The Beauty of Fit:
Proportion and Anthropometry in Chair Design

A Thesis
Presented to
The Academic Faculty

by

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In Partial Fulfillment
Of the Requirements for the Degree of
Masters of Industrial Design in the
College of Architecture

Georgia Institute of Technology
April 2005

The Beauty of Fit:
Proportion and Anthropometry in Chair Design

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April 18. 2005

To Matt, whose faithful love and
encouragement made this possible.
You are my perfect fit.

ACKNOWLEDGEMENTS

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GLOSSARY

Acromial Height Sitting   The vertical distance between a sitting surface and the
                                acromion landmark on the tip of the shoulder -- the outer
                                end of the scapula to which the collarbone is attached.

Buttock-Knee Length   The horizontal distance between a buttock plate placed at
                                the most posterior point on either buttock and the anterior
                                point of the right knee.

Buttock-Popliteal Length   The horizontal distance between a buttock plate placed at
                                the most posterior point on either buttock and the back of
                                the right knee.

                                ("Anthropometric data analysis sets manual", 1994)

SUMMARY

The goal of this study is to create a method for designers to reconcile the critical

functional and aesthetic requirements in chair design. This paper presents a brief history

of the design of chairs, an overview of historical types of proportional systems, a

discussion of anthropometry and the technical requirements of chair design. The body of

the study involves the affects of the application of anthropometric measurement to the

proportions of two Modernist chairs; the *Zig Zag* chair by Gerrit Reitveld and the *Grand

Confort* or *LC2* chair by Le Corbusier, Perriand and Jeanneret. Changes to the

proportions of the chairs will be proposed in an attempt to fit a variety of people,

including outliers in the population. The findings of the study indicate that the chairs

resulting from the anthropometric changes are not considered beautiful or well

proportioned when they contradict the structural logic of the original design. By

determining a hierarchy of functional requirements and understanding the anthropometric

values associated with it, a designer can develop the product's aesthetics and test them

during the design process using this method.

CHAPTER 1

INTRODUCTION

One could imagine that there are as many different types of chairs as there are types of

people. It is an object that is available to most everyone. In its different embodiments it

can be humble or regal, made of traditional wood or high-tech polymers, simple in

concept or highly charged with meaning. Fundamentally, the requirements for a chair are

few. It is essentially a horizontal surface at a logical distance from the ground meant to

support the human body while sitting. A vertical surface is provided for back support. It

can have arms or be armless. (Schwartz *et al.*, 1968) While these are the basic elements,

a chair is more than the sum of its component parts. The psychological relationship with

the user, perhaps stronger than with any other type of furniture, can connote symbolism

about status and beliefs. The history of chair design reflects its role as a barometer of

culture and how it responds to technological changes. (Fiell & Fiell, 1993) Fiell and

Fiell write that the success of a particular chair can be evaluated by how skillfully a

designer has synthesized aesthetics and function while addressing a specific need. (Fiell

& Fiell, 1993) Designer George Nelson writes that the form of a chair is comprised of

three factors: function, aesthetics and material. (Nelson, 1994) Critic Vincent Scully

writes that there are three ways to evaluate a chair: its relation to the body, its emblematic

or communicative function and its craft. (Cranz, 1998) My theoretical position would

recognize that chairs are designed with an emphasis on one of the two categories: the

aesthetic and the functional.

In her book, <u>The Chair: Rethinking Culture, Body and Design</u>, Galen Cranz discusses the difference between the aesthetic and the functional and coins the types as "status furniture" vs. "technical furniture." (Cranz, 1998) She says, "The ID approach to chairs has taken a turn down the path of ergonomics with little expressive symbolism, the artistic approach, in contrast, might have articulated or celebrated the mechanics of the human body more delightfully." (Cranz, 1998) Are these two approaches capable of reconciliation? What methods can be developed for designers to follow? What is the role of new technologies and measurement data? What happens when these technologies are used in the design process along side of traditional design principles and practices?

Industrial design departments in higher education have different philosophies – some emphasize form making skills, others are more conceptual. Areas of concentration in design can include research, engineering, production, sustainability or ergonomics. (Richardson, 2005) None of these areas are mutually exclusive, but one is usually emphasized over the others. In an academic setting, the relationship with other departments can influence the focus of an Industrial Design department. Fine Arts, History, Theory, and Architecture have obvious strong connections to the aesthetic approach, while practices originating in science, such as User Research, Task Analysis, Anthropometrics and Ergonomics, as well as advances in computer and material science pertain to a functional approach. In this study, I am interested in seeing the effects of the combination of these influences. Specifically, I am looking at the affects of the application of anthropometric measurement to the proportions of two Modernist chairs; the *Zig Zag* chair by Gerrit Reitveld and the *Grand Confort* or *LC2* chair by Le

Corbusier, Perriand and Jeanneret. Changes to the proportions of the chairs will be proposed in an attempt to fit a variety of people, including outliers in the population. It is my contention that the perceived beauty and pleasing proportions of the chairs will be affected negatively by these changes.

In order to discuss this in depth, I will offer a brief history of chair design and particularly, issues of concern in the Modern movement. Historical concepts of systems of proportion and the body will be presented. I will also discuss the issues surrounding the availability and use of anthropometric data and the functional requirements in chair design. I will then present the study I developed, discuss its method, results and conclusions.

CHAPTER 2

CHAIR HISTORY

The chair can be seen as a sign of civilization. It was probably the first type of furniture created – meant not just to provide support off the ground, but to convey status and authority. (Schwartz et al., 1968) Images of early chairs can be found in the records of ancient civilizations. In Egypt, the chair changed very little for several thousand years – typically it was pictured with a low seat and slightly reclining back; examples of thrones and folding stools also exist in these records: the throne being very architectural in form, while the stool was often adorned with animal carvings.

Figure 1 Egyptian Chairs

Both objects were symbols of authority; the throne was associated with the regalia of the pharaohs and the stool was provided for traveling dignitaries.

The first aesthetically significant chair form was created in ancient Greece. The *klismos* was a graceful, symmetrical chair which became a prototype of designs that reappeared throughout the centuries of chair design that follow. ("Klismos", 2005)

Figure 2 Greek *klismos*

Roman styles borrowed heavily from the Greeks, and the *klismos* continued to be reinvented. Like the Egyptians, the Romans also had a folding stool, *sella-curulis,* which conveyed authority and status. (Ramsay, 1875) The *sella-curulis* continued to be used in the middle-ages by both civil and religious dignitaries. ("Timeline of art history", 2000-2005)

Figure 3 Roman *sella-curulis*

Gothic and Romanesque art illustrate the influence of architecture on chair design. In the famous *Merode Altarpiece* painted by the Master of Flemalle (Robert Campin) in 1427. The bench-like chairs in this image are not for dignitaries, but were typical of common domestic interiors.

Figure 4 *Merode Altarpiece*, Master of Flemalle (Robert Campin), 1427

During the Renaissance, the design of the *klismos* and the *sella-curulis* type chairs were revived and were transformed into the Savonarola chair. The *Savonarola* chair was an x-shaped stool with the addition of a back constructed entirely in wood. (Akintilo, 2001)

Figure 5 Renaissance *Savonarola* chair

The Renaissance also saw the embellishment of a previously simple chair type – the wood side chair called the *sgabello* was covered with ornate carvings by craftsmen. In the Renaissance, the decoration and form were not as integrated as they were in the ancient world. (Schwartz et al., 1968)

Figure 6 Renaissance *Sgabello* chair

The chairs in the 16th century had classical motifs such as urns and columns carved in to their legs and arms. Straight, upright backs and seats were meant to encourage the formal

postures that were the social norm. (Cranz, 1998) Classical architectural motifs continued to appear through the 17th century. New scroll, leaf and shell adornments from contemporary buildings were repeated in carvings on the chair frames; but upholstery and cushions were also common. The proportions of the court furniture of Louis XIV became monumental to reinforce images of importance, to match the scale of huge rooms, as well as to accommodate the expansive court fashions typical of the time. (Cranz, 1998)

Figure 7 Louis XIV Armchair

The democratizing 18th century was characterized by interest in individual and human rights and issues such as comfort were addressed in chair design.   It was also in this century that chair styles become known by the name of their designer. Chippendale, a furniture crafter, was the first to have his name associated with a style. Greek revivalism also becomes evident in the styles of the French Empire, the English Regency and the Austrian and German Beidermeier.

Figure 8 Chippendale chairs

Figure 9 French Empire chair

Figure 10 English Regency chair

Figure 11 Beidermeier chair

In the 18th century, chair making was a distinct craft regulated by guilds. Chair makers made use of pattern books that codified what was considered the best rules and proportions for chair production which advanced a physiological and aesthetic point of view. (Cranz, 1998)

The first real innovations in chair design began in the mid 19th century as the Industrial Revolution rapidly changed the way things were produced and people lived. By the turn of the century, designers were creating new chair forms made possible by advances in technology. The pursuit of new chair forms also arose from the interest of artists and architects to break from the past to find original forms of expression. Furniture production began to leave the workshop of the craftsperson and enter the atelier of the designer, the architect and the artist. (Fiell & Fiell, 1993)

The chairs examined in this study come from this tradition. There is a link between the reproduction of traditional furniture and artifice. (Nelson, 1994) Through their formal language, followers of De Stijl and the International style were pursuing an expression of

beliefs they held as universal truths. They also embraced the technology of their age;

thus, chair design and manufacture became part of the industrial process.

Chair design also became more intrinsically tied to the architectural process. The

influence of architecture on chair design is historical (as shown in the previous passages);

however, in the modern era, architects were responsible for both the building and the

artifacts for the interior.   Once their designs were mass produced, architects could further

disseminate their ideologies. (Fiell & Fiell, 1993) Critic Allen Greenberg states that,

"modernist chair design, as an expression of aesthetic ideas, requires clarity and

conciseness and compromises in design, for the sake of comfort, especially in details, are

often difficult for the designer to accept." (Cranz, 1998) Designer chairs are a microcosm

of the designer environment. But at the same time, it is a metaphor for the body. It acts

as mediator between the geometrical, abstract expression of modern architecture and the

human form. (Cranz, 1998)

If you remove contemporary chair design from the rule of aesthetic ideology, function

becomes privileged. Industrial design has used the disciplines of anthropometry and

ergonomics to develop new chair forms. These largely fall in the category of task, or

office chairs. It is hard to discern a philosophy, but easy to determine the functional

criteria. Adjustability to accommodate a range of people became a common requirement

of the office chair. Adjustability is emphasized in their form factor through the use of

knobs and levers.

Even though adjustability was a primary criteria in many designs, its value can be questioned. In the early 1960s arguments were made against the value of adjustable chairs. When there are more than two dimensions to adjust, users have difficulty in determining what fits them best. This is worsened by fatigue. (Cranz, 1998) In an article in Progressive Architecture, Vernon Mays states that people often end up more uncomfortable than they might have been in a simple straight back chair. (Cranz, 1998) As early as 1969, a paper was published that suggested that chairs be made in two sizes in order to offer better fit to more people. It wasn't until the early 1990s that manufacturers began to produce chairs in different sizes; Herman Miller introduced the Aeron Chair in 1994 and Haworth released its version in 1997. (Cranz, 1998) These design of these chairs relied heavily on the anthropometric data available to the designers.

Before discussing the functional aspects of anthropometry and the body, the aesthetic issues of proportions and the body must be examined.

CHAPTER 3

PROPORTIONAL SYSTEMS

This project grew out of an interest in proportional systems and their use in industrial

design. Industrial design, as a practice, is very young. However, it is rooted in the

ancient disciplines of art and architecture. Within ancient cultures, beauty and proportion

were defined through two approaches: the idealization of The Physical and The

idealization of The Abstract. Systems were based on the human body or geometric

principles.

Ancient Egypt used a system of measure based on a human's body. The standard length

used in furniture design was the royal cubit. At 524 mm long, it was approximated to be

the length of a man's forearm. It was divided into seven smaller units called palm

widths, and each palm width was subdivided into 4 thumb sized digits. There was also a

smaller cubit measuring six palm widths. (Killen, 2003) Another measure which was

used was called the fist which equaled one and one-third handbreadths and was the

system for laying out the proportions of their statuary. (Doczi, 1981) When working in

two dimensional media, Egyptian artists employed a modular grid. The human figure

was divided in to 14 equal parts that corresponded to landmarks on the body. The

Egyptians did not incorporate perspective views into their drawings and tended to draw in

elevation and overviews. (Pheasant, 1986)

Proportions in ancient Greece were not based on the human body. Instead, the Greek

pursuit of knowledge created the disciplines from which their proportional systems arose.

The Golden Mean is perhaps the best known of all proportional systems. It was defined

by Euclid in the 3rd century. (Livio, 2002) He was a mathematician who is largely

responsible for the development of geometry. Euclid divided a line in to two sections,

whereby the ratio of the smaller section to the larger section is equal to the ratio of the

larger section to the whole. It can be expressed using the formula A/C = AB/BC.

Numerically, it is an irrational number and is rounded to 1.618. It is symbolized by the

Greek letter phi Φ.

Figure 12 The Golden Mean Φ

It is also referred to as the Golden Section, the Golden Ratio and the Golden Number.

This proportion has garnered so much attention because of the astonishing range of

places that it appears. It is found not only in geometry, but in nature as well. It is seen in

the arrangement of apple seeds in a five pointed star, which is composed of triangles with

the golden ratio between its long and short sides. Each stage of growth of the nautilus

shell can be encompassed by a Golden Rectangle as it grows in a logarithmic spiral. It is

the same spiral created by successively larger Golden Rectangles progressing from a

center point. (Doczi, 1981)

Figure 13 Logarithmic Spiral

Figure 14 Nautilus Shell

The examples seen in nature led the Greeks to seek this same ratio in the human body.

Greek sculptor Polykleitos was said to have written a now lost work on the proportions of

the human body. In his book, *The Power of Limits: Proportional Harmonies in Nature,*

Art and Architecture, Gyorgy Doczi has analyzed Polykleitos's famous sculpture

Doryphoros or *The Spear Bearer*. He identifies landmarks on the figure that correspond

with the Golden Mean. The entire figure is encompassed by a Golden Rectangle with Golden Section points at the knees, the navel, the genitals, the breasts and the chin. He analyzes the *Aphrodite of Cyrene* and finds similar results. (Doczi, 1981)

One cannot discuss the Golden Ratio without mentioning the Fibonacci sequence. Fibonacci was a mathematician living during the 13th century, a time that was characterized by a renewed interest in classical civilization. He discovered a series of numbers whereby each number is the sum of the preceding two numbers. The sequence begins: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, and so on. As the numbers progress, the ratio of a number to the number before it approximates 1.618, or the Golden Ratio. (Livio, 2002)

The Renaissance interest in classical thought resurrected what has become one of the most famous images of man, Leonardo's *Vitruvian Man*, which symbolized the desire to integrate perceived perfection as expressed through geometry with the expression of the human form. Vitruvius was a Roman architectural theorist writing around 15 BC. He developed a system of body part ratios based on archaic measurements.   (Pheasant, 1986)   He was very specific with his proportions of his idealized male figures. These were laid out in his treatise.

- a palm is the width of four fingers
- a foot is the width of four palms
- a cubit is the width of six palms
- a man's height is four cubits (and thus 24 palms)
- a pace is four cubits
- the length of a man's outspread arms is equal to his height

- the distance from the hairline to the bottom of the chin is one-tenth of a man's height
- the distance from the top of the head to the bottom of the chin is one-eighth of a man's height
- the distance from the hairline to the top of the breast is one-seventh of a man's height
- the distance from the top of the head to the nipples is one-fourth of a man's height
- the maximum width of the shoulders is one-fourth of a man's height
- the distance from the elbow to the tip of the hand is one-fifth of a man's height
- the distance from the elbow to the armpit is one-eight of a man's height
- the length of the hand is one-tenth of a man's height
- the distance from the bottom of the chin to the nose is one-third of the length of the face
- the distance from the hairline to the eyebrows is one-third of the length of the face
- the length of the ear is one-third of the length of the face

("Vitruvian man", 2005)

He justified his dimensions by showing that a man of these proportions would fit perfectly within a square inscribed in a circle. Vitruvius wrote that this system of human body proportions was to be used as a guide in architectural planning.

Figure 15 *Vitruvian Man*, Leonardo da Vinci, 1490

Renaissance artist Leonardo da Vinci took Vitruvius' figure and made some fundamental changes. He inscribed the man first standing with arms outspread in a square and then spread eagle in a circle. He laid one figure over the other to create one image whereby the circle was no longer tangent to the square at the corners as it had been previously. Because of this, the earlier figures had disproportionately long limbs. (Gorman, 2002) Leonardo also used the Golden Ratio in his study. He indicated that the figure was divided by the Golden Ratio at the navel as well as being divided in half at the groin. (Elam, 2001)

Little new work was done with the application of the Golden Mean to the study of human proportions for several hundred years. Interestingly, it was an architect who broke with aesthetic and theoretical tradition in his work who returned to study it. (More on Le Corbusier's life and work in the section on the *LC2* chair.) In 1950, Le Corbusier published *Modulor: A Harmonious Measure to the Human Scale Universally Applicable to Architecture and Mechanics; Modulor II* was published in 1955. His goal was to create a proportional system that reconciled the inherent beauty of the Golden Ratio with the needs of the human body. He used three squares to generate Golden Rectangles which produced measures proportional to the human body. The human body, in this case, was defined as a six foot tall English male with one raised arm. (Ostwald, 2001) The Golden Section divisions that were created were further divided to become more useful. Le Corbusier named the resulting measures the *Modulor* and defined it as, "a measure based on mathematics and the human scale: it is constituted of a double series of numbers, the red series and the blue." (Le Corbusier, 1980)

Figure 16 *The Modulor, Red and Blue Series,* Le Corbusier, 1955

Figure 17 Construction of *The Modulor*

There is a distinction between Le Corbusier's intensions for his system of proportions and those of the Egyptians, Greeks, Vitruvius and Leonardo. In earlier systems, aesthetics were the primary consideration and the proportions they developed were to be used in the *representation* of human forms. Even in architectural applications, the aesthetic value of measures based on the human body was paramount. Idealized

proportions could be used to drive the design because of the scale of the work. The fit

between the body and a building is not intimate as it is between the body and a chair. A

five foot tall woman can pass through a door just as easily as a six foot tall man providing

the door affords a few centimeters for clearance. The functional experience is no

different if they pass through the enormous door of a cathedral. The only requirement to

be met is the minimum height and width.

Figure 18 *The Modulor*, postures, Le Corbusier, 1955

When Le Corbusier illustrated his figure in different postures, he put the body in motion

and in contact with objects in the environment. When the figure sits in a chair, or leans

on a counter, function becomes privileged. The questions of how and for whom are

raised. One does not need anthropometric data to know that not everyone is a six foot tall

man. In fact, at the beginning of his research, Le Corbusier was basing his proportions

on the size of the French man and when the dimensions did not work well with the

geometry, he abandoned the Gallic man in favor of the taller English man. The female figure was only briefly considered and then decided against. (Le Corbusier, 1980) The Modular is regarded as an important part of Le Corbusier's work; however, it never gained popularity in practical application. One could speculate that it is because the books he wrote on the subject are difficult to understand due to the rambling prose and unclear diagrams. (Ostwald, 2001) However, I theorize that it is because the discipline of Industrial Design was developing its own practices and body of knowledge from which to draw rather than relying so heavily on art and architectural traditions. At the time the *Modulor* was published, anthropometric data was becoming more widely available to designers.

