Results Overview

Muscle damage (TNF-α)

Your gene variants are linked to average TNF-a levels. This does not increase your risk of exercise-induced muscle damage.

Average Risk

Muscle performance (ACTN3)

Your muscle fibres produce intermediate levels of alpha-actinin-3, benefitting strength and power.

Moderately Higher Levels

Fast twitch muscle activation

Your genetic and lifestyle data suggest you have roughly equal proportions of fast- and slow-twitch muscle fibres.

Fast & Slow

Lactate threshold response

You carry gene variants associated with a greater improvement in lactate threshold following training.

Increased Responder

Musculoskeletal soft tissue injury risk (COL5A1)

Your gene variants are linked to a higher risk of soft tissue injury.

Higher Risk

Mitochondrial growth and endurance

Your gene variants are linked to enhanced growth of new mitochondria in response to endurance training.

Higher growth

VO2 max trainability

You experience an average increase in VO2 max in response to endurance training.

Average Responder

Resting heart rate and heart rate variability

You carry an average to high number of genetic risk variants linked to elevated resting heart rate and lower heart rate variability.

Moderately Higher Genetic Risk

Caffeine and endurance performance

Your genes suggest you could benefit from caffeine, but may reap less benefit than fast metabolisers.

Average Impact

Exercise-induced blood capillary growth

You carry gene variants that lead to moderately lower increases in capillary-to-fibre ratio after endurance exercise training.

Moderately Lower Responder

Red blood cell production and endurance performance

Your gene variants are associated with higher red blood cell production and better endurance performance.

Higher production

Muscle damage (TNF-α)

Muscle Building

TNF-α (Tumour Necrosis Factor-alpha) is a cytokine (cell-signalling protein) that promotes inflammation. High levels of TNF-α can cause excessive inflammation, which has been linked to exercise-induced muscle damage, impaired muscle recovery, poor insulin function and an increased risk of various inflammatory diseases. This trait looks at variants of your TNF gene, which affects expression of TNF-α and influences your susceptibility to inflammation.

Your result

Higher Risk

Moderately Higher Risk

Average Risk

Your gene variants are linked to average TNF-a levels. This does not increase your risk of exercise-induced muscle damage.

TNF-α (Tumour Necrosis Factor alpha) is a cell signalling protein that promotes inflammation.

High levels of TNF-α in the bloodstream and within tissues are linked to increased inflammation.

Short-term, appropriate inflammation is a key part of recovery from exercise.

Excessive inflammation is associated with damage to muscle tissue following strenuous exercise, impaired recovery, poor insulin function, and a higher risk of cardiovascular disease.

This trait analyses several different variants of your TNF gene, which affects expression of the TNF-α protein.

You carry TNF gene variants associated with average expression of TNF-α.

Based on your gene variants alone, you are not more prone to excessive levels of inflammation.

Your gene variants suggest that you are not at an increased risk of conditions linked to inflammation e.g. cardiovascular disease, diabetes, and inflammatory bowel disease.

You are not at an increased risk of muscle damage in response to eccentric exercise.

An unhealthy, high-fat diet and deposition of visceral fat around your internal organs can nevertheless lead to excessive inflammation, regardless of your gene variants.

This trait is useful for assessing your risk of inflammation based on your gene variants. A blood test for inflammatory markers (e.g. CRP) is required to more accurately assess current levels of inflammation.

This trait focuses on TNF gene variants. Other traits (e.g. IL-6 and inflammation), diet, exercise, sleep, smoking and psychological stress all influence levels of inflammation.

Recommended Actions

Perform strength training to improve your body composition. Strength training will help keep your body fat levels healthy to prevent higher TNF-a release from adipose (fat) cells.

Moderate your fat intake. High-fat diets can elevate TNF-a levels and other inflammatory markers.

Eat high antioxidant foods such as berries, lychee, grapes, broccoli, bok choi. This will keep your antioxidant defences high and inflammation levels healthy.

Muscle performance (ACTN3)

Muscle Building

Dubbed the “gene for speed,” the ‘R’ variant of the ACTN3 gene has been widely linked to elite sprint and power performance. In fact, an analysis of the DNA of professional sprinters revealed that every single athlete with a 200m PB faster than the 2012 Olympic qualifying time (20.65 seconds) carried the ‘R’ variant. This variant enables the production of alpha-actinin-3, a contractile muscle protein that facilitates fast, explosive muscle contractions. Conversely, non-carriers of the ‘R’ variant, who have the XX ACTN3 genotype, cannot produce this protein, and are described as having alpha-actinin-3 deficiency. While the inability to produce alpha-actinin-3 does not cause disease or disability, it may make muscle fibres more susceptible to certain types of damage during exercise. In this trait, you’ll find out whether you have the ACTN3 genotype of a sprinter or endurance athlete, understand what this means for your risk of certain injuries, and receive advice on how to improve your strength and power performance.

Your result

Higher Levels

No Production

Moderate Higher Levels

Your muscle fibres produce intermediate levels of alpha-actinin-3, benefitting strength and power.

Your ACTN3 gene encodes alpha-actinin-3: a protein in fast-twitch (Type II) muscle fibres that is involved in forceful, high-velocity muscle contractions.

People carrying one or two copies of the ‘R’ variant of the ACTN3 gene are able to produce alpha-actinin-3. Studies suggest that this is advantageous for activities involving explosive movements, such as sprint and power events.

The R variant has also been linked to: greater baseline muscle strength, larger fast-twitch (Type II) muscle fibre diameter, a

greater response to resistance training, lower injury risk, and lower levels of exercise-induced muscle damage.

