An excerpt from **Congruent Exercise: How to Make Weight Training Easier on Your Joints**
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The Squat, the Leg Press, and Your Spine

The absolute first priority for anyone training with weights should be to avoid a catastrophic injury. That should be obvious, but consider the following:

- In 2002, Flex magazine reported on a competitive bodybuilder, performing a barbell squat with 675 pounds for a photo shoot. As he bent his knees, he lost control of the descent, landing on his knees, then falling backwards with the weight. His quadriceps and patellar ligaments were torn, resulting in multiple surgeries, months of rehab, and putting his ability to walk at risk.
- In 2003, Club Industry magazine reported on a lawsuit brought by a man using a Smith machine for squats. He wasn't able to control the descent of the bar, the machine did not have bottom stops, and so his spine was crushed between the bar and the floor, leaving him quadriplegic.

These and other weight training incidents, which involve a range of trainees from guys working out at home and in commercial gyms to high level athletes, are always reported as tragic, freak accidents. And it is tragic that these people suffered life-altering injuries doing something that was supposed to be life-enhancing, and that clearly they weren't intending on getting injured, so in that sense, these are accidents.

But what is especially tragic is that even though these are standard exercises, the injuries they could cause are predictable and preventable. An analysis of even the most fundamental biomechanics suggests that the "freak" occurrence is when you push these exercises hard and *don't* get hurt.

The Barbell Squat is widely considered the "King Of Exercises", used by bodybuilders, powerlifters, athletes, and general gym tough guys. Most of whom regard the leg press as a poor substitute, reserved for beginners, rehabilitation, and your generally-less-than-serious trainee.

Using the current buzzword, the Squat is considered more "Functional" than the Leg Press. So, the Squat must load the human body in a way that best matches the structures of the body, and the Leg Press doesn't, right?

Not so fast.

The bones and muscles below the waist

Take a look at the human skeleton, starting with the pelvis.

The pelvis itself is a pretty solid block of few bones. It sits on top of the femurs, thick solid beams of bone. Below the femurs are the tibia and fibula, not as thick as the femurs, but still solid shafts, both of which with the foot form a tripod to support the standing body.

As far as muscles, we see big, superficial muscles connecting the pelvis to the femur and lower leg. On the back side, the gluteus maximus connects the pelvis to the femur (one big muscle). The hamstrings (3 muscles) connect pelvis and femur to the lower leg. On the front side, the quadriceps (four heads of muscle, merging into one attachment)) connect the pelvis and femur to the lower leg.

Below the waist, in short, we have big muscles and bones, with few attachments, pulling in few directions. While there are numerous deeper muscles around the joints, their function is to stabilize the joints, so the bigger muscles can drive the limbs with force and over a greater range around the joint.

The bones and muscles above the waist

Starting at the pelvis and looking towards the head, we see three sections of vertebrae: 5 lumbar**,** 12 thoracic, and 7 cervical. The size and shape of each is related to their function. The lumbar are the biggest and strongest of the column with interlocking processes, preventing rotation. This stability is to support the weight of the entire upper body.

Next up is the thoracic. The lower vertabrae are about the same size as the lumbar, but each next, higher vertebrae gets smaller, as each supports less weight. Each thoracic is not as locked in to the next, as the lumbar

are, which allows for rotation. We need more general mobility in the thoracic, compared to the lumbar, because this is also where the ribs attach, which have to accommodate breathing.

The top section of the spine, the cervical, has the smallest vertebrae with the least amount of interlock. These only have to support the weight of the head, and require the most mobility (as a unit) of the three regions.

Generally, the overall organization of the bones of the spine is a pyramid: stronger and thicker at the bottom, supporting less weight towards the top. Let's look next at the muscles around the spine, moving from deepest to most superficial.

The deepest layer are the rotatores, each of which connect each vertebrae to the next adjacent, running almost horizontally. Visually, these are stacked from top to bottom, and each individual muscle is very short. Next are the multifidis, which connect each vertebrae diagonally to the next; also stacked top to bottom, and individually not as short as the rotatores. Each individual muscle in these sets of muscles only connects one vertabra to the next. The shortness of these muscles suggests that their function is not so much to twist the spine, as it is to hold the spine steady and prevent twisting of the spine.

The most superficial layers, the semispinalis and the erector spinae, are individually longer, and connect over more than the next vertebrae. Part of the semispinalis connects the head to different points in the thoracic; part of it connects the neck to different parts of the thoracic; and part of it connects the upper portion of the thoracic to the lower portion. Parts of the erector spinae connect the pelvis and thoracic to higher points on the thoracic and cervical spine. These sets of muscles, which can contract over a greater distance, seem more suited to moving the spine (although the functions probably don't break up that neatly).

Compare the structure above the pelvis with that below.

