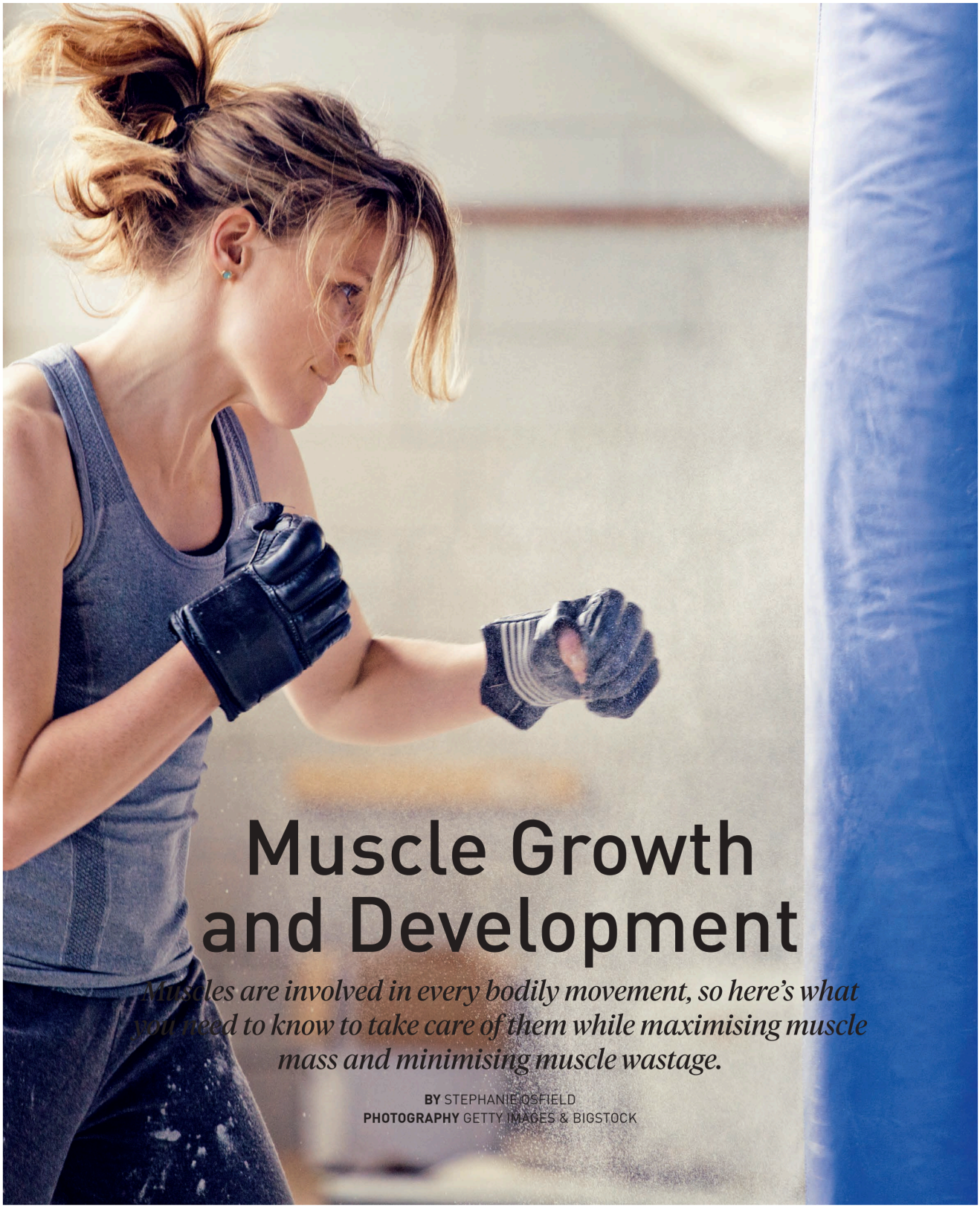
- Muscles

WellBeing | special report MUSCLE



Muscle Growth and Development

Muscles are involved in every bodily movement, so here's what you need to know to take care of them while maximising muscle mass and minimising muscle wastage.

