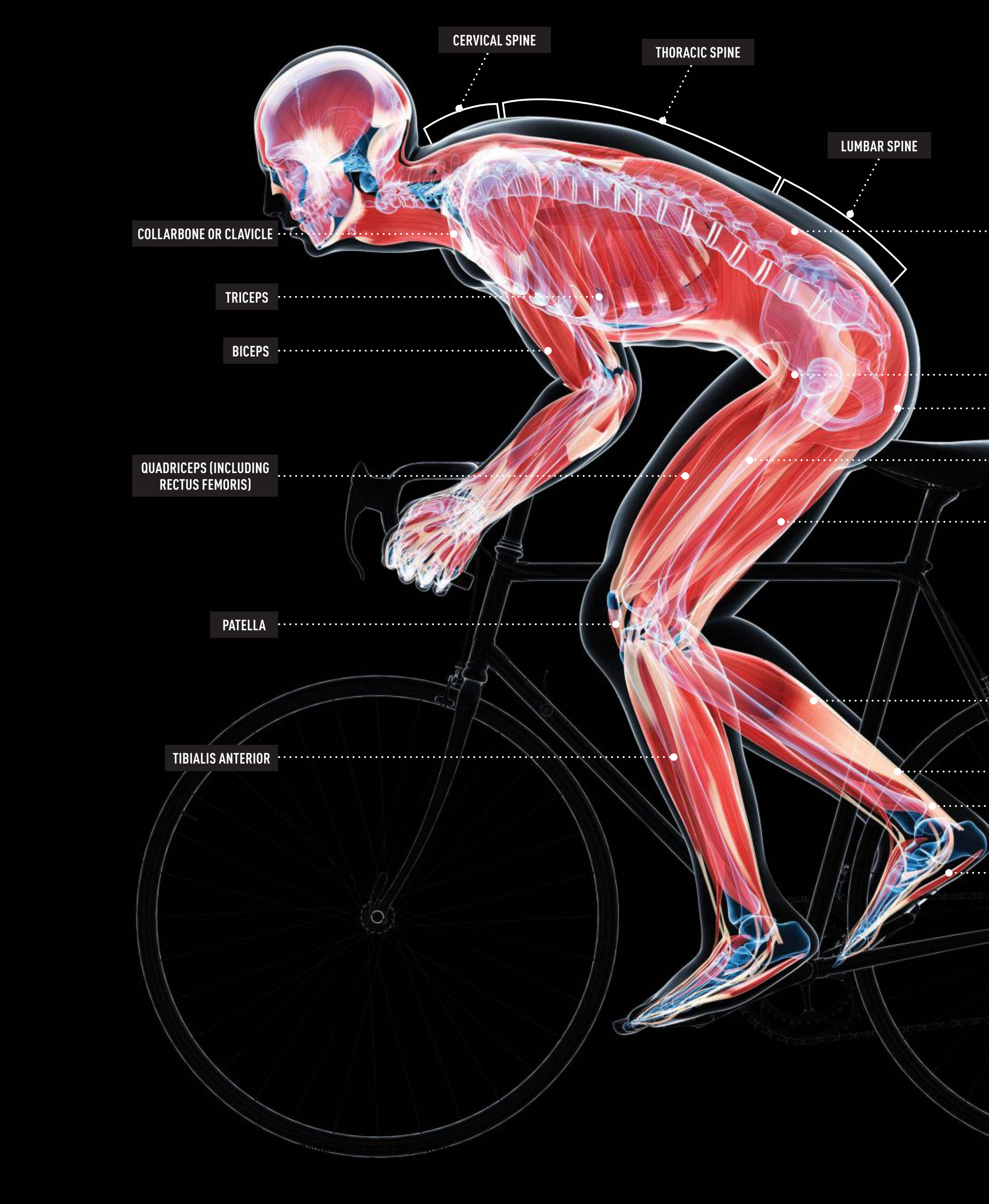
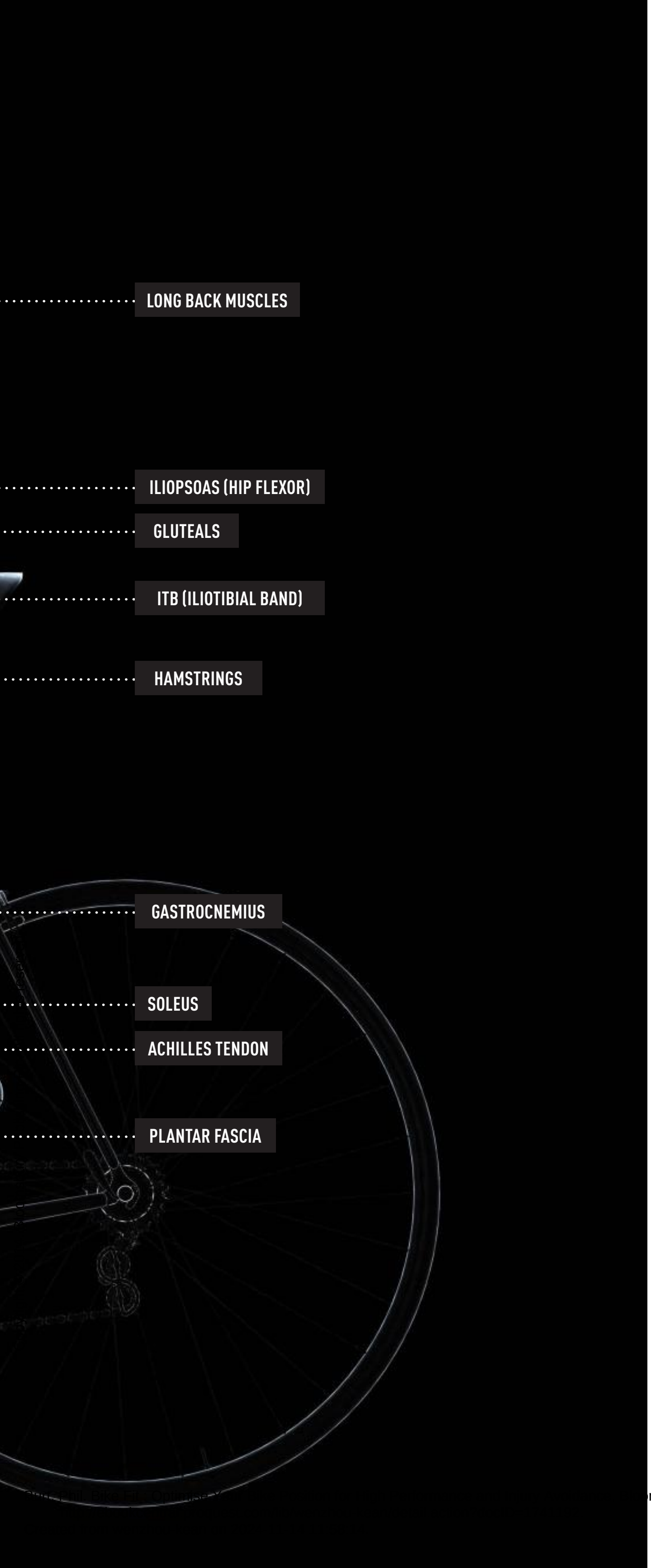


