A compendium on

SITTING ERGONOMICS

MALMSTOLEN
RYGGRADEN I SVENSK ERGONOMI

The purpose of this compendium...

... is to describe, in an instructional way, how sitting affects the human body and how to prevent or relieve the disorders that sitting can cause in a variety of ways. Based on scientifically accepted knowledge in subjects related to sitting, we will also describe how and why Malmstolen is designed to contribute to the prevention and alleviation of the disorders that sitting can cause.

It is worth emphasising, as we will be doing often, that the design solutions we have selected are the closest we could achieve in conforming to the scientific evidence that is available today and that we have been able to identify. If any reader disagrees with the factual information mentioned in this compendium, you are more than welcome to contact us. There is no prestige for us on any one solution or in any specific mindset. If there is anything that can be scientifically verified and is missing in this compendium, or that is disproved by new information, we are completely open to accept it.

Sitting ergonomics

Contents

Forword

Never before have people sat as much as they do today, and never before have the consequences been so great as large sections of the global population are gradually changing lifestyles from being physically active to being predominantly still. Back problems alone (back, shoulders, neck), where our sitting lifestyle is the major villain of the piece, are expected to cost around SEK 70 billion per year in Sweden! In an article published in 2009 by the Centre for Musculoskeletal Injury Research at the University of Gävle it states that "a reasonable estimate of the Swedish social costs for sick leave and sickness benefit caused by muscle and joint disorders is SEK 50,000. Per minute. Every day, every week, all year round." Huge sums of money in other words.

Malmstolen AB started in 1994 and over that relatively short time, the computerization of society has increased enormously in which the Internet is also a major contributing factor. As a consequence, we sit more than ever before in front of the computer, every day, for much longer periods than before, and sometimes for virtually the whole day. In addition, our lives outside the workplace, also involve sitting for long periods. In the car, at your computer at home, watching TV, etc. Considering how many thousands of years humankind has lived a mobile/physically active life behind the spear, bow and arrow, plough, etc., a life that the human body through evolution is intrinsically adapted to, it is perhaps not surprising that the major changes we have made to our lifestyles over the last 50-75 years alone are taking their toll.

In an ideal world, our lives and work today would be as mobile and diverse as they have been historically, but for this to happen or be possible now is probably unrealistic – regrettably! An attempt to partially counterbalance some of the problems that sitting can cause is to make our workplaces "ergonomic". The word ergonomic means to adapt working tools and methods to suit human capabilities and limitations. When it comes to sitting, the last 30-40 years, where the problems arising from sitting have become increasingly evident, a variety of ideas, philosophies, and sometimes pure myths have tried to grab the limelight and claim the correct interpretation of the word "ergonomic". The variants of this over the years have been and are still in some places so numerous, that for the layman it must be incredibly difficult to know what is true and who to listen to.

When Malmstolen AB started, the decision and strategy taken from the very beginning was to build the business based on strict and proven scientific research and acquired knowledge. Much of this knowledge is rooted in the laws of physics since Isaac Newton's day. We did not want to simply "design a chair" and then look for any scientific arguments that we could use to justify its existence.

The key topics related to sitting are physics, biomechanics, "general" physiology and neurophysiology. If we do not use a scientific basis to understand human's actual capabilities and limitations and how the physical forces affect us and how your body reacts to these forces, how can we adapt working tools and methods in an optimal and above all correct way? The harsh physical reality does not care a jot about myths, philosophies or sophisticated marketing. The physical causes also include psychological factors that can affect how we experience conditions like pain and fatigue. As a reader trained in the above topics would surely recognise, much of what is mentioned in this compendium is not exactly new knowledge. However, what may be surprising is that so many people do not apply the knowledge that actually exists. What are the consequences this may have had? Can many of the problems that exist be partly blamed on this?

However, scientific knowledge is changing with new developments, not least the knowledge of how the human body physiologically is affected and reacts to various forms of load. Malmstolen AB's ongoing goal is to keep up to speed with these developments, and as far as technically and economically feasible, and within reason, further develop our chairs to encompass this new knowledge. Being able to translate background knowledge into a technical solution – a chair – with the required properties is of course paramount.

With our linguistic usage, examples and general approach we have tried to aim this publication at "ordinary" people with an interest in their work environment, but we also believe that people more informed in ergonomics may find the material useful in different ways, not least as an explanation of the design of Malmstolen. Some people may think that our examples are too "trivial", but our intention is to show that the physical principles are not so remarkable. However, they are key to understanding load-related problems. IF any ambiguities etc. arise as you read this, you are welcome to contact us with your queries. We shall endeavour to try to answer them.

Erik Malm, Malmstolen AB, Stenungsund, 2012.

Basic Spinal Anathomy

Before we concentrate on more detailed questions about sitting, you may need to know some basic knowledge of spinal anatomy.

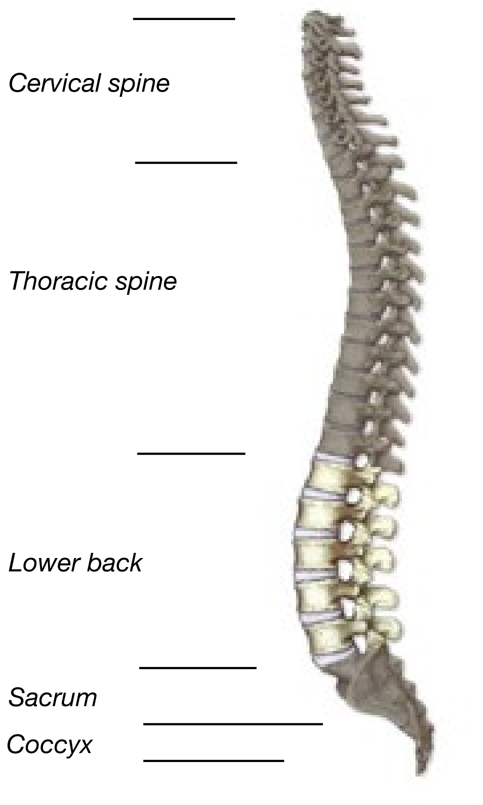
The human body consists of several different systems. They are all interdependent on each other in order for the body to function. We will now look closer at three of these systems, which are particularly important for the function of the spine and working capacity.

The three systems are:

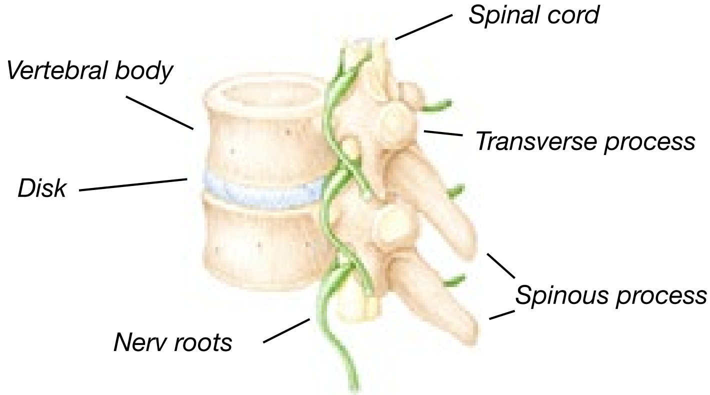
1) The Skeletal system 2. Muscle ystem 3. Nervous system

We can liken these three systems to individual legs of a tripod. If you experience problems with one leg, the load on the other two may ultimately result in the entire structure collapsing.

1) The Skeletal system
If we look at the part of the total skeletal system that make up the upper body, these are the backbone and ribs that form the chest, and the arms. The spine has three principle functions: support organ, movement organ and protection organ for the spinal cord and nerve roots.
You may think that these properties are difficult to reconcile, but this has been solved by the vertebral column being divided into different movement segments. These consist of intervertebral disks, joints, and the adjacent vertebrae.



The **vertebrae** number 32-33 of which the uppermost 24 are normally free and separate. The remaining lower vertebrae have grown together into two bones; the sacrum, and coccyx. The 24 free vertebrae are spread over 7 neck vertebrae, 12 thoracic vertebrae (in which the ribs are firmly joined) and 5 lumbar vertebrae.
The vertebrae are constructed so that the outer section is made of compact bone. The interior is made up of spiculae. In a normal and varied load, the spiculae are sufficiently abundant in number and grow in a variety of directions to form strong vertebra.

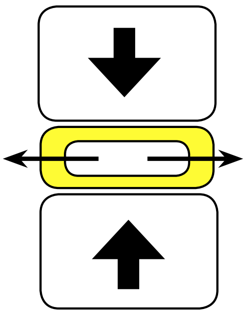


The disks are located between the non-fused vertebrae. The disks are comprised of a jelly-like nucleus that is 90 % composed of water. When we reach our 70s, the amount is reduced to about 70 %. The nucleus is surrounded by concentric/elastic fibres arranged in a variety of layers, similar to the cord of a tyre. The central parts of the disks lack pain-sensitive nerves. However, the peripheral parts have many such nerves.

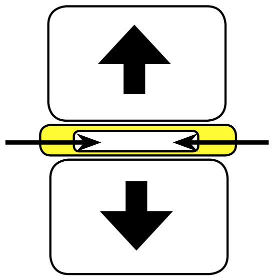
As the disk interiors lack blood vessels (they disappear in early childhood), they must rely on their surroundings for their nutrient replacement. This takes place by diffusion of fluid. The prerequisite is that the disks are sometimes exposed to load, and sometimes relief. The process is similar to how fluid moves in a sponge that lets in and releases liquid alternately.

The process proceeds for both long and short cycles.
The long cycle: The time of the day we find ourselves in standing, walking and sitting position, our disks are exposed to pressure. Fluid is pressed out and the thickness is reduced during the load period. When the disks are relieved such as when we lie down, fluid is sucked in instead.

The short cycle: When we move and our disks are subjected to the pump effect this movement produces, fluid also migrates in and out of the disks.

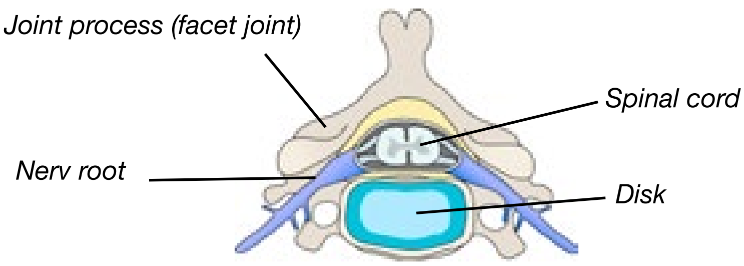


When the disk is loaded fluid is pressed out of the disk



When the disk is relieved fluid is sucked into the disk

The main function of the disks is to act as shock absorbers and to contribute to spinal mobility. That the replacement of nutrients works is therefore very important in optimising the function of the disks



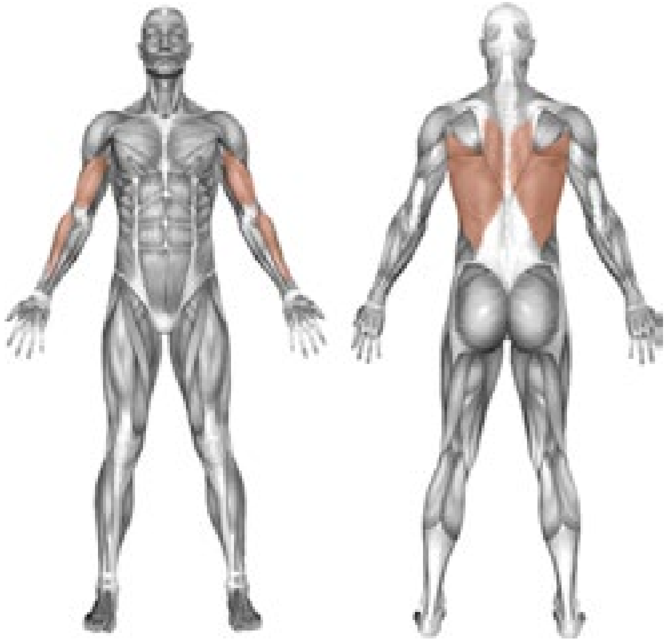
Vertebra and disk in section, as seen from above

The vertebrae have
a **joint process** that joins the vertebrae with each other. To describe this in a simple way, cartilage grows as a protective coating between these facet joints. Cartilage surfaces facilitate the ability of the joints to move. The entire spinal structure is then held together by an amount of ligament that runs along the spine.

The spinal cord is protected inside what is known as the spinal canal. The front of the canal wall is formed by a pair of vertebrae and disks with a ligament lining. The rear wall and side walls are formed by vertebral arches with intermediate ligament and joint process. Each “floor” has a nerve root entry through an opening between the vertebrae’s joint process - the intervertebral hole.

2. The muscle system

The muscles are what allows us to move mechanically. The very complex back and torso muscles make it possible to bend and twist through the various muscle groups being activated and deactivated alternately. The back muscles are in layers. The exterior layers are dynamic and control the movements of the shoulder, arm and neck. The deeper layers of muscle work more statically and are chiefly responsible for maintaining body posture. The muscle that more than any other is important for maintaining our upright posture is called músculus eréctor spinae.