BY STEPHANIE OSFIELD
PHOTOGRAPHY GETTY IMAGES & BIGSTOCK



Protein and carbs are a muscle-building combo.

Your body's muscular system is an important network of soft, elastic tissue. From larger muscles such as the quadriceps in your thighs to smaller muscles including the orbicularis oris in your lips, your muscles have many functions. They:

- **Generate movement.** Muscles move by contracting and relaxing. When they contract, they shorten and push together, making the muscle look bulkier. When they relax, the fibres move apart and the muscle lengthens and thins. Many muscles are attached to your skeletal framework and help to move your bones and limbs. In some areas of the body, their contractions also ensure the movement or nourishment of important bodily fluids.
- **Stabilise your joints.** The fibres of skeletal muscle are held together by sheaths of connective tissue.
- **Affect metabolism and body temperature.** When they are burning energy to move, your muscles become warmer, which is why your body warms up after exercise. Muscle tissue also helps boost your metabolism.
- **Help keep you upright.** The muscle groups attached to the bones in your legs, abdomen and spine are particularly important for this function.

The makeup of muscle

Your body houses an estimated 600 to 700 muscles, which make up around 40 per cent of your body weight. There are three major types of muscle:

- **Smooth muscle**, which is in organs and areas such as the gut
- **Skeletal muscle**, which is connected to the bone
- **Cardiac muscle**, which keeps your heart beating

Muscles also come in different shapes: flat (eg diaphragm and forehead), circular (eg pupils in eyes, entrance to bladder), triangular (eg deltoids in your arms) and spindle-shaped (eg biceps and triceps).

Each muscle contains tens of thousands of tiny fibres and each fibre is made up of long, thin cells packed together in bundles. The more muscle fibres, the stronger the muscle. Nerves activate muscle cells via electrical impulses that stimulate the cells to contract or relax. Your muscles also contain blood vessels that remove waste products and carry nutrients from your food to energise your muscles so they can move.

Feeding your muscle

Muscles are fuelled by glucose. This comes from carbohydrate foods such as rye bread, fruit, rice and vegetables such as corn.

Muscles also contain two kinds of protein, myosin and actin, so protein foods are pivotal to muscle development and maintenance.

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Under a microscope, proteins look a little like necklaces: they are made up of strings of attached molecules called amino acids, which contain important chemicals such as carbon, hydrogen, oxygen and nitrogen. Of the 20 existing amino acids, nine are considered "essential" because they are critical to the health and proper function of your body and mind.

Protein is a necessity for optimal health, fat loss and muscle gains and is important to the function of all the cells in the body. Aim for a palmful of protein at each meal, whether from foods such as chicken and eggs or plant sources such as legumes (chickpeas).

Your body houses an estimated 600 to 700 muscles, which make up around 40 per cent of your body weight.

Some exercise experts recommend that within an hour of exercise, you should eat some healthy protein and preferably a little carbohydrate to go with it. Together, protein and carbs have been shown to increase protein uptake in cells, which helps build muscle tissue after exercise. Meat, beans, eggs and chicken are excellent sources. Banana in yoghurt can provide a food mix of carbs and protein.

Muscle stealers

Certain lifestyle factors can cause muscle tissue to be broken down more rapidly, resulting in an overall loss of muscle mass. These factors include stress, rapid weight loss and kilojoule restriction.

Stress

When you almost trip down the stairs and your heart rate and perspiration suddenly ramp up, you release stress hormones such as cortisol and adrenalin. Cortisol is catabolic, which means that it can decrease anabolic hormones including IGF-1 and GH, which both help to encourage muscle growth; and increases protein and muscle breakdown when cortisol is released as part of the fight-or-flight stress response.

As your body thinks you are facing an emergency, its job is to then pull blood sugars and fats and protein from where they're stored in tissue and get them into your bloodstream to give you a quick source of energy. It also encourages you to store more fat, particularly unhealthy visceral fat in your belly.

If you're under chronic stress — or even if you've had a stressful couple of days — the excess cortisol can put your body into a state of constant catabolism that is breaking down your muscle.