CERVICAL SPINE
THORACIC SPINE
LUMBAR SPINE
COLLARBONE OR CLAVICLE
TRICEPS
BICEPS
QUADRICEPS (INCLUDING RECTUS FEMORIS)
PATELLA
TIBIALIS ANTERIOR



02

BIKE-RELATED ANATOMY

BIKE-RELATED ANATOMY

In this chapter, we will examine the roles of certain muscles, joints and tendons in terms of cycling-force (torque) production, stability, posture, attenuation and ventilation. The overriding importance of power needs to be offset against your ability to hold and sustain a cycling posture or position. An understanding of which muscles are involved with both is very worthwhile.

The locomotion of cycling is made possible by the coordination of a series of contractile elements (muscles) creating force, which is transferred through a series of levers (bones) via joints to create torque at the pedals. Muscles are essentially a vast array of a series of sliding filaments. These filaments can hold static positions (isometrics), create force by shortening (concentric), or modify (attenuate) load by controlling the gain in muscle length (eccentrics).

Imagine holding a tin of beans in your right hand, with your elbow at a right angle to your body, while keeping absolutely still. The biceps muscle in your arm is not shortening or lengthening, but it is still working against gravity to hold the arm and tin of beans where it is. This is an isometric contraction. If you move the tin towards your shoulder by flexing your elbow, you shorten the biceps muscle. This is called a concentric contraction. If you then slowly lower your muscle in a controlled way (i.e. you lower your hand, rather than just letting it drop), your biceps is lengthening but is still working to control the weight of the tin against gravity. This is an eccentric contraction.