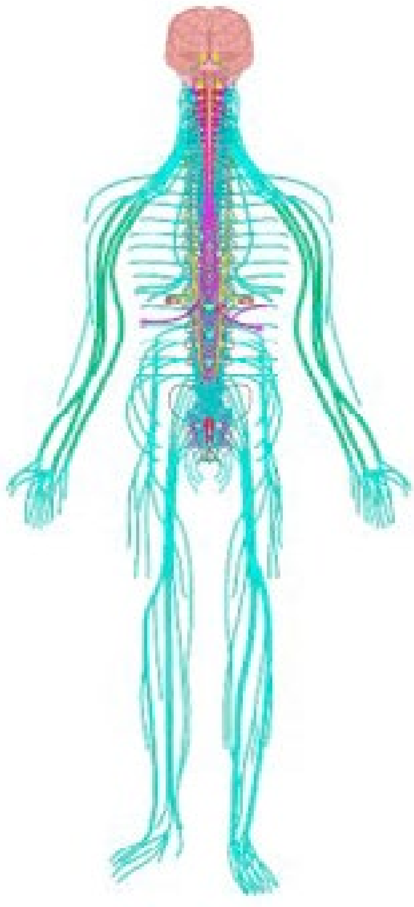


There is a dense web of blood vessels inside the muscles (known as the vascular system). The muscles are provided with nutrients and oxygen from the blood which carries away waste products. Body movements make it generally easier for the heart to transport blood to the muscles and particularly in the finest blood vessels, the capillaries, in the outer muscle layer. It is also easier for blood to flow through a muscle that is relaxed than one exposed to a static load where the blood vessel is contracted for a long period.

3. The nervous system

Almost all body functions depend on signals from the brain in order to function. These signals are transmitted via the nervous system to the muscles and organs in the body. You can liken the nervous system to electrical wiring in a house.

The most vital part of the nervous system is the spinal cord which is susceptible to injury. It is therefore very well protected inside the back's skeletal system. Nerve fibres run from the spinal cord that branch out in the body. The nerves not only convey information to the body but also gather information for the brain. Pain is a good example of such information gathering. We will return to how the nervous system reacts to loads later in this compendium.



Sitting ergonomics

When we talk about ergonomics related to sitting, for example, at computer workstations, the importance of movement and variation is often mentioned. We do this by reference to the fact that, for thousands of years, humans have lived an active life in which we hunted prey, farmed the land and so on. It is this kind of lifestyle our bodies and its functions have been adapted to through evolution, an environment where the body is dynamic and variable in terms of movement and loads. This is consequently a very important factor to consider.

When so many people spend so much time sitting in their lives, at work, at home and in transport between destinations, the risks of contracting the different types of disorders that sitting can actually cause increase dramatically. Pain in the back, shoulders and neck are the most common types of disorder we are referring to.

In order to take the right action, we must understand the factors that contribute to the problems. There is a conflict between the life humans are adapted to and the sedentary life so many people are now living. Ergonomics, which originally came to light in the 1950s but only really began to become a concept about 30-40 years ago, has focused on a few different areas over the years. There have been discussions about which sitting positions are good or bad, and psychological factors have been highlighted as important and even crucial for how we experience fatigue and pain. Active and mobile sitting, "the best sitting posture is the next one" has been another focus of discussion. Very often groups have been formed that are focused on one or the other explanation, and "conflicts" between the different factions have at times become quite fierce and probably quite entertaining to outsiders.

Man is a complex creature. The forces of physics affect us, and our body design and our bodily functions are adapted to suit these forces. Over the millennia humans have also developed properties that affect our social skills, and general survival and reproductive success. Physics, biology/physiology and psychology in a glorious mix in other words. To ensure good ergonomics, we must have overall understanding, but also understand the smaller components of the big picture. However, it is dangerous if we try to isolate the smaller components from the big picture, as this will increase the risk of erroneous conclusions.
If we regard this as a chain with many links, it is important to try to make each link as strong as possible to make the whole chain strong. "No chain is stronger than its weakest link" as we know is a well-known that can easily be applied to sitting problems.

To try to be as instructive as possible, we thought we'd take everything one step at a time. We believe that the words "logical" or "obvious" will appear in your head a few times when you are perusing the following pages. The examples that were mentioned in the foreword, may seem "trivially simple", but the key physical principles are no more remarkable than that.

Loads

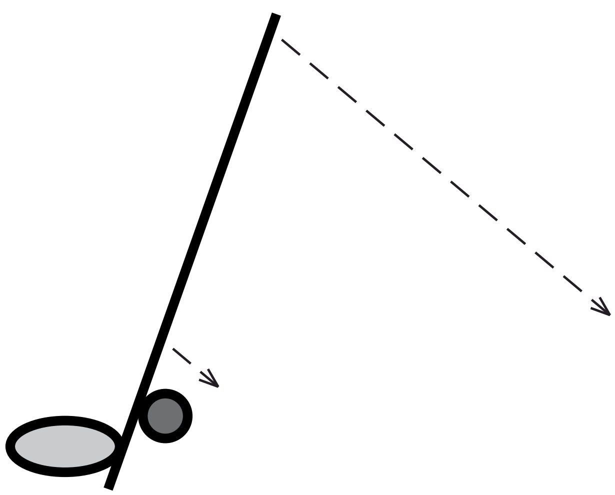
Gravity
As we all know, the law of gravitation is ever present on earth. If you drop an apple from your hand, it will fall to the ground. This is obvious knowledge today that is hard to contest, right?

The loads our bodies are exposed to when we talk about musculoskeletal disorders are mainly caused by gravity. If gravity did not exist, would we have experienced loads similar to those that we have when gravity exists? And if we did not experience any loads, would we have had any musculoskeletal disorders? Interesting questions...

However, it is the case that gravity and loads exist. It is the physical reality we live in. As this document is all about sitting, we will naturally be mainly concentrating on this topic.

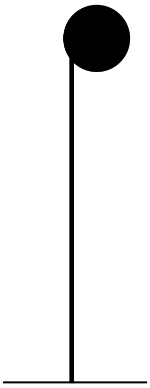
We intend to begin with a series of examples and questions where gravity is very much involved. Everybody already knows that the gravitational direction is straight down towards the centre of the earth.

Levers/Moment arms
We also believe that most people know what a lever is. We use a lever when, for example, we need to pry up a stone with the help of a crowbar. If we keep our hands at the top of the crowbar and pull in the direction of the arrow we will gain better strength when prying the stone than if we are further down the crowbar, right?



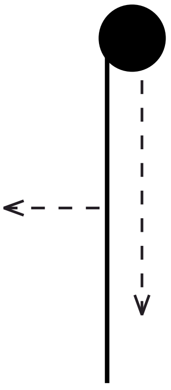
When we talk about the physical aspects of musculoskeletal disorders, knowledge about gravity and levers is essential. To continue:

Example 1:



If you attach a heavy ball at the top of a stick as shown in the diagram above, which outcome is most likely?
A) the stick remains in place?
B) it falls to the right?
C) it falls to the left?

Example 2:
We now replace the rigid bar with a softer, more flexible version. Imagine yourself in that situation and it starts to resemble a human body, which of course is pliable. Chiefly in the upper body, otherwise in the rest of our joints.

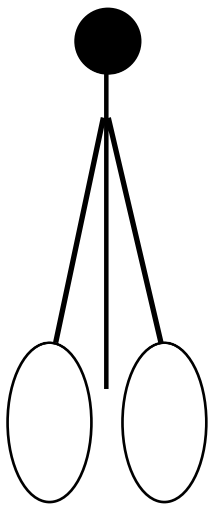


The stick is now an elastic, flexible material. The ball is the same and is positioned on the stick in the same manner as before. The gravitational pull means the ball wants to fall down. The stick will then start to bend and bulge to the left before it falls completely. Does this sound like an accurate description?

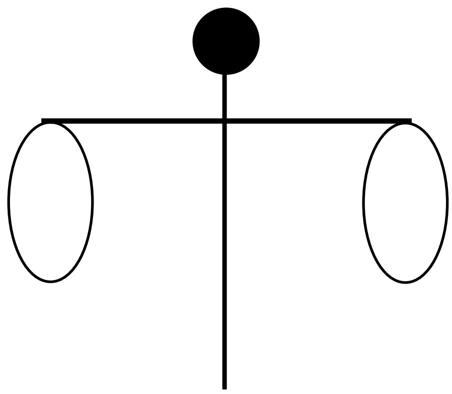
Example 3:

If you, as in the schematic diagram below, are to carry TWO heavy shopping bags in each hand, when do you experience the heaviest bags (how quickly will you feel most tired in your back, arms and shoulders)?

A) When you have your arms at the side of the body



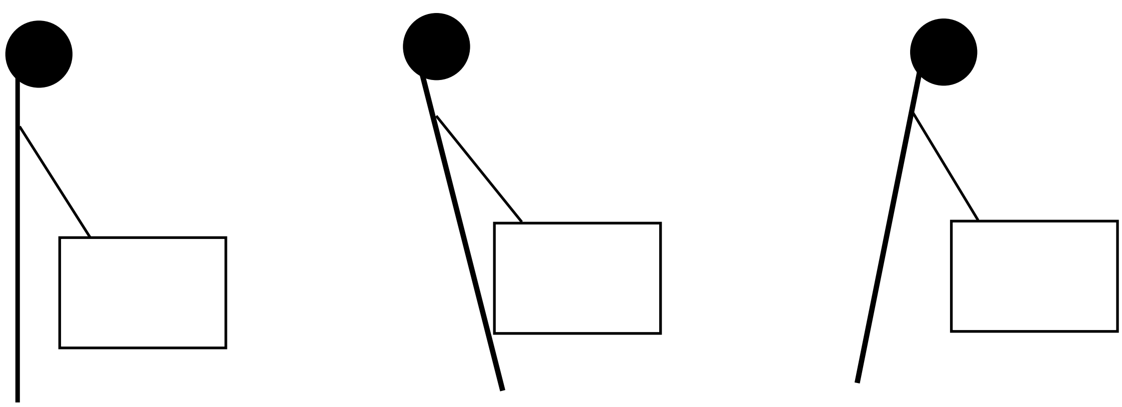
B) When you have your arms straight out from the side of the body



Is your answer to Examples 1 and 3 possibly B)?

Examplel 4:

You have to carry a crate of bottles and keep the crate in front of your body. Which of the options below feels easiest to carry the crate, i.e. when it is easiest to keep your balance so you do not fall forwards?



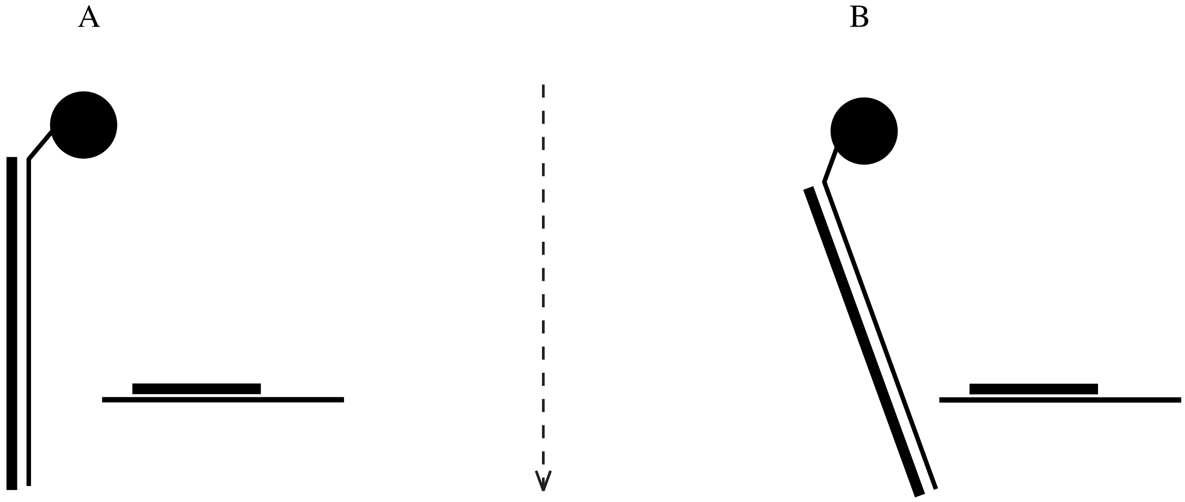
A B C

Now we have put another small stick ("neck") in the large stick ("back"). At the other end of the neck the ball (the 'head') is attached. The dashed line indicates the force of gravitational direction. You should now understand that these simple sketches are now symbolising the human body. The thick line behind the body represents a backrest.

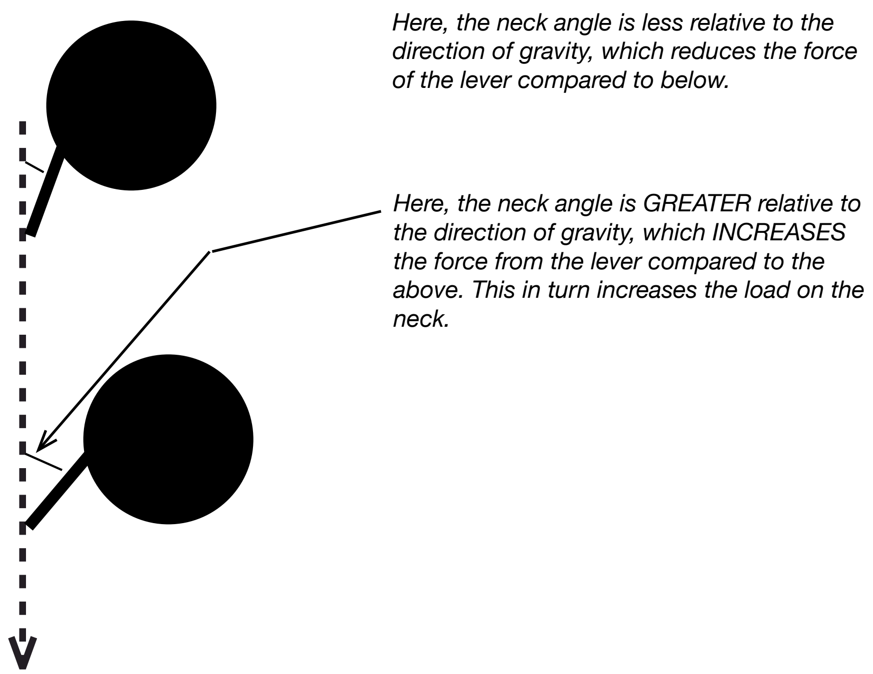
Example 5:

You are now sitting at your desk. In front of your desk, you have a book (it could also be a keyboard). Below you see two options of sitting with your body when looking at the book.

