The Science Of Stress: How To Reduce Back Pain While Sitting

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1. The Context

As a professor of spine biomechanics for over 30 years, we investigated back pain mechanisms in work, sport and leisure activities. I've been asked many times, "what is the best chair for sitting", "What should one do for back pain when sitting".

The answer is always, "It depends". This document will provide a context to address these issues together with some discussion of the science to support the development of several principles to guide convergence on "what is the best chair", "what is the ideal seating posture", and how to reduce the stresses associated with sitting.

2. General Science Related To Sitting

Professor Nachemson's classic work (1966), using intradiscal pressure measurements, documented the higher loads on the discs in various sitting postures compared to the standing posture. Sitting is not an unloaded activity!

Normal sitting causes flexion in the lumbar spine and people, if left alone, generally sit in a variety of flexed postures (Callaghan and McGill, 2001b). Sitting generally involves lower abdominal wall muscle activity (particularly the deep abdominal muscles) compared to standing, and unsupported sitting generally involves higher extensor activity (for sitting; Callaghan and McGill, 2001b).

Sitting slouched minimizes muscle activity and increases load in the spinal discs and passive tissues (Fig.1), whereas sitting more upright requires higher activation of the psoas and the extensors (Juker et al., 1998). Full flexion increases disc annulus stresses; although this posture has produced disc herniations in the lab (e.g., Wilder et al., 1988), substantial simultaneous load was needed. In fact, Kelsey (1975) discovered a specific link between prolonged sitting and the incidence of herniation. But association is not causation. We have not been able to initiate a herniation with sitting postures alone. Rather, the cumulative herniating trauma is most often caused in places such as the gym and as a result of poor lifting form throughout the day. But, once the collagen delaminations caused by exposure to flexion and load in the annulus have been initiated, then sitting adds to the trauma.

Thus, those who cannot tolerate sitting for a period of time have already begun the cumulative trauma cascade. Paradoxically, those who have never stressed their spines usually find sitting comfortable for prolonged periods.

Fig.1: Slouching increases load in the spinal discs and passive tissues

2.1. Discussion Of The Sitting Posture

People are different. There is no ideal sitting posture given the variance in body types, different body segment length proportions, past injury and pain history, to name a few.

The ideal sitting posture is one that continually changes. The following paragraphs give the background as to why this is true.

3. The Science Of Stress

All systems in the body need a level of stress for optimal health. Stress is needed to challenge the system and create adaptations that build a robust and pain-free capacity for life. Too little stress and the system is weak. However, too much stress results in its accumulation at a rate faster than the body can repair itself. Thus, there is a tipping point where stress promotes either regeneration, if below the tipping point, or degeneration, if the tipping point is exceeded.

But stress and applied load have several components. The first is magnitude. One example of this would be the weight of the object you are lifting. Stress and load also have a frequency of application component that results in cumulative load, such as when repeating an activity over and over again. Body tissues will fatigue to injurious levels when the frequency of exposure is too high. Finally, stress and load have a duration component, which is important to interpret health issues associated with a prolonged low level activity such as sitting. Tissues in the body are viscoelastic, meaning that the tissues slowly deform under this constant load. If the applied load and stress remains for a period of time, the deformation continues to accumulate.

The biological variable that determines damage to the tissue is strain. This is the micro deformation that occurs between the cells that make up tissues such as bone, spinal discs, connective tissue, and more. If there is sufficient strain, discomfort is felt, followed by pain and then finally micro disruption.

Consider a benign activity such as laying in bed. If one lays in bed and does not change posture, they experience discomfort. If they still do not change posture, they'll experience pain. And if they still continue to resist posture change, they will experience injury. This would be in the form of a bedsore, for example.

The way the body migrates stress from one tissue to another is through posture change. Posture change disrupts accumulated stress, pain, discomfort, and the possible eventual tissue breakdown. Thus, the ideal sitting posture is one that is variable and changes to migrate stress , so that the accumulated strain never exceeds the tipping point.

The strategies that different people use to change posture can influence discomfort and pain triggers. Transitioning from a slouched to an upright posture is usually accomplished with two approaches. Contrary to common perception, even when sitting upright, the L5/S1 joint is still quite flexed (60% of its neutral-to-full-flexion range, on average; Dunk et al., 2009). When correcting this posture, some choose to lift the rib cage, hinging more at the thoracolumbar region primarily using the thoracic erector spinae. Not surprisingly, this strategy often results in midback discomfort or pain and responds to corrective movement strategies such as the Lewit exercise (shown in chapter 10 of Back Mechanic; McGill, 2015).

