FITNESS FOR HILLWALKING, HIKING AND BACKPACKING

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HILL FIT

BY CHRIS HIGHCOCK

STRENGTH!

THE MISSING ELEMENT IN YOUR TRAINING

Fitness for Hillwalking, Hiking and Backpacking

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The missing element in your training

By
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ABOUT THE AUTHOR

Chris Highcock has a regular fitness column in the leading UK walking and backpacking magazine, TGO (The Great Outdoors). He has been obsessed by fitness since he started training with weights as a teenager and later gained BAWLA (British Amateur Weightlifting Association) qualifications as a leader and teacher in weight training. Now he operates a popular blog at www.conditioningresearch.com that highlights current developments in exercise and fitness science. Conditioning Research was chosen as one of Outside Online Magazine's 'Top 10 Fitness Blogs for 2011'.

While his fascination is with fitness, his passion is for the mountains. He spends as much time as he can in the hills of his Scottish home, gradually ticking off Munros and smaller hills. In recent years he has walked in the mountains of Andalusia in Spain and is looking forward to further exploring these hills. Photographs and accounts of his walks are posted on his blog "Cairn in the Mist" www.cairn-in-the-mist.blogspot.com. Chris believes that fitness is not an end in itself; all this training is functional and is about facilitating enjoyment! Strength makes everything easier and therefore it all becomes more fun. Being fit lets you get out into the hills more often and lets you enjoy it more when you are there.

DISCLAIMER AND/OR LEGAL NOTICES

The information provided in this booklet is for educational purposes only. The author is not a doctor and the material is not meant to be taken as medical advice. The information provided in this booklet is based upon Chris' experience as well as his interpretation of the current research available. The advice given in this booklet is meant for healthy adults only. Readers should consult their doctor to ensure that this advice is appropriate for their individual circumstances, particularly if they have any health issues or pre-existing condition. This booklet is for informational purposes only and the author does not accept any responsibilities for any liabilities or damages, real or perceived, resulting from the use of this information.

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1 WHY THIS BOOKLET?

This booklet is focused on something that every walker, hiker and backpacker needs. It weighs nothing but will make your pack lighter. Equipped with this, your trips to the hills will be safer; each walk will be easier and more fun.

I am not talking about gear: a new piece of clothing or lightweight shoes; it is not about the latest rucksack or fashionable waterproof shell. I am not a gear geek and I get tired of the way in which kit dominates the outdoor magazines and blogs, as if all you really need is another tent or pair of trousers to transform your time outside. So often the "secret" is presented as something material – buy this gear and you will have a better time in the mountains. Of course, the magazines get much of their funding from the adverts for the gear companies, so it is understandable that the focus is often on "stuff".

The ultimate piece of lightweight gear

But it is not that easy. I am not selling something extra for your wardrobe or gear cupboard. What I have is more valuable, more versatile and a lot more satisfying. I am offering you a way to improve your ***fitness;*** indeed more than that: I am looking at the key neglected element of hill-fitness: ***strength***.

What you might want from this booklet is a step-by-step guide to turn you into a tireless machine, powering up and down hills with no effort, a tranquil smile on lips that barely part with your easy breathing. What you really need for your days on the hills to be safer, less draining and more rewarding is something much simpler: basic functional strength. Thankfully, strength is not hard to develop: it takes some application and effort, but not a lot of time.

What you will find in this booklet

I am going to look at the importance of strength and how to get stronger. I will consider the key principles that are needed to make your work-outs effective and safe then look at the most appropriate exercises to use: moves that minimise risk but which can be done at home, without expensive equipment. I'll also look at the difference between exercise (which has the explicit purpose of developing fitness) and general activity or recreation.

The **Hillfit Strength Routine** will take you through a basic set of exercises that you can start to apply immediately, regardless of your current level of strength. I will explain how to progress as you get stronger. There are a few other things that can make your walking easier: your walking style (gait), your balance and general lifestyle issues like sleeping more and sitting less, but they are topics for other booklets.

At the end I give references to some scientific research, which supports the principles on which the routine is built. I also point to other resources and books that you might want to investigate as you learn more about rational physical training.

Something that works

It is not about the gear. Too often we are seduced by the marketing men to think that new kit will transform our day on the hill. Shaving 1 kg from your pack-weight is all very well, but if you are still out of condition and struggling to climb the stairs without getting winded even with no pack, then your priority should be your fitness.

I offer something different in this booklet, something that works. It is an approach that you can easily accommodate in your life. It is safe, free from hype, evidence-based and built on scientific principles.

2 WHO IS THIS PROGRAMME FOR?

This is not a training programme for the elite hill-runner or those looking to get their marathon time under 3 hours, although all athletes will benefit from strength training. Such athletes, due to their genetic makeup as much as their training, are already far beyond the average. The focus of this booklet is on getting the typical man or woman more prepared for their days in the hills, within the constraints of limited spare time and competing priorities. If you enjoy time walking in the outdoors (hillwalking, backpacking, hiking or whatever you call it) and want to enjoy it more, tackling those days with less pain and effort, then the programme I outline in this booklet is for you.

It is for you if you want to enjoy your walking more

The aim is to make your time in the hills more fun. It is more fun when it feels easier; it is easier when you are able to walk with less effort; it is less effort when you are stronger. Strength means that the climbs do not leave you as breathless or with muscles burning with excess lactic acid.

Properly designed and executed exercise is the method we will use to achieve that cascade of effects. This will also bring broader health benefits, but the focus is to make it easier for you to enjoy time in the outdoors. Look on the health benefits as free bonus gifts!

It is for you if you have no time or desire to go to a gym

The programme is time-efficient and requires no special equipment. If you have two 15-minute slots in your week you can complete this routine at home and reap great benefits for your health. The only investment you need to make is some time.

It is for you if you want to keep things simple

Like the best modern backpacking equipment, the routine is basic, functional and lightweight. It is minimal, not because that is fashionable in this time of ultra-light backpacking, but because effective exercise is simple and does not need much time or complexity.

3 WHY STRENGTH FOR A WALKER?

What attributes come to mind when you picture a fit, well-conditioned hill walker? You might think of agility, flexibility or maybe stamina. "Strength" is probably not on your list, as people associate strength with weightlifters or bodybuilders, but not with the demands of a day in the hills. Consequently, folk too often shy away from strength training, thinking that it means "bodybuilding" sessions in a gym. When they decide to train and get fit for a hill-walking holiday, a jog round the block is the usual solution. However, that approach does not really deliver what we need, which is *strength* and the benefits that will come with it. So why is strength so important?

The glass

The strength coach, Dan John, uses a nice example: your absolute strength is like a drinking glass. Whatever you want to achieve in terms of physical performance, endurance, flexibility, resilience, has to fit into your glass. If you have a small glass, i.e. little absolute strength, you will not fit much in there. If you have a big glass, you will be able to fit a lot more inside. No matter what your fitness goal, being stronger will help you get there faster. As Dan John says:

> *"…if I can get you stronger, it's going to be easier long term… not only to get your goals, but to maintain your goals over a long time. The bigger we can make your glass, the easier it is for you to attain and maintain your goals… the bigger your glass, the easier it is going to be."*[1]

That sounds like nice rhetoric, but what does it really mean? Why is strength so important, not only for walking in the hills, but for everyday life?

Stronger muscles are more efficient

It is *easier* for stronger muscles to do the same tasks. Greater strength means less effort will be required to do anything, from lifting a weight to walking up a hill. Imagine that you have 20 "units of strength" per muscle fibre, while your weaker friend only has 10 units. If it takes 2,000 units to climb a hill, your cardiovascular system will only have to support the work of 100 fibres (2000 divided by 20) to get you to the top, whereas your pal will need to recruit and fuel 200 fibres (2000 divided by 10). You get to the top feeling fine but he is out of breath because his cardiovascular system had to provide oxygen to power twice as many muscle fibres. When you are stronger, your heart and lungs do not need to toil as hard to support the same amount of muscle-work. Stronger

muscles make everything easier. This is what making your glass bigger means. With stronger muscles, everything gets easier and you can go further for longer.

Injury prevention: stronger muscles protect you from injury

Stronger muscles, bones and connective tissues are more resilient and therefore less prone to injury. This strengthened structure acts as the body's major shock-absorber to protect you from the trauma of impact, whether as a result of a fall, or the repeated minor insults of every step that you take. Strong muscles also enable you to maintain good posture, which itself prevents injury by directing the force of your movements through the most appropriate structures and tissues. This avoids excess wear–and-tear on your bones, tendons and ligaments.

Colin Gordon of Edinburgh Deep Tissue Massage says:

> *"Lack of strength is a major contributing factor to the problems I see in many clients. Lack of strength makes it difficult to maintain good posture, you tire more quickly, resulting in compensatory movements that put strain on other areas and increase the likelihood of injury; a stronger athlete is more injury-resistant*."[2]

Getting stronger – through appropriate exercise – not only makes each step *easier*, it makes each step *safer*.

4 THE HEALTH BENEFITS OF STRENGTH TRAINING

While this booklet is concerned with fitness, there are also more important benefits from strength training in terms of health. It is important to realise that health and fitness do not necessarily coincide and are certainly not the same thing.

Fitness is not health, but it helps

Fitness is specific: it describes your ability to do a particular task, whether that is picking up 100 lbs or climbing a mountain. Health can be defined in a variety of ways, but is concerned with the overall operation of all your body's systems (e.g. heart, lungs, brain, nerves, hormones) and to ensure they are working optimally. You can be fit for a specific task yet still be unhealthy overall. Ultimately your long-term health and how you can preserve it should be your primary concern. People accept that exercise has a role in health. The media and government often put out messages that it can reduce the risk of cancer, heart disease, diabetes or dementia. When hearing this people assume that they need to do aerobic or "cardio" (cardiovascular) exercise, such as jogging, cycling or going to fitness classes. Strength training and its amazing effects on overall health are so often neglected. Strength training can do so much more for your health than jogging or riding a stationary bike, as we will now see.

Functional strength fights ageing

Being able to function into old age requires strength. Muscle loss (also called sarcopenia, from the Greek meaning "poverty of flesh"), is the degenerative loss of skeletal muscle mass and strength associated with ageing. Researchers are now realising that fighting the gradual loss of muscle is the most effective tactic to slow down the general physical effects of ageing. Starting in your 30s, you lose 1-2% of your muscle mass each year; strength training can slow this decline. Developing strength and maintaining muscle mass reverses the effects of getting older.

As we have seen, being stronger makes everyday tasks – like picking up your shopping bags or standing up from a chair – easier. The stronger you are as you age, the more function and independence you will retain, both essential to health.