By contrast, people with the XX genotype of the ACTN3 gene are unable to produce alpha-actinin-3. This genotype is overrepresented in elite endurance athletes, but is linked to a greater injury risk and greater exercise-induced muscle damage.

You carry one copy of the ‘R’ variant. Your ACTN3 genotype is: RX.

Your fast-twitch (Type II) muscle fibres produce moderate levels of the alpha-actinin-3 protein. This supports explosive, high-velocity muscle contraction and makes your fibres more resistant to mechanical stress.

Elite sprinters and power athletes are more likely to have your genotype (RX) vs. the XX genotype. Meta-analyses suggest elite power athletes are roughly 1.1 to 1.6 times more likely to carry the R variant.

Some studies find people with your genotype (RX) have greater baseline muscle strength and relatively greater strength gains in response to resistance training, although the evidence is mixed.

You may be less vulnerable to inflammatory muscle damage following exercise, especially exercise involving eccentric muscle contraction. R variant carriers are shown to leak less muscle protein (e.g. creatinine kinase, myoglobin) into their bloodstream after intense exercise, indicating lower muscle damage.

Compared to the XX genotype, people with your genotype (RX) are also less likely to sustain non-contact muscle and ligament injuries during exercise, particularly ankle sprains.

People with your genotype are shown to be more flexible and have a greater range of motion compared to those with the RR genotype. This may be due to relatively higher production of another muscle protein that influences muscle stiffness, alpha-actinin-2.

Recommended Actions

Introduce some sprint training into your week. Sprint for 20 secs and then rest for up to 3 mins, repeating 3-5 times. Sprinting can induce greater hypertrophic signalling in your genotype.

Learn how to perform Olympic lifts such as hang cleans and power cleans. These types of strength exercise require fast, explosive movements and make use of your higher alpha-actinin-3 content in fast-twitch muscle fibres.

Take 5 g of creatine monohydrate post-workout. Supplementing with creatine after resistance exercise can help increase muscular strength and power production.

Keep hydrated by sipping water regularly throughout the day, and especially during workouts. When dehydrated, your fast-twitch muscle fibres lose more strength compared to your slow-twitch muscle fibres. Inadequate fluid intake can therefore impair your power production during exercises.

Include plenty of nitrate-rich foods in your diet. Nitrates (found in foods such as beetroot, kale, and rocket) have been observed to increase force production in fast-twitch muscle fibres which could further enhance your power performance.

Get jumping in your workouts. Including some box jumps or lateral hops (forms of plyometric training) will help to increase your muscle strength and power.

Fast twitch muscle activation

Muscle Building

You've probably heard before that we have two distinct types of muscle fibres: slow-twitch and fast-twitch. A more accurate picture, however, would be that our skeletal muscles are composed of a broad spectrum or continuum of muscle fibres, which differ in how fast they contract and how they generate and use energy. At one end of this spectrum, we have slow-oxidative (Type I) fibres that contract slowly (hence the "slow-twitch" moniker). Using aerobic respiration (i.e. using oxygen) to generate a steady supply of energy, these fibres can sustain repeated contractions over a long time. As such, they are useful for endurance events requiring prolonged efforts. At the opposite end of the spectrum, we have fast glycolytic (Type IIx) fibres that have the quickest contraction speed, generating a high force in a short amount of time. Alas, reliant on anaerobic respiration (without oxygen), which yields less energy, these fibres fatigue quickly. Also sitting at the fast-twitch end of the spectrum, are fast oxidative glycolytic (Type IIa) fibres, which contract less rapidly than their Type IIx counterparts, but can use both aerobic and anaerobic respiration for energy and so fatigue less quickly. Both Type IIa and IIx fibres are important for resistance, power, and sprint activities. We also have hybrid muscle fibres (e.g. Type I/IIa and Type IIa/IIx), which can be thought of as intermediates between the different fast and slow-twitch fibres. Unsurprisingly, the relative proportions of these different types of muscle fibres are influenced by how we exercise, but our genetics are also important. It is estimated that roughly half of the differences in our muscle fibre composition are due to variation in the genes we inherit.

Your result

- Fast
- Slow
- **Fast & Slow**

Your genetic and lifestyle data suggest you have roughly equal proportions of fast- and slow-twitch muscle fibres.

Broadly speaking, we have two types of muscle fibre: slow-twitch (Type I) and fast-twitch (Type II). Fast-twitch fibres can be further subdivided into: fast oxidative glycolytic (Type IIa) fibres and fast glycolytic (Type IIx) fibres.

Our muscle fibre composition is plastic. This means that the relative proportions of Type I, Type IIa, and Type IIx fibres in a muscle can change over time and are shaped by how we exercise. Resistance training is widely shown to increase our proportion of fast Type IIa fibres. Endurance training increases the proportion of slow Type I fibres.

Our genetic make-up also strongly influences our muscle fibre composition. A study of twins found that about 45% of differences in muscle fibre composition are due to genetic factors.

Variants of individual genes, including ACTN3, ACE, AGTR2, HIFA, and VEGFR, have been linked to differences in muscle fibre composition. For example, carriers of the ACTN3 ‘R’ variant have been found to have a greater proportion of Type IIx fibres in their thigh muscles.

Your combined gene variants and lifestyle data suggest you are likely to have roughly equal proportions of slow-twitch Type I and fast-twitch Type II fibres.

Equal proportions of Type I and II fibres can give you a good balance between being able to perform quick and powerful muscle contractions, while exercising for longer without tiring.

