The Future of Ergonomic Office Seating

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Introduction

As a topic of interest, seating has occupied researchers for centuries. Hundreds of books, research studies, journal articles and symposia have focused on some aspect of humans as they sit and the objects on which they sit. Why so much attention? In part, because there is a Zen-like duality to sitting and seating—simplicity and complexity; moving and staying; comfort and discomfort (see sidebar). Also, effective sitting and seating relate directly to the activities in which a person engages.

THE DUALITY OF SITTING

The act of sitting is simple—just bend your knees and put your bottom in the seat.

But sitting involves a set of complex structures—bones, muscles, cartilage, tendons, joints, and nerves. It is an inherently dynamic activity. Even when we "sit still" our bodies are constantly moving. Sitting involves large and small motions. Maintaining balance and slight position changes involve micro motions. Larger macro motions involve moving our arms and legs.

"Both larger 'macro –movements' and very small 'micro –movements' are essential for our well being. The only truly effective way to maintain a seated posture for extended durations is to continuously cycle through a range of natural, centered and healthful positions. This requires a chair that allows users to dynamically shift between a range of stable postures." (Lueder, 2005).

So, while sitting is natural, maintaining one seated position for a long time (like the traditional office task position) is not natural. When we sit erect or in a forward leaning position we place enormous stress and tension on our bodies, particularly the lower or lumbar area of the back and spine. That's why some seating researchers maintain any chair will become uncomfortable over time.

Today, one can find a wide array of chairs reflecting the current understanding of ergonomic experts and designers as how to best support traditional office tasks.

But office work is changing. Traditional jobs involving only one primary, forward oriented task are giving way to new approaches to work and a wide variety of task postures and positions.

This white paper addresses five related issues:

1. The importance of ergonomic seating

2. How do we sit?

3. What research tells us about sitting

4. What a chair should do

5. The future of ergonomic office seating

1. The Importance of Ergonomic Seating

***Sitting* versus *seating* – What's the difference?**

Sitting is an activity – It's something people do. Sitting is active, involving motion, balance, position, posture, and control. Sitting is an innate behavior involving both body and mind. Sitting is natural. People sit in a wide variety of ways and places. People don't need to learn how to sit. Sitting is simple.

Seating is a category of devices – People use seats to support themselves when they sit. Seating includes anything people sit on or in. The most common form of seating is a chair. But seating can also include benches, stools, swings, pillows, balls, baskets and such (Lueder & Noro, 1994). Using a seat – any modern, complex, highly adjustable, task chair – is not natural. Complex seating often requires training. Users may need to learn to use them. Seating can be complicated.

Ergonomics is the science of making things fit people instead of asking people to fit things (2003, MedicineNet) – It applies knowledge of human behavior and work activities to the design of devices, jobs and environments. Good ergonomics foster work environments that are safe, facilitate effective performance and are easy to use.

Because the majority of office work is performed from a seated position, understanding and correctly applying the ergonomics of office seating is critical to delivering work environments that are safe and support performance. To do so requires consideration of the task, work behaviors and activities of people in the office work setting.

2. How Do We Sit?

People sit in thousands of different positions. Casual observation of people at work shows a wide variety of postures and positions (figure 1). We sit upright and erect, we slouch, we sit on our feet, we cross our legs, we straddle chairs, we sit sideways, we balance on the front edge, we tip back on the back legs. We literally sit almost anyway you can imagine. This natural tendency has been called "free posturing" (figure 2) (Kroemer, 1994).

Figure 1. Observed postures

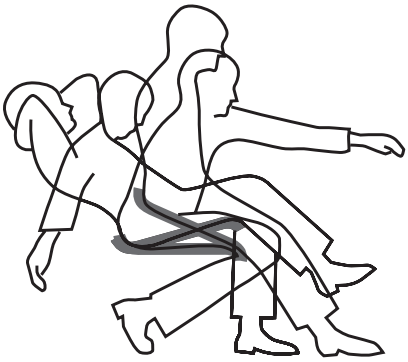

Figure 2. "Free posturing"

Answering the seemingly simple question of "how do we sit?" is critical to the design of effective seating. Should a seat support the entire range of positions people assume when sitting? If so, how can a seat do this without constraining postures? If not, who chooses which postures to support?

