TABLE OF CONTENTS

1 INTRODUCTION

Seating is a primary focus of every office environment. It is the first and most essential workstation element that should fit the needs of the user and the tasks at hand. In an ideal world, once the chair meets these needs, the rest of the workstation can be positioned relative to the employee in the chair. Therefore, correct chair design is a critical component in every ergonomic office setting. Proper chair design should encompass the following attributes: adequate support, task efficiency, posture adjustability, and comfort (Treaster and Marras, 1987). Conversely, poor chair design may result in decreased productivity, disgruntled employees, pain and discomfort, and even musculoskeletal disorders.

An essential element crucial to chair design is the seat pan. The primary job of the seat pan is to provide adequate support for the buttocks and thighs. The sitting bones, or bony protrusions in the buttocks known as the ischial tuberosities, are the focal points of pressure due to the weight of the body while seated in a properly adjusted (for height and tilt) seat pan. The tissues surrounding these bones are exposed to extremely high pressures and are the sources of discomfort for seated workers. "The occurrence of high local pressure at the human-seat interface is known to cause soft tissue deformation leading to restricted blood and nutrient flows, and thus human discomfort" (Kumar et al., 1994). Over long periods of time, high-pressure regions can also cause rapid fatigue, pressure sores, cardiovascular problems, and other medical ailments. Uniform distribution of body weight over the entire seat pan is recommended in order to minimize areas of high pressure (Treaster and Marras, 1987; Key et al., 1979; Lindan et al., 1965). Research has also concluded that uniformly distributed body weight over the buttocks region and minimal weight under the thighs results in increased comfort and worker efficiency (Sanders and McCormick, 1987). Therefore, in order to study seated pressure distribution, an accurate form of measurement is important in ergonomic chair design.

Many different efforts have been made over the years in order to quantify seated pressures. Several attempts failed based on levels of sensitivity, spatial resolution, intensity, and analysis tools (Treaster and Marras, 1987). However, the innovation of pressure sensors and transducers lead to more accurate ways to monitor, measure, test, record, and analyze pressure data. Pressure sensors, like the one used in this study, are devices that read pressure changes, convert these changes into data, and relay this data to recorders or switches. The Tekscan™ pressure measurement system used in this study incorporates sensor technology, data acquisition hardware, along with processing and analysis software. The force sensors used in the Tekscan™ pressure mats are extremely thin, grid-based devices specifically designed to test and evaluate seat pans at optimal spatial resolution (sensor spacing). The pressure measurement software also includes calibration and equilibration capabilities in order to accommodate different levels of sensitivity. Data analysis tools provided in the Tekscan™ software allows users to locate areas of interest (high pressure) and displays temporal, force, and pressure characteristics on-screen. The system also performs basic mathematical operations, such as peak pressure distribution, averages, minimums, maximums, and center of force calculations.

1.1 Objective

The primary objective of this investigation was to evaluate the pressure distribution characteristics of seven seat pans and foam types. More specifically, and as outlined in the proposal, the following are detailed objectives of the study:

- To evaluate the differences associated with seat pan contour
- To evaluate the differences associated with foam type
- To evaluate the differences between competitors' products

2 METHOD

2.1 Experimental Design

Task. In order to capture the fundamental job variability in typical office work, four different tasks were performed in the following order during the investigation: upright relaxed sitting, typing, writing, and reading. Standardized materials for typing, writing, and reading tasks were provided. Tasks were performed at an adjustable workstation. Observed postures and document placement were controlled for each task performed in order to provide posture consistency among tasks for every chair.

Independent Variables. Using seven office chairs from three manufacturers, the investigation evaluated the effects of three areas of interest on seated pressure distribution: seat pan contour, foam type, and chair manufacturer. The seat pans varied in seat type, foam type, width, and material thickness (see Table 2.1 and Figure 2.1).

TABLE 2.1: Seating Specifications

Chair #	Seat Type	Foam Type	Seat Pan Width[1] (cm)	Material Compression[2] (cm)
1	BB-J757x (Slab)	Slab foam	51.5	4.0
2	BB-J757, N1 (Slab)	Slab foam	51.5	4.0
3	BB-J2507 (S'port)	S'port foam	53.0	4.0
4	BB-J2507 (Slab)	Slab foam	53.0	4.5
5	BB-J757 (Molded)	Injection mold	51.0	4.0
6	Humanscale (Freedom)	Injection mold polyurethane	46.0	2.0
7	Steelcase (Leap)	Molded urethane	47.0	2.0

[1] Seat pan width: the horizontal distance between outermost edges of seat pan (left and right edges)
[2] Material compression: the vertical distance between the top surface of the seat pan and horizontal line of maximum compression

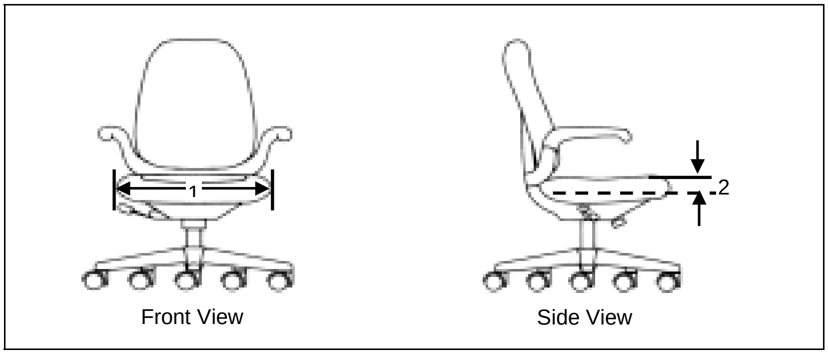


Figure 2.1: Illustration of Chair Dimensions Specified in Table 2.1

Dependent Variables. Two objective and one subjective measures were evaluated for each chair. The two objective measures, average peak pressure and average contact area applied to the buttock, were collected during each of the four tasks using the Tekscan™ pressure measurement system. Once the tasks were complete, the subjective measure of discomfort (in the buttock and thigh region) was evaluated using a discomfort survey. See Appendix H for the discomfort survey template used in this investigation.

2.2 Participants

Thirty subjects (15 male, 15 female) participated in this experiment. Subject's ages ranged from 20 to 54 years with an average age of 29.8 years. Subjects were recruited from the university and surrounding population. In addition to weight and age, six anthropometric measurements were taken. By comparing these data points to standard anthropometric data table, our subject population spans approximately 90% of the American population in each of the six measures recorded.

The mean (std dev) male height was 177.79 (8.76) cm; mean (std dev) male weight was 87.2 (13.9) kg. The mean (std dev) female height was 160.92 (5.08) cm; mean (std dev) female weight was 62.2 (12.5) kg. Therefore, the participant sample size is representative of the general adult population (Stoudt et al., 1965). Summary anthropometric data for the participants is presented in Table 2.2.

TABLE 2.2: Participant Anthropometry

	Height (cm)	**Weight** (kg)	**Age** (yrs.)	**ULL**[1] (cm)	**LLL**[2] (cm)	**Standing HW**[3] (cm)	**Seated HW**[4] (cm)	**Seated EH**[5] (cm)
Total Subjects (n=30)	169.4 (11.1) (152.5-195.2)	74.9 (18.2) (52.7-114)	29.8 (9.7) (20-54)	42.5 (4.2) (34.8-52.3)	41.7 (3.6) (35.3-51.6)	35.9 (2.5) (30.4-43.6)	40.4 (3.2) (33.5-47.5)	61.6 (3.1) (54.4-68.5)
Male Subjects (n=15)	177.8 (8.8) (161.2-195.2)	87.2 (13.9) (67.2-114)	28.7 (9.2) (22-54)	44.5 (3.4) (39.5-52.3)	44.1 (2.9) (39.8-51.6)	36.3 (2.1) (33.6-40.4)	41.3 (3.1) (35.9-46.4)	62.2 (2.8) (58.7-68.5)
Female Subjects (n=15)	160.9 (5.1) (152.5-169.5)	62.2 (12.5) (52.7-99.4)	30.9 (10.4) (20-54)	40.4 (4.0) (34.8-47.3)	39.3 (2.6) (35.3-43.2)	35.4 (2.9) (30.4-43.6)	39.6 (3.2) (33.5-47.5)	60.9 (3.2) (54.4-66.3)

Note: Data is presented as mean values with standard deviations in parentheses and ranges (min-max) below.
[1] Upper leg length: the vertical distance from the trochanter below the hip flexor muscles to the midpoint of the lateral condyle
[2] Lower leg length: the vertical distance from the lateral condyle to the lateral malleolus
[3] Standing hip width: the maximum horizontal distance at the hips while standing
[4] Seated hip width: the maximum horizontal distance at the hips while seated
[5] Elbow height: the vertical distance from the floor to the bottom of the elbow while seated

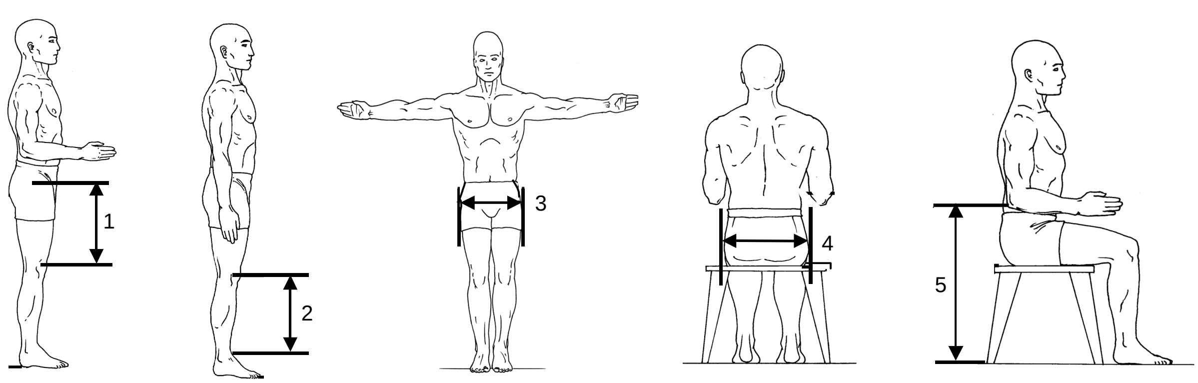


Figure 2.2: Illustration of Anthropometric Dimensions Specified in Table 2.2

2.3 Procedure

Screening Session. Participants were for health concerns and discomfort over the past five years, particularly of the low back region. For example, subjects that experienced chronic or acute pain in the upper or lower back were not eligible for the study. Each subject received standard verbal instructions regarding the experiment and provided written informed consent. Each subject was also informed that he/she could stop the experiment and withdraw from the study at any time. Once instructions were reviewed and consent was granted, anthropometric dimensions were measured.

Test Session. Subjects participated in a single two-hour test session. The session included setup, performance of four office tasks for each of seven different chairs and discomfort survey completion.

Setup included participant changing into "scrub" pants (i.e. with out back pockets or seams across the seatpan) and shirt provided by the experimentor and adjustment of the seat height and workstation setup. Seat height adjustments were then made in order to ensure that the subjects' thighs were parallel to the floor. Participants were asked to keep both feet flat on the floor while performing all tasks. Once the seat height was adjusted, the motorized height adjustable workstation was configured for the subject. The top portion of the workstation, supporting the monitor, was adjusted such that participant's eye height was level with the first line of letters on the monitor screen. The lower portion of the workstation supporting the keyboard and mouse was adjusted such that participant's elbow angle was at approximately 90°, wrists were straight, and shoulders were relaxed while typing (see Figure 2.3). Workstation height was not adjusted between different tasks, but left at the standard heights specified during setup.

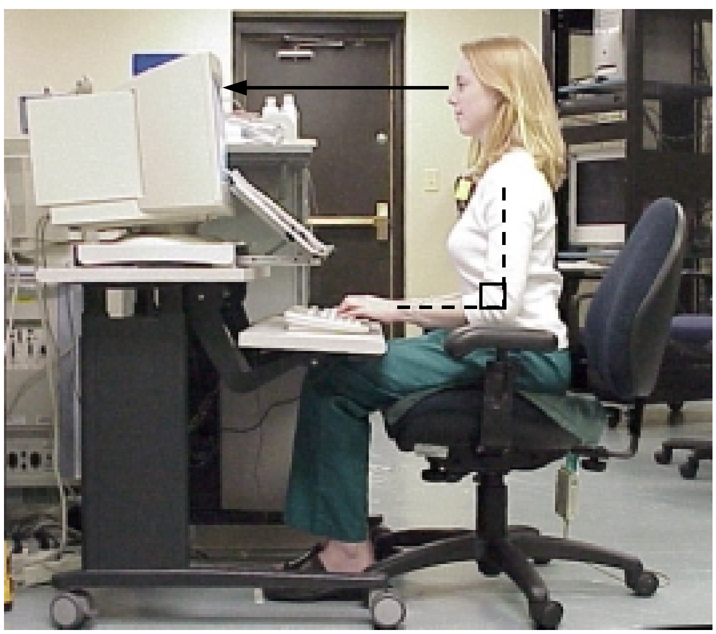


Figure 2.3: Experimental Workstation Setup

Positioning. Participants performed four office tasks for each of seven chairs; upright relaxed sitting, typing, writing, and reading tasks. Each task was performed for approximately 3 minutes in order to acclimate the subject to the task before a 5-second recording was taken. Participants were instructed to sit as far back in the seat pan as possible without their backs touching the backrest or the backs of their legs touching the front of the seat pan. The chairs order was randomized. Participants were allowed to rest between tasks to minimize discomfort and fatigue.