Type IIa and IIx fibres can generate 6 and 10 times the peak power of Type I (slow-twitch) fibres, respectively. They also have a greater capacity for hypertrophy (an increase in size and strength) elicited by exercise. Increasing your proportion of Type IIa and IIx muscle fibres may therefore improve strength and power performance, and help you gain muscle.

Strength training typically converts Type IIx into Type IIa fibres, resulting in a higher proportion of Type IIa fibres, but a lower proportion of Type IIx fibres. Sprinting or adding high-velocity muscle contractions (e.g. plyo push ups) to strength workouts can help you retain Type IIx fibres while boosting the proportion Type IIa fibres.

As we age, our proportion of Type II (particularly Type IIx) fibres declines, resulting in a loss of strength and power. Strength training can help to preserve Type II fibres and slow down this decline.

Recommended Actions

Introduce some sprint training into your week. Sprint for 20 secs and then rest for up to 3 mins, repeating 3-5 times. Sprinting activates fast-twitch muscle fibres, so using exercises such as sprinting will help to increase your proportion of fast-twitch muscle fibres.

Complete 1 minute each of 5-8 exercises, rest for 2-3 minutes and then repeat the circuit 2 more times. Circuit training has been shown to be a great way to activate slow-twitch muscle fibres and help increase muscular strength.

Learn how to perform Olympic lifts such as hang cleans and power cleans. These types of strength exercise require fast, explosive movements which are perfect for fast-twitch muscle fibres.

Use L-arginine as a pre-workout supplement. When taken prior to exercise, L-arginine has been shown to have a protective effect against muscle fibre damage, as well as preserving performance and promoting muscle build.

If looking to increase your proportion of slow-twitch fibres, try supplementing with 500 mg of quercetin alongside a mug of green tea. Some promising studies have shown quercetin can aid the switching of type IIa fibres to type I, and green tea aids its absorption in the body.

Get jumping in your workouts. Including some box jumps or lateral hops (forms of plyometric training) will help to increase your muscle strength and power as these types of exercise predominantly recruit fast-twitch muscle fibres.

Try alternating the volume and intensity of your training. For example, carrying out resistance training with heavy loads for 3-5 reps with long rest intervals (3-5 mins) or lighter loads for 8-12 reps with shorter rest periods of 30-90 seconds. This will allow you to target your fast- and slow-twitch muscle fibres.

Take 5 g of creatine monohydrate post-workout. Fast-twitch muscle fibres require creatine to produce phosphocreatine, which provides quick energy that can help increase power and muscle strength.

Include plenty of nitrate-rich foods in your diet. Nitrates (found in foods such as beetroot, kale and spinach) have been observed to increase force production in fast-twitch muscle fibres, reducing the effort required for an exercise and allowing you to exercise for longer periods.

Stick to the recommended maximum saturated fat intake of 30 g per day. Consistently overeating saturated fats can impair contractile force in your fast-twitch muscle fibres, negatively impacting your ability to build muscle.

Lactate threshold response

Endurance

If you were to start jogging on a treadmill and then gradually ramp up the speed, you will eventually reach a point where you characteristically “feel the burn”. As we pick up pace, our mitochondria, responsible for generating energy using oxygen through a process called aerobic respiration, eventually fail to keep up with our muscles’ energy demands. In response, our muscles increasingly switch to anaerobic respiration, which allows us to generate energy without oxygen. When this happens, however, one of the byproducts of anaerobic respiration, lactic acid, quickly starts to build-up in our bloodstream. Lactic acid rapidly dissociates into H+ ions and lactate, and it is this accumulation of H+ ions that is responsible for the burning sensation we experience. Similarly, if you were to continuously sample your blood as you ramp up your running speed and exercise intensity, there will come a point where the concentration of lactate rapidly starts to rise. This point is known as our lactate threshold. Typically, the better your aerobic fitness, the higher your lactate threshold. This is because the mitochondria in your muscles are better able to keep up with the energy demands of exercise using aerobic respiration, without the need to switch to anaerobic respiration. Endurance training allows all of us to improve our lactate threshold, but the amount we improve is also influenced by our genetic make-up. In this trait we look at your PPARD and PPARGC1A genes, variants of which have been shown in the Tuebingen Lifestyle Intervention Program Study to affect the size of increases in lactate threshold with exercise.

Your result

Lower Responder

Moderately Lower Responder

You carry gene variants associated with a greater improvement in lactate threshold following training.

Your lactate (or anaerobic) threshold is the intensity of exercise at which lactate starts to rapidly accumulate in your bloodstream. It marks a transition point where your muscles

Moderate Responder

Increased Respond

No data

switch from aerobic (using oxygen) to anaerobic (without oxygen) respiration to produce energy.

Lactate threshold is a good indicator of your aerobic fitness and is widely shown to predict endurance performance (such as marathon time). A higher lactate threshold means you can sustain a higher intensity of exercise (e.g. faster running speed) before lactate and hydrogen ions accumulate in the bloodstream, leading to muscle fatigue.

We can all increase our lactate threshold through training, but our genetics influence how well we respond. Certain variants of genes involved in the function of our mitochondria - the components of our muscle cells responsible for aerobic respiration - have been shown to affect improvements in lactate threshold, as well as insulin sensitivity, in response to training.

The beneficial AA (rs2267668) and Gly/Gly (rs8192678) genotypes of the PPARD and PPARGC1A genes, respectively, have been linked to greater improvements in lactate threshold and insulin sensitivity after 9-months of moderate endurance exercise.