Though exercising might seem to be the best way to burn off the cortisol, there's one problem: exercise also prompts the release of cortisol. In a healthy, well-functioning body, that rise is only temporary but if you have health, hormonal or stress issues, then your cortisol may be chronically elevated. Mild, moderate and high-intensity exercise may then raise cortisol further and, the more taxing the workout, the higher the cortisol release.

This is beneficial for many people but may be bad news for your muscles if you've been living in a stressed-out state for a lengthy period of time. If that is the case, engage in some slow-moving exercise such as yoga and tai chi to naturally counter the cortisol increase. This will have calming effects on your body and mind, helping to lower cortisol levels and preserve your muscle. In addition, make sure you regularly engage in activities that promote relaxation and calm, such as mindfulness, meditation and yoga nidra.

Rapid weight loss

In the first week or two of a diet, the buzz you feel when your clothes suddenly become

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Marathon runners are often born with more slow-twitch fibres.

a little looser is due to the burning of your carbohydrate stores (also called glycogen). For every 1 gram of glycogen you burn, you also lose 3g of water, which is why it's so easy to lose a little weight when you first restrict kilojoules. Unfortunately, you'll regain this fluid as soon as you eat more carbs or kilojoules.

Meanwhile, most diets cause you to lose muscle as opposed to fat. Rapid weight loss, which occurs at the start of a very low-kilojoule diet, can lead to an unhealthy ratio of 60 per cent muscle loss to 40 per cent fat loss. So don't be fooled into thinking that a big, rapid drop on the scales is good news. In fact, it most likely means your body is in a catabolic state where you're exercising too much and eating too little and, as a result, your body is using your muscle for fuel.

As muscle is more active than fat tissue, the less muscle you have, the fewer kilojoules you burn. No matter how many protein shakes or powders you consume or how much exercise you do, you won't stop the process of losing muscle if you're not eating enough kilojoules. To lose mostly body fat and preserve muscle mass and density, you need to reduce body weight as slowly as possible.

Meanwhile, chronic dieting over years can cause a condition called sarcopenia — literally, "poverty of flesh". A person suffering from sarcopenia can be of normal weight or even underweight but have a high body-fat percentage due to loss of muscle from long periods of restricted kilojoules. This may cause someone in their 20s, 30s or 40s to have the same lower amount of muscle as someone in their 70s or 80s.

Retention of muscle mass is very important for health and for maintaining a healthy weight. "With age, we tend to lose muscle mass, but people who go on starvation diets tend to lose significant muscle mass," says Stephen Boutcher, associate professor at the School of Medical Sciences, University of NSW.

"Studies show that women who go on a starvation diet, reducing their daily kilojoule intake by 50 per cent, lose about 3 kilograms of muscle over a 16-week period. Since it

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has been estimated that an increase of 1kg of muscle could use up just under 3kg of fat per year, any loss of muscle mass can cause the opposite of the desired effect and actually result in a lower loss of fat, which is why retaining or increasing muscle mass is very important."

Severe kilojoule restriction

When you skip meals and slash your portion sizes, your body starts to think you are facing a famine. A whole array of hormonal reactions then take place that cause your metabolism to slow down and lead your body to conserve more fat. At the same time, eating a low-kilojoule diet or skipping meals both prompt the fight-or-flight response. This again triggers cortisol, which can be continuously wasting away the very muscle that would otherwise help you maintain a fast metabolism and help you burn more fat so you maintain a healthy weight.

To break this muscle-wastage cycle, eat smarter. If you've been skimping on kilojoules while following food plans such as paleo, raw or vegan, start gradually increasing your kilojoule intake to ease your body out of starvation mode. Gauge how your body is responding to the change and increase your kilojoules every week by about 500kJ until you're back to a higher kilojoule intake. This will help you preserve more muscle. If you must undergo a period of kilojoule restriction, do it for several weeks, not months or years. Or engage in intermittent fasting, where you cut kilojoules two days a week.

Moving to make muscle

With age, muscle can atrophy. This is why exercise is so important. It can help you conserve muscle and build more.

