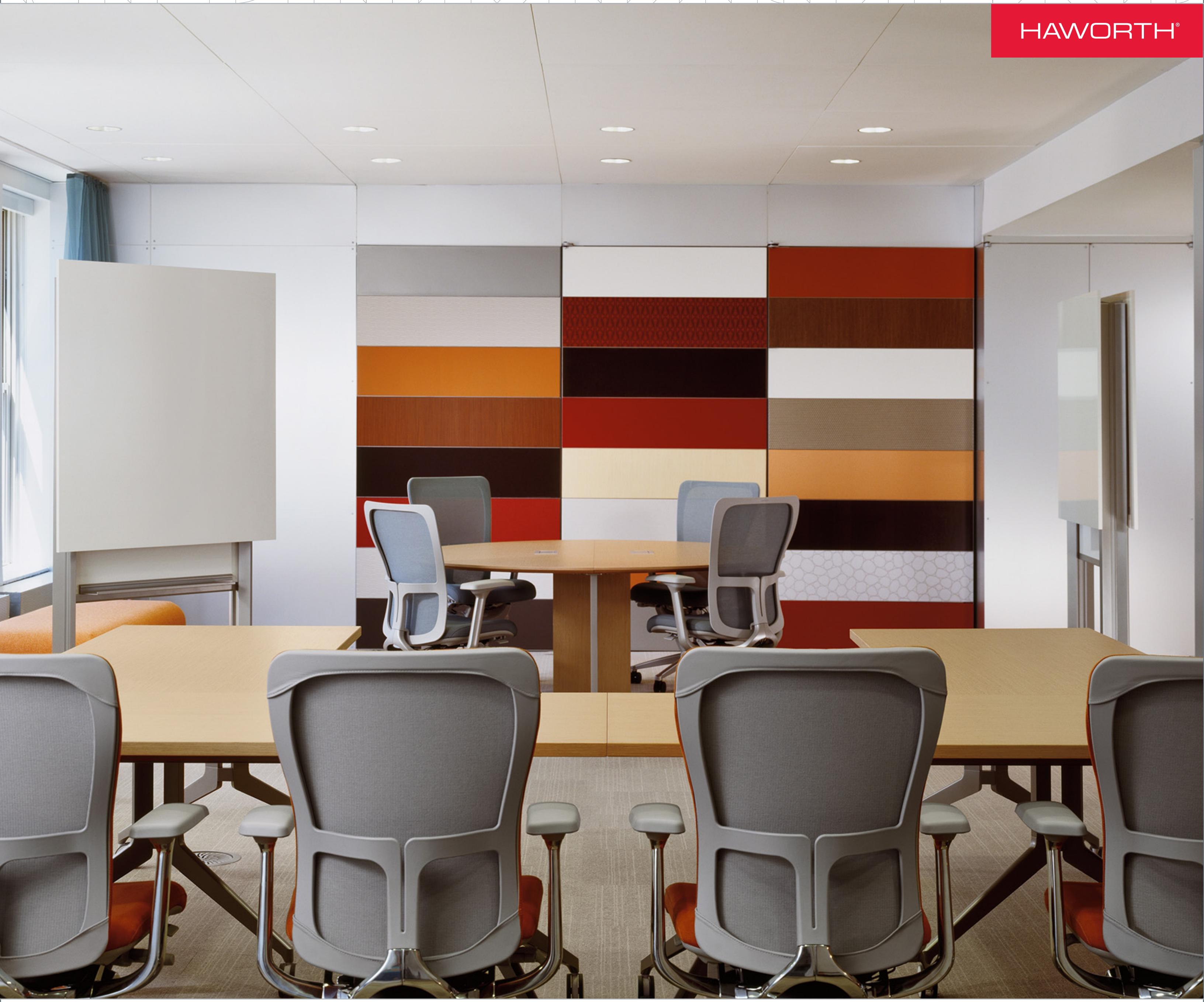

The Research Behind Zody

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More than two years of persistent research and development led to the product design innovations that are Zody. Haworth commissioned the Human Performance Institute at Western Michigan University (WMU) to complete a research study to evaluate and quantify comfort of the low back while sitting in a task chair. Haworth also did extensive research and development internally that complemented as well as utilized the WMU research to help design Zody's lumbar and pelvic support (PAL™) and tension/comfort of the mesh. Research was also conducted on the seat pan and other components of the chair to ensure the overall comfort and usability experience of the chair. Throughout the research, every effort was made to ensure that the comfort components of the chair were consistent with the intended design. The result of all this work is what we have in Zody today: an ergonomically advanced, exceptionally comfortable, sleek, and stylish chair that works with the body, not against it.