Glucose metabolism and insulin sensitivity

An important health-benefit of intense exercise is that it increases insulin sensitivity in your muscles. Insulin is a storage hormone: it removes glucose (sugar) from your blood and puts it into storage as glycogen in the muscles, where it can be easily burned for fuel, or in fat cells for storage for longer-term energy requirements. But, if you never do any hard muscular work, the glycogen in your muscles will never get burned up because that fuel will not be needed.

If that happens, the muscles remain full of glucose; glucose in the blood can't get into the "full" muscle cells so it starts to build up. Your body does not want high levels of circulating glucose, as that causes all sorts of problems. So, it will always try to get the sugar stored away somewhere, by producing more insulin, which acts by giving the sugar access into cells. If the muscle cells are always full of sugar already they become "resistant" to insulin and they don't let the sugar in. That means more sugar and more insulin floating round in the blood. When it can't get into the muscles the sugar is taken to the liver, where the high insulin levels act as a signal to attach it to fatty acids for storage in fat cells. These tend to remain sensitive to insulin and will let the sugar in for storage as fat. Thus, if your muscles are not burning sugar then the only place for excess sugar to go is to get stored as fat.

Thankfully, this process can be reversed with *intense* exercise. Through hard training the muscles will burn the stored glycogen in the muscle fibres. This frees up space in the muscles for more sugar from the blood; sugar that was backing-up in the blood can now be moved into the muscle, instead of being stored as fat.[3] The muscles become more sensitive to insulin, so less insulin is required. With less insulin you will not be storing as much fat. Gentle walking or easy activity will not stimulate this process, only hard exercise.

Burning body fat

Proper strength training makes it easier to lose body fat. There are at least three elements to this:

- As said above, when muscles are emptied of glycogen, sugar can be moved from the blood to the muscle, insulin levels will fall and any excess sugar is less likely to be stored as fat.
- A higher muscle mass leads to a higher resting metabolic rate. In other words you will "tick over" at a higher level, burning more calories whatever you are doing and even when doing nothing.
- You will burn calories while doing strength training, but also after the workout as your body restores its energy stores and rebuilds its damaged tissues.

These elements will also make it easier for fat to be released from fat cells, to be burned as fuel. The process is mediated by an enzyme called hormone-sensitive lipase, which is inhibited by high levels of insulin in your blood. Increased insulin sensitivity through strength training will reduce insulin levels and so hormone-sensitive lipase will be better able to release fat from storage to be used as fuel.

Leptin sensitivity

Leptin is another related hormone which is important for health and, especially, for body composition. This is the "satiety" hormone, which signals when you have had enough to eat. Leptin resistance means you can no longer detect the signal to stop eating; many obese people are resistant to leptin and literally don't know when to stop. Intense exercise has been shown to make people more sensitive to leptin and its effects, so an uncontrolled appetite should be less of a problem.

Metabolic rate

Maintaining and building muscle mass has other important effects. Muscle is the body's primary site for burning fuel, both fat and blood sugar. The more muscle you have, the more calories are burned while resting and the better you will be at metabolising your food, reducing the risk of obesity, diabetes and other modern "diseases of civilisation."

Bone strength and bone mineral density

Strength training also plays a key role in maintaining strong bones. The popular belief that weight-bearing activity leads to stronger bones is partially true: muscles provide one aspect of the stimulus that causes bones to get stronger and denser. Strong muscles maintain tension on the bone, causing it to grow thicker and stronger. Weaker muscles do not pull on the bones in the same way, resulting in thinner, less dense and more fragile bone. Dense bones, additional muscles to cushion any impacts and stronger muscles to maintain function and prevent falls, are all huge benefits to health, especially as we get older, when a fall can have devastating consequences.

Flexibility

Don't confuse this with stretching! When we think of flexibility we tend to think of people doing various static stretches, often hamstring or calf muscles. However, scientific research indicates that such stretches can actually make performance worse, increasing the potential for injury and doing nothing to reduce muscle soreness. Often,

the problem is not a lack of flexibility but of functional strength; the muscles are too weak safely to control movement around the joints. Recent research has found that, even in the absence of stretches, strength training can markedly improve the safe range of motion at joints, as those muscles become better able to manage movement.

There is a role for stretching for particular tight muscles; sedentary life tends to leave the desk-bound person with tight hip flexors for example, but that is a topic for a different booklet! For now remember that stretching is generally over-rated and certainly risky for your warm-ups as we will see in chapter 10.

Balance

Balance is a fascinating topic and an under-appreciated sense. To keep your centre of gravity balanced over your base of support, your brain brings together information from three different systems:

- The **visual** system – you see the position of your body in relation to your surroundings;
- The **vestibular** system – your inner ear detects movement in different planes; and
- The **proprioceptive** system – sensors in your muscles and ligaments ("proprioceptors") plot the position of your body in space.

If the brain senses that you are overbalancing, corrective action is taken: muscles unconsciously contract or relax until balance is restored. Often balance deteriorates with age, resulting in falls and injury, partly due to weakness in the muscles. If the muscles are too weak to maintain the appropriate position of the body then balance will always be poor.

Balance is vital to walking in the outdoors where you will be on uneven and unstable terrain. Balance exercises will help proprioception, but strengthening the muscles to allow them to maintain your balance is the real key. There are specific and simple exercises that you can do to strengthen the proprioceptive system: the most basic of these is simply to spend time each day stood on one leg; e.g. I recommend that everyone brushes their teeth while balanced on one leg and to build this simple habit into your daily routine.

Blood pressure

People may fear that strength-training will cause dangerously high blood pressure. However, research indicates that proper strength-training *reduces* blood pressure with

consequent reductions in all the associated health-risks that go with hypertension. This is especially true if you avoid holding your breath and straining, a key performance principle that we will look at in chapter 7.

Cardiovascular benefits

The cardiovascular system consists of the heart, lungs and blood vessels. Its primary function is to transport fuel (fat, sugar with oxygen to burn it) to the muscles and to remove the waste products that are produced. The system works 24 hours a day, (otherwise you are dead!), performs harder when you are jogging or walking up hill and functions *intensely* with strength training. Strength training has important cardiovascular benefits: studies have concluded that it works the heart and lungs just as hard and effectively as the more usual steady-state approaches, such as jogging or riding a stationary bike.

Cardiovascular health is stimulated by resistance training leading to increased efficiency of the heart and lungs to pump nutrients to the muscles. The only way to really activate that cardiovascular system is through working the muscles hard, in a way that is not possible with steady-state activity. This has the effect of directly stimulating the heart and blood vessels. Aerobic conditioning is *specific* to each particular activity, such as walking, and is often internal to the muscles and related to the neurological efficiency that develops as you practice that particular skill.

The risks from this exercise are also limited; strength training can dilate blood vessels in the muscles, so that it is easier for the heart to pump blood through them. Proper strength training has real cardiovascular benefits. When each muscle fibre is stronger, the heart and blood vessels have to do less work, recruiting fewer fibres for any given task. The stronger you are the less hard your heart and lungs have to work.

5 HOW TO GET STRONGER

Have I convinced you that strength training is a good idea, both for its impact on your fitness for the outdoors but also for free bonuses for your overall health?

Stronger muscles can:

- Make walking easier;
- Protect you from injury; and
- Promote a wide range of health benefits.

It is win, win, win!

Getting stronger: adaptation and overload

Two principles of exercise science apply: *adaptation* and *overload*. Both are demonstrated by the legend of Milo of Croton, a wrestler at the ancient Olympics. Allegedly he got strong enough to lift an adult bull by starting in childhood and lifting and carrying a newborn calf, repeating this feat daily as the beast grew to maturity. As the calf got bigger Milo got stronger. He *adapted* to the increasing load by growing stronger. All modern strength-training simply mimics Milo's approach: by challenging muscles with increasing loads they adapt, getting stronger so they can cope with such loads in future. This is the principle in biology called *hormesis:* a stressor that has a beneficial effect. The body reacts to the stress imposed on it to become stronger and better able to cope with any future repeat of that stress. Think of a sun tan: sunlight is a stressor, but the skin reacts with a tan to protect it from damage. This is *adaptation*: muscles react to training loads imposed on them, by increasing their ability to cope. *Overload* simply describes how muscles increase in strength by working against gradually increased loads. If you don't increase the load there will be no need for adaptation.

The purpose of exercise

If you put the health benefits of exercise together with these ideas about the need for *overload* to create *adaptation* you can understand some ideas about exercise. The purpose of exercise is to recruit and stimulate as many muscle fibres as possible, emptying them of glucose and getting them to a point when they cannot fire anymore. For this to occur, a muscle or group of muscles must be given a load sufficient enough to initiate a "sequential recruitment" of fibres, within a time-frame that permits the maximum number of fibres to be recruited.

Sequential recruitment is the activation of all of the different fibre-types: slow-, intermediate- and fast-twitch. Effective exercise uses all the power of the slow-, then the intermediate-, then the fast-twitch fibres.

- **Slow-twitch fibres** – these fibres are abundant but not very powerful, which is why we need a lot of them to do our various day-to-day tasks. With little power they do not use much fuel or create many waste products. It is the waste products which account for the "burn" you feel in a working muscle, so if you only use the slow fibres you don't get the "burn" and you are not using much fuel.
- **Intermediate-twitch fibres** – there are fewer of these but they are more powerful, using more fuel and generating more waste products and thus a bigger "burn" in the muscles. As the slow-twitch fibres get exhausted and stop working, these intermediate-twitch fibres take over.
- **Fast twitch-fibres** – these are the least abundant but most powerful muscle fibres. As the slow- and intermediate-twitch fibres get exhausted and drop out of action, these fibres take over. They do the same work but need more fuel and generate more waste products.

Exercise should be hard enough to stimulate all of the slow-, intermediate- and, ultimately, all of the fast-twitch fibres. This feels like an increase in the "burn" and then you know that you are successfully increasing your muscle fibre involvement and working all of them. The key in all this is getting exhausted and allowing the muscles to fail. Easy exercises that don't stress the muscles will not cause overload and will not call for any adaptation. They do not burn through the slow- and intermediate- fibres to get to the fast-twitch fibres and therefore will not release the glycogen from all those fibres.

Recent research by Stuart Philips, from McMaster University, in Canada, found that the important element in productive strength training was not the amount of weight lifted, but getting to muscle failure.

> *"Rather than grunting and straining to lift heavy weights, you can grab something much lighter but you have to lift it until you can't lift it anymore. We're convinced that growing muscle means stimulating your muscle to make new muscle proteins, a process in the body that over time accumulates into bigger muscles."*[4]

When you work hard, the body reacts by building more strength and more muscle, just in case you call on it to do that sort of thing again.

