Supporting the Spine When Seated

THE SCIENCE AND RESEARCH BEHIND THE MIRRA® 2 CHAIR

The human spine is dynamic and requires dynamic support during seated periods. The four regions of the spine have unique attributes and requirements; a good work chair should address those unique requirements. A work chair should also provide proper support for variations in spinal anatomy.

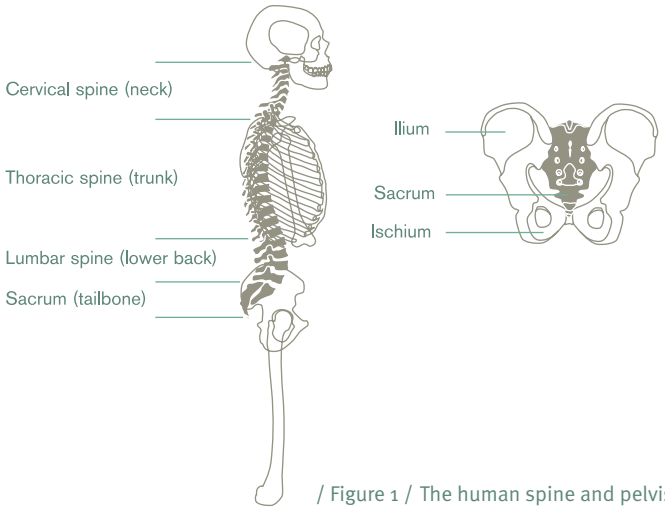
What We Know

Despite the fact that all human spines contain the same set of parts, the sizes and relationships among those parts vary. Over the years, we've discovered much about the differences and nuances of human spines.

Herman Miller was one of 40 industry partners participating in the CAESAR® (Civilian American and European Surface Anthropometry Resource) survey, the first large-scale, three-dimensional anthropometric survey of civilians in the United States., the Netherlands, and Italy (the latter two are the anthropometrically largest and smallest populations in Europe). Prior to the CAESAR survey, anthropometric data was often based exclusively on a fairly homogenous test group—military personnel—and provided linear measurements only, such as lengths and circumferences. Because of the measurement techniques and population of subjects, the CAESAR survey results present a more comprehensive and realistic database of anthropometric information than previous surveys.

Through the CAESAR data, we have gained valuable knowledge about the diversity in shape and size of the civilian population. Moreover, CAESAR has provided us information about differences in body proportions, including the spine, and not just differences in weights and heights.

A brief anatomy lesson sheds light on the ways the Mirra 2 chair addresses spinal variations. / See Figure 1 /

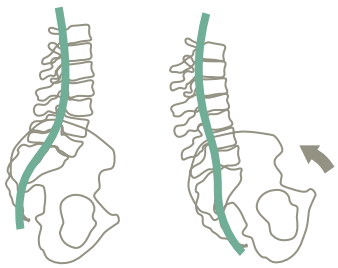


/ Figure 1 / The human spine and pelvis

The cervical region is in the neck area of the spine, from the skull to the shoulders. It is highly flexible and strong. The neck balances and supports the head, which weighs about eight pounds (3.63 kilograms). The thoracic region is the upper and middle parts of the spine. Because it is connected to the rib cage, the thoracic region has very little mobility. The lumbar is the region of the lower back that contains only five lumbar vertebrae, though they are the largest vertebrae in the spinal column. The lumbar region is capable of a great deal of movement. Below the lumbar area lies the sacrum, made up of five fused vertebrae held between the pelvic bones on each side.

When properly aligned and balanced, the thoracic spine region has a kyphotic curve, which is slightly convex, or outward. The cervical and lumbar spine regions have a lordotic curve, which is slightly concave or inward. Together, these 12 outwardly curved vertebrae and 12 inwardly curved vertebrae give the spine its "S" shape, essential to a healthy and strong back. They create the balance and the shock absorbers for the movements of the body.

These natural curves need to be supported and maintained to keep the back and spine relaxed and free of pain and pressure. They must also be supported as they change shape when the body moves. When a person moves from standing to sitting, the top of the pelvis tends to rotate backward, and the lumbar curve flattens or even moves into a kyphotic curve. Further, the pelvis dictates the curve of the spine in all seated postures. When the pelvis rotates out of its natural forward curve into a rearward position, pressure increases on the intervetrabral discs. / See Figure 2 / Also, muscle activity increases as the body attempts to restore balance lost when the lordotic curve changes. The result can be muscle fatigue and



/ Figure 2 / The position of the pelvis determines the shape of the lumbar spine.

discomfort through the entire back; however, when the pelvis maintains a controlled forward rotation, the spinal curve of the back remains aligned both naturally and comfortably.

Historically, it was believed there was a relationship between a person's thoracic and lumbar regions based on height and gender, but this has not been proven. The apex to the thoracic curve has a big variance. There is no relationship between the apex of the kyphotic curve of the upper back and the apex of the lumbar curve of the lower back. Through CAESAR, we learned we couldn't be prescriptive; there was no perfect ratio to design to.

