Allsteel®

The Advantages of a Perforated Seat with Springs

Exploring the comfort of Inspire™

As students participate in their classes, they should be able to concentrate on what is being taught and not be distracted by the discomfort of their chair. No matter how exciting the subject or the teacher, it is both challenging and ergonomically incorrect to sit perfectly still.

As we sit, the bones in our pelvis (referred to as the ischial tuberosities, or ITs) push against the muscles and tissues in the buttocks. Depending on weight and body dimensions, we may have more or less cushion in this area. Over time, pressure builds up in the IT area, and we feel uncomfortable. Our body shifts positions to alleviate this pressure buildup. A chair that lessens this pressure and faciliates movement can allow for better concentration during learning.

The Allsteel Inspire chair was designed to be such a chair, by relieving pressure and allowing movement for its occupants. The seat is perforated with Y-shaped channels, allowing the seat pan to flex which relieves pressure across the buttocks and thighs. Additionally, four integrated springs between the seat and frame help absorb energy and buffer the movements of the individual in the chair. These features help promote movement and make the sit more comfortable (especially through a long lecture).

A study was conducted to test the design elements of the Inspire chair and assess their impact on measurable comfort. A standard Inspire chair with a perforated seat and four springs (referred to as perforated seat) was tested against a modified Inspire seat without the perforations or springs (referred to as solid seat).

Figure 1

Perforated seat with springs.

Solid seat without springs.

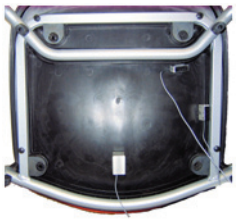
Measurements were taken as participants in the study sat and moved in different positions, simulating "real-world" movements.

Experimental Setup

Two chairs were used in this experiment. They were identical in every way except that the solid seat chair did not have the Y-shaped perforations and the springs to dampen movement. All other aspects of the chair (frames, casters, and backs) were the same. The chairs were instrumented with pressure mapping sensors (Xsensor X2 40:40 pressure maps) on the seat and backrest to measure the amount of distributed pressure the subjects had in these areas of the chair. An accelerometer was attached to the bottom of the seat to measure the dynamics of the seat and springs. There were also two inclinometers attached to the bottom of the seat to measure the angles of the seat during movement.

Figure 2

Pressure mapping pads on seat and back.



Accelerometer mounted on bottom, center of seat. Inclinometers mounted on front left (measures side-to-side) and left side (measures fore-aft) of the seat.

Subjects

Three subjects were used in the study: one female and two males.

Table 1

Study Participants by Height and Weight

Subject	Percentile Height	Percentile Weight
Female 1	1-5%	2-10%
Male 1	10-25%	26-50%
Male 2	90-92%	90-92%

Movements/Postures

Three positions that were used to simulate realistic movements in the chair:

1. Standing and then sitting in the chair.
2. Leaning and picking up/dropping an object while sitting.
3. Sitting with legs in and then out.

Standing/Sitting

Subjects started in the standing position, sat down on the chair, waited for five seconds, and then stood back up again. This cycle was repeated a total of five times. Pressure maps were taken to illustrate pressure distribution on the seat during movements. Accelerometer readings recorded the reaction of the springs to the individual sitting, and inclinometers measured the front and side angles of the seat. The pressure maps and accelerometer readings were mainly used for analysis in this portion of the experiment.

Leaning/Reaching

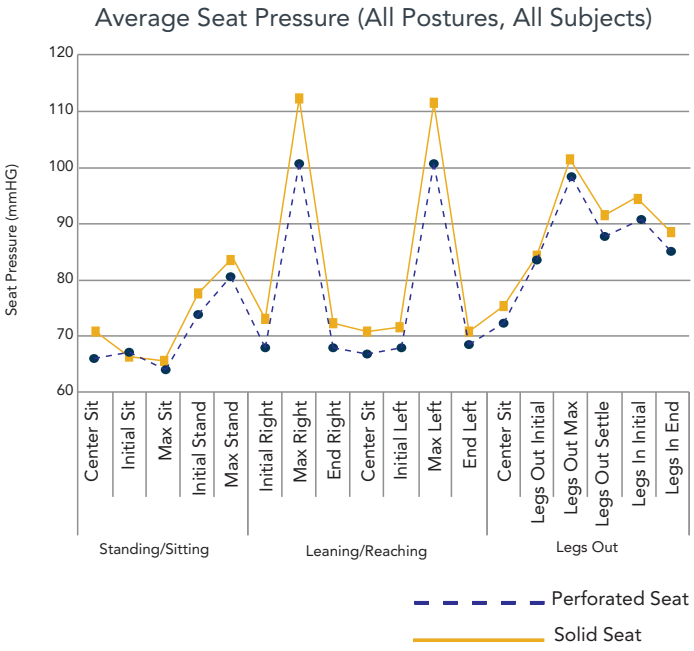
This movement simulated someone leaning in the chair to pick up an item from the floor or side of the chair. From the seated position, subjects reached for an object on the right side of the chair and then placed the object on their left side. This cycle was repeated a total of five times. Pressure maps and inclinometer readings were most important for this posture.