Discomfort. After the last task was performed for each chair, participants were asked to complete a subjective discomfort survey. The survey consisted of rating the discomfort level associated with an individual seat pan and its fit to the buttocks and thighs region. A 0 to 10 rating scale (0.5 increments) was used with the survey; 0 was the lowest level of discomfort and 10 was the highest level of discomfort. Subjects were instructed not to rate the discomfort of their back since no backrests or support was provided during the experiment. The results of the discomfort survey are presented in Table 3.1.

Pressure Distribution. Recordings of instantaneous peak pressure, average peak pressure, average contact area, and noted postures were collected for each task performed in every chair per subject. Both instantaneous and average peak pressures were concentrated primarily around the ischial tuberosities. The recording parameters for measuring both peak pressure and contact area with the Tekscan™ system are presented below in Table 2.3.

TABLE 2.3: Recording Parameters

Frames to Record	**Frequency** (frames/sec)	**Period** (sec/frame)	**Duration** (sec)	**External Sync**	**Noise Threshold**
51	**10**	**0.1**	**5**	**COM2**	**3**

Once all tasks were performed and recordings were documented, participants completed a discomfort survey. Participants were also given a 5-minute break after all tasks were performed and recordings were taken for the first three test chairs.

2.4 Statistical Analysis

In order to assess the effects of seat pan type upon pressure distribution and discomfort, the recorded data were fit with Normal distributions and parameters were compared under the conditions of the study. The Shapiro-Wilk (Goodness of Fit) test for normality and analysis of variance (ANOVA) were performed using the SAS JMP (Version 4.0.4) Statistical Discovery Software. The results from the Shapiro-Wilk test are summarized in Table 2.4. Note: The closer the W value is to 1.0, the closer the residual data of each dependent variable is to meeting the conditions for normality. Refer to Appendix B for detailed statistical analysis of normality.

Table 2.4: Goodness-of-Fit Test Results for Normality (Shapiro-Wilk Test)

Dependent Variable	**W**	**Probability < W**
Average Peak Pressure	0.967966	< 0.0001
Average Contact Area	0.983686	0.1506
Discomfort Rating	0.943843	0.0000

The effect of anthropometric dimensions, tasks, and seat types on peak pressure, contact area, and discomfort was investigated. One-way analysis of variance was performed to determine significant differences between seat types. The differences between seat types were considered significant at $p < 0.05$, based on the Tukey-Kramer means comparison test.

3 RESULTS

The primary focus of this investigation was the effect of seat type on peak pressure, contact area, and discomfort. The results presented in this section show that seat type significantly affected these measures. Still, other parameters were also found to have significant effects. Certain anthropometric dimensions such as weight, gender, upper leg length, seated hip width, and height were factors found to affect pressure distribution and discomfort while seated. Task, however, was not a significant factor in affecting pressure and discomfort measures. The resulting effects of seat type on peak pressure, area, and discomfort are presented in tabular form in Table 3.1 and chart form in Figures 3.1, 3.2, and 3.3.

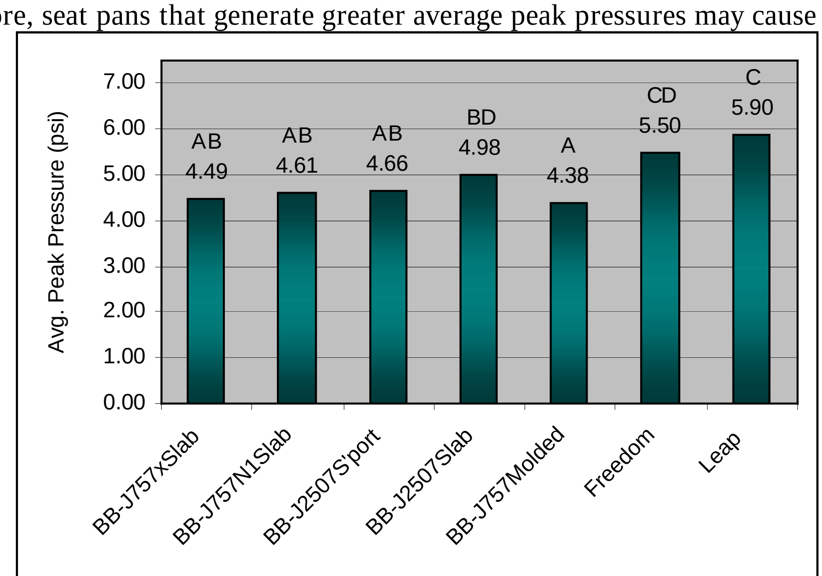
TABLE 3.1: Effects of Seat Type on Peak Pressure, Area, and Discomfort

Chair #	**Seat Type**	**Average Peak Pressure** (PSI)	**Average Contact Area** (in^2)	**Average Discomfort Rating** (0 to 10 scale)
1	BB-J757x (Slab)	4.49 (1.55) AB	233.24 (22.84) A	1.80 (1.28) A
2	BB-J757 N1 (Slab)	4.61 (1.39) AB	239.13 (21.43) A	2.17 (1.67) A
3	BB-J2507 (S'port)	4.66 (1.35) AB	241.41 (21.90) A	1.83 (1.52) A
4	BB-J2507 (Slab)	4.98 (1.46) BD	203.63 (23.30) B	3.45 (2.59) B
5	BB-J757 (Molded)	4.38 (1.38) A	239.71 (21.74) A	2.21 (1.72) A
6	Humanscale (Freedom)	5.50 (1.92) CD	192.71 (24.49) C	3.60 (2.65) B
7	Steelcase (Leap)	5.90 (1.56) C	207.02 (20.90) B	3.11 (2.21) B

Note: Data is presented as mean values with standard deviations in parentheses. The Tukey-Kramer test showed that seat types labeled in groups A, B, C, and D are significantly different between groups.

3.1 Peak Pressure

High average peak pressure applied to the ischial tuberosities and thigh region may result in reduced blood flow and discomfort. Therefore, seat pans that generate greater average peak pressures may cause restricted blood flow and greater discomfort. The seat pan of the Leap Chair by Steelcase produced the greatest average levels of peak pressure about the ischial tuberosities for the buttock and thigh region (see Figure 3.1). The seat pan of the Freedom chair by Humanscale produced the second highest levels of peak pressure as all five of the BodyBilt chairs resulted in significantly lower levels of peak pressure. The BodyBilt J757 Molded seat pan produced the lowest average peak pressure of all seat types. In a pair wise comparison of the five BodyBilt seat pans, one statistically significant difference in average peak pressure was identified



Note: The Tukey-Kramer test showed that chair types that are not statistically different have similar labels (i.e. chairs within group A are not statistically different).

Figure 3.1: Effects of Seat Type on Peak Pressure

between models J757 Molded and J2507 Slab. The average peak pressure of the J2507 Slab seat pan was significantly greater than that of the J757 Molded seat pan, therefore implying that the J757 Molded seat pan was significantly better in reducing peak pressure than the J2507 Slab model for the participants of this study.

Anthropometric dimensions were also found to impact average peak pressure as well. In order of significance, these dimensions were gender, standing hip width, weight, upper leg length, seated elbow height, and height of participants. The results of the ANOVA including the F-ratio and corresponding p-values for determining significance of independent variables on peak pressure are presented in Table 3.2 below (Note: the greater F-ratio, the greater the significance of effect on peak pressure).

Table 3.2: Significant Results from ANOVA for Peak Pressure

Personal Characteristics	Analysis of Variance	
	F-Ratio	Probability > F
Gender	75.32	< 0.0001
Standing Hip Width	61.13	< 0.0001
Weight	43.84	< 0.0001
Upper Leg Length	40.70	< 0.0001
Seated Elbow Height	32.37	< 0.0001
Height	13.46	0.0003

Outlined below are the general effects of participant anthropometry on peak pressure using a one-way ANOVA (See Appendix D for one-way analysis of peak pressure statistics):

- *Gender*. Peak pressure about the buttock and thigh region was significantly higher among male subjects than peak pressure among females. The mean (std dev) peak pressure for male subjects was 5.18 (1.71) psi while the mean (std dev) for female subjects was 4.68 (1.47) psi.

- *Standing hip width*. Excluding a few outliers, statistics identified a positive trend in peak pressure as standing hip width increased.

- *Weight.* In general, as participant weight increased, average peak pressure increased as well.

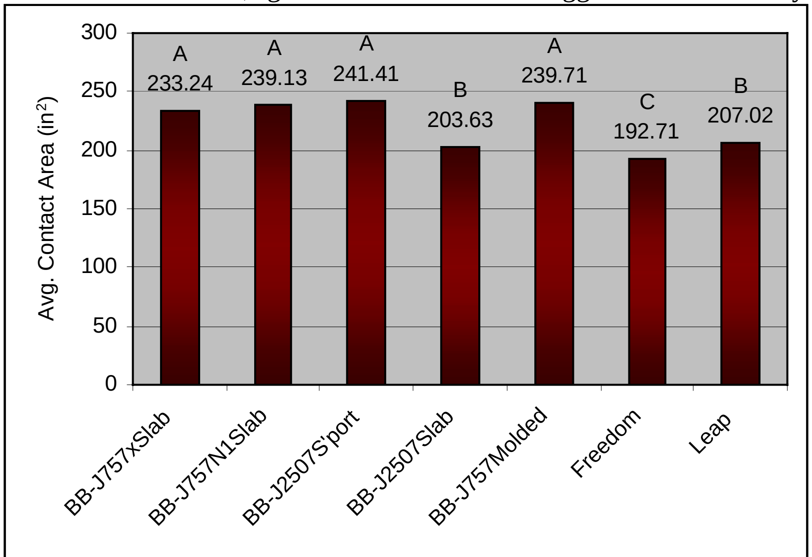
- *Upper leg length*. Analysis of upper leg length also resulted in a positive trend in peak pressure and upper leg length (with the exception of two outliers).

- *Seated elbow height*. Despite the significance of seated elbow height from the analysis of variance, a general trend could not be determined between seated elbow height and peak pressure from the one-way statistics.

- *Height.* One-way analysis of height with peak pressure resulted in similar effects as standing hip width and upper leg length. However, peak pressure seemed to remain somewhat constant about the range of 152 to 180 cm, and then steadily increased from 180 cm to 195 cm.

3.2 Contact Area

Average contact area about the buttocks and thighs to the seat pan provides another means of evaluating pressure distribution and discomfort. In most cases, greater contact area suggests more evenly distributed pressure over a larger area, resulting in decreased peak pressure and increased comfort. The seat pan of the BodyBilt J2507 S'port model produced the greatest average contact area about the buttock and thigh regions while the Freedom seat pan produced the least contact area (see Figure 3.2). All of the BodyBilt seat pans, except for the J2507 Slab model, resulted in significantly higher levels of average contact area than the Humanscale Freedom and Steelcase Leap chairs. Analysis of the five BodyBilt seat pans showed that the BodyBilt J2507 Slab seat pan produced significantly lower levels of contact area than the other four BodyBilt models studied. There were no significant differences in average contact area between the BodyBilt J757x, J757 N1, J2507 S'port, and J757 Molded seat pan models.



Note: The Tukey-Kramer test showed that chair types that are not statistically different have similar labels (i.e. chairs within group A are not statistically different).

Figure 3.2: Effects of Seat Type on Contact Area

As expected, several anthropometric dimensions were found to have an impact on average contact area. In order of significance, these dimensions were seated hip width, weight, lower leg length, gender, seated elbow height, upper leg length, and standing hip width of participants. The results of the ANOVA are presented in Table 3.3 below (Note: the greater F-ratio, the greater the significance of effect on average contact area).

Table 3.3: Significant Results from ANOVA for Contact Area

Personal Characteristics	Analysis of Variance	
	F-Ratio	Probability > F
Seated Hip Width	111.66	< 0.0001
Weight	98.32	< 0.0001
Lower Leg Length	90.75	< 0.0001
Gender	41.01	< 0.0001
Seated Elbow Height	10.84	0.0010
Upper Leg Length	10.60	0.0012
Standing Hip Width	9.66	0.0019

Outlined below are the general effects of participant anthropometry on contact area using a one-way ANOVA (see Appendix E for one-way analysis of contact area statistics):

- *Seated hip width*. As seated hip width increased, subsequent contact area increased.

- *Weight.* As participant weight increased, the corresponding average contact area increased as well.

- *Lower leg length*. There was a small increase in contact area as lower leg length increased.

- *Gender.* Contact area about the buttock and thigh region was significantly greater for male subjects than contact area for females. The mean (std dev) contact area for male subjects was 233.83 (28.08) in^2 while the mean (std dev) for female subjects was 210.99 (25.92) in^2.