Muscular actions and reactions are controlled by stimulation from nerves linked to the central nervous system (spinal cord and brain). Too often the neuro part of neuromuscular control is forgotten or overlooked. You can have a massive muscle but if it is poorly controlled or coordinated it will not fulfil its potential. Our force-producing muscles are attached to our bones (or levers) by tendons, which are made up of fibrous material with a linear organisation ideal for transferring force. All the muscles involved in cycling locomotion generate force in order to turn the pedal. 'Torque' is used to describe the force applied to a lever that results in rotation through an axis, and is therefore appropriate for describing force in terms of pedalling.

ANATOMY OF THE LOWER BODY

Joints have multiple axes of motion. The coordination of joints so that they move in the required motion for a given task is a hugely complicated process involving many different elements, such as muscles, joints and nerves. Excessive (too lax) or limited (too stiff) motions can affect the joints above or below that motion in the kinetic chain. This is an important point to realise, that one movement at one part of the body affects the movement of the next like a series of levers.

For example, an observed irregular motion at the knee may be a result of irregularities in the foot or hip, and not necessarily isolated to the knee.

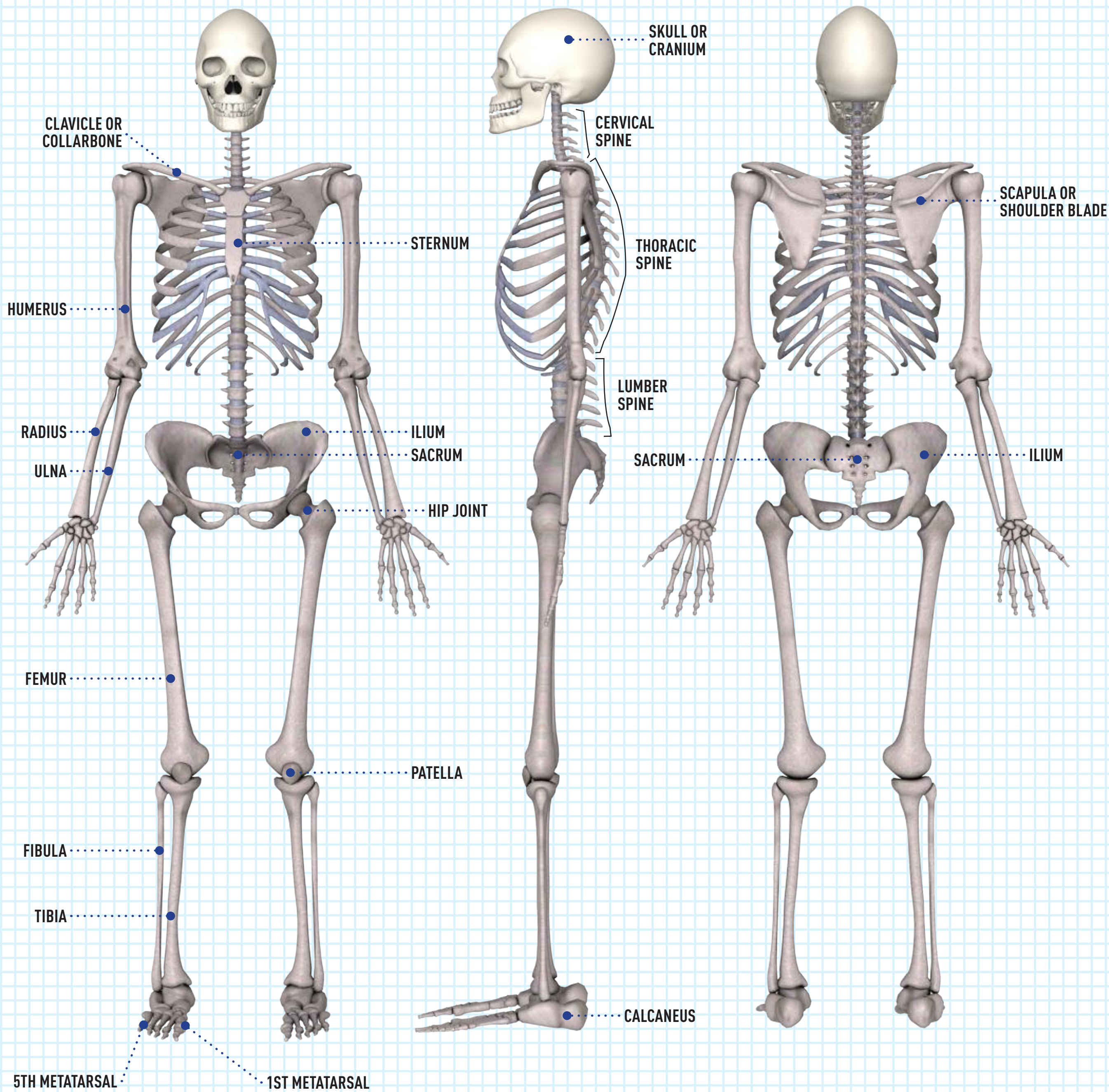
HIP

The hip is part of the pelvis, and is the beginning of the torque chain for pedalling. The pelvis has a socket called the acetabulum that holds the head of the femur (or thigh-bone) to form the hip joint.