INTRODUCTION

Why are some chairs comfortable while others are not? Although we all think we know when we're comfortable, convictions about comfortable seating remain very subjective and elusive. Nonetheless, Zody's research and design team accepted the challenge of creating a new chair that would be more comfortable for more people than its predecessors. Their approach required that the art and science of comfort be integrated — proceeding in parallel and informing each other with lots of "cross-talk." The science thus addressed applied seating issues, and the design tackled problems framed by scientific investigation.

WMU LUMBAR RESEARCH–THE ATTEMPT TO QUANTIFY COMFORT

During the development of Zody, the team decided it wanted this chair to have superior lumbar support to help maintain the lumbar curvature (lordosis) that occurs normally in the spine of the lower back when standing. When seated, the bottom of the back tends to round out as the tailbone is curled under causing the curvature to disappear, which can cause lower back pain when seated. So it is important to maintain the lumbar curvature (lordosis) that occurs normally in the spine of the lower back. To identify these support criteria, the team needed to ask people a question that really hasn't been asked before in seating research - how much support does the person sitting in the chair really want and where do they want it located? In an attempt to quantify this, Haworth undertook a research project with Dr. Tycho Fredericks and Dr. Steve Butt, Human Performance Institute, Department of Industrial & Manufacturing Engineering at Western Michigan University (WMU).

This research focused on identifying the amount of support that users felt provided them maximum comfort in both the upright and reclined torso positions[1]. In order to achieve this, pressure mapping technology was utilized to determine the appropriate pressure and the locations of pressure any given participant might desire in the low back region. A specially designed test chair was developed by Haworth to use in this research (Figure 1).

Figure 1: Experimental Test Chair

The test chair has 35 spring-loaded diodes that can be adjusted to support the low back region (Figure 2). The participants used a self-powered screw-driver via a remote control to adjust the diodes to get the support they wanted in their lower backs. Each diode was individually adjusted by the participant. The threads on the screws were such that the participant could only gradually increase or decrease pressure through changes in the forces applied by the diodes. The diodes were covered by a pressure mapping system.

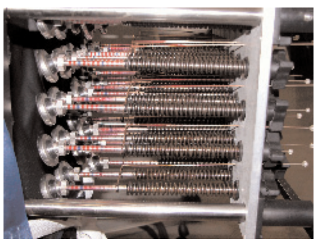

Figure 2: Spring-loaded Diodes

Each subject participated in three trials. During the first and second trial, the diodes were set in an extreme position (fully extended or fully retracted). Participants started the trial by typing for five minutes. After five minutes, the participants were asked to adjust all the diodes on both sides of their backs using the remote control for the screwdriver so they felt the support they were receiving was comfortable. After adjusting the diodes, participants typed for another five minutes and were asked to make any further adjustments they wanted to the support to make it more comfortable. This procedure was repeated until the participant did not want to make any more changes.

At the end of trial one, the participants took a 20 minute break and then repeated the same procedure over again. The third trial occurred three to five days after trials one and two to see if the participant would pick the same level of support as comfortable. The end result was that for all three trials, participants were consistent in the amount of low back support that they preferred.

Initial Findings

- Approximately 70 percent of the participants self selected asymmetrical lower back support to maximize comfort.
- There was a lack of uniformity in desired support.
- Anthropometric variables may have an affect on self-selected low back support.
- Asymmetry in lower back pressure does not correlate with eye or hand dominance. (This study is on-going and will continue through 2006 to further validate the original findings of the study and to collect data that will be utilized in future chair development projects at Haworth.)

As the Zody team continued the development of the lumbar system, it took all of the initial findings from this research into consideration and applied them to the design of the lumbar system for Zody.

Development of Zody's Lumbar Support

The pressure map data helped to quantify the lumbar support characteristics. Figure 3 shows the average of 60 participants' pressure maps. The darker colors indicate where people wanted more support. Numerically, it was found that the participants desired a range of support from two to forty lbs. in their lower back area with an average amount of support between 15 and 16 lbs. When comparing the amount of support participants wanted on either the right or the left sides of their lower backs, there was an average difference of approximately three lbs of support from one side to the other (the range went from zero to seven lbs). Patterns of support as to where participants wanted the support —or did not want support — located on their lower backs were also identified from the pressure maps. One particular area where participants did not want support was on their spines.