In which of the options is load least on the neck?

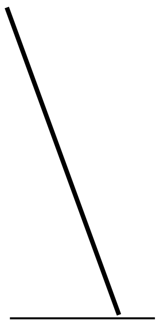


Dare we guess that you chose option B) again? Perhaps some people think this example was a bit trickier. To clarify:



That we used mostly rigid "sticks" in several of the previous examples has been to ensure we describe, as simply as possible, how the principles of gravity and the lever work. We will now make it a little more complicated by using material that is flexible, such as ordinary A4 paper:

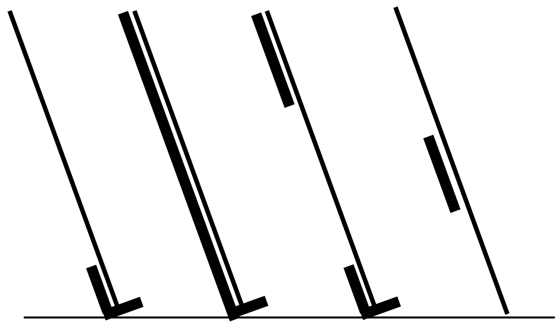
Example 6:



If you attempt to place an ordinary sheet of A4 paper on the desk surface as outlined above, what outcome is then most likely when you release the paper?

A) the paper remains in the position it is placed in?
B) the bottom edge of the paper slides to the right on the desk and that the paper thereby falls to the left?
C) it falls to the right?

Example 7:



If you are to give the A4 sheet support, e.g. with a document holder ensuring it stays flat, in which option will you succeed best in?

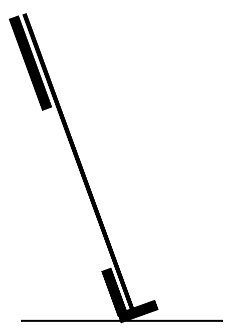
A) when it is only supported in its lower part?
B) when it is supported over its entire surface?
C) when it is only supported in its lower part AND upper part?
D) when it is only supported in the centre of its surface and with no support at the bottom or top?

Example 8:

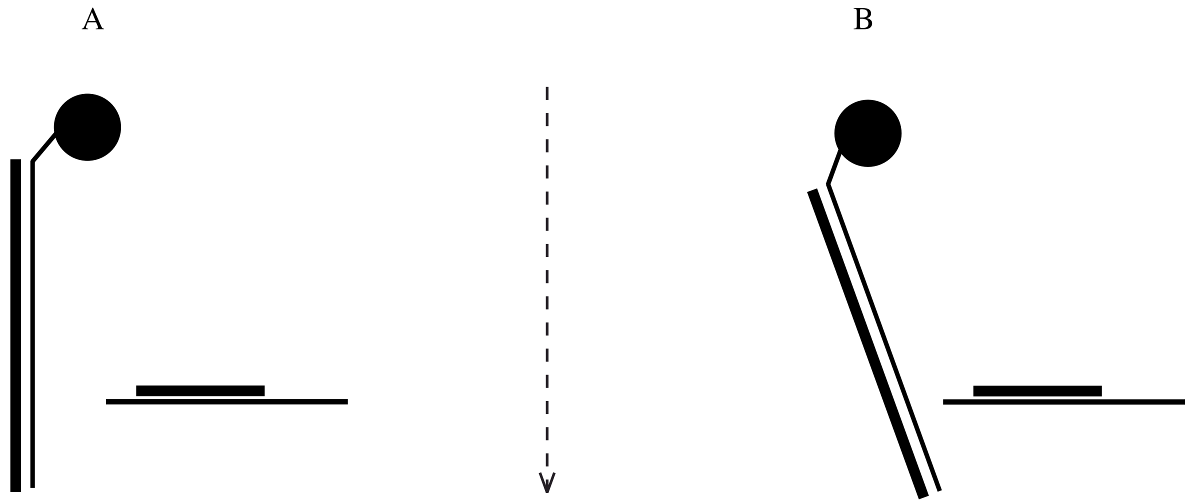
If we go to Example 7 again and consider option C:

The sheet leans on a document holder, which we think gives the paper support as per the diagram. What happens to the sheet?

A) It remains unchanged.
B) It will "arch" to the left through the space.
C) It falls to the right



Is B) once again your choice in Examples 6, 7 and 8?

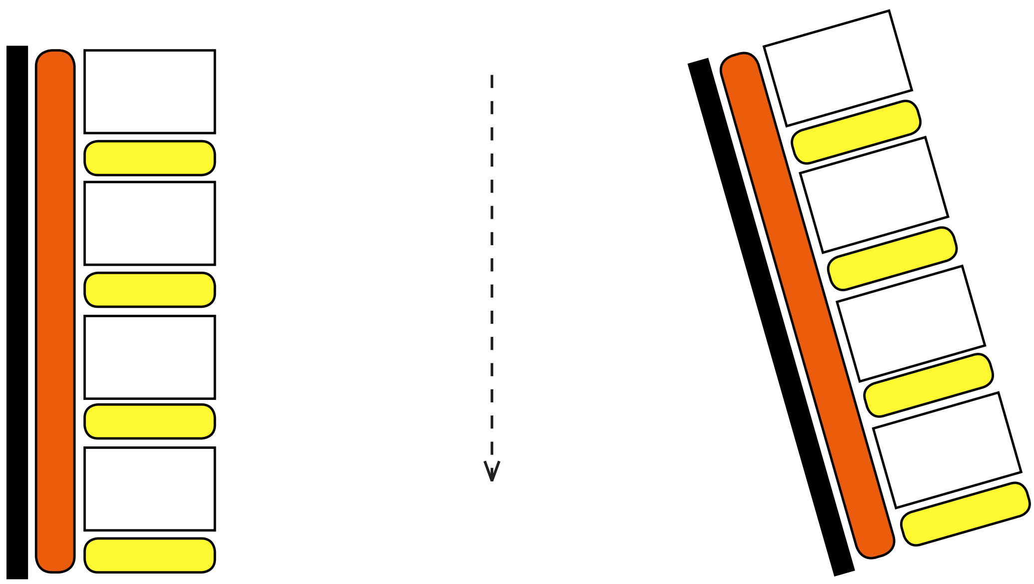


Example 9:

We will now look at Example 5 again. However, we will now focus on the back and the backrest. In which of the cases is the back best supported and relieved from the backrest?

Is B) once again your choice?

To clarify a little: The sketches below are partially exploded sketches from the above. The black line is the backrest, red symbolises the back muscles and the other represents the vertebrae of the spine with the discs in between. When the spinal column and disks are affected by gravitation in the vertical direction as in the example to the left, the load is higher than in the example to the right. Here part of the load is picked up by the backrest instead. When the head is front heavy as per the principle shown in Example 1, the musculature in the neck and back must also work statically to avoid head and upper body from falling forwards in the example below left. When you lean back such as in the example to the right, the musculature is also relieved as the backrest helps to keep the back upright instead and the angle of the head relative to the gravitational direction is reduced.



Movement. And movement.

We now begin to concentrate more on how the human body reacts to loads. We have already mentioned the importance of movement and variation with respect to our physically active biological history. We have also studied gravity and levers on previous pages. With a little more knowledge of how these forces affect a mass, dead or' alive, hard or elastic, we will now study the different types of movements and how they are related to a load etc.

Example 10:
Imagine you are waiting for a train on a platform. You are standing still and are temporarily resting your weight on one leg. After a while, you switch the weight to your other leg. After a little while more, you switch the weight back to your first leg. Once you have done this a few times, you may decide to take a short walk.

The movements you have made are primarily because
A) you have wanted to move OR
B) you have grown tired in the first leg and, therefore, changed legs, and later started to walk around?

Example 11:
Imagine you are sitting on a hard wooden chair. You are able to sit completely still for a while, but soon will most likely change your sitting position. After a while, you change your sitting position again and the longer you sit in the chair, the more you have to change position. Eventually, you may find yourself constantly changing position. Do you do this just because
A) you want to move OR
B) you are trying to find a new and hopefully more comfortable sitting position?

Example 12:
You are carrying a heavy bag of groceries in one hand. After a while, you move the bag over to the other hand, and a few moments later you switch back to the first hand again. The longer you are forced to carry the bag, the more often you change hands and maybe put it on the ground for a while to rest your arms. Do you do all this because
A) it's simply fun to change hands (or rest) OR
B) because you are getting tired in your arms and therefore change hands (or rest)?

Dare we guess you answered B) in these examples too?

These questions are particularly pertinent when studying the human body's reaction to static loads, as in these cases. What had happened to the body if we are NOT able to switch legs, sitting posture or arms? Are we agreed that it is most likely that sooner or later it would have led to great fatigue, aches, and later to really agonizing pain? It is not uncommon that physical stress like this also causes mental stress. There are even forms of torture that are based on this knowledge.

Load-related movement
The above are examples of “load-related movements.” Movement is a symptom of the body being subjected to a high load. If we do not react instinctively to begin with, sooner or later we will do it consciously – we change position, switch arm, etc., to get relief and not get too tired in the part of the body being exposed to the load. On the other hand, a new part of the body is then exposed to the load and when it becomes too much we change again. The movements that the body generates here are simply the body’s own defence against loads that are too great.

What’s happening in the body
We will, in a way that is easy to understand, try to explain what happens in the body physiologically when exposed to loads such as those we have just exemplified.

As part of their design and functionality, all living organisms are adapted to compensate for, and interact with, physical forces. The pattern of movements, the position of the internal organs and the way we work is, in one way or another, controlled by this.

There is a part of our nervous system called the muscle spindle system. The main “task” of this system is to sense the body’s balance in any space in relation to gravity. It also senses and controls the basic tension of the muscles which is required to keep the body upright, otherwise we would immediately collapse. As the name suggests, it is a question (in millimetres) of stretch-sensitive spindles that sit along the muscle fibres, but also on ligaments.
If we return to the example where we carried a heavy crate:

The weight from the crate that we carry in front of us would, if we were totally relaxed and not leaning backwards, cause us to lose balance and fall forwards. When we lift the crate, the muscle spindle system senses that the muscles are stretched as the spindles are also stretched. In order to counteract this loss of balance and/or avoid over-stretching the muscles, signals are now transmitted from spindles both to other spindles in the body and to the spinal cord
and the brain (central nervous system), which responds by sending out signals to the muscles with the message “act now so you can brace yourself and not fall over.” Muscles are thereby activated. When this happens, nutrients and oxygen begin to be consumed i.e. “fuel”, in order to be active. In this combustion process “waste gas” or toxins are also formed. Most people have heard of lactic acid, but there are other substances in these waste products, among others those that are directly pain stimulating. There are also substances that excite chemically sensitive nerve cells, resulting in new signals being sent to the system to activate the muscles even more.
When a muscle is subjected to a static load, where the periods of rest are too few and too short for the muscles to relax enough to recuperate, the consequence may be that the muscle is “poisoned” by the waste products and the process described above could eventually become self-perpetuating (chronic illness). Fatigue and pain are usually the first symptoms, followed by the deterioration of coordination skills, muscles weaken and if the stress continues long enough, the muscle numbs and loses all its strength. Inflammation of muscular attachments is another familiar symptom. Even seemingly small loads can lead to this result over time. A tense musculature also inhibits blood circulation, which further contributes to the problems. If you had to stand completely

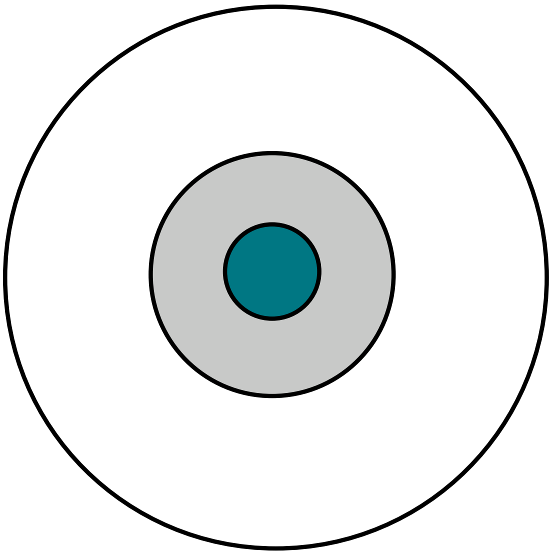
still and continue to keep hold of the crate, sooner or later you would collapse and/or dropped the crate on the ground. The same applies to the grocery bag, right?

In order not to end up in such a difficult situation, the body reacts automatically by wanting to relieve the loaded structure. One way is to generate a move = load-related movement.

Activity-related movement

When we advocate movement and variation when talking about ergonomics, as said previously it is with reference to the fact that our biological history is one of physical activity. The lion's share of this physical activity has consisted of "activity-related" movements, i.e. moves that we have performed to achieve a goal, such as running to catch a prey.

The ideal situation of course, would have been, as we have already mentioned in the foreword of this document, that our work tasks at the computer workstation contained a large enough amount of natural movements to perform these tasks, and with such a rich variety, that the static loads are predominantly or even completely eliminated. Unfortunately, reality is often another story, especially in computerised environments in which many people work today. We must of course make the work tasks as full of as much movement and variation as possible, but we also need to be realistic. Somewhere along the line the work also needs to be rational and profitable, and this unfortunately often conflicts with the positive visions. This means that we must adapt to the reality that actually exists in these environments and identify the solutions that work best based on the prevailing factors. Working with solutions that are not achievable in the environment in question does not produce the desired results. At worst, it may even aggravate the problem.



The white field symbolises the amount of dynamic movements and variation the human body is adapted to through its biological history.

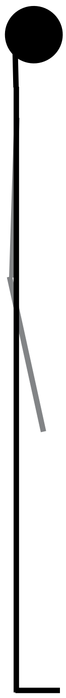
The light grey field symbolises the amount of movement and variation, we SHOULD have a minimum of to escape the realms of "the static loads."

