Importance of Chair Designs That Support the Lower Back

The act of sitting can place many stresses on the body. A healthy posture—when the spine is properly aligned—promotes greater overall comfort, including improved concentration and endurance through long hours of seated task work. Recent research studies examine the seated human body at work and explore how chairs can enable office workers to sit more comfortably and naturally.

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Clerical workers stood on the job until around the middle of the 19th century. When employers concluded that their workers might be more productive in a seated position, people began to sit at the office.1, 2

Studies in the late '80s found that professional-level office workers spend about 70 percent of their time sitting in their offices, usually for 45 minutes at a stretch. Deskbound workers such as telephone operators, telemarketers and data entry workers spend nearly 100 percent of their working time sitting.3

Begin With the Body
Sitting is a mechanical interaction between six important body elements: vertebrae, pelvis, discs between the vertebrae, muscles and skin. The mechanical act of sitting is controlled by a complex interaction between the skeletal system and the soft-tissue structures. The primary skeletal structures influencing the mechanics of posture are the spinal column and the pelvis. The soft-tissue structures are the intravertebral discs, muscles, ligaments and tendons.

Vertebrae
The intricate stack of 24 vertebral bones called the spine or spinal column is one of the most important structures in the body when it comes to seating. Assuming a standing or upright-seated posture, the sequence of 24 vertebrae subtly forms three natural curvatures. Beginning at the top of the spinal column, the cervical region (neck) consists of seven vertebrae that produce a forward spinal curvature known as a lordosis. Next, the thoracic region (mid back) consists of 12 vertebrae that provide a rearward spinal curvature or kyphosis. At the bottom of the spinal column, the lumbar region (low back) consisting of five vertebrae promotes another forward spinal curvature or lordosis.

Pelvis, Sacrum and Ischial Tuberosities
The base of the spine is called the sacrum. It is a large, triangular fusion of five vertebrae wedged between two pelvic bones called the ilia. Together, these three bones are known as the pelvic girdle. The two primary bones of the pelvis that we sit on are called ischial tuberosities. The pelvis can rotate forward or backward, changing the curvature of the lumbar region (lower back).

Intervertebral Discs
The intervertebral discs are tough lozenges of fibrous cartilage with a thick fluid in the center. They separate the broad center plates of the vertebrae from each other and give the spine flexibility and cushioning. In addition to the main discs between the vertebral plates, thinner layers of cartilage cushion the smaller weight-bearing lateral joints (facets) between vertebrae. The disc cores are living; in adult humans they obtain nutrients by filtration through the disc walls.

Muscles
Muscles of all shapes and sizes surround the spine. The strong, thick layers of muscles along the outside of the spine keep an unsupported torso upright by contracting, the way a tight guy rope keeps a tent pole upright.

Ligaments
Ligaments are tough, inelastic connective tissue binding bone to bone (as opposed to tendons, which connect muscle to bone). A web of ligaments holds the spinal column together and attaches the spine to the pelvis. Ligaments, like other tissues, are subject to fatigue.

Skin and Tissues
The skin and other tissues (muscle, fat, blood vessels and nerves) of the buttocks, thighs and back need a constant flow of blood to stay healthy. Too much external pressure for long periods can reduce the blood flow and cause other kinds of damage, ranging from wringing fluids out of cells to impeding the transmission of nerve signals.

How the Body Sits
The act of sitting down from a standing posture begins with a slightly forward lean (to keep the body balanced) and a bending of hips and knees. The long thigh bones (femurs) rotate in their pelvic sockets, while the strong ligaments attaching the femurs to the pelvis pull on the rear of the pelvis, rotating it back. About 65 percent of the total change of angle takes place in the hip joint; the rest happens mainly through pelvis rotation.4,5,6

The backward rotation of the pelvis pulls the lower back into a straighter shape. Most of the shape change happens in the first three or four vertebrae above the pelvis, although six or seven vertebrae in all are involved.7 In the process, the front edges of the vertebrae squeeze closer together while the back edges spread apart, putting great pressure on the front portions of the intervertebral discs.

The straightening of the lower back moves the spine a few centimeters away from the upper body's balance center, or center of gravity. Where the torso was once nearly balanced over this inward curve of the spine, it is now markedly front-heavy in relationship to the straightened curve of the spine.8,9 To keep the torso from slumping forward, the lower back muscles on the outside of the spine contract strongly and steadily.10,11

The discs, already stressed by being pinched at their front edges, are further compressed by the muscle contractions. Fluid seeps out slowly from the discs, flattening them slightly over the course of the day. Flattened discs make the cartilage-cushioned vertebral facets bear more weight and may also put some pressure on the nerves emerging from between the vertebrae. Sitting with a flattened lumbar spine (kyphosis) can put two to three times more pressure on the intervertebral discs than sitting in a way that maintains the lumbar spine's natural curve (lordosis).

