Herman Miller

Everybody Deserves a Good Chair

Everybody deserves a good chair. But what is a good chair? For almost 100 years now, researchers have been trying to answer that question. This research summary examines their work and tries to establish whether they have reached any significant conclusions.

So What?

You may be asking yourself what difference it makes: A chair is a chair, right? Well, not quite. First, people who sit down to work for long periods of time run a high risk of low-back injury, second only to those who lift heavy weights,[1] and the risks increase with age.[2] Also, the total number of lost work days and the cost of each back injury are increasing.[3]

Second, as economies worldwide shift over to white-collar work, more people are sitting down on the job than ever before. In fact, you are probably reading this summary at work, and you're likely to be sitting down. In a recent study, the Herman Miller Research Group observed and cataloged movements of 40 office workers for a combined total of 160 hours. As a group, these workers spent 93 percent of their time sitting in an office chair.[4]

Finally, people in every office are doing work that has been radically influenced by the computer. They don't have to get up as often,[5] because all the information they need is one keystroke away. And with much of the information "processed" on screen, they have less variety in their work and fewer reasons to work away from the computer.[6]

Three Research Models

There are literally reams of research on seating. To approach it systematically, the material has been broken into models. (It is important to remember that the models are simplified ways of categorizing the inferences drawn from the material and were not models actually used by the researchers.)

The static model covers research that assumed there was a proper way to sit at work. Since the 1700s, designers have designed chairs that will support or even enforce correct posture.

The dynamic model covers research recognizing that people move a lot as they work sitting down and that they get up a lot to move around between bursts of work. Chairs put into this model are those that support, and even encourage, motion.[7]

The holistic model covers research that examines the chair in the context of its use.[8] Research in this area is not limited to seating, but includes information valuable to furniture and computer manufacturers, to architects and designers, and to companies and their employees as well.

The three models are not bound by a strict chronology, with the most discredited ideas appearing earliest. In fact, influential researchers from 1924 on have articulated holistic principles,[9] and researchers started writing about dynamic seating in the late 1950s.[10,11] What the passage of time has revealed is that some early research is no longer relevant because white-collar work has been changed so dramatically by the computer.

The Spine

There is little disagreement about this basic fact: The human spine and muscular/skeletal system are two areas most vulnerable to the stresses of sitting.

The spine looks like a long, bony centipede, tapering at the neck and pelvis, and is composed of 32 individual vertebrae linked together by ligaments. Pads of fluid-filled cartilage, called discs, maintain the correct vertical spacing between the vertebrae and cushion the bones, which may otherwise grate on each other or pinch nerves as the spine flexes. The base of the spine is called the sacrum. The spine "works" well when a person stands, curving gently inward at the lower back and neck and outward between the shoulder blades and at the pelvis. When a person stands, the disc pressures are lower than when the person sits.[12]

Numerous studies of the discs—by A. Nachemson, D. Chaffin, S. Andersson, and K.H.E. Kroemer, among others—show that a slow and subtle pumping action occurs when we are in motion. Nutrients are drawn in through the disc walls and waste products forced out. When we are immobilized, as when we sit for long periods of time, this pumping action is severely reduced and may weaken the disc walls. This weakness may lead to disc rupture—a serious, painful, and frequently disabling event.

Most office work is done sitting down since it permits a high degree of hand-eye coordination and upper-body stability. When a person sits, the inward (lordotic) curve of the lower back straightens or even begins to curve outward (kyphotic)—something you can feel in your own lower back by placing your hand there as you sit down. It's the rotation (or tilt) of the pelvis that influences spinal alignment, because the base of the spine, the sacrum, is rigidly attached to the pelvis.

The reversed spinal curve puts higher pressure on the discs and may contribute to their deterioration and herniation. For this reason, some researchers say the spine is not "well designed" for sitting. They believe people are evolving too quickly from a standing being (Homo Erectus) to a sitting being (Homo Sedens).

