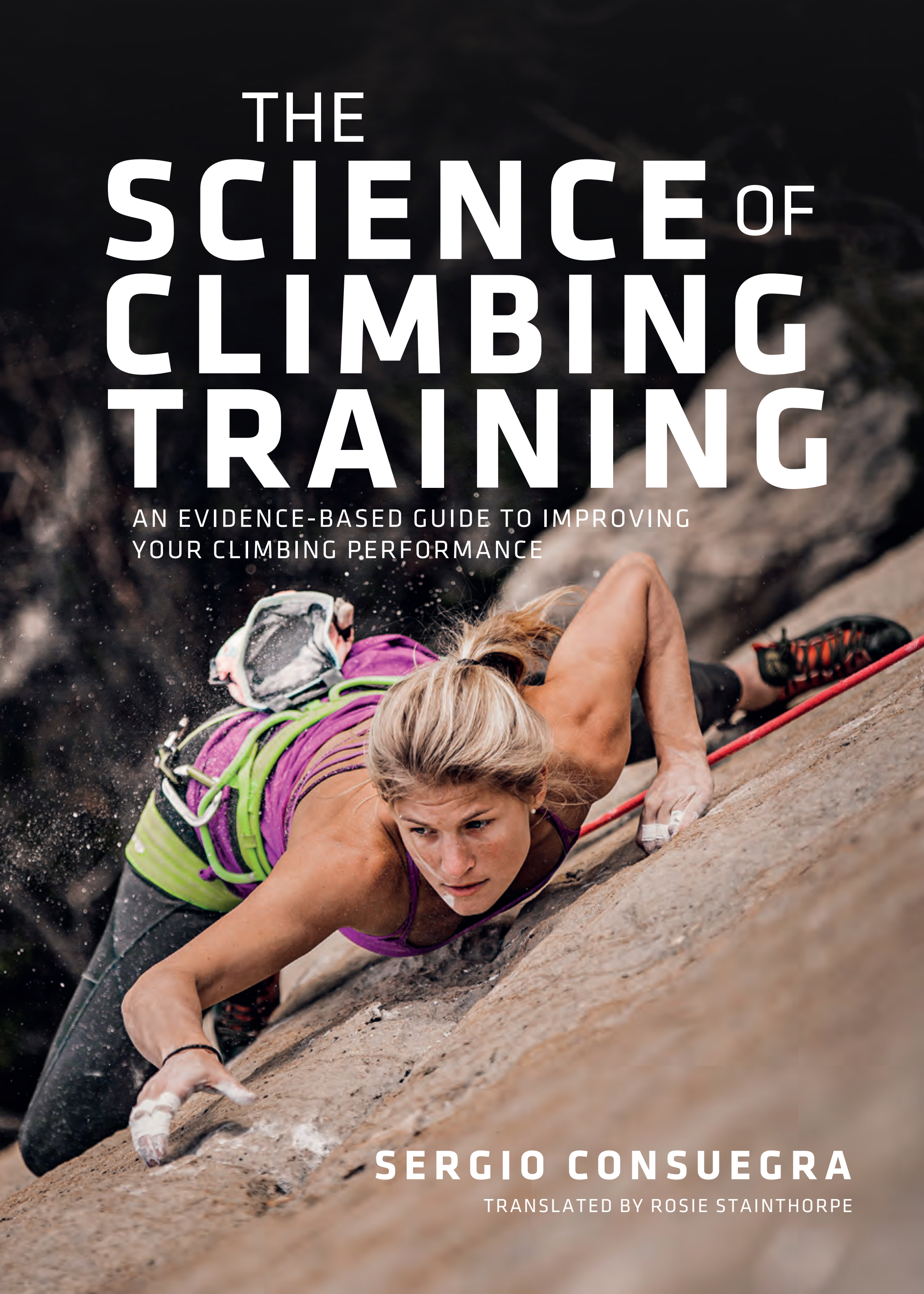
THE SCIENCE OF CLIMBING TRAINING

AN EVIDENCE-BASED GUIDE TO IMPROVING YOUR CLIMBING PERFORMANCE



SERGIO CONSUEGRA

TRANSLATED BY ROSIE STAINTHORPE

THE SCIENCE OF CLIMBING TRAINING

AN EVIDENCE-BASED GUIDE TO IMPROVING YOUR CLIMBING PERFORMANCE

SERGIO CONSUEGRA

TRANSLATED BY ROSIE STAINTHORPE

Vertebrate Publishing, Sheffield
www.adventurebooks.com

The Science of Climbing Training

Sergio Consuegra

Translated by Rosie Stainthorpe

First published in English in 2023 by Vertebrate Publishing. Originally published in Spanish in 2020 by Ediciones Desnivel as *Entrenamiento de Escalada basado en la Evidencia Científica*.

Vertebrate Publishing
Omega Court, 352 Cemetery Road, Sheffield S11 8FT, United Kingdom.
www.adventurebooks.com

Front cover: Svana Bjarnason during golden hour on *Homage a Catalunya*, a F7b+ slab in Abella de la Conca, Spain. Photo: Lena Drapella.

Photography by Rubén Crespo unless otherwise credited.

Graphics by Javier Fernández de Cara, unless otherwise credited.

Original design by Lluís Palomares.

A CIP catalogue record for this book is available from the British Library.

ISBN 978-1-83981-182-1 (Paperback)
ISBN 978-1-83981-183-8 (Ebook)

10 9 8 7 6 5 4 3 2 1

Vertebrate Publishing is committed to printing on paper from sustainable sources.

Printed in the United Kingdom by Severnprint Ltd, a carbon neutral printer.
Printed on FSC Mix Credit certified paper.

CONTENTS

INTRODUCTION

There is an overwhelming amount of information available to us about training for climbing. The rapid growth of sports culture, bigger and better climbing walls, easy access to climbing-related content, the internet … All have played a huge part in advancing the incredible sport of climbing. However, due to the sheer quantity of information, it's not always easy to sift through and select the most accurate sources. Most people – and not only in the world of climbing – base their training on word of mouth, what friends or influencers are doing, the 'no pain, no gain' mantra, what they've always done, or so-called 'bro science'.

The aim of this book is to provide quality information for a broad range of readers: from climbers taking the next step in their training (whether they're climbing F6a or F8a) to coaches looking to optimise their athletes' training.

It boasts no revolutionary or magic training methods (although you might be shocked by the science behind some popular methods). Instead, it analyses the sporting needs of climbers from the perspective of exercise and sports science to provide an evidence-based approach to climbing training.

