells, they are converted into acetyl coenzyme A (acetyl-CoA), which enters the **Krebs cycle** to make ATP, the energy currency of the cell. This whole process is the main source of energy during fasting or prolonged exercise.

How does my body use glucose?

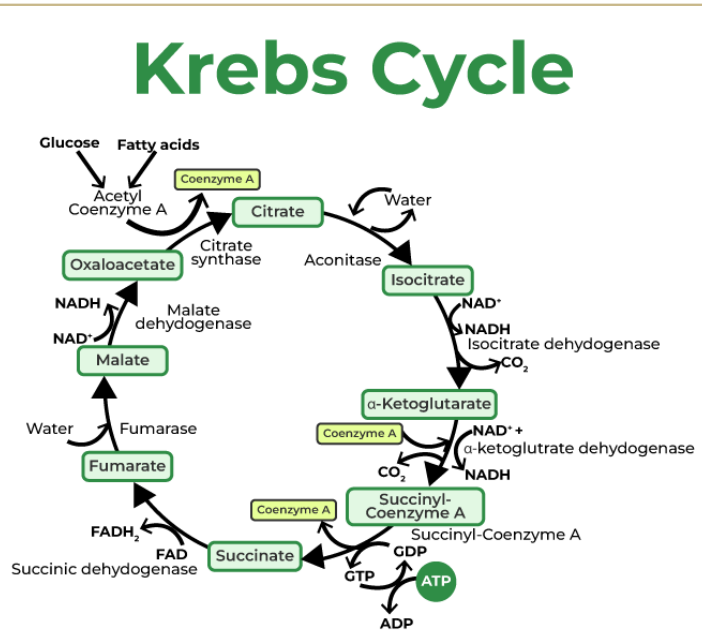
Glucose is stored in the liver and muscles as **glycogen**. Each glycogen molecule contains between 2,000 and 60,000 glucose molecules. Glycogen breakdown is triggered by adrenaline and by glucagon, a hormone from the pancreas. Inside muscle cells and other organs, glucose is broken down and enters the Krebs cycle to produce ATP, just like fatty acids.

How does protein provide energy?

Protein is broken down into its building blocks, amino acids. These are converted into pyruvate or acetyl-CoA and enter the Krebs cycle, just like glucose and fatty acids.

The Krebs cycle and the role of oxygen

As the diagram shows, the Krebs cycle produces CO_2 and water. Notice that oxygen does not appear in the Krebs cycle itself. However, the Krebs cycle depends on the **electron transport chain** running in the background to keep it going, and the electron transport chain requires oxygen.



The Krebs cycle. Figure by Marshall E. McCabe, Atlas BioFitness.

What happens at very high intensity?

When you exercise very hard, your muscles need energy faster than the aerobic system alone can supply. Fast glycolysis takes on a bigger share, turning glucose into pyruvate and then lactate more quickly than the lactate can be used. Lactate then starts to build up in your blood. This does not mean your muscles are "out of oxygen"; it means production is outpacing clearance.

> **Myth-buster: lactate is a fuel, not a waste product**
>
> Lactate is produced all the time, even at rest. It is not a waste product: your heart, slow-twitch muscle fibers, and brain burn it as fuel, and your liver turns it back into glucose. It builds up in the blood only when you produce it faster than you can clear it.
>
> The "burn" of hard exercise comes mainly from acid (hydrogen ions) produced when energy is used very quickly. Lactate is a marker of that strain, not its cause. Training increases your ability to clear and use lactate.[13]

What happens to lactate?

The detailed answer:

Where	What happens
Muscles and heart	Lactate + NAD^+ ⇌ pyruvate + NADH + H^+ Pyruvate → Krebs cycle → ATP (energy), CO_2, and water
Liver and kidneys	Lactate → Cori cycle → glucose
Kidneys	Some is excreted in the urine

Oxygen is not directly required. However, the electron transport chain is needed to regenerate NAD^+ (nicotinamide adenine dinucleotide). Without NAD^+, the Krebs cycle comes to a halt and lactate cannot be processed. This does not have to happen right away while you are exercising.

PART 3 · TESTING YOUR FITNESS

5. Cardiopulmonary Exercise Testing (CPET)

At Atlas BioFitness: a fitness assessment, not a diagnostic test

At Atlas BioFitness we use a Korr CardioCoach metabolic test, a fitness assessment that measures the gases you breathe. It is not a diagnostic heart test (there is no electrocardiogram, ECG). Full clinical CPET with an ECG, done in a hospital or cardiology lab, is used to evaluate heart and lung disease. If you have symptoms, we will refer you for medical evaluation.

This section explains the science behind both. Section 6 explains your Atlas test and report.

What is CPET?

Cardiopulmonary exercise testing (CPET) looks at how your body responds to exercise. That response involves your lungs, heart and blood vessels, blood, nervous system (neuropsychological response), and skeletal muscles. CPET evaluates the response at both submaximal and peak exercise. It is used to assess exercise performance, functional capacity, and impairment, and to investigate unexplained exercise intolerance and exercise-related symptoms.