In particular, exercise helps to strengthen muscle fibres and give you a more muscular body composition.

1. Strengthening muscle fibres

Muscles have two different types of fibre that stimulate muscle contraction in different ways. They're called fast- and slow-twitch fibres in reference to the speed at which they contract. Think of slow-twitch fibres as the slow lane — they have more endurance because their main fuel source takes much longer to deplete. Fast-twitch fibres, the express lane, are able to produce power more quickly — for example, when you run for the bus — but their fuel source is in short supply so they fatigue faster.

Though training can enhance both types of fibre, genetics appears to be the overriding factor as to which type of exercise you excel at, based on whether you were born with a higher percentage of slow- or fast-twitch fibres in your body. Different kinds of exercise stimulate different kinds of muscle fibre:

When you have more lean muscle, your metabolic rate is higher, even when you're resting. This is because muscle is a tissue that constantly requires rebuilding and repair and your body burns kilojoules as it helps keep muscle tissue healthy.

- **Aerobic exercise.** Slow-twitch fibres, which are more abundant in areas such as the calves, trunk and forearms, are involved in aerobic activity and are geared towards using oxygen for energy. These are engaged in everyday activities such as stepping into the shower or walking to the car. Marathon runners are often born with more slow-twitch fibres, which make them better able to do aerobic exercise over longer durations. Most people have a mix of slow- and long-twitch fibres but, if at school you were better over long distances

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than sprints, it's likely you were born with more slow-twitch fibres.

- **Anaerobic exercise.** Your fast-twitch muscle fibres, which are used in anaerobic exercise, allow you to engage in quick and strong movements such as lifting a child or bag of groceries, running to catch a ball or swinging a golf club. As you age or become unfit, not only do your fast-twitch muscle fibres start to lose tone, they may also atrophy so that you find certain activities and even household chores (such as lifting a heavy load of washing) more taxing than you used to. This is why it's important to ensure you engage in anaerobic activities, thus maintaining your muscle strength and health by ensuring that your fast-twitch fibres don't lose their condition.

2. More muscular body composition

Exercise is the most effective way to combat visceral fat because it increases your body's ratio of lean muscle to fat. Muscle is more metabolically active; that means when you have more lean muscle, your metabolic rate is higher, even when you're resting. This is because muscle is a tissue that constantly requires rebuilding and repair and your body burns kilojoules as it helps keep muscle tissue healthy.

Muscle is also denser than fat — that's why some people appear to gain weight on the scales as they get fitter. Don't let that demotivate you; it means your body composition is becoming healthier. If you're trying to maintain a healthy weight or boost fitness, try to judge your success by how you fit into and feel in your clothes, how many centimetres you've lost from your waistline or thighs and how much easier it is to walk up a flight of stairs.