The lower back muscles are not the only ones at work. Because unsupported sitting is unstable, even a body that seems to be sitting still moves continually and imperceptibly, making tiny rocking movements over the ischial tuberosities.12,13

At the same time, the skin and muscles under the ischial tuberosities are compressed. The large buttock muscles, the gluteus maximi, slide aside, leaving the ischial tuberosities resting on a cushion of fat and skin. Blood flow and the filtering of nutrients and waste products to and from the disc cores are inhibited. Even well-constructed chairs create localized pressures capable of stopping blood flow.

After a period of time in one position, the muscles in the lower back become fatigued and the sitter tends to relax them in favor of letting the ligaments help hold the torso upright.14,15,16 If there is no postural support to keep the lower back in a lordotic position and the torso upright, the person tends to slump down and forward, causing an outward-curving shape in the lower back, stretching ligaments and further increasing compression of the discs.

Simultaneously, the head comes forward, forcing the muscles at the back of the neck to work to keep the head in its original position.17 Muscle tension at the back of the neck may increase as much as 50 percent when a person changes from an upright to a slumped sitting posture.

When Body Meets Chair

If a chair provides lumbar or pelvic support, the lower back muscles relax with less downward and forward slumping of the torso. The backrest can keep the lower back in a lordotic shape. Further, pelvic support can fill the space that exists between the lower back and the seat back. If the backrest is reclined, the discs also get some relief, sharing with the backrest the job of holding up the torso. A more balanced alignment shifts the primary weight-bearing role of the upper torso to the skeletal structure and, as a result, muscles are far less stressed.

Overall, the act of sitting can place many stresses on the body. The most obvious ergonomic risk factors are the compressive forces experienced by the discs and the sustained static exertions maintained by the back muscles. This may explain why people who sit all day have about as much lower back pain as people who spend most of their time in a standing position.18 In fact, the more we sit, the higher our risk of herniated discs and other back troubles.19

As part of a recent study, researchers observed and cataloged movements of 40 office workers in their work stations for a combined total of 160 hours (above). As a group, these workers spent 93 percent of their time sitting in an office chair.20

For the purposes of studying the seated human body at work, ergonomists have identified three postures based on the location of the body's center of mass: reclining, upright and forward leaning. Because the reclined position was often observed to be the preferred posture among people seated at work, even for early users of VDTs and personal computers, work chair designers have focused their efforts on creating backrests that provide appropriately placed support and tilt mechanisms that maintain support as the sitter moves through various postures.21

However, the same study of seated behaviors suggests that as a greater percentage of office work tasks are performed on the computer, people are spending a smaller percentage of time in the reclined postures that were traditionally preferred for activities such as telephoning, reading from hard copy, conversation and even continuous keyboarding. This study found that people performing computer-related tasks used upright or forward leaning postures nearly 75 percent of the time.22

The finding is significant because each of the three postures affects the shape of the lumbar spine, or lower back, differently. Because the pelvis is rigidly attached to the sacrum, and the sacrum is fixed to the lumbar spine, any rotation of the pelvis influences the shape of the lumbar spine. Any condition that produces a change in one of the spinal curvatures will cause compensatory changes in the other curves to maintain balance and conserve muscular energy. In addition to being the location of the body's center of mass, the pelvis serves as the attachment point for 20 major muscle groups that function to initiate movement and to counterbalance gravitational forces in both the upper and lower body.23,24

When a person moves from a standing to a seated position, the pelvis tends to rotate backward, causing the lumbar spine to flatten from its natural lordotic (inwardly curved) shape or even to assume a kyphotic or outward curve, resulting in increased pressure on the intervertabral discs and increased muscle activity as the body attempts to restore balance. This results in increased fatigue and discomfort for the sitter over the course of the workday.25

Research has shown that, in reclined postures, adding lumbar support and increasing the angle between the seat and backrest of a chair allows for a natural forward rotation of the pelvis, which reduces disc pressure and muscle activity in the lower back. However, the effect of lumbar support is much reduced when the sitter is in an upright or forward-leaning posture.26

Support the Pelvis

For years, experts in design, ergonomics and medicine have recognized the importance of seating design that controls the rearward tilt of the pelvis. Recent research found that the addition of a wedge-shaped "pelvic support" just behind the ischia stops the rearward rotation of the pelvis in upright postures and prevents the unnatural flattening or kyphotic curving of the lumbar spine.