The dark green field symbolises the actual amount of movement and variety our work task contains in order to perform the task.
If we can get the work task to include more natural movements and variation moments of an activity-related nature, this would be ideal. The problem is that if and when this ambition conflicts with the logistics, to get effective and rational flows incorporated into the execution of our work, then we usually lose sight of this good ambition. A large amount of work carried out under tight time constraints makes it even more difficult to perform movement and variation that is not directly related to the work task. We are employed to do the work we are paid for effectively and profitably. This is an unfortunate fact of life for the vast majority of people. We need to find all possible means to compensate for this. Movement and variation must be supplemented with work tools, work postures and work practices, that as far as possible can reduce the loads that we know can generate problems.

NOTE: The above figure is only schematic and does not specify the exact conditions as these may vary from workplace to workplace and from person to person.

Work positions

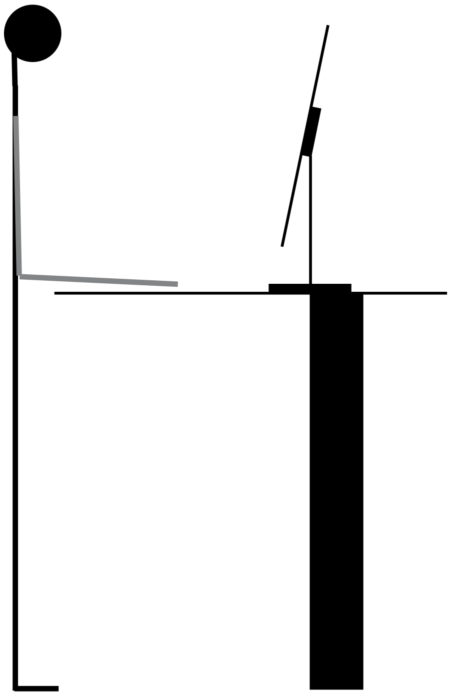
The sitting body position is the most common posture at a computer workstation. Either the traditional desk or in more modern workplaces height-adjustable sit-stand desks are used. The latter variation of the desk of course allows more opportunity for variation.
We now want to look at the different and common work positions for this type of workplace and how these can affect the body, positively and negatively. When we detail different chair designs later in the compendium, we will provide a little more in-depth information on the topic of sitting positions.



Standing
The standing body position, as the sketch to the left symbolises, is the body's "neutral position" relative to the direction of gravity. When we stand up, the back assumes its natural S-shape (although it is now not visible in the sketch, which is drawn as simply as possible). It is often said that the body is "in balance" in this posture. However, if by balance we mean equilibrium, this assertion is incorrect. The head's "attachment" to the vertebral column means that its centre of gravity lies in front of the spine. If you were to completely relax, your head would fall forwards, followed by your back and the rest of your body.

When the body is dynamic and mobile and physically active, its centre of gravity changes and moves all the time, and the loads in the body and muscles are variably active, something our bodies (within reasonable bounds) are designed for. When we are forced to stand still, however, the body can begin to sense the loads that it is being expose to in a more static form in a completely different way.

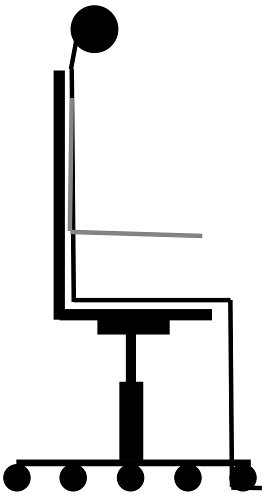
If we go back to Examples 1 and 2, and Example 10, we can now understand that the body is affected in a similar way in the sitting still position. The back and neck muscles must work to prevent the head falling forwards with the result that the upper body generally wants to fall forwards too. Your legs/feet can also begin to swell up if you stand still for a long period.



Standing at a desk

With a height-adjustable desk in standing position we find ourselves roughly in this position. If your arms are hanging freely in the air, they form a lever in relation to your back. If they are resting on the desktop, it is easier to gain relief. The load described above under “Standing” remains, although somewhat reduced if the arms are relieved on the desk. If you have a need to look at the keyboard when typing, your head will fall forwards. This not only considerably increases the load of your neck but also on your spine, see Example 5.

Standing has the advantage that we assume human’s “default position”. The disadvantage is that when this standing becomes static, the body is subjected to loads as above. Additionally, energy consumption in the body when standing is about 20-25 % higher than when sitting.



90° position

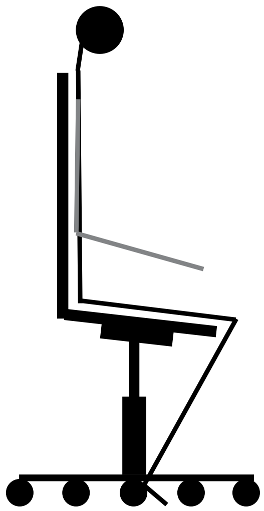
For decades this was the most commonly recommended sitting posture. Hip joint and knee joint at a 90° angle.

The posture is easy to teach. In order to work reasonably, the backrest must provide good support for the entire lumbar region. When your body is subject to a particular weight, this affects the extension of the muscles and ligaments primarily in the lower back. This results in the pelvis falling back resulting in the back arching. If a backrest provides support, light stresses occur instead. Disk pressure is also great in this position. If the backrest does not have a lumbar shaped support, the body tends (in addition to collapsing) to want to slide back on the chair more than otherwise. The head’s centre of gravity also has an affect just as with a stationary neck and back. If you have to look at your keyboard, this will increase this pressure further.

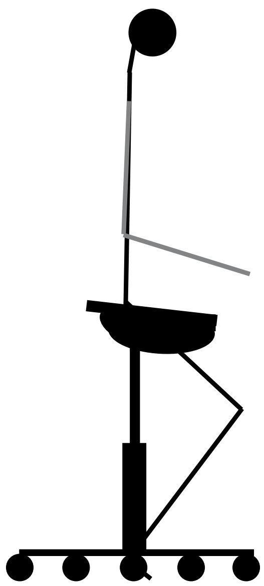
Rider position

As the name implies, a sitting posture that resembles that of riding a horse is the goal. The seat height is higher so that the thighs can slope downwards and the lower legs/feet can be placed under the seat. The back assumes for the most part the S-shape it has when standing. The

upper body usually leans slightly forwards. This sitting posture is also frequently recommended because it has advantages compared to the 90° sitting position as the back is easier to balance. If the work task involves a lot of movement and variation, this position typically works well as a basis for active sitting. However, you must be aware that there is a major and crucial difference between sitting in the rider position on a horse and a chair - the horse will probably move, which means natural dynamic motion variation. The chair's motion is governed by our own activity and load-related movements. If the chair is optimised for the rider position this increases the risk of static sitting unless the chair allows workable sitting postures with good support and relief. In an upright position, the head's centre of gravity remains in front of the back in the same manner as previously mentioned in sections such as "Standing".
A common behaviour when you start to grow tired in the rider position is to move your feet in front of the chair. The back profile cannot then be maintained without a muscular effort if no help is available from a properly designed backrest. The perception of many people in a forward leaning seat is that they slide off the chair. You then try to resist with your legs and tighten more easily throughout the whole body.



Sit-stand sitting
The "Sit-stand" position means a semi-standing position and it can perhaps be seen as a more "extreme" variation of the rider position but with the same objective, to get the upper body in balance as if you are standing. You often sit in a work chair where the seat resembles a horse or bike saddle. The chair may also have a smaller backrest. This type of sitting posture is frequently used with associated chairs when sit-stand desks are used with the desk normally being in standing position.
This position also makes it vital that the work task is really full of variation and movement. There are no other positions to assume without increasing the load drastically.



The free, mobile ”active” sitting position
This model of sitting is based on the theory that the body is looking to move, that the best sitting position is the next one etc., and is justified by the fact we are adapted for a mobile life. The argument is also put forward that the body never adopts any specific sitting position, but that we spontaneously and naturally are constantly looking for a variation of sitting positions. By way of example “free-float” chairs where the seat and backrest move independently of each other in order to follow the movements of the body are often designed based on this philosophy.
A very important aspect to take into account from a load ergonomic perspective with respect to this philosophy, is the cause the movements have. Are they activity or load-related?

Reclined sitting position
Provided that the seat is properly designed with, among other things, a backrest that is able to maintain the spine’s natural S-shape, and distribute the pressure over the largest possible area, a reclined sitting position, about 120°, is arguably the position that gives the best relief for your body (see the Example 7 B among others). This is basic physics. A neckrest of the right design further contributes positively to this.
BUT, how good the support and relief you get in this position may be, the body is still loaded (as long as gravity exists), albeit on a smaller scale. Sooner or later the body will react to the load, and if the chair can only provide this sitting position, the reclined position will ultimately also become static.

Heart, lungs and digestive system
It is important to note that when the body collapses, such as when we arch with the upperbody, the digestive organ and the space for the lungs and heart are pressed together. When time begins to be a factor, this can negatively affect the performance of these body parts. If this is the case, this easily causes tiredness. Keeping the back straight therefore has benefits in this instance.

What can we do and how?

As mentioned earlier, it is optimal and always desirable if we can get every sitting person's work tasks to contain as many natural dynamic movements and variation steps as possible. However, we must also take into account the actual reality that prevails at a specific workplace. A rational and efficient work flow is also important from a business perspective and, unfortunately, these two factors are frequently in conflict, especially at computer workstations which involve a lot of sitting. Let us say that a work task contains 10 variations/movement moments, but it should contain at least 30 in order to achieve the positive effects we want. Add a time limited work schedule with deadlines that must be kept. We will perform more movements/variation than the work task actually includes/absolutely needs to be done? It is obviously good that we recommend and seek movement and variation, but if there are no realistic opportunities to achieve the amount necessary for it to be an effective benefit, we have to supplement with ergonomic work aids to an even greater extent than otherwise with the right characteristics, movement patterns and processes that can greatly reduce the risk of musculoskeletal disorders.

The reason why we once again reiterate the meaning of the above is that this it is an extremely important issue, and for the vast majority it is the harsh reality they work in. We must be realistic and not "vague" and out of touch with unachievable reality visions and "philosophies".
If we look back over the past 30-40 years and consider the recommendations and actions we have carried out, should we consider that we have been successful in the field of musculoskeletal disorders when they are more common and cost more than ever? Have we applied the right skills over the years? Have we made erroneous analyses/diagnoses because of incorrect and/or insufficient knowledge, have we gained accurate experience when we have obviously not been as successful as we should reasonably have been if we had planned and done the right things over all these years? Have the various tools been designed correctly and/or used correctly? Can the designs have been influenced by a deficient knowledge base? Or is it the case that it is very difficult or even impossible to solve musculoskeletal disorders?

Many of the measures recommended over the years, and to some extent still recommended, in the context we have addressed in this compendium, are often based on the analysis of the symptoms of a load, not the cause. We provide medicine for the symptom, but as long as the cause remains we will never solve the problem. A classic example: "Look at the children sitting in school, they do not sit still in their chairs but move about all the time. Therefore, we need chairs that follow body movements." Although simply put, is this not a typical case of something that, to a very high degree, describes load-related movements? Sure, the kids have a lot of energy (activity-related movements) but the kids still complain that the chairs are so uncomfortable and they are forced to sit in them long enough that it is impossible to sit still without getting tired or aching! DESPITE this, many people say that the example with the children here is proof that the body is seeking movement. Can such an analysis really be accurate? Is load-related movement something to be stimulated? Does this mean we should consciously create discomfort and loads on the body so that our defences force us to move?

The above is a good summary of the starting point for good ergonomic customisation.

What can we do and how do we create a good ergonomic workplace?
As sitting today, especially in the case of prolonged periods, is associated with highly computerised environments, we will concentrate on this aspect. For the sake of simplicity, we have arranged general and appropriate measures in paragraph form; we will deal with the details about the chairs later:

A) The work task can contain as many activity-related movements and dynamic variation moments as possible without this, or at least as little as possible, affecting the efficiency of performing the work task.

B) The option of different working/sitting postures with the minimum possible static load, particularly when time is a factor.

C) Tools and work aids maintain the necessary quality and functional class, based on scientifically based knowledge (where most is elementary physics and pure logic), ensuring they do not become the weak link in the chain. Desks, chairs, lighting, computer monitors, keyboards, control devices, etc. and all the settings and placement of these components is important for the overall configuration working.

D) The user takes the time to learn how to use his equipment, as well as the producers of equipment making them as user-friendly as possible WITHOUT jeopardising the properties that are really important for optimal ergonomic functionality. If users do not want to learn how the equipment works, which usually is not very difficult when compared to a mobile phone, DVD player, remote control for a television, stove, washing machine, quick keys on the computer, etc., are they entitled to demand good ergonomic equipment from their employer? Does an employer not have the right to demand from their staff that they are prepared to learn to use the equipment if large investments are being made to improve their conditions of work? A consensus in these issues should contribute positively to a good working environment, and in other respects as well as this could indicate a positive psychosocial environment!
We are now digging deeper into these aspects in order to look more specifically at the potential for a good workplace.

A) The movement and variation content of a work task
Coming up with accurate advice on all the issues here is of course difficult as there are variables on the layout of the workplace and how the relevant person works at the workstation. However, one basic idea is:

• that the work tasks carried out frequently and that are important for efficiency are within an easily accessible working radius without the body needing to adopt unfavourable working postures.

• that static rhythmic movements are avoided. This may for example be avoided by switching between right and left hands when working with a computer mouse. If this option can be supplemented with a centred control device, an additional possibility has been offered.