CHAPTER 4

ANTHROPOMETRICS

Anthropometrics is the study of human body measurements. Many disciplines make use

of anthropometry; advances have been made in medicine, anthropology, military science,

criminology, engineering and design with its application. Its earliest practical use was

the development of a system to identify criminals in France in the late nineteenth century

by Alphonse Bertillon. ("Anthropometry", 2005) While his methods eventually were

criticized for being cumbersome and unreliable, his contribution to the development of

this science was far reaching. His book, *Signaletic Instructions Including the Theory and*

Practice of Anthropometrical Identification, was translated to English and was introduced

for use in the penal system in the United States shortly after it was written. (Moenssens,

1971) It should be noted that there are records of anthropometric measures dating back

to the early 1700s. These are largely records used by the military to classify and identify

men in their units. In the United States, the slave trade also made use of anthropometry

for identification purposes. (Cuff, 2004)

While anthropometry was originally used to for identification, other applications were

developed in the twentieth century. It became a valuable tool for describing relationships

between populations and for individuals within a population. Anthropologists use

historical anthropometry to understand economic and social changes in a culture. (Cuff,

2004) The medical community uses anthropometric data to assess the well-being of their

patients – many people are familiar with the "growth charts" used to measure the physical development of children.

More than any other sector, the defense industry has driven research in anthropometric methods and data. This began when World War I created the need for standardized uniforms for a large fighting force. The sample size of the population was unprecedented. Of course, this was a skewed sample, because of the age, gender and health of the soldiers. (Krupa, 1994) The military continued to lead anthropometric research because of its access to subjects and because of the performance needs of military equipment. The automobile industry also became a driver in the field, as the sophistication and functional requirements in transportation design grew. This became true of the design of other commercial products.

Henry Dreyfuss, who is the best known advocate of anthropometry for design, began to development guidelines for designers of commercial products around World War II. (Krupa, 1994) The sample populations his data was generated from was still largely from the military and therefore, skewed, but it was nevertheless, an improvement on the "rule of thumb" approach common in design practices. In 1955, he published the *Measure of Man* which provided data on anthropometric percentiles for the American adult male and female. It was comprised of diagrams of human figures with measurements for a specific gender, age group and percentile. It has been expanded and improved upon over the decades, often criticized, but it is still in use today.

Figure 19 Chart from the *Measure of Man*, Henry Dreyfuss, 1955

Before proceeding with the discussion of how anthropometrics can be used by designers, more information on the methods of data collection should be addressed. Specific instruments have been developed to take anthropometric measures. The anthropometer, or beam caliper, the spreading caliper and the sliding caliper are the traditional instruments for measuring body size.

Figure 20   An anthropometer

Of course, more advanced technology has been developed for data collection. These include photometry, stereophotography, videography, motion capture and 3D scanning.

3D scanning is most current technology available, and will be discussed further as it the source of the data used in this project.

There are several ways to gather and express body measurements. The anthropometrist must be equipped with an understanding of anatomy and trained in handling human subjects. Subjects are palpated in order to locate specific landmarks on their body. Measurements between landmarks are taken in various positions, usually standing and sitting, but sometimes prone or supine. Heights from the floor, assorted circumferences, body breadths, and depths are recorded. These measurements provide the data necessary to create a numeric representation of the subject. In recent years, an effort has been made to standardize and codify measurement and landmark definitions. ("Anthropometric data analysis sets manual", 1994)

Problems can arise in the data collection process. These include differences in the practices of data collectors, inaccurate use of instruments, incorrect posture of the subject, and the difficulty of measuring soft tissue due to displacement. Reliability, accuracy and validity are critical in measurement verification. (Anthrotech, 2001)

These issues exist in more advanced methods of data collection as well, including 3D scanning. 3D scanning affords more information than traditional methods and is the most advanced technology at this time. In 1992, planning began for a large, international anthropometric survey. CAESAR, or the Civilian American and European Surface Anthropometry Resource, was a collaboration of more than 35 companies, several

government agencies from six different countries. Georgia Institute of Technology was one of the participants. The population of the survey included 4,431 American and European adult males and females between the ages of 18 and 65 years old. (Salvendy, 2005) Subjects were scanned in North America, Italy, and the Netherlands. Each subject was scanned in three different poses – standing, sitting with arms at rest and sitting with arms outstretched. Fifty-nine point-to-point or surface measurements were calculated from the scan points indicating body landmarks. Forty measurements were taken the traditional way using calipers and tape measure. The survey was the first of its kind to provide 3D human models along with the anthropometric and demographic data collected. (Robinette, 2003)

The real value of anthropometry lies not in the raw data, but in its application. Statistics must be performed to make the data meaningful. General descriptive statistics such as the median, the standard deviation and the population size are adequate to calculate percentiles. (See Appendix A for the descriptive statistics I ran on the raw CAESAR data as it related to this study.) Percentiles are the primary point of reference for designers. Traditionally, designers look at the dimensions of the 5th percentile female and the 95th percentile male for the measure they are considering in an effort to accommodate the largest percent of the population. However, it is important for the designer it is important for a designer to recognize that key anthropometric measurements may be poorly correlated with one another. That means that a woman may be at the 50th percentile for height and the 5th percentile for weight. Percentiles are only specific to the dimension that they describe – there is no such thing as an "average" person. (Pheasant, 1986)

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When more than one dimension is used, larger percentages of the population may be excluded. Using the 5th to 95th percentile rule, 10% of the population is excluded. If you were to design with 13 dimensions under these guidelines, up to 52% of the population would have one or more "aspects" (weight, height ...) that fall outside of the design parameters. (University, 2005)

It is possible that the entire population will not need to be accommodated, depending on the criteria of the design. One of the goals of the CAESAR survey was to have representative subpopulations in the larger sample. (Robinette, 2003) Subject selection and percentiles will be discussed further in the methods section of the paper.

CHAPTER 5

ERGONOMICS AND FUNCTIONAL REQUIREMENTS

In design, anthropometry and ergonomics usually go hand in hand. Ergonomics is the

study of man at work. More precisely, it is the study of people using equipment in

specific environments to perform certain tasks. (Pheasant, 1986) By understanding

human anatomy, kinetics and principles of physics, the ergonomist can develop best

practices to minimize injury and maximize efficiency in the workplace, home and school.

Much study has been done on the issue of seating because of the increased use of

computers in the workplace. In the United States alone, 40 million people sit in office

chairs every workday. ("If the chair fits: All shapes and sizes", 2001)

The goal of office chair designers is to create chairs that fit the largest range of sizes

possible. Most workers don't have a choice of chair size or style when they are hired.

Manufacturers have tried to create chairs that are adjustable in several critical

dimensions. Even so, chair manufacturer Herman Miller estimates that chairs that are

designed to fit 95% of the population probably only accommodate 75%. The number

may even be lower because of the inability of the users to correctly adjust the chair to fit

themselves. ("If the chair fits: All shapes and sizes", 2001) They contest that the "one

size fits all" solution is the best and developed a method to facilitate the successful

accommodation of a greater percentage of the population. Instead of working with a

"middle-out approach" resulting in one chair design, they designed the same chair in

three sizes, using an "end-to-middle" approach. They compare this to the range of sizes

that shoes or bicycles come in. They contend that almost everyone will fit one of the three chairs, even with minimal adjustment. This method resulted in the Aeron chair. (Stumpf, 2002a)

How do you determine what constitutes a good fitting chair? There are some basic guidelines that do not vary greatly source to source. It is when the chair is used in conjunction with other equipment that the debate arises. (Grandjean, 1980; Pheasant, 1986; Zacharkow, 1988) Postures differ depending on the task at hand – people tend to lean forward while reading at a desk, lean backward while talking on the phone and have their upper extremities in any variety of positions. (Stumpf, 2002b) The relationships of size, angle, position and movement between components are complex.

In order to limit this study to the question at hand – how are the proportions of chairs that have been designed with an emphasis on aesthetics affected when they are scaled to fit different anthropometric values – the chairs in question are "occasional chairs" rather than "task chairs." This implies that they are only used occasionally and do not have a specific function. (Pheasant, 1986) The questions in the ergonomic evaluation of task chairs regarding appropriateness for the task and comfort level over duration of time are not at issue here.

The guidelines that follow are for a user sitting in what is called the 90-90-90 position. This means that their lower legs are at a 90 degree angle to the horizontal ground plane.

Their knees are bent at 90 degrees, as are their hips. Their upper legs are parallel to the ground and their back is in contact with the back rest. (Cranz, 1998)

There are four major dimensions to account for when designing a chair: seat height, seat depth, seat width and back height. In the past, seat height was based off of the anthropometric measure of the popliteal crease. With the scanned information provided in the CAESAR database, the seat height was determined by measuring the actual height of the stool the subject sat on. It is included in the scanned image. This is a technological advance that gives more accurate information. The industry average for seat height is 43.18 cm. The range in adjustable task chairs is 40.6 to 50.8 cm. ("If the chair fits: All shapes and sizes", 2001)

Determining seat depth requires some calculating. The anthropometric measure used most often is the buttock – popliteal crease length. If this is unavailable, (it is not available in the CAESAR data that is available to Georgia Tech) a combination of other dimensions can provide the needed information. Further detail on alternative measures is given in the method section. Seat depth recommendations range from 33 to 43 cm. (Goonetilleke, 1997) The user should be able to sit with their back against the backrest and still have space between the edge of the seat and the back of the knee. (BIFMA, 2005) A minimum of 5.8 to 7.62 cm and a maximum of 15.24 to 20.32 cm are recommended. (Goonetilleke, 1997)

The requirements for seat width are somewhat more flexible than those for seat height and depth. In most cases, the minimum width is all that is required. Usually, there is a two-way constraint on a dimension – too high is just as bad as too low. (Pheasant, 1986) Unless a seat is highly contoured, excess width does not generally affect the user. The minimum width is the hip breadth plus an allowance for movement and clothing. 50 to 76 cm on each side is usually adequate. (ILC, 2005)

Of all of the dimensions, the back rest height is most dependent on the type of activity the sitter is engaged in. Back rest heights are classified as low level – below the shoulder blades, mid level – upper back and shoulder, and high level – head and neck. (Pheasant, 1986) For task chairs, the upper and lower back should be supported. A space between the seat and the backrest to allow room for the buttocks is also recommended. The angle of the back rest to the seat ranges from between 90 to 110 degrees. (Cranz, 1998) Typically, the backs should not be higher than the bottom of the shoulder blades. (BIFMA, 2005) However, it is more difficult to develop criteria for the back height of an occasional chair. I have found no data to support any particular guideline. I have developed a method to address this in the definition of fit section for the chairs in the study.

CHAPTER 6

STUDY #1

6.1 Introduction

The information in the previous sections was offered in order to lay a foundation for this study. The purpose of this study is to find out how the perceived level of beauty and proportion of the *Zig Zag* and the *LC2* chair is affected when the chairs are scaled to fit people with varying anthropometric measurements.

This will be presented in separate sections for each chair. Historical and functional information is given to introduce the chair. This will be followed by a description of the survey instrument and methods used to develop the scaled versions. The results and discussion will conclude each section.

Figure 21 Gerrit Rietveld   Figure 22 Charlotte Perriand, Pierre Jeanneret
                                                          and Le Corbusier

6.1.1 *Zig Zag* Chair – History

Figure 23 *Zig Zag* chair, Gerrit Rietveld, 1932-33

Gerrit Rietveld was born in 1889 in Utrecht, the Netherlands. His cabinet-maker father

taught him his trade at an early age; by the time he was twelve, Rietveld was designing

his own chairs. (Russell & Read, 1980) Rietveld was a member of the Dutch modernist

movement, De Stijl, whose aim was to develop a universal aesthetic language that

abandoned decorative adornment in favor of a logical, functional style that was

appropriate to modern life. ("De stijl", 2005)   He trained as a draftsman and then as an

architect, completing his studies in 1919. (Labuttis, 2005) His most significant work

followed shortly afterward; the *Schröder House* was completed in 1924. It is considered

the first truly modern house and is the emblem of De Stijl architecture. (Mulder *et al.*,

1999) For Rietveld, furniture design was closely integrated with his architectural projects

and gave him a laboratory to explore some of the aims of De Stijl and the functionalist

movement. For him, these aims included the development of architecture and design that

would help people experience space; the use of mass production for the democratization

of this experience, and "a sobriety that would liberate people from the tyranny of the superfluous." (Kèuper *et al.*, 1992) Rietveld published throughout his career. In his 1953 essay *Rational Design*, he focused on mass production. The letter press was used as an example of efficient mechanized output. He espoused the value of the system of matrixes it employed and the fast, flexible combinations it allowed. With one versatile piece of equipment, a publisher could produce endless types of printed material. (Kèuper et al., 1992) He had already been exploring the possibilities of design and mass production as early as the 1910s and 1920s. Fellow De Stijl member, Theo van Doesburg, described his most famous piece of furniture, the *Red Blue* chair of 1918 as "an abstract-real sculpture, created with the intention of demonstrating that an aesthetic and spatial object could be constructed with linear materials and made by machinery." (Russell & Read, 1980)

Figure 24 *Red Blue* chair, Gerrit Rietveld, 1918

Figure 25 Rietveld outside his studio sitting in the *Red Blue* chair

In 1932-33, Rietveld worked on his design for the *Zig Zag* Chair following a long series of investigations into the development of a cantilevered chair. Manufacturing developments in bent tubular steel allowed the design of chair forms. Rietveld experimented in tubular metal, which proved to be too weak at the welds to support the form. Other prototypes were created out of plywood with a metal frame, a version of bent steel plate was proposed but never built, and other new materials, such as vulcanized fiberboard were considered. (Kèuper et al., 1992) An efficient design of the *Zig Zag* Chair was finally created with four pieces of solid wood constructed with dovetail joints (and on some versions, brass nuts and bolts). (Fiell & Fiell, 1993) The original was made of one inch elm cupboard planks left untreated. Rietveld went on to experiment with different finishes, including some brightly lacquered chairs in red or green with contrasting edges. (Kèuper et al., 1992; Russell & Read, 1980)

Figure 26 Red and green lacquered *Zig Zag* chair

The chair was slim in profile and small in size. It measured only 43.18 cm wide by 36.83 cm deep by 73.66 cm high.   Rietveld described this chair as a divider of space, like a screen, in contrast to the cage-like space of a chair with four legs. (Van Onck, 1999) He goes on to say that the chair, "is, as it were, a tiny partition in space that leaves the space untouched. It is not a chair, but a designer's joke. I always called it the *Zig Zag*…" (Kèuper et al., 1992)   Rietveld went on to do further explorations of this chair form. In the 1930s and 1940s, he created versions with armrests of various configurations, versions with perforations in the backrest, versions with softened angles and even versions for children.

Figure 27 Variations on the *Zig Zag* chair

Kèuper describes the design as "tolerating" these changes. (Kèuper et al., 1992) They lack the simplicity and synthesis of form of the original which is an elegant resolution of the form, function and construction.

It is the elegance of this chair that led me to select it for my study. While this section has addressed the aesthetic qualities of the chair, the following section will address its functional qualities and establish a method to define the population it fits.

6.2.2 *Zig Zag* Chair – Definition of Fit

In order for operations to be performed on the original chair, a definition of fit needed to be created. This was determined by measuring the original design's seat height, seat depth, and back height. Once the basic dimensions were established, a dimension critical to the functional requirement of the chair was named.

Seat height was the easiest dimension to match to an anthropometric value to in CAESAR because it is clearly defined in the database. The next step was to measure the seat depth of the original design, add to it the clearance of 50.8 cm and match it to an anthropometric value in CAESAR. Since this dimension is so small in the *Zig Zag* chair and matches to a percentile so low on the chart, it was not considered to be the driving dimension of the design in terms of function. The back height is generally more subjective in a chair of this nature, with no predetermined measure being functionally necessary. The seat height of 431.8 mm is functionally most important and therefore

became the "critical" dimension. Because the dimensions of the original chair are too small to have any meaningful correspondence with male anthropometric values, the versions of this chair will be for the female population only.

Seat Height of chair will be the same as the CAESAR Seat Height Measurement. This chair fits a 48th percentile female at 431.8 mm high. This is the critical dimension for this chair upon which other dimensions are based.

SHZZ = CSH

Seat Depth of Chair will equal CAESAR Buttock-Knee Length less 88.5 mm (for the thickness (entero-posterior dimension) of the knee for women) less 50.8 mm for space between the seat edge and the Popliteal crease. (Buttock – Popliteal Crease Length was not presented in the CAESAR data available to me.) The thickness of the knee was determined by calculating the differences between the Buttock-Knee Length and the Buttock-Popliteal Length for the 1, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99 percentiles. These differences were then averaged resulting in the 88.5 mm figure. The standard deviation was 2.5.   (Koncelik, 1996)

SDZZ = CBKL - 139.3

Back Height of the chair will equal the CAESAR Acromial Height Sitting multiplied by 54%. This number was calculated by making the assumption that the back height of the chair accommodated a 48th percentile female as did the Seat Height. The Acromial

Height of a 48th percentile female is 565 mm. The back height of the original chair was

304.8 mm. The back of the chair is 54% as high as the Acromial Height of the 48th

percentile female it is assumed to fit.
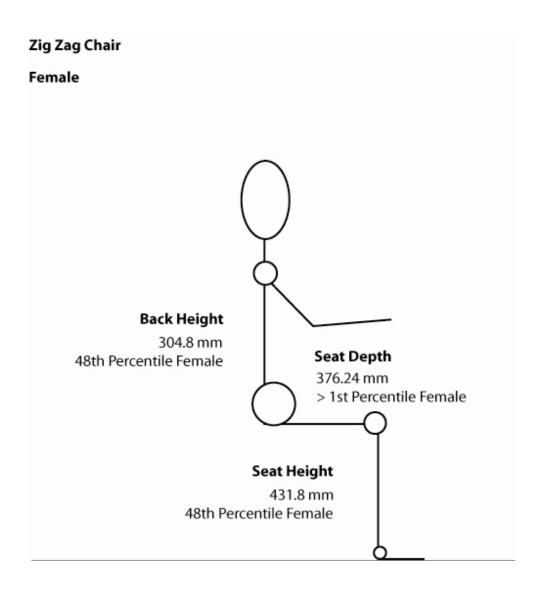
BHZZ = CAHS (54%)

Zig Zag Chair

Female

Back Height
304.8 mm
48th Percentile Female

Seat Depth
376.24 mm
> 1st Percentile Female

Seat Height
431.8 mm
48th Percentile Female

Figure 28 Zig Zag Chair Diagram of Fit

6.2.3 *Zig Zag* Chair – Redesign

Once the dimensions of the original chair were determined, and the "definition of fit" was established as seen above, nine versions of the chair were developed. Initially, I had planned on creating only three variations of the original. They would be based on percentiles uniformly applied to each critical dimension. These percentiles would be at the extremes of the population and at the median. These percentiles would be at the extremes of the population and at the median. This method would show us what the chair would look like for an individual whose anthropometry is uniformly (in their seat height, seat depth and back height) at the extremes. This method does not address the subjects in the population who have a seat height, depth and back height dimensions are not of the same percentile. These theoretical individuals are outliers of the population. (Salvendy, 2005)

To come up with the dimensions for the redesigned chairs, the three critical measures of seat height, seat depth and back height, and their values at the 10th percentile and the 90th percentile were placed in a matrix. In statistics, the empirical rules states that a bell shaped curve will include 68% of the population will lie within one standard deviation away from the median in each direction. 95% is included when you move two standard deviations away and three standard deviations will include 99.7% of the population. (Rumsey, 2003) Different disciplines use different standards of inclusion. Typically, designers select the 5th and 95th percentiles to bracket the population. This includes 90% of the population. I chose to use the 10th and the 90th percentiles, knowing that it would only include 80% of the population. I made this decision after investigating the ratios

resulting from a matrix of 1st and 99th percentiles.   The extremes resulted in gross distortions that would result in chairs that would appear functionally less useable – I felt that the data collected from the surveys would not be as informative if this were the case.