6 EXERCISE VS. ACTIVITY: YOU STILL NEED TO WALK!

The true purpose of exercise is to apply a stimulus to recruit all of the muscle fibres to set off a cascade of health benefits, not least of which is the strengthening of the muscle as it adapts to the stimulus. The best results come from controlling the stimulus to get the benefits, without the risk of injury through inappropriate motions or too much wear-and-tear. Thus exercise is focused on delivering these benefits, safely and efficiently. Getting an adaptive response is the domain of exercise.

Ken Hutchins of Renaissance Exercise points out that *exercise* is not about fun but delivering those benefits:

> *"…We exercise not to enjoy the exercise, but so that we can apply our improved bodies gained form the exercise to enjoy all the other activities (or inactivity) in our lives."*[5]

Activity is something different and encompasses all sports and recreation, e.g. hillwalking, climbing, football. These have specific skill-sets to which you can apply your strength. Each of these activities can have exercise benefits, but they may not be the safest or most efficient ways of obtaining those benefits. Thus, the first thing to do is to develop strength through exercise routines, then learn and practice the skill-set specific to the preferred sport or activity, applying that strength to become safer, more capable and tougher.

My hillwalking is not "exercise". Exercise is what I do to make my hillwalking more enjoyable.

Skill training

Hill walkers, hikers, backpackers need to develop strength through exercise, but also practice and develop walking skills as strength facilitates walking. The skill-set of good gait, balance and posture must still be central. Walking is not the best way of *exercising*, but is a great activity and you must spend time honing that skill. Just as a tennis player might benefit from strength in the serve, they still need to develop that skill; your serve is your walking style. Strength is essential and you also need to learn to walk efficiently and effectively. One simple thing to do to start to think about your gait is to spend as much time as possible barefoot. Getting out of stiff and restrictive footwear can reset your walking style and get your brain used to controlling your steps more naturally.

Natural life is active

"Normal" activity can be defined as that which our ancestors would have done; then a lot of daily activity was standard. Replicating the "native human activity pattern", as far as is practical in modern life, would mean that everyone would be much more active. One review stated that:

> *"A large amount of background daily light-to-moderate activity such as walking was required. Although the distances covered would have varied widely, most estimates indicate average daily distances covered were in the range of 6 to 16 km."*[6]

Green exercise beats the blues

Walking is natural but also essential for our psychological well-being. Indeed research into the structure of the brain indicates that the brain is "plastic" and can be moulded and physically changed. Aerobic exercise unleashes a cascade of neurochemicals and growth factors that physically build the brain's infrastructure. Scientists have also identified many psychological benefits from simply walking in the outdoors, called "green exercise". Therefore, not exercising outdoors may contribute to many health problems, including depression.

Thus, walking, especially outside, is natural and psychologically beneficial, but is not the best way to get exercise benefits. For that we need to control the stimulus and use it to obtain an adaptive response and apply that strength to make us better walkers.

7 PERFORMANCE PRINCIPLES

With all this background, what is the best way to perform exercises? I give the key principles of how to exercise, how to safely get those health benefits: recruiting all those fibres, emptying the glycogen stores and developing cardiovascular fitness. Remember, this is about a controlled stimulus to get an adaptive response and safely to stress the muscles, not about trying to mimic the motions of walking.

One set

You only need to perform one set of each exercise. Once you have exhausted the muscle fibres, knocking out the slow-, intermediate- and the fast-twitch fibres there is no benefit to resting and then going at it all over again. You need to rest and recover, letting the muscles adapt and grow stronger, which will take a few days. A recent review stated that you:

> "*…can obtain appreciably the same strength gains by performing only a single set of each exercise 1 or 2 times per week, compared to higher volume workouts*".[7]

Again this is about safety and efficiency. If you can do it with one set, why do more? There is more to life than training.

Slow down

Perform the exercises slowly and deliberately. There are several reasons why such slow motion is useful.

- **Safety** – moving slowly reduces the force from acceleration that is applied and limits the risk of injury that comes from jerking or heaving;
- **Posture** – moving slowly allows you to maintain correct body position so you can focus on the target muscles;
- **Constant tension** – moving slowly limits momentum, which would remove tension from the muscles and leads to acceleration. Mechanical tension on the muscle is a factor, along with microscopic damage to the fibres and general metabolic stress, in promoting muscle growth and strengthening (the process called hypertrophy).
- **Concentration** – moving slowly and deliberately lets you focus on the movement, which helps your motor skills.

If you want a more precise prescription as a guide, then I would advise that you aim to take 10 seconds each for both the lifting and lowering portions of the movements, taking special care to go smoothly at the turnarounds – the top and bottom of the motion. Remember that we want the benefits of exercise while we wish to avoid unnecessary wear and tear. Moving slowly and deliberately will help minimise those risks.

Indeed when we think about the purpose of exercise – sequentially recruiting muscle fibres – you do not even have to move; fibres can be recruited with motionless exercise, in which time and load are the only factors. One of the key moves in our routine, the wall sit, is motionless. However, overall we are looking for a relatively slow motion.

Breathe

Breathing should be natural and relaxed:

- Do not hold your breath
- Do not exhale forcefully
- Do not grunt or scream.

As things get harder, keep breathing, with your mouth open and jaw relaxed, perhaps "panting" a little to get the oxygen in as necessary. Don't hold your breath as this only raises blood pressure unnecessarily and takes some of the benefit from the muscles.

"Pack" the neck

"Packing the neck" is a way to keep your head aligned properly. Look straight ahead with the chin slightly down, as if you are trying to make a double chin. Do not move your head or neck or look around. That would increase the chance of pulling or straining a neck muscle.

Progression

Remember the principle of overload: if you want to keep adapting you will need to keep challenging your muscles a little more in each workout. You can do this by increasing the weight you are lifting, spending more time under tension, or by changing the mechanics of the exercise so that it gets harder. The **Hillfit Strength Routine** will explain how to progress by using each of these approaches in the different exercises that it includes.

Workout frequency

The optimal frequency of training varies between individuals, but as a general rule you should work out no more than twice a week, e.g. Monday and Thursday. If you are not progressing after a few workouts in a row, other recovery factors may need to be checked: are you eating enough quality food? Are you sleeping enough? Are you limiting stress in your life? If the answer is "no", you may require additional rest days and need to take an extra day or two off.

Don't worry if you are only working out once a week. If you are also doing tough walks in the hills you will need the extra time to recover. The key is progress. As long as you are getting stronger you are training enough. If in doubt, train less often.

Effort not weight – go to failure

As discussed, you need to work hard to recruit the muscle fibres. It is about effort rather than lifting heavy weights, but it is important to keep moving in an exercise until you can't move anymore and you reach a point of momentary muscular failure. All of the muscle fibres are exhausted and not able to fire anymore.

> *"The evidence suggests that individuals should be encouraged to train to momentary muscular failure, as this appears to maximize muscle fibre recruitment and, according to most of the research to date, will maximize gains in strength and power."*[7]

8 EXERCISE SELECTION

I have talked about why strength is important, how to train for strength and the principles that apply in your exercise performance. Now I address *which movements* to choose. The aim is exercise, not recreation, picking moves that allow us to stimulate the muscles safely and under control.

The functional myth

You do not need to mimic the motion of hillwalking to improve the strength to walk. This fallacy of "functional training" has led many astray in recent years. The key is to strengthen the muscles and then apply this strength to your skill area, be it walking or throwing a discus. For example, walking with weights attached to your ankles and wrists might add load to your muscles but there are safer ways to stress those muscles. In any case, walking with weighted hands and feet is a different skill from normal walking. The idea is to build strength with sensible training, then apply that to the skill, which is walking.

Safety first

Various factors should inform your choice of exercise: safe movement, strengthening muscle without over-stressing the joints and using exercises specifically to strengthen the areas most often injured, to minimise the chance or severity of an injury. Thus we need to pick moves that track natural muscle and joint function so as not to put either in a vulnerable position for injury. Hillwalking itself might carry some injury risk, but the exercises we choose to gain fitness for walking should be safe in themselves. The hills are dodgy enough and you do not want to injure yourself in the gym and then end up being kept out of the mountains. The old Latin adage must apply: *Primum non nocere* – first do no harm!

Congruent

Ideally, exercise should also use movements that have the muscle at its strongest when the leverage is weakest. In terms of biomechanics, we need to match maximum muscle torque with the point of the maximum moment arm. This is what Bill DeSimone calls congruent exercise (see Resources section), and I have mainly chosen exercises that take this into account.

Low skill

I have also chosen movements that are relatively easy for the average person to learn. These focus on the *muscles* that are being stressed, i.e. simple gross motor movements that do not require great co-ordination or skill. It is a waste of time if you need to spend weeks learning to do a particular exercise. Keep it simple.

Convenience

There are many ways to apply an appropriate exercise stimulus to your muscles, e.g. weights (bar-bells and dumb-bells), bodyweight exercises or even gym machines. Your muscles experience the tension, the fibres work and are exhausted whether you are lifting a dumb-bell or your own bodyweight in a squat.

Convenience is a massive determinant of how well people stick to training programmes. People are more likely to stick to their programme if it is something that they can do at home without needing to go to a gym: 68% of home based exercisers were still training after 2 years while only 36% of gym based trainees kept at it.[8]

The **Hillfit Strength Routine** can be done at home with minimal equipment. It is convenient and should be easy to do during your week. A cheap set of dumb-bells would open up a range of new options for your training, but they are not needed as you can do a lot with just bodyweight in your own home.

The minimalist's routine

Using these principles it is possible to design a simple routine, using very basic movements to work and strengthen all of the body's major muscle groups. This will be a minimalist routine but will be efficient with a big impact on the body's strength and resilience.

Think about lightweight backpacking: you only take what you need so that your journey is easier and more efficient. Equipment is basic and functional, often having multiple uses. You are not weighed down with excess baggage. I want to approach training in the same way, so that you do what you need to do and no more, with technology and techniques that will have multiple effects.

Natural movement patterns

Exercise coaches have tried to classify basic human moves in different ways, but it comes down to these five motions:

- **A push** – pushing something away from you.
- **A pull** – pulling something towards you.
- **A squat** – a fundamental movement, essential for function.
- **A bend / hinge** – bending to pick up something from the floor, not with the knees, but with the strong muscles of the hips.
- **Walk / gait** – walking, running, jogging.

Some coaches like to include other moves like a lunge or a twist, but they are really covered by gait. These moves also overlap in some ways, but together they stress all the major muscle groups in the body. The **Hillfit Strength Routine** is built around these moves, but adapted to promote safety and allow progression.

9 THE HILLFIT STRENGTH ROUTINE

We finally get to the routine, the programme that will get you stronger, fitter for the hills and healthier!

The moves

The programme is built around four basic, foundational moves, done once or twice a week.