The first part explains what training is and how different training methods are governed by the physiological and biomechanical processes that occur in the body.

The second part looks at how to improve specific needs (such as finger strength and forearm muscle endurance) and general needs (basic physical conditioning, pulling strength, pushing strength, strength training for injury prevention, and so on) for the different demands and types of climbing.

The third and final part, after gathering together all the pieces of the puzzle, suggests the best ways in which you can fit them together. It looks at adjusting training volume and intensity and tapering to encourage supercompensation, all to achieve improved performance, a higher grade, ticking your long-standing project or climbing your dream route.

To sum up the contents of this book in just a few words, I'd go with my personal training philosophy: 'don't train more: train better'. And I'd like to think this book will, in the words of Alvin Toffler, help you to 'learn, unlearn and relearn'.


NDOOR CLIMBING SINCE 2018
FACTORY
DONOSTIA

1

THE PROCESS OF TRAINING

DEFINITION

To begin, it's important to set a common understanding of what 'training' is. According to Bernal Ruiz (2006), training is a voluntary process that entails a transformation of physical and psychological functional systems. It occurs through the application of external stresses and in reaction to specific internal conditions in the body, and it's designed to improve performance in a particular situation.

Let's break this down into several key points.

The first thing to note is that training is a *process*; it is not a one-off session at the wall or the gym. It's also *voluntary*, meaning it's not going to happen while you're sitting on the sofa, scrolling through social media or talking about climbing at the pub. You have to get out there and train.

Then we get to the *transformation* of both *physical* and, especially in climbing, *psychological* systems. There's a clear and proven link between these two factors. Without sufficient physical training, no athlete will ever perform at their best. However, all the physical training in the world means nothing without the motivation, focus or resolution to win, take that next step, stick to the training or give that final push at the end of a race. And vice versa, regardless of how well prepared we are on a psychological level, without physical training, we'll never reach our full potential. What's more, with poor physical form, we start to doubt whether we can keep going or make that next move … a vicious cycle that we'd do well to avoid.

The *external stresses* and *internal conditions* are two of the most important factors, and so we'll look at these in greater depth later on in the book. Basically, training must require genuine effort and the difficulty (technical, physical, psychological, and so on) of training exercises needs to vary according to the climber's level of training. For example, doing 10 pull-ups is not as hard for a F8a climber as it would be for a complete beginner whose previous hobbies amount to lying on the sofa and eating junk food.

The final thing to note is that our training should lead to a *higher level of performance*. If it doesn't, then something's gone wrong and we'll have wasted precious time and energy.

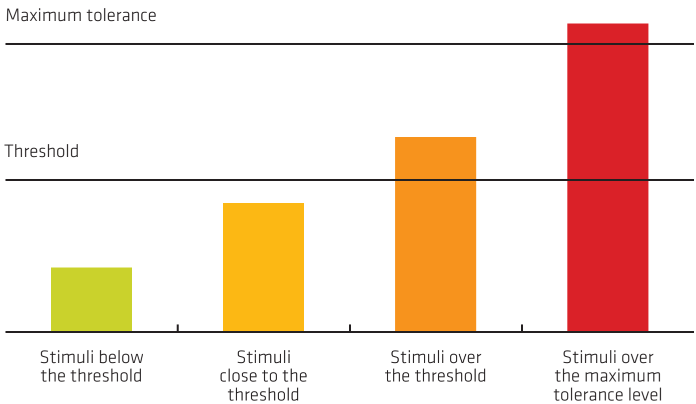
So, to get better at climbing, we just need to climb more and try harder routes? Unfortunately, it doesn't quite work like that, and it's the same for any sport: unless we're just starting out and don't climb very often, doing more won't make us any better and we won't climb any harder, no matter how hard we try.

Repeatedly doing any sport with no variation or evolution and, above all, no additional physical conditioning, leads to two possible scenarios: plateauing as we fail to master new techniques, or injury. If we never leave our comfort zone, where we climb and train comfortably, enjoy ourselves, feel proficient and capable, never try too hard or ever get frustrated, we'll never see any evolution or improvement because we're always doing the same thing. It would be like trying to train by brushing our teeth or drinking a glass of water. It's outside of this comfort zone where the magic happens: things evolve, changes occur … However, without the necessary physical conditioning for the demands of our sport, we'll overload the most commonly used muscles, tendons, and so on. This can lead to excessive wear, agonist/antagonist imbalance and, most probably, to an injury that could stop us from climbing at all.

So, to climb better we need to train for climbing: we should dedicate our midweek sessions to training at the wall or the gym, and save climbing outdoors for the weekends (unlike many climbers who just tend to climb outdoors).

INTENSITY AND THRESHOLDS

How hard should I train? To answer this question, we must first understand the term 'threshold'. According to the *Oxford English Dictionary*, it is: 'a level, rate or amount at which something comes into effect'. Remember that functional adaptations are achieved by exposure to successively greater training stimuli. This is based on the Arndt–Schulz law, which basically states: 'stimuli that fall short of the threshold have no [training] effect'. This can be seen in the following graph:



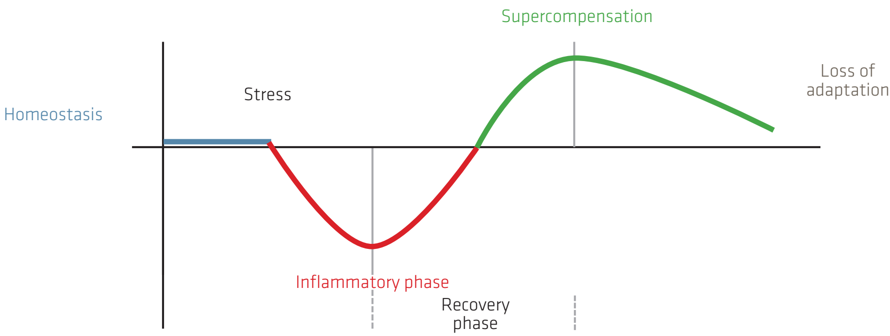
This graph demonstrates four possible scenarios:

- Stimuli below the threshold: no training effect. If our training doesn't require much effort, if it feels easy, then we're wasting our time.
- Stimuli close to the threshold: training effect if repeated, although some authors believe this only has a maintenance effect.
- Stimuli over the threshold: TRAINING EFFECT. These are the stimuli that we want. They take us out of our comfort zone and require just the right amount of effort. They make us dig deep and give that little bit extra.
- Stimuli over the maximum tolerance level: risk of overtraining syndrome and injury. If we need a few days to recover from a training session, we're probably over this level.