Legs Out

From the seated position, subjects leaned against the backrest and then put their legs forward, simulating a relaxed posture with their legs out. They then moved their legs in. This cycle was repeated a total of five times. Pressure maps and inclinometer readings were important for this posture.

Test Results

Figure 3

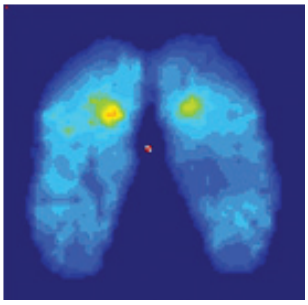


Graph showing the dynamic average pressure mapping values as subjects changed position. The perforated seat had an overall lower average seat pressure than the solid seat.

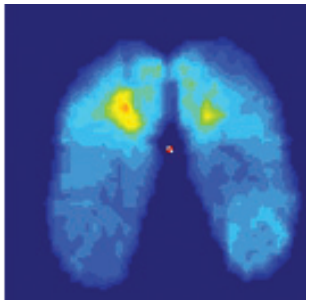
Standing/Sitting

Pressure maps showed that there was a 6% reduction of average pressure for participants when they sat in the perforated seat vs. the solid seat. A reduced average pressure means less pressure on muscles and nerves and the ability to sit with more comfort over time.

Figure 4



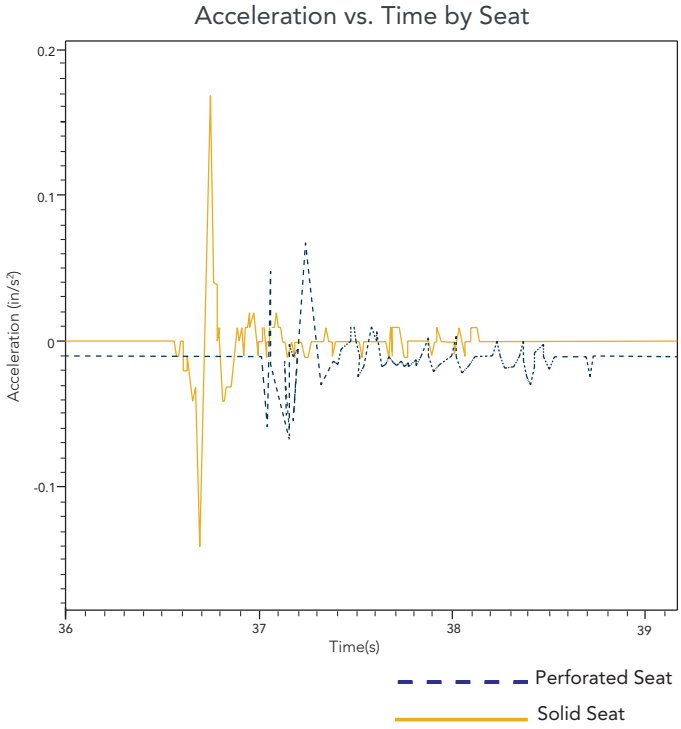
Standing then sitting in perforated seat with springs.



Standing then sitting in solid seat without springs.

The accelerometer readings showed that the springs absorbed the sitting energy in the perforated seat. When participants sat in the solid seat, there were higher peaks and 0.4 seconds less time of energy dissipation. With less time of energy dissipation, the user absorbs the shock of sitting or getting out of the chair instead of allowing the springs to absorb that energy. This can cause more fatigue and discomfort for the individual.

Figure 5



The perforated seat had a lower deceleration rate over a longer period of time because of the four springs suspending the seat. The solid seat had a higher deceleration value over a shorter period of time.

Leaning/Reaching

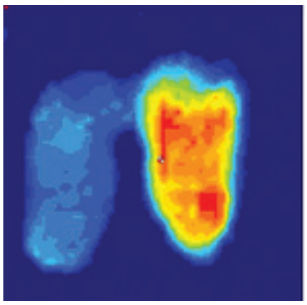
The ideal pressure map contains an even distribution of lower pressure colors and avoids as many of the high pressure colors (red and orange-red) as possible. As participants leaned to the right or left to retrieve or place an object, their pressure maps showed a transfer of high (red) pressure on the side of the chair to which the participant was leaning (see Figure 7). In all trials for all subjects, the perforated seat had less pressure and reduced peaks compared to the solid seat. When comparing the three highest pressure categories between the perforated and solid chairs, there was a 60% reduction of these pressure points in the perforated seat when subjects leaned to the left and right. The dynamic combination of the perforated seat and springs allows for this reduction of high pressure points, which should lead to increased comfort while moving.