- **Wall sit** (squatting)
- **Push-up** (pushing, with stress on pulling muscles to stabilise)
- **Modified row** (pulling move)
- **Hip extension** (safe bend / hinge move)

That is all that is required for a basic strengthening routine. The rest of this section will describe how to do each move and how to progress, making it harder as you get stronger.

The wall sit

The wall sit fits the requirements for a lower body exercise. It is a simple, low-skill movement that is easy to learn and good for strengthening the big muscles of the thighs and hips. The wall sit is less complex than a squat, but using it you can quickly and safely produce similar results.

- Stand with your back against a wall. Your feet should be shoulder width apart and toes pointing straight forwards. Keep your hands flat against the wall (see picture).
- Take a step forward so that your feet are approximately the length of your thighs away from the wall.
- Bend you knees and slide your back down the wall. Ultimately you want to get to a position where your ankles, knees and hips are all at 90 degrees (the 90/90/90 position).
- Hold that position for up to 90 seconds.
- Return to the starting position.

Progression:

Once you can hold the basic position for 90 seconds, you need to introduce progression to the exercise so that you are constantly stimulated to adapt. With this move the progressions use increased time and different positions. Sequential progressions are:

1. **Partial wall sit**. Go through the steps above, but instead of lowering your body so your knees are at right angles, stop when you are only half way down. Hold this position for as long as you can. Focus on the idea of pushing through the floor with your heels. Keep breathing and try to relax your face. Once you can hold this for 90 seconds, at the next workout move on to progression 2.

2. **Wall sit with support**. This time descend so that your ankles, knees and hips are all at 90 degrees (the 90/90/90 position). Put your hands on your knees so your arms form struts to support some of your weight. Again hold this position for as long as you can, pushing through your heels. Once you can hold this for 90 seconds, at the next workout move on to progression 3.

3. **Full wall sit.** As in the previous progression, get in the wall sit position, but this time hold your hands by your sides so all of the work is being done by your legs and hips. Again, the aim is to maintain this position for at least 90 seconds; when you can do this move on to progression 4.

4. **Weighted wall sit.** Once you can hold 90 seconds in the 90/90/90 position, we need to start adding some resistance. Improvise a weight, e.g. bottles of water in your rucksack worn on the front of your body and start the progression all over again.

A static hold under load

Holding that position at the bottom of the wall sit is where the exercise is most effective. This is the "congruent" position that makes it safer, i.e. the muscles are applying maximum torque while the moment arm (the lever) is at its largest. As you hold that position, you are forcing more muscle fibres to be recruited: first the slow-twitch, then the intermediate- and finally the fast–twitch fibres. Each set of fibres will work to exhaustion before recruiting the next set. Aiming for a 90 seconds time under load (TUL) should ensure that the exercise is neither too easy nor too hard so you work through all of the muscles fibre types.

> *"If you use a weight that is too light, you will recruit the slow-twitch fibres into service, but because they fatigue so slowly, by the time you have started to recruit the intermediate fibres, some of the same slow-twitch motor units will have started to recover. They will then recycle back into the contraction process, thus preventing you from ever engaging the*

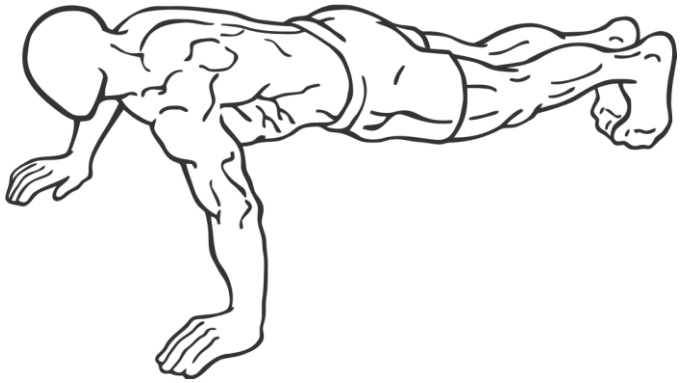
> *higher-order muscle fibres….*
> *…the problem is similar with a weight that allows only one or two reps. All motor units (slow and fast) are activated, but the fast-twitch units fatigue so fast that the set will terminate before you've had the opportunity to thoroughly involve and stimulate the bulk of your slow- and intermediate-twitch fibres."*[9]

In the wall sit progression we are not dealing with different weights initially, but different leverage positions. The principle is the same though as you want to apply the stimulus for an appropriate length of time so that it is neither too easy nor too hard.

The push-up plank

A push-up plank is a pre-requisite for doing a push-up, as you need to be able to hold a good, solidly-aligned posture before you can do a proper push-up. There is no point in telling you to do 10 push-ups if you can't hold this position!

- Start off in the "push-up plank position": face down, arms straight, hands shoulder-width apart, with a straight line running from your head to your ankles (see picture). This is the top position of the push-up.



- Keep everything tight: tense your stomach, squeeze your buttocks together, keep your neck packed, looking at the floor and keep breathing easily.
- Hold this position, gradually building up (10 seconds, 20, 30, 45) until you are able to hold it for 1 minute. This is the first step in your progression. Then you move onto the push-up.

The push-up

The next exercise in the routine is the push-up. The push-up is a fundamental upper-body exercise developing strength in the pushing muscles of the chest, triceps and shoulders but also training postural control and core stability. It is my favourite exercise and if all you did were wall sits and push-ups you would be making a significant impact on building strength. However, the full push-up is a hard exercise and most people need to work up to it. Therefore I have given a series of progressions to help you work up to

the full push-up and then beyond.

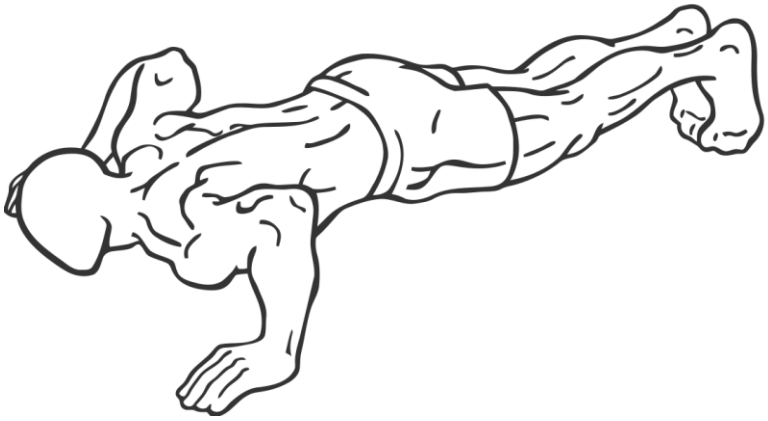
Progression to push-up

1. **Wall push-up:** Stand facing a wall at arms length. Touch the wall with your fingertips, arms shoulder width apart and then bring your palms down to the wall. Bend your elbows, bringing your head to the wall and then press back up. Move slowly and under control. Even through you are standing up, keep tense in that plank position. Don't count repetitions but work to time: keep moving until you fail, i.e. where you can no longer get any motion. Once it takes you longer than 90 seconds to fail, move to progression 2.

2. **Knee push-up:** Get in the push-up plank position, with everything taut. Instead of your toes being on the ground, do the exercise with your knees on the ground, torso straight, palms flat on the ground, hands shoulder width apart, lower your chest to the ground and then push yourself up. Be sure to get a full range of motion at the top. Again, don't count repetitions but work to time and keep moving until you fail. Once it takes you longer than 90 seconds to fail move to progression 3.

3. **Desk push-up:** Stand a few feet away from a secure, hip- height object (e.g. table or desk) and grab the object with straight arms, shoulder-width apart. Keeping your torso straight in that plank position, lower yourself until your chest touches the object, wait a second, then push yourself back up. Again, don't count repetitions but work to time and keep moving until you fail. Once it takes you longer than 90 seconds to fail, move to progression 4. The photos below show the exercise using a bench, but you could use a table or the counter in your kitchen.

4. **Full push-up:** Start off in the "push-up plank position": face down, arms straight, hands shoulder-width apart, with a straight line running from your head to your ankles. This is the top position of the push up. Keep the straight line from ankles to head and bend the arms to lower the body until your upper arms are parallel with the floor, then reverse direction. Keep your elbows in rather than flared out, with maybe a 45 degree angle between your upper arms and your torso. Body weight should be lifted by the arms; don't be tempted to use the lower half of your body to pull yourself up. Move smoothly and under control.



Keep your head neutral (don't drop your forehead to the ground), and keep your core and buttocks tight throughout the motion. Move slowly and under control, paying particular attention to slow "turn-arounds" at the top and bottom of each movement. Once it takes you longer than 90 seconds to fail, move to progression 5.

5. **Weighted push-up:** Put on a rucksack containing weights, e.g. a few bottles of water, and start the progression again.

Again, you are aiming for a TUL which is enough to work through a sequential recruitment of fibres, ideally between 60 and 90 seconds.

The modified row

The row will work the opposite muscles to the push-up, the pulling muscles of the upper back and arms. It can be hard to address this motion without using machines or dumbbells. However the plank position you hold in the push-up will stress the pulling muscles of the back to some extent but we will work the muscles more directly with the towel row.

Row progressions

Again for this move, the measure of progress is TUL, aiming to reach failure in about 90 seconds. If it takes longer, move to the harder version and then start progressing again.

1. **Towel rows:** Find a big beach towel and tie the top two corners together forming a knot at one end. Place the knot over the top of a door and shut it so that the towel is jammed. Take care to make sure that the towel is secure over the top of the door so that you are not going to fall backwards.

For safety, please ensure that the towel you choose is robust enough to support your weight and that you have put it over the side of the door so that you are pulling it shut, not open.

Hold the towel with both hands, place your feet near the door, then lean back. As in the push-up, keep everything tight and tense in a plank position.

Squeezing your shoulder blades together, pull yourself towards the door using your arms. There should be a line from your head to your heels with just your arms moving.

Again work to failure and if it takes more than 90 seconds to get there move to progression 2.

Again, always take great care that the towel is secure over the top of the door so that you are not going to fall backwards.

2. **<u>Weighted rows</u>**: Put on a rucksack with weight (e.g. a few bottles of water) while you perform the exercise.

Proper posture

The buttocks (the glutes, consisting of gluteus maximus, gluteus medius and gluteus minimus) are some of the most powerful muscles in the body. They are essential for good posture and fundamental to walking and climbing, pulling the legs back as we step forward. They are also involved in picking up heavy objects as we "hinge" at the hip. Unfortunately, too often the glutes do not work as they should; they can get weak and lazy, perhaps due to the amount of time we spend sitting, and then "forget" how to contract, resulting in bad posture (some physiotherapists talk about *gluteal amnesia*!). When posture is poor, your weight will not be carried through the appropriate structures. This leads to inappropriate tension in muscles, excess wear-and-tear in joints and reduced efficiency in your movement, so that walking will be harder. All this sets us up for injury, pain and an inefficient gait.