You exercise on a bicycle or treadmill while the resistance to pedaling, or the steepness of the treadmill, gradually increases. When the pedaling resistance and speed are known, we can calculate how much work you are doing at every level. As your training progresses, repeat tests show whether you are becoming more efficient. CPET is a training tool for athletes, and it is also used to assess people with known heart and lung conditions, such as chronic obstructive pulmonary disease (COPD) or emphysema, and people with shortness of breath.

How does CPET work?

Once you have been exercising for more than a few minutes, you rely on the oxidative (aerobic) system, using oxygen to burn fat, carbohydrate, or muscle for energy (see Section 4). This depends on three systems:

- **Lungs**, to absorb oxygen and exhale CO_2
- **Heart and arteries**, to transport oxygen and CO_2
- **Muscles**, to use the oxygen

Any one of these three systems can limit your maximum ability. Most often the heart is the limiting factor unless you have serious lung disease such as COPD, because we are born with more spare capacity in our lungs than in our heart.

During the test, you wear a mask that continuously measures how much air you breathe and how much oxygen and CO_2 are in the air you breathe out. Room air is 21% oxygen and 0% CO_2. If your exhaled air is 18% oxygen, you have used 3%. From this we calculate how much oxygen you use over time, most commonly in milliliters (mL) of O_2 or CO_2 per minute. Your heart rate is also monitored, and you will be asked how you are feeling.

Key terms on your CPET report

Term	Meaning
VO_2	Oxygen uptake, in liters per minute
VCO_2	Carbon dioxide production, in liters per minute
VO_2max	The highest rate at which your body can take in and use oxygen during whole-body exercise, confirmed by signs that you reached your ceiling. It depends on how much blood your heart pumps (delivery) and how much oxygen your muscles extract (use). An indicator of aerobic fitness.
VO_2max index	VO_2max adjusted for your body weight (mL/kg/min), or expressed in metabolic equivalents (METs). One MET is 3.5 mL/kg/min.
VO_2peak	The highest VO_2 you reached on the day (best averaged value, e.g., over 30 seconds), whether or not it was a true maximum
Extrapolated VO_2 Max (Korr)	A prediction made by extending your heart rate–VO_2 line up to an age-formula maximum heart rate. It is an estimate, not a measurement; we use your measured value.
LT1 and LT2 (lactate thresholds)	LT1: the level of oxygen uptake at which your blood lactate first rises above its resting level (it corresponds to VT1). LT2: the point at which lactate starts to build up rapidly (it corresponds to VT2).
VT1 (first ventilatory threshold)	The intensity at which your body begins to use carbohydrate as a significant fuel and lactate first rises. Breathing and CO_2 output start to rise faster than oxygen uptake. It is similar to moving from Zone 2 to Zone 3. You can still talk and exercise for a long time. In healthy people, VT1 occurs at or above about 40% of predicted VO_2max. It occurs earlier (at a lower VO_2) in people with heart disease and later in endurance-trained athletes.
VT2 (second ventilatory threshold; respiratory compensation point, RCP)	The point at which lactate and acid build up faster than your body can clear it. Your breathing then rises faster than your CO_2 output as you "blow off" the extra acid. Breathing becomes hard and exercise soon becomes unsustainable. It corresponds roughly to LT2 and marks the top of Zone 4.
Aerobic efficiency	VO_2 per unit of work: the amount of oxygen you use for a given amount of work

Term	Meaning
Watts (W)	A measure of power (work rate), determined by how fast and how hard you pedal
VE (minute ventilation)	The volume of air you breathe out per minute
Cardiac output	How much blood your heart pumps per minute: the amount pumped with each beat times the number of beats per minute
Fick principle	A calculation of cardiac output from the oxygen content of your arterial and venous blood
Maximum heart rate (MHR)	The fastest your heart can beat. It is often estimated as 220 minus your age (or 208 - 0.7 × age[12]), but these are only estimates: individuals often differ by 10 or more beats per minute. Your measured peak heart rate is better.
Maximum cardiac output	The most blood your heart can pump. It can increase with training, up to 4–5 times your resting cardiac output.

What are ventilatory thresholds?

Ventilatory thresholds are transition points in your metabolism as exercise intensity increases. This guide uses only two terms: **VT1**, the first threshold, and **VT2**, the second threshold (also called the respiratory compensation point, RCP).

Your Korr report uses different names for these two points; see the box "Reading the labels on your Korr report" in Section 6.

- **At VT1** you shift from using mainly fat to using more and more carbohydrate, and blood lactate first rises above resting levels. It is the top of easy, conversational exercise. Remember, we have limited carbohydrate stored, so we cannot sustain this for a long time. On your CPET graph, breathing and CO_2 output start to rise faster than oxygen uptake.
- **At VT2** lactate builds up faster than your body can clear it. To buffer the acid, you breathe out extra CO_2, and your breathing rises even faster than your CO_2 output. Oxygen uptake keeps rising toward your VO_2max, but the effort soon becomes unsustainable.