3. What Research Tells Us about Sitting

Years of research have helped build a substantial body of knowledge about sitting and seating. But, research quantity does not necessarily translate to a comparable degree of knowledge.

The father of modern seating research observed, years of research "does not appear to have led to much improvement in the general quality of seats, nor has it stemmed the tide of clinical complaints about back pains." (Branton, 1969)

Thirty years later, a compilation of the work of leading seating researchers cautioned:

- **"Although a vast body of research on seating in recent years has greatly advanced our understanding, we are left with many gaps in how to address users' discomforts and support their activities." (Lueder & Noro, 1994).**

A review of research literature illustrates five main characteristics common to most studies of sitting and seating:

Ergonomic research on seating focuses mainly on the biomechanics of sitting – that is, it measures the position and relationship of the spine and pelvis, muscle contractions, pressure distributions, etc. This is an important beginning to understanding sitting and seating, but, as noted above, sitting is a dynamic activity. To understand the requirements of people sitting while at work, it is necessary to move beyond the biomechanics of sitting and consider the nature of work behaviors and sitting in context.

Many studies concentrate on so-called "risk factors" – These are conditions and actions that increase the probability of pain, discomfort and injury due to constrained postures associated with sitting for a long time while performing sedentary tasks. But these risk factors are diminished when seating supports the dynamic nature of sitting and the inherent movement, both large and small.

The constructs of comfort and discomfort are not well understood – Many studies presume comfort is the lack of discomfort. But recent evidence suggests comfort and discomfort are distinctly different but complementary constructs. (See sidebar)

COMFORT & DISCOMFORT

"We propose a model for perception of discomfort/ comfort. Discomfort is associated with biomechanical factors (joint angles, muscle contractions, pressure distribution) that produce feelings of pain, soreness, numbness, stiffness and so on…feelings of discomfort increase with time on task and fatigue. Eliminating physical constraints can reduce discomfort, *but this does not necessarily produce comfort* (emphasis added)

"Comfort is associated with feelings of relaxation and well –being. The sensation of comfort may be amplified by an aesthetic design of the chair or office. *The absence of these feelings will not lead to discomfort* (emphasis added) because adverse biomechanical conditions are necessary for this."

— L. Zhang, M. Helander, & C. Drury (1996) "Identifying Factors of Comfort and Discomfort in Sitting." Human Factors. Volume: 38. Issue: 3. pg 377 – 389.

Most seating research focuses solely on one or two specific sitting positions – Researchers often use an erect or forward leaning task posture, common when writing at a desk or operating a computer. While such postures may predominate, they are by no means the only positions people assume. Few, if any research has studied the variety of ways people sit in a broader context of work (Festervoll, 1994).

Design of task seating relies on anthropometric data or body size measurements – Yet, these data are not without qualifications and gaps. Measurements of the seated position are standardized as erect with feet flat on the floor and the relevant joints (knees, hips, thighs, elbows) held at 90°. This has been called the "cubist" approach (Mark & Dainoff, 1994). This erect posture is seldom adopted in reality possibly because it increases the probability of discomfort due to lumbar pressure and strain. Nonetheless, data from studies using this position to measure body size while seated continues to inform seating design and design standards (See Appendix). Much of the data in anthropometric databases were collected many years ago. As such, they do not reflect changes in populations attributable to diet and health (e.g., obesity), nor changes due to increased diversity through immigration. Therefore, it is possible to conclude: Anthropometrics is to seating as arithmetic is to calculus—it's fundamental, it's important but it's not the complete answer (Springer, 2009).

In considering the future of ergonomic office seating it's important to consider, what do we know, what don't we know and, most importantly, what we think we know that just isn't so. As applied to the design of future office chairs, seating research has the following limitations:

- It does not consider the full context of office work and the associated behaviors, positions and postures people assume at work.
- It emphasizes discomfort, risk and injury
- It does not provide clear guidance as to what constitutes a comfortable chair
- It relies on old and limited data regarding body dimensions and postures.