Colin Gordon of Edinburgh Deep Tissue Massage (www.edinburghdtm.com) says:

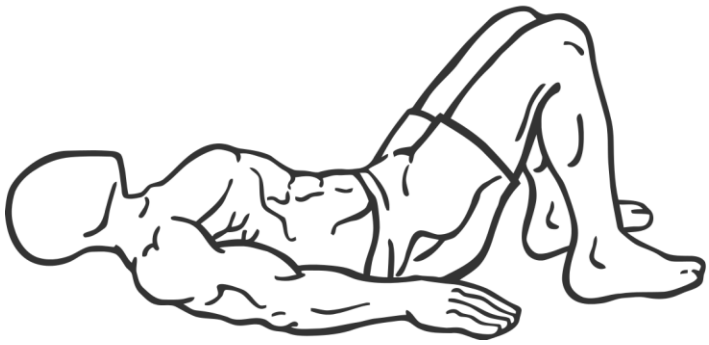
> *"When we are sitting the glutes are stretched. Over time this causes them to become inactive, weak and tight. Their primary role is to stabilise the pelvis when we walk or run. If this muscle can't do its job properly it will reduce stability in the pelvis as we move. This causes muscles in the upper body to have to work harder to stabilise the torso since we lack the foundation of a solid pelvis."*[10]

The hip extension

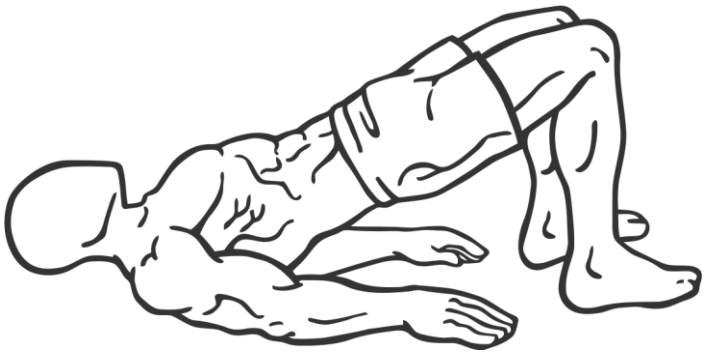
The hip extension helps to fix the damage, activating and strengthening the glutes. This will "wake them up" so they fire properly when we stand, walk, or run and can be used

as a warm up before exercise to "switch on" your buttocks. This is probably not the most "congruent" exercise in terms of biomechanics, but it is simple to learn and a good place to start in working the glutes.

- Find a padded but firm surface, e.g. a carpeted floor, thick yoga mat or even use a foam sleeping pad. Lie flat on your back, legs bent, feet drawn near the buttocks, heels pushing into the floor. Place the extended arms beside your hips for stability.
- Squeeze your buttocks together and push through the heels to lift the pelvis. Raise the hips by tightening the buttocks, thrusting your groin upwards. There should be NO movement in your feet.



- Make sure you begin the exercise by actively contracting your glutes or else the hamstrings will contract first. Think of holding a large coin between your buttocks. Try to get your hips in line with your upper legs.



- Hold the hips raised with buttocks clenched for a second, then lower, maintaining the tension in the glutes. Move slowly and continue until you fail. When it takes longer than 90 seconds to fail, move to a harder progression.

Hip extension progressions

Weighted hip extension: Rest a rucksack filled across your groin and start the

progression over at the first level. Add weight to the sack – again maybe some bottles of water as you get stronger.

The Hillfit Strength Routine

That is it: four movements, done properly once or twice a week. Don't underestimate the potential of this simple routine. To be honest, the meat is in the wall sit and the push up. If they are progressing you will be getting stronger. These are basic moves but they are engineered to do a task, to work the target muscles intensely, and to do it safely with the fewest barriers in terms of risk, equipment, skill acquisition or time.

If you enjoy this training and want some more variety then after a few months you can look to buy a cheap set of adjustable dumb-bells and learn some new exercises. The principles of exercise, i.e. safe, simple and intense, will remain the same but with some added resistance there are a few more moves that are possible. One or two books that I recommend in the appendix would give you some ideas for effective training with dumbbells, particularly Fred Fornicola's book, *Dumb-bell Training for Strength and Fitness* (see Resources).

However, even if you only keep to this basic routine for a long time you will get stronger. Don't think you need equipment or that you have to join a gym. You don't need to spend money to train. Your muscles need hard intense exercise; that can come from a machine in a gym or from a push up. The muscles can't tell the difference although your wallet might!

10 WARMING UP OR STRETCHING THE TRUTH?

One thing that has not been mentioned so far is the idea of "warming up". There are some real benefits that come from preparing your muscles and connective tissues for the stress of exercise. Exercise scientists look at things like increased heart rate, body temperature and blood flow to the muscles, reduced muscle viscosity and better "extensibility" of tendons and ligaments. All these mean that your body will be able to handle movements better. Within the **Hillfit Strength Routine**, most of these benefits will actually come *during* the exercise. You do not need to worry too much about warming up, especially if you follow the performance principles and are moving slowing so that force is minimised. The first few repetitions prepare the muscles, connective tissue and joints for the harder work that follows as you approach failure.

However, there is one practice that I do want to warn against as a preparation for exercise, whether you are thinking about strength training or hill walking. Let's put it simply: do not stretch before your exercise.

Stretching – magic movements?

People think that stretching before activity is good and we hillwalkers are as prone to this assumption as other athletes. I've seen hikers stretching before they hit the mountain. Surely it prevents soreness, avoids injury and prepares muscles for the rigors of exercise?

Strangely enough, while people are busy stretching, sports scientists have published studies showing that static stretching before exercise does not prevent injuries, will not reduce soreness and, in many cases, will actually make you slower and weaker!

Injury, soreness and performance

Static stretching is where you hold a position at the very edge of your muscles' range of motion. There is evidence that this increases the muscle's range of motion, but in fact this is not necessarily a good thing! Studies have found no proof that stretching prevents injury.[11]

Despite what you might think, there is also no evidence that stretching stops muscle pain after exercise. One review found "very consistent" evidence that post-exercise stretching has "minimal or no effect on the muscle soreness experienced 1-3 days after [exercise]."[12] A recent article in the British Journal of Sports Medicine commented on

an update of this research[13] with a title that said it all: "Stretching before or after exercise does not reduce delayed-onset muscle soreness."

Other studies have indicated that stretching before exercise may make you *slower*, *weaker* and *less efficient,*[14] not something that you want for a day on the hill! This phenomenon is not yet fully understood, but there are a couple of possible explanations:

- Static stretching of the spring-like muscles and tendons makes them less able to store energy, so that they get "loose" when you walk and then become less efficient;
- Stretching may have a "neuromuscular" effect by disrupting the signal between brain and muscles.

It is probably a combination of these factors, but whatever the cause, stretched muscles tend to be weaker and perform less well.

So how do you warm up?

If stretching is not good, what should you do to warm up? In terms of your strength training, as I said the benefits that you want from the warm up will come early in each exercise and prepare you for the tougher final "failure" end of the set.

For your actual hiking a good way to prepare is with "dynamic stretches": moves that put your muscles through the range of motion required for walking, without the extreme reach-and-hold poses that can cause problems. Begin to walk slowly, gradually getting to your usual pace and then introduce some dynamic drills:

- March for 10 steps, lifting your knees high with each step;
- Kick your heels up behind you for a few steps so they almost touch your buttocks;
- Swing your arms back and forth;
- Finally take some long, lunging steps.

These moves will prepare your muscles, increase heart rate, body temperature and blood flow, helping you walk efficiently without damaging your performance.

11 BEYOND STRENGTH

This booklet has focused only on strength training and the aim was to address what is probably the most important missing element in the fitness training of most hillwalkers, hikers and backpackers. Jogging round the block simply will not cut it – you need to exercise properly and that means strength training

As I've mentioned a couple of times, you still need to walk. Developing strength is only a means to an end; you need to apply strength to the skill set of hill walking with a good, well-developed gait.

Efficient and safe walking of course involves more than strength. You need to consider:

- Working on your balance;
- Maintaining good posture and core strength;
- Adopting a more efficient gait;
- Getting enough sleep;
- Sitting less and being more active in everyday life; and
- Spending more time outdoors.

These are all important and will each make your time in the hills more rewarding and less exhausting, but they are beyond the scope of this booklet. For now focus on your strength training, which is the foundation of all fitness.

Get stronger, then get into those hills and enjoy yourself!

12 REFERENCES & RESOURCES

I have listed a few books and research papers below for those of you that want to look further or want to reassure yourself that I am not just making all this stuff up.

References cited in the text:

1. Dan John: This quote is from Dan John's presentation: Intervention. This is a 3-disc DVD set, 3.5 hours of lecture, and includes Dan's handouts and a PDF of his writing since filming the workshop. You also receive a transcript of the lecture and an MP3 audio file of the full workshop included on the DVD. More details are available at: http://www.davedraper.com/fitness_products/product/DJI.html

2. Colin Gordon: This quote was taken from a post on Colin's blog at: http://www.edinburghdtm.com/blog/2011/03/a-week-in-exercise/. We have also discussed the importance of strength in several conversations.

3. Jensen J, Rustad PI, Kolnes AJ, Lai YC. The role of skeletal muscle glycogen breakdown for regulation of insulin sensitivity by exercise. Front Physiol. 2011;2:112. Epub 2011 Dec 30.

4. Stuart Philips: This quote is from a report in Science Daily on Aug 11, 2010: *Building Muscle Doesn't Require Lifting Heavy Weights, Study Shows.* http://www.sciencedaily.com/releases/2010/08/100811125943.htm

> *Current gym dogma holds that to build muscle size you need to lift heavy weights. However, a new study conducted at McMaster University has shown that a similar degree of muscle building can be achieved by using lighter weights. The secret is to pump iron until you reach muscle fatigue.*

The full research is at Burd et al. "Low-Load High Volume Resistance Exercise Stimulates Muscle Protein Synthesis More Than High-Load Low Volume Resistance Exercise in Young Men". *PLoS ONE* (2010); 5(8): e12033 DOI: 10.1371/journal.pone.0012033

5. Ken Hutchins of Renaissance Exercise. "*The Renaissance of Exercise: A Vitruvian Adventure*" p15, available from Ken's website.

6. See *Achieving hunter-gatherer fitness in the 21st century"* in the Resources. O'Keefe JH, Vogel R, Lavie CJ, Cordain L. Achieving hunter gatherer fitness in the 21st century. *American Journal of Medicine* (2010); 123(12):1082-6.