This should explain how hard to train: just hard enough, neither too little nor too much. As I said in the introduction: 'don't train more: train better'. Now let's look at how our bodies respond to stimuli that exceed the threshold to just the right degree, which is precisely what it means to 'train'.

HOMEOSTASIS, GAS AND SUPERCOMPENSATION

Homeostasis is when the body is in a state of equilibrium. In other words, when synthesis and degeneration are in balance (remember the body is in a constant state of regeneration: from our skin to the cells in our bones). If something, in this case training, disrupts homeostasis, the body will establish a new state of balance through regenerative or anabolic processes. This is known as general adaptation syndrome (GAS), a theory developed by Hans Selye.

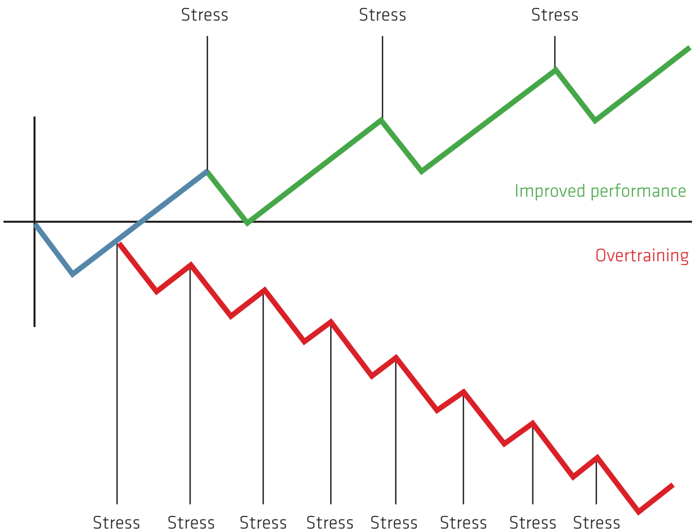


As seen in this graph, external stress disrupts the level of homeostasis in the body, leading to the inflammatory phase. During this phase, our body releases stress hormones such as adrenaline and steroid hormones such as corticosteroid (of which cortisol is the most well known). These hormones trigger physiological processes that allow us to withstand the *external stress* – the training – at the expense of 'damaging' our body, by creating what's known as *internal stress*.

When the external stress stops, the body tries to recover as quickly as possible. In other words, you're already recovering in the changing room after your session. To better withstand any similar external stress in the future, the body supercompensates to a heightened level of homeostasis, making you stronger than you were before the training session.

The bad news is that you'll lose the resulting adaptations if more stress isn't applied soon after the supercompensation phase. This is because the body adapts to the actual demands of our everyday lives. Logically, if something isn't needed and takes energy to maintain, the body will simply get rid of it to best adapt to our day-to-day needs. In even more bad news, the more extreme the adaptations (the harder you train), the faster they are lost because they're of least use. For example, the external stress that a sprinter would need to shave an extra hundredth of a second off a 100-metre sprint isn't really that useful for their body on a day-to-day basis. Training is like building a house: it can take years to build, but can be demolished in a matter of minutes.

That said, we have to be very careful about when we apply subsequent stress. If the body is still in the inflammatory phase, we risk entering a process called catabolism (degradation). If we don't realise this is happening, we could end up with overtraining syndrome and risk spending far more time at the doctor's than out at the crag, which is exactly what we don't what to happen. Luckily, it's difficult to fall into this trap unless you're training far too much and far too often.



THE PRINCIPLES OF TRAINING

The principles of training are a set of rules that help us to develop and manage our training. For me, the most important of these are:

- *The principle of active and mindful participation:* perhaps the very reason behind this book. Understanding why we do things a certain way when training.
- *The principle of individualisation:* one that is often ignored. It means that any training should be adapted to the trainee's morpho-functional characteristics and level of ability. In other words, doing something just because it works for a friend is a big mistake.

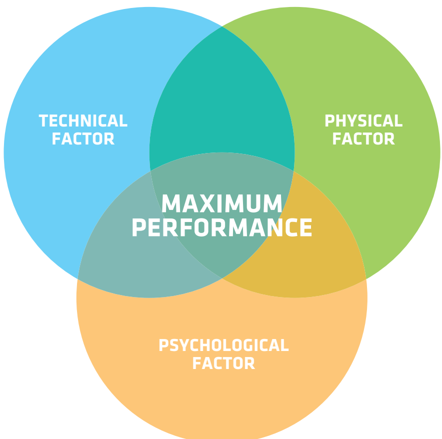
- *The principle of specificity:* one of the most disheartening. It means that the gains from a certain exercise are not transferable to other situations. For example, training on a bike to improve aerobic capacity won't dramatically improve your aerobic capacity for long mountain walks. Similarly, the strength gained from doing pull-ups on a bar is only transferable to pulling down vertically on a bar-type hold.
- *The principle of continuity:* as the name suggests, only going to the gym once a month is simply a waste of membership fees.
- *The principle of variety:* training the same things in the same way is not going to work. You can't just repeat the same exercises for an entire season as the body will adapt and you'll see no improvement in performance. In the words of Albert Einstein: 'If you want different results [in our case, improved performance], do not do the same things.'

WHAT TO TRAIN

Now we know what training is, the logical thing to ask is: 'What should I train?'

In climbing, as in all sports, there are two types of training: visible training (physical factors) and invisible training (rest, nutrition, psychology, and so on). They are very closely linked and completely interdependent. Let's look that the specific factors that affect climbing performance:

- The technical factor (technique)
- The psychological factor (motivation, activation or arousal, fear, and so on)
- The physical factor (the physical condition of the climber)



The ability to maximise and synchronise each of these factors is key to achieving the best possible performance.

This book deals exclusively with the physical factor of climbing. If you want to explore the other two factors, there's lots of information out there about mental training and technique, although it's always best to seek advice from a qualified professional.

In the simple yet meaningful words of renowned American football coach Vince Lombardi: 'Fatigue makes cowards of us all.' We could say that in climbing, a sport where these factors are so deeply connected, you need good physical form not only for individual moves but to respond to the wider challenges of any given climb. For example, imagine you're totally spent on the ninth pitch of a route, graded say F7a, and there are still five pitches to go: one F7b+ and four at F6b or above. It's going to be a real fight to finish the climb. Imagine you're also in a pretty committed situation, where you can't just abandon the route … things are really not looking good. This will of course affect your mental game. So, in this simple example, we've already touched on two of the three factors.