Now the good news: When a person sits in a chair and uses its reclining backrest, disc pressure drops by as much as 20 percent. And when someone sits upright and uses the chair's armrests, muscle activity is also reduced. These phenomena are described variously by numerous researchers in this field.

The Muscles

All physical actions involve both static and dynamic muscle activity. When a person works on a keyboard, for example, the arms are held still, but the fingers move dynamically. All activity is fatiguing, but fatigue can be delayed in onset and intensity if the activity is rhythmic and dynamic.

Dynamic activity is characterized by the alternate contraction and relaxation of muscle fibers, pumping oxygen-rich blood in and forcing out waste products like carbon dioxide and lactic acid. Dynamic activities include walking, running, and swimming. Because these activities are rhythmic, it takes less muscular effort to keep them up for long periods of time.

On the other hand, static activity is very difficult to keep up, even for brief periods of time, without feeling fatigue or pain. Static activity is characterized by the constant contraction of muscle fibers, which causes congestion, traps waste products, and prevents the flow of oxygen and nutrients into the tissue. Static activities include holding any posture for a period of time—standing still, bending one's head forward, holding one's arm out from the body, for example.

When people feel fatigue, they intuitively do a number of things to relieve the affected muscles. They may shift positions to come at tasks from a new angle, find ways to support their hands or arms, use the other hand for the same task, take short rest breaks, or switch to another activity for a while.

Research supports the benefits of intuitive responses to fatigue. One experiment showed that people tend to use several muscle groups to accomplish a single task, shifting from one group to the other long before the activity becomes painful.[13] Other research showed the benefits of providing arm or elbow support, especially for work done at shoulder level or higher.[14,15] Finally, research also showed that rest breaks of as little as 10 seconds increase the ability of a fatigued group of muscles to continue working.[16]

The Static Model: The So-Called “Right” Way to Sit

Physiological research that began in the 1940s continues to the present; many of its findings fit into what has been called the static model of research. The supposition of this static model is that it is possible to identify the “right” way to sit.

There were a lot of rules in the offices of the 1940s, 1950s, and 1960s—a desire for external evidence of order and stability, unwritten codes for behavior and dress, and subtle markers to separate people with high social standing and education from those without it. In these paper-based offices, the exemplar of the “right way to sit” was the secretary.

Sitting Upright

The highly trained, professional secretary was generally a woman who worked at a mechanical typewriter. She sat on her so-called secretarial chair with both feet firmly on the floor, ankles touching, knees touching, and her upper legs forming a perfect 90-degree angle with her torso. Her back was upright, her head turned slightly to the side to view what today would be called the source document, her elbows were held in close to her sides, and her hands hovered over the keys.

She had to use considerable force to type, because the keys were mechanically operated; when she reached the end of the line, she pushed a lever to ratchet the paper upward and return the carriage to the left margin.

Seating research focused on this person and tried to design a chair that would adequately support her. It clearly assumed that her posture was appropriate and that she would maintain it whenever she worked at the keys.

And yet, chair designs varied widely: Some back supports were adjustable, other chairs provided only upper-back support, while others supported the lower back better. Seat shape and dimensions varied widely, as did cushion firmness. Some chairs had casters; others, glides.

The only agreement seemed to be about armrests, which were almost uniformly excluded from discussions of chair features. Perhaps “rest” had no place in this work environment.

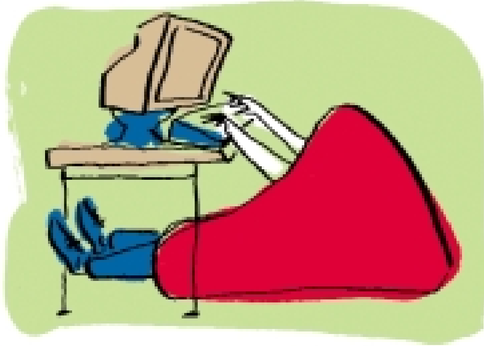
While the research continued to focus on various aspects of “good chairs” for “correct posture,” office technology began to change. The manual typewriter was gradually replaced by an electric one. A key replaced the carriage return lever, and the left hand, once free to swoop across the face of the machine at the end of each line of text, now simply hovered, like the right hand, over the keys.