7. Southampton Solent Review: "Evidence-Based Resistance Training Recommendations." *Medicina Sportiva* (2011); 15(3): 147-162. DOI: 10.2478/v10036-011-0025-x Copyright © 2011 Medicina Sportiva. Full study available at: http://versita.metapress.com/content/h86m566718338834/fulltext.pdf

8. A review of the research in 2005 found that both exercising at home or at a centre improves the health and physical function of older adults. But, people tend to stick with exercising at home more than in a centre. You can access the research via the link at http://summaries.cochrane.org/CD004017/physical-activity-programs-for-older-adults

9. *Body by Science***,** an important book by Doug McGuff, MD, and John Little (2009) which I recommend in the resources, explains the issue. The book is available at Amazon or via the authors' website at http://www.bodybyscience.net/home.html/

10. Colin Gordon: This quote is from Colin's blog at http://www.edinburghdtm.com/blog/2010/09/getting-your-5-a-day/

11. Stretching doesn't reduce injury risk. Thacker SB, Gilchrist J, Stroup DF, Kimsey CD, Jr. The Impact of Stretching on Sports Injury Risk: A Systematic Review of the Literature. *Medicine and Science in Sports and Exercise* (2004); 36(3): 371-378.

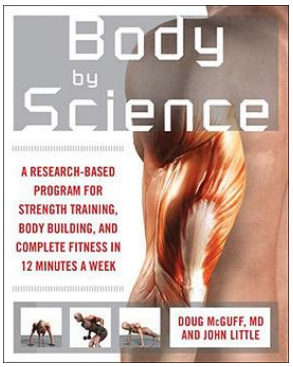
12. Stretching, whether before, after, or before and after exercise, does not produce clinically important reductions in delayed-onset muscle soreness. Herbert RD, de Noronha M, Kamper SJ. Stretching to prevent or reduce muscle soreness after exercise. Cochrane Database of Systematic Reviews 2011; Issue 7. Art. No.: CD004577. DOI: 10.1002/14651858.CD004577.pub3

13. Stretching before or after exercise does not reduce delayed-onset muscle soreness *British Journal of Sports Medicine* bjsports-2011-090599 Published Online First: 17 October 2011

14. Stretching can impair performance. Winchester J et al. Static Stretching Impairs Sprint Performance in Collegiate Track and Field Athletes *Journal of Strength and Conditioning Research* 2008; 22(1): 13-19 doi: 10.1519/JSC.0b013e31815ef202

Useful books

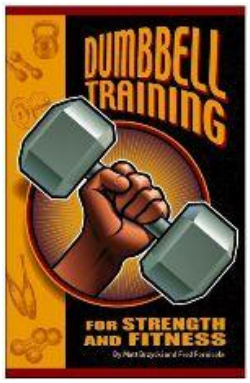
Body by Science



In Body By Science, bodybuilding powerhouse John Little teams up with fitness medicine expert Dr. Doug McGuff to present a scientifically proven formula for maximizing muscle development in just 12 minutes a week. Backed by rigorous research, the authors prescribe a weekly high-intensity program for increasing strength, revving metabolism, and building muscle for a total fitness experience.

The Body by Science website is here with some great articles and information.

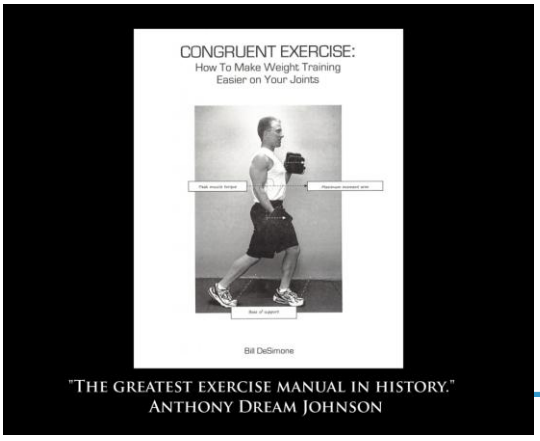
Dumbbell Training for Strength and Fitness



Fred Fornicola in this book outlines some simple straightforward dumbbell exercises and puts them together in basic routines. The principles he applies are those that we have examined in this booklet – safe, effective and intense exercise.

You can order the book directly from Fred through his website: http://www.premierepersonalfitness.com/products_books_dumbbell_training.php

Congruent Exercise by Bill DeSimone

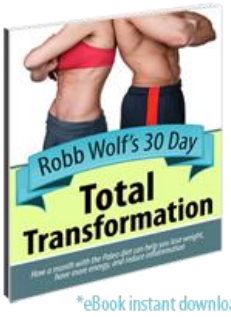


"Your workout shouldn't hurt' Weight training has undeniable benefits: improved muscle tone, strength, and self-esteem, to start. But experience shows that with those benefits come the risk of joint aches, injuries, and accidents. Can you get the benefits of weight training with less risk to your shoulders, back, and knees? Yes, and Congruent Exercise

shows you how. You will discover: How the conventional wisdom in the gym compares to proper muscle and joint function; how to perform both home and gym exercises to minimize the risk of injury, while making your effort more productive; the biomechanics of why and how that works."

Contact Bill DeSimone to find out more about this excellent resource: *To reserve a copy, email* him at optimalexercise@comcast.net with "Congruent Exercise" as the subject line. Bill posts updates and excerpts at www.facebook.com/CongruentExercise The book is available from Amazon

Paleo Solution / 28 day transformation



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The research

Evidence-Based Resistance Training Recommendations
Fisher J., Steele J., Bruce-Low S., Smith D.
Medicina Sportiva (2011); **15**(3): 147-162.

Abstract

Resistance training produces an array of health benefits, as well as the potential to promote muscular adaptations of strength, size, power and endurance. The American College of Sports Medicine (ACSM) regularly publish a position stand making recommendations for optimal achievement of the desired training goals. However, the most recent position stand (as well as previous ones) has come under heavy criticism for misrepresentation of research, lack of evidence and author bias. Therefore this paper proposes a set of scientifically rigorous resistance training guidelines, reviewing and summarising the relevant research for the purpose of proposing more logical, evidence-based training advice. **We recommend that appreciably the same muscular strength and endurance adaptations can be attained by performing a single set of ~8-12 repetitions to momentary muscular failure, at a repetition duration that maintains muscular tension throughout the entire range of motion, for most major muscle groups once or twice each week**. All resistance types (e.g. free-weights, resistance machines, bodyweight, etc.) show potential for increases in strength, with no significant difference between them, although resistance machines appear to pose a lower risk of injury. There is a lack of evidence to suggest that balance from free weights or use of unstable surfaces shows any transference to sporting improvement, and explosive movements are also not recommended as they present a high injury risk and no greater benefit than slow, controlled weight training. Finally, we consider genetic factors in relation to body type and growth potential.

A Critical Analysis Of The ACSM Position Stand On Resistance Training: Insufficient Evidence To Support Recommended Training Protocols
Carpinelli RN, Otto RM, Winett RA
Journal of Exercise Physiology online (2004); **7**(3): 1-60.

Abstract

In February 2002, the American College of Sports Medicine (ACSM) published a Position Stand entitled Progression Models in Resistance Training for Healthy Adults. The ACSM claims that the programmed manipulation of resistance-training protocols such as the training modality, repetition duration, range of repetitions, number of sets, and frequency of training will differentially affect specific physiological adaptations such as muscular strength, hypertrophy, power, and endurance. The ACSM also asserts that for progression in healthy adults, the programs for intermediate, advanced, and elite trainees must be different from those prescribed for novices. An objective evaluation of the resistance-training studies shows that these claims are primarily unsubstantiated. **In fact, the preponderance of resistance-training studies suggest that simple, low-volume, time-efficient, resistance training is just as effective for increasing muscular strength, hypertrophy, power, and endurance—regardless of training**

experience—as are the complex, high-volume, time-consuming protocols that are recommended in the Position Stand. This document examines the basis for many of the claims in the Position Stand and provides an objective review of the resistance training literature.

The role of skeletal muscle glycogen breakdown for regulation of insulin sensitivity by exercise.

Jensen J, Rustad PI, Kolnes AJ, Lai YC.

*Frontiers in Physiology. (2011);**2**: 112. Epub 2011 Dec 30. doi: 10.3389/fphys.2011.00112*

Abstract

Glycogen is the storage form of carbohydrates in mammals. In humans the majority of glycogen is stored in skeletal muscles (~500 g) and the liver (~100 g). Food is supplied in larger meals, but the blood glucose concentration has to be kept within narrow limits to survive and stay healthy. Therefore, the body has to cope with periods of excess carbohydrates and periods without supplementation. Healthy persons remove blood glucose rapidly when glucose is in excess, but insulin-stimulated glucose disposal is reduced in insulin resistant and type 2 diabetic subjects. During a hyperinsulinemic euglycemic clamp, 70-90% of glucose disposal will be stored as muscle glycogen in healthy subjects. The glycogen stores in skeletal muscles are limited because an efficient feedback-mediated inhibition of glycogen synthase prevents accumulation. De novo lipid synthesis can contribute to glucose disposal when glycogen stores are filled. Exercise physiologists normally consider glycogen's main function as energy substrate. Glycogen is the main energy substrate during exercise intensity above 70% of maximal oxygen uptake ([Formula: see text]) and fatigue develops when the glycogen stores are depleted in the active muscles. After exercise, the rate of glycogen synthesis is increased to replete glycogen stores, and blood glucose is the substrate. Indeed insulin-stimulated glucose uptake and glycogen synthesis is elevated after exercise, which, from an evolutional point of view, will favor glycogen repletion and preparation for new "fight or flight" events. In the modern society, the reduced glycogen stores in skeletal muscles after exercise allows carbohydrates to be stored as muscle glycogen and prevents that glucose is channeled to de novo lipid synthesis, which over time will causes ectopic fat accumulation and insulin resistance. The reduction of skeletal muscle glycogen after exercise allows a healthy storage of carbohydrates after meals and prevents development of type 2 diabetes.

Home versus centre based physical activity programs in older adults

Ashworth NL, Chad KE, Harrison EL, Reeder BA, Marshall SC.

Cochrane Database of Systematic Reviews. (2005); Jan 25;(1):CD004017

Abstract

BACKGROUND: Physical inactivity is a leading cause of preventable death and morbidity in developed countries. In addition physical activity can potentially be an effective treatment for various medical conditions (e.g. cardiovascular disease, osteoarthritis). Many types of physical activity programs exist ranging from simple home exercise programs to intense highly supervised hospital (center) based programs.