This book will analyse what to train to avoid these situations (at a higher or lower grade, on single or multi-pitch routes, alpine routes, boulder problems, and so on). Simply put, the physical factor is shaped by the following physical qualities: strength, endurance (cardiovascular), speed and flexibility. As you'll see throughout this book, strength and flexibility are the most important in climbing. Speed, in this context, is determined by strength and technique. Endurance, except when the approach to the crag is so strenuous that poor cardiopulmonary capacity will in fact affect climbing performance, is not a limiting factor *per se*. In any case, this will all be explored in greater depth.

3

UNDERSTANDING AND OPTIMISING MOBILITY

WHAT IS MOBILITY? FLEXIBILITY, ELASTICITY AND STIFFNESS

Mobility is a broader and more useful concept than others which we tend to use in the world of sport, such as flexibility or elasticity. Although mobility is affected to a certain degree by flexibility and elasticity, it cannot be defined solely by these terms. Mobility or range of motion (ROM) is, in fact, 'the amount of movement that exists in a joint and that is determined by the design of the joint' (Leal, Martínez and Sieso, 2012; Tortora and Derrickson, 2011; within Peláez Maza, 2015a).

There are several factors that affect the amount of movement in our joints:

- *The design of the joint itself:* this is determined by evolution and genetics so it's not something we can change. For example, the shape of our femoral neck bone will determine whether it's possible for us to do the splits.
- *Elasticity:* this is the ability of something (in this case, soft tissue) to return to its original state without deforming or breaking. Therefore, we can't be more elastic or less elastic: we either are or we aren't. There's no in between.

- *Muscle stiffness, tightness or tension:* this occurs when our muscles try to resist any form of deformation (or stretching). It is determined by the number of collagen fibres in our bodies (which is also genetic and so something else we can't change) and by our nervous system. There are numerous receptors in our muscles and tendons (we'll explore this later on in the book) that continually send sensory signals to the brain, providing information about how our muscles should move. If these mechanoreceptors detect that a joint may be unstable, they'll send a danger signal to the brain, and the brain will send a stop signal to the relevant muscles to stop this joint from moving. This prevents the joint from entering a potentially dangerous range of motion, protecting it from harm. Thus, some authors believe that stiffness (as a mechanical factor) is not a limiting factor of ROM and that mobility is instead limited by the nervous system (Piepoli, 2019).
- *Flexibility:* this is the ability of a material to bend without breaking (Nacleiro, 2011, within Peláez Maza, 2015a). By definition, improving flexibility is not the same as improving mobility, which in reality is what any athlete wants to do (although good mobility does require muscular flexibility to prevent injury).

So, do we really get 'tight' muscles? If tightness is a defence mechanism (against injury) and (static/passive) stretching attempts to turn off this mechanism, does it make any sense to stretch when that might increase our risk of injury? And will this help improve our ROM?

ACTIVE VS PASSIVE FLEXIBILITY AND MOBILITY RESERVE

The brain is like an overprotective parent who's obsessed with keeping us safe, but sometimes this excessive protection can have the opposite effect.

Luckily, the brain is constantly being fed information about the body (such as body position, tension, muscle length) and using this information to instruct us to move or not move, or perform a certain action or not. For example, if you sprain your ankle, the brain will not only issue pain signals to stop you from fully weighting your foot but will also orchestrate a new pattern of movement (limping) so you can still walk. All this information comes from numerous sensory receptors (proprioceptors) that are located around the body (in muscles, tendons, ligaments, joint capsules, and so on) and which are directly connected to the nervous system. To keep things simple, we'll just mention three different types:

- *Muscle spindles:* receptors which measure and report on variations in muscle length and the speed at which these variations occur.
- *Golgi tendon organs:* receptors found in tendons, next to the bone–tendon junction, which report on variations in muscle contractions.
- *Joint receptors:* receptors that are embedded in joint capsules, ligaments, and so on, which report on the position of the joint.

Using the information sent by these receptors, the brain controls the mobility of each and every joint in the human body. In practice, this range of motion is divided into:

- *Active flexibility:* the ROM we can achieve voluntarily. How far apart we can spread our legs or if we can bend over and touch our knees, our toes or get our hands flat on the floor. As muscle tension is determined by the brain based on the information received from mechanoreceptors, active ROM will vary depending on what action is being performed and when it is being performed (Latash and Zatsiorsky, 1993).
- *Passive flexibility:* the ROM we can achieve with the assistance of an external force that moves the joint into a certain position, such as a band, or our hands. However, there's a difference between the limit of our active ROM and the point at which the joint is at immediate risk of injury. This difference exists so when any sort of external force is applied (for example, a fall or a collision), the joint has a small margin of extra mobility before reaching breaking point.

The difference in mobility between active and passive ROM is referred to by some authors as our mobility reserve. It is the range of motion that we can't access voluntarily but which we could tap into with training.

MYOTATIC REFLEX AND AUTOGENIC INHIBITION/INVERSE MYOTATIC REFLEX

The body uses two basic reflexes, among other things, to control muscle tone:

- *Myotatic reflex:* this measures and controls muscle length. In response to stretching, this reflex causes the muscle to contract in order to resist the stretch.
- *Autogenic inhibition or inverse myotatic reflex:* this measures and controls muscle tension. In response to intense and prolonged tension (as created by passive stretching), the proprioceptors send signals to the brain to relax the muscle in order to prevent any damage. By relaxing the muscle, the brain inhibits its ability

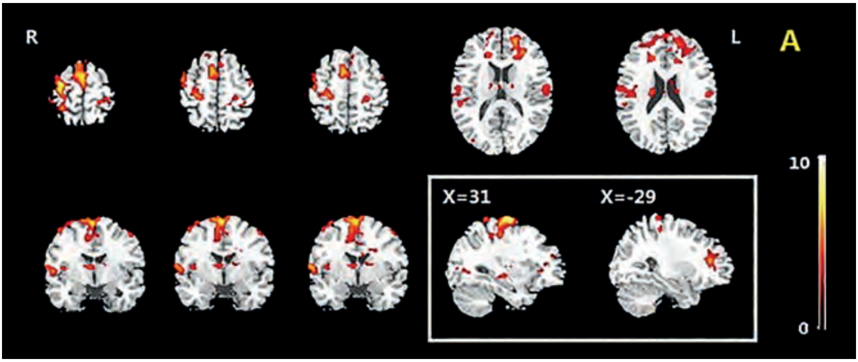
to produce force. As such, it doesn't seem that sensible to activate this reflex in climbing or in any other sport. In fact, inhibiting muscle response to improve joint mobility, precisely when we want the best possible response from our muscles (during sport or training), doesn't make any sense at all. This is why we should avoid passive or static stretching of agonist muscles before or during training as it would send contradictory signals to the brain (contract, relax, contract, relax, and so on), which can easily lead to injury.