Typists, selected for their speed (words per minute, or WPM), and formerly frustrated by the slowness of the mechanical typewriters, found that the new machines were capable of going fast enough to keep up with them. More work began to get done in less time.

Then in the early 1970s, technology changed again, this time drastically. Along came the desktop computer, and researchers noted an increase in health complaints associated with using it.[17] Working on these early computers while sitting in a chair that accommodated only an upright posture led to eyestrain, fatigue, and back, neck, and shoulder pain.[18,19]

While the notion of a single “correct” way to sit continued to appear in research, a new “correct” seated posture was being identified. This posture was observed in astronauts and underwater workers. What seemed to be a natural resting posture for humans in low gravity was characterized by a slight bending of the knees, a more open angle between the torso and thigh (128-135 degrees), a restoration of the lower-back curve found while standing, and upward floating arms. Both the knees and elbows were held rather widely apart.[20]

People who sat this way at normal gravity could do so in either a reclined or a forward-leaning position. Researchers found that muscle activity and disc pressures were reduced while reclining,[21] but not while leaning forward.[22]



Leaning Forward

Meanwhile, computer users were leaning forward a lot. Perhaps it was necessary, because the characters on early computer screens were not always easy to read, and there was often a reflection on the screen from overhead lighting. In addition, early keyboards were attached to monitors and could be reached most comfortably by sitting closer to the work surface.

Designers in the 1980s tried to provide chairs that would support a forward-leaning posture. The best-known chair of this type is the "kneeling" chair. When someone sits in it, most of the weight is forward of center, and the angle between the upper legs and torso is quite open. Because the seat cushion tilts the pelvis forward and down, the person is "encouraged" to maintain the natural curve in the lower back.[23]

The major drawback seems to be that if one grows tired of this position, the chair won't let the person sit any other way. And in one case, even though the users in a study knew how important it was to maintain the "correct" lower back curve, they still slumped when they got tired.[24] And without a back rest to lean against, they seemed to get tired quite often. However, many computer users still sit leaning forward, especially when doing document-intensive work.[25]

Reclining

Other computer users lean back in a race car driver's posture. This reclined posture also opens up the torso-thigh angle and tilts the pelvis; and if the chair has a well designed backrest, leaning back reduces disc pressure and muscle activity.[26]

Reclining requires a combination of skill and the right equipment to be an effective work posture: One needs a computer screen clearly visible from a distance, a keyboard tether long enough to stretch from the terminal to the lap, and ideal ambient lighting with no screen glare at any angle. In addition, the user must be able to touch-type, because as soon as the user's head comes forward to look at the keyboard or screen, the body follows, as does the chair.

In Summary

While there is research enough to support the validity of any single "correct" posture, such a narrow focus makes it more likely that benefits of alternative postures will be overlooked. Further, the problem with designing a chair that supports only a single posture is that there are health risks associated with maintaining static postures and that people simply don't sit still.

The Dynamic Model

As chair designer Bill Stumpf was among the first to document in the late 1970s, people at work move—a lot.[27] Like most seminal observations, it was obvious to anyone who thought about it, but few had realized its importance before.

A recent Herman Miller study that observed and cataloged the movements of 40 office workers found the group on average made 53 changes in their torso posture per hour. The same group averaged over 180 changes in their arm position per hour. Administrative people made the most torso movements, and technical/professional workers the least. Customer service workers averaged the most changes in arm postures, and executives the least.[28]

When making a phone call, people play with a desk toy, leaf through a catalog, or doodle. While writing, they lean on an elbow, lean back in the chair, look up for inspiration, or unwrap that stick of gum they've been saving. While in a meeting, they fidget, squirm, twist, tilt, and turn. When calculating, filing, or entering data, they are in constant motion, not all of it related to the task at hand.