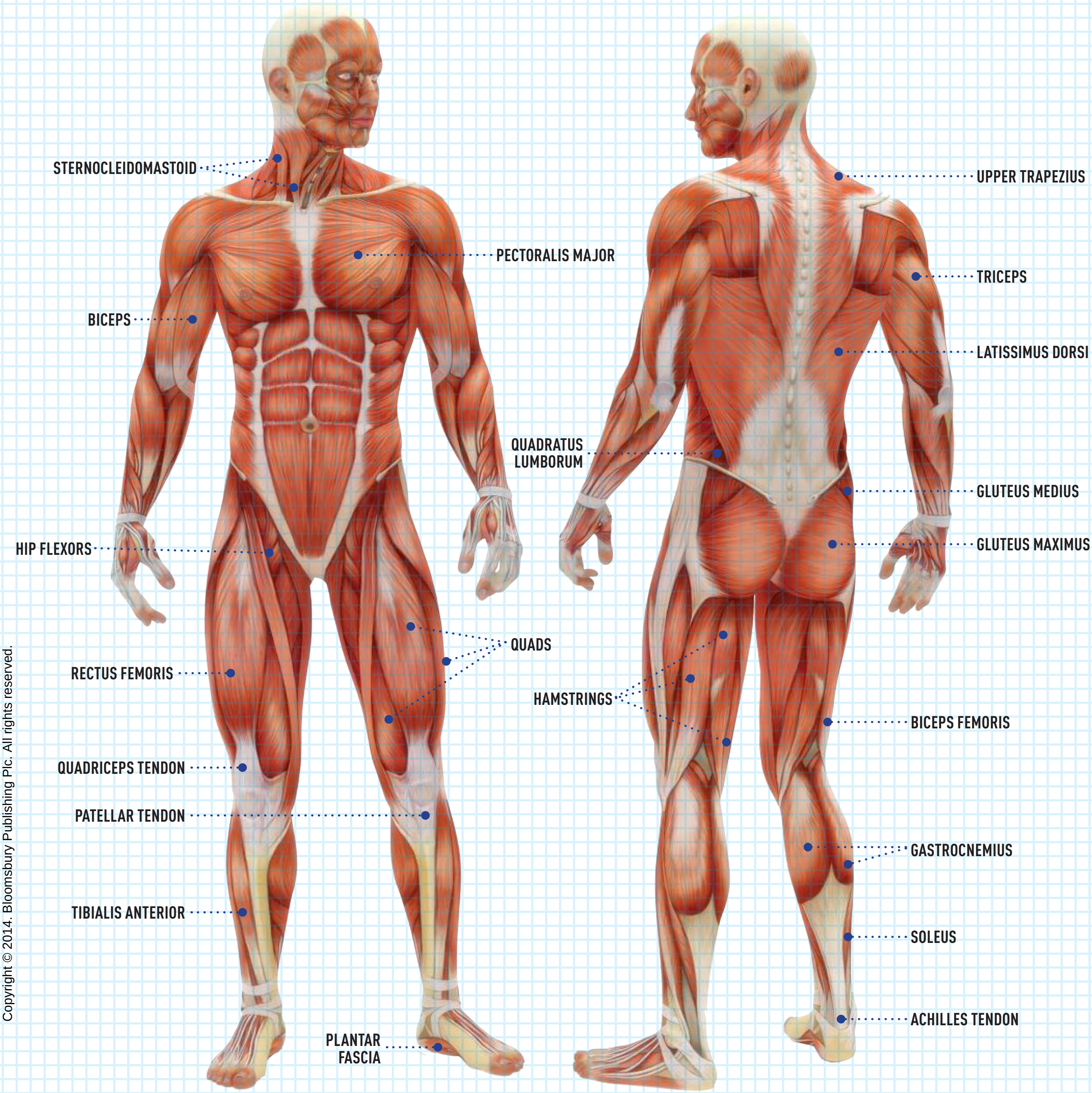
The hip joint allows and guides the motions of flexion, extension and rotation in the act of bicycling. Irregularities in hip joint motion frequently limit the ability of the hip (and therefore the leg) to travel through the top part of the pedal stroke.