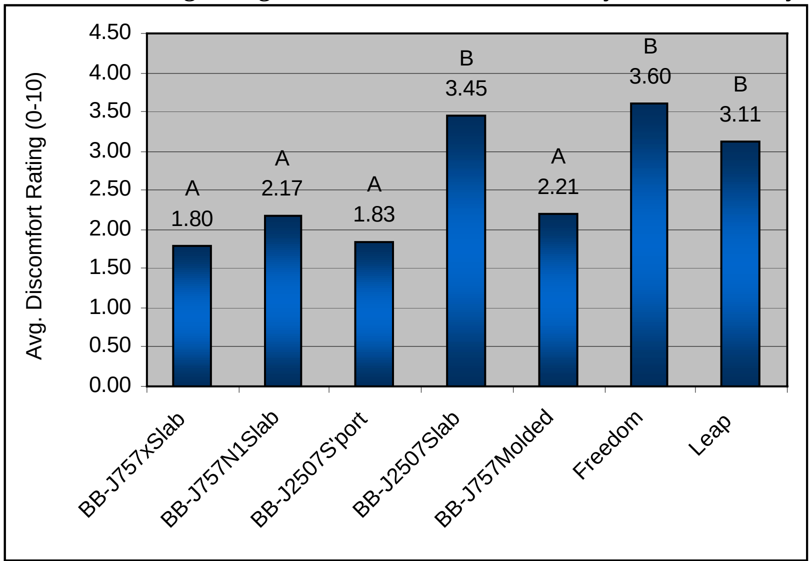
- *Seated elbow height*. Despite the significance of seated elbow height from the analysis of variance, a general trend could not be determined between seated elbow height and contact area from the one-way statistics.

- *Upper leg length*. Analysis of upper leg length showed similar findings as that of lower leg length, resulting in a positive trend in average area and upper leg length (with the exception of two outliers).

- *Standing hip width*. Excluding a few outliers, there was a positive trend in contact area as standing hip width increases.

3.3 Discomfort

Discomfort surveys are subjective measures of preference and discomfort. In this case, subjective discomfort ratings focused on the buttocks and thighs region were recorded and analyzed. Generally, seat pans that exhibit the greatest ratings of discomfort usually correlate with high levels of peak pressure and low levels of contact area. As shown in Figure 3.3, the seat pan of the Freedom chair by Humanscale produced the greatest average levels of discomfort about the buttock and thigh region. However, the BodyBilt J2507 Slab resulted in high average discomfort levels very close to that of the Freedom seat pan. Excluding the BodyBilt J2507 Slab model, the BodyBilt seat pans showed significantly lower ratings of discomfort than the competitor products. Results showed no statistically significant differences in discomfort existing between the BodyBilt models J757x, J757 N1,



Note: The Tukey-Kramer test showed that chair types that are not statistically different have similar labels (i.e. chairs within group A are not statistically different).

Figure 3.3: Effects of Seat Type on Discomfort

J2507 S'port, and J757 Molded. There were no significant differences in discomfort between the BodyBilt J2507 Slab, Humanscale Freedom, and Steelcase Leap seat pans.

Certain anthropometric dimensions were also found to have an impact on average discomfort ratings as well. In order of significance, these dimensions were weight, standing hip width, upper leg length, gender, and age of participants. The results of the ANOVA including the F-ratio and corresponding p-values for determining significance of independent variables on contact area are presented in Table 3.4 below (Note: the greater F-ratio, the greater the significance of effect on discomfort).

Table 3.4: Significant Results from ANOVA for Discomfort

Personal Characteristics	Analysis of Variance	
	F-Ratio	Probability > F
Weight	26.32	< 0.0001
Standing Hip Width	24.13	< 0.0001
Upper Leg Length	13.76	0.0002
Gender	10.77	0.0011
Age	9.27	0.0024

One-way ANOVA only provided one conclusive and significant relationship between the anthropometric dimensions and discomfort. General trends could not be determined between the remaining personal characteristics and discomfort. Outlined below is the general effect of participant gender on subjective discomfort (see Appendix F for one-way trends analysis of discomfort).

- *Gender.* Discomfort ratings about the buttock and thigh region were greater among female subjects than discomfort ratings among male subjects. The mean (std dev) discomfort rating for female subjects was 2.68 (2.14) while the mean (std dev) for male subjects was 2.51 (2.08).

4 DISCUSSION

The objectives of this study were: 1) to evaluate the differences associated with seat pan contour 2) to evaluate the differences associated with foam type and 3) to evaluate the differences between BodyBilt and competitor seat pans. These objectives along with the limitations of this study are discussed in this section.

4.1 Seat Pan Contour

To determine the effects of seat pan contour on pressure distribution and discomfort measures, means comparison tests of average peak pressure, average contact area, and subjective discomfort were performed and analyzed (see Appendix G for detailed Tukey-Kramer means comparison test results). The seat pan types used for analyzing seat pan contour are summarized in Table 4.1.

Table 4.1: Seating Specifications for Seat Pan Contour Analysis

Chair #	Seat Type	Foam Type	Seat Pan Width[1] (cm)	Material Compression[2] (cm)	Pressure Grouping	Contact Area Grouping	Discomfort Grouping
1	BB-J757x (Slab)	Slab foam	51.5	4.0	AB	A	A
2	BB-J757, N1 (Slab)	Slab foam	51.5	4.0	AB	A	A
4	BB-J2507 (Slab)	Slab foam	53.0	4.5	BD	B	B

Note: The Tukey-Kramer test showed that chair types labeled in groups A and B are significantly different between groups.
[1] Seat pan width: the horizontal distance between outermost edges of seat pan (left and right edges)
[2] Material compression: the vertical distance between the top surface of the seat pan and horizontal line of maximum compression

Average Peak Pressure. There were no significant differences in average peak pressures between the specified seat pan types. Therefore, no conclusion can be made as to which seat pan contour was best in reducing average peak pressure between the BodyBilt J757x, J757 N1, and J2507 Slab models.

Average Contact Area. Means comparison results showed significant differences in average contact area between the following pairs of seat types (in order of significance):

- BodyBilt J757 N1 and BodyBilt J2507 Slab. The average contact area about the buttocks and thighs was significantly greater for the J757 N1 model as compared to the J2507 model. This suggests that the contour of the J757 N1 model resulted in a more even distribution of weight than the J2507 model for the range of participants in this study.

- BodyBilt J757x and BodyBilt J2507 Slab. As shown in section 3.2, the average contact area about the buttocks and thighs was significantly greater for the J757x model as compared to the J2507 model. These results suggest that the contour of the J757x model also resulted in a more even distribution of weight than the J2507 model for the range of participants in this study.

However, there were no significant differences in average contact area between the BodyBilt J757x and J757 N1 seat pan models. Thus, it cannot be assumed that the J757 N1 model provides more evenly distributed pressure over the seat pan than the J757x model.

Discomfort Ratings. Significant differences in discomfort were found between the following seat types (in order of significance):

- BodyBilt J757x and BodyBilt J2507 Slab. The average discomfort ratings about the buttocks and thighs were significantly greater for the J2507 model as compared to the J757x model.

- BodyBilt J757 N1 and BodyBilt J2507 Slab. The average discomfort ratings about the buttocks and thighs were significantly greater for the J2507 model as compared to the J757 N1 model.

However, there were no significant differences in discomfort levels between the BodyBilt J757x and J757 N1 seat pan models.

In summary, the contours of the BodyBilt J757x and J757 N1 models are recommended over the J2507 Slab model due to greater levels of average contact area and lower discomfort ratings.

4.2 Foam Type

To determine the effects of foam type on pressure distribution and discomfort measures, means comparison tests of average peak pressure, average contact area, and subjective discomfort were performed and analyzed (see Appendix G for detailed Tukey-Kramer means comparison test results). The seat pan types used for analyzing foam type are summarized in Table 4.2.

Table 4.2: Seating Specifications for Foam Type Analysis

Chair #	Seat Type	Foam Type	Seat Pan Width[1] (cm)	Material Compression[2] (cm)	Pressure Grouping	Contact Area Grouping	Discomfort Grouping
2	BB-J757, N1 (Slab)	Slab foam	51.5	4.0	AB	A	A
3	BB-J2507 (S'port)	S'port foam	53.0	4.0	AB	A	A
5	BB-J757 (Molded)	Injection mold	51.0	4.0	A	A	A

Note: The Tukey-Kramer test showed that chair types labeled in groups A and AB are not significantly different between groups.
[1] Seat pan width: the horizontal distance between outermost edges of seat pan (left and right edges)
[2] Material compression: the vertical distance between the top surface of the seat pan and horizontal line of maximum compression

Average Peak Pressure. There were no significant differences in average peak pressures between the specified seat pan types. Therefore, no conclusion can be made as to which foam type was best in reducing average peak pressure between the BodyBilt slab foam, S'port foam, and injection mold foam.

Average Contact Area. Means comparison results showed no significant differences in average contact area between any of studied foam types. Therefore, no conclusion can be made as to which foam type was best in maximizing the distribution of weight across the seat pan surface.

Discomfort Ratings. No significant differences in discomfort were found between the three identified foam types. Again, no conclusion can be made as to which foam type minimized discomfort for the range of participants in this study.

In summary, foam type did not significantly affect peak pressure, contact area, or discomfort.

4.3 Competitor Comparison

To evaluate the differences between BodyBilt seat pans and those of competitor products, average peak pressure, average contact area, and subjective discomfort were analyzed (see Appendix G for detailed Tukey-Kramer means comparison test results). In this evaluation, the competitor products included the seat pans of the Humanscale Freedom chair and the Leap chair by Steelcase. The seat pan types used for analyzing competitor products are summarized in Table 4.3.

Table 4.3: Seating Specifications for Competitor Product Analysis

Chair #	Seat Type	Foam Type	Seat Pan Width[1] (cm)	Material Compression[2] (cm)	Pressure Grouping	Contact Area Grouping	Discomfort Grouping
1	BB-J757x (Slab)	Slab foam	51.5	4.0	AB	A	A
3	BB-J2507 (S'port)	S'port foam	53.0	4.0	AB	A	A
4	BB-J2507 (Slab)	Slab foam	53.0	4.5	BD	B	B
5	BB-J757 (Molded)	Injection mold	51.0	4.0	A	A	A
6	Humanscale (Freedom)	Injection mold polyurethane	46.0	2.0	CD	C	B
7	Steelcase (Leap)	Molded urethane	47.0	2.0	C	B	B

Note: The Tukey-Kramer test showed that chair types labeled in groups A, B, and C are significantly different between groups.
[1] Seat pan width: the horizontal distance between outermost edges of seat pan (left and right edges)
[2] Material compression: the vertical distance between the top surface of the seat pan and horizontal line of maximum compression

Average Peak Pressure. There were several significant differences in average peak pressures between the BodyBilt and competitor seat pan types below (in order of significance):

- BodyBilt vs. Steelcase. The average peak pressures associated with the Bodybilt seat pans were significantly less than the average peak pressures associated with the Steelcase Leap seat pan. Of the BodyBilt models, the J757 Molded seat pan produced the greatest difference in peak pressure than the Steelcase product, while the J2507 Slab model produced the lowest difference in peak pressure than the Steelcase product. Results indicate that all of the BodyBilt products produced less concentrations of pressure while seated than the Steelcase product for the range of participants in this study.

- BodyBilt vs. Humanscale. Means comparison results also showed significant differences in average peak pressure between BodyBilt and Humanscale seat pans. The average peak pressures applied to all but one of the Bodybilt seat pans were significantly less than the average peak pressure applied to the Humanscale Freedom seat pan. The BodyBilt J2507 Slab model was not significantly different than the Humanscale product. Of the BodyBilt models, the J757 Molded seat pan produced the greatest difference in peak pressure than the Humanscale product, while the J2507 S'port model produced the least significant difference in peak pressure than the Humanscale product. These results indicate that all but one of the BodyBilt products produced less concentrations of pressure while seated than the Humanscale product for the range of participants in this study.

- Humanscale vs. Steelcase. There were no significant differences in average peak pressures between the two competitor seat pan types. Therefore, no conclusion can be made as to which competitor of BodyBilt was best in reducing average peak pressure.

Average Contact Area. Means comparison results showed significant differences in average contact area between the BodyBilt and competitor company seat types (in order of significance):

- BodyBilt vs. Humanscale. There were significant differences in average contact area between Bodybilt and Humanscale Freedom seat pans. The average contact area applied to all of the Bodybilt seat pans were significantly greater than the average contact area applied to the Humanscale Freedom seat pan. Of the BodyBilt models, the J2507 S'port seat pan produced the greatest difference in contact area than the Humanscale product, while the J2507 Slab model produced the least difference in contact area than the Humanscale product. These results indicate that all of the BodyBilt products may afford a more even distribution of body weight over the seat pan than the Humanscale product for the range of participants in this study.

- BodyBilt vs. Steelcase. Means comparison results also showed significant differences in average contact area between BodyBilt and Steelcase seat pans. The average contact areas applied to all but one of the Bodybilt seat pans were significantly greater than the average contact area applied to the Steelcase Leap seat pan. The BodyBilt J2507 Slab model, however, was not significantly different than the Steelcase product in resultant contact areas. Of the BodyBilt models, the J2507 S'port seat pan produced the greatest difference in peak pressure than the Steelcase product, while the J757x model produced the least significant difference in peak pressure than the Steelcase product. These results indicate that all but one of the BodyBilt products may afford a more even distribution of body weight over the seat pan than the Steelcase product for the range of participants in this study.

- Humanscale vs. Steelcase. The average contact area applied to the Steelcase Leap seat was significantly greater than the contact area applied to the Humanscale Freedom seat pan. These results indicate that the Steelcase product may afford a more even distribution of body weight over the seat pan than the Humanscale product for the range of participants in this study. This may be due to a slightly larger seat pan width provided by the Steelcase product.