OBJECTIVES: To assess the effectiveness of 'home based' versus 'center based' physical activity programs on the health of older adults.
SEARCH STRATEGY: The reviewers searched the Cochrane Central Register of Controlled Trials (CENTRAL) (1991-present), MEDLINE (1966-Sept 2002), EMBASE (1988 to Sept 2002), CINAHL (1982-Sept 2002), Health Star (1975-Sept 2002), Dissertation Abstracts (1980 to Sept 2002), Sport Discus (1975-Sept 2002) and Science Citation Index (1975-Sept 2002), reference lists of relevant articles and contacted principal authors where possible.
SELECTION CRITERIA: Randomised or quasi-randomised controlled trials of different physical activity interventions in older adults (50 years or older) comparing a 'home based' to a 'center based' exercise program. Study participants had to have either a recognised cardiovascular risk factor, or existing cardiovascular disease, or chronic obstructive airways disease (COPD) or osteoarthritis. Cardiac and post-operative programs within one year of the event were excluded.
DATA COLLECTION AND ANALYSIS: Three reviewers selected and appraised the identified studies independently. Data from studies that then met the inclusion/exclusion criteria were extracted by two additional reviewers.
MAIN RESULTS: Six trials including 224 participants who received a 'home based' exercise program and 148 who received a 'center based' exercise program were included in this review. Five studies were of medium quality and one poor. A meta-analysis was not undertaken given the heterogeneity of these studies. CARDIOVASCULAR. The largest trial (accounting for approximately 60% of the participants) looked at sedentary older adults. Three trials looked at patients with peripheral vascular disease (intermittent claudication). In patients with peripheral vascular disease center based programs were superior to home at improving distance walked and time to claudication pain at up to 6 months. However the risk of a training effect may be high. There are no longer term studies in this population. Notably home based programs appeared to have a significantly higher adherence rate than center based programs. However this was based primarily on the one study (with the highest quality rating of the studies found) of sedentary older adults. This showed an adherence rate of 68% in the home based program at two year follow-up compared with a 36% adherence in the center based group. There was essentially no difference in terms of treadmill performance or cardiovascular risk factors between groups. CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD). Two trials looked at older adults with COPD. In patients with COPD the evidence is conflicting. One study showed similar changes in various physiological measures at 3 months that persisted in the home based group up to 18 months but not in the center based group. The other study showed significantly better improvements in physiological measures in the center based group after 8 weeks but again the possibility of a training effect is high. OSTEOARTHRITIS**.** No studies were found. None of the studies dealt with measures of cost, or health service utilization.
AUTHORS' CONCLUSIONS: In the short-term, center based programs are superior to home based programs in patients with PVD. There is a high possibility of a training effect however as the center based groups were trained primarily on treadmills (and the home based were not) and the outcome measures were treadmill based. There is conflicting evidence which is better in patients with COPD. **Home based programs appear to be superior to center based programs in terms of the adherence to exercise (especially in the long-term).**

Exercise like a Hunter Gatherer: A Prescription for Organic Physical Fitness
O'Keefe JH, Vogel R, Lavie CJ, Cordain L.
Progress in Cardiovascular Diseases (2011); **53** 471–479

Abstract
A large proportion of the health woes beleaguering modern cultures are because of daily physical activity patterns that are profoundly different from those for which we are genetically adapted. The ancestral natural environment in which our current genome was forged via natural selection called for a large amount of daily energy expenditure on a variety of physical movements. Our genes that were selected for in this arduous and demanding natural milieu enabled our ancestors to survive and thrive, leading to a very vigorous lifestyle. This abrupt (by evolutionary time frames) change from a very physically demanding lifestyle in natural outdoor settings to an inactive indoor lifestyle is at the origin of many of the widespread chronic diseases that are endemic in our modern society. The logical answer is to replicate the native human activity pattern to the extent that this is achievable and practical. Recommendations for exercise mode, duration, intensity, and frequency are outlined with a focus on simulating the routine physical activities of our ancient hunter-gatherer ancestors whose genome we still largely share today. In a typical inactive person, this type of daily physical activity will optimize gene expression and help to confer the robust health that was enjoyed by hunter-gatherers in the wild.

Achieving hunter gatherer fitness in the 21st century
O'Keefe JH, Vogel R, Lavie CJ, Cordain L.
American Journal of Medicine (2010); **123**(12): 1082-6.

Abstract
The systematic displacement from a very physically active lifestyle in our natural outdoor environment to a sedentary, indoor lifestyle is at the root of many of the ubiquitous chronic diseases that are endemic in our culture. The intuitive solution is to simulate the indigenous human activity pattern to the extent that this is possible and practically achievable. Suggestions for exercise mode, duration, intensity, and fre- quency are outlined with a focus on realigning our daily physical activities with the archetype that is encoded within our genome.

Exercise restores leptin sensitivity
Ropelle ER, Flores MB, Cintra DE, Rocha GZ, Pauli JR, et al.
IL-6 and IL-10 Anti-Inflammatory Activity Links Exercise to Hypothalamic Insulin and Leptin Sensitivity through IKKβ and ER Stress Inhibition.
PLoS Biology (2010); **8**(8): e1000465 DOI: 10.1371/journal.pbio.1000465
Reported in Science Daily here: Exercising Restores Sensitivity of Neurons That Make One Feel Full

Abstract

Overnutrition caused by overeating is associated with insulin and leptin resistance through IKKβ activation and endoplasmic reticulum (ER) stress in the hypothalamus. Here we show that physical exercise suppresses hyperphagia and associated hypothalamic IKKβ/NF-κB activation by a mechanism dependent upon the pro-inflammatory cytokine interleukin (IL)-6. The disruption of hypothalamic-specific IL-6 action blocked the beneficial effects of exercise on the re-balance of food intake and insulin and leptin resistance. This molecular mechanism, mediated by physical activity, involves the anti-inflammatory protein IL-10, a core inhibitor of IKKβ/NF-κB signaling and ER stress. We report that exercise and recombinant IL-6 requires IL-10 expression to suppress hyperphagia-related obesity. Moreover, in contrast to control mice, exercise failed to reverse the pharmacological activation of IKKβ and ER stress in C3H/HeJ mice deficient in hypothalamic IL-6 and IL-10 signaling. Hence, inflammatory signaling in the hypothalamus links beneficial physiological effects of exercise to the central action of insulin and leptin.

Physiological response to circuit weight training in borderline hypertensive subjects.

Harris KA, Holly RG.

Medicine and Science in Sports and Exercise (1987); **19**(3): 246-52.

Abstract

Male subjects (10 experimental, 16 control) with borderline hypertension (140/90 to 160/95 mm Hg) participated in a circuit weight training program for 9 wk to assess its efficacy and safety. Resting blood pressure and heart rate were measured under standardized conditions prior to and following each session and at several locations in the circuit. Subjects were assessed pre- and post-training. Upper and lower body strength increased 12.5 and 53% when assessed by one-repetition maximum lifts for bench press (57 to 64 kg) and leg press (134 to 205 kg), respectively. Total weight lifted per circuit increased 57% (4,374 to 6,866 kg). Lean body mass increased 2.2% (64.0 to 65.4 kg), skinfold thicknesses decreased, and other measures of body composition remained unchanged. Cardiovascular endurance as assessed by arm ergometry maximal oxygen uptake increased 21.1% (1.9 to 2.3 1 X min-1), and by 7.8% as assessed by treadmill maximal oxygen uptake (40.9 to 44.1 ml X kg-1 X min-1). Resting heart rate and systolic blood pressure did not change. Diastolic blood pressure fell from 95.8 to 91.3 mm Hg. All changes were significant to at least P less than 0.05. Thus, circuit weight training can elicit marked improvements in muscular strength and modest improvements in body composition and cardiorespiratory endurance. Circuit weight training does not exacerbate resting or exercise blood pressure and may have beneficial effects.

Resistance Training vs. Static Stretching: Effects on Flexibility and Strength

Morton SK, Whitehead JR, Brinkert RH, Caine DJ.

Journal of Strength & Conditioning Research (2011); **25**(12): 3391-3398. doi: 10.1519/JSC.0b013e31821624aa

Abstract

The purpose of this study was to determine how full-range resistance training (RT) affected flexibility and strength compared to static stretching (SS) of the same muscle–joint complexes in

untrained adults. Volunteers (n = 25) were randomized to an RT or SS training group. A group of inactive volunteers (n = 12) served as a convenience control group (CON). After pretesting hamstring extension, hip flexion and extension, shoulder extension flexibility, and peak torque of quadriceps and hamstring muscles, subjects completed 5-week SS or RT treatments in which the aim was to stretch or to strength train the same muscle–joint complexes over similar movements and ranges. Posttests of flexibility and strength were then conducted. There was no difference in hamstring flexibility, hip flexion, and hip extension improvement between RT and SS, but both were superior to CON values. There were no differences between groups on shoulder extension flexibility. The RT group was superior to the CON in knee extension peak torque, but there were no differences between groups on knee flexion peak torque. **The results of this preliminary study suggest that carefully constructed full-range RT regimens can improve flexibility as well as the typical SS regimens employed in conditioning programs.** Because of the potential practical significance of these results to strength and conditioning programs, further studies using true experimental designs, larger sample sizes, and longer training durations should be conducted with the aim of confirming or disproving these results.

Low-Load High Volume Resistance Exercise Stimulates Muscle Protein Synthesis More Than High-Load Low Volume Resistance Exercise in Young Men

Burd NA, West DWD, Staples AW, Atherton PJ, Baker JM, Moore DR, Holwerda AM, Parise G, Rennie MJ, Baker SK, Phillips SM.

PLoS ONE (2010) **5**(8): e12033. doi:10.1371/journal.pone.0012033

Abstract

Background We aimed to determine the effect of resistance exercise intensity (% 1 repetition maximum—1RM) and volume on muscle protein synthesis, anabolic signaling, and myogenic gene expression.

Methodology/Principal Findings Fifteen men (21±1 years; BMI = 24.1±0.8 kg/m2) performed 4 sets of unilateral leg extension exercise at different exercise loads and/or volumes: 90% of repetition maximum (1RM) until volitional failure (90FAIL), 30% 1RM work-matched to 90%FAIL (30WM), or 30% 1RM performed until volitional failure (30FAIL). Infusion of [ring-13C6] phenylalanine with biopsies was used to measure rates of mixed (MIX), myofibrillar (MYO), and sarcoplasmic (SARC) protein synthesis at rest, and 4 h and 24 h after exercise. Exercise at 30WM induced a significant increase above rest in MIX (121%) and MYO (87%) protein synthesis at 4 h post-exercise and but at 24 h in the MIX only. The increase in the rate of protein synthesis in MIX and MYO at 4 h post-exercise with 90FAIL and 30FAIL was greater than 30WM, with no difference between these conditions; however, MYO remained elevated (199%) above rest at 24 h only in 30FAIL. There was a significant increase in AktSer473 at 24h in all conditions (P = 0.023) and mTORSer2448 phosphorylation at 4 h post-exercise (P = 0.025). Phosporylation of Erk1/2Tyr202/204, p70S6KThr389, and 4E-BP1Thr37/46 increased significantly (P<0.05) only in the 30FAIL condition at 4 h post-exercise, whereas, 4E-BP1Thr37/46 phosphorylation was greater 24 h after exercise than at rest in both 90FAIL (237%) and 30FAIL (312%) conditions. Pax7 mRNA expression increased at 24 h post-exercise (P = 0.02) regardless of condition. The mRNA expression of MyoD and myogenin were consistently elevated in the 30FAIL condition.