Due to its length and the size and number of the muscles surrounding it (the gluteal, and quadriceps of the thigh/knee), large amounts of torque can be generated around the pelvis.

THE **SKELETAL** SYSTEM



THE **MUSCULAR** SYSTEM



PELVIS

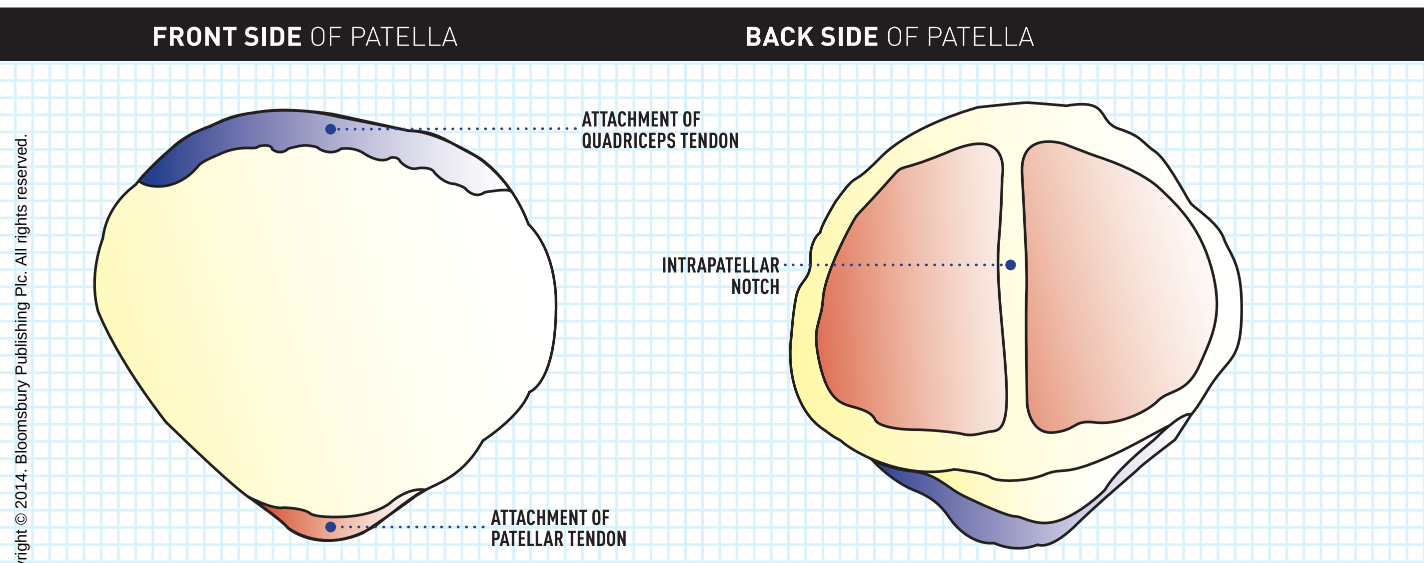
The pelvis is largely composed of two bony regions: the ischium and the ilium. These two bones articulate between the sacrum (the large triangular bone at the back of the pelvis) and the base of the spine at what is called the sacroiliac joint. Those who suffer from problems of the lower back may well have heard of this joint, as it is very close to the lumbar spine, and can be the cause of pain. The ischium is an important part of the body in cycling because the hamstrings originate there, in the area known as the ischial tuberosity. Also important for cycling is the group of muscles that make up the hip flexors, and in particular the inner hip muscles known as the iliopsoas. These are made up of the iliacus, which fills the curve of the ilium on either side, and the two psoas muscles, which originate from the last three vertebrae. The hip flexors are an important muscle group in cycling, but their role is often misinterpreted, and problems with them are frequently misdiagnosed. In fact, they contribute little (10–15 per cent) in the actual pulling up of the femur, except in maximal or sprint cycling, and become tight and/or painful, not due to their workload, but because of the very closed hip position cyclists sustain for long periods of time. See p. 104 for more on this.

KNEE AND UPPER LEG

The knee consists of three bones: the femur (thigh), the tibia (shin) and the patella (kneecap). The femur projects downward to sit on top of the tibia and is the longest bone in the body. Torque is related to the size of the lever producing it: large forces through long levers, such as the femur, result in large torque. The patella acts as a fulcrum through which the force produced from the quadriceps and glutei is transferred to the tibia, and ultimately to the pedal.