There are eight possible combinations of these variables are shown in Table 1.

Table 1 Matrix of Possible Combinations of Seat Height, Seat Depth and Back Height

Seat Height	10th	90th	10th	10th	10th	90th	90th	90th
Seat Depth	10th	90th	10th	90th	90th	10th	90th	10th
Back Height	10th	90th	90th	90th	10th	90th	10th	10th

In addition to these combinations, I created an "average" chair with all three dimensions based on the percentile of what I determined to be the "critical" dimension. In the *Zig Zag* Chair, the critical dimension was the seat height, which fit a 48th percentile female. The "average" chair was then composed of a 48th percentile seat height, seat depth and back height. The resulting versions are shown in Table 2.

Table 2 Combinations of Dimensions for the Redesigned *Zig Zag* Chairs

	Original	v.1	v. 2	v. 3	v. 4	v. 5	v. 6	v. 7	v. 8	v. 9
Seat Height	48th	48th	10th	90th	10th	$10t^{h}$	10th	90th	90th	90th
Seat Depth	$>1^{st}$	48th	10th	90th	10th	90th	90th	10th	90th	10th
Back Height	48th	48th	10th	90th	90th	90th	10th	90th	10th	10th

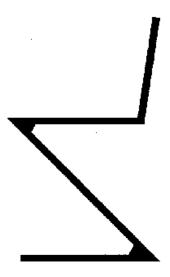Figure 29   Rendering of Original Chair

Figure 30   Right Side Orthographic of Original Chair
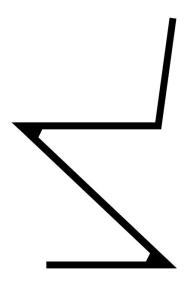
Figure 31 Rendering of Version 1

Figure 32 Right Side Orthographic of Version 1

Figure 33   Rendering of Version 2
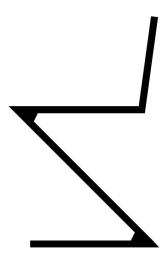

Figure 34   Right Side Orthographic of Version 2

Figure 35   Rendering of Version 3
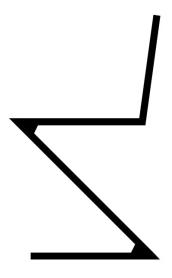

Figure 36   Right Side Orthographic of Version 3

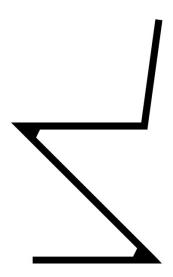Figure 37   Rendering of Version 4

Figure 38   Right Side Orthographic of Version 4

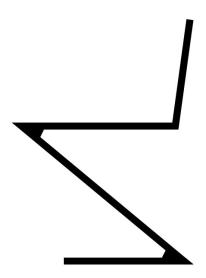Figure 39   Rendering of Version 5

Figure 40   Right Side Orthographic of Version 5

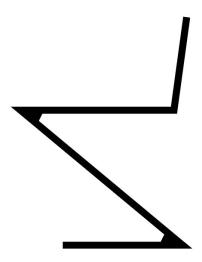Figure 41   Rendering of Version 6

Figure 42   Right Side Orthographic of Version 6

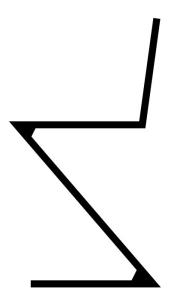Figure 43   Rendering of Version 7

Figure 44   Right Side Orthographic of Version 7

Figure 45   Rendering of Version 8
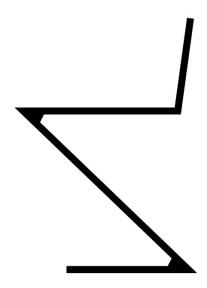

Figure 46   Right Side Orthographic of Version 8
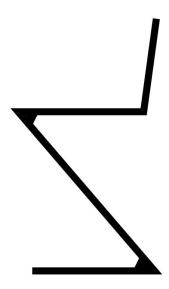
Figure 47   Rendering of Version 9

Figure 48   Right Side Orthographic of Version 9

The chairs were created in Form Z, a 3D modeling software. In order to limit the changes in the design to the key dimensions, certain parameters for building the models were established. The back of the chair is rectangular. All the sides are parallel. However, the seat, leg and base taper in and out. Since the width of the chair was not altered, the angle of the tapers changed according to the length of each segment. The length of the base was not changed to maintain consistency in the variations of the design. I recognize that some of the variations of the chair are functionally untenable because of this. Each of the variations was placed in the same environment for the perspective shots to be taken. Lighting and camera angle were not changed.

6.2.4 Design and Execution of the Survey

I designed a survey to measure the differences in the perceived beauty and proportionality of the variations of the chairs. The survey was constructed to ascertain the desired information about the original chair first, and then the nine versions constructed using the formulas presented in the preceding section. Full size plots of the chairs in right profile and in perspective were displayed in the jury gallery of the College of Architecture. The posters were hung so the base of the chairs in profile view was at floor level. This was done to establish a baseline for the different chairs and to communicate the scale of the chairs as they would be seen sitting on the ground.

The survey consisted of two sections. The first section was to assess the perceived and proportionality of the chairs. After establishing if they were familiar with the original

design, the same three questions were asked using a Lickert scale for each of the ten

versions of the chair.

On a scale of one to ten, with one being the least and ten being the most,
1) How beautiful do you think this chair is?
2) How well proportioned is this chair?
3) Which one dimension, if any, of this chair seems to stand out the most as being badly proportioned? -- e.g. the seat width looks too narrow; the seat height looks too low.

Seat Height	too high	too low
Seat Depth	too deep	too shallow
Seat Width	too wide	too narrow
Back Height	too high	too low
Back Width	too wide	too narrow
None	this chair is well proportioned	

The students were also given the option of writing comments for each chair. They were

then asked to rank the chairs in order from best proportioned to worst.

The second section asked four questions regarding perceived fit. The chairs were

grouped according to seat height, seat depth and back height. For each dimension, the

student was asked which group looked like it would be the best fit for him or her. The

student was also asked which chair looked like it would fit the most people.

The students were also asked for their age, gender, and studio instructor's name.

The survey was tested by four graduate students prior to being administered to the sample

group. It was well received. Feedback included rewording question 32, regarding

ranking the chair from best proportioned to worst. Rather than giving them the chair

number and having them assign it a rank, the rank number was given and the student was asked to fill in the chair number. Other feedback regarded formatting. Changing spacing and font properties helped to clarify the instructions. (See Appendix B for the entire survey.)

The survey was administered on March 16, 2005 to 34 Industrial Design students from the College of Architecture. The survey was approved by Georgia Tech's Institutional Review Board and was determined to need a Documentation of Waiver of Consent due to the minimal risk to the participants. The students were recruited verbally by me and by their studio instructors. Because students are considered an "at-risk population" they were told that participation was voluntary and that there would be no penalty for refusing and no benefit for participating.   Complete information regarding their rights was included with the survey material.

Figure 49 Installation of Survey Posters; Subject Taking Survey

The students came in small groups, were given the surveys and were told to read through the instructions and to ask me if they had any questions. I indicated verbally where to

begin and collected the surveys upon completion. In general it took students less than 15

minutes to complete the survey.

6.3 Results

I interpreted the data in several ways to gather certain information. I wanted to see what

the relationship was between the scores given to each chair according to its perceived

beauty and proportion. A median score was calculated for each chair. The chairs were

then ranked according to these scores. An overall score and rank was given based on the

average of the beauty and proportion scores.

Table 3 Scores and Ranking of the *Zig Zag* Chair for Beauty and Proportion

	Beauty	Rank	Proportion	Rank	Overall Score	/ Rank
Original Chair	6.30	3	6.16	5	6.23	4
Version 1	5.57	7	5.43	7	5.5	7
Version 2	5.73	6	5.97	6	5.85	6
Version 3	6.39	2	6.89	1	6.64	1
Version 4	6.03	5	6.30	4	6.17	5
Version 5	4.67	8	3.94	8	4.31	8
Version 6	4.11	10	3.29	10	3.7	10
Version 7	6.26	4	6.37	3	6.32	3
Version 8	4.46	9	3.92	9	4.19	9
Version 9	6.41	1	6.41	2	6.41	2

I was satisfied to see that there was little variation between the scores for beauty and the

scores for proportion given each chair. This is particularly true for the highest and lowest

ranking chairs.

Because an average provides limited information, I created histograms to show the

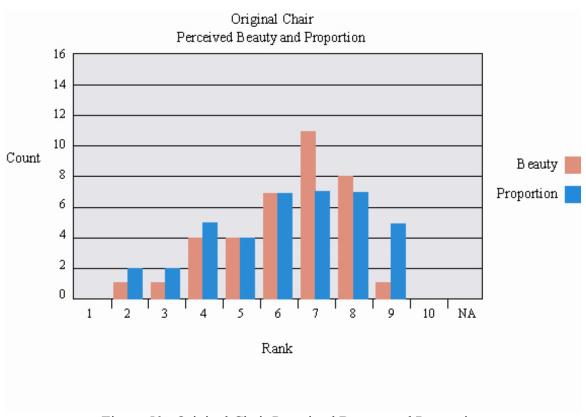frequency of each score for each chair.

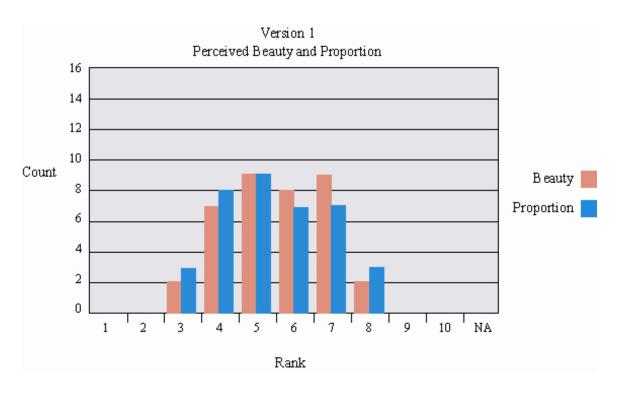Figure 50   Original Chair Perceived Beauty and Proportion

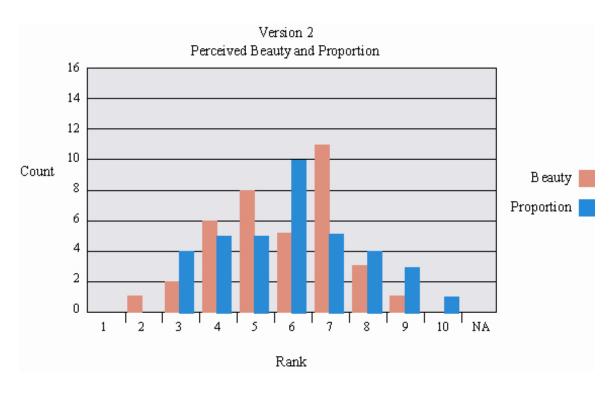Figure 51   Version 1 Perceived Beauty and Proportion

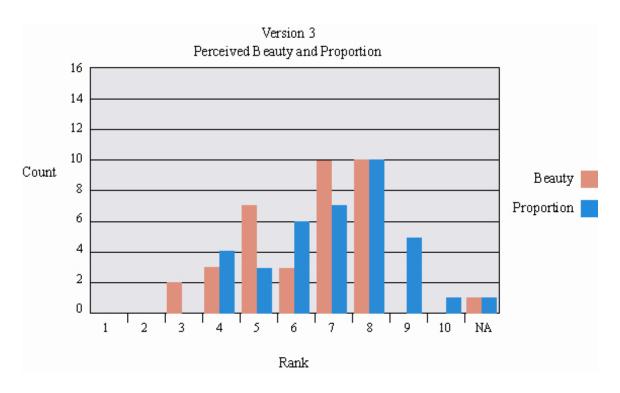Figure 52   Version 2 Perceived Beauty and Proportion

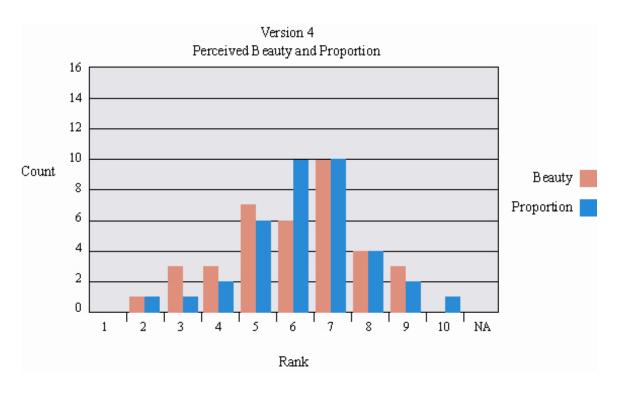Figure 53   Version 3 Perceived Beauty and Proportion

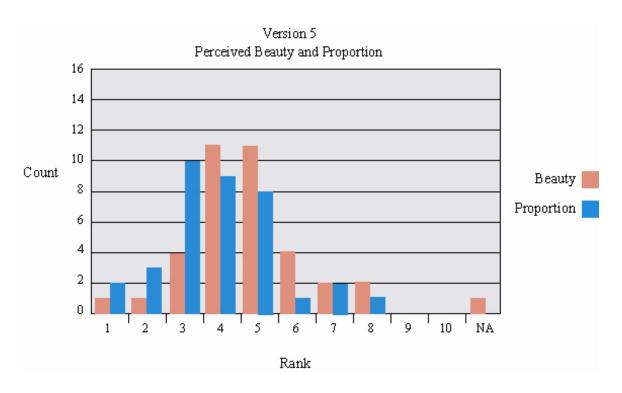Figure 54   Version 4 Perceived Beauty and Proportion

Figure 55   Version 5 Perceived Beauty and Proportion
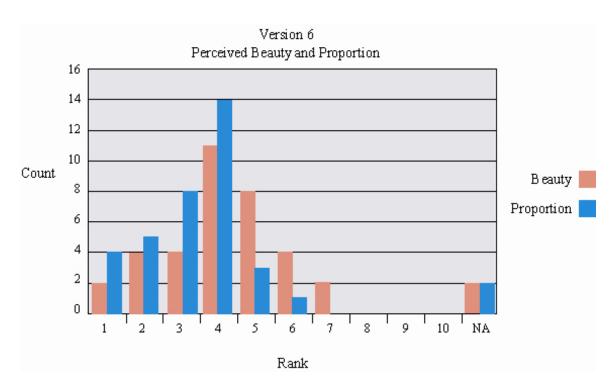

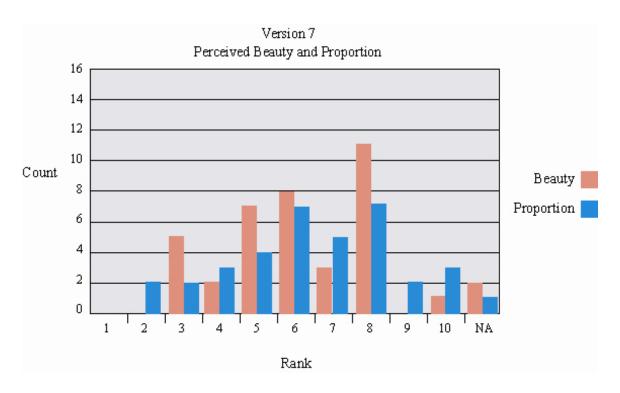Figure 56   Version 6 Perceived Beauty and Proportion

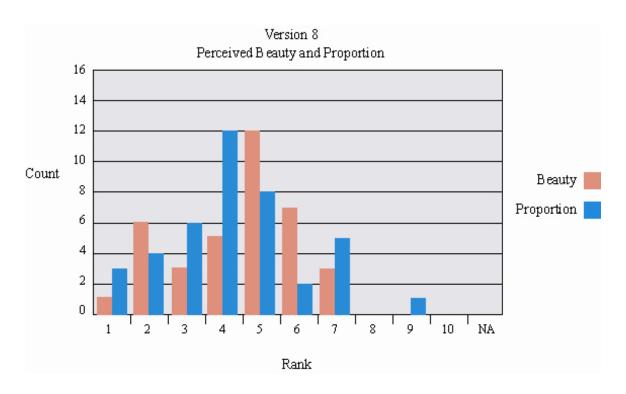Figure 57   Version 7 Perceived Beauty and Proportion

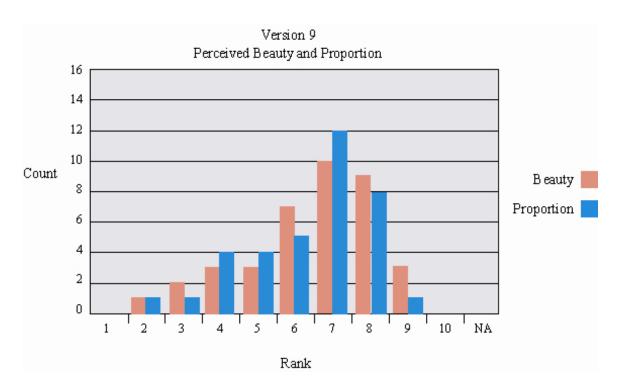Figure 58   Version 8 Perceived Beauty and Proportion

Figure 59   Version 9 Perceived Beauty and Proportion

These graphs reveal that the subjects were not giving the same score for beauty and proportion as evidenced by the difference in the frequency of each rank. The skew shown in each of the charts reinforces the rank that that chair received. It also reveals that out of the 34 subjects each giving two scores for each of the ten versions, for a total of 680 scores given, a score of 10 was only given four times. The highest frequency a score received was on the chair which was given the lowest rank for both beauty and proportion.

I was also interested to see if there was agreement on which dimension seemed most problematic.