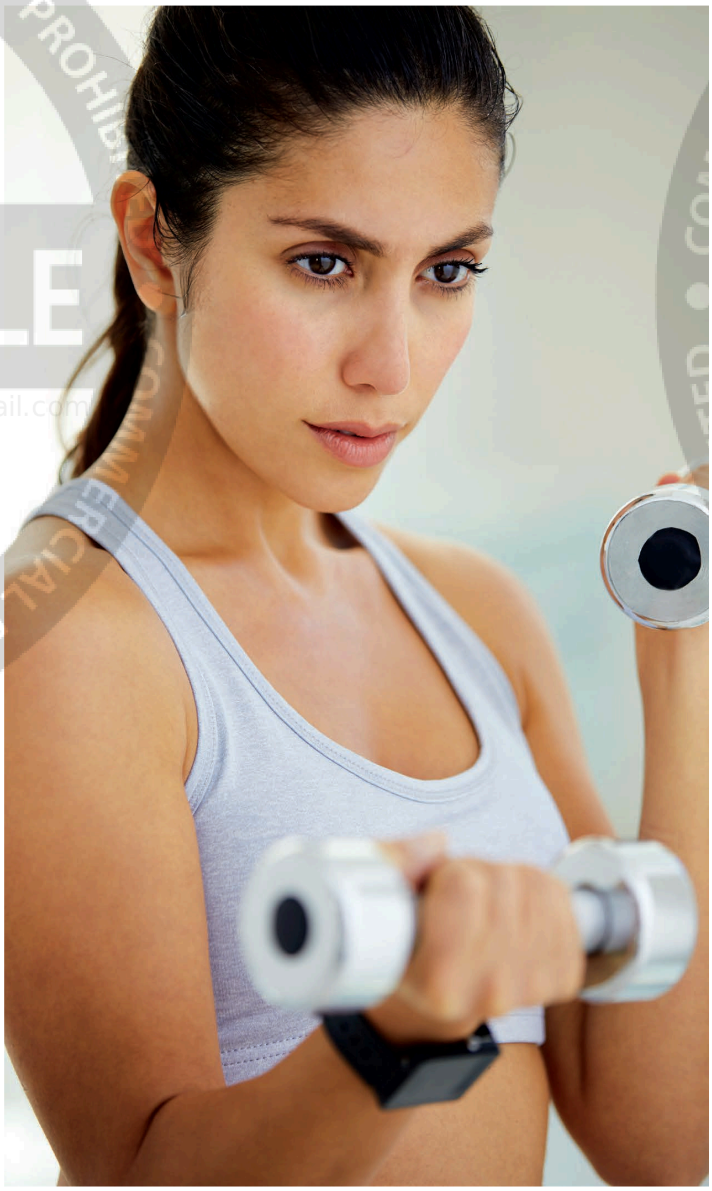
You can also use body-composition scales to track any changes to your muscle-to-fat ratio on a regular basis. These scales rely on an electrical current sent from your feet through the body to measure the resistance of different body tissues.

To help burn fat and build muscle, exercise smarter, not just harder. Maximise the benefits of your workout routine by:



Swimming is a good form of exercise for building and toning muscle and working a range of muscle groups.

- **Cross-training for variety.** Aerobic swimming, cycling, running and rowing are all good forms of exercise for building and toning muscle and working a range of muscle groups.
- **Working out with weights.** Strength training improves your lean muscle mass so you burn more fat, even at rest. Aim for at least three to four sets of eight to 12 reps. Women don't have enough testosterone to create big, bulky muscles. In fact, weight training builds more lean muscle, which will help you burn more kilojoules. Two one-hour sessions of weight training each week can also help blitz belly fat and prevent middle-age spread, according to research at the University of Pennsylvania. If bulking up concerns you, use a lighter weight and do more repetitions. Strength training is how you avoid getting "skinny fat", or losing muscle when you're in a fat-burning kilojoule deficit. Resistance training, where your muscles contract against an external resistance, is similarly good for muscle building.
- **Practising Pilates and yoga.** These exercises involve movements such as twists and planks, which help strengthen underutilised muscles such as the oblique muscles that run down the sides of your abdomen.
- **Pushing harder for short bursts.** High-intensity interval training allows you to expend a large amount of kilojoules in a short space of time and quickly uses up your glycogen stores so that your body then starts to burn fat for fuel. In the process, you become leaner and build more muscle. On the treadmill, you can try interval training by doing a 10-minute routine of sprinting for 30 seconds followed by a slower 30-second period of recovery between each burst. Afterwards, these intervals of anaerobic exercise increase your EPOC (excess post-exercise oxygen consumption), which stays elevated for hours to keep you burning kilojoules. As you get accustomed to this change, lengthen the duration of the intense bursts or shorten the rest intervals.



- **Adding challenges.** Your body is very clever so it will adjust to exercise. For that reason, aim to keep changing your workout every four to six weeks to ensure you continue to build new muscle due to the different challenges. That may be as simple as adding hills and stairs to walks, doing an extra 10 pull-downs on a machine or using a different stroke when swimming.
- **Stretching.** Your muscles need to be stretched regularly to keep them in good shape. Stretch all your major muscles after each workout

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and preferably every day during yoga flows. Muscles often tighten as a result of sitting for long periods and as part of the ageing process. Stretching lengthens your muscles and prevents exercise- and age-related shortening.

