Thor's

Guides

Musculoskeletal System

Beta

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About Thor Falk

I am a 40-something father and husband who currently lives in France. I spent most of my working live so far "flying-high" in professional services and finance, based out of London, with a fair amount of travel. I had been a chubby teenager who struggled, more or less successfully, to keep his weight under control during school and university. However, the perks of my job – working lunches, hotel breakfasts, too many drinks – and a sedentary lifestyle had over the years taken their toll, and I ended up over 130kg at 186cm. Fat. And out of shape.

I was of course always thinking about doing something about it – I somehow just never did. Priorities! Until that one day when … nothing really, actually. I started dieting, and I started working out, and I lost 20-30kg of body fat, gained some muscle, and I just started feeling better overall. It wasn't an easy journey, and was not without hiccups but I am content. One thing is very clear though: things would have been much simpler had I known then what I know now!

About Thor's Guides

If you are on a quest to lose weight, to get fitter, and to generally improve your health – especially after decades of abusing your body – then there are a number of things you simply need to know about the functioning of the human body. Many people have ignored this, and they might have done more harm than good – think yoyo-dieting, injuries, and lasting metabolic damage.

You don't need to know everything there is – you can't anyway – but there is a minimum level of knowledge that everyone simply should have. I have been down that particular rabbit hole – in fact, I am still in it – and I spent a lot of time researching everything related to the human body. I have come across a lot of information – too much, really – and the *Thor's Guides* series is my attempt to separate what is important from what isn't, in order to save you the time to reinvent the wheel.

To be clear: I am not promising an entertaining read. The information in Thor's Guides is dense, and focused on the area at hand. I am in particular not usually providing much information why a certain piece of information is important, and how the whole puzzle fits together. This is part of a forthcoming project – my book – and the Guides will be an important part of that.

Disclaimer

You know that this had to come somewhere, so here it is:

(1) Nothing in this book constitutes advice. The author is not licenced to advise in matters related to health, nutrition, and exercise, and he does not propose to do so.

(2) The author has carefully researched the information provided in this publication. Despite of this, this information could be false, and it the author can not be held responsible should such incorrect information cause damage, be it directly or indirectly.

(3) The reader is advised to independently check all the information provided, especially if he or she relies on it in circumstances where damage could occur.

In brief: whatever you do (or don't do), get all the information and advice you need, use your head, make your judgment, go for it, and take responsibility for what you are doing.

About Beta

Some of the Guides are in Beta. This means that I was not yet able to source and/or verify some specific of the specific facts contained in the Guide, and that I therefore had to make some assumptions. I will usually point out where exactly this is the case.

Whether or not a Guide is labelled Beta does not really make a difference. In either case, the Disclaimer and use-your-head-policy apply – just a bit more so on the Beta Guides than on the more settled ones.

Good Luck, and Enjoy !!!
-Thor Falk

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Muscoskeletal system

This book is not the place to present the details of the musco-skeletal system – for once this requires many pictures and I neither have those nor can I create them. Having said this, as usual there are a number of good references on the Internet, and I will link to them throughout the text. At the very least one needs to know the names of the major muscles and bones and how they roughly work together, otherwise it will be rather tough to understand many of the exercise descriptions in books or on the Internet.

Here we concern ourselves with four elements of the human body: bones, muscles, tendons, and ligaments.

Bones and joints

We all know what bones are – those white thingies inside the body that are only visible at Halloween or in horror movies, that keep it from collapsing into a big heap on the floor. Joking aside – bones are important, and bones need to be taken care of. Clearly nutrition – and in particular calcium – is a key aspect there. What is less appreciated however is that exercise is also important: bones are living tissue, and like all other living tissues they will adapt and strengthen when stressed (and weaken if not, for that matter). There are no specific exercises for bones that I am aware of, but generally strength training – in particular of the low-rep / high-load variety – does not only benefit the muscles and connective tissue, but also the bones.

Before we start going into the nomenclature of the bones in the human body, here a couple of related definitions that come up in descriptions of movement an bio-mechanics, and that are worth knowing. Firstly there is "to flex" and "to extend" – note that one does not flex muscles (they "extend" and "contract" – more on this below) but joints. For most joints, the meaning of **flexion** and **extension** is clear: the former is folded, the latter long. It is a bit tricky for those joints that go both ways – there the natural direction is called flexion, and the flexion in the other direction is called "hyper-extension".