SH1 = Seat Height   too low

61

SH2 = Seat Height   too high
SD1 = Seat Depth   too shallow
SD2 = Seat Depth   too deep
SW1 = Seat Width   too narrow
SW2 = Seat Width   too wide
BH1 = Back Height   too low
BH2 = Back Height   too high
BH1 = Back Width   too narrow
BH2 = Back Width   too wide
N = None   this chair is well proportioned
NA = No Answer

Figure 60   Original Chair Dimension Perceived to be Most Problematic

Figure 61   Version 1 Dimension Perceived to be Most Problematic

Figure 62   Version 2 Dimension Perceived to be Most Problematic

Figure 63   Version 3 Dimension Perceived to be Most Problematic

Figure 64   Version 4 Dimension Perceived to be Most Problematic

Figure 65   Version 5 Dimension Perceived to be Most Problematic
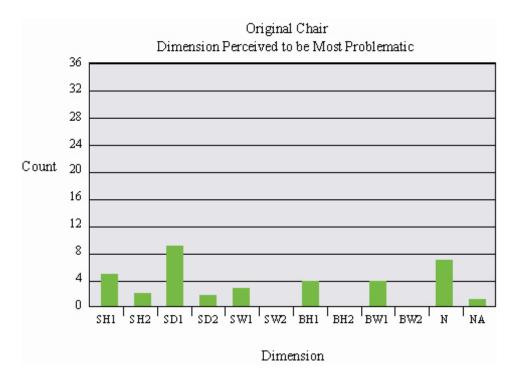

Figure 66   Version 6 Dimension Perceived to be Most Problematic
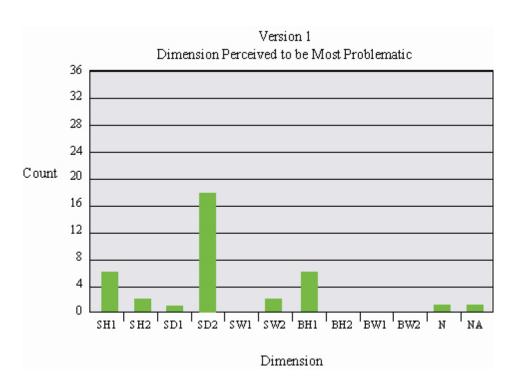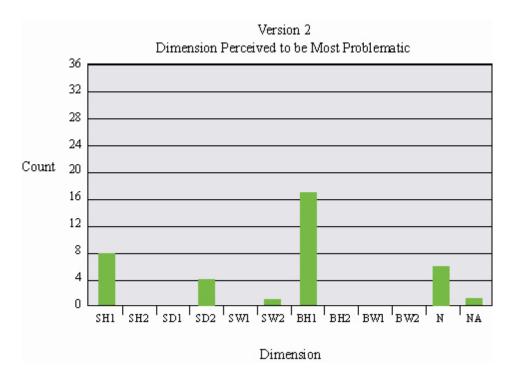
Figure 67   Version 7 Dimension Perceived to be Most Problematic

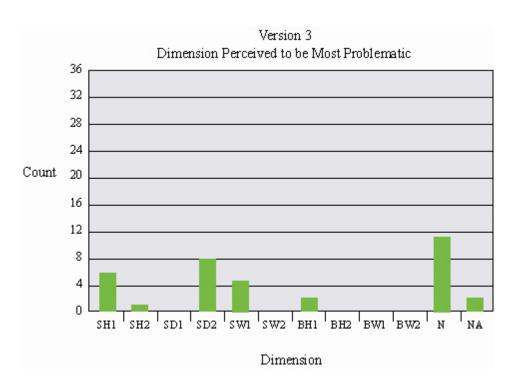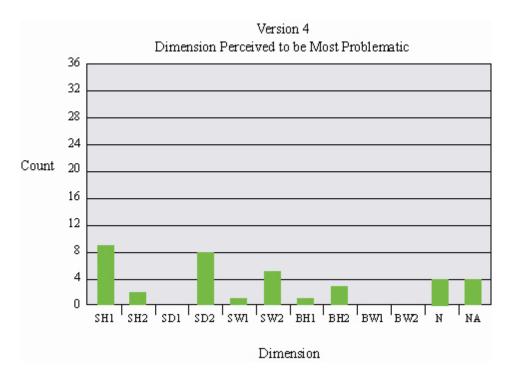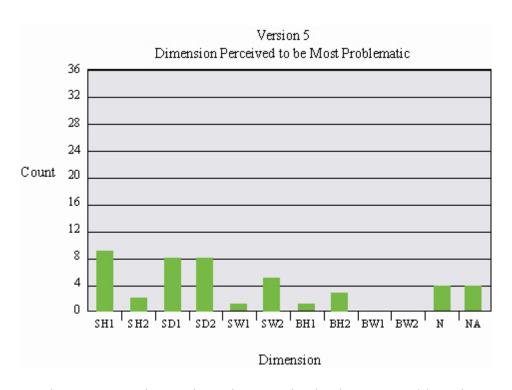Figure 68   Version 8 Dimension Perceived to be Most Problematic

Figure 69   Version 9 Dimension Perceived to be Most Problematic

Again, the chairs with the lowest score had the highest frequency for one problematic dimension. Versions 6 and 8 had 28 and 22 subjects selected the same dimension as being the problem. In both cases, the seat height was considered too deep. Version 9 which is ranked first in beauty, second in proportion, and second overall, had the most subjects (14) choose none of the proportions as being a problem. Version 3 which is ranked second in beauty, first in proportion, and first overall, had 11 subjects choose none of the proportions as being a problem. Third place finisher, Version 7, had 10 subjects say there was no problem, however, 17 said the seat height was too high. The original chair had every dimension except width named as a problem. Eighteen of the subjects said Version 1's seat depth was too deep. Version 2 was considered to have a back height which was too low. Versions 4 and 5 were considered to have a seat height which was too low for its depth.

The final set of questions regarding best perceived fit garnered the following results.

Figure 70   Best Perceived Fit for Subject

Figure 71   Best Perceived Fit for Most People

Not surprisingly, the 90th percentile was chosen for the Seat Height and Back Height as being likely to be the best fit for the subject, while the Seat Depth for the 90th percentile was considered to be too deep. Again, remember that the original chair had certain dimensions which were so small that it could not accommodate any adult male. However, one questions whether the judgment made on the Seat Depth was affected by the dimension of the seat base.

Interestingly, when asked which chair would likely fit the most people, the chair which had all the dimensions to accommodate the 90th percentile tied with the version which had a 10th percentile seat depth and 90th percentile seat and back height. The shallowness of the seat depth seemed less important than the scale of the other dimensions.

6.4 Discussion

The chair that had all three variable dimensions measured for a 90th percentile female was considered the most beautiful. The chairs considered the least beautiful had seat depths for the 90th percentile and back heights for the 10th. The factor mentioned most often as being as problem was the seat depth that was too deep. It was cited 114 times – more than twice as often as any other dimension. In fact, the second most frequently chosen selection, with 53 responses, was that there was no problem at all.   My interpretation of this is that the seat depth is the most critical dimension when considering the proportions of the chair. (See Appendix C for the raw data from the survey.)

In the definition of fit, it was determined that the seat height was the critical dimension for functionality. Each chair has a structural logic. The chair should be used as prescribed earlier – the user's feet rest on the floor, there is space between the back of the knees and the edge of the seat, and the user's back touches the back rest. Because the seat depth was so shallow, there would be space between the chair edge and popliteal crease for everyone in the population. The fit for the back height was based on the fit of the seat height. The existing seat height, however, clearly fit a specific percentile. Logic would indicate that this dimension is the one that must accommodate the user. However, the survey showed that a seat height at both extremes was acceptable.

So why is the seat depth so important? When the chairs were scaled, I made the decision

to leave the base at its original length. I believe that this affected the perception of the

seat depth. Several of the chairs that resulted looked unstable. When seen from a side

view, the eye reads the strong parallel lines of the seat and the base. These are the only

parallels from that view. In fact, the only others in the whole chair are in the width of the

seat back. The chair is very planar in it nature. Rietveld described it as being a slice in

space. From the side, the chair is reduced to four lines. The simplest chair is a cube for a

seat and a plane for a back rest. (See early Egyptian thrones.) I think the eye starts to

create a volume for the chair base as it reads the parallel lines. When this perceived

volume becomes structurally illogical because of the discrepancy in the lengths of the

seat and base, its proportions become displeasing. In order to minimize this, the volume

needs to be balanced. The original chair had a seat height and an overall depth at 431.8

mm and created the impression of a square when seen from the side. When adjusting this

chair for fit, the first dimensions to be established should be the seat depth and base

depth.   The seat height is the secondary dimension to establish, because it seems that a

range of seat heights is more acceptable. Several subjects made written comments that

Version 9, with its seat height at the 90th percentile and the seat depth and back height at

the 10th, looked more like a bar stool than a chair. This version received the highest

overall score. Version 3, with all dimensions accommodating the 90th percentile was

ranked second.

It is important to remember that these chairs were constructed from the possible

combinations provided by the matrix. The likelihood of some of the combinations of

measurements occurring in an actual subject is slim. With this in mind, I chose to create a

second survey using actual subjects selected from the CAESAR database. I also wanted

to see the results of the scaling on a chair whose form was more volumetric than the

planar *Zig Zag* chair. I chose the *Grand Confort*, or *LC2* chair by Le Corbusier and his

collaborators, Charlotte Perriand and Pierre Jeanneret.

CHAPTER 7

STUDY #2

7.1 Introduction

In order to better understand this method, I performed a second survey on another chair.

7.1.1 *LC2* Chair – History

Figure 72 *Grand Confort* or *LC2* chair, Le Corbusier, Charlotte Perriand & Pierre Jeanneret 1929

Le Corbusier was born Charles Edouard Jeanneret in La Chaux de Fonds, Switzerland in 1887. (Russell & Read, 1980) Considered one of the most significant modern architects of the 20th century, he has also been called the "most important Modernist chair designer in France," by Frank Russell in his discussion of chairs of the 20th century. (Russell, F., p.113) From a family of watchmakers, Le Corbusier trained as an artist, traveled in his twenties throughout Europe studying architecture. From 1908-1910, he studied in Paris with Auguste Perret who was a pioneer of the use of reinforced concrete. He worked in

the studio of Peter Behrens 1910 to 1912. (Becker, 2005) During the course of his life,

Le Corbusier was a visionary, working as artist, architect, city planner, furniture designer,

and theoretician.   He disseminated his ideas through many publications, most notably,

the journal *L'Esprit Nouveau*, and the books <u>Towards a New Architecture</u> and <u>Modulor I</u>

<u>and II</u>. (Blake, 1960) Set forth in his writing was the idea that the house was a "machine

for living". This new definition of design called for new materials, new methods of

production and the reevaluation of social trends and conventions. (Russell & Read, 1980)

His "Five Points of Architecture" presented strategies to realize his revolutionary ideas:

> "(1) The pilotis elevating the mass off the ground, (2) the free plan,
> achieved through the separation of the load-bearing columns from
> the walls subdividing the space, (3) the free facade, the corollary of
> the free plan in the vertical plane, (4) the long horizontal sliding
> window and finally (5) the roof garden, restoring, supposedly, the
> area of ground covered by the house." (Tse, 2002)

His strategies make use of inversion; the building is elevated above the ground rather

embedded into it, the walls become non-structural, a garden replaces an attic.

(Colquhoun, 1981) The strategy of inversion which presents itself in his architecture is

seen on a more intimate scale in his furniture design – particularly in the chair. In 1922,

Le Corbusier opened a studio in Paris with his cousin Pierre Jeanneret. (F.C., 2005)

Charlotte Perriand joined the studio in 1927 as "associate in charge of interior

equipment." (Perriand *et al.*, 2003) Le Corbusier proposed that furniture in the home

should be treated as "equipment" in the "machine for living." It was to be functional,

efficient and standardized (Perriand et al., 2003) Perriand and Le Corbusier were

interested in using industrial materials, abandoning the applied ornament of previous

generations. In the journal *The Studio* in April 1929, Perriand wrote that "METAL plays

the same part in furniture as cement has done in architecture. IT IS A REVOLUTION.

If we use metal in conjunction with leather for chairs…we get a range of wonderful

combinations and new aesthetic effects." (Russell & Read, 1980) The range of chairs

produced responded not only to the new materials available to them, but to an
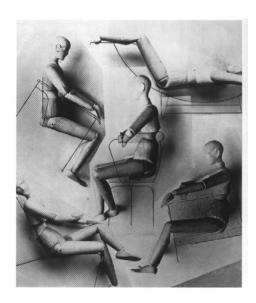
investigation of seating postures.

Figure 73   Photomontage illustrating different seating positions, Perriand, c. 1929

In the beginning of their studies, a distinction had been made between seating positions

for men and for women, but by 1929, this distinction had disappeared. There were no

"masculine" or "feminine" chair types. McLeod credits this reduced reference to gender

to the elimination of figurative imagery in Modernism. Instead, scale, color and setting

were the important variables. (Perriand et al., 2003) The chair types that developed

included the *basculant*, or swinging back; the *chaise longue*; the *siège tournant*, or

revolving chair; and the *fauteuil*, or easy chair. (Russell & Read, 1980)

Figure 74   *Chaise basculant* or *LC1,* Le Corbusier, Perriand & Jeanneret, 1928

Figure 75   *Chaise longue* or *LC4,* Corbusier, Perriand & Jeanneret, 1928

Figure 76   S*iège tournant* or *LC7,* Corbusier, Perriand & Jeanneret, 1928

Figure 77   *Grand Confort* or *LC2* chair, Le Corbusier, Perriand & Jeanneret 1929

As "machines-for-sitting," these chair types were made to accommodate different seated positions. The fauteuil, which will be examined in depth in this discussion, was a descendant of the club chair and could be called a "machine-for-relaxing." (Perriand et al., 2003) Le Corbusier, Perriand and Jeanneret named the chair *Le Grand Confort.* It was first exhibited in 1929 at the Salon d'Automne and was shown the same year with the chaise longue at the villa for the Church family at Ville d'Avray. (Fiell & Fiell, 1993)

Le Corbusier's strategy of inversion is seen in the structure of this chair. It is as if a traditional upholstered chair has been turned inside-out. Five leather-upholstered cushions are supported by a frame of chromed tubular steel. This chair is essentially a metal cage measuring a cubic meter. Perriand called it a *panier à coussins* or "cushioned basket." (Perriand et al., 2003) Two versions of differing widths were created. Perriand described them in her notes as *fauteuil confort* and *fauteuil canapé*. (Marcus & Le, 2000) They have come to be known as the *LC2* and the *LC3* chair.

LC2   *LC3*

Figure 78   *LC2* and *LC3* chairs, Le Corbusier, Perriand & Jeanneret 1928-29

In her essay, *New Designs for Living,* Mary McLeod suggests that the two sizes were meant to accommodate both men and women. (Perriand et al., 2003) The change in scale in the two chairs is primarily in the seat width. The *LC3* is nearly 24 cm wider than

the *LC2*. According to notes and drawings from the studio, this extra width was to accommodate spreading out and slouching. (Cranz, 1998) The *LC2* chair measures 76 cm wide by 70 cm deep by 67 cm high. The *LC3* measures 99 cm wide by 73 cm deep by 62 cm high. The seat height for both chairs is 43.18 cm. This brings up the question of fit which will be discussed in the following section at length. While this chair predates Le Corbusier's development of the *Modulor* system of measure, this chair closely fits the 6 foot tall man the system is based on.

7.2 Methods

7.2.2 *LC2* Chair – Definition of Fit

The same procedure that was used for defining the fit of the *Zig Zag* chair was followed for the *LC2* chair. The original design's seat height, seat depth, and back height were measured. Seat height was matched to a value in the CAESAR database. The seat depth was calculated and because this dimension is so large in the *LC2* Chair (558.8 mm) and corresponds to a percentile so high (98th) on the chart, it was considered to be the driving dimension of the design in terms of function. In order for an individual to sit back fully in this chair and still have his feet on the floor with his knees at a 90 degree angle, he would have to meet or exceed this measurement plus the clearance determined for fit. The back height is generally more subjective in a chair of this nature, with no predetermined measurement being functionally necessary. The seat depth of 558.8 mm is functionally most important and therefore the "critical" dimension.

Seat Height of the chair will be the same as the CAESAR Seat Height Measurement. This chair fits a 9th percentile male at 431.8 mm high.

SHLC = CSH

Seat Depth of Chair will equal CAESAR Buttock-Knee Length of a 98th percentile male less 88.5 mm (for the thickness [the entero-posterior dimension] of the knee for men) less 50.8 mm for space between the seat edge and the popliteal crease.

SDLC = CBKL - 139.3

Back Height of the chair will equal the CAESAR Acromial Height Sitting multiplied by 35%. This number was calculated by making the assumption that the back height of the chair accommodated a 98th percentile male as did the Seat Depth. The Acromial Height of a 98th percentile male is 682 mm. The back height of the original chair was 238.76 mm. The back of the chair is 35% as high as the Acromial Height of the 98th percentile male it is assumed to fit.