Discomfort Ratings. Significant differences in discomfort were found between the BodyBilt and competitor seat pan types (in order of significance):

- BodyBilt vs. Humanscale. There were significant differences in average discomfort ratings between Bodybilt and Humanscale seat pans. The average discomfort ratings for all but one of the Bodybilt seat pans were significantly lower than the average discomfort ratings of the Humanscale Freedom seat pan. The BodyBilt J2507 Slab model, however, was not significantly different than the Humanscale product in resultant discomfort ratings. Of the BodyBilt models, the J757x Slab seat pan produced the greatest difference in subjective discomfort than the Humanscale product, while the J2507 Molded model produced the least difference in discomfort level when compared to the Humanscale product. Results indicate that all but one of the BodyBilt seat pans were preferred in terms of comfort over the Humanscale seat pan by the range of users in this study.

- BodyBilt vs. Steelcase. Means comparison results also identified significant differences in average discomfort ratings between BodyBilt and Steelcase seat pans. As shown in section 3.3, the average ratings of all but one of the Bodybilt seat pans were significantly lower than the average discomfort ratings of the Steelcase Leap seat pan. The BodyBilt J2507 Slab model was not significantly different than the Steelcase product in resultant discomfort ratings. Of the BodyBilt models, the J757x Slab seat pan produced the greatest difference in subjective discomfort than the Steelcase product, while the J757 Molded model produced the least significant difference in peak pressure than the Steelcase product. Results indicate that all but one of the BodyBilt seat pans were preferred in terms of comfort over the Steelcase seat pan by the range of users in this study.

- Humanscale vs. Steelcase. Based on the means comparison of Tukey-Kramer Test statistics, there were no significant differences in average discomfort ratings between the two competitor seat pan types. Therefore, no conclusion can be made as to which competitor of BodyBilt was preferred in terms of comfort.

In summarizing the differences between BodyBilt and competitor seat pans, four of the five BodyBilt seat pans are recommended over both Humanscale and Steelcase due to lower levels of peak pressure, greater average contact area, and lower discomfort ratings.

4.4 Limitations

The results of this study should be interpreted with regards to its limitations. First of all, participants with substantial musculoskeletal disorders were not included in this study; therefore, those office workers with such problems were not represented. Secondly, the experiment was based on a relatively short trial time. As such, participants were exposed to different seat pans for only a short period of time. Long-term exposure may have dissimilar effects as the body adapts to different chairs or as task postures change. Lastly, this experiment utilized an ideal height adjustable workstation. At work some individuals may be exposed to workstations that do not adjust to their ideal needs and may be forced to sit in awkward postures while performing their tasks.

5 CONCLUSION

This research demonstrated the dominance of ErgoGenesis office chair seat pans featuring BodyBilt seating solutions over their competitors. With the exception of the J2507 Slab model, the BodyBilt seat pans surpassed competitor seat pans in all categories of analysis, including peak pressure minimization, contact area maximization, and discomfort limitation. The J2507 Slab model, however, produced significantly less positive effects compared to the other BodyBilt models.

The seat pan contours of the BodyBilt J757x and J757 N1 models are recommended over the J2507 Slab model due to greater levels of average contact area and low discomfort ratings. Analysis of foam type showed no significant effect on peak pressure, contact area, or discomfort. Four of the five BodyBilt seat pans were superior to competitor products (Humanscale and Steelcase) due to lower levels of peak pressure, greater contact area, and lower discomfort ratings. Additional research may be needed to further explore the effect of foam type on pressure distribution and discomfort measures.

6 REFERENCES

Key, A.G., Manley, M.T., and Wakefield, E. (1978–79). Pressure redistribution in wheelchair cushion for paraplegics: its application and evaluation, *Paraplegia*, 16, 403–412.

Kumar, A., Bush, N.J., and Thakurta, K. (1994). Characterization of occupant comfort in automotive seats. *IBEC 94*, Automotive Body Interior and Safety Systems.

Lindan, O., Greenway, R.W., and Piazza, J.M. (1965). Pressure distribution on the surface of the human body: I. Evaluation in lying and sitting positions using a bed of springs and nails, *Archive of Physical Medicine and Rehabilitation*, May, 378–385.

Sanders, M.S. and McCormick, E.J. (1987). *Human Factors in Engineering Design*, McGraw-Hill, New York.

Sember, J.A. (1994). *Hard Facts About Soft Machines: The Ergonomics of Seating*. In: Rani Lueder and Kageyu Noro (Eds.), Taylor & Francis, London.

Stoudt, H.W., Damon, A., McFarland, R.A., and Roberts, J. (1965). Weight, height, and selected body dimensions of adults 1960 – 1962. *Public Health Service Publication No. 1000* – Series 11, No. 8, Dept. of Health, Education, and Welfare, National Center for Health Statistics, Washington, D.C.

Treaster, D. (1987). Measurement of seat pressure distribution, *Human Factors*, 29, 563–575.

Wu, X., Rakheja, S., and Boileau, P.-É. (1998). Study of human – seat interface pressure distribution under vertical vibration, *International Journal of Industrial Ergonomics*, 21, 433–449.

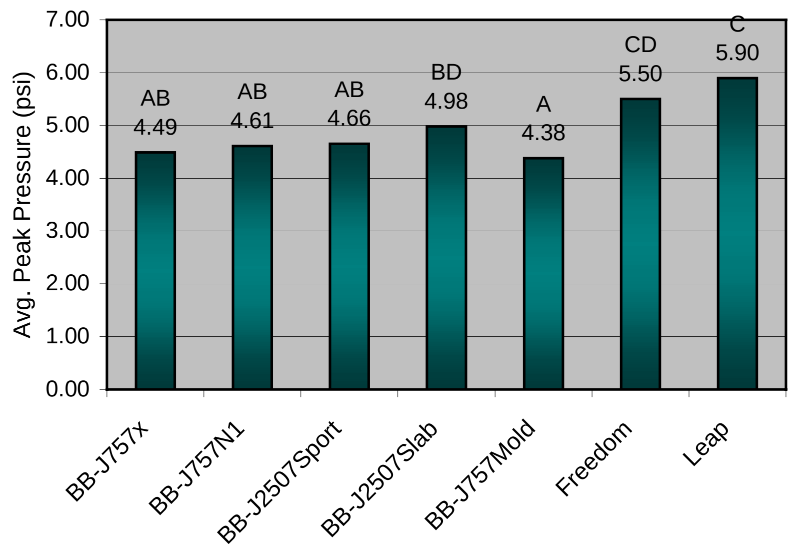
Appendix A – Effects of Seat Type on Dependent Variables

TABLE A.1: Effects of Seat Type on Average Peak Pressure

Chair #	**Seat Type**	**Average Peak Pressure** (PSI)
1	BB-J757x (Slab)	4.50 (1.60) AB
2	BB-J757, N1 (Slab)	4.57 (1.39) AB
3	BB-J2507 (S'port)	4.68 (1.39) AB
4	BB-J2507 (Slab)	5.00 (1.50) BD
5	BB-J757 (Molded)	4.31 (1.39) A
6	Humanscale (Freedom)	5.51 (1.97) CD
7	Steelcase (Leap)	5.83 (1.57) C

Note: Data presented as mean values with standard deviations in parentheses.
Note: The Tukey-Kramer test showed that chair types that are not statistically different have similar labels (i.e. groups A and AB are not statistically different)

Figure A.1: Effects of Chair Type on Peak Pressure



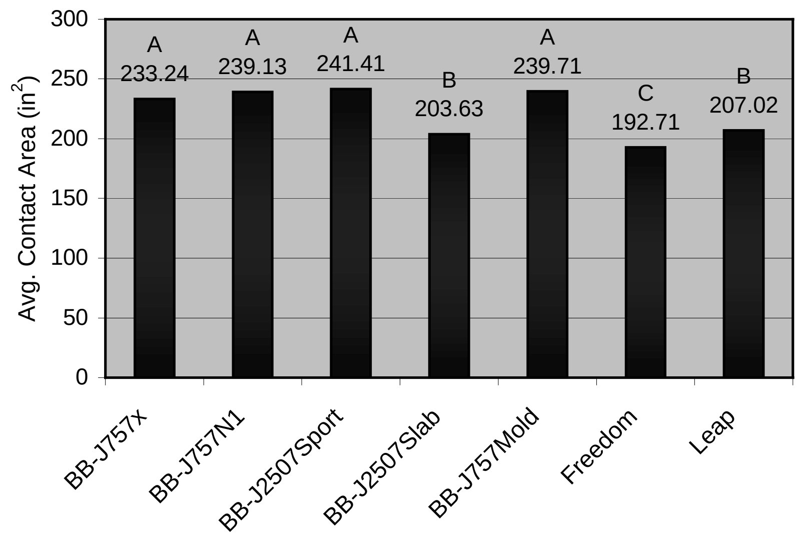
Note: The Tukey-Kramer test showed that chair types labeled in groups A, B, and C are significantly different between groups.

TABLE A.2: Effects of Seat Type on Average Contact Area

Chair #	Seat Type	Average Contact Area (in^2)
1	BB-J757x (Slab)	231.84 (22.93) A
2	BB-J757, N1 (Slab)	238.00 (21.72) A
3	BB-J2507 (S'port)	240.78 (22.51) A
4	BB-J2507 (Slab)	201.85 (22.87) B
5	BB-J757 (Molded)	238.76 (22.08) A
6	Humanscale (Freedom)	191.06 (24.45) C
7	Steelcase (Leap)	205.12 (20.26) B

Note: Data presented as mean values with standard deviations in parentheses. The Tukey-Kramer test showed that seat types labeled in groups A, B, C, and D are significantly different between groups.

Figure A.2: Effects of Chair Type on Contact Area



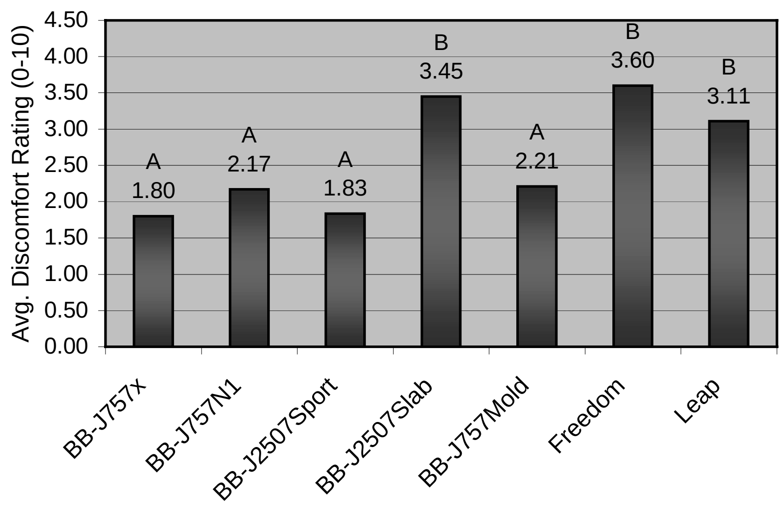
Note: The Tukey-Kramer test showed that chair types labeled in groups A, B, and C are significantly different between groups.

TABLE A.3: Effects of Seat Type on Subjective Discomfort

Chair #	**Seat Type**	**Discomfort Rating** (0 – 10)
1	BB-J757x (Slab)	1.89 (1.27) A
2	BB-J757 (Slab)	1.96 (1.30) A
3	BB-J2507 (S'port)	1.95 (1.51) A
4	BB-J2507 (Slab)	3.43 (2.68) B
5	BB-J757 (Molded)	2.21 (1.78) A
6	Humanscale (Freedom)	3.75 (2.65) B
7	Steelcase (Leap)	3.04 (2.26) B

Note: Data presented as mean values with standard deviations in parentheses. The Tukey-Kramer test showed that seat types labeled in groups A, B, C, and D are significantly different between groups.

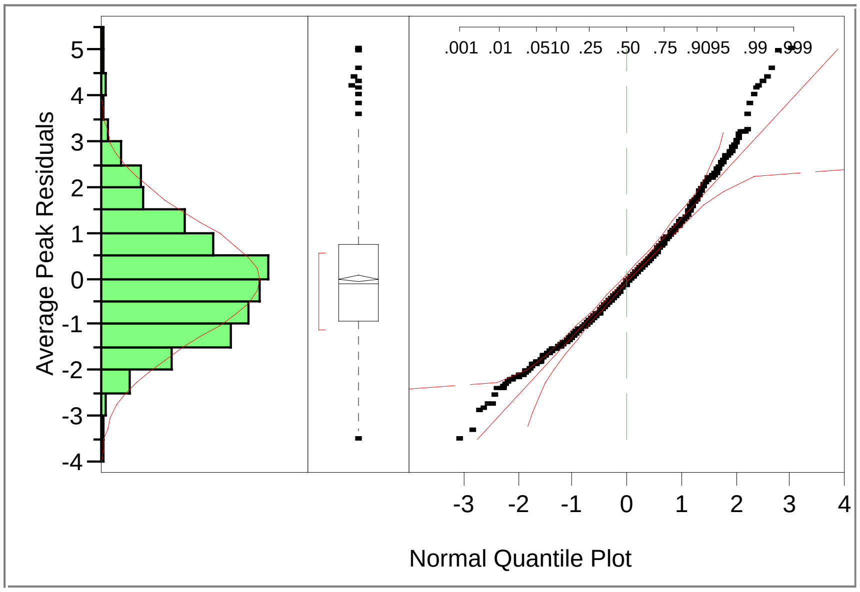
Figure A.3: Effects of Chair Type on Discomfort



Note: The Tukey-Kramer test showed that chair types labeled in groups A and B are significantly different between groups.