Some key facts about VT1:

- VT1 is a submaximal measure of aerobic capacity: the exercise level at which breathing (ventilation) begins to increase faster than oxygen uptake.
- In healthy untrained people, VT1 usually occurs at about 45–65% of measured peak VO_2. It can occur at a higher percentage in endurance-trained people.
- Exercise training increases the VO_2 at which VT1 occurs.

Can a VO_2 max test identify my lactate threshold?

Not directly, but it can estimate your **ventilatory threshold**, which is a related but distinct measure. A VO_2 max test measures maximal oxygen consumption during increasing exercise. The lactate threshold is the point at which lactate builds up in your blood faster than it can be cleared. Measuring lactate threshold accurately requires blood samples at several exercise intensities.[1]

Advanced VO_2 max testing can estimate the ventilatory threshold by finding breakpoints in breathing and CO_2 output in the gas-exchange data. This correlates reasonably well with lactate threshold, but it is not the same.[1] Ventilatory and lactate thresholds usually fall close together, but they are measured differently and are not identical: VT1 corresponds roughly to LT1, and VT2 to LT2.

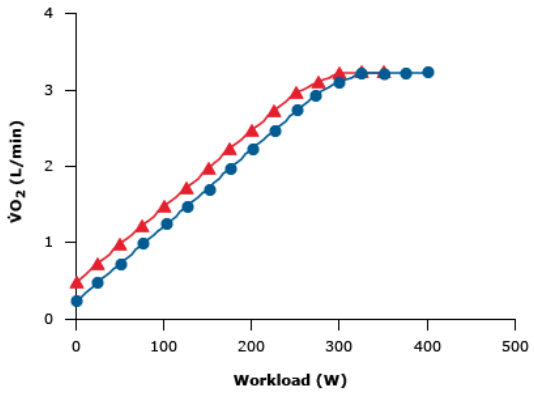
How are VO_2max and lactate threshold related?

Studies show that higher VO_2max values tend to go with higher lactate thresholds. However, the relationship is not always straightforward: training status and individual differences also play a role.

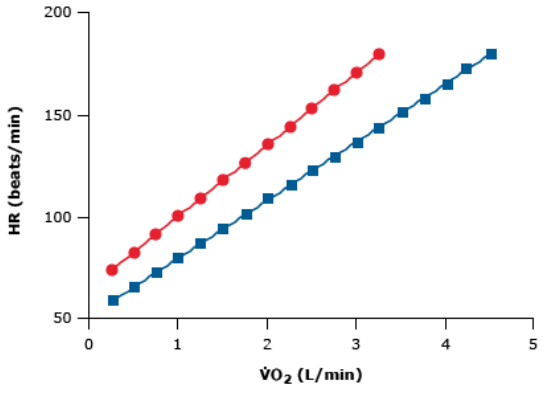
> **Key point**
>
> For precise lactate threshold values, a dedicated lactate threshold test with blood sampling remains the gold standard. Athletes and coaches who need exact numbers should request one rather than relying on a VO_2 max test alone.

Graphs from a typical CPET

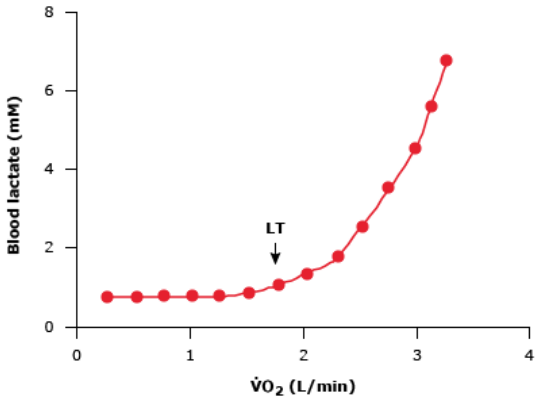
These graphs illustrate the principles above. Figures by Marshall E. McCabe, Atlas BioFitness.



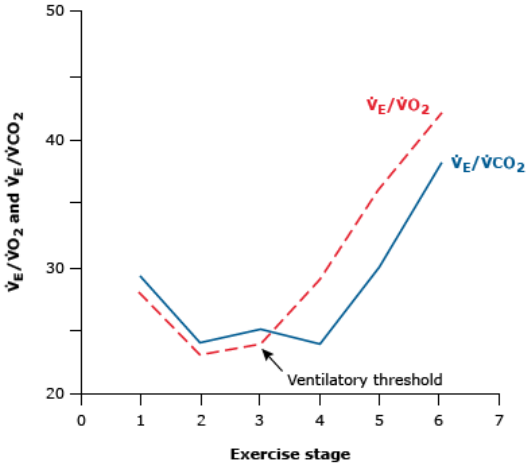
Oxygen consumption and workload during exercise



Heart rate and oxygen consumption during exercise



Lactate threshold during exercise



Ventilatory threshold

Is the test safe?

CPET is safe for most people, including many people with stable, well-managed heart or lung conditions. Our staff screen everyone before testing. Please tell us about any heart or lung condition, chest pain, recent illness, or medications, and we will make sure the test is right for you.