BHLC = CAHS (35%)

LC2 Chair

Male

Back Height
238.76 mm
98th Percentile Male

Seat Depth
558.8 mm
98th Percentile Male

Seat Height
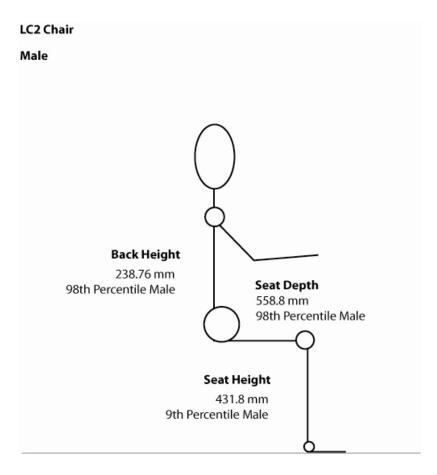431.8 mm
9th Percentile Male

Figure 79   Diagram of Fit for *LC2* Chair

7.2.3 *LC2* Chair – Redesign

Once the dimensions of the original chair were determined, and the "definition of fit" was

established as seen above, six versions of the chair were developed. Upon completion of

the first survey using theoretical outliers, I chose to create variations based on actual

subjects selected from the CAESAR database. The purpose of this was two-fold. While

the permutations created from the matrix of measures for the variations on the *Zig Zag*

chair revealed valuable information, some of the combinations are unlikely to occur in

the human population. The likelihood of a subject having legs where the upper leg is in

the 90th percentile and a lower leg that is in the 10th percentile is slim. The ratio of the

10th percentile seat height to the 90th percentile seat depth is .65. (As a point of reference,

the median ratio of the length of the tibia to the femur is .85. for adults. This is called the

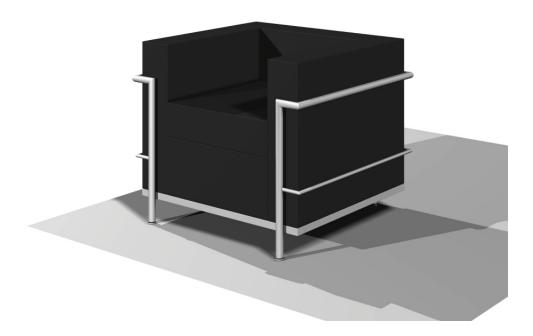crural index. [Wang, 2004])

Figure 80   Rendering of Original Chair

Figure 81   Right Side Orthographic of Original Chair

Figure 82   Rendering of Version 1
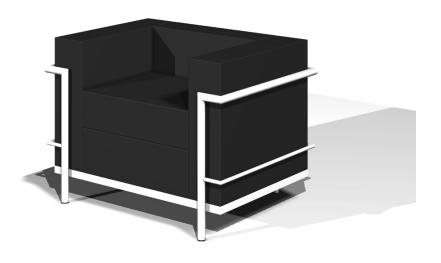

Figure 83   Right Side Orthographic of Version 1

Figure 84   Rendering of Version 2

Figure 85   Right Side Orthographic of Version 2

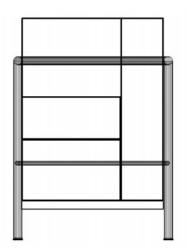Figure 86   Rendering of Version 3

Figure 87   Right Side Orthographic of Version 3
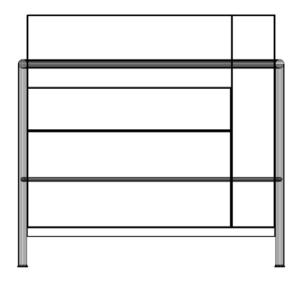
Figure 88   Rendering of Version 4

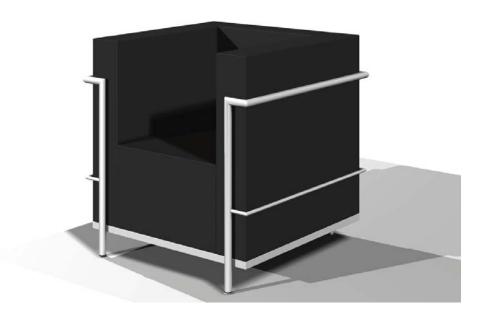Figure 89   Right Side Orthographic of Version 4

Figure 90   Rendering of Version 5

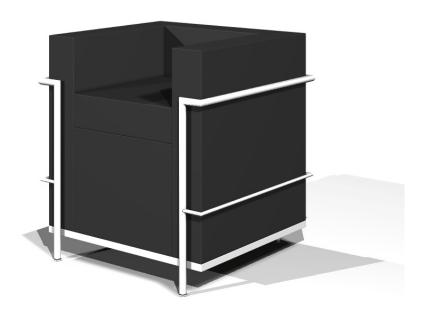Figure 91   Right Side Orthographic of Version 5
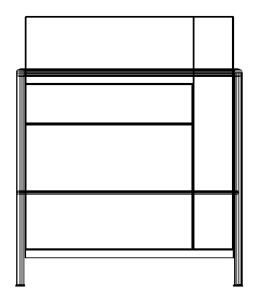
Figure 92   Rendering of Version 6

Figure 93   Right Side Orthographic of Version 6

Figure 94   Subject with Lowest Back Height

Figure 95   Subject with Highest Back Height

Figure 96   Subject with Shallowest Seat Depth

Figure 97   Subject with Deepest Seat Depth

Figure 98   Subject with Lowest Seat Height

Figure 99   Subject with Highest Seat Height

I was also interested in being able to reference the image from the 3D scans of the

subjects. This helps to illustrate the vast difference in body types that we as designers are

trying to accommodate.

For each dimension, Seat Height, Seat Depth, and Back Height, two subjects were chosen

-- one with the greatest value for that dimension and one with the lowest value. In the

case of a tie for the dimension in question, the other dimensions in question were referred

to. The subject who was at the extreme in more of the dimensions was selected. This

method addresses the outliers of the population. Because these subjects are the 1st and

the 99th percentiles, they are the least likely to be accommodated. Even a chair that is

designed with anthropometrics and fit in consideration would typically exclude them --

the accepted practice is to design for the 5th to the 95th percentiles. Version 1 is for a

subject with the lowest seat height. Version 2 is for the lowest back height. Version 3 is

for the shallowest seat depth. Version 4 is for the deepest seat depth. Version 5 is for the

highest back height. Version 6 is for the highest seat height.

The variations of the chairs were modeled in Form Z. In order to limit the changes in the

design to the key dimensions, certain parameters for building the models were

established. The width was never altered. The seat, back and side cushions are 12.7 cm

thick. This was also true in the redesigns. The height of the bottom of the chair from the

floor was not changed to maintain consistency in the variations of the design. The radius

of the tubular steel and the height of the metal frame at the base were retained. Each

version was placed in the same environment for the perspective shots to be taken. The

camera angle was not changed and the lighting was only slightly adjusted to reduce glare

from the reflective surface of the chrome elements.

7.2.4   *LC2 Chair* -- Design and Execution of the Survey

The survey used to evaluate the *Zig Zag* chair was also used for the *LC2* chair. The

changes made to it reflected the different number of chairs being evaluated.

As before, the survey was constructed to ascertain the desired information about the

original chair first, and then the six versions constructed using the formulas presented in

the preceding section. To be consistent with the first survey, full size plots of the chairs

in right profile and in perspective were displayed in the same location. The posters were

hung so the base of the chairs in profile view was at floor level. This was done to

establish a baseline for the different chairs and to communicate the scale of the chairs as

they would be seen sitting on the ground.

The survey consisted of two sections. The first section was to assess the perceived and

proportionality of the chairs. After establishing if they were familiar with the original

design, the same three questions were asked for each of the six versions of the chair.

Using a Lickert Scale, they were asked the following.

On a scale of one to ten, with one being the least and ten being the most,
1) How beautiful do you think this chair is?
2) How well proportioned is this chair?

3) Which one dimension, if any, of this chair seems to stand out the most as being badly proportioned? -- e.g. the seat width looks too narrow; the seat height looks too low.

Seat Height   too high   too low
Seat Depth   too deep   too shallow
Seat Width   too wide   too narrow
Back Height   too high   too low
Back Width   too wide   too narrow
None   this chair is well proportioned

The students were also given the option of writing comments for each chair. They were then asked to rank the chairs in order from best proportioned to worst.

The second section asked four questions regarding perceived fit. The chairs were grouped according to seat height, seat depth and back height. For each dimension, the student was asked which group looked like it would be the best fit for him or her. The student was also asked which chair looked like it would fit the most people. The students were also asked for their age, gender, and studio instructor's name.

The survey was administered on April 5, 2005 to 33 Industrial Design students from the College of Architecture. The survey was approved by Georgia Tech's Institutional Review Board and was determined to need a Documentation of Waiver of Consent due to the minimal risk to the participants. The students were recruited verbally by me and by their studio instructors. Because students are considered an "at-risk population" they were told that participation was voluntary and that there would be no penalty for refusing and no benefit for participating. Complete information regarding their rights was included with the survey material.

The students came in small groups, were given the surveys and were told to read through the instructions and to ask me if they had any questions. I indicated verbally where to begin and collected the surveys upon completion. In general it took students less than 15 minutes to complete the survey.

7.3 Results

The data was interpreted in the same manner as the results from the first survey. At question was what the relationship was between the scores given to each chair according to its perceived beauty and proportion. A median score was calculated for each chair. The chairs were then ranked according to these scores. An overall score and rank was given based on the average of the beauty and proportion scores. (See Appendix D for the raw data from the survey.)

Table 4   Scores and Ranking of the *LC2* Chair for Beauty and Proportion

	Beauty	Rank	Proportion	Rank	Overall Score	/ Rank
Original Chair	6.94	1	6.69	2	6.82	1
Version 1	6.53	2	6.72	1	6.63	2
Version 2	6.08	3	5.77	3	5.93	3
Version 3	5.36	4	5.14	4	5.25	4
Version 4	5.06	5	4.64	5	4.85	5
Version 5	4.22	6	3.92	6	4.07	6
Version 6	4.17	7	3.53	7	3.85	7

As in the first survey, there was a little variation between the scores for beauty and the

scores for proportion given each chair.   Because an average provides limited

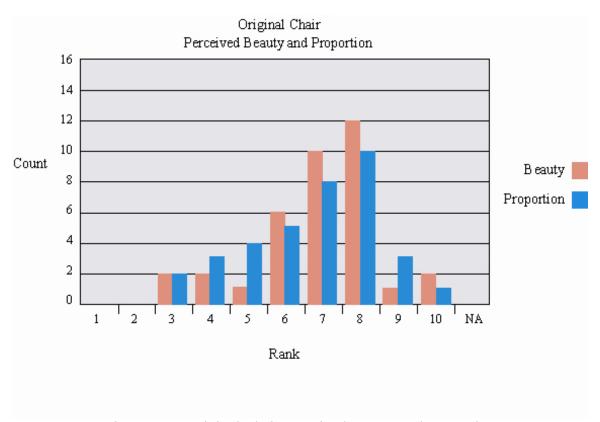information, I created graphs to show the frequency of each score for each chair.

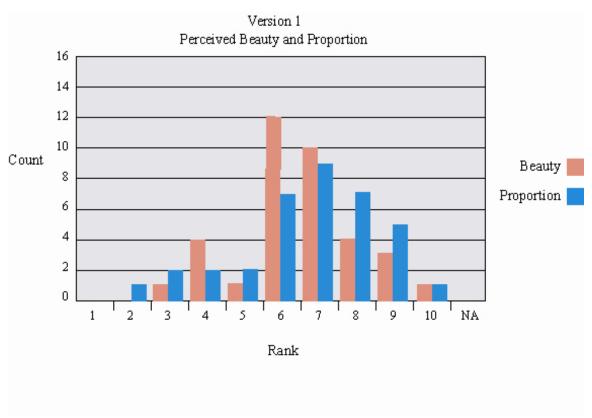Figure 100   Original Chair Perceived Beauty and Proportion

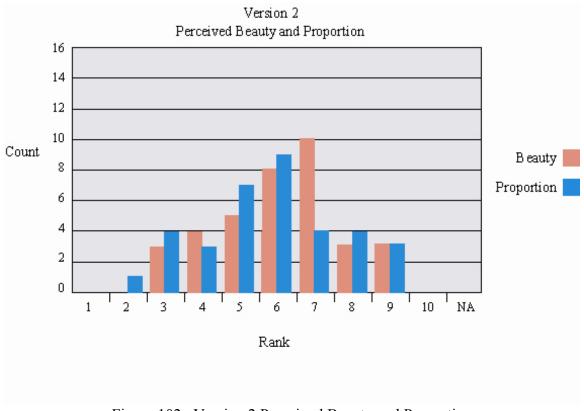Figure 101   Version 1 Perceived Beauty and Proportion

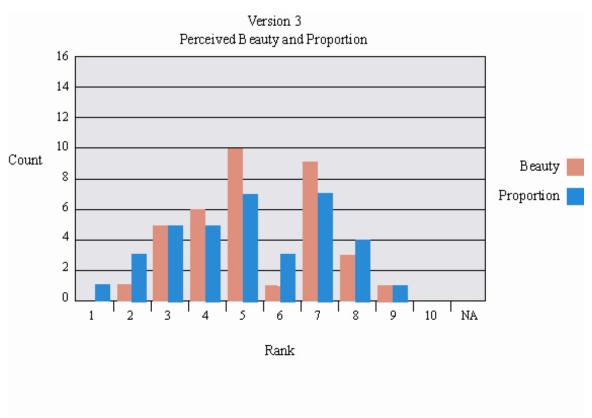Figure 102   Version 2 Perceived Beauty and Proportion
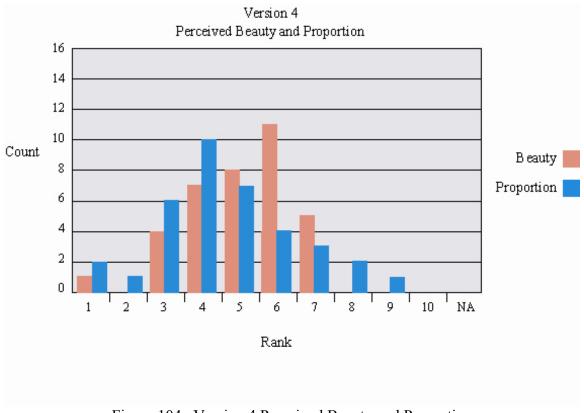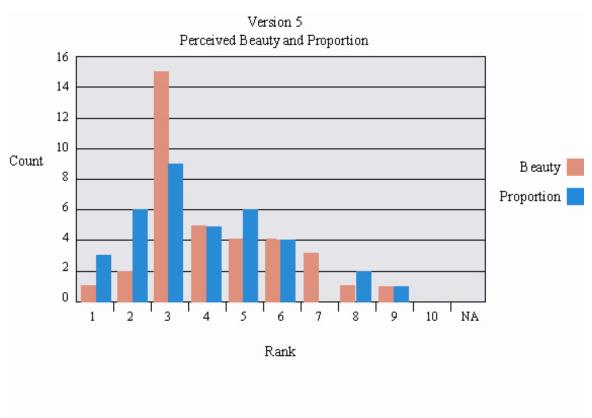
Figure 103   Version 3 Perceived Beauty and Proportion

Figure 104   Version 4 Perceived Beauty and Proportion

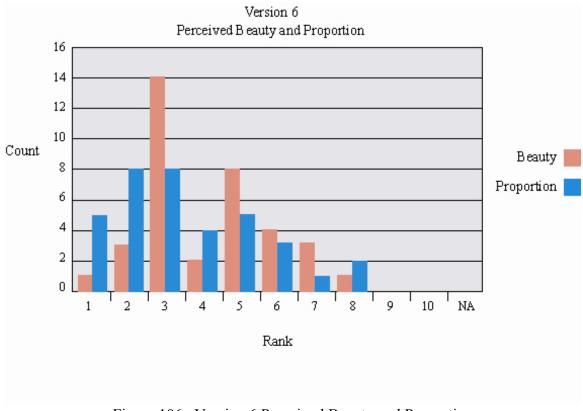Figure 105   Version 5 Perceived Beauty and Proportion

Figure 106   Version 6 Perceived Beauty and Proportion

These graphs reveal that the subjects were not giving the same score for beauty and proportion as evidenced by the difference in the frequency of each rank. In all cases except one, Version 1, the chair received higher overall scores for beauty than for proportion. A score of 10 was only given four times out of a possible 396 scores given. The lowest score of 1 was given 14 times.

I was also interested to see if there was agreement on which dimension seemed most

problematic.

```
SH1 = Seat Height     too low
SH2 = Seat Height     too high
SD1 = Seat Depth      too shallow
SD2 = Seat Depth      too deep
SW1 = Seat Width      too narrow
SW2 = Seat Width      too wide
BH1 = Back Height     too low
BH2 = Back Height     too high
BH1 = Back Width      too narrow
BH2 = Back Width      too wide
N = None               this chair is well proportioned
NA = No Answer
```
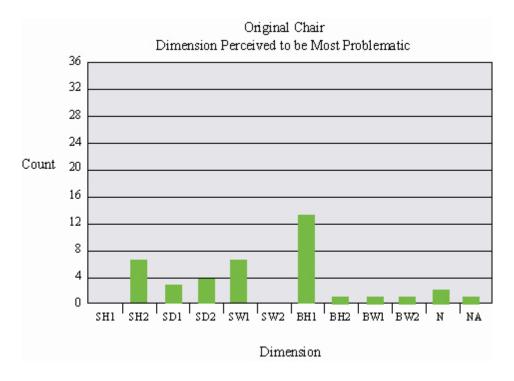

Figure 107   Original Chair Dimension Perceived to be Most Problematic
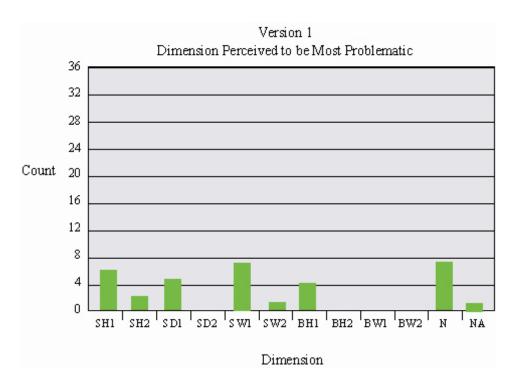
99

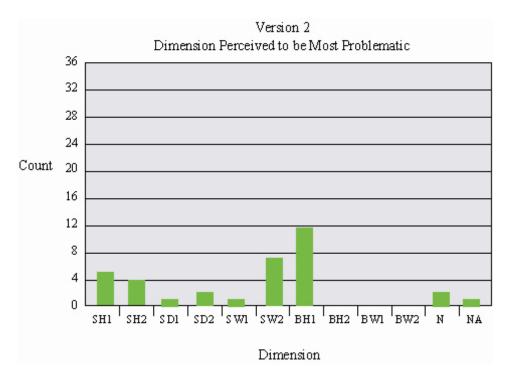Figure 108   Version 1 Dimension Perceived to be Most Problematic

Figure 109   Version 2 Dimension Perceived to be Most Problematic
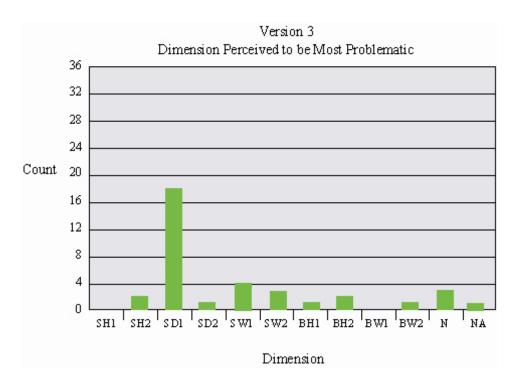
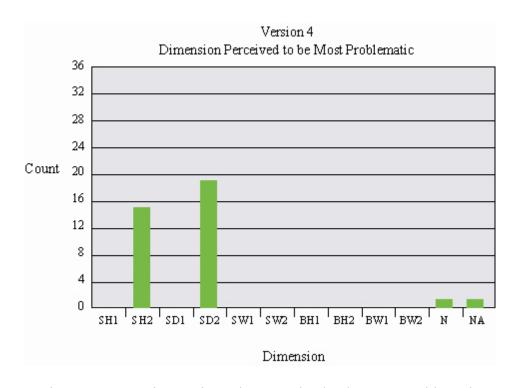Figure 110   Version 3 Dimension Perceived to be Most Problematic

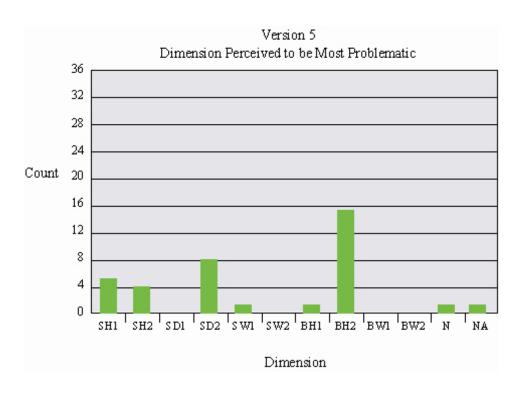Figure 111   Version 4 Dimension Perceived to be Most Problematic

Figure 112   Version 5 Dimension Perceived to be Most Problematic
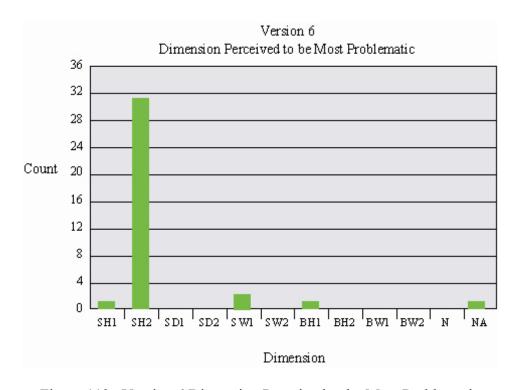

Figure 113   Version 6 Dimension Perceived to be Most Problematic

Again, the chair with the lowest score had the highest frequency for one problematic dimension. 86% of subjects selected the seat height as being too high in Version 6. This was for the subject from CAESAR who was the outlier for the highest seat height. The dimension most often listed as the problem dimension corresponded to the outlier it fitted in every case but Version 1. In Version 1, the back height was selected as being too low more than twice the number of times the seat height was selected to be too low. This version fit the outlier with the lowest seat height. Interestingly, the highest ranking score only had 2 subjects indicate that they thought it was well proportioned and that no one dimension was problematic. Twelve subjects said that the back height was too low. Back width was mentioned only once as being too wide – this was for Version 3 which had the shallowest seat depth.

