Chair Design Beyond Gender and Age

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The Cinderella Chair – is there such a thing as the right fit?

In the fairytale Cinderella, Prince Charming uses a glass slipper to find his mystery princess because it fits only her, unique foot.

If each of us could choose our own office chair, it, too, would adjust to our specific shape. But in the real world, companies specify only offer one or a few models as a corporate standard. So the challenge for designers is to find a visually appealing, ergonomic chair that fits the dimensions of most users — and can adjust easily to their specific needs.¹

Anthropometrics and Chair Design

Anthropometry is the “science of measurement and the art of application that establishes the physical geometry, mass properties and strength capabilities of the human body.” Anthropometric data helps designers determine the size and shape of an ideal chair. Anthropometric data for most male and female body dimensions overlap so designers work to sizes that span the range from a 5th percentile female to a 95th percentile male. If female dimensions are smaller than the 5th percentile or male dimensions are larger than the 95th percentile, these chair designs won’t fit. If 50% of the target population is male and 50% is female, that means these design limits will not provide a good fit for 5% users.

FIGURE 1 Anthropometric dimensions of most importance to chair design.

Using anthropometric data is complicated because a person who is at a particular percentile for one body dimension will not necessarily be at the same percentile for other body dimension. In other words, a woman who is at say the 5th percentile for height will not necessarily be at the 5th percentile for all other body dimensions and a man who is at the 95th percentile for height will not necessarily be at the 95th percentile for all other body dimensions. A survey of seven chair design dimensions for a sample of 778 people found that almost one-third fell outside of the 5th to 95th

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percentile range for at least one body dimension, and between one in six and one in 12 did not fit the chair on at least one pertinent body dimension.  

**User Diversity**

Anthropometric data is further complicated when workforces are diverse. In the 2000 U.S. census, more than one million residents reported coming from 37 different ancestries, while 100,000 residents reported originating from 92 different ancestries. Therefore, U.S. anthropometric data needs to be a composite of all these ancestries, which can be complicated, since races may be similar in certain dimensions, but different in others. For example, African Americans have proportionally longer lower limbs than European Americans, who have longer lower limbs than Asian Americans.

Unfortunately, anthropometric data resources tend to be limited because they are usually dated, restricted to young healthy adult samples from certain ethnic groups and regions, and focus on skeletal dimensions at the exclusion of soft tissue contours. Even when a designer uses the best anthropometric data available there can be mismatches. For instance, a study of 30 students from southern China showed that the recommended seat depth of 38 cm was too long for the dimensions of the users and that seat depths between 31 and 33 cm were appropriate.

Rather than a single chair model that fits the majority of the population, some manufacturers offer chairs in different sizes. However, this complicates inventory management, especially in environments with high turnover, or where one chair has many users (such as 24/7 operations).

## Choosing an ergonomic chair — making an informed choice

Unfortunately, when specifying a chair for a corporate environment, it’s impossible to know the body shape of every individual user. Considering the following variables can help designers choose a chair that suits most:

### Chair Strength

Must support the weight of the average user. Body weight can affect both durability and adjustability — a lightweight person may have problems operating controls designed for heavier users, while a heavy person may exceed stability limits. Special seating may be required for exceptionally heavy or light users.

### Seat dimensions

The seat supports the greatest proportion of body weight and must provide the following features:

- **Seat height** - Must support the hips, buttocks and thighs while the user’s feet are on the floor or footrest. The height of the front edge of the chair seat should align with the popliteal (back of the knee) height of the user. The seat height may have to be readjusted whenever the seat tilt is changed.

- **Seat depth** - Must offer clearance behind the knees. When a user sits back against the chair backrest, there should be adequate clearance between the seat pan and the back of the knees to avoid any compression problems.

- **Seat width** - Should be wide enough to comfortably accommodate the width of the hips, but not too wide that the user cannot easily rest their elbows on the chair arms.

- **Seat pan material** - Must comfortably distribute pressure and not restrict movement. Breathable materials help prevent heat and moisture buildup and reduce discomfort.

- **Seat-to-back angle** – Must allow for a reclined sitting posture with a thigh-to-torso angle beyond 90° to reduce abdominal pressure, promote the lumbar curve and reduce strain on the lumbar spine.
Backrest dimensions – Must support individual body weight and stabilize the body when reclining. The backrest should be contoured and adjustable to maintain a neutral lumbar curve. Backrests that end below the shoulder blades or are narrow are ideal for tasks that require unobstructed upper body mobility. Taller, wider backrests that end at or are higher than the shoulder blades, provide better support for reclined sitting. In addition, the chair backrest should offer the following features:

- **Backrest height** - Must provide comfortable support for the lower and upper-back.
- **Head/neck support** - Must provide adjustable head/neck support if the back is high enough to provide head/neck support for extreme reclined sitting. This lowers neck muscle activity by more than 35% and shoulder muscle activity by more than 64%.
- **Lumbar support** - Must allow for vertical adjustment to accommodate different lumbar heights and depth adjustment to accommodate different lumbar curves. The apex of preferred lumbar support is about 17 to 23 cm (7-10 inches) above the seat pan.
- **Backrest width** - Should be wide enough to allow adequate hip clearance when the user sits back in the chair. If the backrest is too wide, it may restrict comfortable elbow movement and impede upper body mobility.
- **Backrest contour** - Should be contoured to the user’s back and should not restrict comfortable elbow movement or limit upper body mobility.
- **Backrest angle** - Should allow for a range of angles. Most users choose a reclined posture of 25º.
- **Dynamic backrest** - A backrest that moves and provides support as the user changes posture is preferred to a static back.

Controls – Intuitive control placement increases usability so all controls should be easy to operate from the seated position. The ability to correctly operate chair controls also affects comfort. Research shows that most users tend to prefer controls with long levers versus short levers and buttons.

Research also demonstrates that use of adjustments increase with the number of controls, and that chairs with more controls are judged to be the most comfortable. Office workers who receive training on the use of chair controls have significantly higher percentages of adjusting behaviors, and take greater advantage of chair adjustments.

Armrests – For many tasks, arm support reduces upper body fatigue, allows for easier shifts in body position, and makes it much easier to enter and exit the chair. Armrests also help decrease body flexion, which reduces stress in the knee and hip joints during sitting-to-standing transitions. This is especially important for aging workforces.

Armrests should be adjustable in height, width and depth to comfortably support the forearms or elbows while sitting with relaxed shoulders. Armrests should not limit access to the worksurface or any other chair adjustments.

All too often, users adjust their body to the chair rather than adjusting the chair to their body. A recent study found that 61% of 100 Dutch office workers and 24% of 236 Spanish office workers never made any adjustments to their chairs.

**Fitting Exceptional People**

Modern ergonomic office chairs accommodate most but not all users, and significant design changes are sometimes needed to accommodate people at the extremes of anthropometric dimensions. For example, the range of seat height adjustment must change from 10 cm to 24 cm as the design limits are increased to 99.9% of people. Even if a chair had this adjustment range, it would not accommodate individuals with some form of dwarfism or gigantism.

Other physical changes can happen to make normally sized adults exceptional. For instance, after the first three months of pregnancy, body mass and shape change although temporarily. Other changes, such as significant weight gain or loss, can be problematic if the individual is not refitted.

**Challenges for Chair Design**

Even though a chair may be able to adjust over the desired range, this does not guarantee it will always fit a person’s body.
Anthropometric data gives information on skeletal dimensions and overall body characteristics, but it does not address other important factors, such as form, appearance and movement. For example, even though a chair meets all the adjustment criteria, whether it has a woven fabric, plastic, leather or mesh finish can affect comfort.

User behavior will also affect comfort. A study observing eight men and eight women showed that regardless of the chair or task, the average lumbar and trunk angles were more flexed for men than for women, with women sitting with the pelvis rotated anteriorly and men sitting with the pelvis rotated posteriorly.  

A higher lumbar backrest placement and lower upper-back and neck rest placement is better for women than men, and some women need additional space between the seat and the backrest for thigh/hip/buttock clearance. When sitting on a chair with a pivoting seat pan, women position their center of mass and hip joints anterior to the chair pivot point while men locate their center of mass and hip joints posterior to the pivot point. When a backrest is provided, women sit with their center of mass closer to the seat pan center of pressure than do men. Other variables, such as age and health can also influence sitting posture.

Chair image and appearance is also closely related to customer satisfaction. Users distinguish between aesthetics and comfort parameters more easily than between ergonomic features and perceived chair comfort directly correlates with ratings of chair aesthetics. Ultimately, the optimal fit of the chair and the quality of the user’s experience of chair comfort depend on the interactions between user characteristics, the tasks that the user is performing and the chair design.

Today, users can choose from a wide variety of ergonomic chairs and while no chair will be universally well suited to optimally fit all body types, a good chair with appropriate adjustability will provide a comfortable fit for a majority of users. Choosing the best ergonomic chair for the greatest number of users requires knowledge of anthropometric data but also information on body types, user preferences and task demands.

Unfortunately, even when given a good ergonomic chair, many users do not adjust it appropriately. Instead, they adjust their postures inappropriately, increasing the risk of discomfort and back injury.

Complex and awkward controls deter users from making adjustments to their chair. Innovative chair designs that demystify chair adjustments, reduce the apparent complexity of controls, and are supplemented with improved training on the use of chairs and appropriate sitting postures will result in greater comfort for everyone.

References