Patello–femoral joint

The patello–femoral joint is the knee joint we most often talk about in cycling because of its role as the fulcrum, transferring push to the pedal. The picture below shows an oblique lateral view of the knee and the position of the patella on the femur. The patella is triangular in shape and is a 'sesamoid' bone – one that forms within a tendon. The bony prominence onto which the patellar tendon attaches is the tibial tuberosity.



The patella (kneecap) has the job of working with the quadriceps tendon in which it sits to focus the transfer of force from the quads to the lower leg via the tibia. It moves smoothly across the base of the femur and knee joint.

The quadriceps tendon attaches the quadriceps to the patella and the patellar tendon attaches the patella to the tibia. The picture on p.29 (bottom right) shows the cartilage surface of the patella and the intra-patellar notch, which glides inside the groove created by the two condyles (or knuckles) of the end of the femur. The patello–femoral joint is a particularly smooth cartilage surface, with a coefficient of friction nine times that of ice sliding over ice. For this reason, a number of factors that can cause the patella to move too far out of the groove can cause pain.

The act of pedalling requires coordinated motions from many of the muscles of the lower body. Measuring the electrical activity within muscles (electromyography) during cycling confirms that the quadriceps and the glutei are the primary torque-producing muscles in pedalling. In other words, your thighs and your bum muscles are the key.

Quadriceps

The quadriceps is at the front of the thigh and is made up of four muscles: the vastus lateralis, the vastus medialis, the rectus femoris and the vastus intermedius (which sits under the rectus femoris). The quadriceps is an extender of the knee. When the quadriceps is engaged in a concentric (or shortening – remember the baked bean tin on p. 26) manner, the knee straightens or extends. The rectus femoris is the only quadriceps muscle to cross the hip and knee and is therefore termed a 'bi-articular' muscle, and can flex the hip. More often than not tightness in this muscle will be responsible for knee pain (in this case, patello–femoral pain) as it increases the compressive force around the joint when it is too short or not functioning as well as it should. The extension or propulsive force couple is completed by the gluteus maximus, or hip extender.

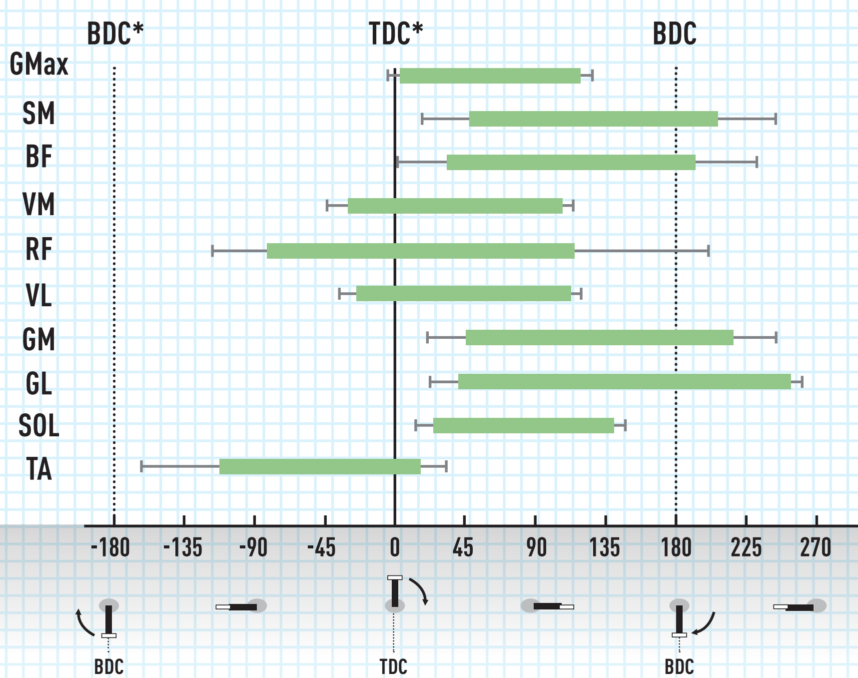
Hamstrings

The hamstrings, comprised of the biceps femoris, semimembranosis and the semitendinosis, stabilise the knee during the bottom of the pedal stroke and help direct the leg through the back part of the pedal stroke.

LOWER LEG

In cycling, the lower leg is responsible for transferring force from the quadriceps and glutei to the pedal. It consists of the tibia, fibula, ankle and foot. The ankle is made up of the talus that sits on top of the calcaneus (heel bone). The foot is generally

EMG READING OF A CYCLIST



ELECTROMYOGRAPHY

Electromyography (or EMG) is a technique for analysing the biomechanics of movement using electrodes on the surface of the skin (or in some cases, needles inserted into the muscles) to detect electrical potential generated by muscle cells. The instrument used is called an electromyogram. The EMG to the right shows when the various muscles fire over the course of the pedal cycle.