PART 3 · TESTING YOUR FITNESS

6. Your Test at Atlas BioFitness

Your Atlas BioFitness VO_2 max test uses a Korr CardioCoach system. You walk or run on a treadmill while the speed or incline gradually increases, wearing a mask that measures the oxygen you take in and the CO_2 you breathe out, and a chest heart-rate strap that records your pulse. It is a **fitness assessment**, not a diagnostic heart test.

Why test your VO_2 max?

Cardiorespiratory fitness is one of the strongest predictors of how long and how well you live. In a large study of adults who had treadmill tests, higher fitness was linked to lower risk of death, with no upper limit to the benefit. The American Heart Association recommends treating fitness as a "vital sign." The biggest gain in health comes from moving out of the lowest fitness group.[7,8]

Reason to test	What the test gives you
Starting point	An objective baseline for your fitness level, thresholds, and fuel use, so progress is measured rather than guessed
Personal training zones	Heart-rate (and speed or incline) zones set from your own VT1 and VT2, instead of age formulas
Stuck or plateaued	Shows whether your aerobic base (VT1) or your ceiling (VO_2peak) is holding you back, so we can change the right thing
Returning to training	After illness, injury, pregnancy, or a long break, resets your zones to your current fitness (medical clearance first where needed)
Health and longevity	Compares your result with age- and sex-matched norms; fitness is a strong risk marker you can change
Weight management	Shows how well you burn fat at easy intensities and where you switch to carbohydrate
Tracking progress	A retest after a training block, typically every 8–12 weeks or more, under the same conditions

How to prepare for your test

Small things can change your results, so we ask everyone to prepare the same way each time:

- No hard training for 24–48 hours before the test.
- Eat a light meal 2–3 hours before. Keep your meal timing the same for every retest.

- Caffeine: no restriction, unless you are also having a resting metabolic rate (RMR) test that day. In that case, avoid caffeine before your visit.
- Sleep well the night before. If you are ill or have a fever, we will reschedule; never test while acutely sick.
- Take your usual medications, and tell us about all of them, especially beta-blockers, which lower your heart rate.
- During the test, avoid talking in the mask (we will agree on hand signals) and touch the handrails only lightly for balance.

Why the mask fit matters

If breath escapes around the mask, it is never measured, so your oxygen uptake reads falsely low and the thresholds can be hidden or misplaced. We size the mask carefully and check the seal before you start. Facial hair can make a good seal harder, so let us know if you feel air escaping around your cheeks or eyes.

Why we might repeat a test

- You stopped well before your true maximum (for example, because of leg fatigue or discomfort).
- The mask leaked, or the heart-rate signal dropped out.
- Nervous or deep breathing early in the test distorted the readings.
- Something was different on the day: illness, poor sleep, a hard workout, or a big meal.

How to read your Korr report

Your report opens with a summary page, followed by graphs and tables. These are the parts that matter most:

> **Reading the labels on your Korr report**
>
> **"Aerobic Threshold (AeT)" ≈ VT1**: the top of easy, conversational exercise.
>
> **"Anaerobic Threshold (AT)" ≈ VT2**: the point where hard exercise becomes unsustainable.
>
> Medical textbooks sometimes use "anaerobic threshold" for VT1, so this guide uses only VT1 and VT2.

On your report	What it means for you
VO_2 Max / Peak	Your **measured** peak oxygen uptake (mL/kg/min). This is your result.
Extrapolated VO_2 Max	A prediction made by extending your heart-rate line to an age-formula maximum (220 minus age). It is not a measurement and can differ a lot from your measured value. We use your measured value.
AeT and AT heart rates	Your VT1 and VT2 heart rates. The software finds these automatically, so we check them against your graphs before setting your zones.

On your report	What it means for you
Heart-rate training zones	Five zones with matching heart rates, speeds, and inclines. We check that your Zone 2 sits below your VT1 and adjust the zones if needed.
Recovery heart rate	How fast your heart rate falls after you stop (see below).
Fitness level	Korr's category. We also compare your measured value with standard age- and sex-specific norms (ACSM and the FRIEND registry).[14]
Percent fat and carbohydrate; "Effective Fat Burn"	Where your body changes from mostly fat to mostly carbohydrate (the "crossover"), and the intensity at which you burn the most fat calories (FATmax).
Respiratory exchange ratio (RER)	Your fuel mix (about 0.70 fat, 1.0 carbohydrate). See the notes below.

A few notes on RER

- Very early in the test, nervous or deep breathing can make your RER look high and then briefly low. We ignore the first few minutes.
- Above about 1.0, RER tells us how hard you worked rather than which fuel you used.
- An RER of about 1.10 or higher near the end of the test is one sign that you gave a maximal effort.

VO_2max or VO_2peak: did I reach my maximum?

VO_2max is the highest rate at which your body can take in and use oxygen during whole-body exercise. If your test shows clear signs that you reached your ceiling, we call the result VO_2max. Otherwise we call it **VO_2peak**, the highest value you reached that day. Signs of a maximal effort include:

- Your oxygen uptake levels off even though the treadmill keeps getting harder (a "plateau")
- An RER of about 1.10 or higher during exercise
- A heart rate near your expected maximum
- You rated the effort as very hard or maximal (about 17 or more on the 6–20 Borg scale, or 9–10 on the 0–10 scale)

A VO_2peak is still a valid result for tracking your fitness and setting zones.