By contrast, carrying the 'G' variant of the PPARD gene and/or the 'Ser' variant of the PPARGC1A has been associated with lesser gains in lactate threshold and insulin sensitivity.

You are classified as a: HIGH RESPONDER. You carry gene variants associated with a greater improvement in lactate threshold following training.

You have both the beneficial PPARD 'AA' and PPARGC1A 'Gly/Gly' genotypes. People with both these genotypes are shown to have significantly higher improvements in lactate threshold compared to those without these genotypes.

In the Tuebingen Lifestyle Intervention Program study, subjects with your genotypes (AA + Gly/Gly) improved their lactate threshold by 120% after performing at least 3 hours moderate endurance exercise per week for 9 months. Subjects without these beneficial genotypes only improved their lactate threshold by 11%.

You may also more greatly improve your insulin sensitivity in response to training. In the Tuebingen Lifestyle Study, subjects with your genotypes (AA + Gly/Gly) increased their insulin sensitivity by 40%, whereas those without your genotypes only improved insulin sensitivity by 4%.

Your PPARGC1A genotype (Gly/Gly) is overrepresented in elite endurance athletes and may confer an advantage for endurance performance. A recent meta-analysis of case-control studies found that elite long-distance runners and cyclists were 1.75 times more likely than non-athletes to have the Gly/Gly genotype versus other genotypes.

Greater improvements in lactate threshold in people with your PPARGC1A genotype (Gly/Gly) may be partly due to higher production of the PPARGC1A protein in muscle tissue. This protein is involved in promoting the growth of mitochondria and improvements in muscle energy pathways in response to endurance training.

Recommended Actions

Progressively increase the distance you run or cycle with each training session. This will increase the efficiency at which your muscles use oxygen, pushing your lactate threshold up and allowing you to work harder for longer.

Include some cardiovascular exercise every day, such as going for a brisk walk, or cycling to work. Regular cardiovascular activity will help to increase your lactate threshold, and will improve your insulin sensitivity.

If supplementing with high dose vitamin C and E (1000 mg), avoid taking these during periods of heavy endurance training. These vitamins can impair certain exercise-induced adaptations, such as increases in PGC-1a expression, which can negatively impact your ability to increase your lactate threshold.

Perform interval training with 2-4 minute intervals at an intensity of 85-95% HRmax, followed by 3-5 minutes resting. Interval training has been shown to be an effective form of training for improving your lactate threshold.

Run for 2 minutes and walk for 1 minute, and repeat 6 times. This is a simple way to try out some interval training to increase your lactate threshold.

Musculoskeletal soft tissue injury risk (COL5A1)

Endurance

Do your genes make you more prone to sports injuries?It's estimated that 100 million people across the world experience an exercise-related soft tissue injury each year. Our volume of training is one obvious risk factor for such injury, with those of us exercising more frequently more likely to damage soft tissues such as ligaments and tendons. Elite athletes, for example, have a 5 times higher rate of Achilles tendinopathy, which is characterised by degeneration of the Achilles tendon. But, did you know our genetics also plays a significant role?In this trait we look at variants of your COL5A1 gene, which has been widely linked to the risk of musculoskeletal soft tissue injuries, including ligament tears, tendon rupture, and Achilles tendinopathy.

Your result

- **Higher Risk**
- Average Risk
- No Data

Your gene variants are linked to a higher risk of soft tissue injury.

Collagen is a structural protein that is a key component of musculoskeletal soft tissue, including tendons and ligaments.

Changes in the composition of collagen fibres (fibrils) can make tendons and ligaments more susceptible to exercise-related injuries, such as Achilles tendinopathy, tennis elbow, and anterior cruciate ligament (ACL) tears.

An increase in the proportion of Type V collagen in fibrils may make tendons and ligaments more vulnerable to degeneration and tearing.

The 'T' variant (rs12722) of the COL5A1 gene, which encodes part of the Type V collagen protein, is associated with an increased risk of exercise-related soft tissue injuries.

You carry two copies of the 'T' variant linked to an increased risk of soft tissue injury. Your COL5A1 (rs12722) genotype is TT.

A recent meta-analysis found that people with your genotype were 1.5 times more likely to have a ligament injury such as an ACL tear (compared to those without the 'T' variant).

You may also have a greater risk of Achilles tendinopathy - an overuse injury of the tendon that connects your calf muscles to your heel bone.

Your genotype (TT) has also been linked to a twice greater risk of tennis elbow (lateral epicondylitis) compared to other genotypes (CT + CC).

Type I collagen is the most abundant collagen in tendons and ligaments, giving them mechanical durability. A higher ratio of Type V to Type I collagen in ligament and tendon fibrils may underlie the greater injury risk seen in people with your genotype.

Recommended Actions

Make sure you include at least 2 days of strength training into your routine each week. Strength training is important for maintaining healthy tendons and ligaments, and is particularly important for reducing injury risk if you do lots of cardiovascular exercise.

Add eccentric exercises like heel drops and nordic hamstring curls into your workouts a few times a week. Eccentric exercises, which focus on the lengthening of the muscles, are important for strengthening these injury prone areas.

Try supplementing with 5-15 g of collagen a day. Collagen helps to strengthen soft tissue and can aid in muscle recovery.

Get jumping in your workouts. Including some box jumps or lateral hops (forms of plyometric training) have been shown to reduce injuries due to neuromuscular adaptations that occur. Getting your landing mechanics right is key. See the videos in related products on how to correctly perform these exercises.

Add 1-2 unilateral exercises such as single leg deadlifts into your workouts. Exercising each side in isolation helps to further develop strength and stability around the joints, reducing the risk of injuries.