• that the equipment used in for tasks carried out less frequently, wherever possible, is located further away from the ordinary working radius. This forces you to move, for example, walking to the photocopying machine, getting up to go to the bookshelf to

retrieve a binder, etc. Pause gymnastics/micro breaks at regular intervals are also good. Note that this is a question of activity-related movement.
This leads us to:

B) Different working and sitting positions

• to regularly vary between sitting and standing if you have a height-adjustable desk is very good. It is important that when you sit, you must then sit optimally and when you stand, you should do it optimally. Anything in between, such as traditional sit-stand seating, is usually not a good solution, except for short periods. You cannot maintain a relaxed and upright body posture without static muscular activity unless you get the right support from your chair. However, if the work task involves a lot of movement and variation at a higher working level, this solution could work very well. We will return to this later.

• that when sitting you can use as many workable sitting postures as possible, from upright to reclined, where the upper body can maintain its natural S-shape in all positions. This without the muscles having to work for long periods and statically to maintain this profile.

That means offering a chair with the right kind of beneficial movement characteristics, but also the best possible support and relief under the laws of physics. We will also return to these details later.

C) The location and setting of equipment

• that the desks can be height adjustable. The lower down and higher up the desk can be adjusted, the better the chance of getting a personalised working height. A sit-stand desk with a setting range of about 62-130 cm probably covers most people's needs. The basis of a good working height, is that your arms and shoulders are not pushed up and/or your elbows are pressed up/out from your body as is the case when the desk is too high or when your arms are hanging freely and your wrists are angled upwards, which easily happens when the desk is too low.

• that the computer screen has the correct setting in terms of height, angle and viewing distance. Strong backlighting or that light from objects like windows and lamps are reflected onto the screen should be avoided. Good placement and set-up of the computer screen is important in reducing the risk of awkward body postures that might otherwise be required in order to be able to see properly.

• that the keyboard can be reached comfortably without stretching your arms forwards or hanging over the desk to reach. If you use a mouse and especially if you use it a lot, it should be kept in front of your body. An outwardly rotated arm beyond shoulder width increases the risks of complaints like mouse elbow. Neutral angles in the wrists should also be the aim.

• The position of lights and their settings is also important. The details are controlled by the lamp design, lighting angles, etc. Please consult the supplier for the best advice.

D) Learn about how your equipment works!

This cannot be stressed enough! No equipment is "self-thinking", at least to the extent that it is adequate for the best ergonomic solutions. It's your health we're talking about!

Why malmstolen look and acts like it does

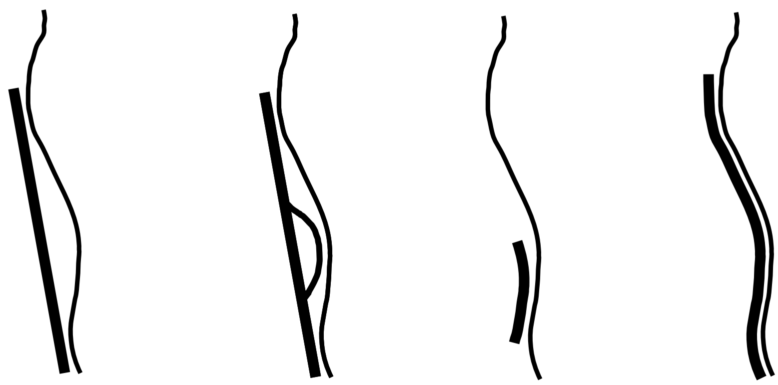
The starting point for Malmstolen design is based on scientifically accepted knowledge that is available on topics related to load ergonomics that allow us to manufacture chairs that, as far as possible and economically feasible, can prevent but also relieve and perhaps even cure load-related disorders. The last claim is of course dependent on the type of problem you have and that the chairs are used correctly and that the associated tools are also properly set. The better our chairs can be on alleviating problems, the better they should reasonably be on prevention, which remains our main goal. This is where you can save a lot of money. We have placed no prestige on selecting or excluding any specific design solution or "sitting philosophy". The solutions we have chosen are those we have been able to find scientific evidence for, and as long as no other "philosophies" from a broad scientific perspective can be verified, we will leave them be as they are.

The term SAAR™
In order to summarise the criteria underlying Malmstolen's features in an instructional way, we have coined the term SAAR. This is a Swedish acronym for Support, Relief, Relaxation and Movement. These four points are important individually, BUT it is only when they interact together that we can obtain the optimal ergonomic solution we seek.

Support
The chair's contact surfaces to the body, i.e. the backrest and seat, must distribute body weight over the largest possible surface. Which would you prefer to lie on, one nail or 100,000? The latter, right? Weight distribution is key for both the backrest and seat. The backrest is designed to help your back to maintain its natural S-shape WITHOUT your back muscles having to tighten statically for a long period to achieve this result. This is for all the sitting positions where the body is not fully responsible for balancing the spine at the correct curvature, which when sitting can be achieved in a correctly adopted "rider position". However, the S-shape looks different for different people and therefore the shape of the backrest must be adapted to suit the user and not vice versa, which is the most common scenario.

Example 13:

Which of the backrest options do you think ensures the best conditions for maintaining the spine's natural S-shape?



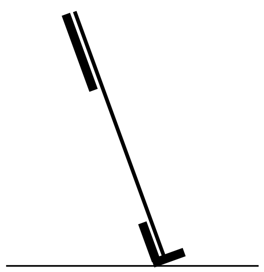
A) B) C) D)

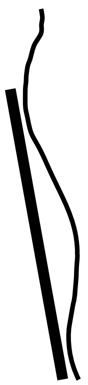
I wonder if you answered D)?

Let us study more what happens with the three other solutions in more detail.

A) If the backrest's contact surface to the body is completely flat when the back curvature has
an S-shape, it is easy to see that you have very poor support (the principle is explained in Example 7). If you relax, it is impossible to get your back to maintain its curvature (closest to success is when you sit in a correctly adopted "rider position" as mentioned earlier). The thoracic spine (scapular region) wants to drop down due to the forces of gravity. When this happens, the lumbar spine bulges and the pelvis tilts backwards (compare with Example 7C). To keep your back straight you have to tension, which means that you quickly get tired, which many people experience in their muscles in the lower thoracic spine. The pressure on the spinal disks is also great. When the body is not able to stay upright for very long for this type of load, it is common that you collapse when your strength runs out. The muscle tension/activity does decrease, but it is rather the spinal disks that take even more punishment as they are now also misaligned. In addition, the ligaments along the spine have to take much of the load when the muscles are no longer doing this. This will soon result in discomfort and pain. After a while the muscles will start to work to straighten up the body again. This whole phenomenon is a well known risk factor for back related problems associated with sitting.

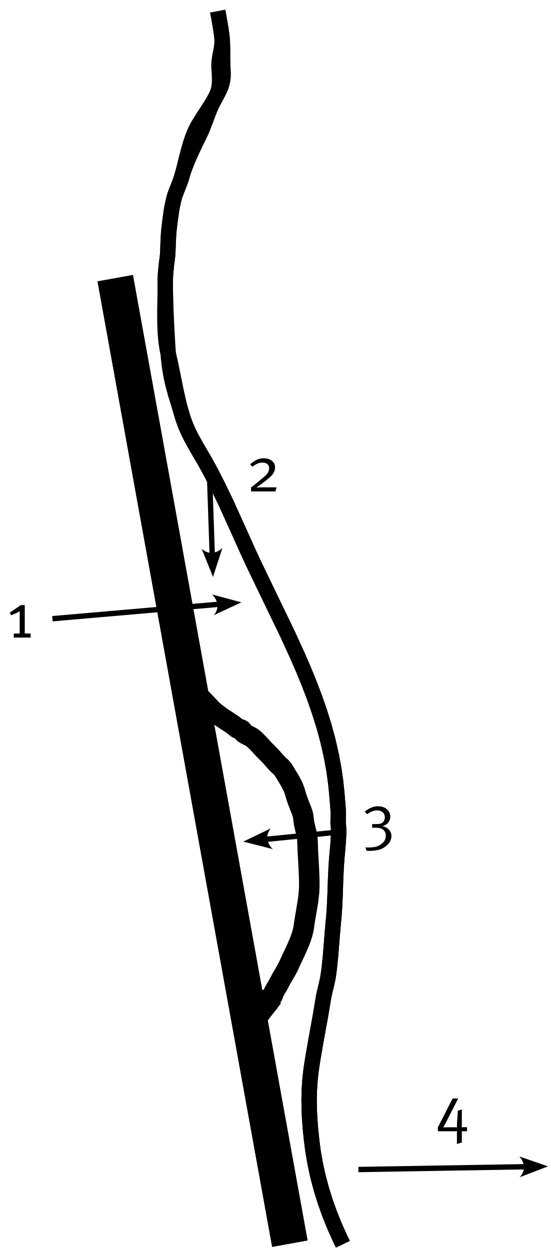
If you sit at a desk and work, another phenomenon usually arises. The body collapses, but the desk remains the same height. This presses up the shoulders. If you are also stressed out, it is easy to lift the shoulders for this reason as well. If we are working in front of a computer screen at this point, we usually bend back our neck/head to the "vulture position" in order to look at the screen. When the muscles in the shoulders and neck are compressed and/or static this inhibits blood circulation. The phenomenon is similar to holding a water hose with both hands, and moving the hands towards each other so that the hose is folded. This inhibits or stops the flow of water, right? As already known, shoulder and neck problems are very common musculoskeletal disorders. Here we can identify an important cause.
Everything described here also occurs easily when sitting without any back support at all. Again, it is only in the properly adopted rider position where the body can really balance itself. You should be able to fall asleep without collapsing, which as we showed earlier is not possible as the head's centre of gravity lies in front of the spine. As this position is also extremely static on a chair, very few people can manage to maintain this position for longer than a few minutes.





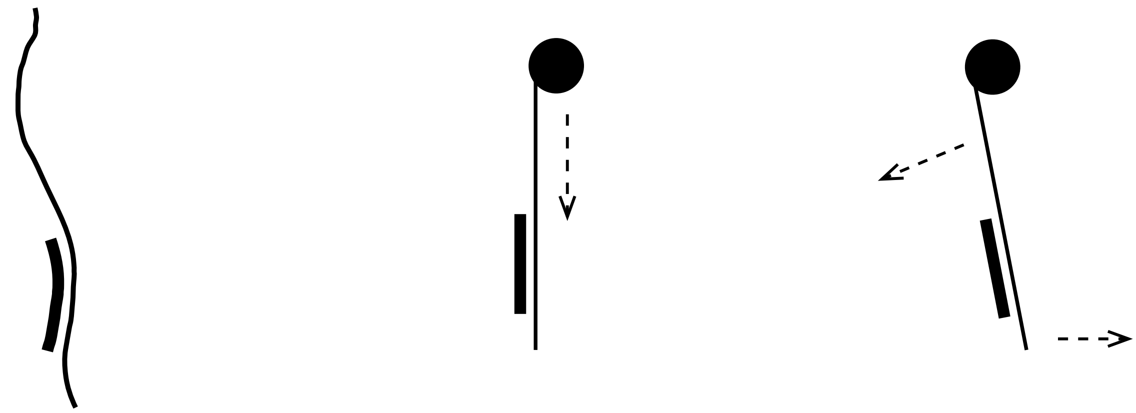
B) One way to try to prevent the body from collapsing and to relieve the body is fitting the backrest with any type of lumbar support. This could be a solid form, a cushion for example or an air bladder that can be pumped up to support the lumbar region. In cars, it is not unusual for a belt to be fastened with a handle instead. The belt then engages a limited portion of the lumbar region. These types of solutions rarely support the entire area of the back as the support is only intermittent. The diagram below exemplifies this. The following will happen, especially if you are subject to prolonged sitting:

As there is a void (arrow 1) without support under the thoracic spine/shoulder blades, this part of the body will still be affected by gravity. As in example A) on the previous page, the thoracic spine wants to drop downwards (arrow 2) and the lumbar spine is bent/pelvis tilts backwards (arrow 3). However, when a lumbar support of this configuration is now in place, the back will not collapse as in example A). On the other hand, the point of pressure from the backrest on the body at the contact surface will increase. Blood flow will then be inhibited in this region due to the increased point pressure, and the length of the muscles is also affected, which may increase the tensions. The body will sooner or later react to this. The muscle that has been subject to extra load, e.g. in the lower part of the thoracic spine, will usually grow tired after a while and eventually start to get sore. This fatigue/pain usually leads to a movement as a defensive measure = load-related motion.



What also happens is that a power exchange occurs. This force will need to be neutralised, and this is achieved by the body, sooner or later, attempting to push forwards (arrow 4), namely that we end up sliding to the front of the chair. It is not unusual that this sliding movement occurs. Is this not the principle we deliberately adopt when we use a crowbar to pry up a stone?
After a while we try to sit back on the chair again, but the phenomenon is repeated. The longer we sit, the more often this will happen over time. We become ever more tired and many of the movements we perform are load-related.

C) Here, a short backrest is used that only supports a small portion of the lumbar spine. The advocates of this solution say that you prevent the lumbar spine from collapsing by directing a horizontal force towards it, as it will collapse due to the vertically directed force that gravity exposes the body to. It is said that the limited support surface used in this way is enough to keep the body in a relaxed upright position. Unfortunately, this solution is a physical impossibility (see Examples 1 and 2), although most possible to implement if we sit in the rider position as described previously and that we sit entirely still in this exact position. It is then the position will keep us upright. The slightest change to this sitting position will affect the centre of gravity and the levers, and this in turn the loads on and in the body. In addition, body weight is distributed over a small area, which significantly increases the concentrated load.
A vertically downwardly directed force can only be neutralised by an equal force being directed in the opposite direction, upwards. This is one of Isaac Newton's laws. Applying a horizontally directed force in this case only moves the force. Otherwise, the exact same thing happens as in the A) and B) examples above, although further strengthened as there is now nothing such as friction from the backrest that can prevent the thoracic spine from collapsing.