THREAT PERCEPTION AS A LIMITING FACTOR OF ROM

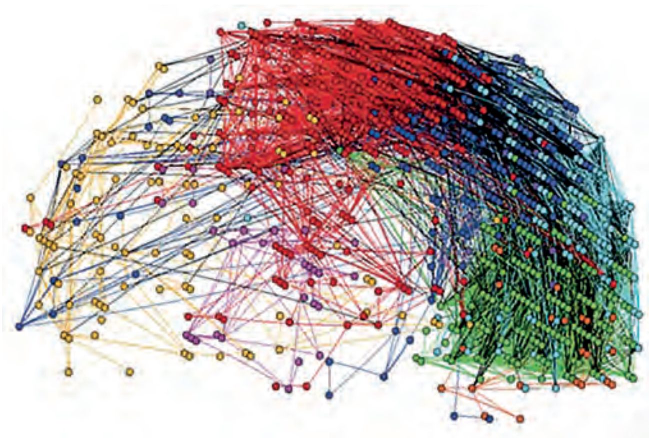
Why would the brain limit a joint's range of motion? The brain is an expert at making predictions. It anticipates all possible outcomes and will attempt to give the best possible response based on past experience. For example, if you're about to jump from a certain height, your brain will assess this height and produce what it thinks is the right amount of force to break your fall. This calculation is based on past experiences of you jumping from the same or similar heights. In response to stretching, mobilisation or the need to move, the brain considers all possible factors (such as how comfortable you are, if you're in a safe environment, the necessity of the action, good or bad past experiences) and forms a response. If, for whatever reason, it decides that moving a joint into a certain position means it will lose control of the joint, and if this lack of control could lead to injury, it will react in two ways: inhibiting the muscles responsible for moving the joint, and creating tension and pain in another place in order to bypass the 'zona incerta' in the brain, which it is proposed plays a role in gating sensory input and controlling pain.

BRAIN MAPS, SIMS AND DIMS

The brain is home to millions of interconnected neurons. It is the control centre for the whole body and decides how and when we move. To do this, it contains a representation of every muscle in the human body. When a group of neurons – a neural circuit – is activated, it controls a certain muscle. To perform a specific movement, several of these circuits are activated at the same time (to use a crimp above your head, you need to raise your arm, turn your hand, move your fingers, and so on). To perform a movement that you've done before, the brain uses a 'map' of these circuits to produce this movement.



ACTIVATION IN DIFFERENT AREAS OF THE BRAIN FOR FINGER FLEXION (LI *ET AL.*, 2015)



REPRESENTATION OF BRAIN CONNECTIVITY (MEUNIER *ET AL.*, 2010)

These maps are closely linked to the brain's powers of prediction as they are continually updated with new experiences. For example, when you throw for a hold on a new route, your brain activates its map for holding an edge. However, since you've never held this specific hold before, it doesn't know if this is the right map. Using the information it receives about visual perception, body position, and so on, it decides on what it thinks will be the best map for the job. When you make contact with the hold, your brain will readjust its map or create a new one, depending on the information received about the size, depth, texture and other characteristics of the hold.

But what's this got to do with mobility? It's simple: the brain will perceive a potential threat if it has to rely on a damaged or corrupted map of the movement that we want to perform (if an injury, awkward body movement or bad experience has damaged the map). A damaged map could be missing key information about the joint, in which case the brain will restrict its movement in order to prevent injury. Likewise, if there's no map for the movement we want to perform, this will also be seen as a potential threat and we'll need to inform the brain that the movement is safe.

This is where things get interesting, with the appearance of SIMs and DIMs (Moseley and Butler, 2015). SIMs (Safety In Me) are things that make us feel strong, happy, more secure, and suchlike. DIMs (Danger In Me) are things that we feel might endanger our body, life, happiness, and so on. They function as positive or negative neurotags that are attached to actions or feelings and which activate different sets of brain maps. As such, they affect how the brain responds to different situations. As this is quite a complicated topic, let's use an example based on climbing. Helen was training at the climbing wall a few days ago. She did a drop-knee on a boulder problem, slipped and hurt her knee. She had some physiotherapy for the pain in her knee and she's now made a full recovery. She goes back to the wall and is about to try the same problem again. Her brain starts predicting what might happen: it knows that she hurt herself on this move before and, what's more, the brain map for this move is now damaged. This is when a DIM will appear, signalling danger: be on alert, watch out. She tenses up, her muscles become stiff and she can't move fluidly. She pulls on the problem and can't even get to the move to try the drop-knee. She needs to retrain her brain and create a SIM so that she isn't afraid of drop-knees and can move fluidly and confidently through them.

OPTIONS FOR OPTIMISING MOBILITY

After all this, what can we do to improve mobility? There are a number of options, and each works in a different way and is more or less useful depending on the person:

- *Breathing and relaxation techniques:* although it seems like the simplest thing in the world, breathing and relaxation can help improve joint mobility. Feeling stressed puts the sympathetic nervous system in a state of high alert, anticipating danger. As we saw earlier, if the brain senses danger, it won't let us do anything that it doesn't think is safe. What's more, on a cellular level, the shape and density of the fibroblasts in our fascia are affected by incoming electrical impulses (a phenomenon known as piezoelectricity), meaning they're affected by emotions and, of course, anxiety is a powerful emotion.

- *Techniques to reduce descending inhibition:* many physiotherapy techniques and paraphernalia such as foam rollers, massage sticks and different size/texture balls are based on the age-old principle of massage. This helps increase blood flow in the massaged area and therefore boosts oxygen supply (improving the predisposition of this area to exercise). It also stimulates the proprioceptors, creating a signal to activate the mechanisms of descending pain inhibition (meaning less pain information reaches the brain). In turn, this can improve stretch tolerance and therefore ROM (Støve *et al.*, 2019).