The system below the pelvis provides for speed and power: big, superficial muscles pull on few, solid beams of bone, moving through large ranges of motion, in few directions. Above the pelvis, there's no muscle match for the glutes or quads; and even if there were, the spine isn't a beam like the femur. With the spine, many muscles only have to hold or move slightly, the next vertebrae. This system provides stability, with mobility, for the overall spine.

What does this suggest about putting a barbell across your shoulders?

With bodyweight alone, the muscles and joints of the spine are fully capable of holding the torso and head steady, while the bigger muscles (glutes, quads, and hams) move the legs and propel the upper body. In this example, the spine does function as a "column". Manual laborers have known this for years: "Lift with your legs, not your back", means "hold your spine steady, while you bend at your hips and knees".

Put a barbell across your shoulders, however, and the situation changes. Now, instead of a decreasing load from pelvis to head, we have dramatically reversed the load: even just a bar at shoulder level is significantly greater than the weight of the head. Neither the muscles nor the vertebrae are structured to support this: the closer the vertebrae are to the head, the smaller they are; and that there is no single mass of muscle connecting the lower vertebrae to the head and neck. The same weight that is appropriate to challenge the glutes and quads, working through the largest, strongest bones and muscles in the body, also has to be supported by the dozens of smaller muscles around each individual vertabrae.

Practically, if you squat with a barbell, your back muscles will get stronger, up to a point. But the spine also has discs and nerves that are being loaded with the bar on your back, which doesn't apply to the femur. As the glutes and quads get stronger and need more weight to challenge them, your back is taking on more strain in a variety of ways. The fact that you got through today's squat workout, or a year's worth, or a career's worth, is irrelevant; just because you avoided an immediate, acute injury, doesn't mean the cumulative strain is erased. "I've done this exercise for years and never had a problem"…yet.

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Tips for a safer barbell squat

If your tool of choice is the barbell, whether by necessity or preference, the first thing you have to do is avoid the immediate injury. You may still be subject to overuse over time, and you may still get hurt with the precautions in place, but probably not with permanent, life-altering injuries.

1. **Center the bar, and always use collars.** Deep muscles make small adjustments for centering and balance. Extending the weight laterally makes excessive demands on them, that will probably never come up in any other context, and is too risky.
2. **Use structural barriers to avoid being pinned by the barbell**. Horizontal rails should be sturdy enough and set high enough to keep the bar off you. If you use a smith machine, the bottom stops must be set no lower than the sticking point; don't rely on the hooks.
3. **Ideally use 3 human spotters who are paying attention**. One at each end of the barbell, to catch and lift it off you, and a center one to steer, either the barbell or you out of the way.
4. **Stay tight at the end of the set**. Even with locked knees, you can still make the weight "heavier" by accidentally creating new moment arms by slouching, which would risk straining the deep muscles and worse. Maintain your posture until the bar is placed in the supports.

Of course, the most direct way to avoid injury with a barbell is:

5. **Don't put a barbell over your spine, face, jaw, and throat.** If you're open to the idea, that is.

Tips for a safer leg press

1. **Don't go so deep you round the back**. The curves in your spine are there for a reason. With normal curves, even though the overall spine is curved, the discs between vertebrae are flat. Bend or flatten a curve, and the disks get pinched on one side and bulge on the other. Over time, this can lead to problems.
2. **Use a structural stop at the bottom.** Either set the seat on a machine or stops on a plate loader so you have enough room at the bottom.
3. **Don't buckle the knees under the weight**. This potentially allows the quads to rest, which means the joint is supporting the weight, not the muscles.
4. **"Teacup in a saucer, not a shot glass".** With machines, try to hear the slightest "ping", not a crash, at the weight stack between reps.
5. **Support the lumbar curve.** Ideally, use a seat back with the lumbar curves built in (eg. Nautilus Nitro Leg Press). The Nitro doesn't have a seat height adjustment, so either fit your back into the curves leaving a couple inches between you and the seat, or use pads to raise up. For other leg presses, a lumbar pillow could be used.

For many people, even if the barbell was capable of delivering unique, phenomenal benefits, the risk simply isn't worth it. There are other, effective ways of working the same muscles, and safer, more appropriate ways of using the spine than with the barbell squat. The barbell is a perfectly adequate tool, especially compared to what was available before it, but it's not magic or super-science.

Gym lore and muscle media have created an aura around certain exercises and approaches that isn't necessarily supported by basic biomechanics. Spines don't change (at least not in a good way) based on your goal; they are always going to be safer with lighter weight towards the top, and at holding posture and preventing changes to posture, compared to lifting and supporting top heavy loads. Whether you are a bodybuilder, mixed martial artist, competitive athlete, or just staying in shape, it won't help if your exercises are "functional" and your back is not.

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