The final set of questions regarding best perceived fit garnered the following results.
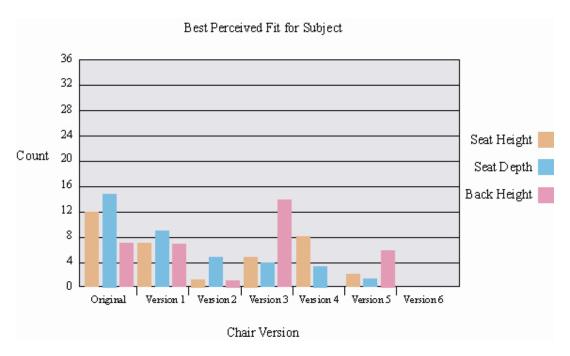

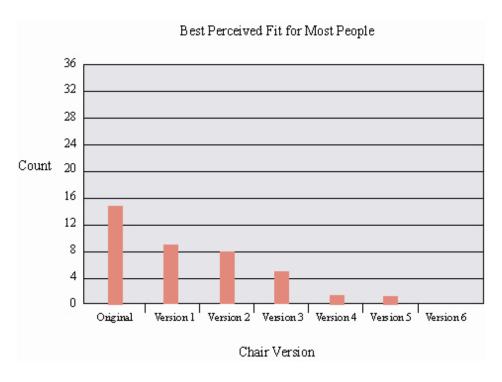Figure 114   Best Perceived Fit for Subject

Figure 115   Best Perceived Fit for Subject

The original chair was most frequently selected for best perceived fit for the subject and

for the general population in all dimensions but back height. This corresponds with the

back height as being cited as too low on the original, event though it was selected as the

most beautiful and well proportioned.

7.4 Discussion

It is very clear by the results which chairs were least preferred. The description of the

original chair as cage-like sheds light as to why these chairs received the lowest scores.

In the case of Version 5, with the highest back height (which also determines the arm rest

height), the chair becomes even more cage-like. Even though it would fit the long-torso-

ed person it is scaled for, it creates the impression that most users would be trapped in it.

It appears to be restrictive. On the other hand, Version 6, with the highest seat height

loses all feeling of being cage-like. It appears as if the user would be perching on it,

rather than sitting in it. This goes directly back to the designers' intent. The structural

logic of the original chair demands that the user sit way back in to it. The depth of the

seat demands this if the user is to relax against the back rest. The low height of the back

rest offers support for the lower back, and as it wraps around the chair and is transformed

in to arm rests, providing support for the forearms without restricting them. Remember

that Le Corbusier and partners were addressing posture as they developed different chair

types. It seems that the aesthetic proportion of the seat depth and the back height is most

critical. This corresponds with the assessment that the seat depth was the critical

dimension in the functional criteria. The critical functional dimension was not the same

as the critical aesthetic dimension in the *Zig Zag* chair survey.

CHAPTER 8

CONCLUSION

In the introduction, I stated that a chair is more than the sum of its component parts. I also proposed that the designer has a primary concern when creating a chair; it is either an aesthetic or a functional one. I then asked if these two approaches can be reconciled when the designer uses anthropometric data to determine formal proportions.

The methods laid out in this study were not meant to develop a prescriptive set of proportions that are considered beautiful to be forced on the chair over and above its functional requirements. It has already been shown that the idealized proportional systems from history are best suited for representation, not function. However, those principles should not be entirely dismissed. There is still a place in chair design for the aesthetic, the abstract, the conceptual. The brief history of thousands of years of chair design presented here testify to that.

Anthropometry in product design owes much to the development of the discipline in other fields. The technology of 3D body scanning is already being integrated into the design of other products. The garment industry, which has always been concerned with the question of fit, is pushing the envelope to find ways to integrate this technology into their business model. Body scanning data, such as that found in CAESAR, is being used to grow the ways they meet their customers' needs. There are four basic ways this is happening.

1) Mass-Customization for single order production (made-to-measure)
2) Mass-Customization with size-prediction (finding the best fit from a 3D scan) without customized production
3) Custom design using the scan of the individual client
4) Size surveys using the scan data to create new size systems. (Heyd, 2003)

Research is being done to automatically integrate body scan data in CAM software for the generation of patterns. (Carrere, et al., 2001) I speculate that these models of production will be investigated for use in the furniture industry. Already, the parametric programming capabilities of CNC machinery is allowing for the inexpensive short production runs that would have been prohibitively expensive using traditional manufacturing models. Other manufacturers that sell directly to consumers, like the automotive industry, are finding that their markets are more fragmented, of lower volume and customer driven. (Yucesan, 2002) Furniture manufacturers are faced with the problem of keeping large inventories because they do not know what the customer will accept. (Oh, et al., 2004) As mass-customization becomes more viable, I have no doubt that furniture manufacture will change. The design principles behind the products must change as well. This is an area for further research.

It is my hope that the processes offered here will give designers a new way to consider the critical functional and aesthetic requirements in chair design. While this study dealt with changes to pre-existing designs, the same principles can be used when generating a new chair, or any other product that has an intimate fit with the body. By determining a hierarchy of functional requirements and understanding the anthropometric values associated with it, a designer can develop the product's aesthetics and test them during the design process. While the survey is based on subjective opinions, it still provides

quantifiable data that can be used to more closely define the aesthetic parameters. In the

end, all designers want to create beautiful products that meet the user's needs. This

research is meant to be a means to that end.

APPENDIX A

American Adult Females Ages 18 - 65

Female Seat Height

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
Seat Height	1243	268	358	626	434.99	30.175	.764	.069
Valid N (listwise)	1243							

Seat Height

N	Valid	1243
	Missing	15

Seat Height

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	358	1	.1	.1	.1
	362	1	.1	.1	.2
	364	1	.1	.1	.2
	376	1	.1	.1	.3
	380	3	.2	.2	.6
	382	10	.8	.8	1.4
	384	10	.8	.8	2.2
	386	11	.9	.9	3.1
	388	37	2.9	3.0	6.0
	390	15	1.2	1.2	7.2
	392	16	1.3	1.3	8.5
	394	10	.8	.8	9.3
	396	14	1.1	1.1	10.5
	398	18	1.4	1.4	11.9
	400	13	1.0	1.0	13.0
	402	17	1.4	1.4	14.3
	404	26	2.1	2.1	16.4
	406	25	2.0	2.0	18.4
	408	24	1.9	1.9	20.4
	410	18	1.4	1.4	21.8
	412	36	2.9	2.9	24.7
	414	22	1.7	1.8	26.5
	416	28	2.2	2.3	28.7
	418	26	2.1	2.1	30.8
	420	22	1.7	1.8	32.6
	422	33	2.6	2.7	35.2
	424	35	2.8	2.8	38.1
	426	28	2.2	2.3	40.3
	428	37	2.9	3.0	43.3
	430	37	2.9	3.0	46.3

432	32	2.5	2.6	48.8
434	34	2.7	2.7	51.6
436	29	2.3	2.3	53.9
438	34	2.7	2.7	56.6
440	28	2.2	2.3	58.9
442	33	2.6	2.7	61.5
444	38	3.0	3.1	64.6
446	35	2.8	2.8	67.4
448	28	2.2	2.3	69.7
450	29	2.3	2.3	72.0
452	28	2.2	2.3	74.3
454	26	2.1	2.1	76.3
456	24	1.9	1.9	78.3
458	28	2.2	2.3	80.5
460	25	2.0	2.0	82.5
462	17	1.4	1.4	83.9
464	27	2.1	2.2	86.1
466	17	1.4	1.4	87.4
468	16	1.3	1.3	88.7
470	18	1.4	1.4	90.2
472	13	1.0	1.0	91.2
474	10	.8	.8	92.0
476	11	.9	.9	92.9
478	9	.7	.7	93.6
480	12	1.0	1.0	94.6
482	7	.6	.6	95.2
484	8	.6	.6	95.8
486	5	.4	.4	96.2
488	6	.5	.5	96.7
490	2	.2	.2	96.9
492	3	.2	.2	97.1
496	4	.3	.3	97.4
498	2	.2	.2	97.6
500	1	.1	.1	97.7
502	2	.2	.2	97.8
504	6	.5	.5	98.3
506	1	.1	.1	98.4
510	2	.2	.2	98.6
512	1	.1	.1	98.6
514	4	.3	.3	99.0
516	3	.2	.2	99.2
518	1	.1	.1	99.3
520	1	.1	.1	99.4
530	1	.1	.1	99.4
534	1	.1	.1	99.5
562	1	.1	.1	99.6
566	1	.1	.1	99.7

	572	1	.1	.1	99.8
	580	1	.1	.1	99.8
	590	1	.1	.1	99.9
	626	1	.1	.1	100.0
	Total	1243	98.8	100.0	
Missing	System	15	1.2		
Total		1258	100.0		

Female Buttock-Knee Length

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
buttockknee_length	1258	316	489	805	587.01	37.120	.613	.069
Valid N (listwise)	1258							

buttockknee_length

N	Valid	1258
	Missing	0

buttockknee_length

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	489	1	.1	.1	.1
	496	1	.1	.1	.2
	497	1	.1	.1	.2
	498	1	.1	.1	.3
	501	1	.1	.1	.4
	502	1	.1	.1	.5
	504	1	.1	.1	.6
	505	1	.1	.1	.6
	506	1	.1	.1	.7
	507	3	.2	.2	1.0
	508	2	.2	.2	1.1
	509	1	.1	.1	1.2
	510	2	.2	.2	1.4
	511	1	.1	.1	1.4
	512	1	.1	.1	1.5
	514	2	.2	.2	1.7
	515	2	.2	.2	1.8
	517	2	.2	.2	2.0
	518	2	.2	.2	2.1
	519	1	.1	.1	2.2
	521	1	.1	.1	2.3
	522	4	.3	.3	2.6
	523	4	.3	.3	2.9
	524	4	.3	.3	3.3
	525	5	.4	.4	3.7
	526	2	.2	.2	3.8
	527	2	.2	.2	4.0
	528	5	.4	.4	4.4
	529	4	.3	.3	4.7
	530	4	.3	.3	5.0
	531	1	.1	.1	5.1
	532	4	.3	.3	5.4
	533	3	.2	.2	5.6

534	6	.5	.5	6.1
535	5	.4	.4	6.5
536	6	.5	.5	7.0
537	5	.4	.4	7.4
538	4	.3	.3	7.7
539	10	.8	.8	8.5
540	5	.4	.4	8.9
541	6	.5	.5	9.4
542	10	.8	.8	10.2
543	5	.4	.4	10.6
544	6	.5	.5	11.0
545	7	.6	.6	11.6
546	5	.4	.4	12.0
547	8	.6	.6	12.6
548	7	.6	.6	13.2
549	9	.7	.7	13.9
550	17	1.4	1.4	15.3
551	8	.6	.6	15.9
552	9	.7	.7	16.6
553	8	.6	.6	17.2
554	9	.7	.7	18.0
555	12	1.0	1.0	18.9
556	16	1.3	1.3	20.2
557	10	.8	.8	21.0
558	7	.6	.6	21.5
559	11	.9	.9	22.4
560	18	1.4	1.4	23.8
561	10	.8	.8	24.6
562	15	1.2	1.2	25.8
563	5	.4	.4	26.2
564	16	1.3	1.3	27.5
565	13	1.0	1.0	28.5
566	10	.8	.8	29.3
567	15	1.2	1.2	30.5
568	17	1.4	1.4	31.9
569	16	1.3	1.3	33.1
570	14	1.1	1.1	34.3
571	9	.7	.7	35.0
572	15	1.2	1.2	36.2
573	12	1.0	1.0	37.1
574	14	1.1	1.1	38.2
575	16	1.3	1.3	39.5
576	20	1.6	1.6	41.1
577	13	1.0	1.0	42.1
578	14	1.1	1.1	43.2
579	17	1.4	1.4	44.6
580	19	1.5	1.5	46.1

581	13	1.0	1.0	47.1
582	12	1.0	1.0	48.1
583	19	1.5	1.5	49.6
584	12	1.0	1.0	50.6
585	19	1.5	1.5	52.1
586	14	1.1	1.1	53.2
587	12	1.0	1.0	54.1
588	17	1.4	1.4	55.5
589	15	1.2	1.2	56.7
590	12	1.0	1.0	57.6
591	13	1.0	1.0	58.7
592	8	.6	.6	59.3
593	7	.6	.6	59.9
594	12	1.0	1.0	60.8
595	17	1.4	1.4	62.2
596	12	1.0	1.0	63.1
597	15	1.2	1.2	64.3
598	12	1.0	1.0	65.3
599	10	.8	.8	66.1
600	14	1.1	1.1	67.2
601	8	.6	.6	67.8
602	10	.8	.8	68.6
603	13	1.0	1.0	69.6
604	10	.8	.8	70.4
605	8	.6	.6	71.1
606	12	1.0	1.0	72.0
607	12	1.0	1.0	73.0
608	1	.1	.1	73.1
609	9	.7	.7	73.8
610	7	.6	.6	74.3
611	19	1.5	1.5	75.8
612	7	.6	.6	76.4
613	13	1.0	1.0	77.4
614	8	.6	.6	78.1
615	10	.8	.8	78.9
616	7	.6	.6	79.4
617	11	.9	.9	80.3
618	11	.9	.9	81.2
619	11	.9	.9	82.0
620	5	.4	.4	82.4
621	7	.6	.6	83.0
622	10	.8	.8	83.8
623	8	.6	.6	84.4
624	8	.6	.6	85.1
625	13	1.0	1.0	86.1
626	7	.6	.6	86.6
627	9	.7	.7	87.4

628	5	.4	.4	87.8
629	8	.6	.6	88.4
630	8	.6	.6	89.0
631	7	.6	.6	89.6
632	3	.2	.2	89.8
633	6	.5	.5	90.3
634	5	.4	.4	90.7
635	4	.3	.3	91.0
636	6	.5	.5	91.5
637	4	.3	.3	91.8
638	2	.2	.2	92.0
640	3	.2	.2	92.2
641	2	.2	.2	92.4
642	6	.5	.5	92.8
643	5	.4	.4	93.2
644	6	.5	.5	93.7
645	2	.2	.2	93.9
646	7	.6	.6	94.4
647	4	.3	.3	94.8
648	5	.4	.4	95.2
649	4	.3	.3	95.5
650	3	.2	.2	95.7
651	3	.2	.2	95.9
653	6	.5	.5	96.4
654	1	.1	.1	96.5
655	3	.2	.2	96.7
656	2	.2	.2	96.9
657	3	.2	.2	97.1
659	1	.1	.1	97.2
660	2	.2	.2	97.4
661	3	.2	.2	97.6
664	1	.1	.1	97.7
665	1	.1	.1	97.8
666	1	.1	.1	97.9
671	1	.1	.1	97.9
672	2	.2	.2	98.1
673	1	.1	.1	98.2
675	1	.1	.1	98.3
676	1	.1	.1	98.3
677	1	.1	.1	98.4
680	1	.1	.1	98.5
687	1	.1	.1	98.6
688	2	.2	.2	98.7
691	3	.2	.2	99.0
694	1	.1	.1	99.0
695	2	.2	.2	99.2
698	1	.1	.1	99.3

706	3	.2	.2	99.5
707	1	.1	.1	99.6
712	2	.2	.2	99.8
720	1	.1	.1	99.8
785	1	.1	.1	99.9
805	1	.1	.1	100.0
Total	1258	100.0	100.0	

Female Acromial Height Sitting

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
acromial_height_sitting	1258	205	467	672	567.47	29.699	.158	.069
Valid N (listwise)	1258							

acromial_height_sitting

N	Valid	1258
	Missing	0

acromial_height_sitting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	467	1	.1	.1	.1
	475	1	.1	.1	.2
	481	1	.1	.1	.2
	489	2	.2	.2	.4
	495	1	.1	.1	.5
	496	1	.1	.1	.6
	497	1	.1	.1	.6
	498	1	.1	.1	.7
	499	2	.2	.2	.9
	500	2	.2	.2	1.0
	501	2	.2	.2	1.2
	503	1	.1	.1	1.3
	504	2	.2	.2	1.4
	505	1	.1	.1	1.5
	506	1	.1	.1	1.6
	507	1	.1	.1	1.7
	508	3	.2	.2	1.9
	509	5	.4	.4	2.3
	510	1	.1	.1	2.4
	511	1	.1	.1	2.5
	512	4	.3	.3	2.8
	513	3	.2	.2	3.0
	514	4	.3	.3	3.3
	515	3	.2	.2	3.6
	516	4	.3	.3	3.9
	517	2	.2	.2	4.1
	518	6	.5	.5	4.5
	519	7	.6	.6	5.1
	520	1	.1	.1	5.2
	521	3	.2	.2	5.4
	522	3	.2	.2	5.6
	523	3	.2	.2	5.9
	524	5	.4	.4	6.3

525	7	.6	.6	6.8
526	14	1.1	1.1	7.9
527	9	.7	.7	8.7
528	7	.6	.6	9.2
529	6	.5	.5	9.7
530	7	.6	.6	10.3
531	8	.6	.6	10.9
532	11	.9	.9	11.8
533	3	.2	.2	12.0
534	11	.9	.9	12.9
535	7	.6	.6	13.4
536	13	1.0	1.0	14.5
537	11	.9	.9	15.3
538	12	1.0	1.0	16.3
539	12	1.0	1.0	17.2
540	9	.7	.7	18.0
541	9	.7	.7	18.7
542	14	1.1	1.1	19.8
543	19	1.5	1.5	21.3
544	15	1.2	1.2	22.5
545	20	1.6	1.6	24.1
546	11	.9	.9	25.0
547	8	.6	.6	25.6
548	12	1.0	1.0	26.6
549	13	1.0	1.0	27.6
550	22	1.7	1.7	29.3
551	12	1.0	1.0	30.3
552	16	1.3	1.3	31.6
553	14	1.1	1.1	32.7
554	14	1.1	1.1	33.8
555	14	1.1	1.1	34.9
556	15	1.2	1.2	36.1
557	12	1.0	1.0	37.0
558	11	.9	.9	37.9
559	18	1.4	1.4	39.3
560	25	2.0	2.0	41.3
561	15	1.2	1.2	42.5
562	15	1.2	1.2	43.7
563	21	1.7	1.7	45.4
564	25	2.0	2.0	47.4
565	12	1.0	1.0	48.3
566	11	.9	.9	49.2
567	19	1.5	1.5	50.7
568	16	1.3	1.3	52.0
569	17	1.4	1.4	53.3
570	22	1.7	1.7	55.1
571	20	1.6	1.6	56.7