Eat tomatoes, broccoli, peppers and kale. These are great food sources of vitamin C, which is a key vitamin involved in the production of collagen.

Eat your fruits and vegetables raw whenever possible. Cooking, especially boiling, strips the food of much of its water-soluble vitamins, such as vitamin C. Vitamin C is important for collagen synthesis, helping strengthen soft tissue.

Add some meat and shellfish to your diet. These are rich in zinc and protein, which are both important components in the production of collagen.

Pre-soak lentils and chickpeas before eating them. These legumes are rich in zinc and copper and, by soaking them, the bioavailability of these minerals are increased. This allows more to be absorbed to be used in collagen production.

Don't always do your workouts at high intensity. Mixing up your workouts with some lower intensity work reduces the risk of overtraining and injury, as well as maximising your training adaptations.

Mix up the type of activity you are doing. Whether in your occupation or your training, repetitive movements for long periods of time will increase the chances of injury. Switching some running for cycling, or trying out an exercise class are easy ways to mix up your activity.

Mitochondrial growth and endurance

Endurance

If you were to run as fast as possible for a period of time, your body will use three different energy systems to generate ATP, the chemical energy currency that our muscles need to contract.In the first few seconds, you rapidly form ATP in the absence of oxygen by breaking down phosphocreatine (a short-lasting muscle fuel store) and glycogen (via a process of anaerobic respiration). As you keep running beyond 15 to 30 seconds, these two systems alone will fail to keep up with the energy demands of your muscles. It's at this point that we start to become reliant on our mitochondria. Dubbed "the powerhouses of the cell," as you may recall from high school biology lessons, mitochondria use oxygen to generate ATP through the process of aerobic respiration. After approximately 1 minute of sustained exertion, aerobic respiration by mitochondria is the main system by which we generate energy.Unsurprisingly, one of the ways our muscles adapt to the energy demands of endurance training is to form new mitochondria. Exercise stimulates our existing mitochondria in muscle fibres to grow and divide, allowing us to better supply muscles with energy. This growth process is called mitochondrial biogenesis and is regulated by various genes.In this trait, you'll find out whether you have a variant of your PGC1A (PPARGC1A) gene shown to enhance mitochondrial biogenesis, improve energy supply to muscles, and confer greater endurance performance gains.

Your result

Lower growth

Higher growth

Your gene variants are linked to enhanced growth of new mitochondria in response to endurance training.

Mitochondria are responsible for aerobic respiration: the process by which our muscles generate energy for contraction using oxygen. Endurance activities, such as long-distance running, swimming, cycling, and walking, rely mostly on aerobic respiration for energy.

In response to endurance training, we switch-on genes that promote the generation of new mitochondria in muscle fibres. This process, known as mitochondrial biogenesis, enhances our ability to supply muscles with energy and improves our endurance performance.

The PGC1A (PPARGC1A) gene is a key gene that is switched-on by endurance exercise. It encodes a protein called PGC-1α, which stimulates mitochondrial biogenesis and improves our muscles' ability to use fat and glucose for energy.

The PGC-1α protein also promotes the conversion of fast- into slow-twitch muscle fibres. Slow-twitch (type 1) fibres contain more mitochondria, allowing them to generate energy using aerobic respiration for repeated muscle contraction, without fatiguing. This makes them suited for endurance activities.

People with two copies of the Gly variant (rs8192678) of the PGC1A gene (Gly/Gly genotype) are shown to produce higher levels of the PGC-1α protein. This can enhance mitochondrial biogenesis, fast-to-slow-twitch muscle fibre conversion, and performance gains in response to endurance training.

By contrast, people carrying one or two copies of the Ser variant produce lower levels of the PGC-1α protein and may respond less effectively to endurance training.

You carry two copies of the Gly variant, which is linked to greater PGC-1α production. Your PGC1A (rs8192678) genotype is: Gly/Gly.

Studies show that people with your genotype (Gly/Gly) produce higher levels of PGC-1α and experience less age-related decline in PGC-1α production compared to other genotypes.

Higher PGC-1α production in your genotype (Gly/Gly) may enhance your capacity to develop new mitochondria in response to endurance exercise. One study found that people with your genotype showed more pronounced increases in mitochondrial enzyme activity following 10 weeks of cycle training.

The same study also suggests that you may more effectively convert fast- into slow-twitch muscle fibres. Following 10 weeks of cycle training, subjects with your genotype (Gly/Gly) increased the proportion of slow-twitch (type 1) fibres in thigh muscle by 19% (compared to -1.5% in other genotypes).

Higher PGC-1α production and enhanced mitochondrial biogenesis may help you to improve performance more greatly after endurance training. A small study found that untrained subjects with your genotype (Gly/Gly) improved their VO2max (a measure of aerobic fitness) more significantly than those with other genotypes following 10 weeks of cycle training.

Your PGC1A genotype is overrepresented in elite endurance athletes and may offer an advantage for endurance sports. A 2022 meta-analysis found that, compared to non-athletes, national and international level long-distance runners and cyclists were 1.75 times more likely to have your genotype (Gly/Gly) vs. other genotypes.

Recommended Actions

Exercise at a moderate intensity for at least 30 mins, 5 times a week. This can be going for a run or a brisk walk, or doing some household cleaning (vacuuming or mopping). Keeping yourself active regularly will help to increase PGC-1α expression and mitochondrial growth.

Limit carbohydrate intake in the evening and then complete a fasted low-intensity training session the following morning. This is a component of the sleep-low strategy which has shown beneficial impacts on endurance performance.