Other people instead focus more on flexing the hips, which aligns the spine above it. Comparing the two strategies, Casthanhero, Duarte, and McGill (2014) found roughly equivalent spine loading — thoracic erectors in the rib lift strategy and the psoas and hip flexors in the pelvic tilt strategy. A combination of the two was preferred by most people and resulted in the least spine loading and greatest comfort.

Thus, changing lumbar postures causes a migration of the loads from one tissue to another. Sitting upright relieves pain due to this load migration. Callaghan and McGill (2001b) suggested that no single, ideal sitting posture exists for any length of time.

Rather, a variable posture is recommended to minimize the risk of tissue overload. For example, Snijders, Hermens, and Kleinrensink (2006) suggested that a cross-legged sitting posture stabilizes the sacroiliac joints via passive tensioning of the iliolumbar ligament and piriformis muscle.

The body is designed to bear stress of certain types in certain locations or on specific anatomical parts. For example, if the sitting surface is too soft then the stress is transferred to the soft tissues of the posterior thighs and buttocks. This causes tissue compression ischemia, discomfort, and possibly pain.

The ischial tuberosity (sit bones) of the pelvis are designed to bear the load of sitting but a reasonably stiff surface interface is required. However, when sitting on a surface that is too hard, the point load on these bones will focus the stress on a small area of the ischial tuberosity and create a stress concentration sufficient for discomfort and pain (Fig.2). Sitting posture, the duration of the posture, the softness and cushioning of the sitting surface, and the amount of soft tissue and weight of the person are all variables that modulate this relationship and ultimately the sitting experience.

As a result, frequent posture change, the promotion of comfort, and the avoidance of pain are all aided by a chair that allows for posture change.

Fig.2: Sitting on surface that is too hard will cause stress on the ischial tuberosities (red), resulting in discomfort and pain.

4. The Mechanisms Of Pain And Sitting Health

We have used several setups in the laboratory and clinic to probe the mechanisms of discomfort and pain when sitting. For example, we have used an animal spine model where we can control spine posture, the time spent in that posture, and more, directly measuring the stress concentrations.

There are some people who can sit with impunity – in other words sitting does not cause pain or discomfort. But this is the rare person. In our animal studies, when we create the postures in the spine together with the loads of long duration sitting, we have never created any measurable damage to a spine that does not already have existing damage. But when we survey the population we find that most people have existing mechanical damage to their low back, such that exposure to long duration sitting stress will ultimately create pain.

The most common example of existing damage is in the annulus of the disc. These spine disc joints are not ball and socket joints like a hip joint or a shoulder joint, but rather fall into the category of an adaptable fabric. The discs of the spine are made of collagen fibers held together with a ground substance. These fibers are arranged in layers much like an onion (Fig.3). Bending the spine with no load does not result in any measurable change.

However, when the spine is bent over and over again under load, for example with poor bending technique and combined with flexed sitting, a critical combination of load and bending cycles is reached that passes the tipping point, and the fibers slowly delaminate. This would be akin to taking your shirt between your thumb and finger with two hands and moving your hands back-and-forth in opposition. Eventually, delamination of the threads will occur and a hole will form in the shirt.

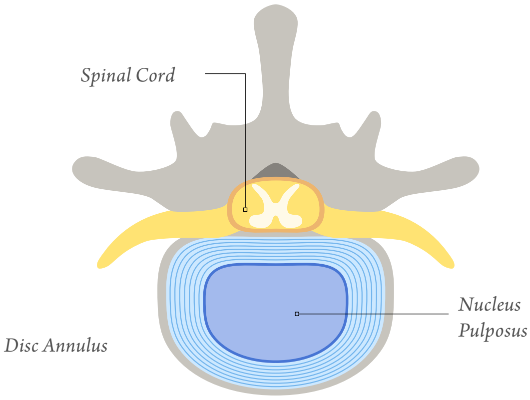

Fig.3: Normal spine disc

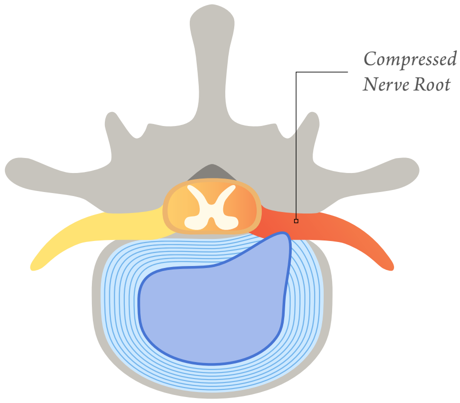

Fig.4 : Herniated disc

The second essential element is that the inside of the disc is a gel known as the nucleus. When exposed to load, the gel is compressed, creating hydraulic pressure that will seep through any delamination of the collagen and leads to a disc bulge (Fig.4). When a person has this pre-existing delamination of the collagen, sitting for a prolonged period of time with flexion bending of the spinal joint can lead to a bulge in the posterior part of the disc.