572	14	1.1	1.1	57.8
573	11	.9	.9	58.7
574	16	1.3	1.3	59.9
575	23	1.8	1.8	61.8
576	10	.8	.8	62.6
577	14	1.1	1.1	63.7
578	20	1.6	1.6	65.3
579	15	1.2	1.2	66.5
580	15	1.2	1.2	67.6
581	11	.9	.9	68.5
582	10	.8	.8	69.3
583	12	1.0	1.0	70.3
584	16	1.3	1.3	71.5
585	17	1.4	1.4	72.9
586	14	1.1	1.1	74.0
587	16	1.3	1.3	75.3
588	11	.9	.9	76.2
589	14	1.1	1.1	77.3
590	16	1.3	1.3	78.5
591	13	1.0	1.0	79.6
592	10	.8	.8	80.4
593	13	1.0	1.0	81.4
594	14	1.1	1.1	82.5
595	11	.9	.9	83.4
596	16	1.3	1.3	84.7
597	10	.8	.8	85.5
598	8	.6	.6	86.1
599	10	.8	.8	86.9
600	7	.6	.6	87.4
601	8	.6	.6	88.1
602	6	.5	.5	88.6
603	7	.6	.6	89.1
604	12	1.0	1.0	90.1
605	6	.5	.5	90.5
606	9	.7	.7	91.3
607	3	.2	.2	91.5
608	8	.6	.6	92.1
609	7	.6	.6	92.7
610	4	.3	.3	93.0
611	8	.6	.6	93.6
612	6	.5	.5	94.1
613	4	.3	.3	94.4
614	3	.2	.2	94.7
615	4	.3	.3	95.0
616	4	.3	.3	95.3
617	2	.2	.2	95.5
618	1	.1	.1	95.5

	Frequency	Percent	Valid Percent	Cumulative Percent
619	3	.2	.2	95.8
620	1	.1	.1	95.9
621	5	.4	.4	96.3
622	4	.3	.3	96.6
623	4	.3	.3	96.9
624	2	.2	.2	97.1
625	2	.2	.2	97.2
627	2	.2	.2	97.4
628	1	.1	.1	97.5
631	1	.1	.1	97.5
632	1	.1	.1	97.6
633	3	.2	.2	97.9
634	2	.2	.2	98.0
635	2	.2	.2	98.2
636	2	.2	.2	98.3
638	3	.2	.2	98.6
639	1	.1	.1	98.6
640	3	.2	.2	98.9
641	1	.1	.1	99.0
643	2	.2	.2	99.1
644	1	.1	.1	99.2
649	1	.1	.1	99.3
650	1	.1	.1	99.4
651	2	.2	.2	99.5
652	1	.1	.1	99.6
657	1	.1	.1	99.7
664	1	.1	.1	99.8
667	1	.1	.1	99.8
668	1	.1	.1	99.9
672	1	.1	.1	100.0
Total	1258	100.0	100.0	

Female Hip Breadth Sitting

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
hip_breadth_sitting	1257	345	318	663	408.31	45.888	1.185	.069
Valid N (listwise)	1257							

hip_breadth_sitting

N	Valid	1257
	Missing	1

hip_breadth_sitting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	318	2	.2	.2	.2
	320	1	.1	.1	.2
	323	1	.1	.1	.3
	324	1	.1	.1	.4
	328	3	.2	.2	.6
	330	1	.1	.1	.7
	331	1	.1	.1	.8
	333	3	.2	.2	1.0
	334	2	.2	.2	1.2
	335	3	.2	.2	1.4
	336	1	.1	.1	1.5
	337	2	.2	.2	1.7
	338	3	.2	.2	1.9
	339	1	.1	.1	2.0
	340	1	.1	.1	2.1
	341	3	.2	.2	2.3
	342	4	.3	.3	2.6
	343	2	.2	.2	2.8
	344	3	.2	.2	3.0
	345	6	.5	.5	3.5
	346	2	.2	.2	3.7
	347	7	.6	.6	4.2
	348	4	.3	.3	4.5
	349	7	.6	.6	5.1
	350	9	.7	.7	5.8
	351	6	.5	.5	6.3
	352	10	.8	.8	7.1
	353	12	1.0	1.0	8.0
	354	7	.6	.6	8.6
	355	2	.2	.2	8.8
	356	9	.7	.7	9.5
	357	7	.6	.6	10.0
	358	5	.4	.4	10.4
	359	5	.4	.4	10.8

360	8	.6	.6	11.5
361	9	.7	.7	12.2
362	8	.6	.6	12.8
363	7	.6	.6	13.4
364	13	1.0	1.0	14.4
365	9	.7	.7	15.1
366	13	1.0	1.0	16.1
367	6	.5	.5	16.6
368	12	1.0	1.0	17.6
369	11	.9	.9	18.5
370	12	1.0	1.0	19.4
371	13	1.0	1.0	20.4
372	8	.6	.6	21.1
373	8	.6	.6	21.7
374	12	1.0	1.0	22.7
375	24	1.9	1.9	24.6
376	18	1.4	1.4	26.0
377	11	.9	.9	26.9
378	9	.7	.7	27.6
379	17	1.4	1.4	29.0
380	15	1.2	1.2	30.2
381	9	.7	.7	30.9
382	14	1.1	1.1	32.0
383	14	1.1	1.1	33.1
384	19	1.5	1.5	34.6
385	11	.9	.9	35.5
386	8	.6	.6	36.1
387	10	.8	.8	36.9
388	10	.8	.8	37.7
389	12	1.0	1.0	38.7
390	10	.8	.8	39.5
391	17	1.4	1.4	40.8
392	7	.6	.6	41.4
393	9	.7	.7	42.1
394	11	.9	.9	43.0
395	7	.6	.6	43.5
396	12	1.0	1.0	44.5
397	11	.9	.9	45.3
398	14	1.1	1.1	46.5
399	17	1.4	1.4	47.8
400	14	1.1	1.1	48.9
401	15	1.2	1.2	50.1
402	10	.8	.8	50.9
403	8	.6	.6	51.6
404	16	1.3	1.3	52.8
405	11	.9	.9	53.7
406	13	1.0	1.0	54.7

407	9	.7	.7	55.4
408	11	.9	.9	56.3
409	12	1.0	1.0	57.3
410	14	1.1	1.1	58.4
411	11	.9	.9	59.3
412	15	1.2	1.2	60.5
413	14	1.1	1.1	61.6
414	16	1.3	1.3	62.8
415	8	.6	.6	63.5
416	19	1.5	1.5	65.0
417	12	1.0	1.0	66.0
418	6	.5	.5	66.4
419	8	.6	.6	67.1
420	8	.6	.6	67.7
421	14	1.1	1.1	68.8
422	10	.8	.8	69.6
423	8	.6	.6	70.2
424	9	.7	.7	71.0
425	8	.6	.6	71.6
426	7	.6	.6	72.2
427	6	.5	.5	72.6
428	6	.5	.5	73.1
429	6	.5	.5	73.6
430	5	.4	.4	74.0
431	8	.6	.6	74.6
432	9	.7	.7	75.3
433	7	.6	.6	75.9
434	10	.8	.8	76.7
435	13	1.0	1.0	77.7
436	8	.6	.6	78.4
437	6	.5	.5	78.8
438	8	.6	.6	79.5
439	6	.5	.5	80.0
440	5	.4	.4	80.4
441	7	.6	.6	80.9
442	4	.3	.3	81.2
443	5	.4	.4	81.6
444	7	.6	.6	82.2
445	5	.4	.4	82.6
446	8	.6	.6	83.2
447	2	.2	.2	83.4
448	6	.5	.5	83.9
449	7	.6	.6	84.4
450	5	.4	.4	84.8
451	4	.3	.3	85.1
452	4	.3	.3	85.4
453	5	.4	.4	85.8

454	7	.6	.6	86.4
455	4	.3	.3	86.7
456	4	.3	.3	87.0
457	4	.3	.3	87.4
458	1	.1	.1	87.4
459	5	.4	.4	87.8
460	5	.4	.4	88.2
461	3	.2	.2	88.5
462	1	.1	.1	88.5
463	3	.2	.2	88.8
464	4	.3	.3	89.1
465	3	.2	.2	89.3
466	2	.2	.2	89.5
467	4	.3	.3	89.8
468	5	.4	.4	90.2
469	2	.2	.2	90.4
470	3	.2	.2	90.6
471	4	.3	.3	90.9
472	3	.2	.2	91.2
473	5	.4	.4	91.6
474	4	.3	.3	91.9
475	1	.1	.1	92.0
476	3	.2	.2	92.2
477	2	.2	.2	92.4
478	3	.2	.2	92.6
479	3	.2	.2	92.8
480	2	.2	.2	93.0
481	3	.2	.2	93.2
482	4	.3	.3	93.6
483	2	.2	.2	93.7
484	1	.1	.1	93.8
486	3	.2	.2	94.0
487	2	.2	.2	94.2
488	1	.1	.1	94.3
489	4	.3	.3	94.6
490	1	.1	.1	94.7
491	4	.3	.3	95.0
492	1	.1	.1	95.1
493	2	.2	.2	95.2
494	2	.2	.2	95.4
496	1	.1	.1	95.5
501	1	.1	.1	95.5
502	3	.2	.2	95.8
503	1	.1	.1	95.9
504	2	.2	.2	96.0
507	1	.1	.1	96.1
508	1	.1	.1	96.2

		Frequency	Percent	Valid Percent	Cumulative Percent
	511	3	.2	.2	96.4
	512	1	.1	.1	96.5
	513	1	.1	.1	96.6
	514	3	.2	.2	96.8
	515	3	.2	.2	97.1
	517	1	.1	.1	97.1
	518	1	.1	.1	97.2
	524	2	.2	.2	97.4
	525	1	.1	.1	97.5
	528	3	.2	.2	97.7
	530	2	.2	.2	97.9
	531	2	.2	.2	98.0
	532	2	.2	.2	98.2
	533	1	.1	.1	98.2
	535	1	.1	.1	98.3
	536	2	.2	.2	98.5
	537	2	.2	.2	98.6
	541	1	.1	.1	98.7
	542	1	.1	.1	98.8
	545	1	.1	.1	98.9
	546	1	.1	.1	99.0
	554	1	.1	.1	99.0
	557	1	.1	.1	99.1
	558	1	.1	.1	99.2
	560	1	.1	.1	99.3
	567	1	.1	.1	99.4
	570	1	.1	.1	99.4
	592	1	.1	.1	99.5
	593	1	.1	.1	99.6
	595	2	.2	.2	99.8
	610	1	.1	.1	99.8
	650	1	.1	.1	99.9
	663	1	.1	.1	100.0
	Total	1257	99.9	100.0	
Missing	System	1	.1		
Total		1258	100.0		

Female Weight

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
weight	1258	117.23	39.23	156.46	68.7308	17.27816	1.754	.069
Valid N (listwise)	1258							

weight

N	Valid	1258
	Missing	0

weight

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	39.23	1	.1	.1	.1
	39.91	1	.1	.1	.2
	41.50	1	.1	.1	.2
	42.18	1	.1	.1	.3
	43.76	1	.1	.1	.4
	43.99	1	.1	.1	.5
	44.22	4	.3	.3	.8
	44.44	2	.2	.2	1.0
	44.90	5	.4	.4	1.4
	45.12	2	.2	.2	1.5
	45.80	2	.2	.2	1.7
	46.03	3	.2	.2	1.9
	46.49	1	.1	.1	2.0
	46.71	2	.2	.2	2.1
	46.94	3	.2	.2	2.4
	47.17	5	.4	.4	2.8
	47.39	1	.1	.1	2.9
	47.62	4	.3	.3	3.2
	47.85	2	.2	.2	3.3
	48.07	3	.2	.2	3.6
	48.30	2	.2	.2	3.7
	48.53	3	.2	.2	4.0
	48.75	2	.2	.2	4.1
	48.98	3	.2	.2	4.4
	49.21	5	.4	.4	4.8
	49.66	5	.4	.4	5.2
	49.80	1	.1	.1	5.2
	49.89	7	.6	.6	5.8
	50.11	1	.1	.1	5.9
	50.20	1	.1	.1	6.0
	50.34	7	.6	.6	6.5
	50.57	3	.2	.2	6.8
	50.79	2	.2	.2	6.9

51.02	4	.3	.3	7.2
51.25	9	.7	.7	7.9
51.47	10	.8	.8	8.7
51.70	6	.5	.5	9.2
51.93	9	.7	.7	9.9
52.15	7	.6	.6	10.5
52.38	2	.2	.2	10.7
52.61	7	.6	.6	11.2
52.83	8	.6	.6	11.8
53.06	4	.3	.3	12.2
53.29	13	1.0	1.0	13.2
53.51	7	.6	.6	13.8
53.74	8	.6	.6	14.4
53.97	2	.2	.2	14.5
54.20	5	.4	.4	14.9
54.42	3	.2	.2	15.2
54.65	6	.5	.5	15.7
54.88	15	1.2	1.2	16.9
55.10	10	.8	.8	17.6
55.33	10	.8	.8	18.4
55.56	9	.7	.7	19.2
55.78	10	.8	.8	20.0
56.01	6	.5	.5	20.4
56.24	15	1.2	1.2	21.6
56.46	12	1.0	1.0	22.6
56.69	16	1.3	1.3	23.8
56.92	10	.8	.8	24.6
57.14	6	.5	.5	25.1
57.37	11	.9	.9	26.0
57.60	9	.7	.7	26.7
57.82	6	.5	.5	27.2
58.05	11	.9	.9	28.1
58.28	22	1.7	1.7	29.8
58.50	6	.5	.5	30.3
58.73	10	.8	.8	31.1
58.96	10	.8	.8	31.9
59.18	14	1.1	1.1	33.0
59.41	8	.6	.6	33.6
59.64	6	.5	.5	34.1
59.86	9	.7	.7	34.8
60.09	10	.8	.8	35.6
60.32	9	.7	.7	36.3
60.54	10	.8	.8	37.1
60.77	6	.5	.5	37.6
61.00	3	.2	.2	37.8
61.22	14	1.1	1.1	39.0
61.45	7	.6	.6	39.5

61.68	15	1.2	1.2	40.7
61.90	7	.6	.6	41.3
62.13	9	.7	.7	42.0
62.36	8	.6	.6	42.6
62.59	6	.5	.5	43.1
62.81	9	.7	.7	43.8
63.04	6	.5	.5	44.3
63.27	5	.4	.4	44.7
63.49	9	.7	.7	45.4
63.72	13	1.0	1.0	46.4
63.95	13	1.0	1.0	47.5
64.17	9	.7	.7	48.2
64.40	9	.7	.7	48.9
64.63	8	.6	.6	49.5
64.85	6	.5	.5	50.0
65.08	14	1.1	1.1	51.1
65.31	8	.6	.6	51.7
65.53	8	.6	.6	52.4
65.76	7	.6	.6	52.9
65.99	10	.8	.8	53.7
66.21	10	.8	.8	54.5
66.44	9	.7	.7	55.2
66.67	6	.5	.5	55.7
66.89	13	1.0	1.0	56.8
67.12	7	.6	.6	57.3
67.35	8	.6	.6	57.9
67.57	9	.7	.7	58.7
67.80	8	.6	.6	59.3
68.03	7	.6	.6	59.9
68.25	4	.3	.3	60.2
68.48	21	1.7	1.7	61.8
68.71	7	.6	.6	62.4
68.93	6	.5	.5	62.9
69.16	6	.5	.5	63.4
69.39	5	.4	.4	63.8
69.61	5	.4	.4	64.1
69.84	9	.7	.7	64.9
70.07	9	.7	.7	65.6
70.29	6	.5	.5	66.1
70.52	4	.3	.3	66.4
70.75	7	.6	.6	66.9
70.98	8	.6	.6	67.6
71.20	5	.4	.4	68.0
71.43	3	.2	.2	68.2
71.66	8	.6	.6	68.8
71.88	9	.7	.7	69.6
72.11	6	.5	.5	70.0

72.34	5	.4	.4	70.4
72.56	7	.6	.6	71.0
72.79	5	.4	.4	71.4
73.02	4	.3	.3	71.7
73.24	2	.2	.2	71.9
73.47	13	1.0	1.0	72.9
73.70	7	.6	.6	73.4
73.92	2	.2	.2	73.6
74.15	2	.2	.2	73.8
74.38	1	.1	.1	73.8
74.60	5	.4	.4	74.2
74.83	3	.2	.2	74.5
75.06	3	.2	.2	74.7
75.28	11	.9	.9	75.6
75.51	1	.1	.1	75.7
75.74	4	.3	.3	76.0
75.96	1	.1	.1	76.1
76.19	6	.5	.5	76.6
76.42	7	.6	.6	77.1
76.64	3	.2	.2	77.3
76.87	10	.8	.8	78.1
77.10	1	.1	.1	78.2
77.32	4	.3	.3	78.5
77.55	4	.3	.3	78.9
77.78	7	.6	.6	79.4
78.00	7	.6	.6	80.0
78.23	2	.2	.2	80.1
78.46	2	.2	.2	80.3
78.68	11	.9	.9	81.2
78.91	1	.1	.1	81.2
79.14	2	.2	.2	81.4
79.37	2	.2	.2	81.6
79.59	1	.1	.1	81.6
79.82	1	.1	.1	81.7
80.05	2	.2	.2	81.9
80.27	6	.5	.5	82.4
80.59	1	.1	.1	82.4
80.73	2	.2	.2	82.6
80.95	2	.2	.2	82.8
81.18	1	.1	.1	82.8
81.32	1	.1	.1	82.9
81.41	2	.2	.2	83.1
81.63	5	.4	.4	83.5
81.86	1	.1	.1	83.5
82.09	5	.4	.4	83.9
82.31	5	.4	.4	84.3
82.54	2	.2	.2	84.5