Through our ongoing research and participation in CAESAR, we understand the human anatomy in general and the seated spine and back in particular. Our understanding gives us the ability to design and produce products such as the Mirra 2 Chair that truly support the unique requirements of the regions of the human spine.

Therefore

A good work chair will address those unique requirements of the four regions of the spine: cervical, thoracic, lumbar, and sacrum. It will naturally support all the regions of the spine as a person shifts seated postures throughout the day.

And, a good work chair needs to be flexible in order to address the macro variables of human size and micro variables of back/spine scale.

Design Problem

The body needs to move. It's a natural response, even when sitting. A Herman Miller study on seating behavior found that seated people move their torso an average of 53 times an hour. Nearly 28 percent of those moves involve leaning or turning (Dowell et al., 2001).

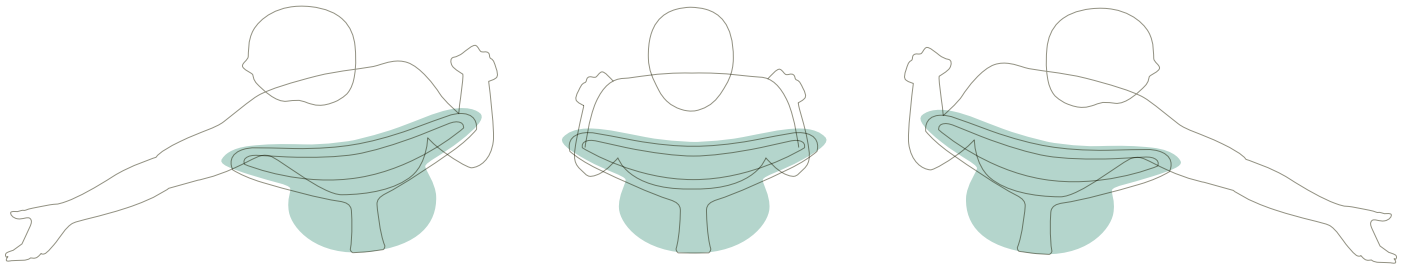
Most work chairs have backrests that are too rigid to allow the sitter's torso to move the way it prefers. To compensate, sitters tend to move away from the backrest, thereby losing the support for the back.

Nor do most work chairs equitably support the entire spine, from the thoracic region to the sacrum, and the unique requirements of each of those spinal areas. While they may provide support to the lower back, the upper back is often overlooked.

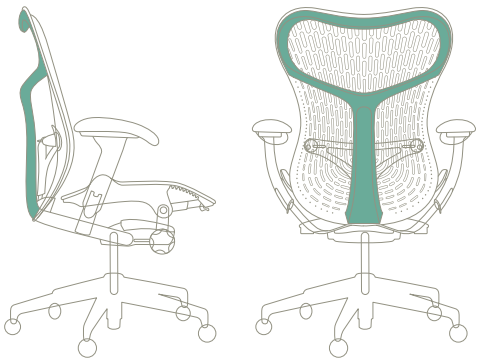
With most traditional foam-and-fabric chairs, or those with integral frame structures, the contour of the backrest may mimic the general contour of the human spine, but it does not respond to the individual's shape and scale or allow much flexibility in movement.

Design Solution

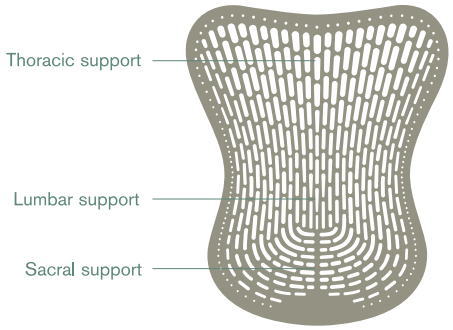
Provide a work chair that supports the entire spine and addresses the differences in the spinal anatomy within that support. The construction of the Mirra 2 Butterfly Back™ allows it to mirror naturally the leaning and turning motions of the sitter.



/ Figure 3 / The Loop Spine provides torsional flex, giving the sitter the freedom to move, lean, and bend, while the back of the chair moves and bends in the same way.



/ Figure 4 / The Loop Spine connects to the chair in only two areas—at the base and at the top of the backrest—which allows flexibility. Without an integral structure, Mirra 2's Butterfly Back can flex as the sitter flexes.



/ Figure 5 /Gradient perforations in the Butterfly Back are calibrated and tuned to the spine's natural range of motion. The pattern allows for greater or lesser flex within the chair's backrest, similar to the differences in the flexibility range of the spine.