Relief
You get good relief when the contact area is as large as possible, as this reduces the pressure per unit of area, and when the body can be made to maintain its natural S-shape with a minimum static load on the body. A properly designed backrest and seat are very important in this regard, combined with the chair's other adaptation options and various sitting positions, which also affect the load in the body.
If with the words "musculoskeletal disorders" we are referring to the loads that are a problem that results in a disorder, then it should logically be desirable to reduce the loads that might be the cause of these problems. Is this the right way of thinking?

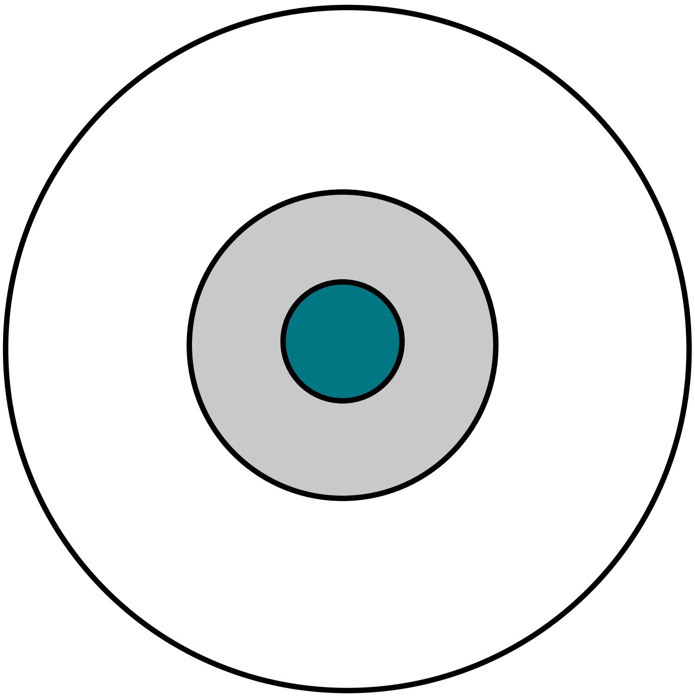
Relaxation
When we have good support according to the laws of physics we can ensure a good, relaxed posture as above, as the body is able to relax a lot easier. Having relaxed muscles means blood circulation works much better than when having tense muscles. If we have reached this stage, we have come a long way in reducing the risk of musculoskeletal disorders. BUT...

Movement
If we can ONLY offer support/relief/relaxation, we have certainly come a long way, BUT movement and variation, as already mentioned a number of times, is very important

for the body. However, with good support and good relief we do not aim to make the body passive, but the goal is to provide the best basic conditions as we can to achieve optimal blood circulation and the lowest static load level possible. The vast majority of movements must be activity-related, where both movements and variation further contribute to improved blood circulation and a variable load in the body. Movements and variation are mainly achieved through our work tasks containing as many natural dynamic motions as possible, and not that we intentionally or through ignorance create problems for the body that it must defend itself against.

Summary

We refer to the figure which first appeared a few pages back in the compendium:



If we can be in the light grey field, or better still, in the white field with regard to activity-related movements, this would be excellent. If we are in these fields only because of load-related causes, it is reasonable to assume we have done something fundamentally wrong. The less opportunity we have for activity-related movements in our actual working environment, which also takes into account optimal productivity, the more important it becomes to take into account the factors we have described using the concept of SAAR. In today's computerised work environments, there are unfortunately obvious difficulties in solving the equation "sufficient amount of activity-related movements versus good productivity" with reference to what has been mentioned previously in connection with the above figure. Malmstolen is designed to provide the best possible movement variation with the lowest possible static load in order to reduce the risks of musculoskeletal disorders as far as possible. This is the main focus for people who work in computerised environments. We want to make the link in the chain that a chair represents in a workplace as strong as we can.

Malmstolen design

Every component included in Malmstolen has a thought behind it, but as with all technological designs, you have to compromise unfortunately. We may gain one thing, but lose another. Our goal has been to reach a compromise from an overall perspective that gives the chair the best ergonomic benefits. We would perhaps have improved some components more, but then we run the risk of side effects, which brings down the overall value. There are also solutions we could introduce, but these add so much to the cost that very few people are willing to pay for them.

The parts that predominantly affect the body in a chair physically are the backrest and the seat as these elements form the contact surfaces to the body. For this reason we will start by describing them.

Backrest

Malmstolen uses four different systems.

The first two, System Therapod and System Cpod, are both based on the same basic principle. Elastic and, if necessary, adjustable straps are attached to a plastic shell (Therapod) or a plastic frame (Cpod). The basic shape of the shell/ frame and the straps mean the whole backrest surface lies against the user's back. It is dynamically flexible and conforms to the user's personal back profile. In principle we achieve the same as in Example 13 D), that the shape of the backrest is a parallel curve to the spine's natural S-curvature.
This means that the upper body gains support and the weight is distributed over a large area, providing good relief. Upon delivery of a chair, these two adjustable systems are set in a carefully calculated standard position. In this position the backrest conforms itself to suit the shape of the user's back in about 85 % of the cases.
However, let us say that a person has an extra deep lumbar spine and the standard setting is NOT adequate. You then have the possibility to fine-tune the shape of the backrest to fit exactly. All these features are patented.

The straps are elastic for two reasons, one being self-formability, the second is that the backrest support surface is dynamically flexible. If you arch your back for whatever reason, for example if you bend to reach a pen on the desk or the like, your back sinks into the backrest thanks to the elasticity. If you relax, you straighten your body up again. If the backrest had been rigid, we would have pushed the body away from the backrest with the risk of losing the support that can help your back to remain upright.

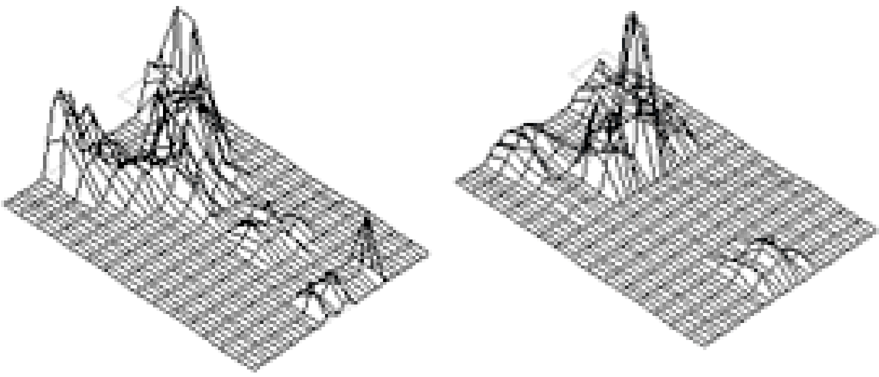
Another feature related to the backrest is that the back post which links the backrest to the rest of the chair is made of spring steel. This means that the chair is never completely statically locked even when you lock the chair's tilt function. This elasticity is a small but important feature for stimulating load variation, motion and blood circulation and nutrient exchange in the spinal disks.

Our third backrest solution, System RelActive, is another system we use. Here it is true you cannot manually adjust the formability, BUT this solution is exceptionally good at adjusting itself. We are confident enough to claim that this system provides almost unsurpassed support and relief, while contributing to good movement dynamics.

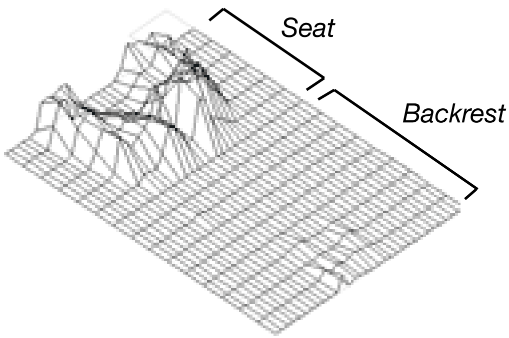
Seat

Malmstolen has two different seats, one with a standard cold foam padding, the second is developed in conjunction with the Swedish bed manufacturer DUX. As the additional cost of a DUX seat is negligible, virtually everyone opts for the more exclusive seat. The simpler variant might be suitable if you are very short and have a low weight.

There are coil springs inside the DUX seat that the manufacturer calls DUX Pascal. We use slightly different hardnesses for this spring system in different parts of the seat thereby ensuring excellent load distribution capabilities.



Pressure measurement chart on Premium chairs from two of the largest manufacturers in The Nordic region. The seat and backrest are indicated in the figure to the right



Malmstolen. The more even the surface, the better the weight distribution.

The differences in the appearance of the above figures depend on the way in which they were sent to us. We have not been able to influence this, but the important thing is to study how these differences are, and how they are distributed.

On both Malmstolen seat models the front is gently rounded. This avoids pressure in the knee folds where there is both a nerve and blood vessel accumulation. This rounding also facilitates the movement of your legs.

LiquiCell is a gel membrane that is standard on the seats of our RelActive and HiActive chairs. It is positioned between the fabric and the foam and further contributes to a good load distribution. However, the main feature is that it reduces the shear force, the "slide-forward force" load on the body when it is folded into a sitting position most noticeable during prolonged sitting.

LIQUICELL®

®LiquiCell is a registered trademark of LiquiCell Technologies Inc.

Malmstolen design in general

Malmstolen has all the adjustment options that an office chair of the highest ergonomic quality should have. It is important to stress that the adjustments are there to be able to customise the chair to suit the specific user and his/her capabilities and limitations, this in addition to that already described on the design and properties of the backrest and seats. For a single user of the chair this usually only occurs once when setting the default when the chair is delivered. If there are multiple users of the same chair, we have a quick solution for that too.

You can achieve some things with simple solutions, but never achieve everything. Individual differences cannot be addressed with general solutions. For this reason we have chosen a solution where you actually adjust the seat individually according to requirements.

The neckrest can be adjusted in height and depth and angle. Support extends to the head/neck. The contact surface is large for good weight distribution. The surface also moulds itself a bit more to the curvature of the user's neck.

The backrest is vertically adjustable. Depending on the chair model, the backrest can be tilt adjusted in various ways.

There are several armrests. They can be easily adjusted vertically and laterally. The advanced cushion can also be adjusted in depth and turned inwards about 25°. The pivotal point is located far back on the cushion under your elbow. This is an important detail. If the pivotal point is located further down the cushion your elbows will rotate outwards affecting the load on the shoulders and other body parts negatively.

The different models have different underframe/mechanisms. Malmstolen uses two types of tilts (described on next page), and a "manual" mechanism.

The seat can be moved depthwise depending on leg length.

The star base is made of recycled aluminium. Available in black lacquer and polished design. The shape allows you to put your feet up on the base as a variation option.

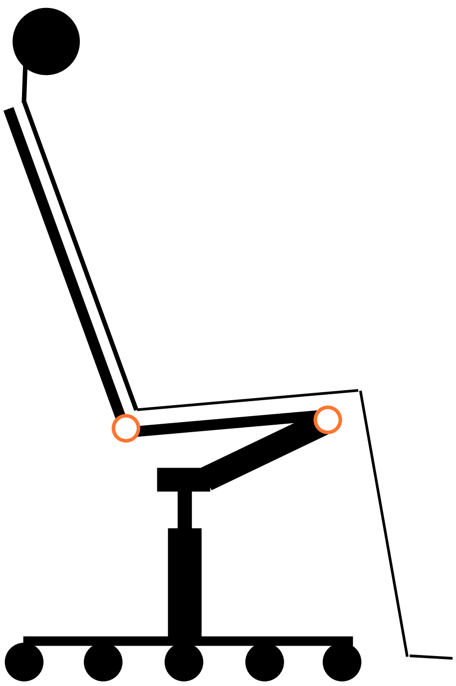
Castors are available in different hardnesses for soft and hard floors.

Why different types of mechanisms/underframe?

The mechanism is the heart or the motor on a chair. This is where the various options and ”central” adjustments are made. When we talk about ergonomic chairs, the importance of the chair being adjustable is emphasised, and that it preferably also has a tilt function. We have put great effort into selecting and, where necessary, modifying the mechanisms that Malmstolen use. WHAT settings do we want, HOW do the different parts move in relation to each other and in terms of tilting, WHAT kind of tilt is necessary to ensure the best characteristics? Crucial factors for us in creating the good ergonomics we are looking for. As previously mentioned, technology is full of compromises, but we have aspired to find the compromise that gives both greater breadth and depth in terms of functionality.

Malmstolen currently uses four different mechanisms:

- ”Knee-tilt” (Malmstolen 4000 and R4)
- ”Syncroglide” (Malmstolen 7000, Cpod and R7)
- ”Manual” (Malmstolen 6000)
- ”Central tilt mechanism” (ONLY for Malmstolen High5)



Knee-tilt

Our two largest body joints are the knee and hip joints. This is the basic reason that we use the tilting mechanism which has its axis of movement as close to our knee joint as possible. The movement joint that controls the backrest inclination is also placed as close to the hip joint as possible. The following outline diagram explains:

When you tilt in a knee tilt mechanism, the whole seat moves in the knee joint. The chair’s joint at the hip joint can only be adjusted manually in order to set the basic angle between the seat and backrest. However, the backrest is suspended on a back post of spring steel, which enables the backrest to bend back slightly when leaning backwards in the chair. In conjunction with the patented elastic backrests, this gives a beneficial effect for movement dynamics in the torso, the hip angle does not become statically locked but remains flexible when you tilt forwards and backwards with the chair.

Syncroglide mechanism:

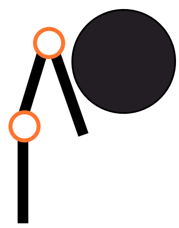
Just as with a knee tilt mechanism, this mechanism also has its axis of movement under the knee joint. In addition the chair also moves at the hip joint when you tilt. This means that it has a different movement pattern compared to a knee tilt. A syncroglide mechanism is essentially a synchronous mechanism, the backrest moves about twice as much backwards as the seat folds down when tilting backwards (ratio about 2:1). However, an important and essential difference is that the syncroglide mechanism also allows the seat to slide in line with the backrest when you tilt backwards. A traditional synchronised chair does not do this, with the result that the backrest loses contact with the back's lower portions when you tilt backwards. To then make contact between the backrest and your back you must now substantially arch your back. With a syncroglide mechanism you have permanent contact with the backrest, which is essential for good ergonomics.