In this context also the term "**planes of movement**" is sometimes used, usually in the context that a certain set of exercises A is neglecting a movement in a particular plane which is why the set exercises B (which is described in a new book, video, whatever) is so much better. I personally find those designations less useful, but it is probably still worth knowing that the **transversal** plane is the one parallel to the ground, the **coronal (or frontal)** plane the one through shoulders and hips, and **sagittal** plane is the one separating the right and left part of the body.

The other definitions that are sometimes important are proximal and distal: they denote attachment points of the muscles (or rather, their tendons) on the skeleton. Thereby, **proximal** refers to the attachment closest to the centre of the

body, and **distal** to the one closes to its extremities. For example, the proximal attachment point of the biceps is somewhere at the shoulders, and the medial one is at the elbow.

So what are the bones in the human body that one should know by name? Let's start from the legs: the **femur** is the big one in the upper leg (the one that needs to go at least parallel to the floor when squatting), and the **tibia** the one in the front of the lower leg (the one to protect when playing football, or hockey). The one in the back is called **fibula**. The **patella** is the small bone floating on the knee. The equivalent bone in the upper arm is called **humerus**, and the one's in the forearm are the **ulna** (this is the one you would use to block a karate kick) and the **radius**. In the feet the bones are – from proximal to distal – the **tarsals**, the **metatarsals** and the **phalanges**. The equivalent bones in the hand are the **carpals**, the **metacarpals**, and again the **phalanges**.

In the torso, the main system of bones is of course the **spine**. Its segments are (from top to bottom) the **cervical spine**, **thoracic spine**, and the **lumbar spine** which together consist of 24 vertebrae. Those vertebrae are numbered from top to bottom on a per-segment basis (C1-C7, Th1-Th12, L1-L5). The three spinal segments are curved, and the inflection points are where the segments meet, ie C7/Th1 and Th12/L1. It is a bit difficult to describe the direction of curvature in words so I won't try but it is worth looking at a picture to understand what the natural curve of the respective segments is. Below the articulate part of the spine are the **sacrum** and the **coccyx**, which together consist of another 9 vertebrae, which are fused.

At the lower end of the spine are the bones of the **pelvis**. Their names are little known outside of Pilates classes. However, because of the importance of the latter I will enumerate the most important one's here: apart from the sacrum and the coccyx there is the **ilium** (with the all-important **iliac crest** which is one of the key indicators of proper hip alignment), the **ischium**, and the **pubis**.

Finally, the **sternum** is the small plate of bone in front of the **ribcage**. At the back is the **scapula**, two small plates of bone floating over the muscles of the shoulder, and whose main purpose is to ensure that the bar does not slide down the back when squatting. The scapula also connects the **clavicle (or collar bone)** to the humerus.

Muscles

Muscle fibres

Before I go into an enumeration of the important muscles in the human body I want to touch a topic that is probably more discussed on T Nation than in the medical literature: the different types of muscle fibres. Depending on when you last studied this topic you might know that muscle fibres can be classified as red or white, or as slow twitch and fast twitch, or as Type I and Type II, or even Type IIa, IIb, IIx.

First a step back though: there are three major muscle types in the human body, the skeletal muscle, the smooth muscle, and the cardiac muscle. Let me quickly deal with the **cardiac muscle** first: it is very similar to skeletal muscle, except that it has been optimised for continuous performance – obviously going to failure on say the biceps is rather pleasant for some individuals (cf Arnold's famous comment on The Pump, and how he considers it as satisfying as some other partner-based activities that are not usually performed in the gym), whilst training to failure on the cardiac muscle would not generally be considered a good idea. The heart mostly operates in an aerobic mode. An interesting soundbite here is that the heart can actually use the lactate produced in the anaerobic glucose metabolism and "finish burning" it. This is really quite clever: in periods of high anaerobic performance the heart will need a lot of fuel, and rather than using glucose that the liver has just recycled from all the lactate floating around it simply burns the lactate. This is a win-win: nice fuel for the heart, and less work for the liver.