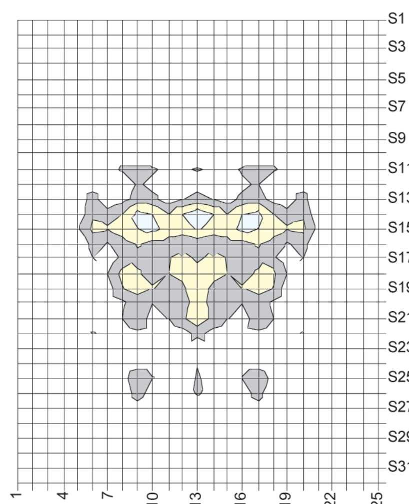

Figure 3: Average of 60 Participant's Pressure Maps

Accordingly, the lumbar support pad for Zody was designed to provide individuals with the range of support they wanted in the areas they wanted it

Table 1: Comparison Amount of Lumbar Support Available Based on Flex/Deflection of Lumbar Support Arm

	Lighter Support	Medium Support	Heavier Support
Amount of Lumbar Arm Deflection	.125"	.25"	.50"
Amount of Lumbar Support – Minimum	2 lbs	5 lbs	13 lbs
Amount of Lumbar Support – Maximum	9 lbs	16 lbs	33 lbs
Asymmetric Difference in Lumbar Support	2.5 lbs max	4 lbs max	7 lbs max

when it worked in combination with the entire support system.
The system includes:

- Back Frame
- Springs in the Adjustment
- Zoned Tension in the Suspension Mesh
- Lumbar Pad

The Lumbar Pad

Based on the data collected from the WMU Lumbar Research, the lumbar mechanism was designed to provide adjustable support and independent adjustment between the left and right side of the pad to accommodate the 5th percentile female to the 95th percentile male. Since the range of support provided is dependent on the degree to which the occupant deflects into the lumbar support system, the data was grouped and analyzed by the amount of support that was desired. The average weight of participants in the WMU Lumbar Research was approximately 160 lbs. At this weight, the lumbar support arm is deflected 0.25". Table 1 shows the range of support as it relates to the lumbar support arm flex.

The lumbar pad was designed so that it responds differently to people based on the amount of support they desire. To ensure that people only receive support where they want it, the lumbar pad is formed of concentric rings that are interconnected by relatively small flexible webs. Each ring is a different thickness with the outer ring being the thinnest and the inner ring being the thickest. This design allows the rings to move independently of the others to allow greater pressure distribution to the back of the user while being able to conform to the proper ergonomic contours. Additionally, the positioning of the connecting webs on the lumbar pad provides support in areas as determined preferable by the participants in the study. The pad responds at lighter support settings by providing a large, uniform support pattern. The pad responds at heavier support settings by providing concentrated areas of support. Zody's lumbar is superimposed over the pressure map to show how the shape of the lumbar pad covers all of the areas where support was desired (Figure 4).

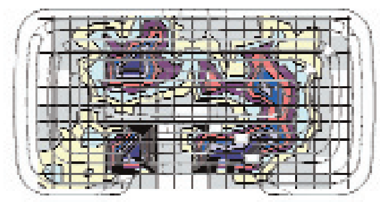

Figure 4: Zody's Lumbar Superimposed Over an Individual Pressure Map

In order to ensure that all of the components of the system worked together to achieve this goal, the pressure map data that WMU collected was used as engineering inputs to Finite Element Analysis (FEA) that was completed to tune the design of the system components. The FEA shows the reaction force that a person would feel as the desired amount of support is applied to his/her back (Figure 5).

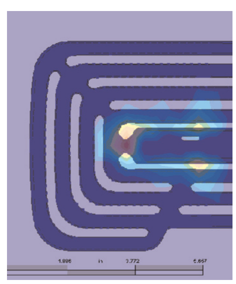

Figure 5: FEA of Reaction Force

The FEA was rerun in combination with design changes to the various system components until all of the components of the system worked together to provide both the amount of support that participants in the study identified as maximizing their comfort and where they wanted the support located. Further validation was completed after all of the components were fine-tuned during the FEA. This consisted of having individuals sit in Zody with the lumbar system in place to validate its comfort and ability for people to achieve the range of support they wanted in the lower back. Zody also provides users the opportunity to select varying amounts of support on either the right or the left sides of their lower backs, which participants in the WMU Lumbar Research self-selected as maximizing their comfort. This is achieved by independently rotating the handles allowing users to adjust the amount of support on either the right or left side of their bodies. The lumbar pad has also been designed so that it can be adjusted vertically along the back of the user — Zody's lumbar has four inches of height adjustability. Ultimately, this combination of adjustments allows the users to more accurately adjust the lumbar support to fit their individual needs.