Appendix B – Normality Analysis of Dependent Variables

Figure B.1: Normal Distribution Residuals for Average Peak



Normal(-2e-15,1.29213)

Quantiles

100.0%	maximum	5.039
99.5%		4.419
97.5%		2.867
90.0%		1.714
75.0%	quartile	0.764
50.0%	median	-0.118
25.0%	quartile	-0.937
10.0%		-1.535
2.5%		-2.130
0.5%		-2.820
0.0%	minimum	-3.509

Moments

Mean	-1.89e-15
Std Dev	1.29213
Std Err Mean	0.0445827
upper 95% Mean	0.0875068
lower 95% Mean	-0.087507
N	840

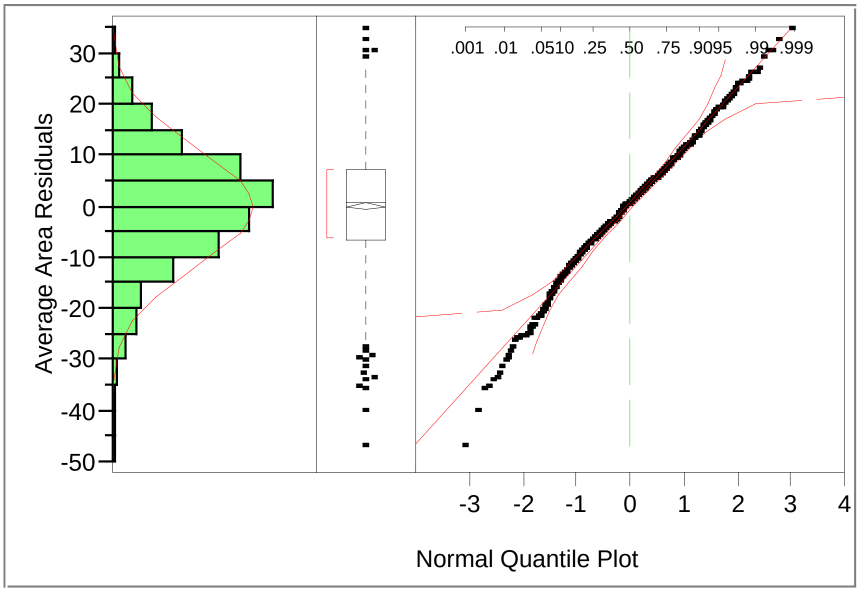
Fitted Normal
Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	-0.00000	-0.08751	0.087507
Dispersion	Sigma	1.29213	1.23316	1.357070

Goodness-of-Fit Test
Shapiro-Wilk W Test

W		Prob<W
0.967966		<.0001

Figure B.2: Normal Distribution Residuals for Average Contact Area



Normal(-3e-13,11.5376)

Quantiles

100.0%	maximum	34.77
99.5%		30.39
97.5%		22.28
90.0%		13.86
75.0%	quartile	7.15
50.0%	median	0.53
25.0%	quartile	-6.49
10.0%		-14.29
2.5%		-25.31
0.5%		-34.83
0.0%	minimum	-46.73

Moments

Mean	-2.82e-13
Std Dev	11.537604
Std Err Mean	0.3980852
upper 95% Mean	0.7813598
lower 95% Mean	-0.78136
N	840

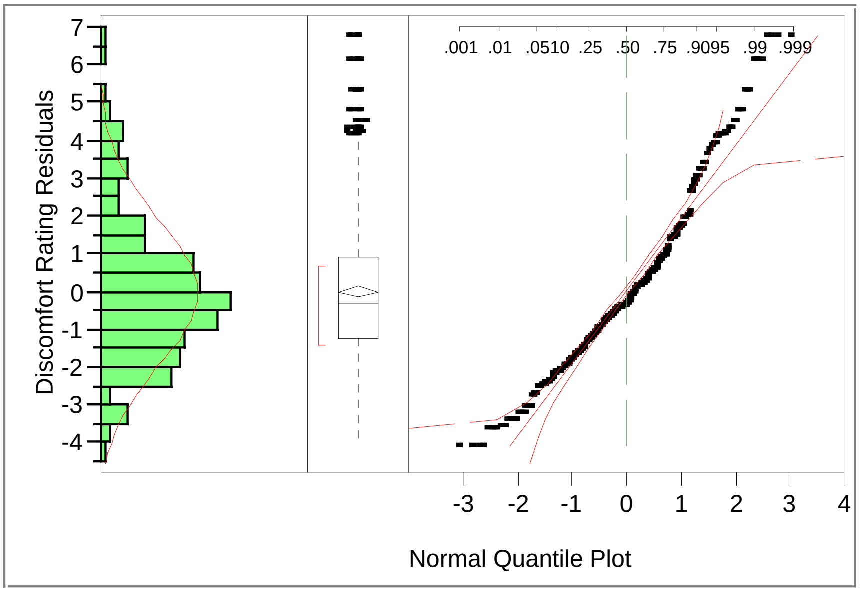
Fitted Normal
Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	-0.0000	-0.7814	0.78136
Dispersion	Sigma	11.5376	11.0110	12.11746

Goodness-of-Fit Test
Shapiro-Wilk W Test

W		Prob<W
0.983686		0.1506

Figure B.3: Normal Distribution Residuals for Discomfort Rating



Normal(-3e-14,1.92861)

Quantiles

100.0%	maximum	6.818
99.5%		6.685
97.5%		4.361
90.0%		2.958
75.0%	quartile	0.910
50.0%	median	-0.323
25.0%	quartile	-1.258
10.0%		-2.138
2.5%		-3.221
0.5%		-3.971
0.0%	minimum	-4.073

Moments

Mean	-2.84e-14
Std Dev	1.9286101
Std Err Mean	0.0665434
upper 95% Mean	0.130611
lower 95% Mean	-0.130611
N	840

Fitted Normal
Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	-0.00000	-0.13061	0.130611
Dispersion	Sigma	1.92861	1.84059	2.025538

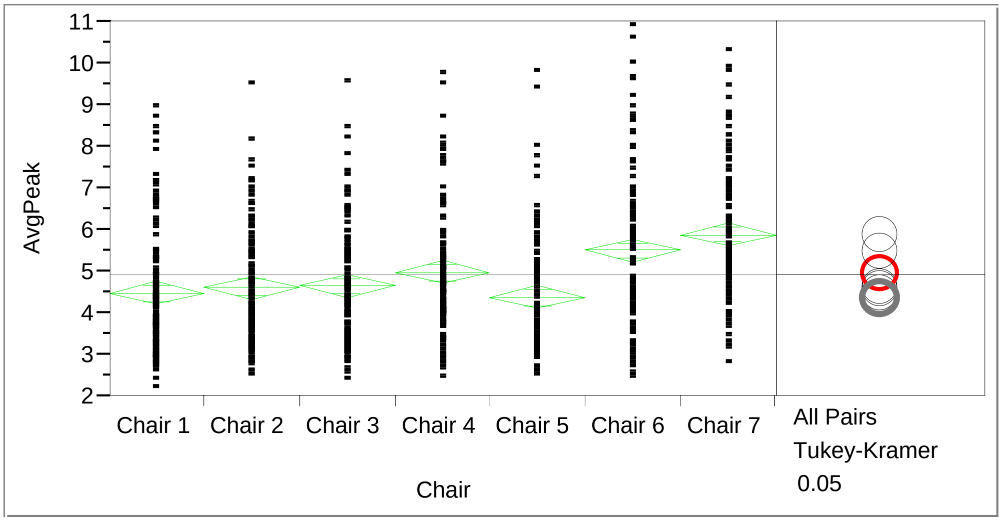
Goodness-of-Fit Test

Shapiro-Wilk W Test

W		Prob<W
0.943843		0.0000

Appendix C – One-way Analysis of Dependent Variables by Seat Type Data

Figure C.1: One-way Analysis of Average Peak Pressure By Seat Type



Oneway ANOVA

Summary of Fit

Rsquare	0.107077
Adj Rsquare	0.100645
Root Mean Square Error	1.528167
Mean of Response	4.930512
Observations (or Sum Wgts)	840

Analysis of Variance

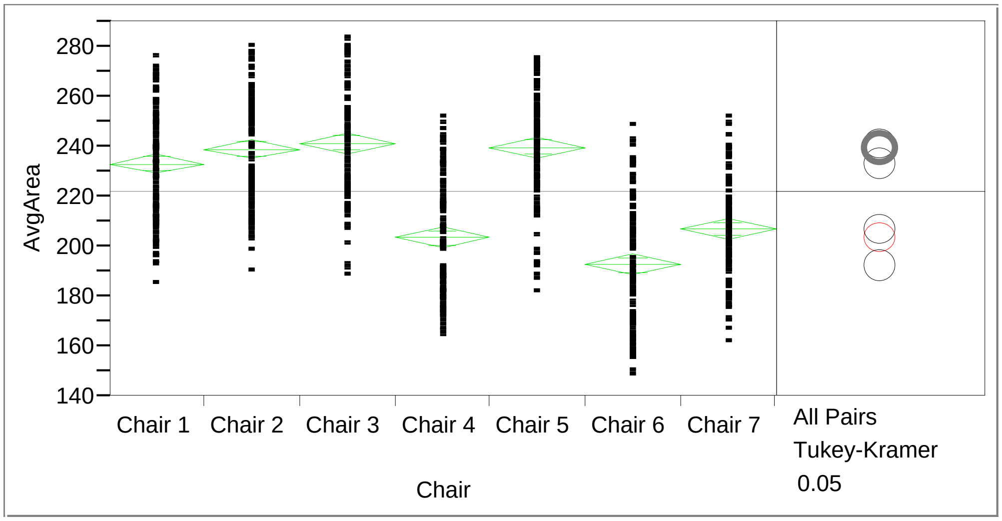
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Chair	6	233.2746	38.8791	16.6485	<.0001
Error	833	1945.3005	2.3353		
C. Total	839	2178.5751			

Means for Oneway ANOVA

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
BB-J757x (Slab)	120	4.49133	0.13950	4.2175	4.7651
BB-J757N1 (Slab)	120	4.60775	0.13950	4.3339	4.8816
BB-J2507 (S'port)	120	4.65508	0.13950	4.3813	4.9289
BB-J2507 (Slab)	120	4.98183	0.13950	4.7080	5.2556
BB-J757 (Molded)	120	4.37792	0.13950	4.1041	4.6517
Humanscale (Freedom)	120	5.50067	0.13950	5.2269	5.7745
Steelcase (Leap)	120	5.89900	0.13950	5.6252	6.1728

Std Error uses a pooled estimate of error variance

Figure C.2: One-way Analysis of Average Area By Seat Type



One-way ANOVA

Summary of Fit

Rsquare	0.420636
Adj Rsquare	0.416463
Root Mean Square Error	22.39934
Mean of Response	222.4069
Observations (or Sum Wgts)	840

Analysis of Variance

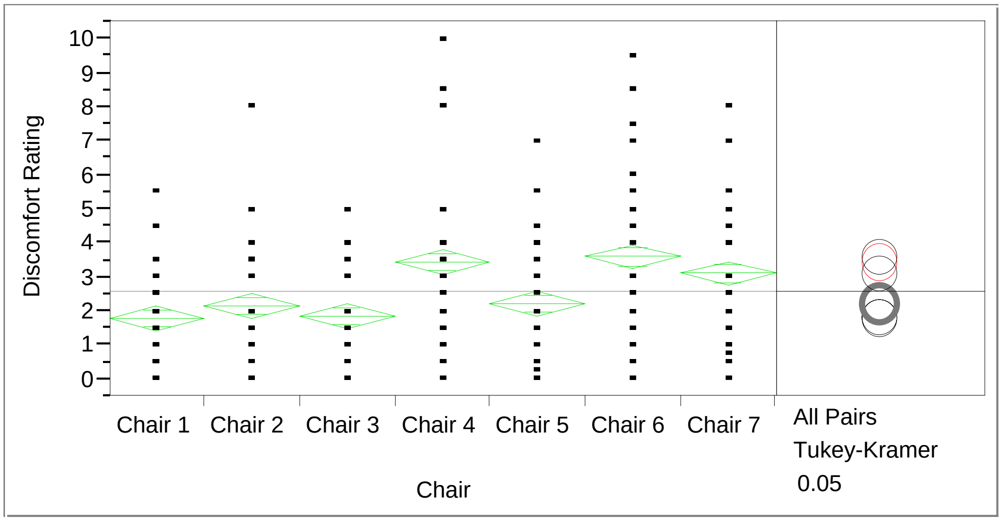
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Chair	6	303438.50	50573.1	100.7973	<.0001
Error	833	417941.51	501.7		
C. Total	839	721380.00			