Manual:
This mechanism is our simplest model. It is used on chairs such as workbench chairs with a high gas spring and foot ring. It has no tilt function, but the inclination of the seat can be set manually lifting the relevant control. The adjustment is then made, and you then release the control again and the chair is in the position you selected. The same applies to the angle between the backrest and seat.
Chairs with this mechanism are also used widely in industrial environments for assembly work, etc. In office workplaces, we only recommend this version if the chairs are used for shorter stints. For longer periods, we recommend our tilting mechanisms. However, If you find it difficult to adjust to a chair with a tilt function, this manual mechanism can be an alternative.

Controls
All the mechanisms Malmstolen has chosen have ”master controls” that are controlled by moving them up and down. No ”push-turn-lift-simultaneous-control”! These controls are used for the seats' central functions such as sitting height, tilt and back incline. Other controls for features that are very rarely used, are more concealed to ensure you do not use them by mistake. When a default setting is made, only one lever is usually used, the one for the tilt (lock/unlock). If you have the tilt in a permanently unlocked position, you use no lever at all.

Armrest
With a good desk, the armrests can be redundant, but for those who need or want them, we have several different types to choose from. The most advanced models have height adjustment with a stroke length that is both high enough and low enough to come in under the desk. These particular armrests have a cushion that can be moved depthwise and rotated inwardly about 25°. However, it is important that the point of rotation is far back under the cushion. Otherwise your elbow will rotate out and create loads in the shoulder region.

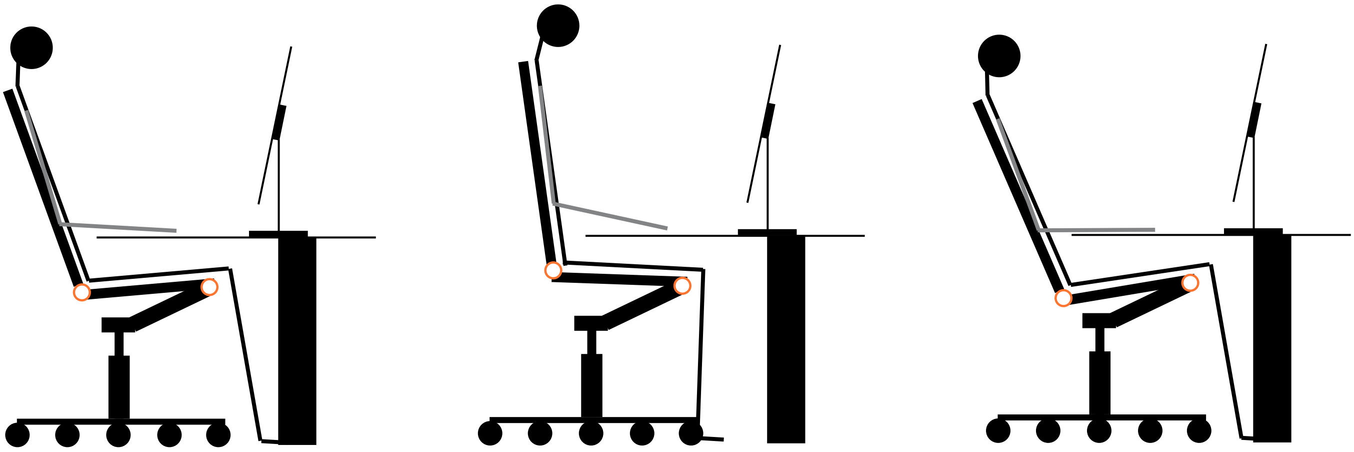
Neckrest
The Malmstolen neckrest is of the “upside down V” model with twin joints, the best technical solution we could find on the market. A simple and effective mechanism that really allows the neckrest to engage your head instead of the other way round.



NOTE: Increases the options for more workable sitting positions with relief to the head/neck.

Explaining more about our chairs with knee tilt and syncroglide tilt

Our tilting mechanisms have their joints, axes of movement, at our body's knee and hip joints. The advantage of this is even clearer when the chairs are to be used in a working environment.



A) B) C)

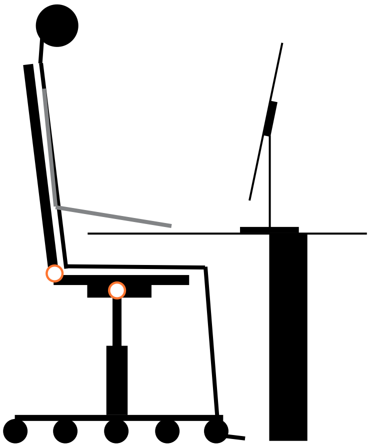
When you tilt forwards/backwards on a chair with a knee tilt or syncroglide mechanism,your backside moves up and down. Your hands, when they are placed as in the sketches, such as a keyboard, only move depthwise, instead of up and down. This is when your hands are also directly above the chair's knee joint. This provides a major advantage. We can sit in both forward and reclined workable sitting positions along with and all positions in between the outermost positions.

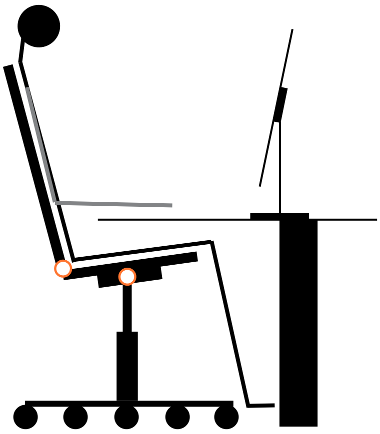
Let us start with A), the slightly reclined position for knee joint chair. You have rolled in the chair so that the desk top is resting lightly against your stomach. Now, if you lean forward towards a more upright position, the desk presses against your stomach and shoulders and is pushed upwards. By rolling out the chair slightly you can compensate for this.

If from A) you lean back, you have to stretch your arms forwards to reach the keyboard. You compensate for this by rolling in the chair towards the desk so that the top presses lightly against your stomach.

By simply rolling the chair forwards/backwards a few centimetres as above and constantly having the desk top that lightly rests against your stomach, you can significantly increase the spectrum of workable sitting positions. You can then also usually ensure good support for your arms from the desk surface. For this to work, the chair/tilt spring resistance must be adjusted to suit the user's body weight so that the chair balances. Otherwise, the chair will feel unstable and most people will lock the tilt mechanism fully. Malmstolen models 4000 and R4, and 7000 and R7 balance body weights of approximately 45-95 kg. Malmstolen Cpod balances body weights of about 70-135 kg.

Why do we NOT use central tilt and "free-float" mechanisms in our traditional chairs?


A)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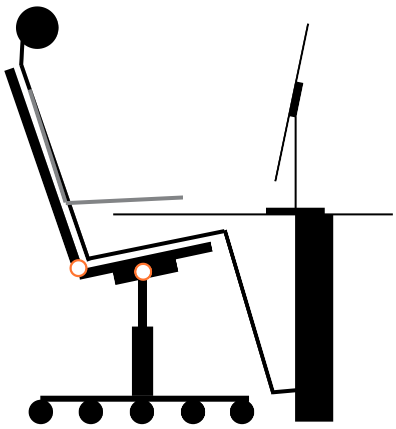
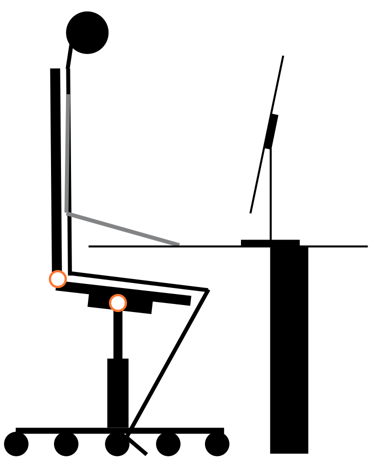
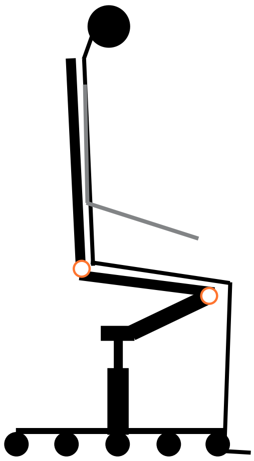
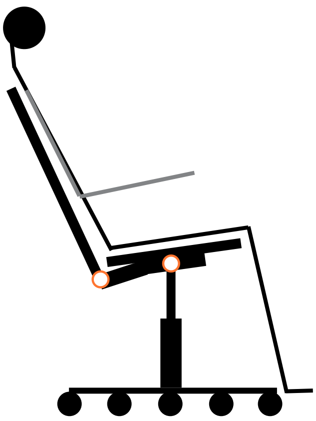
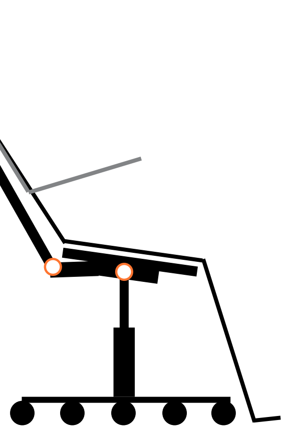

C)


D)

With a CENTRAL TILT, that is where the movement axis is located for the tilt directly under the seat in which as in the sketches above, it is difficult to sit in different positions forwards/backwards without affecting the position of the body/arms/hands in relation to the desk. When you tilt backwards this lifts your hands, whose vertical position you then have to compensate in order to reach the keyboard. If you tilt forwards, you reduce the angle of the elbow instead. This creates levers and load torque that may adversely affect, among other things, your shoulders. Also angles that make it harder for your body to work. What also happens, if we assume that A) is the default setting of the seat height, desk height, etc., is that when you tilt backwards, the front of the seat pushes your legs up so that your feet lose contact with the floor, something that makes many people feel unstable in their chair. You then MUST climb with your feet up on the star base to get support, otherwise the load substantially increases in your body if your feet are dangling in the air. This increases the pressure the thighs and hamstring muscles. This muscle is shortened as the pelvis then wants to fold backwards = the back arches. If a backrest still resists, this creates tension instead in the lumbar region, which propagates upwards.
If we have D), rider position, as a starting position instead of A), we have a higher seat height from the outset which makes this position optimal. If we lean backwards from this position, this "need to climb" increases further. If we have a sitting height lower than A) as a starting position, it will certainly be better if we tilt backwards, but forwards leads to that the "knees reach your ears" to make the description clear. With a central tilt mechanism you can optimise the setting for ONE sitting position, but as soon as we change to the new positions they become much worse than when you do the equivalent with a knee or syncroglide tilt. This limits the variety of workable sitting positions. For this reason, Malmstolen has chosen NOT to use this type of mechanism in its traditional chairs (although we can if we choose to).



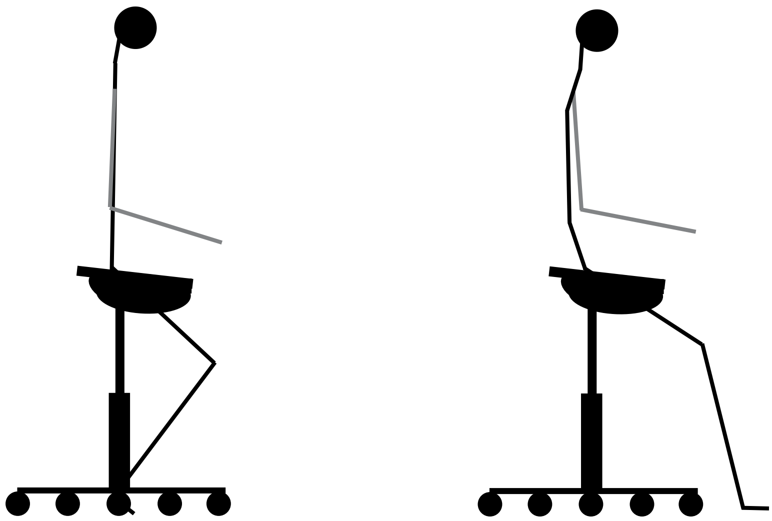

HOWEVER, if we set a knee tilt or syncroglide chair with the rider position as basic position, that is with a higher sitting height in the basic position, the feet will also "dangle in the air" when we tilt backwards. Consequently, the slightly reclined sitting position where you reach down with your feet to the floor is the best starting position to ensure the best possible workable sitting positions with a knee tilt or syncroglide chair.

On a chair with a FREE-FLOAT mechanism, the seat and the backrest move freely and independent of each other. The argument is usually that the body is constantly seeking movement and the chair then follows the movements you make. The reasons why Malmstolen does NOT use this type of mechanism, which we could have done if we had chosen to, are several. Unfortunately, the body usually seeks support and relief because the body is exposed to loads. The movement we are talking about in this type of chair is more of the load-related character. If the body is looking for support and relief and the backrest and seat then give way to follow the movements without the right support being achieved, what have we gained? Instead, the body starts to tension on its own, which means you are likely to increase problems instead of reduce them. We then create even more load-related movements that the chair follows but does not counteract the causes, a kind of Catch 22. This requires good body awareness/control to master this type of sitting. Most people who use this type of tilt usually lock it completely due to the instability you are said to experience.
Some people comment on the importance of being able to stretch the body to virtually a horizontal position as a variation option. The idea is good, but as Malmstolen does

not have this particular function, we recommend that you stand up and maybe walk around for a while instead. This produces better benefits. An almost horizontal position is also much harder to work in.
In some Free-Float chairs, but also some synchronous-chairs, the backrest does not follow far enough forwards. If you want to sit more upright you have no support, as many people wish. If you lean backwards, the backrest usually comes in touch with your lower back and only the shoulder blades are supported, as with most synchronous chairs. Some of the chairs have seats that normally remain in a horizontal position when you have tilted furthest forward, but that can be made to tilt forwards if you actively press against the seat edge. If you relax, the seat moves back to the horizontal position and your back arches unless you tense in an attempt to remain upright, or if you continue to push the seat down in the tilt position.