PELVIC SUPPORT DESIGN AND EVALUATIONS

When sitting, a backward rotation of the pelvis occurs, which decreases a person's lumbar lordosis[2]. This can cause lower back pain when a person is seated. To provide support in the lumbar area, most chairs have adjustable lumbars, which people can adjust in height and depth to help maintain the "normal" curvature of their backs. The Zody development team decided to supplement the lumbar support by designing a pelvic support that would work in combination with the lumbar to keep the pelvis from rotating backwards, and thus help maintain the curvature in the lumbar region of a person's back.

An initial design of the pelvic support was created based on a review of anthropometric data as well as a comparison of the differences in the shapes and sizes of women's and men's pelvises[2, 3, 4, 5]. The initial prototype was made adjustable so that users could provide information on what height they wanted the pelvic support and how much support was comfortable when it was placed on a chair. Individuals were asked to sit in the chair and provide their initial "gut" reaction as to how the pelvic support should be adjusted to meet their comfort needs. It was found that the majority of the people wanted the support at the same height (which was consistent with the review of the anthropometric data). The range of tension and average force that users wanted the pelvic support to have was analyzed. From this analysis, it was determined the pelvic support could be made to meet most users' needs if flexibility was built into it.

The support was also designed to be removable. Prototypes were made using the data collected and additional evaluations were completed in which individuals re-evaluated the nonadjustable pelvic support when it was in the chair. Additional minor changes were made at this time based on comments — specifically from men who were wearing belts — which resulted in the final design of the pelvic support.

BACK (TORSIONAL) FLEX EVALUATIONS

During the development of the Haworth Improv Desk chair, it was found that people prefer some side-to-side torsional flex, which means the backrest follows the user as it moves. This increases mobility and comfort when reaching sideways for objects. Using the norms developed for the Improv Desk, Tas, and other competitive chairs as benchmarks for Zody, it was determined that the ninety-fifth percentile male should be able to deflect the top corner of the backrest approximately two inches. Lighter people will deflect the top corner of the backrest less, but are still able to deflect the top corner. Individuals ranging in size from the fifth percentile female to the ninety-fifth percentile male tested several prototypes to ensure the benchmark was met.

MESH TENSION COMFORT EVALUATIONS

The suspension mesh is the material that the user's back comes in contact with and through which the lumbar support can readily be felt; so it was important to fine tune the mesh to work with the lumbar. Several studies were completed to identify what the upper and lower back mesh tensions should be so that the mesh complemented the lumbar's support. The studies revealed that the optimum mesh tension was not uniform in the upper back and lumbar region of the backrest. This led to the development of a manufacturing system that would allow the mesh to be attached at different tensions along the back frame. Results from the final study indicated the mesh provided good support with and without the lumbar and pelvic support.

SEAT PAN COMFORT STUDIES

Research to determine the importance of seat pan criteria (size, shape, etc.) to the comfort of users started in January 2003. One study included installing seven different prototype seats on the same chair frame to place focus on the seat pan and not on other features of the chair. The chairs also had a mechanism that would provide a similar ride/recline as was intended for Zody. Of the prototype seat pans, four were identified as having potential and were then placed in another study in which they were tested against the seat pan determined to be the comfort target for Zody as well as three competitive seat pans. Again, all of the seat pans were mounted on the same chair frame for comparison. At the end of this study, the seat pan that came closest to the comfort target was selected and further modified until it surpassed the comfort target.

CONTROL AND HANDLE DESIGN

The design and activation of the controls was based on recommendations from ergonomic data[2, 3, 6, 7, 8]. Individuals evaluated all of the controls for their location, size, shape, and feel, how to activate, force to activate, and understandability of icons. Specifically, individuals that had/have hand injuries or poor hand strength were asked to evaluate the controls for ease of activation. Additionally, 5th percentile females were asked to make sure that they could reach and activate all of the controls, and 95th percentile men were asked to make sure that the controls were large enough to accommodate the size of their hands and still allow them to easily activate the controls.

CONCLUSION

In summary, more than two years of persistent research and development led to the product design innovations that are Zody. Haworth commissioned the Human Performance Institute at Western Michigan University to complete a research study to evaluate and quantify comfort. Additionally, Haworth did extensive research and development internally that focused on specific components of the chair as well as its overall comfort. Throughout the research every effort was made to ensure that the comfort components of the chair were consistent with the intended design. The result of all of this work is what we have in Zody today: an ergonomically advanced, exceptionally comfortable, sleek, and stylish chair that works with the body, not against it.

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