Conclusions/Significance These results suggest that low-load high volume resistance exercise is more effective in inducing acute muscle anabolism than high-load low volume or work matched resistance exercise modes.

Exercise benefits for the brain

John J Ratey, MD, is an Associate Clinical Professor of Psychiatry at Harvard Medical School, Research Synthesizer, Speaker, Author, and Clinical Psychiatrist maintaining a private practice in Cambridge, Massachusetts. He has lectured and published 60 peer reviewed articles on the topics of Aggression, Autism, ADHD, and other issues in neuropsychiatry, and has authored or co-authored seven books.

His latest book, Spark: The Revolutionary New Science of Exercise and the Brain, presents an understanding of neurobiology with worldwide research to inspire the reader to embrace exercise as a means to achieve optimal brain performance. You can find out more at the website: **Sparking Life**

Green exercise – the benefits of exercise in the outdoors

The Green Exercise Research Team at the University of Essex are looking at the benefits of exercise in natural environments. Their research programme recognises that:

- Contact with green spaces and nature improves psychological health by reducing stress levels, enhancing mood and self-esteem and offering a restorative environment which enables people to relax, unwind and recharge their batteries.
- Participating in physical activity results in positive outcomes for both physical and mental health.

For the last 8 years the Green Exercise Research Team at the University of Essex, has combined these ideas into a programme of research to investigate the synergistic benefits of engaging in physical activities whilst simultaneously being exposed to nature. They have an analysis of the current research with abstracts of the papers at their website: **Green Exercise Research**. For example:

The Mental and Physical Health Outcomes of Green Exercise.
Pretty J, Peacock J, Sellens M and Griffin M.
International Journal of Environmental Health Research (2005); **15**(5), 319-337.
(Available here)

Abstract

Both physical activity and exposure to nature are known separately to have positive effects on physical and mental health. We have investigated whether there is a synergistic benefit in adopting physical activities whilst being directly exposed to nature ('green exercise'). Five groups of 20 subjects were exposed to a sequence of 30 scenes projected on a wall whilst exercising on a treadmill. Four categories of scenes were tested: rural pleasant, rural

unpleasant, urban pleasant and urban unpleasant. The control was running without exposure to images. Blood pressure and two psychological measures (self-esteem and mood) were measured before and after the intervention. There was a clear effect of both exercise and different scenes on blood pressure, self-esteem and mood. Exercise alone significantly reduced blood pressure, increased self-esteem, and had a positive significant effect on 4 of 6 mood measures. Both rural and urban pleasant scenes produced a significantly greater positive effect on self-esteem than the exercise-only control. This shows the synergistic effect of green exercise in both rural and urban environments. By contrast, both rural and urban unpleasant scenes reduced the positive effects of exercise on self-esteem. The rural unpleasant scenes had the most dramatic effect, depressing the beneficial effects of exercise on three different measures of mood. It appears that threats to the countryside depicted in rural unpleasant scenes have a greater negative effect on mood than already urban unpleasant scenes. We conclude that green exercise has important public and environmental health consequences. Keywords: Green exercise, physical activity, mental health, self-esteem, mood, environmental health

The Impact of Stretching on Sports Injury Risk: A Systematic Review of the Literature.
Thacker SB, Gilchrist J, Stroup DF, Kimsey CD, Jr.
Medicine and Science in Sports and Exercise (2004); **36**(3): 371-378.

Abstract

Purpose: We conducted a systematic review to assess the evidence for the effectiveness of stretching as a tool to prevent injuries in sports and to make recommendations for research and prevention.

Methods: Without language limitations, we searched electronic data bases, including MEDLINE (1966–2002), Current Contents (1997–2002), Biomedical Collection (1993–1999), the Cochrane Library, and SPORTDiscus, and then identified citations from papers retrieved and contacted experts in the field. Meta-analysis was limited to randomized trials or cohort studies for interventions that included stretching. Studies were excluded that lacked controls, in which stretching could not be assessed independently, or where studies did not include subjects in sporting or fitness activities. All articles were screened initially by one author. Six of 361 identified articles compared stretching with other methods to prevent injury. Data were abstracted by one author and then reviewed independently by three others. Data quality was assessed independently by three authors using a previously standardized instrument, and reviewers met to reconcile substantive differences in interpretation. We calculated weighted pooled odds ratios based on an intention-to-treat analysis as well as subgroup analyses by quality score and study design. Results: Stretching was not significantly associated with a reduction in total injuries (OR □ 0.93, CI 0.78–1.11) and similar findings were seen in the subgroup analyses.

Conclusion: There is not sufficient evidence to endorse or discontinue routine stretching before or after exercise to prevent injury among competitive or recreational athletes. Further research, especially well-conducted randomized controlled trials, is urgently needed to determine the proper role of stretching in sports.

Stretching to prevent or reduce muscle soreness after exercise.

Herbert RD, de Noronha M, Kamper SJ.

Cochrane Database of Systematic Reviews (2011); Issue 7. Art. No.: CD004577. DOI: 10.1002/14651858.CD004577.pub3

Abstract

Background: Many people stretch before or after engaging in athletic activity. Usually the purpose is to reduce risk of injury, reduce soreness after exercise, or enhance athletic performance. This is an update of a Cochrane review first published in 2007.

Objectives: The aim of this review was to determine effects of stretching before or after exercise on the development of delayed-onset muscle soreness.

Search strategy: We searched the Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (to 10 August 2009), the Cochrane Central Register of Controlled Trials (2010, Issue 1), MEDLINE (1966 to 8th February 2010), EMBASE (1988 to 8th February 2010), CINAHL (1982 to 23rd February 2010), SPORTDiscus (1949 to 8th February 2010), PEDro (to 15th February 2010) and reference lists of articles.

Selection criteria: Eligible studies were randomised or quasi-randomised studies of any pre-exercise or post-exercise stretching technique designed to prevent or treat delayed-onset muscle soreness (DOMS). For the studies to be included, the stretching had to be conducted soon before or soon after exercise and muscle soreness had to be assessed.

Data collection and analysis: Risk of bias was assessed using The Cochrane Collaboration's 'Risk of bias' tool and quality of evidence was assessed using GRADE. Estimates of effects of stretching were converted to a common 100-point scale. Outcomes were pooled in fixed-effect meta-analyses.

Main results: Twelve studies were included in the review. This update incorporated two new studies. One of the new trials was a large field-based trial that included 2377 participants, 1220 of whom were allocated stretching. All other 11 studies were small, with between 10 and 30 participants receiving the stretch condition. Ten studies were laboratory-based and other two were field-based. All studies were exposed to either a moderate or high risk of bias. The quality of evidence was low to moderate. There was a high degree of consistency of results across studies. The pooled estimate showed that pre-exercise stretching reduced soreness at one day after exercise by, on average, half a point on a 100-point scale (mean difference -0.52, 95% CI -11.30 to 10.26; 3 studies). Post-exercise stretching reduced soreness at one day after exercise by, on average, one point on a 100-point scale (mean difference -1.04, 95% CI -6.88 to 4.79; 4 studies). Similar effects were evident between half a day and three days after exercise. One large study showed that stretching before and after exercise reduced peak soreness over a one week period by, on average, four points on a 100-point scale (mean difference -3.80, 95% CI -5.17 to -2.43). This effect, though statistically significant, is very small.

Authors' conclusions: ***The evidence from randomised studies suggests that muscle stretching, whether conducted before, after, or before and after exercise, does not produce clinically important reductions in delayed-onset muscle soreness in healthy adults.***

Plain language summary: Stretching to prevent or reduce muscle soreness after exercise

Many people stretch prior to or after engaging in physical activities such as sport. Usually the purpose is to reduce the risk of injury, reduce soreness after exercise, or enhance athletic performance. This review looked at the effects of stretching on muscle soreness only. The review located 12 relevant randomised controlled studies looking at the effect of stretching

before or after physical activity on muscle soreness. Eleven studies were small with between 10 to 30 people being allocated stretching exercises. In contrast, one study was large with 2337 participants, 1220 of whom were in the stretching group. Ten studies were conducted in laboratories using standardised exercises. The only two studies, which included the only large study, were so-called field-based studies. These examined the effect of stretching on muscle soreness associated with self-selected physical activity. The studies were of low to moderate quality. Some of the studies examined the effects of stretching before physical activity, some examined the effects of stretching after physical activity, and some examined effects of stretching both before and after physical activity. ***The studies produced very consistent findings. They showed there was little or no effect of stretching on the muscle soreness experienced in the week after the physical activity.***

Static Stretching Impairs Sprint Performance in Collegiate Track and Field Athletes
Winchester JB, Nelson AG, Landin D, Young MA, Schexnayder IC.
Journal of Strength & Conditioning Research (2008); **22**(1): 13-19. doi: 10.1519/JSC.0b013e31815ef202

Abstract:

Previous research has shown that static stretching (SS) can diminish the peak force output of stretch-shortening cycle actions while performing a dynamic warm-up (DW) protocol has been shown to enhance performance in similar activities. The purpose of this study was to establish whether the deleterious effects of SS would wash out the performance enhancements obtained from the DW. Eleven males and 11 females, who were athletes of a NCAA Division I track team, performed a DW followed with either a SS or rest (NS) condition. After warm-up was completed, three 40 m sprints were performed to investigate the effects of the SS condition on sprint performance when preceded by DW. Time(s) were obtained from timing gates placed at 0, 20, and 40 m respectively. Testing was conducted over 2 days with a 1 week washout period. Testing order was balanced to eliminate possible order effect. Time for the NS versus the SS group was significantly faster for the second 20 m with a time of 2.41 versus 2.38 seconds (P < or = .05), and for the entire 40 m with a time of 5.6 +/- 0.4 versus 5.7 +/- 0.4 seconds (P < or = .05). ***The results of this study suggest that performing a SS protocol following a DW will inhibit sprint performance in collegiate athletes***.


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