Sit-stand chairs



Malmstolen has not previously had chairs in the segment known as SIT-STAND CHAIRS. Saddle chairs are a good example of this type of chair. There is an obvious application for this type of chair, primarily at little higher desk heights as with height-adjustable desks. If you have a work task that contains a lot of activity-related motions and movements, this is often a very good solution. However, if the work task is designed more exclusively for a more traditional computer workstation that contains a small number of activity-related motions and movements over a long period (unfortunately, the most common in this environment), a traditional sit-stand chair is perhaps suitable as a complement in order to rest the legs a little. This applies if you have a workplace where you are standing up most of the time. However, if you have a height-adjustable desk, it is generally better to stand properly when you want to stand and sit properly when you need to sit, unless the actual work task has a particularly large movement content.
To sit as close as possible in a balanced position in a sit-stand chair, you have to assume the rider position as per the diagram above left. To sit with your feet in under the seat in an exact position that is required to maintain a sitting position, however, extremely few people can handle any length of time longer than just a few minutes. Virtually the entire body weight is distributed over a limited surface from the seat/saddle if you do not sit and tension your legs and thereby lift your body up a little from the seat. This is likely to be very tiring for most people. In addition, the head's centre of gravity is in front of the spine and when we sit so statically locked, the back and neck muscles

are constantly resisting which means the upper body does not begin to drop and/or fall forwards (see Example 1), which means the balance is not 100 %.
Sitting with your feet in under the chair also reduces stability. This static load and instability usually leads fairly quickly to your feet moving forwards in front of the chair (if you look at those sitting on sit-stand chairs, most have their feet right in front of the chair, right?). You then have three point support - both feet + chair. It is then also much easier to move with the chair than when your feet are directly under the chair. However, when your feet are in front of the chair, it is even harder to keep the body upright without tensing. If you relax as if you were going to fall asleep, you collapse like a sack. If you sit in the correct position, you sit slightly statically, and you switch position, for example, you lean more forwards or backwards generating a lot of tension in the body. In an environment that does NOT contain a lot of activity-related motion and movements, is this actually a good solution?

Malmstolen High5 (System HiActive) – a sit-stand chair that goes a little further

Malmstolen has been studying the phenomenon of sit-stand sitting from a scientific perspective for a long time. So far we have not found any material that scientifically confirms the benefits that are usually put forward, that the body ends up in balance, for example, with the sitting solutions that are available in this segment today. Using the results from what we have identified, we have developed a design solution where we try to utilise the benefits, but compensate for the major load disadvantages associated with this type of sitting. Despite this, under the right circumstances, there are benefits of sit-stand sitting and we want to take advantage of these.
With our sit-stand chair Malmstolen High5, we have therefore taken into account a number of factors, all of which are included in our explanatory model SAAR previously described in this compendium.

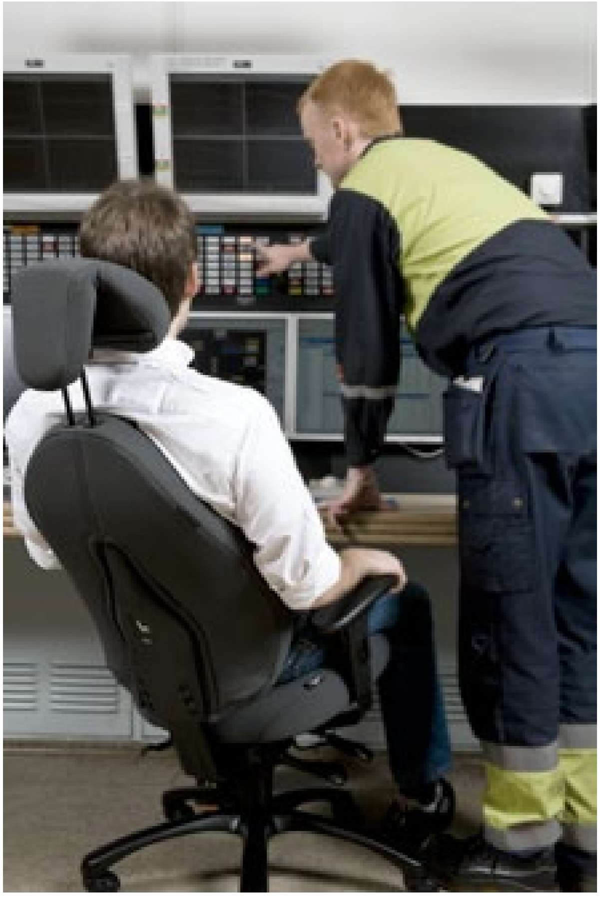
• The chair has a specially adapted high but narrow backrest with a structure that is reminiscent of System RelActive (neckrest is available as an option). This is a very important part of the chair design as the backrest with its structure greatly reduces the static tension in your upper body that sit-stand sitting generates. Your body does not collapse as it might easily do when your body grows tired because of the static loads. The small width also allows excellent mobility. The backrest is vertically adjustable and tiltable.

• With the seat design, or rather the saddle, we have tried to offer the best possible weight distribution between your sitting bones and inner thighs. The front section of the saddle allows you to sit there as well in order to get a more brief rest as a break to standing. The saddle can also be adjusted depthwise in relation to the backrest.

As a result of all the above, we have been more than able to provide ample Support, Relief and Relaxation.

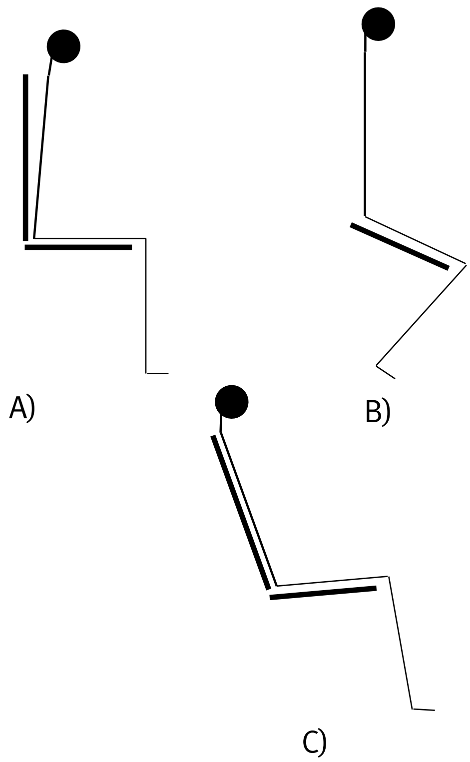
• The chair also has a good mobility, which is very important in this context. Besides, being able to naturally roll it on the floor, it also has a built-in tilt function. The torsion of the tilt is adjustable in relation to the user's weight. We have therefore also met the need for Movement.
As the chair has a very relieving backrest, this now makes it possible to sit in many more sitting positions than just upright, just as with our other chairs. The possibility of variation is thereby increased significantly without the negative static loads needing to increase as they would with a traditional sit-stand chair.

More reasons for a reclined sitting position as the starting point



On previous pages, we have pointed out that the slightly reclined sitting position, where your feet reach the floor, is the starting position which gives the most possibilities for variable sitting. A knee-tilt and syncroglide chair provides the greatest opportunity to succeed (this also works very well on our sit-stand chair Malmstolen High5). We particularly highlight the starting position, as the intention is not to be stuck in this position. There is also the risk that this position becomes static, even if its low load values (with a chair with the right features including a good relieving neckrest, setting and other adaptation of the workplace) mean that the amount of activity-related movements easily outnumber the load-related movements. As mentioned earlier, Malmstolen is designed to provide the best possible movement variation with the lowest possible static load in order to reduce the risk of musculoskeletal disorders as far as possible. It must be possible to work both in an upright sitting position and a reclined position and all the positions in between. This is instead of the chair being optimised exclusively for individual sitting positions where other positions are difficult to assume without the body being exposed to unfavourable loads and/or that there are positions that are not possible to work in. We have, as said previously, put a lot of effort into selecting and adapting mechanisms/ underframes with functions in order to achieve what we are looking for.

Example 14:
If you are to sit in the most comfortable and relaxed position in your chair, whether it be an office chair, TV, sofa or visitor chair, which of the following options is most reminiscent of the position you select (try the chair you are sitting in right now)? Or, if we put the question like this: if you are watching a feature film at the cinema or on television that requires your concentration, which position below comes closest to the one you adopt for the longest time?



The questions we have asked countless times over the years and so far EVERYONE has answered option C), i.e. a slightly reclined position. WHAT is it that makes people prefer this position to others after thousands of years of evolution if any one of the other positions is perceived as being better?
As repeated several times previously, the human body is affected as well as any other masses on our planet by the forces of gravity. When we lean backwards as in the schematic diagram C) above, part of our body weight is placed above the backrest. This relieves the body better, which is basic physics. If we sit for just a few moments, it is not so important how the backrest is designed, but if we sit for longer periods (about 30 minutes or more) the design is all the more important (see Example 14). That the body evidently chooses the more reclined sitting position is because this gives better relief and then it is easier to relax. When we relax, it is easier for blood to circulate in the body and blood circulation is the foundation of the body's functionality. If we throttle the blood flow completely this would soon lead to a drastic end. The body is smart, and ensuring good blood circulation is therefore a key task. Nutrition and oxygen supply around the body works better as does the removal of waste products.

If we make an analogy:
Imagine a waterfall that flows down to a power station. If the water is pumped unobstructed at full power down to the power station, we produce the most energy. WHAT happens if we add a mass such as boulders in the water's course and dig out ditches where the water can run out to the sides? Less water reaches the power station at a lower speed, right? And we then get less energy from the power station...

If we are to concentrate and perform, we must have energy. If we refer to a prolonged period of sitting at a traditional computer workstation, the movement content of the work task in the vast majority of cases is very limited – unfortunately. If we must choose a single sitting position, the slightly reclined position is the one that unequivocally produces the lowest static load in the body. This assumes that the chair is also designed to provide support and relief according to the laws of physics. The static muscle load is lower, along with the disc pressure. The load on the neck muscles is also lower, even more so with a good neckrest. All according to the examples covered in this compendium.

Many argue, however, that a reclined seating position is not possible to work in as we end up too far from the desk. It is only when we are resting or talking on the telephone that this position can be adopted. Using what we have described in the preceding pages, we know that with the right kind of chair design, with the right kind of motion characteristics and the correct positioning of other equipment, it is perfectly acceptable to sit in a reclined position. And vary to adopt other sitting positions. And to stand and walk occasionally.

When we come to the application of Malmstolen, the above represents the basis for the chair's features. By building the chair's movement characteristics based on the slightly reclined position as the default position, we achieve many more workable sitting positions with the lowest possible static load than what we would have had using any other available solution. To date we have not found a technical solution that takes better account of the widest possible perspective in terms of what we want to achieve with our instructional concepts SAAR, Support - Relief - Relaxation - Movement. If we were to find one, we are always open to change.

Some thoughts on sitting

We thought we would conclude with some typical comments about sitting that we have heard over the years.

”***Chairs must be produced and adapted to suit how people actually sit.***”
Why do we sit the way we do? With the chair’s characteristics and settings as well as the layout, characteristics and settings of the rest of the workplace, how does this influence the sitting pattern? Load or activity-related movements? A lot of sitting evidently leads to musculoskeletal disorders. Should we adapt to the symptoms or try to correct the cause of the problem?

If we know that certain sitting leads to problems, should we continue to recommend solutions that advocate this type of sitting or shall we take some extra time to think it through? Using the same logic, do we give a smoker a lighter so that he can continue to light his cigarette despite all the devastating evidence about smoking leading to a wide range of diseases, OR shall we try to get the person to stop smoking and change his lifestyle? If a person is at risk of, or already suffering from, cardiovascular disease, should we encourage factors that contribute to the disease OR should we reduce/remove the threatening factors?

”A chair should not be too comfortable as you will not move in it.”
We should of course not exaggerate, but is there an end into itself in consciously creating problems for the body so that it is forced to perform load-related movements as a defensive measure? Is it better to force a person barefoot on glowing charcoal, which is likely to stimulate both jumping and running, or is running cross-country with good training shoes preferable?

“A chair that is really good, but we only use it for those who have problems, the others will have to use a ’standard chair.”
Is a nutritionally correct diet only for those that already have nutrient deficiency diseases, or is a safety belt in a car only for those who have already crashed?

Summary

Musculoskeletal disorders cost huge sums annually in Sweden. Approximately SEK 50,000/minute of every day, every week, all year round. This according to one estimate from the Center for Musculoskeletal Injury Research. A lot of sitting is a contributing factor to this, and given the extent to which society is dependent on computers, and how this increases the amount we sit still, the costs will continue to rise unless appropriate actions are taken.

Knowledge of physics, technology, biomechanics and physiology is central to understanding the processes that affect the occurrence of musculoskeletal problems. The laws of physics, where Isaac Newton's description of gravity is still just as relevant, are the basis of load theory. The key principles are described in this compendium with simple examples where the answers are likely to be considered by most people as being very logical.

When we understand the principles, and when research is increasingly beginning to understand how our bodies react to purely physiological loads, this is facilitated when preventive/palliative/curative measures are developed. For the person sitting, the chair is of course a key part of his/her existence. What you can do with a chair in this context is central to Malmstolen AB's entire business. Based on the available scientifically accepted knowledge, we try as far as is technically and economically feasible to design chairs that can help reduce the risk of disorders. The chair is certainly key to the person sitting, but the overall work environment also affects the opportunities you have to achieve good results. It is also important that the person sitting uses his/her equipment properly, as also described in this compendium.

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