The role of protein or muscle-building supplements

In the last decade, there has been a huge increase in the use of protein powders to help build muscle. Though food is the best protein source, if you do take protein powders, read the labels to watch out for unhealthy added ingredients such as flavours, sweeteners, fillers, thickeners, colours and preservatives. Some people find that protein supplements encourage them to grow unhealthy gut bacteria and suffer issues such as unpleasant-smelling flatulence, bloating or belly discomfort. This is clearly not good for overall health.

A growing number of companies now offer protein supplements that are natural and free of additives. In that natural state, they can have quite an unpleasant taste, so may need to be added to a little fresh juice to ensure they are more palatable.

The following protein powders are most commonly taken before and after exercise workouts to help enhance muscle growth:

Whey

Whey is a "complete" form of protein, which means it contains all nine essential amino acids. It's also the "it" supplement of the moment. It comes from the liquid part of milk that separates from the curd (a soft white substance that becomes the basis for cheese). There are two main types of whey powder: whey concentrate (usually around 70–80 per cent protein but sometimes as low as 30 per cent)

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and the more expensive whey isolate (about 90 per cent protein).

Most whey concentrates and isolates are available as "intact proteins". That means they have less processing than hydrolysed whey, which has been treated with enzymes or heat to break the long chains of amino acids down into smaller chains. Currently, there's no consensus about which form is better. Though some trainers and experts believe hydrolysed protein is absorbed more rapidly, others believe that it may damage the protein, making it less readily recognised and utilised by the body, thus actually making it unhealthy for the body. Obviously, this type of protein is not a good choice for those who are lactose intolerance or avoid dairy foods.

Casein

Milk is made up of about 20 per cent casein, a complete protein that has high levels of glutamine, the most abundant amino acid (building block of protein) in the body. Casein forms a gel in your stomach and this helps it slow the release and digestion of the amino acids in the powder. Studies suggest that there's benefit in combining whey and casein protein, so some people mix 10g of each for a post-workout shake.

Branched-chain amino acids (BCAAs)

BCAAs are found in protein powders such as whey but are also available as a stand-alone powder, which contains their three different forms: leucine, isoleucine and valine. BCAAs have become very popular in the past five years and are the building blocks of muscle tissue. They are the main amino acids used by your muscles during exercise.

When you work out, a substance called pyruvate is formed from the breakdown of your glycogen and glucose stores. Within your muscles, BCAAS and pyruvate are involved in the formation of alanine, which is then sent to the liver to raise your glucose levels. The glucose can then be sent back to your muscles and used for energy.

Again, this doesn't mean you should overdo your intake. Recent studies have shown that BCAAs can compete with amino acids such as tryptophan and tyrosine, which help produce the "feel-good" chemicals dopamine and serotonin in the brain. In short, too many BCAAs could leave you feeling moody, anxious or depressed.

If you do take protein powders, read the labels to watch out for unhealthy added ingredients such as flavours, sweeteners, fillers, thickeners, colourings and preservatives.

Non-dairy protein

Non-dairy forms of protein powder come from sources such as peas, brown rice and soy. Pea and rice protein are often combined to form a complete protein that also offers fibre and B vitamins. Non-dairy or vegetable protein options are good for those who are lactose intolerant and people with sensitive digestive systems that react to whey and casein by developing gas and bloating. They also clearly suit people following a vegan diet.

There is one drawback in relation to soy protein. There are some concerns about whether the phytoestrogens found in soy protein can be dangerous for women, particularly when concentrated in a protein powder. Phytoestrogens mimic oestrogen and some studies have suggested they may be linked to issues such as breast tenderness and increased risk of breast cancer. If this concerns you, opt for a rice or pea protein powder instead.