Further, no matter what they're doing, they will use various strategies to shift the activity away from tired muscles—stopping briefly, switching hands, changing to another kind of work, or stretching. As a last resort, they can always invent the pressing need to get coffee, make copies, or track someone down for a face-to-face meeting.

Stumpf's observations led to a chair designed to support the ways that people move at work.

What Support will a Good Chair Provide?

Generally, a good chair should accommodate a wide range of postures[29] without feeling resistant or loose. It should be easy to get into and out of. It should permit motion but be stable enough to allow close-up or detailed work. Maybe it should accommodate both paper-based and computer-centered work.[30] And it probably should accommodate at least three kinds of working postures—the reclined, the forward-leaning, and the upright—since there is still no single theory about how people should sit.[31]

Behavior Variables		Percent of Time
Tasks	Mouse	18.74%
	Key	19.70%
	Read VDT	7.73%
	Converse	12.82%
	Phone	12.35%
	Read Paper	17.32%
	Rest	3.86%
	Write	7.60%
Torso Postures	Forward	45.25%
	Upright	26.96%
	Recline	14.50%
	Turn	5.75%
	Lean	4.25%
Upper Extremity Postures	Neutral	28.94%
	Neutral Extended Reach	51.76%
	Far Extended Reach	15.62%

How to tie these results back to specific chair features is still under discussion. It is intuitively obvious that a good chair provides good back support: People who work leaning forward and upright will want to lean back and rest; people working in the reclined position need to feel securely supported.

There are a couple of ways to address back support. For those working in the forward and upright position, lumbar or pelvic support will prevent fatigue and improve comfort. Another way involves the use of armrests. Numerous studies reveal the relationship between armrests and their effect on the body in its seated position. Generally, if armrests are well placed and adjustable, using them has a range of benefits, particularly reducing stress on the neck and shoulders.

There seems to be little argument about features like swiveling and rolling to accommodate motion to and away from the task or the work surface. And there is an assumption by users, if not by researchers, that chairs should be durable and continue to provide the same levels of quality over time.

In Summary

The notion that chairs should both stabilize users and accommodate a range of motion has led to a significant redesign of chairs and a new way of talking about them. Designers are moving in two directions: designing chairs to meet the requirements of specific kinds of work, and designing chairs to accommodate a range of workers and a range of tasks. Ergonomic principles say the chair should first fit the user, then fit the task, and then allow for posture change and a variety of activities.

The Holistic Model

These questions underlie what is being called the holistic model, in which descriptions of good chairs include the contexts in which they're used and the people who use them. Research fitting the holistic model concerns itself with the idea that jobs and tools designed for a homogeneous work force can create problems for those with different attributes or strengths. Product designers are increasingly aware that every design decision made while designing a workstation is important and will have an impact on the users. The research assigned to the holistic category includes statements like the following:

"The modern office is a complex network of interrelated influences that represent a continuous challenge."[32] "No one chair type or line fits everyone."[33] "It is unlikely that any single product or workstation configuration will be satisfactory for everyone."[34]

While research has always acknowledged wide physical differences between the largest male and the smallest female, work force diversity beyond that has largely been ignored. No more: Our work force is changing fast, with more women, minorities, and people with disabilities coming into the workplace as well as workers growing older.

Even the notion that it's possible to design for some imaginary average person has begun to yield to research showing that there really is no such thing as "average": While a range of "average" physical dimensions can be detailed, such as height, weight, and arm, torso, or leg length, no single person will match 10 out of 10 specific "average" dimensions.[35] Studies show that until custom-built workplaces become the norm, adjustability will be the best solution, especially if users understand why and when to adjust chairs, work surfaces, and equipment. If not, they won't adjust them.

What Kinds of Work Are We Doing When We Sit Down?