In many people this causes radiating pain down the legs, and in some people, numb feet and toes. Interestingly, the antidote for this hydraulically driven spine flexion posture mechanism is to provide support to the lumbar spine and de-stress the hydraulic effort in the posterior, or rear part, of the annulus. This is the role of lumbar support in a well-designed chair.

But the science is more involved than this. The discs are hydrophilic, meaning that they suck up fluids at night.

But during the day, gravity and the loads of daily life squeeze the fluids out of the discs. People are tallest when they get out of bed in the morning and then slowly shrink, in some cases even to the magnitude of a couple of centimeters.

In the morning when the discs are fully hydrated, they are a little bit stiffer, and bending forward results in more hydraulic stress with less bend of the spine. People report that when they sit in a chair with lumbar support early in the morning, they don't need much support. But with fluid loss and loss of turgor in the disc as the day progresses, the lordotic curve of their spine increases, so they find comfort with more lumbar support. Therefore, a chair with variable lumbar support facilitates the posture change necessary to ameliorate the natural change in spine mechanics throughout the day.

It is often hard to predict the range of posture change and the nature of the posture change that will reduce the stress concentrations causing pain. At times, the best way is to educate users to employ a variety of movement and posture strategies to reduce discomfort.

The challenge for chair manufacturers is to design for the greatest number of people without over-complicating the chair.

5. What Happens When You Sit For Too Long?

Crossed-Pelvis Syndrome and Gluteal Amnesia

The Czech neurologist Dr. Vladimir Janda proposed the crossed-pelvis syndrome in which those with a history of chronic low back troubles displayed characteristic patterns of what he referred to as weak and tight muscles.
Specifically, he described the features of the crossed-pelvis syndrome (Fig.5) as including a weak gluteal and abdominal wall complex with tight hamstrings and hip flexors. He also developed a technique to correct this aberrant pattern.