Heart-rate recovery

Heart-rate recovery is how much your heart rate falls in the first minute after you stop hard exercise. It reflects how quickly your nervous system switches back to "rest" mode, and a brisk drop is a good sign. On your test, we measure it during an active cool-down (easy walking):

Drop in the first minute (active cool-down)	Guide band	What it means
12 beats per minute or less	Poor	Associated with higher health risk in research studies; worth discussing with your physician[9]
13–20 beats per minute	Fair	Room to improve with regular aerobic training
21–30 beats per minute	Good	A healthy recovery response
More than 30 beats per minute	Excellent	Typical of a well-trained heart

These bands are approximate coaching guides, not a formal medical standard. Only the 12-beat cutoff comes directly from research, and it applies to an active cool-down. If you lie down to recover instead, a cutoff of about 18 beats per minute is used. Heart-rate recovery usually improves as your fitness improves.

PART 4 · TRAINING

7. Training Zones

Training zones are exercise intensities at which your metabolism changes. Most people know them from smartwatches. Your zones are set from **your own VT1 and VT2 heart rates measured on your test**, not from an age formula. Zones 1–2 sit below VT1, Zones 3–4 between VT1 and VT2, and Zone 5 above VT2. The heart-rate percentages below are typical values only; the numbers on your report come first.

We set the top of Zone 2 a few beats below VT1, because heart rate drifts upward during long sessions (cardiac drift).

Zone	Where it sits (from your test)	What it feels like (talk test)	Typical % of maximum heart rate*
1	Easy recovery, well below VT1	Very easy; warm-ups and recovery; full conversation	50–60%
2	Endurance: from the top of Zone 1 up to just below VT1	Steady; you can speak in full sentences	60–70%
3	Tempo: from VT1 to about halfway to VT2	Moderately hard; short sentences. The "gray zone" if overused	70–80%
4	Threshold: the upper part of the VT1–VT2 range, up to VT2	Hard; a few words at a time; sustainable for tens of minutes	80–90%
5	Above VT2	Very hard; only a word or two. VO_2max intervals of a few minutes or less	90–100%

**Typical values only; your test overrides them. In fit people, VT1 can sit at 80% or more of maximum heart rate, so percentage formulas can put your "easy" zone too low (or too high).*

> **"Zone 2" can mean two different things**
>
> This guide (and your Korr report) uses a **5-zone model**, where Zone 2 sits below VT1. Some coaches use a **3-zone model**, where "Zone 2" means the whole band between VT1 and VT2. If someone gives you a Zone 2 target, check which model they mean.

Your Zone 2 width

Your **Zone 2 width** is the range from the top of Zone 1 to just below VT1. We can express it in heart rate (beats per minute), in workload (treadmill speed and incline), and as a percentage of your VO_2peak. It tells us a lot about your aerobic base:

	Wide Zone 2 (VT1 at a high % of VO_2peak)	Narrow Zone 2 (VT1 at a low % of VO_2peak)
What it means	Fat stays a major fuel across a broad range of effort; you clear lactate well	You switch to carbohydrate at modest effort; small increases in pace push you above VT1
In daily life	You can train and stay active for long periods at low strain	"Easy" sessions easily drift into harder tempo work
Often seen in	Endurance-trained, consistently active people	People who are deconditioned, starting out, returning after a break, or have insulin resistance

How to widen your Zone 2 (and raise VT1)

- **Lots of easy volume.** Regular Zone 1–2 sessions, building toward 45–90 minutes as you tolerate them, are the main stimulus for more mitochondria and capillaries.
- **Consistency over months.** These changes build over weeks to months and fade within weeks of stopping. Frequent sessions beat occasional long ones.
- **Gradual progression.** Increase weekly time by no more than about 10% per week, with an easier week every 3–4 weeks.
- **A little hard work.** A small dose of Zone 3–5 work raises your ceiling (see Section 9).
- **Strength training twice a week** supports muscle mass, efficiency, and injury resilience.
- **Retest after about 8–12 weeks** under the same conditions. Success looks like VT1 at a faster speed or steeper incline, and more fat burned at the same heart rate.

> **"Fat-burning zone" is not the same as fat loss**
>
> Your body burns the highest share of fat at easy intensities, and the most fat calories at a moderate intensity just below or around VT1 (FATmax). But losing body fat depends on your overall energy balance across the whole day and week, not on which fuel you burn during a workout. Easy training is valuable because it builds your aerobic base and can be done often.

Zones at a glance: fuel and physiology

These tables link each zone to the type of energy you use, the respiratory exchange ratio (RER, $CO_2 \div O_2$), and the terms physiologists use. Use them to read the results of exercise tests such as VO_2 max and lactate testing.