Means for One-way ANOVA

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
BB-J757x (Slab)	120	233.239	2.0448	229.23	237.25
BB-J757N1 (Slab)	120	239.135	2.0448	235.12	243.15
BB-J2507 (S'port)	120	241.406	2.0448	237.39	245.42
BB-J2507 (Slab)	120	203.631	2.0448	199.62	207.64
BB-J757 (Molded)	120	239.708	2.0448	235.69	243.72
Humanscale (Freedom)	120	192.709	2.0448	188.70	196.72
Steelcase (Leap)	120	207.021	2.0448	203.01	211.03

Std Error uses a pooled estimate of error variance

Figure C.3: One-way Analysis of Discomfort Rating By Seat Type



One-way ANOVA

Summary of Fit

Rsquare	0.114912
Adj Rsquare	0.108537
Root Mean Square Error	1.98461
Mean of Response	2.595238
Observations (or Sum Wgts)	840

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Chair	6	425.9643	70.9940	18.0249	<.0001
Error	833	3280.9167	3.9387		
C. Total	839	3706.8810			

Means for One-way ANOVA

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
BB-J757x (Slab)	120	1.80000	0.18117	1.4444	2.1556
BB-J757N1 (Slab)	120	2.16667	0.18117	1.8111	2.5223
BB-J2507 (S'port)	120	1.83333	0.18117	1.4777	2.1889
BB-J2507 (Slab)	120	3.45000	0.18117	3.0944	3.8056
BB-J757 (Molded)	120	2.20833	0.18117	1.8527	2.5639
Humanscale (Freedom)	120	3.60000	0.18117	3.2444	3.9556
Steelcase (Leap)	120	3.10833	0.18117	2.7527	3.4639

Std Error uses a pooled estimate of error variance

Appendix D – Plots of One-way Analysis of Peak Pressure by Residuals

Figure D.1: One-way Analysis of Average Peak By Gender

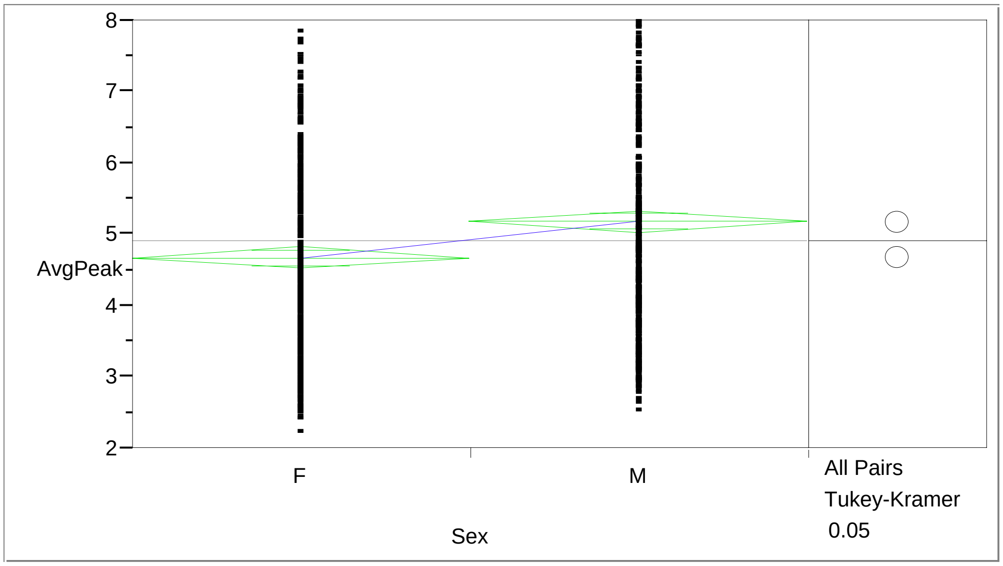


Figure D.2: One-way Analysis of Average Peak By Standing Hip Width (Stand HW)

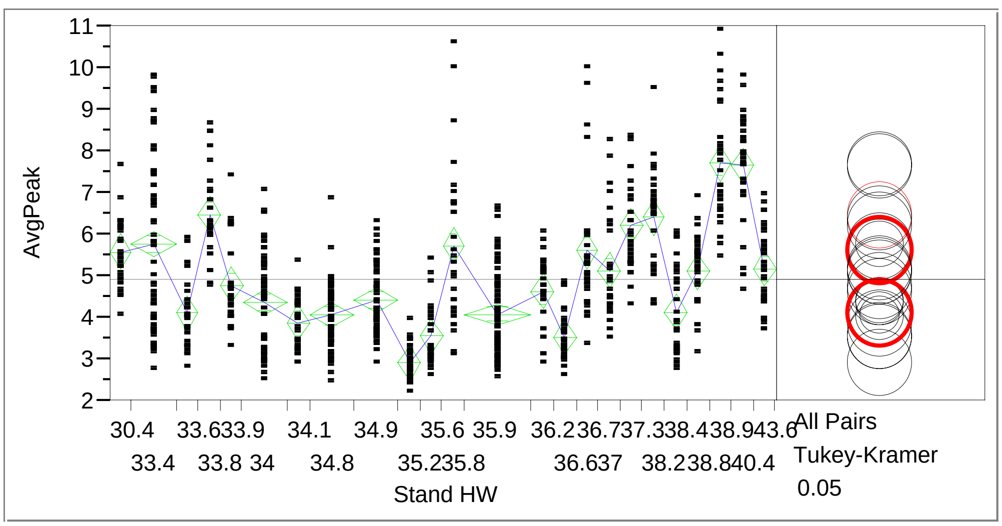


Figure D.3: One-way Analysis of Average Peak By Weight

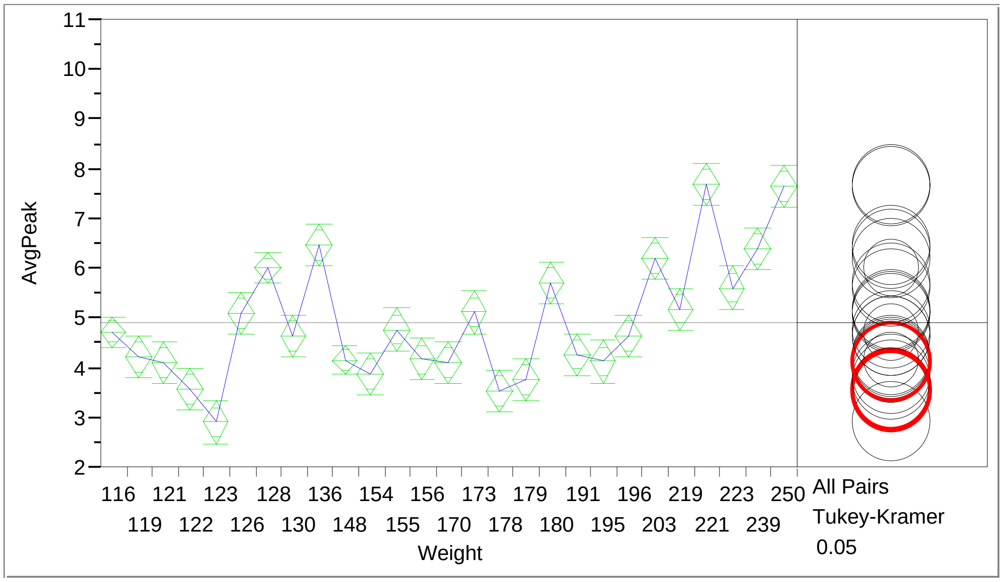


Figure D.4: One-way Analysis of Average Peak By Upper Leg Length (ULL)

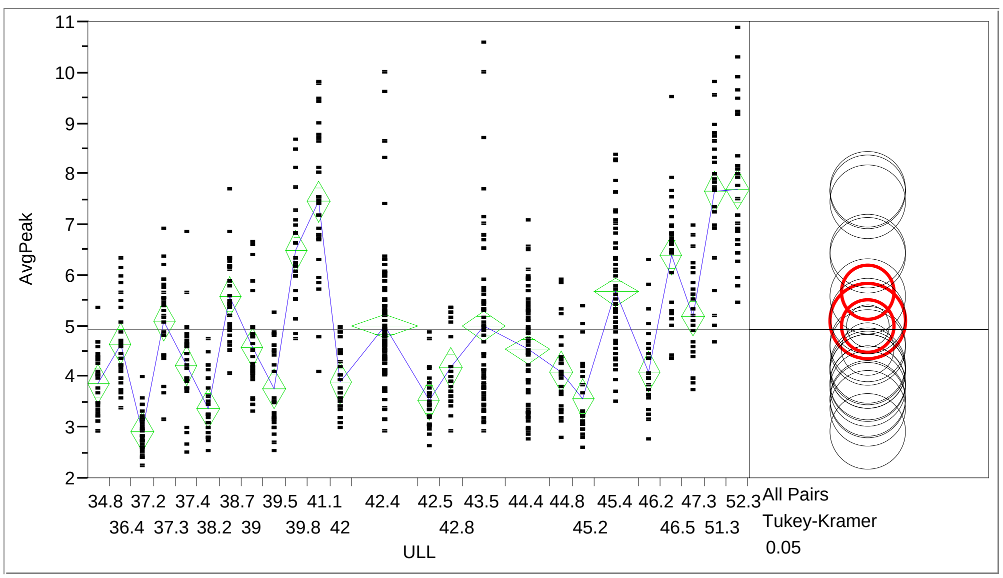


Figure D.5: One-way Analysis of Average Peak By Seated Elbow Height (Seat EH)

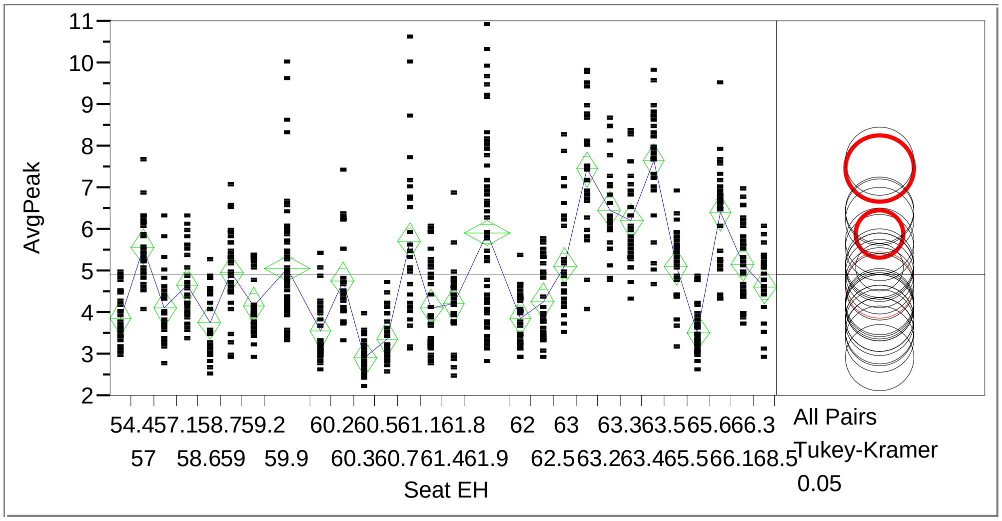
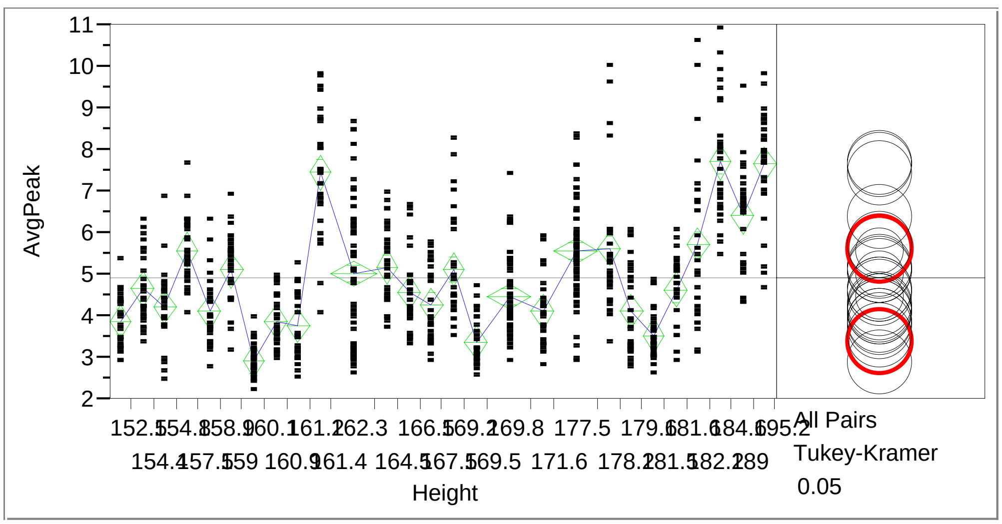


Figure D.6: One-way Analysis of Average Peak By Height



Appendix E – Plots of One-way Analysis of Contact Area by Residuals

Figure E.1: One-way Analysis of Average Area By Seated Hip Width (Seated HW)