The Butterfly Back is supported by the Loop Spine, external to the chair's backrest. It connects to the chair in only two areas—at the base and top of the backrest—which allows torsional flex. This design provides the sitter with the freedom to move, lean, and bend, while the Butterfly Back moves and bends in the same way. Without an integral structure, the Butterfly Back can flex as the sitter flexes, providing dynamic and responsive support and instant conformation to the sitter's individual anatomy. / See Figure 3 & 4 /

The material and design of the Butterfly Back is calibrated and tuned to the spine's natural range of motion. The Butterfly Back's gradient perforations resulted from engineering intentionally focused on the degree and direction of ergonomically-appropriate flex. The pattern allows for greater or lesser flex within the backrest, similar to the differences in the flexibility range of the spine itself. We refer to these areas of the backrest as flex zones. / See Figure 5 /

Given the body's minimal flexibility in the thoracic region, the perforations in the upper area of the Butterfly Back are smaller, supporting the nuanced thoracic movement. The lumbar region, on the other hand, has a great deal of flexibility, so the perforations in the corresponding area of the Butterfly Back are larger and closer together to give greater supported mobility to this part of the spine. As flexibility increases or decreases naturally through the spine, so it does in the Butterfly Back.

The CAESAR survey provided us with new information about the differences in proportions and the relationship between the lordotic (inward) and kyphotic (outward) spinal curves. Women, for example, are more lordotic and have a deeper lumbar curve than men. On average, women's lumbar curves are 12 percent deeper than men's. Yet the height of the lumbar region is about the same for both men and women (Dowell, 1995). An independent lumbar support, then, provides the sitter with the ability to adjust to his or her own lumbar curve. The Mirra 2 chair's adjustable lumbar design offers a simple yet effective way to match the level and location of lumbar support to the sitter's body and preference.

Additional postural support is provided by Mirra 2's passive PostureFit®. It provides constant support to the sacral-pelvic region. A camber shape at the base of the Butterfly Back creates an arched area that gives support. The design helps to control the position of the pelvis and, therefore, the spine. While it is important for a sitter to dynamically fit a chair's backrest to his or her lumbar curve, pelvic support should be stable—always there, always supporting, always "reminding" the pelvis to remain forward.

The entire torso of the person sitting in Mirra 2 is considered, from the natural flexibility in the upper back for reach and movement to flexibility in the lumbar area for fit and, finally, to stability in the pelvic region to promote more healthful postures.

References

Civilian American and European Surface Anthropometric Resource (CAESAR), 1998 - 2003.

Dowell, Bill (1995), "An Estimation of Lumbar Height and Depth for the Design of Seating," *Human Factors and Ergonomics Society Proceedings*.

Dowell, Green, and Yuan (2001), "Office Seating Behaviors: An Investigation of Posture, Task, and Job Type," *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting*.

Stumpf, Walker, and Dowell (2003), "The Benefits of Pelvic Stabilization."

Credits

Bill Dowell was Herman Miller's board-certified Corporate Ergonomist at the time of his death in 2012. During his 28-year career at Herman Miller, Bill was instrumental in leading research into the study of ergonomics and applying the principles of good ergonomic design to our products. In 1991, Bill played a pivotal role in Herman Miller becoming a charter member of the Office Ergonomic Research Committee (OERC). Bill was a key member of the BIFMA Ergonomics Subcommittee that was responsible for the original BIFMA Ergonomic Guideline for VDT Furniture, and was also a member of the committee that revised the BSR/HFES 100 Standard for Human Factors Engineering of Computer Workstations. He was also a member of the CAESAR 3-D surface anthropometric survey and the Human Factors and Ergonomics Society, representing Herman Miller in both groups. Bill's published work includes studies of seating behaviors, seated anthropometry, the effect of computing on seated posture, the components of subjective comfort, and methods for pressure mapping.

Championing research and creativity in the earliest phases of Herman Miller's product development efforts, *Gretchen Gscheidle* leads the team that explores unmet customer needs and responds to strategic questions identified by various organizational leaders. As the research link in all of the company's seating introductions beginning with the Aeron® chair in 1994, Gretchen has a strong record of participation and contribution in product development at Herman Miller. She is a member of the Human Factors and Ergonomics Society and represents Herman Miller on the Office Ergonomics Research Committee. Her research has been published in peer-reviewed journals. Gretchen earned a BFA in Industrial Design from the University of Illinois at Urbana-Champaign and graduated from Northwestern University's McCormick School of Engineering with a Master's of Science in Product Design and Development.

Studio 7.5, located in Berlin, Germany, designed the Mirra chair, the Setu® chair, and, most recently, Mirra 2—a complete redesign of the original. Designers Burkhard Schmitz, Claudia Plikat, Carola Zwick, and engineer Roland Zwick lead the design firm, which opened in 1992. Also active in education, the designers teach industrial design and product design at universities in Germany. An interest in the tools that define how people work has led Studio 7.5 to design software interfaces, office seating, and medical equipment. Studio 7.5 has been collaborating with Herman Miller for over 20 years.

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