Fuel and metabolism

Zone	Main energy source	Type of metabolism	How long you can sustain it	Tempo	RER
1	Mostly fat	Aerobic	Hours	Easy	About 0.80 or below
2	Mostly fat, increasing carbohydrate	Aerobic	Hours	Steady	About 0.80–0.87
3	Carbohydrate and fat	Aerobic, with a rising contribution from fast glycolysis	About 1–2 hours (limited by glycogen stores)	Moderately hard	About 0.87–0.95
4	Mostly carbohydrate	Aerobic plus glycolytic; lactate production and clearance are roughly balanced up to VT2	About 20–60 minutes	Threshold (hard)	About 0.95–1.0
5	Carbohydrate	Fast glycolysis and ATP-PC systems on top of maximal aerobic	Seconds to a few minutes (ATP-PC: about 10 seconds of all-out effort; glycolytic: 15 seconds to 2 minutes; see Section 4)	Maximum	Above 1.0

An RER of 0.7 means pure fat burning and 1.0 means pure carbohydrate burning. During exercise you nearly always burn a mix, so typical zone values fall between about 0.80 and 1.0. Values above 1.0 in Zone 5 reflect extra CO_2 breathed out while your body buffers acid.

Thresholds and lactate

Zone	Ventilatory threshold	Lactate threshold	RPE (0–10)	Blood lactate	Typical % MHR
1	Well below VT1	Below LT1	1–2 (easy to talk)	About 1–1.5 mmol/L	50–60%
2	Up to just below VT1	Up to LT1	3–4	About 1.5–2.0 mmol/L	60–70%
3	Just above VT1: breathing starts to rise more than you need to get oxygen	Between LT1 and LT2	5–6	Above 2 mmol/L and starting to rise	70–80%
4	Up to VT2: breathing becomes rapid as you try to get rid of CO_2	Up to LT2	7–8	Rising, up to about 4 mmol/L	80–90%
5	Above VT2	Above LT2	9–10 (flat out)	Rises rapidly; can be over 20 mmol/L	90–100%

Using VT1 and VT2 in your training

Knowing your VT1 and VT2 helps you train. Staying **below VT1** builds endurance and helps your body adapt to burning fat. **Above VT2**, you work at intensities you can sustain only briefly. This is what athletes need for hard pushes, such as the end of a race, and it is the basis of high-intensity interval training (HIIT).

PART 4 · TRAINING

8. How Your Body Adapts to Training

Muscles

- **Endurance training** increases the number of mitochondria and of capillaries (the small blood vessels in muscle), and shifts muscle fibers toward slow-twitch (endurance) fibers.
- **Resistance training** increases the size of muscle fibers and the thickness and strength of ligaments and tendons.
- Muscles can store more glycogen.
- Your body uses fat for energy more efficiently.

Training below or around VT1 mainly improves your aerobic base, efficiency, and fat-burning capacity. Training near and above VT2 improves your ability to perform high-intensity efforts by improving how your body buffers acid and clears lactate.

Heart and arteries

- The heart muscle enlarges and contracts (squeezes) more forcefully.
- The left ventricle, the heart's main pumping chamber, enlarges.
- Your arteries offer less resistance to blood flow (lower peripheral resistance), so blood is pumped more easily.

Lungs

- Breathing becomes more efficient: you need fewer breaths for the same VO_2 and VCO_2.

PART 4 · TRAINING

9. Types of Training

High-intensity interval training (HIIT)

HIIT alternates short bouts of hard exercise, usually above VT2 (Zone 5), with easier recovery periods. Because you are working above your lactate threshold, you cannot sustain these efforts for long, so the recovery periods let you repeat them. Intervals range from 20–30 seconds to about 4 minutes, depending on the program.

Why HIIT works: stroke volume and cardiac output

The amount of blood your heart pumps each minute is your **cardiac output**: heart rate × stroke volume (the blood pumped with each beat). Your maximum heart rate is set mainly by age and barely changes with training. So when your VO_2max improves, it is mostly because your heart pumps **more blood per beat**, with your muscles also getting better at extracting oxygen.

Hard intervals keep your heart pumping close to its maximum for several minutes per session. Repeatedly filling and emptying the left ventricle at high volume makes the chamber larger and the heart more efficient, and training also expands your blood volume. It is like having a more efficient engine that gets more miles per gallon: more blood per beat means more oxygen delivered, and a higher VO_2max.

Sample programs

Program	Structure	Intensity	Notes
Norwegian 4×4	Four 4-minute hard intervals, each followed by 3 minutes of easy active recovery	Work at about 90–95% of maximum heart rate (Zone 5); recover at about 70%	Heart rate takes 1–2 minutes to reach target. Start with 3 × 3 minutes and build up.
30/30	30 seconds hard, 30 seconds easy; 8–20 repeats	Hard bouts near your VO_2peak speed; easy bouts in Zone 1	A gentler entry point. Add repeats, then sets.
Tabata-style 20/10	20 seconds work, 10 seconds rest, × 8 (4 minutes)	The original study used extremely high intensity[15]	Very demanding; best for well-trained people. Class versions are usually easier.
Sprint intervals	4–6 × 30 seconds all-out, about 4 minutes easy between	Maximal effort[16]	Very time-efficient but very hard; for healthy, well-conditioned people.