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Muscle pain

When you experience muscle pain, it can cause mild or intense discomfort that leads to temporary or lengthy interruptions to your daily life. Different triggers can kick-start the following common types of muscle pain:

- **Stitches.** These muscle cramps in your side usually occur during exercise. It can help to stop gulping air and slow your breathing to a more even rate. Being dehydrated or drinking too much water in close proximity to a workout can also cause stitches in some people. During a workout, aim to take small sips of water, not huge gulps.
- **Cramps.** These can often occur due to lack of minerals, such as potassium, calcium and sodium (salt). Magnesium can help alleviate the pain. This multitasking mineral is needed for your body to complete around 300 enzyme responses. According to the Human Genome Project, more than 3500 proteins also have binding sites for magnesium, which may be why it's such a potent muscle relaxant. Magnesium taxis ions such as calcium and potassium across cell membranes, a process pivotal for nerve impulse conduction, muscle contraction and normal heart rhythms. Magnesium is also the counter-ion for calcium and potassium in your muscle cells. This is why, if levels drop too low, your nerve signals and muscle contractions may be affected, leading to muscle cramps and heart arrhythmias.

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Magnesium glycinate is often recommended because it's a more gut-friendly form that is highly bioavailable and usually well tolerated, causing fewer side effects such as diarrhoea. As well as supplements, try magnesium-rich foods including seaweed, cruciferous vegetables (such as kale, broccoli and cabbage), nuts, cacao, Swiss chard, buckwheat and millet, fish, brown rice, lima beans, okra and banana. Topical magnesium in the form of cream or oil can also help relieve pain when applied to sore muscles and directly absorbed through the skin.

- **Slumped posture.** This can cause muscle strain, so constantly check your posture throughout the day. When standing, keep your weight evenly balanced between both feet and remember to keep your shoulders back, without being strained. When sitting, keep the shoulders back in line with the hips, put your feet flat on the floor or on a footstool and place a small pillow or support behind your back to support your lumbar and remind you to sit up straighter.
- **Unsupportive shoes.** High heels tilt your pelvis forward, throw your centre of gravity out of alignment and force your back muscles to work harder to maintain stability. For maximum back support, women should choose a shoe with a wide, flat heel no higher than 2.5 centimetres and men should minimise wear of loafers and thongs. Lower muscular back pain can also be treated in some people by addressing poor foot posture with orthotic supports in shoes.
- **Poor lifting technique.** Next time you lift a heavy child or box, be conscious of your technique so you minimise muscle strain in the back. When you lift, bend at the knees, not the waist, bring the object as close as you can to your body and, keeping your back straight, use the power in your legs for the lift.

Stretching lengthens your muscles and prevents exercise- and age-related shortening.

- **Post-exercise soreness.** Yesterday, after your new workout, you felt like a warrior. Today, there's so much pain in your bottom, thighs and arms that being upright is an Olympic effort. And stairs? Hello, Mount Everest! Thankfully, within two to three days, the pain subsides.

Day-after exercise pain is known as DOMS (delayed onset of muscle soreness). It occurs when you start a new exercise routine, substantially increase your workout intensity or duration or have taken a break from exercise for several weeks or more due to an interruption such as illness.

DOMS usually occurs one to two days after exercise but can appear as little as eight hours later. It leads to a soreness or stiffness that's not obvious while you're lying still but is felt the moment you start to move. Though not caused by injury, it does indicate that your muscles have sustained a little damage from being pushed beyond what they are accustomed to.

If DOMS occurs, do less intense exercise for a few days until the peak of DOMS subsides or change your workout so that you focus on a different set of muscle groups. Once DOMS has kicked in, it usually resolves within three days. If you're finding the discomfort hard going, apply heat or ice packs, gently massage the area or engage in gentle stretches.

To prevent the development of DOMS pain, ease your way into any new workout by building the intensity and duration over days and weeks. Then you enjoy the benefit of the "repeated bout affect" where your body adapts to the workout and pain is lessened. Even just a few weeks is a long time for muscles to get out of condition as they adapt to change very quickly, including less movement, and need to be gently retrained after an exercise break due to something such as illness.

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• **Going for the burn.** This pain can feel like a deep, almost searing burning in a muscle group and joint as you push them harder than usual during exercises like lunges, squats or a lengthy jog. The burn may be so intense and painful that you struggle to continue. The pain subsides when the exercise stops but your muscles may feel rather wobbly and worn out for hours.