Research fitting the holistic model views sitting as a means to an end, not the end in itself: "What do people do when they sit?" becomes a crucial question.[36] The Herman Miller study cited earlier (observing and cataloging the movements of 40 office workers) found the group spent an average of 47 percent of their time doing computer-related tasks.[37]

How Office Workers Spend Their Time and Position Themselves

Many people today sit down to work on their enemy, their friend, the computer. Whether they sit upright, recline, or lean forward, when they work at a computer, they tend to sit for long periods of time.

The Herman Miller Research Group has found that workers in today's computer-influenced office environments are sitting upright or forward about three-quarters of the time. Typically, their arms are raised somewhat (increasing static activity in the shoulder muscles), and their arms, hands, and head move constantly and with precision.[38]

The human head weighs about 10 pounds. It balances on top of the spine, with its position and movement controlled by a complex of three dozen muscles. These muscles, anchored at the collarbone, shoulders, upper spine, and the base of the skull, have nerves threading through them, running from the spinal column out to the hands and arms.[39, 40]

Most movements of the head away from center are maintained by static muscular activity.[41] Considering the wear and tear on tissue resulting from static activity, it is no wonder that 21 studies in the last 10 years show a link between the use of computerized office equipment and physical discomfort in the head, neck, shoulders, arms, or hands. Research by leading ergonomists, including E. Grandjean, S. Sauter, and the Koffler Group, link this discomfort to such factors as how the computer is used,[42] as well as age, posture, and repetitive motions. It's under debate, but there are some who say problems start to surface when the computer is used as little as 10 to 20 percent of the time.

Yet, some people sit at the computer all day in circumstances that make the average assembly line look like a smorgasbord of interesting and varied work: Documents are broken down into their component parts; those parts are "processed" by people who see the same information and repeat the same set of keystrokes all shift, every shift. There is enormous emphasis placed on speed, accuracy, and uninterrupted work, even though, in some cases, error rates range from 40 to 400 percent when the machine is allowed to set the pace.[43]

The stress levels in such jobs are the highest ever recorded by the National Institute of Occupational Safety and Health (NIOSH), higher than those of air-traffic controllers,[44] with a related high risk of chronic heart disease.[45]

As these warning signals began to come in from the work world, research by Bryan Abas and A. Laville also found that fixed work postures, an emphasis on accuracy and speed, and intense static activity could cause progressive deterioration of joints, muscles, and tendon/ligament sheaths. Awkward hand or arm positions[46] and prolonged sitting or standing[47,48] were also causative factors in distress, pain, and even disability.

Research places blame on factors both within and outside of the workplace. Key workplace factors implicated in problems include weakened musculature or poor work postures, and inadequate environments, equipment, chairs, or job design. Factors outside of work can also contribute: sedentary lifestyles; poor posture, obesity, and health problems; sports injuries; and even the use of poorly designed beds, chairs, sofas, and car seats.[49]

Some researchers today feel strongly that many of these disorders are largely preventable. Furthermore, a poor work environment can be costly: A Norwegian company found that money invested over a 12-year period (1976-1988) in work environment improvements produced a tenfold savings in direct costs, along with significant improvements in employee health.[50]

From NIOSH and government offices to industry and research, the chorus grows: Chairs and equipment are only one part of the problem and the solution. Managers and employees must work together to identify and resolve job design, management, or facility issues as well.

In Conclusion

The early notions of "correct" posture gave way as evidence made it clear that idealized postures were not necessarily healthful—especially not in a work environment dominated by the computer. Yet dynamic changes in posture, healthful in themselves, cannot compensate for the problems of poor workstation design, layout, equipment, lighting, acoustics, or job process. Researchers are finding that relatively minor adjustments to the entire "work envelope" can be significant. While this holistic view makes intuitive sense, it frustrates those who seek a cut-and-dried solution to the influx of problems being associated with white-collar work. It is probably accurate to say that these are now, or soon will be, everyone's problems. The solutions are just as likely to come from users as they are from researchers and designers.

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