I will ignore **smooth muscle** here, other than saying that (a) it can not be actively controlled by the brain, and (b) and it is usually found in blood vessels and the like, so on to the **skeletal muscle**. It is made up of muscle fibres, which themselves are fused muscle cells. The main building blocks of those cells are the proteins actin and myosin. So back to the (skeletal) muscle fibres: the main classification was historically made between Type I ("**slow twitch**") and Type II ("**fast twitch**") as a function of how quickly the fibres can contract in response to a neural impulse. Here Type II denotes fibres of Type IIa, IIx, and IIb[1]. The historic distinction, red and white, is related to whether the fibres can obtain energy through aerobic processes (and hence contain myoglobin, which is red) or not. The **red fibres** are of Types I and IIa, and Types IIx and IIb are the **white fibres** because they rely mostly on anaerobic energy sources.

Type I fibres specialise in the utilisation of fat as a fuel source, and they have no CP buffer system. They are therefore very well adapted for constant base-load efforts – once they get going, they just go, and go, and go, just like the Duracell Bunny – and it is not surprising that they are very important for all kind of endurance activities, or long-slow-cardio ("LSC") as Mark Sisson likes to call it.

For endurance efforts, the Type I fibres are supported by the **Type IIa** fibres that use glucose as a fuel source, and that are the main location for muscle glycogen stores in the body. Muscle recruitment is known to follow a threshold pattern – the IIa's only come into play when the I's are no longer sufficient – which explains the changing fuel mix depending on the effort required: the higher the effort, the more the IIa's are recruited, and the more the overall fuel mix moves towards glucose.

[1] The order *a, x, b* is deliberate: historically *x* and *b* fibers had not been distinguished, and when the distinction had finally been made the *x* fibers are naturally located between the *a* and the *b* fibers. It might have made sense calling them *b1* and *b2* but this is unfortunately not what happened

Type IIa fibres are not limited to aerobic processes however, they can also utilise glucose on the anaerobic (ie, lactated-producing) pathway. Moreover, contrary to the I's, the IIa's have a CP buffer that allows them to rev-up quickly, bridging the time until the aerobic processes are up and running[2].

The **Type IIx** and **Type IIb** fibres finally are geared towards short-term peak power (and therefore they are the top two steps of the threshold recruitment pattern), and they are mainly driven by CP. In fact, the IIb's do not even have the ability to use glucose as a fuel, which probably means – and I am speculating here – that they have rely on the IIx's to recharge their CP buffers, and that in fact the main reason that IIx's can use glucose is so that they can recharge those CP buffers.

Muscles

Now to something easier, which has been more or less known since the Renaissance, when Leonardo Da Vinci and friends sneaked to the cemeteries at night to pursue their anatomical studies: the nomenclature and mechanics of the major muscles in the human body.

There are two major muscles in the (male) human body, the biceps' and the pecs, and those are trained with biceps curls and bench presses respectively, or their Nautilus equivalents. If you would like some information on the minor muscles as well please read on, otherwise feel free skip the rest of this chapter.

Quadriceps: attaches at the tibia distally, and ilium and femur proximally; extends the knee, flexes the hip, stabilises the patella.

Hamstring: attaches at the tibia and fibula distally, and ischium and femur proximally; flexes the knee and extend the hip.

Gluteal muscles: group consists of gluteus maximus, medius, and minimus; attach at the ilium, sacrum, coccyx distally and (indirectly) femur proximally; extends the hip, and adducts and externally rotates the leg.

Erector spinae: attaches at the cervical spine and thoracic spine (T1, T2) distally and thoracic spine (T9-T12) proximally;

Hip flexors: meta-group, consisting of the inner hip group (iliopsoas: psoas minor and major, iliacus), the anterior thigh compartment (rectus femoris - part of quadriceps, sartorius),the medial thigh compartment (pectineus, adductor brevis and longus, and gracilis) and finally the tensor fasciae latae (part of gluteal muscles); flex the hip.