Your muscles are protesting about the reduced amount of oxygen. When this happens because you're pushing harder, you produce a substance known as lactic acid, which builds up in the muscle and causes a burning sensation. This pain is your body's way of slowing you down to prevent permanent damage.

Stop pushing your muscles to the brink. Burning pain is not a sign that you're getting fitter — it's a sign that your body is struggling to cope. Instead, when increasing the duration or intensity of exercise, add just a little more challenge every day and don't push too far beyond your endurance. If going for the burn helps you feel more motivated, put up with the feeling for a few reps or a few metres but don't push on and on in agony. Otherwise you risk causing an injury.

• **Muscle injury.** Ongoing or recurring pain during or after exercise that continues for days and weeks is usually an indication of injury. A similar pain can occur when you pull a muscle, which may be due to strain. Suddenly, you need a whole repertoire of new moves to navigate sitting and standing and negotiating the stairs because you have a pain from muscles in your knees, feet, shoulders, arms or back.

Poor technique is often to blame — for example, lunging with bad knee placement, such as your knees leaning over your ankles. Not warming up and cooling down sufficiently can also contribute to this problem. Or the pain may be triggered by an old injury flaring up or a new health condition such as osteoarthritis. Often, injury or recurring pain is a signal that you need to do other exercises to strengthen the stabilising and smaller muscles around your joints and bigger muscle



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Olive oil and oily fish contain long-chain omega-3 essential fatty acids, which are potent anti-inflammatory chemicals.

Protein is a necessity for optimal health, fat loss and muscle gains and is important to the function of all the cells in the body. Aim for a palmful of protein at each meal.

groups. For example, strengthening your gluteals or the muscles at the back of the hip or on the inside of the legs can help you stop an alignment issue, such as leaning your knees in when you walk or jog.

Avoid any exercises that clearly trigger the pain, and strap or bandage the muscle and joint if possible to help stabilise it during movement. See a GP, physiotherapist or exercise physiologist who specialises in the biomechanics of exercise. Otherwise you risk causing new muscle pains and strains from adjusting your movement to minimise the pain from the injury and, as a result, placing problematic strain on other joints and muscles.

Treating muscle pain

To alleviate muscle pain after an injury, here are three positive measures to take:

1. Apply the RICE method as soon as you can:
- Rest the injured area.
- Ice should be applied for 20 minutes straight after the injury and then for 20 minutes every four hours during the next two days.
- Compress the area lightly with a firm crepe or elastic pressure bandage.
- Elevate the limb above the heart.

After 48 hours, switch to warm packs or hot water bottles and do a few gentle stretches several times a day.

2. Reduce inflammation. The following nutrients can help:
- **Ginger.** Research shows this wonder root can block pain receptors in the brain that respond to triggers, such as inflammation and acidity.
- **Broccoli.** Contains a compound called sulphoraphane, which helps protect the

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cartilage in joints. This ensures the joints work more effectively to support muscle.

- **Turmeric.** This aromatic spice is high in curcumin, which reduces the inflammation that usually occurs when muscles are sore.
- **Olive oil.** Contains oleocanthal, which is similar to chemicals found in the pain-relief drug ibuprofen, shows La Trobe University research. Oily fish such as salmon, tuna, sardines and other deep-sea fish contain long-chain omega-3 essential fatty acids, which are potent anti-inflammatory chemicals.
- **Almonds.** These are rich in vitamin E, which helps reduce the production of prostaglandins, the chemicals that cause pain.
- **Cherries.** These red, round superfoods may be better than aspirin for pain relief, shows research from Michigan State University. Eating cherries or drinking cherry juice daily may help reduce arthritis aches and muscular pain after exercise and lower cholesterol, too.
- **Onions and garlic.** These contain flavonoids including quercertin, which may help counter chemicals that cause pain.

3. Keep moving. The less mobile you are when you have more muscle pain, the fewer nutrients will be circulated to your muscles to aid repair. So stay mobile and, if necessary, see a physio to get some appropriate exercises you can engage in to ease the pain and keep your muscles healthy.

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