Avoid supplementing with antioxidants like vitamin C during training blocks. Antioxidant supplements can impair exercise-induced adaptions such as increased PGC-1α production, limiting performance gains.

Make sure to regularly include foods such as eggs, nuts and green vegetables in your diet. These foods contain a variety of B vitamins, which play an essential role in maintaining mitochondrial function.

Consider using a sauna a few times a week. Regular exposure to heat stress above 40°C (104°F) can help improve mitochondrial biogenesis.

VO2 max trainability

Endurance

In the annual Iditarod Trail Sled Dog Race, Alaskan huskies must run 1600 km carrying a loaded sled, sustaining speeds of up to 16 km/hr for up to 6-8 hours a day. To accomplish such feats of endurance, the huskies must be adept at getting oxygen from the atmosphere into their bloodstream, pumping oxygenated blood to working muscles, and then extracting this oxygen to generate energy for movement. These abilities are neatly reflected in a figure known as VO2 max or maximal oxygen uptake. Generally speaking, the higher your VO2 max, the better your aerobic fitness, with trained Alaskan huskies having a VO2 max as high as 240 ml/min/kg! To put this in context, the ultrarunner Kilian Jornet has a VO2 max of 92 ml/min/kg and Joan Benoit, who won gold in the 1984 Olympic marathon, had a VO2 max of 78.6 ml/min/kg. For untrained individuals, these figures typically range from 26-40 ml/min/kg. We can improve our VO2 max through endurance training, as our body makes adaptations to higher oxygen demands, such as increased stroke volume (the amount of blood pumped out in each heart beat). Alas, the extent to which our VO2 max increases in response to training varies significantly according to our genetics. In this trait, you'll find out whether you are likely to be a "high responder," who greatly increases VO2 max, or a "low responder", who will experience smaller gains.

Your result

- Low Responder
- Higher Responder
- **Average Respond**
- No Data

You experience an average increase in VO2 max in response to endurance training.

Your VO2max (maximal oxygen uptake) is a measure of how well your body delivers oxygen to exercising muscles and how well muscles extract oxygen for energy. It is a good marker of your aerobic fitness.

You can increase your VO2 max through high-intensity endurance training (e.g. interval or fartlek training performed at high heart rates). The amount you can improve your VO2 max (known as VO2 max trainability), however, differs from person to person based on your genetics.

Some people are "high responders" and increase their VO2 max greatly in response to endurance training. "Low responders," while still able to increase their VO2 max with training, tend to experience much smaller improvements.

About half of the difference in VO2 max trainability between people is due to differences in the genes we carry. This trait looks at several common gene variants shown to affect VO2 max response to endurance training.

You are an "average responder". This means you are likely to have average VO2 max gains in response to endurance training.

Your analysis is based on 14-20 of the best-studied gene variants shown to either enhance or impair VO2 max trainability. This includes: ACSL1 (rs6552828), AMPD1 (rs17602729), ACE (rs4343), and ZIC4 (rs11715829).

Overall, your combined gene variants do not significantly enhance or impair your VO2 max trainability.

Your result suggests you have an average capacity to develop adaptations to your heart, blood vessels, lungs, and skeletal muscles in response to high-intensity endurance training. These adaptations all increase VO2 max by improving the extraction and delivery of oxygen to working muscles, and by enhancing muscle energy production.

High-intensity endurance training (performed at 85%-95% of your maximum heart rate) will likely improve your VO2 max. It will also improve other factors linked to better endurance

performance, including your running economy, lactate threshold, and motivation.

Recommended Actions

Include 2-3 days of strength training a week that include 2-4 lower body exercises such as squats, with some plyometric exercises such as lateral hops. Even though you have an average response to training in terms of VO2 max improvements, increasing running economy through strength training can help enhance your running performance.

Perform interval training with 2-4 minute intervals at an intensity of 85-95% HRmax, followed by 3-5 minutes resting. Increasing your lactate threshold through interval training will help improve overall running performance, even if your VO2 max response to training is lower.

Run for 2 minutes and walk for 1 minute, and repeat 6 times. This is a simple way to try out some interval training which can increase your lactate threshold. Improving your lactate threshold can help improve your endurance performance.

Get to your local park and play around with sprinting, jogging and walking between lamposts or landmarks. This form of training called fartlek is where you mix up different speeds during a training session. Fartlek training has been shown to be an effective way to improve your lactate threshold, which will benefit your endurance performance.

Supplement with 300 mg of Ashwagandha root extract, twice daily. Ashwagandha supplementation has shown promising effects on VO2 max, with a 5% increase observed after 8 weeks in one study.

Run or cycle 3 times a week, at a moderate-hard intensity (70-80% HR max). These sessions should be 30 minutes or longer. Having these longer, steady-state aerobic exercise sessions are key to increasing your VO2 max, particularly for high responders.

Include 1-2 high intensity interval training (HIIT) sessions a week. Sprint for 30 seconds followed by 60 seconds of walking, and repeat at least four times. Progress to longer durations of sprinting over time. HIIT has been shown to be a quick and effective way to increase VO2 max.

If new to exercise, start with lower intensity exercise such as walking or light cycling. Transitioning from doing no exercise to some will still increase your VO2 max, and allow your body to slowly adapt to moving more.

Take the stairs more often throughout the day. Incorporating lots of short bursts of stair climbing has been shown to increase VO2 max so it is a good alternative form of interval training for those who are newer to exercise.

Try using a L-arginine supplement. Take 1.5-2 g/day. Studies have shown a mean increase of 0.07 L/min in VO2 max when supplementing with L-arginine.