However, experimentation with different degrees of inclination in the wedge supports found that those that could control pelvic rotation (20 to 30 degrees of incline) led to discomfort and soreness when placed on the seat just behind the ischia. In addition, one person's natural lordotic curve differs from another's, so the amount of pelvic support required to maintain individual spinal alignment varies.27

If there is not sufficient support, the pelvis will rotate backward and flatten the lumbar spine. If there is too much support, the pelvis may be forced to tilt too far forward, creating extreme lumbar lordosis that causes the thoracic and cervical spine to compensate with extreme curves to maintain balance. The result of such a forced posture is increased muscle activity and disc pressure leading to fatigue and discomfort.

Many work chair designs have attempted to control rearward pelvic tilt by lowering the lumbar support to the pelvic level or by providing support for the ilia bones of the pelvis. But these solutions leave an open void between the backrest and the sitter's lower back. This failure to provide evenly distributed support across the entire, contoured surface of the sacral-pelvic region leaves the base of the spine unsupported.

Although the location of the lumbar spine varies greatly from person to person—as much as four inches or +/- two inches—there is little variation (+/- 5/8 inch) among the adult population in the height and width of the sacral-pelvic anatomy.28, 29 This fact has allowed the design of a single-sized back support, shaped to fit the contours of the sacral-pelvic area that adjusts to fill the void between the contours of the sacral-pelvic area and the backrest.

This improved contact and support helps to sustain the forward tilt of the pelvis, which restores natural spinal curvatures to improve posture and muscle balance, thereby reducing fatigue and increasing endurance. Simultaneously supporting the sacrum and the ilia improves surface load distribution across the lower back to provide comfortable, contoured support.

Ergonomics experts reviewed prototypes of the technology designed to achieve this simultaneous support at different points of development to validate the effectiveness of the concept. Technicians also conducted a series of laboratory tests to measure the effect of the support on pelvic rotation and lumbar flexion. They used a coordinate-measurement machine to locate and measure the distance between 15 body landmarks in test subjects sitting in chairs equipped with the technology.

Individual measurements taken from a typical test subject show that a fully engaged device holds the pelvis at an angle 7.2 degrees forward of its location in a chair without such a device or lumbar support and 4.2 degrees forward of its location in a chair equipped with lumbar support alone. Lumbar flexion, a dimension that measures lumbar lordosis, improved 5.5 degrees when subjects sat in a chair with the device compared to the chair with lumbar support alone.30

Combine Pelvic and Lumbar Support

Research confirms that slouching and similar seated postures can cause backaches, headaches, fatigue and poor concentration. A healthy posture—when the spine is properly aligned—promotes greater overall comfort, including improved concentration and endurance through long hours of seated task work.

Good posture balances your body weight on your skeletal structure, as nature intended. This reduces the workload on your muscles, enhances blood circulation throughout the body and relieves pressure on the diaphragm, which improves your breathing and helps prevent fatigue.

When a person slouches, his or her spine goes out of alignment and muscles must work overtime to make up for the lack of skeletal support. That is, they have to hold up the extra weight that is not supported by the skeleton. In addition to wear and tear on the muscles, this also stresses the body's other soft tissues, specifically the ligaments and tendons.

In addition, poor posture places more pressure on the lower back, notably the discs that make up the spinal column. This condition results in the backaches, headaches, and other uncomfortable symptoms that many seated workers experience, and can lead to more serious and chronic lower back problems.

For years, the lumbar-control concept defined the standard for back support in a work chair. Lumbar support alone cannot naturally restore spinal curvatures in a body that is seated in an upright position, especially as people are more likely to sit in upright or forward-leaning postures than to recline while working at the computer.

Because the pelvis serves as the body's center of mass and the primary attachment location for muscles that move the upper and lower body, its rotation into a rearward position causes the body to work to restore balance at the cost of muscle fatigue and discomfort. Filling the void between the lower back and the back of the chair with custom-fitted support addresses the source of many back-problem symptoms—an unaligned spine—rather than the symptoms themselves.

An effective work chair certainly must provide lumbar support. However, recent research indicates that it is more important to provide pelvic support to preserve natural spinal alignment, even in upright postures. A device that stabilizes the sacral-pelvic area of the back to sustain the forward pelvic tilt promotes natural spinal curvatures and muscle balance comfortably and naturally.

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