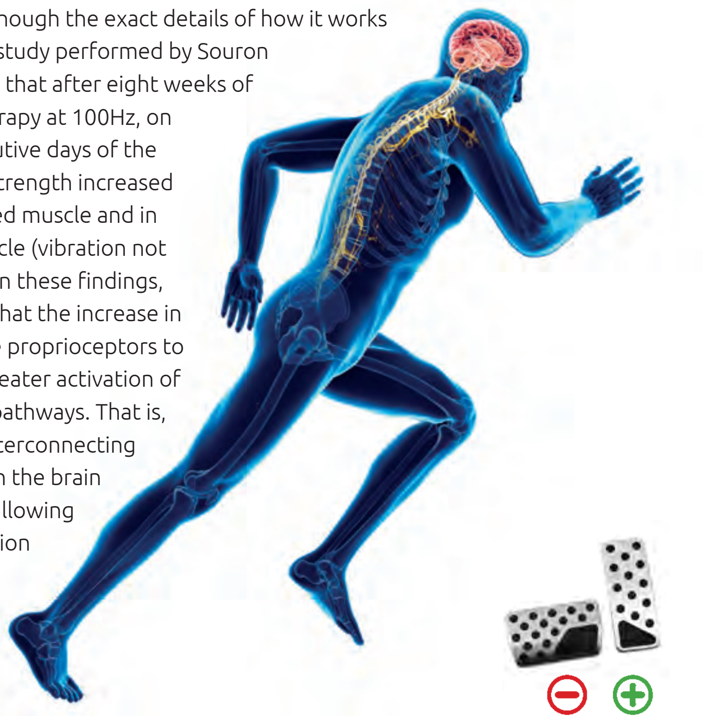
- *Flossing:* this technique involves wrapping a stretchy band around a joint and moving the joint as much as possible for a set period of time (usually no more than two minutes). There are numerous benefits to this type of compression. It holds the joint firmly in place, so the brain knows that the joint is secure and under control. It also holds the superficial fascia in place and pulls on it when the joint moves. This causes the fascia to glide over the muscle, reducing adhesions and therefore improving both the transmission of force through the superficial and deep fascia system and the sliding of muscle fibres. Finally, flossing affects the blood supply to the targeted area. By moving the joint, we're increasing blood supply to the area, but by compressing it at the same time, we're stopping the blood from entering the area. (Warning: this is an effective technique but it can be highly uncomfortable, especially if the joint is injured in any way.) When the compression stops, this build-up

1. ASSESSING ANKLE MOBILITY (DORSIFLEXION). 2. WRAPPING THE JOINT FOR FLOSSING. 3. MOVING THE JOINT TO END RANGE OF MOTION IN ALL POSSIBLE DIRECTIONS. 4. MEASURING THE INCREASE IN ANKLE MOBILITY AFTER FLOSSING.

of blood rushes through the area, carrying away metabolic waste and inflammatory substances, which also significantly reduces pain. This technique is also highly effective for recovering from injuries (Clements, 2015).

- *Improving end-range strength:* another example of the importance of strength. High-intensity isometric exercises (70 per cent of 1RM) have been proven to reduce intracortical inhibition in the contracted muscle, to reduce pain for up to 45 minutes after training and to increase corticospinal excitability, improving maximum voluntary contraction (Rio *et al.*, 2015, within Peláez Maza, 2016). In other words, these exercises give the brain control over the muscle, reducing the perception of threat. There is also strong evidence that submaximal eccentric exercises are highly effective for increasing muscle strength at a low risk of injury as they allow for greater motor control. (In fact, these types of exercises have been used for years in physiotherapy treatments.) As such, doing a few sets of submaximal eccentric contractions at the end range of movement will increase muscle strength and give the brain confidence and control in this range, therefore improving joint mobility. What is intracortical inhibition? As we already know, the brain can detect when a joint is in a potentially dangerous position and will send a pain signal and a signal that inhibits muscular force. The brain 'puts the brakes on' to stop the joint from moving towards the threat. To do this, it sends inhibition signals from the cerebral cortex. Through strength training, proprioception training and local vibration therapy, we can send a message to the brain to 'ease off the brake' and to 'give it some gas' instead, resulting in intracortical facilitation. This makes the area more sensitive, enhancing proprioceptive control, motor control and therefore strength, by reducing the effects of threat perception in the brain.

- *Local vibration:* most coaches won't have heard of this technique as it's more common in rehabilitation than in sports performance. There's an increasing amount of research into the benefits of this technique, although the exact details of how it works remain unclear. A study performed by Souron *et al.* (2017) found that after eight weeks of local vibration therapy at 100Hz, on three non-consecutive days of the week, maximum strength increased in both the vibrated muscle and in the opposing muscle (vibration not applied). To explain these findings, it was suggested that the increase in signals sent by the proprioceptors to the brain led to greater activation of the corticospinal pathways. That is, it improved the interconnecting 'highway' between the brain and the muscles, allowing for more information to be sent and received, therefore improving motor control.

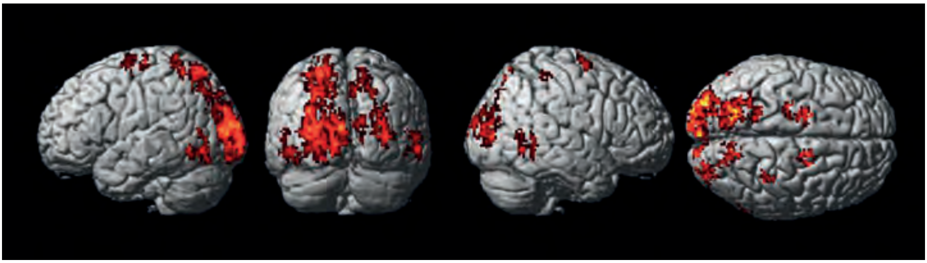


INITIAL ROM IN HIP ABDUCTION

LOCAL VIBRATION + ISOMETRIC CONTRACTIONS IN ABDUCTOR MUSCLES

ROM IN HIP ABDUCTION POST INTERVENTION

- *Motor imagery:* recent studies have shown that in addition to mechanical factors, the nervous system and especially the brain also have a significant impact on ROM. Motor imagery (visualisation, imagery training, mental imagery, and suchlike) is defined as a cognitive task based on the internal reproduction, in this case mental, of a specific movement with no other type of motor stimulation (Cicinelli *et al.*, 2006, within Peláez Maza, 2015b). Athletes have been using these techniques for years to improve the quality of an action or movement and consolidate new techniques. In elite sport, visualisation is considered a fundamental part of training. But what's visualisation got to do with mobility? Although it might seem unlikely that you could improve your range of motion by simply imagining it, mental imagery does have an impact on brain maps. As such, it could be really useful in repairing damaged maps and in increasing cerebral control over our muscles.



CEREBRAL ACTIVATION OF HAND MOTOR MAPS DURING MOTOR IMAGERY EXERCISES (PILGRAMM *ET AL.*, 2016).

So where does this leave stretching? It's important to distinguish between the two main types of stretching: active stretching (resulting from our own actions – we stretch) and passive stretching (resulting from the application of external force – we get stretched).