Figure 6

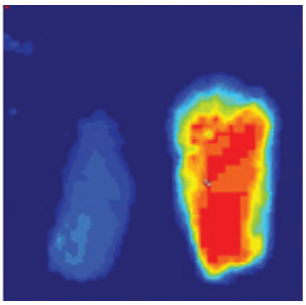
Pressure map coloring scheme. Dark blue is lowest pressure. Blue-green is medium pressure. Red is highest pressure.

The inclinometers also showed more movement in the perforated seat compared to the solid seat. The seat was able to lean two degrees more to each side with the springs, allowing the seat to relieve the pressure under the participant's legs during movement. This lowered the overall pressure felt by the user, as seen in the images in Figure 7.

Figure 7



Leaning to left in perforated seat with springs.

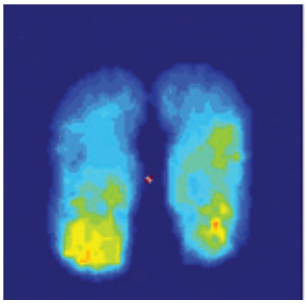


Leaning to left in solid seat without springs.

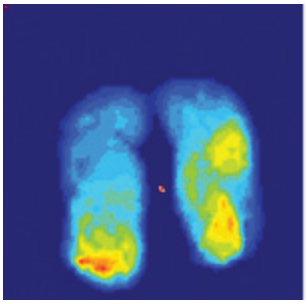
Legs Out

Sitting with the legs out in a relaxed posture produced higher pressure readings on the front edge of the seat (see Figure 8). The solid seat did not show any angular seat movement for the participants and had a higher average and peak pressure reading than the perforated seat design. The inclinometers did not measure any significant differences between the chairs in the fore-aft direction when the legs were extended.

Figure 8



Relaxing posture with legs out in perforated seat with springs.



Relaxing posture with legs out in solid seat without springs.

Conclusions

Three simple experiments were conducted to observe the differences between two chairs: the Inspire seat with Y-shaped perforations and springs and the solid seat without springs. As expected, the Inspire seat outperformed the solid seat in pressure map readings, accelerometer measurements, and inclinometer angles.

Standing/Sitting

The springs in the Inspire seat design allow the chair to move with the individual when he/she sits in the seat and help absorb the energy of sitting, rather than transferring it to the user. Additionally, the fore-aft, left-right, and up-down movements of the seat help make the seat more compliant to the movements of the user. The perforations in the seat help to reduce the sit pressure felt by the individual. Combined, these features should make the Inspire chair more comfortable.

Leaning/Reaching

Polymer seats can be rigid and cause high pressure points and undesirable contact on the edges when users lean to the sides. In the Inspire seat the leaning/reaching posture had lower average and peak pressures compared to the solid seat. Because the energy from movement is absorbed by the springs and not the user's body, the Inspire seat allows the user to feel more comfortable while moving through different postures and positions.

Legs Out

When participants put their feet out, there was less pressure on the front edge of the Inspire seat compared to the solid seat. This means that a user's popliteal area (region behind the back of the knees where blood vessels and nerves run) should experience less discomfort in a relaxed, legs-forward position in the Inspire chair. This reduction in pressure can prevent the legs from falling asleep and make it a better sitting experience for the user.

The Inspire chair's design reduces pressure in both a static and dynamic sit. The springs under the seat and perforated seat design complement each other to make the sitting experience more comfortable for the user. When the user does not have to worry about aches, pains, and discomfort associated with an uncomfortable chair, they will have a greater capability to focus on learning and interacting.

About the Author

Scott Openshaw, M.S., CPE, heads the Ergonomics Group at Allsteel. With an academic background in human biology as well as biomedical and industrial engineering, Scott applies human factors and ergonomics principles to the design of office furniture. Scott has taught rehabilitation engineering at the university level and is currently a doctoral candidate in industrial engineering at the University of Iowa. He is a member of the Human Factors and Ergonomics Society and the Institute of Industrial Engineers. Scott is also a Certified Professional Ergonomist, granted by the Board of Certification in Professional Ergonomics.

Allsteel®

Allsteel Inc.
Muscatine, Iowa 52761-5257

allsteeloffice.com

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Allsteel supports green initiatives in the contract furniture industry as a member of the U.S. Green Building Council. Inspire is an SCS Indoor Advantage™ and level™ certified product.