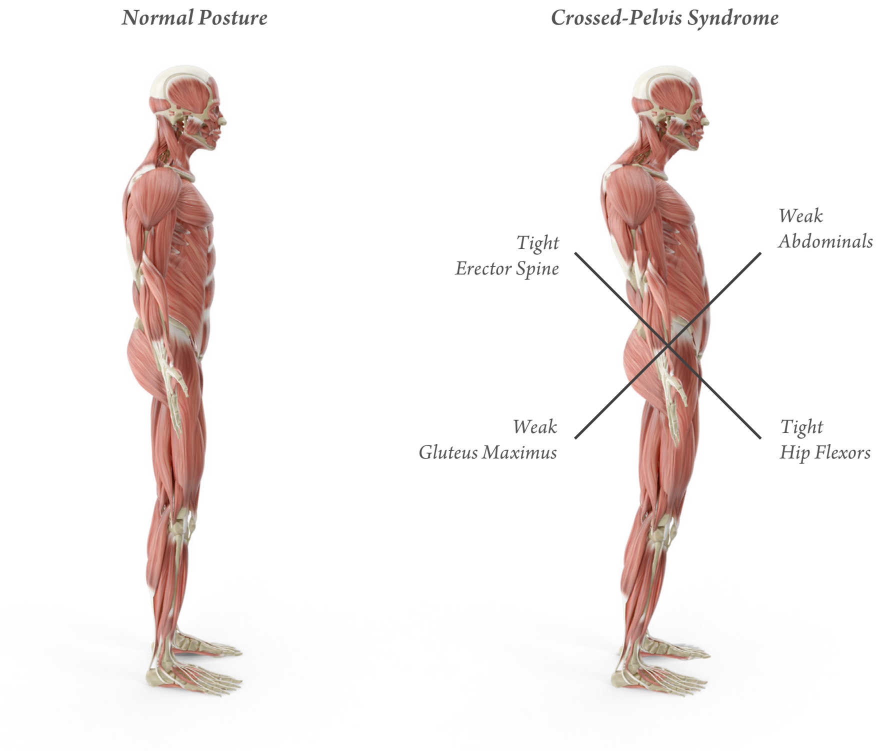

Fig.5 : Crossed-Pelvis Syndrome

Although I have difficulty integrating the terms weak and tight from a scientific point of view, Janda's insights were generally true. Measuring groups of men with chronic back troubles during squatting types of tasks revealed that when they try to accomplish this basic motion and motor pattern of hip extension emphasizing the back extensors and the hamstrings, they appear to have forgotten how to use the gluteal complex. Noticeable restrictions in the hip flexors may or may not be present, but without question the gluteals are not recruited to levels that are necessary to both spare the back and foster better performance.

I refer to this as gluteal amnesia. Our recent work has proven that gluteal inhibition is caused by pain. We induced hip pain with intra-articular pressurization and documented the lower gluteal activation in standardized hip extension tests. Releasing the pressure restored the gluteal activation (Freeman et al., 2013).

It is common for both patients and athletes to arrive at our research clinic with chronic back troubles and a crossed-pelvis overlay. Traditional strength approaches to rehabilitating their backs have failed because strength squat patterns were attempted on aberrant motor patterns. Specifically, the gluteal complex was not able to contribute its share to hip extension, which in turn loaded up the back as the erector spinae crushed the spine. Sparing the back during hip extensor training demands healthy gluteals. Specific training to reprogram gluteal integration is described and demonstrated in part III of my book entitled Back Mechanic.

6. What Makes A Good Chair?

There are many design elements that influence fitment and comfort. For example, the length and width of the seat pan, the height of the seat pan, the stiffness of the seat pan, and the shape of the seat pan all influence this. Personal variables include variance in hip flexibility, which is governed primarily by genetics and training. The combination of personal traits and chair characteristics influence lumbar curve (and stress), and the pitch of the head and neck.

Furthermore, chairs tend to be task specific. There are very good chair designs for work tasks performed at a desk. However, a challenge faced by clinicians is to find a chair that people (clients and patients) can use for multiple tasks, including watching television, gaming, business meetings, and social gatherings. A sofa or similar sitting chair is not an option for many people. They are far too soft and lack sufficient support to allow the stress migrations and distributions critical to achieve comfort and injury resilience. For most people who ask my advice.

7. The Secretlab TITAN Evo

The Secretlab TITAN Evo is a firm chair with adjustable lumbar support, adjustable armrests, and adjustable neck support, to aid in avoiding spine, pelvis, buttock, and leg stress concentrations.

While these are very specific, a self assessment could be created so that the individual could perform the assessment and converge on the best strategy for them. Furthermore, certain spine stabilization exercises have been shown to give people who have pain while sitting enhanced resilience. Users can be coached through a variety of media. If Secretlab is considering broadening their chair package the following may be considered.

8. How To Make Seated Work Less Demanding On The Back

Prolonged sitting is problematic for the back. Unfortunately, this fact seems to be rather unknown in the occupational world. Those recovering from back injuries who return to modified work are often given light duties that involve prolonged sitting.

Such duties are perceived as being easy on the back, but this can be far from the truth. Even though the returning worker states that she cannot tolerate sitting, that in fact she would be more comfortable walking and even lifting, she may be accused of malingering. This is the result of a misunderstanding of sitting mechanics.

Epidemiological evidence presented by Videman, Nurminen, and Troup (1990) documented the increased risk of disc herniation in those who perform sedentary jobs characterized by sitting.

Known mechanical changes associated with the seated posture include the following:

- Increase in intradiscal pressure when compared to standing postures (Nachemson, 1966)
- Increase in posterior annulus strain
- Creep in posterior passive tissues (McGill and Brown, 1992), which decreases anteroposterior
- stiffness and increases shearing movement (Nachemson et al., 1979)
- Posterior migration of the mechanical fulcrum (Wilder et al., 1988), which reduces the mechanical advantage of the extensor musculature (resulting in increased compressive loading)

These changes caused by prolonged sitting have motivated occupational biomechanists attempting to reduce the risk of injury to consider the duration of sitting as a risk factor when designing seated work. A recently proposed guideline suggested a sitting limit of 50 minutes without a break, although this proposal will be tested and evaluated in the future.