The aim of passive stretching is to increase the length of the muscle by reducing muscular tension. But what really happens? In response to external force, the myotatic reflex shortens the muscle to protect it and stop it from tearing. And here's our first contradiction: you try to lengthen a muscle but end up shortening it. So how does this type of stretching work? It inhibits the muscle spindle, inhibits the myotatic reflex and activates the autogenic inhibition reflex. This means that the muscle can't respond, contract or produce any force. Although this can be useful in some situations, it definitely does more harm than good if you're about to do any type of sport.

As for active stretching, let's clear up a common misconception about the mechanics of stretching. The brain doesn't send a signal to stretch the targeted muscle, it sends a signal to shorten the opposing muscle. For example, if you sit on the floor with your legs straight and try to touch your toes, your brain won't send a signal to stretch your back and your hamstrings, but instead to contract the hip flexors. Therefore, the stretching of one muscle is an indirect consequence of the shortening of another.

Now let's distinguish between static stretching, and dynamic or ballistic stretching. Static stretching involves the isometric contraction of the opposing group of muscles to those which we want to stretch. There's different advice on how long to hold these stretches, but a standard duration would be around 30 seconds. This is enough time to inhibit the myotatic reflex in the targeted muscle. However, as we've already seen, this isn't recommended if you're about to do any form of sport, except in very specific cases, and especially not for agonist muscles. The following studies show the effects of static stretching prior to physical exercise:

- Baxter *et al.* (2017) studied the effects of static stretching before running. The results showed that it decreased musculotendinous stiffness and elastic potential energy, reducing running economy and performance for up to an hour after stretching. It didn't reduce the duration or intensity of muscle stiffness or the prevalence of running-related injuries.
- Jelmini *et al.* (2018) performed a maximum strength test on the flexor muscles in both hands using a hand-held dynamometer. They then stretched the dominant hand only and repeated the test. The stretched hand lost 17.3 per cent of its strength. The non-stretched hand lost 10.8 per cent of its strength. This loss of strength continued for up to 15 minutes after stretching.
- Reduced performance after stretching has also been observed in other studies (Lauersen *et al.*, 2014; Kay and Blazevich, 2012; Thacker *et al.*, 2004). These studies found that stretching not only failed to reduce the risk of injury but could trigger an inflammatory response, which would damage soft tissue and therefore increase the risk of injury.

To conclude, static or passive stretching is simply not a good idea (either before or during training). Stretches that are held beyond the myotatic reflex (for longer than eight seconds) reduce the muscle's contractile capacity. They slow down the generation and transmission of electrical impulses. This can cause up to a 30 per cent loss in performance, which can continue for up to an hour after stretching and result in an increased risk of injury. So be very careful with this type of stretching.

Active stretches are repeated concentric contractions of the opposing muscles to those which we want to stretch. Instead of inhibiting the muscle spindle, these stretches activate the antagonist muscles. This generates intracortical facilitation, reduces inhibition and strengthens the muscles, while the brain feels safe and in control and therefore increases the range of motion: a much better scenario for performing at our best! Now we've covered mobility, let's turn our attention to how we can use movement to maximise the efficiency of our training.

4

BRIEF NOTES ON ANATOMY

You might be wondering why there's a section on anatomy in a book about training for climbing. However, understanding how our body is designed will give us a better insight into how it works. One of the objectives of this book is to understand how our body works so we can understand how to design a training plan, why an exercise has to be done in a certain way or why choosing a different exercise could lead to injury.

To simplify the information and make it easier to digest, let's say that most of the time in climbing, the muscles in the upper body are used for *pulling* (the basic action of holding on and pulling up), while the muscles in the lower body are used for *pushing*, or propelling, us up the wall. Between the upper and the lower body lies the core (a firm favourite at the gym), linking these parts of the body and bringing both actions together into one fluid upward motion.

This chapter looks at which muscles and anatomical structures are most important for climbing, keeping the level of detail (and tedium) to a minimum and drawing on information provided by Schünke *et al*. (2005).

LATISSIMUS DORSI

PECTORALIS MAJOR

UPPER BODY: PULLING MUSCLES

To help understand the anatomy of the upper body, the muscles can be divided into three main groups:

- *Torso muscles:* the latissimus dorsi and the pectoralis major are the main muscles in this group and the most important for climbing. The latissimus dorsi is the number one pulling muscle in climbing, while the pectoralis major, far from being its antagonist, helps to stabilise the glenohumeral joint (shoulder) and to move the arm towards and away from the body.
- *Shoulder girdle:* in addition to the shoulder joint, the arm is also attached to the torso by a group of joints and muscles (a girdle) that connects the humerus to the scapula and the clavicle. It also connects the scapula to the spine and the rib cage, and the clavicle to the sternum. This aside, let's look at the shoulder girdle in a little more depth. By understanding the scope and complexity of this structure, we'll see why its stability is so important. On the one hand, the large latissimus dorsi, pectoralis major, serratus anterior and the anterior deltoid, helped by other smaller

TRAPEZIUS

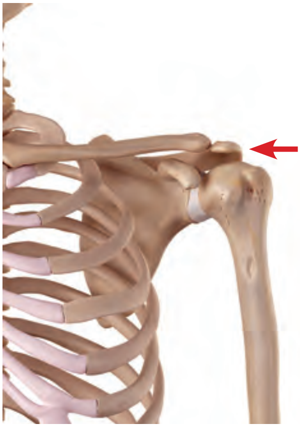
RHOMBOIDS

LEFT: SERRATUS ANTERIOR (NOTE THE EXTENSION FROM THE SCAPULA ROUND TO THE RIBS)

CENTRE: DELTOIDS

RIGHT: NOTE THE EXTENSION OF THE DELTOIDS FROM THE CLAVICLE TO THE POSTERIOR PART AT THE SCAPULA

ROTATOR CUFF



SUBACROMIAL SPACE

SUPRASPINATUS MUSCLE IN THE SUBACROMIAL SPACE

muscles like the teres major and the subscapularis, are responsible for internal rotation and scapular protraction. In contrast, only the infraspinatus muscle and the teres minor are responsible for external rotation, and only the trapezius and rhomboids are responsible for scapular retraction. As a result, if we don't actively counter the predominant action (internal rotation and scapular protraction), we'll end up not only with rounded shoulders but at a much higher risk of injury.