Consider supplementing up to 4000 IU of vitamin D a day. Vitamin D has been shown in some studies to help with improvements in VO2 max capacity, so ensuring you have adequate levels can be beneficial to VO2 max training.

Consider trying Zumba as an alternative to strength training or high intensity interval training that consists of sprinting. Zumba has been shown to increase VO2 max so may be a more enjoyable activity to improve your levels.

Monitor your VO2 max to detect improvements. As well as the lab based assessments, there are easy field tests to estimate your VO2 max such as the 1.5 mile run test. VO2 max can be estimated from your time completing this distance using this equation: (485 / time to complete 1.5 miles) + 3.5. If performing these tests, you should look to consult a trained professional to oversee it.

Resting heart rate and heart rate variability

Endurance

Do you have genes linked to a lower resting heart rate and higher heart rate variability? Aside from winning the Tour de France five times between 1991 and 1995, the cyclist Miguel Indurain is famed for having a resting heart rate of just 28 beats per minute (bpm). While an extreme example, it is not uncommon for both recreational and elite endurance athletes to have resting heart rates significantly lower than the typical adult range of 60 to 100 bpm. Why is this? In response to sustained endurance training, your heart adapts, becoming stronger, larger, and more effective at pumping blood to the rest of the body. In tune with this, your autonomic nervous system - the network of nerves that control unconscious processes such as heart rate, blood pressure, and breathing - also adapts. Greater activity of your parasympathetic nervous system (one of the divisions of your autonomic nervous system) at rest leads to lower resting heart rates. Another outcome of this training adaptation is greater fluctuation in the intervals between your heartbeats. Such higher heart rate variability (HRV) is a measure of better aerobic fitness. As such, HRV is widely used by elite endurance athletes to guide training and monitor progress. In addition to training, our genetics also impact our resting heart rate and HRV. In this trait, we look at up to 9 gene variants shown to explain roughly 1-2% of individual differences in resting heart rate and HRV.

Your result

Increased Genetic Risk

Moderate Higher

You carry an average to high number of genetic risk variants linked to elevated resting heart rate and lower heart rate variability.

One adaptation to endurance training is an increase in the activity of your vagus nerve. This nerve is a major component

Genetic Risk

Moderate Genetic Risk

Lower Genetic Risk

of your parasympathetic nervous system, which acts to slow down your heart rate.

By increasing parasympathetic and vagus nerve activity at rest, endurance training tends to lower our resting heart rate, while increasing our heart rate variability (HRV) - a measure of how much the time between each heartbeat varies.

A lower resting heart rate and higher HRV are both good measures of better aerobic fitness. A study of masters runners, for example, found that those with a higher HRV had faster 10km times.

Conversely, a higher resting heart rate and lower HRV are linked to poorer aerobic fitness, increased risk of cardiovascular disease, and higher mortality. For example, a 2017 meta-analysis found that a 10-bpm increase in resting heart rate was associated with a 15% higher risk of cardiovascular disease.

Genes that affect the activity of the vagus nerve on your heart's intrinsic pacemaker (called the sinoatrial node) can have small effects on your resting heart rate and HRV. This trait looks at up to 9 risk variants of genes linked to a higher resting heart rate and lower heart rate variability (HRV).

You carry an average to high number of genetic risk variants linked to elevated resting heart rate and lower heart rate variability.

Overall, your gene variants are associated with a 2 - 3 beats per minute (bpm) higher resting heart rate (compared to someone without any risk variants). Resting heart rate ranges from 60 - 100 bpm in a typical adult and can be as low as 30 bpm in a trained athlete.

Studies suggest that the risk of negative health outcomes rises linearly with your resting heart rate. Based on this

relationship, a 2 - 3 bpm higher resting heart rate is associated with a 3% to 4.5% higher risk of cardiovascular disease and a 3.4% to 5.1% higher risk of mortality from all causes.

Your gene variants are also linked to lower heart rate variability (HRV). Overall, your gene variants are associated with a roughly 0.3 to 0.4 ms lower RMSSD (root mean square of successive differences between normal heartbeats - a measure of short-term HRV).

Typical RMSSD values vary widely between people depending on factors such as age, sex, ethnicity, time of day, and how long heart rate is monitored. In one study of 8 million Fitbit users, the majority of people had an RMSSD between 20 and 100 ms. Some sources propose a normal range of between 20 and 89 ms.

Endurance training is widely shown to improve parasympathetic control of heart rate and increase your average heart rate variability (HRV). Some studies suggest, however, that people with lower baseline HRV experience less improvement in endurance performance with intensive training.

Low HRV may be a sign of inadequate recovery after exercise and overtraining. A 2021 meta-analysis found that using your HRV to guide endurance training is moderately better than predefined training for improving medium-intensity (i.e. submaximal) endurance performance. HRV-guided training typically involves only performing high-intensity exercise sessions when your HRV has returned to its normal range.

Recommended Actions

If you are able to monitor your heart rate variability, take a rest day or opt for lower intensity training on days when your morning HRV is low. Lower waking HRV has been correlated with poorer exercise performance, particularly during moderate to high intensity exercise. Lower intensity exercise or no structured exercise on these days would therefore be more beneficial.

Try some hatha yoga a few evenings a week. Hatha yoga has been shown to significantly improve heart rate variability, which can enhance your endurance performance.

Add a handful of kale or cabbage to a few meals a week. Leafy green vegetables improve cardiac autonomic function which will help lower resting heart rate and improve heart rate variability.