[2] This induces quite an interesting dynamics: at the beginning of any significant aerobic effort it will be the IIa's that do the work using the energy from their CP buffer, and they will only hand over to the I's once those are up and running

Leg adductors (adductor muscles of the hip): another meta-group, consisting of the adductor brevis, longus, magnus and minimus, and the pectineus, the gracilis and the obturator externus; adduct the leg[3]

Leg abductors: another meta-group, consisting of the gluteal group (gluteus minimus, maximus, and medius) and the sartorius; abduct the leg[4]

Soleus and **gastrocnemius**: attaches at the femur (gastrocnemius) and the tibia and the fibula (soleus) proximally, and the calcaneus (via the Achilles tendon) distally;

Biceps: attaches at the radius distally, and scapula proximally; externally rotates (supinates) the forearm, flexes the elbow, and flexes the shoulder.

Triceps (triceps brachii): attaches at the ulna distally, and the scapula and humerus proximally; extends the elbow, adducts the humerus.

Brachialis: attaches at the ulna distally, and humerus proximally; flexes the ulna.

Deltoids: attaches at the humerus distally, and the scapula and the clavicle proximally; abducts the humerus.

Latissimus (latissimus dorsi) : attaches at the humerus distally, and the thoracic and lumbar spine and the ilium proximally; responsible for extension, adduction, transverse extension (also known as horizontal abduction), flexion from an extended position, and (medial) internal rotation of the shoulder joint; also has a synergistic role in extension and lateral flexion of the lumbar spine.

Pectoralis major: attaches at the humerus distally, and the clavicle and the sternum proximally;

Trapezius: attaches at the clavicle and the scapula distally, and the cervical and thoracic spine proximally; moves scapula and/or the spine.

Rotator cuff muscles: supraspinatus, infraspinatus, teres minor, subscapularis; stabilise the shoulder.

Scapulohumeral muscles: meta-group consisting of rotator cuff muscles (supraspinatus, infraspinatus, teres minor, subscapularis), teres major, carocobrachialis and the deltoid; connects the humerus to the scapula.

Abs (rectus abdominis): attaches at the pubis distally, and the ribs and the sternum proximally.

Obliques: attaches at the pubis and the ilium distally, and the ribs proximally.

Transversus abdominis: attaches at the iliac crest and ribs distally, and the pubis as well as the "middle line of the abdomen" proximally.

Pyramidalis: attaches at the linea alba distally, and the pubis proximally.

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[3] Adducting the leg means bringing it to the centerline (remember: abduction is kidnapping is taking away; adduction is the other way)

[4] Abducting the leg means bringing it away from the centerline (see previous note)

Connective tissue

Tendons, fasciae, and ligaments are the connective tissue of the body, mainly made of collagen, a protein. They are very similar, and the difference in name comes from their different function: tendons connect muscles to bones, fasciae connect muscles to muscles, and ligaments connect bones to bones.

Their main function is the transmission of force (tendons, fasciae) and the structural integrity of joins (ligaments). Their elastic properties they play an important role in their function – for example the Achilles tendons act like springs elastically store and release the "vertical displacement energy" of the body, thereby greatly reducing the workload.

Connective tissue is viscoelastic, ie it can be permanently stretched if sufficient force is applied for sufficient time. Stretching connective tissue is not generally a good idea as this permanently weakens it, and hence care must be taken during stretching exercises that (a) stretches target muscles, not ligaments, and (b) that the muscular stretches do not overly strain the tendons and fasciae.

Connective tissue deteriorates significantly when ageing, the process starting as early as beginning of 30's, and from the 40's onwards athletes must be careful not to overload their connective tissue, as pathologies are frequent. Thereby absolute load is not as much of a problem as a sudden increase in load – for example older lifters are well advised to take a week or two to reconnect to previous PR's even after breaks that only lasted a couple of months.

The most common connective tissue pathologies are tendinopathies, which can refer either to a tendinitis (an acute inflammation of the tendon; also incorrectly spelled tendonitis) or tendinosis (a chronic degeneration of the tendon). Tendinopathies can be treated (either with exercise, typically eccentric loading, or medically) but they tend to be if not chronic then at least recurrent. The most relevant tendinopathies are the following:

- *Tennis / golfer's elbow* (outer/inner elbow tendons)
- *Plantar fasciitis* (plantar fascia, supporting the arch of the foot),
- *Achilles tendinopathy* (Achilles tendon),
- *Jumper's knee* (patellar tendons), not to be confused with *runner's knee* which is related to the patella itself

As for the ligaments, the ACL in the knee is often injured, especially during sports that combine running with contact (eg soccer), and ACL (reconstructive) surgery is a common procedure.