4. What a Chair Should Do

Current research on seating (finally) recognizes there is no correct posture and no one "right way" to sit. Leading researchers now acknowledge that many postures may be comfortable depending on the individual and the work activities (Kroemer, 1994). Unfortunately, this understanding is not universal. Standards and guidelines (e.g., BIFMA G1, ANSI/HFES 100 2007), training materials and seating design still

reflect the belief that ergonomic seating need support a limited few postures. While desk–bound tasks remain the major part of most office jobs, limiting seating design to one or two positions such as an erect computing posture and a talking–on–the–phone, reclining posture discounts the wide variety of positions people assume when engaged in computing and conversing on the phone. It also ignores the wider context of work in which people engage in many other activities and assume a wide variety of postures and positions.

Given the limitations of seating research and traditional approaches to seating design, future ergonomic seating must consider, as an alternative, what a chair *should* do:

Support a person's body – A chair should fit the person who sits in it. If everyone were the same, this would be quite simple. But everyone is different. So the design of a chair must accommodate the range of individuals who will use it. Fortunately, most modern ergonomic chairs do this pretty well – as defined by the criteria of international ergonomic standards. Most ergonomic evaluation of office seating focuses on how well a chair conforms to the dimensional criteria of a particular standard. But conforming to the standards falls far short of meeting the broadest range of users and uses.

Support activity – When considering task seating, *what* people do, *how* they do it and for *how long* are essential pieces of information. Without this information, it is very difficult to determine how best to support people in the performance of their job. Virtually all office jobs include periods of focused concentration and instances of interaction and collaboration with others, periods of sedentary postures while using technology, and periods of dynamic activity. Chairs should support all the activities in which people engage, not just one primary activity.

Promote movement – A chair should promote movement and encourage the natural movements of the body as it provides support. Movement should not require conscious effort, or activating controls. Chairs should move with the user, and make it easy to move. (Festervoll,1994).

Enable performance – An ergonomic office chair is a tool to support people in the performance of their job. As such, it should facilitate, support and enable effective performance. A good chair enables people to be more effective and contributes to improved performance (Springer, 1982, 1991, 2001, 2008; Lueder, 1983, Bell, et. al. 1998).

Be easy to use – To accommodate individual differences in size, chairs usually provide adjustments. The way those adjustments are made must be simple and easy to use. Experience shows, people simply do not want to have to think about their chair when they are trying to work. Unfortunately, some task chairs are so complex that people need to learn how to sit in and adjust those chairs. If a chair requires activating a control to change positions, those controls are seldom used (Vink, et. al., 2007).

Do no harm – The attention paid by seating research on risk factors, discomfort, pain and injury suggests what a chair should not do. To borrow an idea from the healthcare professions, a chair should do no harm. It should not constrain postures or force positions. It should not cause discomfort, stress or pain but should provide unobtrusive support of comfort and motion. Also, the design must consider and minimize the environmental impact of its production, distribution, use and disposal.

To summarize, a chair should do more than simply conform to dimensional criteria from international standards. It should fit people who sit in it, providing support for a wide variety of bodies and behaviors, including various motions and positions. A chair must be easy to use and harm neither users nor the environment.

5. The Future of Ergonomic Office Seating

Design is the process of exploring various creative solutions to a particular issue or question. It doesn't assume there is only one correct answer or solution, but is based on the idea of creative exploration yielding many alternatives. When considering the future of ergonomic seating, the way in which designers solve the problems and address the criteria will be many and varied.

In addition to the essential qualities a chair should exhibit, the future of work and work activity suggest a number of things that need to change in consideration of the future of ergonomic office chairs.

Support the widest variety of diverse work activities – Office work has changed. The era of large groups of people doing one thing all day is over—if it ever truly existed. Computing technology is no longer the massive anchor, tying workers to a particular space or position. Work is increasingly untethered as wireless technologies proliferate. Changes in management approaches and work organization rely on the knowledge and skills of groups of people working individually and together. Work is more collaborative. Workers juggle multiple tasks, in multiple settings and move back and forth among them. Work is multimodal—involving solo, heads down concentrated tasks, connected situation awareness of activity in the immediate surround, interactive collaboration with others, and the ability to move seamlessly among these work modes (figure 4).