Source: F. Hug and S.Dorel (2009) *Journal of Electromyography and Kinesiology* 19(2): 182–98

CRANK ANGLE FROM TDC (°)

*BDC = Bottom dead centre of the pedal stroke
TDC = top dead centre of the pedal stroke

separated into three different regions: rear foot, mid-foot, and forefoot. Irregular motion from the foot can originate from any of these three regions. The long bones of the foot are known as metatarsals, and it is important to know where they are as they are used to position the foot correctly on the pedal.

EMG studies show that, while calf muscles do not add significantly to power created further up the kinetic chain, they do work hard to help the lower leg stay in position and better transfer power to the pedal. If they are not working effectively power can be lost, so they shouldn't be dismissed as irrelevant just because their net contribution might seem less than their size suggests.

Two muscles help to stabilise the foot so that it can create a rigid lever to move the pedal – the gastrocnemius and the soleus. These muscles collectively form the calf muscle. The gastrocnemius has two heads, originating above the knee on the femur and running down to the calcaneus. It combines with the soleus to make the Achilles tendon, which is common to both muscles. The soleus is deep to (further from the skin than) the gastrocnemius and helps make the foot a rigid lever to the pedal. It originates just below the knee (on the tibia and fibula) and travels down to the calcaneus through the Achilles tendon.

Other muscles that support the foot include the ankle invertors, evertors and dorsiflexors. These muscles of the foot and ankle originate on the lower leg and support the arches of the foot.

ANATOMY OF THE TRUNK AND BACK

While the legs do most of the work, they still need a strong base of support, which is where the trunk and back muscles come in. Studies of the back muscles of endurance cyclists show increased activity in the back muscles when the load to the pedals increases.

Muscles of the back are arranged in a series. In the lower back are deep, small muscles called the multifidi and a larger muscle called the quadratus lumborum. These muscles help stabilise the spine under lateral and rotational loads.

The next layer of muscles of the back are the longissimus. These muscles are extensors over multiple segments of the back and help maintain posture and stability while cycling.

Abdominal musculature is mostly used to keep the trunk stable in brief moments under high force. If you are cycling under aerobic conditions you will usually use your abdominal muscules for diaphragmatic breathing.

Originating from the upper back and shoulder are the trapezius and the latissimus dorsi. These are important as stabilisers in cycling because they fix the arms, allowing them to work as anchors. As you push the left pedal, your right arm fixes and pulls on the handlebar through the action of the right latissimus dorsus to stabilise you, and vice versa. Think about when you are pushing hard, climbing or sprinting: you can really feel your arms working in this way. At gentler paces it is still occurring but is not as noticeable.

The biceps also acts as a stabilising muscle in conjunction with the latissimus dorsi, again counteracting torque production from the legs, stabilising the torso by pulling into the handlebar. The right arm counterbalances the torso from torque produced from the left leg and vice versa.

ATTENUATION

Attenuation is essentially load absorption: think of the action of a shock absorber. The main muscles soaking up impact from the road surface while cycling are the triceps and calf muscles. Eccentric muscle action allows loads to be smoothed out or 'attenuated'. Load attenuation of the triceps from handlebar vibration and loading protects the neck and shoulder. Load attenuation from the calf muscles allows the torso and hip/knee to stay stable over bumpy surfaces as well.

POSTURE

Posture is the maintenance of a certain body position and requires appropriate joint mobility, joint/muscle coordination and muscular endurance. Limits in any of these elements can result in postural irregularities. Good posture on the bicycle requires good flexibility through the hamstrings and the glutei muscles: this allows the pelvis to roll forward, keeping the back in a straight position while reaching for the handlebars.

One major factor limiting the back's ability to remain relatively straight while on a bicycle is thoracic immobility: lack of movement in the middle of the spine normally results in the spine flexing too much. Excessive spinal flexion while on a bicycle will limit breathing and compromise your ability to stabilise your spine for torque production to the pedals.

VENTILATION

Ventilation is simply the act of getting air into and out of the lungs. It is crucial for the endurance athlete that this process is as efficient as possible. The lungs reside within a bony cage created by the ribs, which are anchored in the body through a tight articulation to the thoracic spine. There are anatomical and bicycle limiters to ventilation. An example of an anatomical limiter to ventilation would be being too flexed through the thoracic spine (that is, bent forwards), not allowing the ribcage to expand sufficiently. Examples of bicycle position limiters may be compact aero positions that compromise breathing, or rearward saddle tilts that require spinal bending to maintain a seated position on the saddle.