Try to include a minimum of 2 rest days per week. Rest days can still involve some low intensity exercise. By ensuring you have sufficient time to fully recover after training sessions, you will lower your risk of overtraining (which reduces your heart rate variability).

Increase your training load progressively. Don't jump straight into training everyday if you are currently only training a few days a week. Similarly, avoid suddenly increasing the number of high-intensity sessions you perform each week. Slowly progressing your training will limit the chances of overtraining and reduced your heart rate variability (HRV).

Use a sleep tracker to check you are getting at least 7 hours of sleep a night. Poor sleep can lead to reductions in heart rate variability and have further knock-on effects on your endurance exercise performance.

Focus on adequately rehydrating after exercise. You can make your own rehydration drink by mixing 200ml squash with 800ml water and adding a large pinch of salt. Dehydration can lower your heart rate variability (HRV) and slow your recovery rate after exercise.

Include salmon or mackerel in two meals a week. These are rich sources of omega-3 fatty acids, which have been shown to increase parasympathetic regulation of the heart, resulting in improved heart rate variability.

Supplement with at least 1000 mg of omega-3 daily, if not regularly consuming fish. Omega-3 fatty acids can help to improve heart rate variability.

Moderate your alcohol intake. Alcohol prevents the parasympathetic nervous system from helping your body rest during sleep, which leads to lower heart rate variability (HRV) in a dose-dependent way. Two drinks have a significantly greater effect on HRV compared to one drink.

If currently smoking, try nicotine replacement (for example, gums/patches) or talk to your clinician about stop smoking programmes. Smoking increases resting heart rate and reduces heart rate variability (HRV) which impairs endurance performance particularly in exercises involving the lower limb muscles.

Caffeine and endurance performance

Endurance

Could a cup of coffee improve your endurance?Maurice Garin, winner of the inaugural 1903 Tour de France, reportedly stopped at cafes en route to drink coffee, which he claimed helped him to cycle the eye-wateringly long distances. He might have been right; today, studies consistently show that caffeine can improve endurance performance by between 2% and 4%. Differences in the speed at which we break down or ‘metabolise’ caffeine, however, mean that some of us respond better to caffeine than others. "Fast metabolisers", who break down caffeine more quickly, may notice quicker running, cycling and swimming times after consuming caffeine. By contrast, “slow metabolisers” may actually perform worse at endurance activities after caffeine.In this trait, you'll find out whether you're likely to improve your endurance when taking caffeine. Your results are based on CYP1A2 gene variants, which determine how fast you break down caffeine, as well as ADORA2 variants, which affect how sensitive you are to caffeine's potential negative effects, such as anxiety and insomnia.

Your result

- Increased Impact
- **Average Impact**
- Lower Impact
- No Data

Your genes suggest you could benefit from caffeine, but may reap less benefit than fast metabolisers.

Caffeine has been widely shown to improve endurance performance, although the benefits vary considerably from person to person. A meta-analysis of (mainly cycling) time-trial studies found that caffeine improved times by between 3 and 16% versus placebo.

These differences in performance response partly depend on variants of our CYP1A2 gene, which influence how quickly we metabolise or break down caffeine.

Fast metabolisers, who have the AA genotype (rs762551) of the CYP1A2 gene, are shown to derive greater endurance performance benefits from caffeine. Slow metabolisers (CC genotype) may have less improvement or even a drop in performance when taking caffeine.

Variants of our ADORA2A (adenosine A2A receptor) gene can also influence performance response by affecting our sensitivity to caffeine. People with high caffeine sensitivity are more susceptible to insomnia and anxiety, which can impair endurance performance by disrupting sleep and wellbeing.

You are classified as an 'intermediate metaboliser'. This means you break down caffeine less quickly than fast metabolisers, but more quickly than slow metabolisers. Your CYP1A2 (rs762551) genotype is AC.

Some studies suggest you may derive less endurance benefits from taking caffeine. One randomised controlled trial of athletes found that intermediate metabolisers taking caffeine (at doses of 2 and 4 mg/kg bodyweight) did not improve their 10 km cycling time.

Caffeine can impair dilation of the coronary arteries and blood flow to the heart during exercise. Intermediate metabolisers may reap less endurance benefits as they clear caffeine less quickly, which causes longer impairment of blood flow to the heart during prolonged exercise.

You are classified as having 'low sensitivity' to caffeine based on variants of your ADORA2A gene. This means that you are less susceptible to anxiety and insomnia when consuming caffeine.

Your combined CYP1A2 and ADORA2A variants suggest that you may derive less performance benefits compared to fast metabolisers. Due to the small effects of gene variants and

importance of non-genetic factors, you still could get some endurance benefits when consuming 3-6 mg/kg bodyweight of caffeine.

Recommended Actions

Use 3-6 mg/kg of caffeine preworkout. This would mean if you weighed 60 kg, you would take 180-360 mg of caffeine. This dosage range has been shown to provide some benefits to endurance performance for your genotype.

Consume caffeine 60 mins before exercise. This is the ideal period for maximising performance benefits during your workout, based on ISSN guidelines.

If using coffee preworkout, an espresso would be a good option. Espressos contain the highest amount of caffeine compared to other forms of coffee. One single shot contains 63 mg of caffeine.

Avoid caffeine at least 4 hours before going to sleep. Caffeine can negatively impact your sleep quality, and poor sleep can impair muscle adaptations from exercise.

Do not consume more than 9 mg/kg of caffeine per day. There is an increased risk of side effects such as insomnia and negative cardiovascular impacts when more than this amount is consumed daily.