Figure 4. Multi–modal work

Clearly chairs designed to support only one type of activity or one task position are insufficient for this new world of work.

Incorporate cognitive ergonomics – Ergonomics is the science of fitting the task and the environment to the user. Physical ergonomics deals with body shape, size, motion, strength and capabilities—the physicality of people. But that is only half the equation. Work, especially office work, engages both the body and the mind. Cognitive ergonomics examines how our minds work and considers mental processes like focus, attention and memory. Together, physical and cognitive ergonomics constitute a comprehensive approach to people at work. As an example, consider how we organize our personal workspace. The physical location of tools and materials reflects the mental "map" of where we place things. How we organize, locate and access tools, information and materials involves physical and cognitive elements working in concert. Office chairs must go beyond just the physical to support and incorporate the cognitive nature of office work.

Explore and apply the latest technologies – Designers and manufacturers of office seating must constantly explore new materials, tools and technologies. Advances in computing technology allow virtual analysis and testing of design. Nanotechnology is creating amazing new materials with unique properties that can be harnessed to develop new concepts of support, adjustment, aesthetics and comfort; renewable sources for materials will help reduce the environmental impact of manufacturing, distribution, use and disposal.

Exhibit transparent sophistication – Elegant, simple, easy to use products are often made possible by sophisticated and complex science and engineering. Functions and forms impossible to execute a short time ago are commonplace today. But users don't need to understand or even be aware of the knowledge, effort or sophistication involved in designing or making a product, it should just be simple and easy for them to use. Consider the typical garage door opener. Pushing a button (hopefully a well designed, obvious, ergonomically shaped button) causes a mechanism to raise or lower the door. We don't need to understand the technology behind the device. We only want to know, "when I push the button the door moves." The antithesis of transparent sophistication is the modern TV remote control. A crowded array of tiny buttons of various shapes, colors and sizes hint at the power and capability of the device. Yet most people use it to do three simple things—turn the TV on or off, adjust the volume and change the channel.

Maximize environmental intelligence in design – Every effort must be made to minimize the environmental impact and carbon footprint of producing and delivering future products – including ergonomic office seating. The efficiency and sustainability of the materials, shipping, and manufacturing processes should be continually monitored and improved. Using environmentally safe and healthy materials, designing in reuse and recycling, using renewable energy, emphasizing energy efficiency, and minimizing materials all contribute to the environmental intelligence of the design process and actual production. Guidance for achieving this goal is offered by the U.S. Green Building Council's LEED and the Institute for Market Transformation to Sustainability's SMaRT rating systems.

Enhance ease of use – The future office chair must be fluid and flexible in its design and operation. The changes in office work and the wide variety of users and uses demands fewer constraints and more dynamic response from office chairs.

Move beyond active control – Chair design must provide unobtrusive stable support that is responsive to users' positions and motions. To be truly responsive, chairs should not only support, but also encourage, changes in posture and position without the need to think about the chair or activate a control.

Be intuitive – Those few controls requiring active adjustment, like seat height, must be intuitive, and require no training. If actions trigger a response from the chair, they should be easy and simple to perform, so the user learns by doing – preferably the first time. These should be "set and forget" controls.

Go beyond usability – In recent years the concept of usability has been broadened from its original concerns of comfort, convenience and ease of use to include notions of pleasure and delight.

Scientists in ergonomics, industrial design and computer interface design have begun to explore ways to maximize the positive experience of users. Some researchers make the case for comfort being an aspect of usability and pleasure (Coelho, D., 2001). Others suggest that designers should discard the concepts of "ease of use." They suggest the following:

1. Don't think accommodation, think temptation.

2. Don't think beauty in appearance, think beauty in interaction

3. Don't think ease of use, think enjoyment of the experience (Overbeek, et al. 2001)

Future ergonomic office seating will need to go beyond the assumptions and approaches of traditional chairs. Work has and will continue to change. Scientific discoveries are unlocking the mysteries of how our

minds work and how that knowledge can be used to make products that better support work behaviors. New technologies and materials introduce new possibilities for form and function. Environmental concerns and ecological sensibility influence choices of processes and materials. All of these developments open new and exciting possibilities for answering the question, “How can a chair best support people at work?”