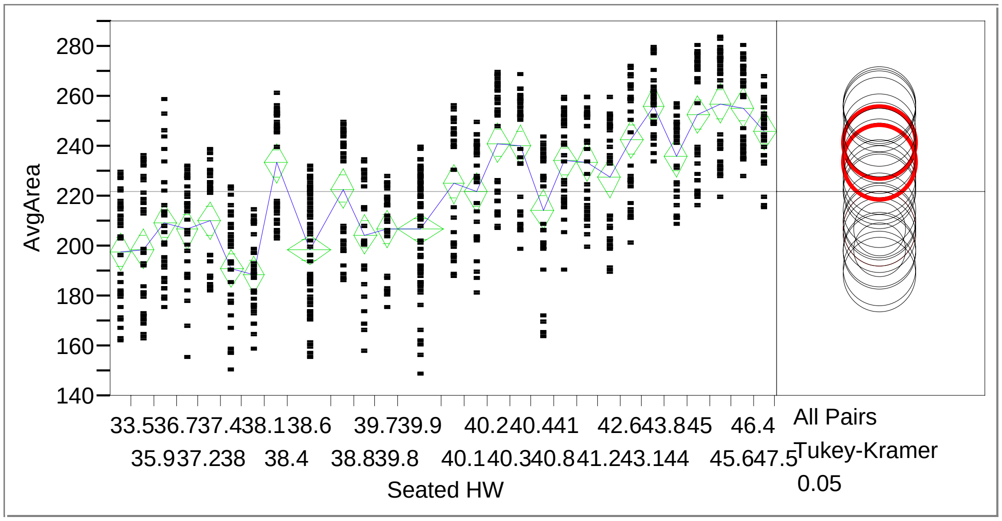


Figure E.2: One-way Analysis of Average Area By Weight

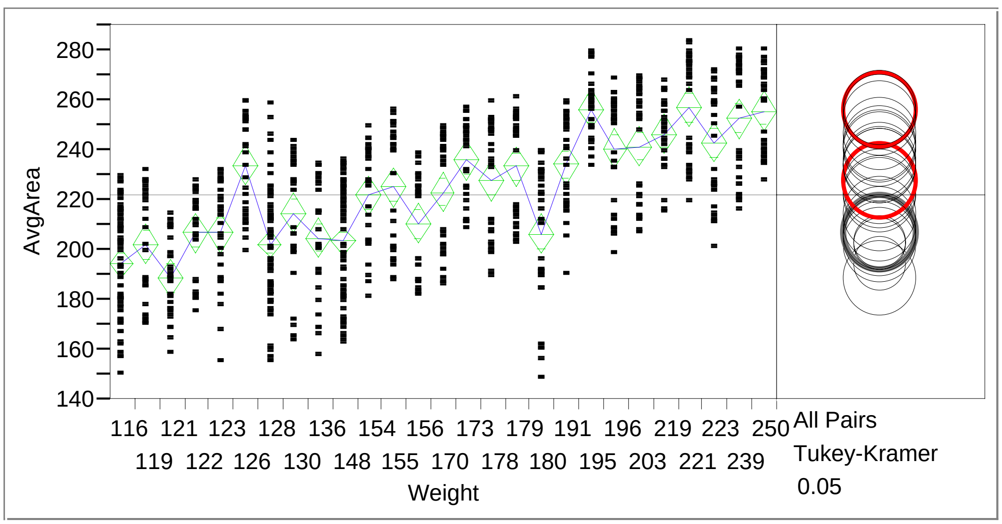


Figure E.3: One-way Analysis of Average Area By Lower Leg Length (LLL)

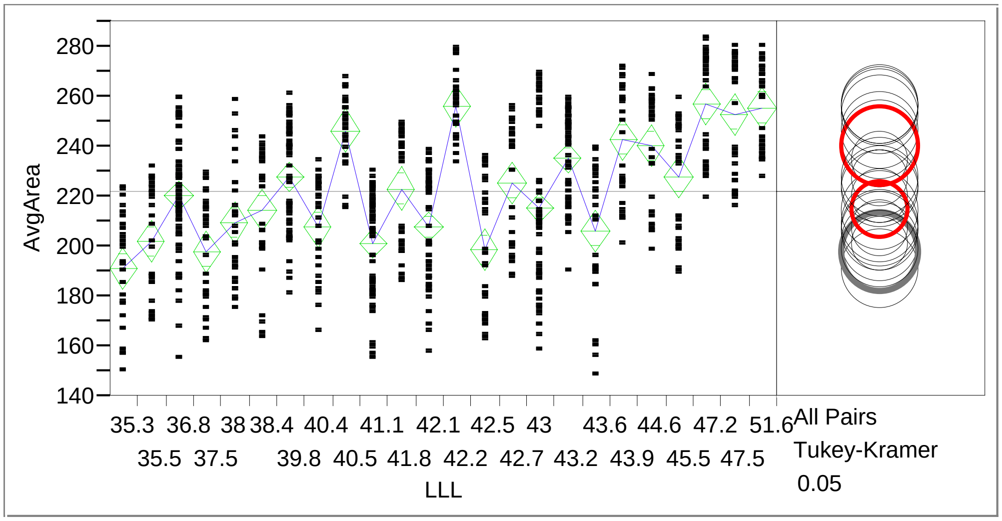


Figure E.4: One-way Analysis of Average Area By Gender

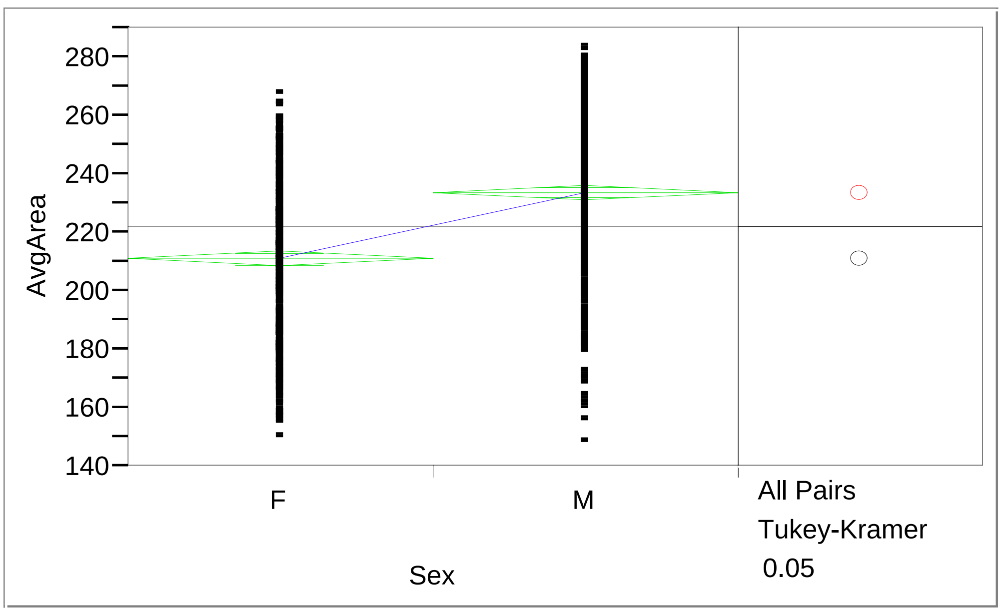


Figure E.5: One-way Analysis of AvgArea By Seat Elbow Height (Seat EH)

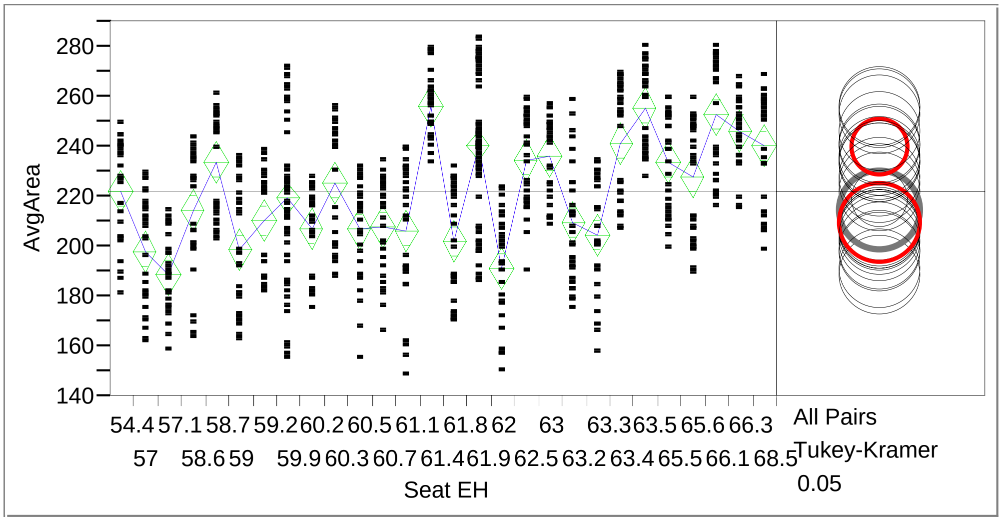


Figure E.6: One-way Analysis of Average Area By Upper Leg Length (ULL)

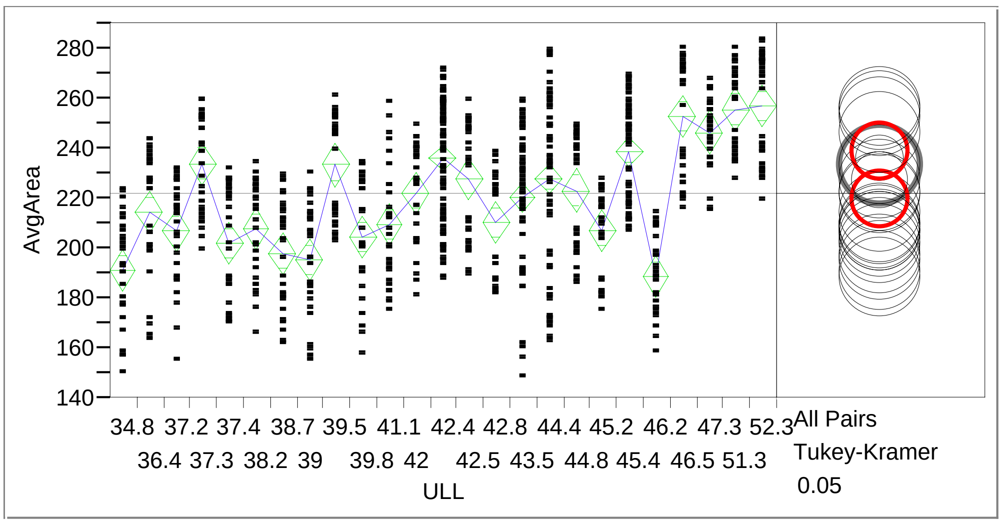
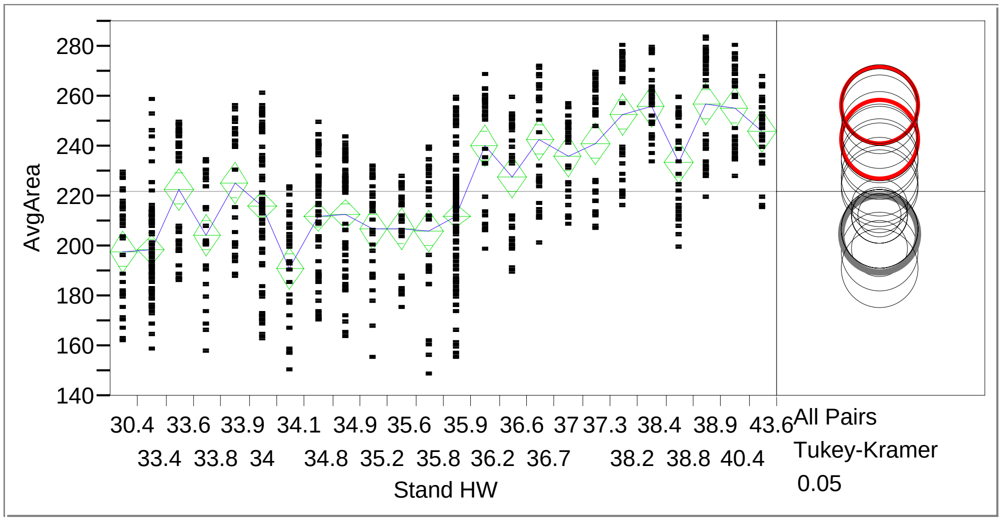


Figure E.7: One-way Analysis of Average Area By Standing Hip Width (Stand HW)



Appendix F – Plots of One-way Analysis of Discomfort Ratings by Residuals

Figure F.1: One-way Analysis of Discomfort Rating By Weight

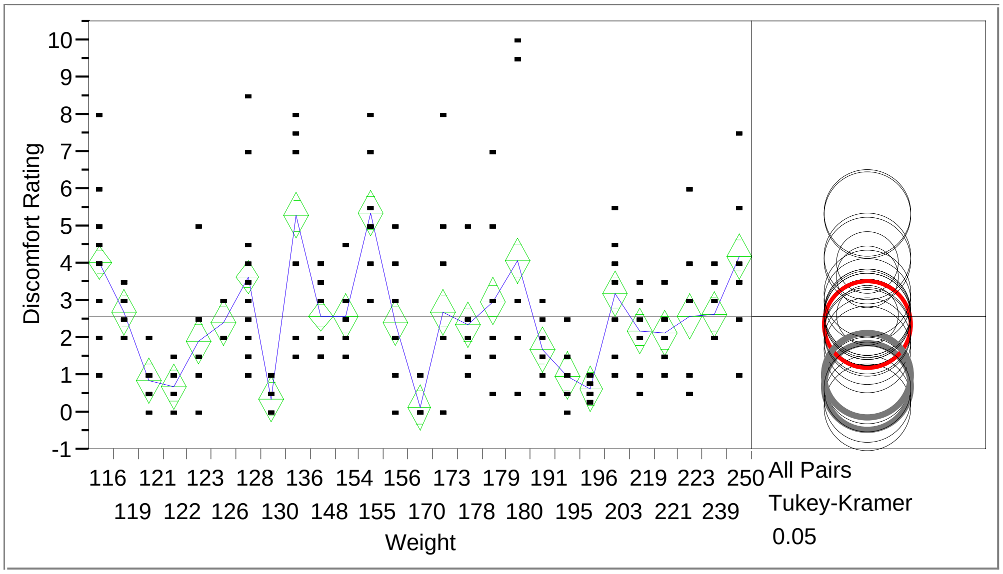


Figure F.2: One-way Analysis of Discomfort Rating By Standing Hip Width (Stand HW)