A classic program is the **Norwegian 4×4**. It mainly trains your heart, increasing how much blood it pumps per beat (stroke volume). It raises VO_2max more than steady training of the same total work, and it also improves endurance.[10]

Are there other benefits?

Yes. Studies report better insulin sensitivity and blood glucose control, lower blood pressure, and gains in muscle oxidative capacity from much less training time. Your body also stays "revved up" for a while afterward, which can increase the calories you burn (excess post-exercise oxygen consumption, EPOC). You do not need special equipment; you just need to raise your heart rate.

Doing HIIT safely

- **Get cleared first** if you have known heart, metabolic, or kidney disease, or symptoms such as chest pain, unusual breathlessness, dizziness, or palpitations.
- **Do not start HIIT** during an illness or fever, with uncontrolled high blood pressure, unstable heart symptoms or rhythm problems, or an acute injury. Pregnancy and complex medical conditions need individual advice.
- **Build a base first.** If you are just starting out, do several weeks of consistent Zone 1–2 work before structured intervals.
- **On beta-blockers?** Your heart rate is blunted, so we set interval intensity by effort (RPE), pace, or power rather than heart rate.



- **Recover.** Allow about 48–72 hours between hard sessions; most programs use 1–3 per week. Rising resting heart rate, poor sleep, low mood, or falling performance are signs to back off.

> **How HIIT and Zone 2 work together: the 80/20 approach**
>
> Zone 2 builds your base: mitochondria, capillaries, fat burning, and VT1. HIIT raises your ceiling: stroke volume, VO_2max, and VT2. In a typical week, about 80% of sessions (or training time) are easy, below VT1, and about 20% are hard, above VT2. Keep easy days truly easy so hard days can be truly hard.[11]

What research has been done?

A good overview, with a summary of several research studies, is on Wikipedia: High-intensity interval training

How do I know if my HIIT is working?

The best way is to recheck your VO_2max after a training block, typically 8–12 weeks, using the same test and preparation.

Endurance training

Classic endurance training is designed to improve heart and muscle performance during aerobic metabolism, so sessions last longer than HIIT. It builds your aerobic base and raises VT1, and it improves cardiovascular performance, though usually not VO_2max as much as HIIT.[10] For example, cyclists do long endurance sessions to train their muscles, then add periods of HIIT for further cardiovascular gains.

Resistance (strength) training

Resistance training, also called muscular or strength training, is designed to increase the size and strength of your muscles. There are three main types:

1. **Muscular strength training** focuses on the maximum force you can produce in a single effort, for example bench press, squats, and deadlifts.
2. **Hypertrophy training** is designed to increase muscle size. The classic approach is 3 sets of 6–10 repetitions to muscle failure.
3. **Muscular endurance training** builds your muscles' ability to keep contracting repeatedly, for example high-repetition weight training, long-distance running, and cycling.

How does training change my muscles?

Muscle hypertrophy (an increase in muscle size) results from micro-tears in your muscles during resistance training.



PART 4 · TRAINING

10. Before and After a Hard Workout

What should I eat before a high-intensity workout?

Carbohydrate loading ("carb loading") means eating a lot of carbohydrates to maximize the stored glucose (glycogen) in your muscles and liver. Elite athletes start 2–3 days before an event. On the morning of the event, they eat a high-carbohydrate meal 3–4 hours before the start.

For regular workouts, have a balanced meal 2–3 hours before, or a smaller carbohydrate-rich snack about 1 hour before.

What should I do after a workout that took me above VT2?

Do not just stop. Do an **active recovery** (cool-down) with low-intensity movement such as walking or slower running. Take deep breaths and rehydrate.

REFERENCE

Appendix: Other Graphs on Your Report

Your Korr report includes some more technical graphs. You do not need them to use your results, and we will walk you through anything important, but here is what they show:

Graph or table	What it shows	What we look for
O_2 pulse	Oxygen taken up per heartbeat (VO_2 ÷ heart rate). A rough indicator of how much blood your heart pumps per beat and how well your muscles use the oxygen.	A steady rise that gradually levels off near your peak. Higher values with training reflect a stronger, more efficient heart.
Ventilatory equivalents (VE/VO_2 and VE/VCO_2)	How much air you breathe for each liter of oxygen taken up or CO_2 breathed out: your breathing efficiency.	The point where VE/VO_2 starts rising helps locate VT1; the point where VE/VCO_2 starts rising helps locate VT2.
V-slope (VCO_2 plotted against VO_2)	CO_2 output compared with oxygen uptake.	The bend where CO_2 starts rising faster than oxygen uptake, which marks VT1.
Stage or interval table	Minute-by-minute values for speed, incline, heart rate, VO_2, RER, and breathing.	We use it to confirm your thresholds and to translate your zones into treadmill speeds and inclines.