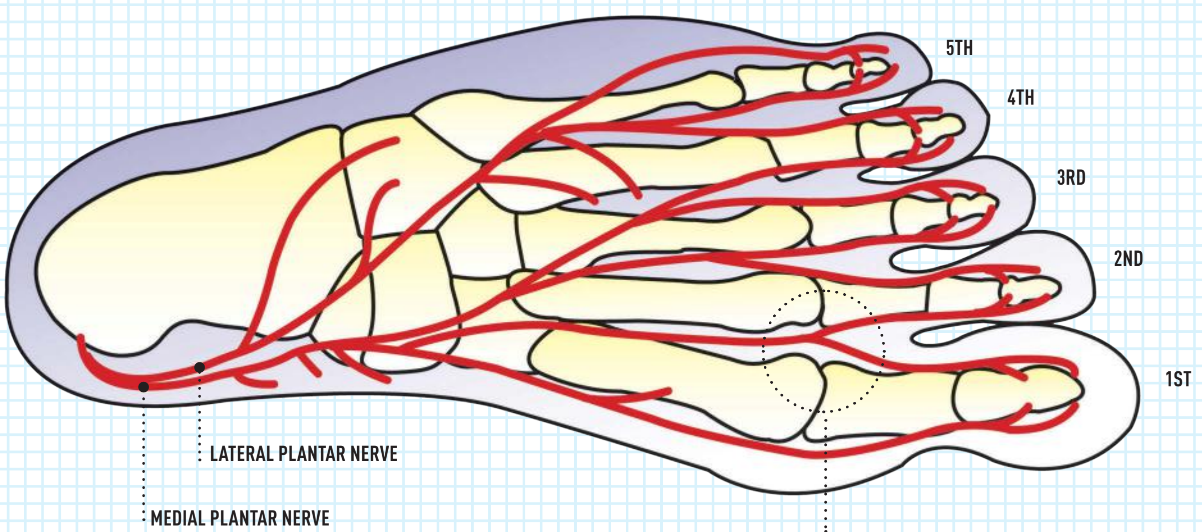
Ventilation for the endurance athlete is most effectively performed through diaphragmatic breathing, in which contraction and relaxation of the diaphragm pulls and pushes air from the lungs. Secondary muscles of ventilation include the intercostals (between the ribs), the abdominal musculature, the trapezius, the levator scapulae and the scalenes. If diaphragmatic breathing is compromised these secondary muscles can become chronically overworked leading to myofascial type pain (i.e. pain between the muscle and the muscle covering). This is often seen in the upper neck and shoulder muscles.

CONTACT POINTS

Simply put, these are the points at which your body touches the bike. We will look at them in more detail later, but it's helpful to examine the anatomical reasons why they are so important to get set correctly.

The three primary anatomical contact points to the bicycle can be sources of numbness and pain. These are: foot to pedal, hand to handlebar and pelvis to saddle. Numbness, weakness and pain can arise when vascular (blood vessel) and neural (nerve) tissues have irregular loading, resulting in compression.

NERVES OF THE FOOT



A common area for nerve compression is between the metatarsals (toes). Between the first and second is the most common (Morton's neuroma). A metatarsal button in a footbed will often totally alleviate the problem.

FOOT TO PEDAL
This view of the bottom of the foot (below, opposite) shows neural distribution. Poor cleat position or irregular support or compression of the foot can result in tissue damage. Amid a complex vascular system of veins, which pump blood towards the heart, and arterioles, which carry oxygenated blood from the lungs to the muscles, are the nerves, here depicted in red. Note their trajectory between the metatarsal heads. Nerves are a primary site of bicycle related foot pain.

HAND TO HANDLEBAR
The two main nerves that supply the hand are the median nerve and the ulnar nerve. These nerves pass through two tunnels as they enter the hand region: the carpal tunnel (median) and the tunnel of Guyon (ulnar). Irregular positioning of the hand to the handlebar can include being positioned too widely, leading to the fingers splaying, or too much weight being placed on the hand due to the overall position. Such positioning can compress nerves, resulting in pain, numbness and weakness in certain muscles. Compression of the median nerve will result in numbness of the first three fingers and half of the fourth, while the ulnar nerve will affect the lateral half of the fourth finger and all of the fifth.

PELVIS TO SADDLE
The saddle region as related to the pelvis has pressure-sensitive arteries and nerves. Irregular compressive loading for anatomical or bike fit reasons will result in numbness, pain and loss of tissue function.

NERVES OF THE **HAND**