9. Reducing Back Trouble During Prolonged Sitting

We have developed a **four-point approach for reducing back troubles** associated with prolonged sitting:

9.1. *Use A Well-Designed Task Chair (In Which I Place The TITAN Evo)*

But use it properly (very few actually do). Many people believe that they should adjust their chair to create the ideal sitting posture. Typically, they adjust the chair so that the hips and knees are bent to 90° and the torso is upright. In fact, this is often shown as the ideal posture in many ergonomic texts. This may be the ideal sitting posture, but for no longer than 10 minutes!

Tissue loads must be migrated from tissue to tissue to minimize the risk of any single tissue accumulating microtrauma. This is accomplished by changing posture. Thus, an ergonomic chair is one that facilitates easy posture changes over a variety of joint angles.

Callaghan and McGill (2001a) documented the range of spine postures that people typically adopt to avoid fatigue. Some have three or four preferred angles. The primary recommendation is to continually change the settings on the chair. Many workers continue to believe that there is a single best posture for sitting and are reluctant to try others. This is, of course, unfortunate, because the ideal sitting posture is a variable one. Many employees need to be educated about how to adjust their chairs and the variety of postures that are possible.

9.2. *Get Out Of The Chair*

There simply is no substitute for getting out of the chair. Some guidelines suggest performing exercise breaks while seated, and some even go as far as to suggest flexing the torso in a stretch.

This is highly problematic. A rest break must consist of the opposite activity to reduce the imposed stressors. Extension relieves posterior annulus stress, but more flexion while seated increases it.

The recommended break that we have developed involves standing from the chair and maintaining a relaxed standing posture for 10 to 20 seconds. At this stage, some may also choose to perform neck rolls and arm windmills to relieve neck and shoulder discomfort from their desk work. The main objective is to buy some time to allow the redistribution of the nucleus and reduce annular stresses. The person then raises their arms over their head and then pushes their hands upward to the ceiling. By inhaling deeply, the person finds that the low back is fully extended. In this way, the person has taken the back through gentle and progressive lumbar extension without having been taught lumbar position awareness or even understanding the concept.

Some will argue that they cannot stand and take a break in their jobs. Instead, they must continue their seated work. These people generally will need to be shown the opportunities for standing. For example, they could choose to stand when the phone rings and speak standing. With these simple examples, they will soon see the opportunities to practice this part of good spine health.

9.3. *Remove Wallet From Back Pocket*

Viggiani and colleagues (2014) documented the point load in the hip capsule and sciatic nerve when sitting on a wallet. Interestingly, some experiments have even used this as an intentional inducer of back pain (Fig.6).

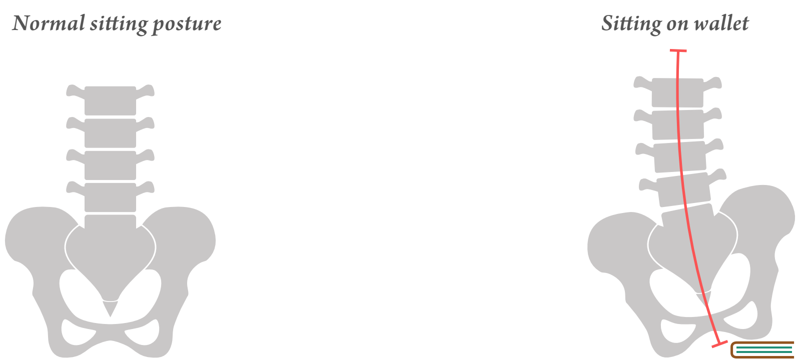

Fig.6 : Sitting on wallet in the back pocket causes bad posture

9.4. *Perform An Exercise Routine At Some Time In The Workday*

Mid-day would be ideal, but first thing in the morning is unwise (see the previous guideline). The so-called ideal sitting posture (90° at the hips, knees, and elbows) described in most ergonomic guides is erroneous. The ideal sitting posture is one that involves a variety of postures.

For example, sitting cross-legged can constitute a break for some. A couple of athletic examples may provide insight as well. Athletes who sit on the bench between plays are often ill-prepared for immediately resuming play (Green et al., 2002). To help combat this problem, they should sit in taller chairs with angulated seat pans to reduce lumbar flexion, and stand and sometimes pace approximately every 20 minutes. In addition, we question the many exercises performed in a seated position, which appear to be for convenience rather than relatedto any scientific rationale.

Here is a good general back routine (see Back Mechanic – backfitpro.com or Amazon; McGill, 2015):

- Hip flexor stretches
- Gluteal activation
- Spine stabilization exercises
- Short walks

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