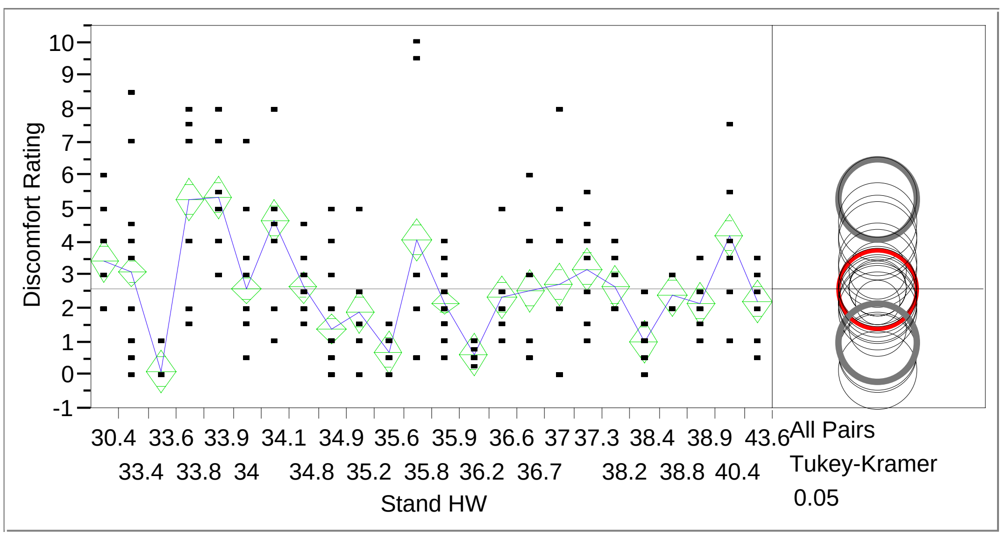


Figure F.3: One-way Analysis of Discomfort Rating By Upper Leg Length (ULL)

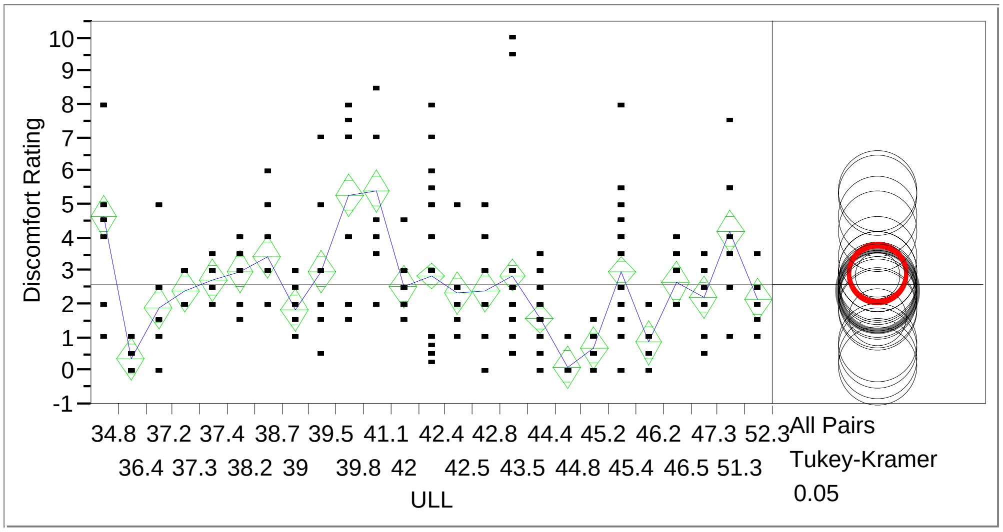


Figure F.4: One-way Analysis of Discomfort Rating By Gender

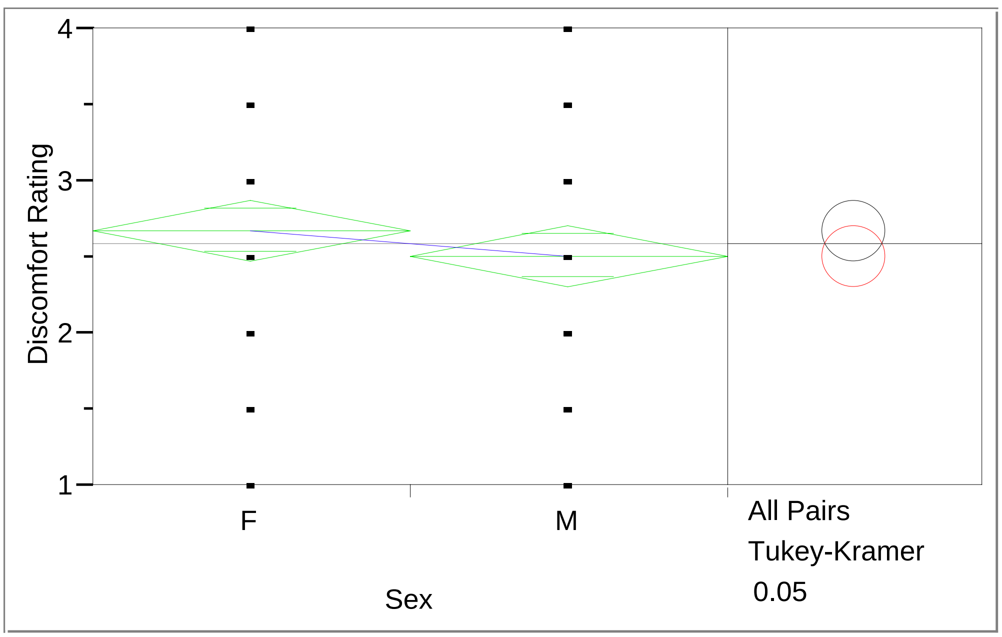
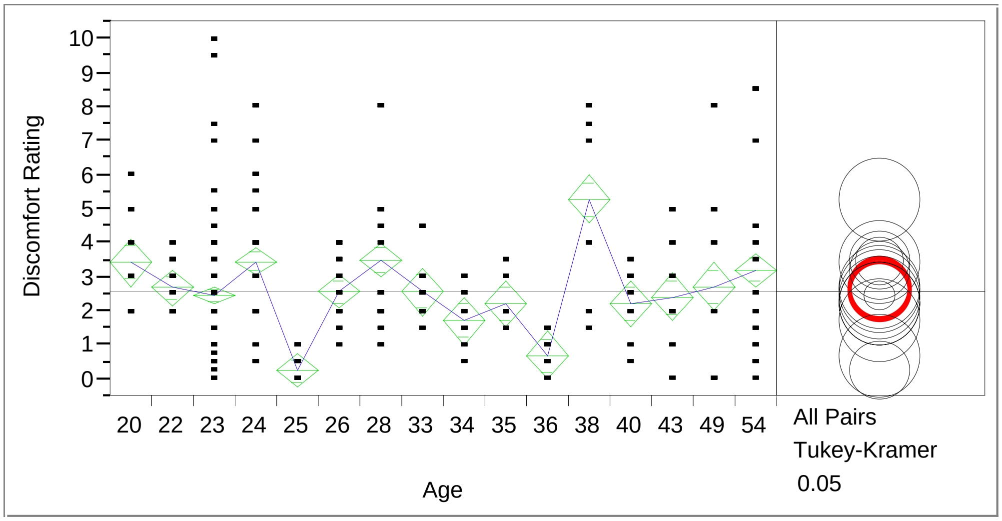


Figure F.5: One-way Analysis of Discomfort Rating By Age



Appendix G – Tukey-Kramer Means Comparison Results

Table G.1: Means Comparison of Average Peak Pressure by Seat Type

Abs(Dif)-LSD	Steelcase (Leap)	Humanscale (Freedom)	BB-J2507 (Slab)	BB-J2507 (S'port)	BB-J757N1 (Slab)	BB-J757x (Slab)	BB-J757 (Molded)
Steelcase (Leap)	-0.58309	-0.18476	0.33408	0.66083	0.70816	0.82458	0.93799
Humanscale (Freedom)	-0.18476	-0.58309	-0.06426	0.26249	0.30983	0.42624	0.53966
BB-J2507 (Slab)	0.33408	-0.06426	-0.58309	-0.25634	-0.20901	-0.09259	0.02083
BB-J2507 (S'port)	0.66083	0.26249	-0.25634	-0.58309	-0.53576	-0.41934	-0.30592
BB-J757N1 (Slab)	0.70816	0.30983	-0.20901	-0.53576	-0.58309	-0.46667	-0.35326
BB-J757x (Slab)	0.82458	0.42624	-0.09259	-0.41934	-0.46667	-0.58309	-0.46967
BB-J757 (Molded)	0.93799	0.53966	0.02083	-0.30592	-0.35326	-0.46967	-0.58309

Positive values show pairs of means that are significantly different.

Table G.2: Means Comparison of Average Contact Area by Seat Type

Abs(Dif)-LSD	BB-J2507 (S'port)	BB-J757 (Molded)	BB-J757N1 (Slab)	BB-J757x (Slab)	Steelcase (Leap)	BB-J2507 (Slab)	Humanscale (Freedom)
BB-J2507 (S'port)	-8.547	-6.849	-6.276	-0.380	25.838	29.228	40.150
BB-J757 (Molded)	-6.849	-8.547	-7.973	-2.077	24.141	27.531	38.452
BB-J757N1 (Slab)	-6.276	-7.973	-8.547	-2.651	23.567	26.957	37.879
BB-J757x (Slab)	-0.380	-2.077	-2.651	-8.547	17.671	21.061	31.983
Steelcase (Leap)	25.838	24.141	23.567	17.671	-8.547	-5.157	5.765
BB-J2507 (Slab)	29.228	27.531	26.957	21.061	-5.157	-8.547	2.375
Humanscale (Freedom)	40.150	38.452	37.879	31.983	5.765	2.375	-8.547

Positive values show pairs of means that are significantly different.

Table G.3: Means Comparison of Discomfort Ratings by Seat Type

Abs(Dif)-LSD	Humanscale (Freedom)	BB-J2507 (Slab)	Steelcase (Leap)	BB-J757 (Molded)	BB-J757N1 (Slab)	BB-J2507 (S'port)	BB-J757x (Slab)
Humanscale (Freedom)	-0.7573	-0.6073	-0.2656	0.6344	0.6761	1.0094	1.0427
BB-J2507 (Slab)	-0.6073	-0.7573	-0.4156	0.4844	0.5261	0.8594	0.8927
Steelcase (Leap)	-0.2656	-0.4156	-0.7573	0.1427	0.1844	0.5177	0.5511
BB-J757 (Molded)	0.6344	0.4844	0.1427	-0.7573	-0.7156	-0.3823	-0.3489
BB-J757N1 (Slab)	0.6761	0.5261	0.1844	-0.7156	-0.7573	-0.4239	-0.3906
BB-J2507 (S'port)	1.0094	0.8594	0.5177	-0.3823	-0.4239	-0.7573	-0.7239
BB-J757x (Slab)	1.0427	0.8927	0.5511	-0.3489	-0.3906	-0.7239	-0.7573

Positive values show pairs of means that are significantly different.

Appendix H – Discomfort Survey Template

Instructions: Please place an “X” on the line where you feel the level of discomfort should be placed for each chair. The scale is broken down into intervals of 0.5. The rating scale is from 0 to 10 where 0 is the lowest level of discomfort and 10 is the highest level of discomfort. NOTE: The discomfort level corresponds to the fit of the buttocks and thighs to the individual seat pan. Please do not rate the level of discomfort for the back.

Chair #_________ Min. Discomfort Med. Discomfort Max. Discomfort

Discomfort Level

0 1 2 3 4 5 6 7 8 9 10

Chair #_________ Min. Discomfort Med. Discomfort Max. Discomfort

Discomfort Level

0 1 2 3 4 5 6 7 8 9 10

Chair #_________ Min. Discomfort Med. Discomfort Max. Discomfort

Discomfort Level

0 1 2 3 4 5 6 7 8 9 10

Chair #_________ Min. Discomfort Med. Discomfort Max. Discomfort

Discomfort Level

0 1 2 3 4 5 6 7 8 9 10

Chair #_________ Min. Discomfort Med. Discomfort Max. Discomfort

Discomfort Level

0 1 2 3 4 5 6 7 8 9 10

Chair #_________ Min. Discomfort Med. Discomfort Max. Discomfort

Discomfort Level

0 1 2 3 4 5 6 7 8 9 10

Chair #_________ Min. Discomfort Med. Discomfort Max. Discomfort

Discomfort Level

0 1 2 3 4 5 6 7 8 9 10