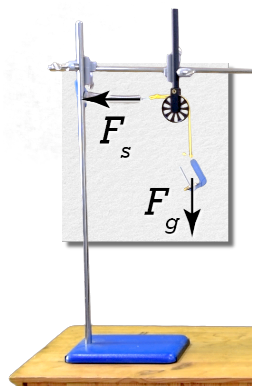
Flipping Physics Lecture Notes:

The Human Spine acts like a Compression Spring

Example: A horizontal spring is attached to a cord, the cord goes over a pulley, and a 0.025 kg mass is attached to the cord. If the spring is stretched by 0.045 m, what is the spring constant of the spring?



Knowns: $m = 0.025kg;\ x = 0.045m;\ k = ?$

Add the free body diagram for all the forces acting horizontally on the spring. Yes, there is a force of gravity acting downward on the center of mass of the spring, however, that will not expand the spring.

Let's define the positive direction as to the right, over the pulley, and down.

$$\sum F_+ = F_g - F_s = ma_+ = m(0) = 0 \Rightarrow F_s = F_g \Rightarrow kx = mg$$

$$\Rightarrow k = \frac{mg}{x} = \frac{(0.025)(9.81)}{0.045} = 5.45 \approx 5.4\frac{N}{m}$$

Note: It rounds to 5.4 not 5.5 beause of the arcane rounding rule. You always round to an even number when the number to be rounded ends in a perfect 5.

Previously, with the same spring oriented **vertically**, we determined the spring constant to be $4.1\frac{N}{m}$.

Why do we get two different spring constants if we take measurements vertically vs. horizontally?
It is because the force of gravity acting down on the center of mass of the spring, along with the corresponding force of tension holding the spring up, expands the spring when it hangs vertically. Notice the natural length of the spring changes based on orientation:

$L_{vertical} = 5.4cm$ & $L_{horizontal} = 5.3cm$ (expansion spring)

This spring is an expansion spring and therefore has a longer vertical length than horizontal length.
A compression spring shows the reverse.

$L_{vertical} = 6.1cm$ & $L_{horizontal} = 6.2cm$ (compression spring)

This is because the force of gravity acting downward on the center of mass of a compression spring, along with the force normal acting upward on the compression spring, compress the spring when it is vertical.

This same thing happens to humans because our spine acts much like a compression spring.♥ Our vertical height when standing is smaller than our horizontal length when lying down. For example:

Mr.p's vertical height = 171.6 mm & Mr.p's horizontal length = 172.5 mm

When humans stand, the intervertebral disks, which are layers of squishy cartilage between the vertebrae of our spine, get squished slightly. These intervertebral "(d)iscs function like coiled springs."♣ This decreases our height when standing and, in fact, our height decreases the longer we stand. That means you are taller when you get out of bed in the morning than when you get in bed at night. And while you are sleeping, your spine slowly expands to make you taller.

This is also why astronauts get taller in space. They still have a force of gravity acting on them; however, there is no corresponding force normal to compress their spines. In space, humans can grow up to 3% taller, that means a 6-foot tall astronaut can gain as much as 2 inches in height. When they return back to Earth, however, they shrink back to their usual height.♠ I will also point out that there could be deleterious health effects caused by the spinal expansion and compression that are currently being studied.

♥ https://www.ncbi.nlm.nih.gov/pubmed/6600017?dopt=Abstract
♣ https://www.mayfieldclinic.com/PE-AnatSpine.htm
♠ https://www.scientificamerican.com/article/astronauts-get-taller-in-space/