6. Conclusion

What should one expect of the ergonomic chairs of the future?

The way in which designers and engineers interpret seating requirements will provide a rich array of products and alternatives. But at a minimum, the next generation office chair will fit your body, not just the dimensional criteria of some published standard. It will be stable, yet promote dynamic, active, natural motion allowing sitting in any position.

The chair will support you in *all* the various activities comprising your work day: from sitting at a computer to talking on the phone to interacting with others; from turning or reaching to bending or stretching. The chair supports you in whatever position you feel most comfortable. The chair will support both the physical and cognitive nature of your work enabling you to be more efficient and effective. It will be simple, natural and easy, intuitive and enjoyable to use.

To accomplish all these goals, the chair will use new materials and technologies in new ways to provide unique and effective forms and functions. These materials and the processes used to produce the chair will be environmentally intelligent and do no harm to either users or the environment.

In short, the future chair will be wonderfully sophisticated, elegant, comfortable, inviting and remarkably simple and natural to use.

Appendix

Anthropometrics, Standards & Guidelines

Anthropometrics is to seating as arithmetic is to calculus – it's fundamental, it's important but it's not the complete answer (Springer, 2009).

Experts from all over the world have formerly been of the opinion that the proper sitting position is the right angle or erect position, illustrated by this selection of drawings that form the basis for international standardization, anthropometrics and the training of furniture designers. (figure 1)*

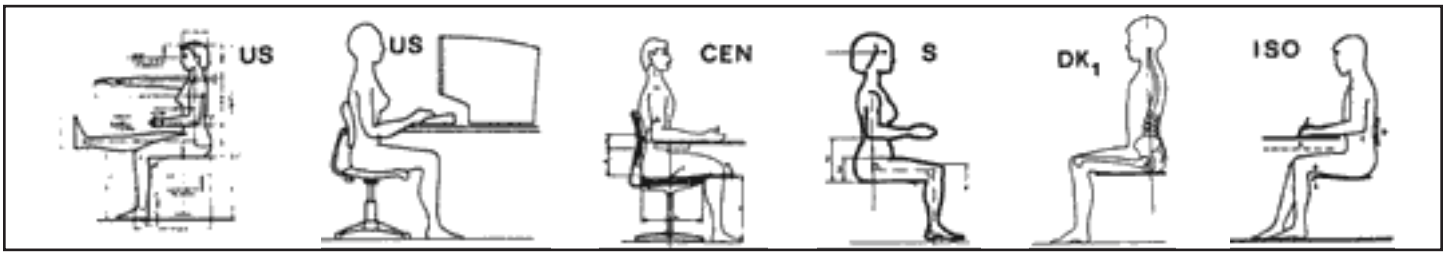

Figure 1

It's not that these pictured standards are wrong. They are useful in comparing seating features and characteristics across different chairs. But it is important to understand they represent an unrealistic ideal of the way people sit at a desk. One researcher goes so far as to offer eight critical questions to ask before considering standards and guidelines – including "are the guidelines based on science?" and "do the data fit your people?"¶

Several studies have found that when given a choice, people tend to sit with a higher seat height than would be suggested by the anthropometric data (popliteal height). Some of this behavior can be explained by the height of the table or desk at which they sit, but the preponderance of evidence supports the notion that people prefer to sit 1.2" to more than 2" higher than the standards would suggest. Doing so allows, and in some cases requires, the extension of the lower leg and the declination of the thigh. Depending on the chair this may put pressure on the underside of the thigh. But the research reports no experience of discomfort from people who choose to sit this way.‡

*A.C. Mandal, "Balancing sitting posture on a forward losing seat" www.acmandal.com.

¶ Ankrum ,D. (2001) "Questioning Office Ergonomic Guidelines" in Alexander, D. & Rabourn R. (ed) *Applied Ergonomics*. London: Taylor & Francis. pg. 227.

‡ Sauter, S. L. and Arndt, R. (1984). Ergonomics in the automated office; gaps in knowledge and practice. In Salvendy, G. (ed.) Human – Computer Interaction. The Netherlands: Elsevier Science Publishers, 411 –414.

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