On the other hand, the socket of the shoulder joint (where the large head of the humerus articulates with the glenoid fossa of the scapula) is so shallow that the glenoid ligament, a fibrocartilaginous structure, is needed to deepen the socket and improve contact. The difference in size between the humeral head and the glenoid fossa makes the shoulder joint incredibly mobile but also very unstable, leading to a high risk of injury. On the subject of injury, the subacromial space also deserves a mention. This space is located between the humerus and the acromion (see image, above), and the supraspinatus tendon runs through it. If the scapula is not properly stabilised (for example, retracted and depressed for deadhangs), this space is compressed and the supraspinatus tendon can become impinged. Bursitis, tendinosis and even tears are some of the nasty injuries that can occur (not to mention long periods of intense rehabilitation and retraining) if we neglect the shoulder girdle and the subacromial space.

BICEPS BRACHII

TRICEPS BRACHII (NOTE THE LONG HEAD THAT RISES FROM THE SCAPULA)

- *Upper arm and forearm muscles:* despite being part of the most important limb in climbing, the upper arm doesn't really have that many muscles. It contains the biceps and the brachialis, which are elbow flexors, and the triceps, which is an extensor muscle. The long head of the triceps also helps the latissimus dorsi to move the humerus towards the torso.

  The forearm and the hand, the stars of the show, are a little more complex. There are 19 muscles in the forearm (eight flexors, eight extensors and three radial) and 11 in the hand. In climbing, we need a good degree of balance and synergy between all these muscles and a high level of strength in different grip positions. That said, the flexor digitorum profundus (FDP) is *the* most important muscle in climbing (Philippe *et al.*, 2012). This is because it flexes the interphalangeal joints in digits two to five, which are the fingers used for dragging. In turn, the flexor carpi ulnaris and the palmaris longus muscle are used most with slopers. The extensors help maintain joint stability, and they move the wrist and forearm into the right position for gripping and pulling. As for pinches, the muscles in the hand do most of the work.


TROPICAL
FEVER

8

WHAT CAN I OPTIMISE IN MY TRAINING SESSIONS?

DEFINITION OF TRAINING GOALS

'If you don't know where you're going, any road will get you there.' This saying highlights the importance of knowing what you're training for. The definition of training goals is the first step to knowing what you should train. Are you preparing for the winter season? The sport climbing season? Is your project a big wall? A boulder problem?

In practice, and except at the most elite levels, the majority of climbers do a bit of all types of climbing (although they usually have a preferred discipline), and they either project individual routes or tick off lots of different routes, progressing climb by climb. Not planning this progression or selection of climbs can mean that if at the end of the season you decide to try a certain route, you won't have done the right type of training for a successful ascent.

SPECIFIC WALL-BASED EXERCISES

TRAVERSING. INTRODUCING THE SESSION'S TARGET TECHNIQUE

The specific warm-up is what most of us skip to at the start of a session. We get straight on the wall, do some traversing, easy climbing, and so on.

The aim here is to activate climbing-specific patterns of movement, activating your muscles for the movements inherent to climbing. So let's really make the most of this part of the warm-up. What are you planning to train today? Campus boarding? Crimpy problems? Endurance? Tailoring your specific warm-up to the focus of your session is a much more efficient way to train. If you're going to train problems with big moves, campusing or dynos, it doesn't make sense to warm up on small crimps and balancey moves, or to avoid having to pull. It would be much more efficient to do traverses, problems or moves that gradually activate the main pulling muscles and to work hand–eye coordination on increasingly difficult dynamic moves. This targeted activation of the most relevant movement patterns and muscle fibres will help you get the most out of your training session.

TIC TAC TOE 1

TIC TAC TOE 2

TIC TAC TOE 3

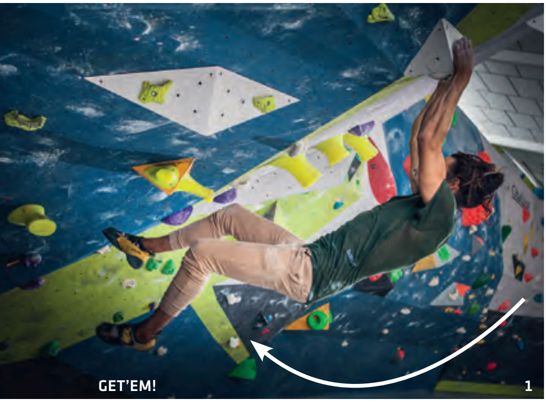
WALL-BASED CORE WORK. RESISTANCE BAND EXERCISES AND BODY TENSION

The next step is specific core activation through exercises integrated into climbing movement. Again, remember that the aim is to activate, not strengthen. Matros *et al.* (2013) suggest the following exercises:

- *Tic Tac Toe:* hang from a hold, ideally on an overhanging wall, and tap the furthest possible hold to your right-hand side with your right foot at knee height (remember that you need to move your hips to properly activate the core) and return to centre. Then tap a hold at hip height and return to centre, and finally tap a hold at head height and return to centre. Link this final move into beginning the exercise on your left-hand side with your left foot but this time in reverse order (head height and centre, hip height and centre, knee height and centre).
- *Diagonal:* on a very overhanging wall, or better still a roof, hang for 10 to 15 seconds using just one hand and the opposite foot. The further apart the holds, the harder the exercise.
- *Get'em!:* like Diagonal, you'll need a steep overhang or a roof. Jump up and grab a hold above your head. Swing your feet towards the wall and try to touch (and stay on!) the furthest possible foothold. To increase the intensity, try a running jump to create extra momentum as you jump and swing.


DIAGONAL


HANG AROUND 1


GET'EM! 1


HANG AROUND 2


GET'EM! 2


HANG AROUND 3


TRAVERSING WITH A RESISTANCE BAND AROUND THE HIPS


TRAVERSING WITH A RESISTANCE BAND AROUND THE FOOT

- *Hang around or Cut loose:* on an overhang or a roof, choose a problem or a traverse of medium difficulty. After each move, cut loose with both feet and put them back on again.
- *Feet forwards:* in this exercise, touch the next handhold with your foot before getting it with your hand. Repeat on each move. The steeper the climb, the easier the exercise (see images on next page).
- *Traversing with a resistance band around the foot or hips:* in pairs, one climber traverses while the other pulls on a resistance band looped around the climber's hips or foot.
- *Body tension boulder problems* (see images on page 81)*:* on this type of problem, both your hands and feet should be a long way from your centre of gravity, meaning you need a lot of full body tension to not fall off. Another way to recruit full body tension is through an exercise called Freeze:
  - » Find a problem with no dynamic moves and 'freeze' in position for two to three seconds after each move. This exercise not only works core strength but also develops lock-off strength, technique and movement efficiency.