REFERENCE

Abbreviations and Glossary

Abbreviation	Meaning
ACSM	American College of Sports Medicine
AeT	Aerobic threshold; the label your Korr report uses for the point that corresponds to VT1
A/G ratio	Android/gynoid ratio: waist (android) fat divided by hip (gynoid) fat
AHA	American Heart Association
AT	Anaerobic threshold; the label your Korr report uses for the point that corresponds to VT2 (some textbooks use AT for VT1, so this guide uses VT1 and VT2)
ATGL	Adipose triglyceride lipase, an enzyme that breaks down stored fat
ATP	Adenosine triphosphate, the energy currency of the cell
ATP-PC	Adenosine triphosphate–phosphocreatine (phosphagen) energy system
BMI	Body mass index: weight relative to height
Borg scale	A 6–20 scale for rating effort (RPE); 6 is no effort and 20 is maximal
bpm	Beats per minute (heart rate)
Cardiac drift	The gradual rise in heart rate during a long session at the same effort
Cardiac output (Q)	Blood pumped by the heart each minute: heart rate × stroke volume
CI	Confidence interval (statistics)
cm^2	Square centimeters (unit for VAT area)
CO_2	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
CPET	Cardiopulmonary exercise testing
Crossover	The intensity at which your main fuel switches from fat to carbohydrate
CRP	C-reactive protein, a marker of inflammation
CT	Computed tomography
Cyclic AMP	Cyclic adenosine monophosphate, a chemical messenger inside cells
DEXA	Dual-energy X-ray absorptiometry
ECG	Electrocardiogram, a recording of the heart's electrical activity
EPOC	Excess post-exercise oxygen consumption

Abbreviation	Meaning
Extrapolated VO_2 Max	A Korr estimate made by extending your heart-rate line to an age-formula maximum heart rate; a prediction, not a measurement
FATmax	The exercise intensity at which you burn the most fat calories per minute
FMI	Fat mass index: fat mass ÷ height^2
FRIEND	Fitness Registry and the Importance of Exercise National Database, a source of fitness norms
GIP	Glucose-dependent insulinotropic polypeptide
GLP-1	Glucagon-like peptide-1
HDL	High-density lipoprotein ("good" cholesterol)
HIIT	High-intensity interval training
HR	Heart rate; in the GLP-1 figure, hazard ratio
HRR	Heart-rate recovery: how far heart rate falls in the first minute after exercise
HSL	Hormone-sensitive lipase, an enzyme that breaks down stored fat
IL-1, IL-6	Interleukin-1, interleukin-6 (inflammatory messengers)
kg/m^2	Kilograms per square meter (unit for BMI and FMI)
LT, LT1, LT2	Lactate threshold; first (about VT1) and second (about VT2) lactate thresholds
MACE	Major adverse cardiac event (such as heart attack, stroke, or cardiovascular death)
MASH	Metabolic dysfunction-associated steatohepatitis (inflammatory fatty liver disease)
MEN 2	Multiple endocrine neoplasia syndrome type 2
MET	Metabolic equivalent; 1 MET = 3.5 mL of oxygen per kg of body weight per minute
mg/dL	Milligrams per deciliter
MHR	Maximum heart rate
mL/kg/min	Milliliters of oxygen per kilogram of body weight per minute
mmol/L	Millimoles per liter (unit for blood lactate)
MRI	Magnetic resonance imaging
mSv	Millisievert, a unit of radiation dose
MTC	Medullary thyroid carcinoma
NAD^+ / NADH	Nicotinamide adenine dinucleotide (oxidized / reduced forms)
O_2	Oxygen
O_2 pulse	Oxygen taken up per heartbeat (VO_2 ÷ heart rate)

Abbreviation	Meaning
Polarized (80/20) training	About 80% easy training below VT1 and about 20% hard training above VT2
RCP	Respiratory compensation point; another name for VT2
RER	Respiratory exchange ratio: CO_2 breathed out ÷ O_2 taken up, measured during CPET
RMR	Resting metabolic rate
RPE	Rating of perceived exertion (0–10 scale, or the 6–20 Borg scale)
RQ	Respiratory quotient: CO_2 produced ÷ O_2 used
SIT	Sprint interval training: short all-out efforts with long recoveries
SV	Stroke volume: blood pumped with each heartbeat
Talk test	Judging intensity by how easily you can speak: full sentences in Zone 2, a few words near VT2
TNF	Tumor necrosis factor
VAT	Visceral adipose tissue (visceral fat)
VCO_2	Volume of carbon dioxide produced per minute
VE	Minute ventilation: volume of air breathed out per minute
VO_2	Volume of oxygen taken up per minute
VO_2max	Highest rate at which your body can take in and use oxygen, confirmed by signs of maximal effort
VO_2peak	Highest oxygen uptake reached during a particular test
VT, VT1, VT2	Ventilatory threshold; VT1 = first threshold (top of easy exercise; Korr "AeT"), VT2 = second threshold, or respiratory compensation point (Korr "AT")
W	Watts, a measure of power (work rate), for example on a bike
Zone 2 width	The range from the top of Zone 1 to just below VT1, in heart rate, workload, or % of VO_2peak

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