82.77	2	.2	.2	84.7
82.99	3	.2	.2	84.9
83.22	3	.2	.2	85.1
83.45	3	.2	.2	85.4
83.67	4	.3	.3	85.7
83.90	1	.1	.1	85.8
84.13	1	.1	.1	85.9
84.35	2	.2	.2	86.0
84.58	1	.1	.1	86.1
85.03	3	.2	.2	86.3
85.26	3	.2	.2	86.6
85.49	2	.2	.2	86.7
85.71	1	.1	.1	86.8
85.94	2	.2	.2	87.0
86.17	3	.2	.2	87.2
86.39	2	.2	.2	87.4
86.62	1	.1	.1	87.4
86.85	1	.1	.1	87.5
87.07	4	.3	.3	87.8
87.30	2	.2	.2	88.0
87.53	1	.1	.1	88.1
87.76	1	.1	.1	88.2
87.98	5	.4	.4	88.6
88.21	1	.1	.1	88.6
88.44	2	.2	.2	88.8
88.66	2	.2	.2	89.0
88.89	2	.2	.2	89.1
89.12	6	.5	.5	89.6
89.57	1	.1	.1	89.7
89.80	1	.1	.1	89.7
90.02	2	.2	.2	89.9
90.48	2	.2	.2	90.1
90.70	1	.1	.1	90.1
90.93	1	.1	.1	90.2
91.38	2	.2	.2	90.4
91.61	3	.2	.2	90.6
91.84	2	.2	.2	90.8
92.06	3	.2	.2	91.0
92.29	1	.1	.1	91.1
92.52	2	.2	.2	91.3
92.97	1	.1	.1	91.3
93.20	6	.5	.5	91.8
93.88	2	.2	.2	92.0
94.10	2	.2	.2	92.1
94.33	2	.2	.2	92.3
95.46	2	.2	.2	92.4
95.69	2	.2	.2	92.6

95.92	1	.1	.1	92.7
96.15	1	.1	.1	92.8
96.60	2	.2	.2	92.9
97.05	1	.1	.1	93.0
97.28	3	.2	.2	93.2
98.19	1	.1	.1	93.3
98.64	2	.2	.2	93.5
98.87	2	.2	.2	93.6
99.09	3	.2	.2	93.9
99.32	1	.1	.1	94.0
99.55	1	.1	.1	94.0
99.77	1	.1	.1	94.1
100.68	2	.2	.2	94.3
101.13	2	.2	.2	94.4
101.36	2	.2	.2	94.6
101.81	2	.2	.2	94.8
102.95	2	.2	.2	94.9
103.17	1	.1	.1	95.0
103.85	1	.1	.1	95.1
104.08	2	.2	.2	95.2
104.76	1	.1	.1	95.3
104.99	2	.2	.2	95.5
105.67	2	.2	.2	95.6
105.90	1	.1	.1	95.7
106.12	1	.1	.1	95.8
107.26	1	.1	.1	95.9
108.84	2	.2	.2	96.0
109.07	2	.2	.2	96.2
109.52	1	.1	.1	96.3
109.75	2	.2	.2	96.4
109.98	1	.1	.1	96.5
110.20	1	.1	.1	96.6
110.88	1	.1	.1	96.7
111.34	1	.1	.1	96.7
112.70	2	.2	.2	96.9
113.83	2	.2	.2	97.1
114.06	2	.2	.2	97.2
114.29	3	.2	.2	97.5
115.19	2	.2	.2	97.6
116.33	1	.1	.1	97.7
116.55	1	.1	.1	97.8
116.78	1	.1	.1	97.9
117.69	1	.1	.1	97.9
118.59	1	.1	.1	98.0
118.82	1	.1	.1	98.1
120.41	1	.1	.1	98.2
120.86	1	.1	.1	98.3

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121.32	2	.2	.2	98.4
124.26	1	.1	.1	98.5
124.49	1	.1	.1	98.6
124.72	1	.1	.1	98.6
125.62	1	.1	.1	98.7
126.30	2	.2	.2	98.9
129.71	1	.1	.1	99.0
131.07	1	.1	.1	99.0
133.79	1	.1	.1	99.1
140.36	1	.1	.1	99.2
141.72	1	.1	.1	99.3
144.67	1	.1	.1	99.4
144.90	1	.1	.1	99.4
145.35	1	.1	.1	99.5
146.49	1	.1	.1	99.6
154.42	1	.1	.1	99.7
154.65	1	.1	.1	99.8
154.88	1	.1	.1	99.8
156.46	2	.2	.2	100.0
Total	1258	100.0	100.0	

American Adult Males Ages 18 – 65

Male Seat Height

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
Seat Height	1073	248	386	634	472.68	33.042	.712	.075
Valid N (listwise)	1073							

Seat Height

N	Valid	1073
	Missing	45

Seat Height

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	386	1	.1	.1	.1
	388	1	.1	.1	.2
	394	3	.3	.3	.5
	396	2	.2	.2	.7
	398	1	.1	.1	.7
	400	1	.1	.1	.8
	402	2	.2	.2	1.0
	406	2	.2	.2	1.2
	408	2	.2	.2	1.4
	410	1	.1	.1	1.5
	412	7	.6	.7	2.1
	414	5	.4	.5	2.6
	416	6	.5	.6	3.2
	418	6	.5	.6	3.7
	420	4	.4	.4	4.1
	422	8	.7	.7	4.8
	424	8	.7	.7	5.6
	426	9	.8	.8	6.4
	428	15	1.3	1.4	7.8
	430	6	.5	.6	8.4
	432	17	1.5	1.6	10.0
	434	13	1.2	1.2	11.2
	436	14	1.3	1.3	12.5
	438	18	1.6	1.7	14.2
	440	20	1.8	1.9	16.0
	442	16	1.4	1.5	17.5
	444	21	1.9	2.0	19.5
	446	19	1.7	1.8	21.2
	448	25	2.2	2.3	23.6
	450	23	2.1	2.1	25.7
	452	20	1.8	1.9	27.6

454	31	2.8	2.9	30.5
456	21	1.9	2.0	32.4
458	29	2.6	2.7	35.1
460	34	3.0	3.2	38.3
462	29	2.6	2.7	41.0
464	32	2.9	3.0	44.0
466	24	2.1	2.2	46.2
468	33	3.0	3.1	49.3
470	20	1.8	1.9	51.2
472	32	2.9	3.0	54.1
474	27	2.4	2.5	56.7
476	20	1.8	1.9	58.5
478	22	2.0	2.1	60.6
480	20	1.8	1.9	62.4
482	9	.8	.8	63.3
484	18	1.6	1.7	65.0
486	18	1.6	1.7	66.6
488	13	1.2	1.2	67.8
490	14	1.3	1.3	69.2
492	16	1.4	1.5	70.6
494	33	3.0	3.1	73.7
496	27	2.4	2.5	76.2
498	27	2.4	2.5	78.8
500	32	2.9	3.0	81.7
502	21	1.9	2.0	83.7
504	27	2.4	2.5	86.2
506	24	2.1	2.2	88.4
508	18	1.6	1.7	90.1
510	16	1.4	1.5	91.6
512	14	1.3	1.3	92.9
514	9	.8	.8	93.8
516	6	.5	.6	94.3
518	4	.4	.4	94.7
520	4	.4	.4	95.1
522	1	.1	.1	95.2
524	3	.3	.3	95.4
526	5	.4	.5	95.9
528	4	.4	.4	96.3
530	5	.4	.5	96.7
532	3	.3	.3	97.0
534	1	.1	.1	97.1
536	2	.2	.2	97.3
538	2	.2	.2	97.5
540	2	.2	.2	97.7
542	2	.2	.2	97.9
544	2	.2	.2	98.0
552	4	.4	.4	98.4

	556	1	.1	.1	98.5
	560	1	.1	.1	98.6
	564	1	.1	.1	98.7
	570	2	.2	.2	98.9
	572	1	.1	.1	99.0
	574	1	.1	.1	99.1
	576	1	.1	.1	99.2
	582	1	.1	.1	99.3
	590	1	.1	.1	99.3
	608	1	.1	.1	99.4
	612	1	.1	.1	99.5
	616	1	.1	.1	99.6
	620	1	.1	.1	99.7
	626	1	.1	.1	99.8
	632	1	.1	.1	99.9
	634	1	.1	.1	100.0
	Total	1073	96.0	100.0	
Missing	System	45	4.0		
Total		1118	100.0		

Male Buttock-Knee Length

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
buttockknee_length	1118	303	433	736	618.50	35.430	.111	.073
Valid N (listwise)	1118							

buttockknee_length

N	Valid	1118
	Missing	0

buttockknee_length

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	433	1	.1	.1	.1
	511	2	.2	.2	.3
	522	1	.1	.1	.4
	525	1	.1	.1	.4
	526	1	.1	.1	.5
	527	1	.1	.1	.6
	530	1	.1	.1	.7
	531	1	.1	.1	.8
	534	1	.1	.1	.9
	535	1	.1	.1	1.0
	537	1	.1	.1	1.1
	543	1	.1	.1	1.2
	544	2	.2	.2	1.3
	546	1	.1	.1	1.4
	547	1	.1	.1	1.5
	548	1	.1	.1	1.6
	549	1	.1	.1	1.7
	550	1	.1	.1	1.8
	551	2	.2	.2	2.0
	552	1	.1	.1	2.1
	553	1	.1	.1	2.1
	554	1	.1	.1	2.2
	555	4	.4	.4	2.6
	556	2	.2	.2	2.8
	557	8	.7	.7	3.5
	558	1	.1	.1	3.6
	559	6	.5	.5	4.1
	560	2	.2	.2	4.3
	561	1	.1	.1	4.4
	562	5	.4	.4	4.8
	563	3	.3	.3	5.1
	564	6	.5	.5	5.6
	565	3	.3	.3	5.9

566	6	.5	.5	6.4
567	4	.4	.4	6.8
568	5	.4	.4	7.2
569	2	.2	.2	7.4
570	8	.7	.7	8.1
571	3	.3	.3	8.4
572	4	.4	.4	8.8
573	5	.4	.4	9.2
574	2	.2	.2	9.4
575	6	.5	.5	9.9
576	8	.7	.7	10.6
577	5	.4	.4	11.1
578	5	.4	.4	11.5
579	7	.6	.6	12.2
580	3	.3	.3	12.4
581	3	.3	.3	12.7
582	7	.6	.6	13.3
583	8	.7	.7	14.0
584	6	.5	.5	14.6
585	11	1.0	1.0	15.6
586	10	.9	.9	16.5
587	11	1.0	1.0	17.4
588	11	1.0	1.0	18.4
589	8	.7	.7	19.1
590	11	1.0	1.0	20.1
591	5	.4	.4	20.6
592	11	1.0	1.0	21.6
593	10	.9	.9	22.5
594	13	1.2	1.2	23.6
595	19	1.7	1.7	25.3
596	15	1.3	1.3	26.7
597	8	.7	.7	27.4
598	7	.6	.6	28.0
599	11	1.0	1.0	29.0
600	9	.8	.8	29.8
601	20	1.8	1.8	31.6
602	17	1.5	1.5	33.1
603	16	1.4	1.4	34.5
604	17	1.5	1.5	36.0
605	14	1.3	1.3	37.3
606	18	1.6	1.6	38.9
607	9	.8	.8	39.7
608	15	1.3	1.3	41.1
609	16	1.4	1.4	42.5
610	7	.6	.6	43.1
611	15	1.3	1.3	44.5
612	8	.7	.7	45.2

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613	11	1.0	1.0	46.2
614	10	.9	.9	47.0
615	11	1.0	1.0	48.0
616	16	1.4	1.4	49.5
617	16	1.4	1.4	50.9
618	21	1.9	1.9	52.8
619	13	1.2	1.2	53.9
620	14	1.3	1.3	55.2
621	14	1.3	1.3	56.4
622	8	.7	.7	57.2
623	8	.7	.7	57.9
624	8	.7	.7	58.6
625	14	1.3	1.3	59.8
626	16	1.4	1.4	61.3
627	7	.6	.6	61.9
628	16	1.4	1.4	63.3
629	15	1.3	1.3	64.7
630	16	1.4	1.4	66.1
631	11	1.0	1.0	67.1
632	12	1.1	1.1	68.2
633	9	.8	.8	69.0
634	15	1.3	1.3	70.3
635	11	1.0	1.0	71.3
636	8	.7	.7	72.0
637	11	1.0	1.0	73.0
638	9	.8	.8	73.8
639	7	.6	.6	74.4
640	12	1.1	1.1	75.5
641	13	1.2	1.2	76.7
642	9	.8	.8	77.5
643	5	.4	.4	77.9
644	6	.5	.5	78.4
645	4	.4	.4	78.8
646	12	1.1	1.1	79.9
647	1	.1	.1	80.0
648	5	.4	.4	80.4
649	7	.6	.6	81.0
650	7	.6	.6	81.7
651	7	.6	.6	82.3
652	8	.7	.7	83.0
653	10	.9	.9	83.9
654	7	.6	.6	84.5
655	7	.6	.6	85.2
656	8	.7	.7	85.9
657	6	.5	.5	86.4
658	5	.4	.4	86.9
659	7	.6	.6	87.5

661	4	.4	.4	87.8
662	3	.3	.3	88.1
663	3	.3	.3	88.4
664	6	.5	.5	88.9
665	7	.6	.6	89.5
666	4	.4	.4	89.9
667	6	.5	.5	90.4
668	7	.6	.6	91.1
669	7	.6	.6	91.7
670	7	.6	.6	92.3
671	4	.4	.4	92.7
672	3	.3	.3	92.9
673	2	.2	.2	93.1
674	3	.3	.3	93.4
675	5	.4	.4	93.8
676	4	.4	.4	94.2
677	5	.4	.4	94.6
678	3	.3	.3	94.9
679	6	.5	.5	95.4
680	2	.2	.2	95.6
682	3	.3	.3	95.9
683	3	.3	.3	96.2
684	2	.2	.2	96.3
685	2	.2	.2	96.5
686	2	.2	.2	96.7
687	1	.1	.1	96.8
688	2	.2	.2	97.0
689	1	.1	.1	97.0
690	2	.2	.2	97.2
691	2	.2	.2	97.4
692	3	.3	.3	97.7
694	2	.2	.2	97.9
695	1	.1	.1	97.9
696	1	.1	.1	98.0
697	2	.2	.2	98.2
698	1	.1	.1	98.3
699	1	.1	.1	98.4
700	1	.1	.1	98.5
701	1	.1	.1	98.6
702	2	.2	.2	98.7
704	1	.1	.1	98.8
707	1	.1	.1	98.9
709	1	.1	.1	99.0
711	2	.2	.2	99.2
712	2	.2	.2	99.4
717	2	.2	.2	99.6
725	2	.2	.2	99.7

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726	1	.1	.1	99.8
731	1	.1	.1	99.9
736	1	.1	.1	100.0
Total	1118	100.0	100.0	

Male Acromial Height Sitting

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
acromial_height_sitting	1118	238	489	727	606.94	34.033	.066	.073
Valid N (listwise)	1118							

acromial_height_sitting

N	Valid	1118
	Missing	0

acromial_height_sitting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	489	1	.1	.1	.1
	512	1	.1	.1	.2
	513	2	.2	.2	.4
	515	1	.1	.1	.4
	521	1	.1	.1	.5
	524	2	.2	.2	.7
	525	1	.1	.1	.8
	526	1	.1	.1	.9
	530	3	.3	.3	1.2
	531	1	.1	.1	1.3
	532	1	.1	.1	1.3
	534	1	.1	.1	1.4
	535	2	.2	.2	1.6
	536	1	.1	.1	1.7
	539	1	.1	.1	1.8
	540	2	.2	.2	2.0
	542	2	.2	.2	2.1
	543	2	.2	.2	2.3
	544	2	.2	.2	2.5
	545	7	.6	.6	3.1
	546	4	.4	.4	3.5
	547	4	.4	.4	3.8
	549	1	.1	.1	3.9
	550	3	.3	.3	4.2
	551	4	.4	.4	4.6
	552	6	.5	.5	5.1
	553	5	.4	.4	5.5
	554	8	.7	.7	6.3
	555	3	.3	.3	6.5
	556	5	.4	.4	7.0
	557	5	.4	.4	7.4
	558	6	.5	.5	8.0
	559	6	.5	.5	8.5

560	1	.1	.1	8.6
561	4	.4	.4	8.9
562	5	.4	.4	9.4
563	11	1.0	1.0	10.4
564	7	.6	.6	11.0
565	6	.5	.5	11.5
566	5	.4	.4	12.0
567	5	.4	.4	12.4
568	10	.9	.9	13.3
569	4	.4	.4	13.7
570	14	1.3	1.3	14.9
571	10	.9	.9	15.8
572	4	.4	.4	16.2
573	8	.7	.7	16.9
574	7	.6	.6	17.5
575	6	.5	.5	18.1
576	14	1.3	1.3	19.3
577	6	.5	.5	19.9
578	13	1.2	1.2	21.0
579	12	1.1	1.1	22.1
580	6	.5	.5	22.6
581	11	1.0	1.0	23.6
582	6	.5	.5	24.2
583	9	.8	.8	25.0
584	10	.9	.9	25.8
585	7	.6	.6	26.5
586	13	1.2	1.2	27.6
587	9	.8	.8	28.4
588	10	.9	.9	29.3
589	11	1.0	1.0	30.3
590	12	1.1	1.1	31.4
591	10	.9	.9	32.3
592	12	1.1	1.1	33.4
593	12	1.1	1.1	34.4
594	13	1.2	1.2	35.6
595	17	1.5	1.5	37.1
596	9	.8	.8	37.9
597	7	.6	.6	38.6
598	12	1.1	1.1	39.6
599	21	1.9	1.9	41.5
600	18	1.6	1.6	43.1
601	11	1.0	1.0	44.1
602	16	1.4	1.4	45.5
603	16	1.4	1.4	47.0
604	8	.7	.7	47.7
605	17	1.5	1.5	49.2
606	8	.7	.7	49.9

607	16	1.4	1.4	51.3
608	9	.8	.8	52.1
609	9	.8	.8	53.0
610	12	1.1	1.1	54.0
611	11	1.0	1.0	55.0
612	9	.8	.8	55.8
613	14	1.3	1.3	57.1
614	14	1.3	1.3	58.3
615	12	1.1	1.1	59.4
616	11	1.0	1.0	60.4
617	12	1.1	1.1	61.4
618	8	.7	.7	62.2
619	12	1.1	1.1	63.2
620	19	1.7	1.7	64.9
621	12	1.1	1.1	66.0
622	5	.4	.4	66.5
623	6	.5	.5	67.0
624	22	2.0	2.0	69.0
625	20	1.8	1.8	70.8
626	16	1.4	1.4	72.2
627	11	1.0	1.0	73.2
628	13	1.2	1.2	74.3
629	11	1.0	1.0	75.3
630	9	.8	.8	76.1
631	12	1.1	1.1	77.2
632	7	.6	.6	77.8
633	9	.8	.8	78.6
634	9	.8	.8	79.4
635	9	.8	.8	80.2
636	12	1.1	1.1	81.3
637	4	.4	.4	81.7
638	13	1.2	1.2	82.8
639	9	.8	.8	83.6
640	7	.6	.6	84.3
641	8	.7	.7	85.0
642	5	.4	.4	85.4
643	10	.9	.9	86.3
644	3	.3	.3	86.6
645	11	1.0	1.0	87.6
646	10	.9	.9	88.5
647	7	.6	.6	89.1
648	4	.4	.4	89.4
649	3	.3	.3	89.7
650	5	.4	.4	90.2
651	8	.7	.7	90.9
652	7	.6	.6	91.5
653	4	.4	.4	91.9

654	5	.4	.4	92.3
655	7	.6	.6	92.9
656	6	.5	.5	93.5
657	3	.3	.3	93.7
658	3	.3	.3	94.0
659	3	.3	.3	94.3
660	1	.1	.1	94.4
661	3	.3	.3	94.6
662	2	.2	.2	94.8
663	4	.4	.4	95.2
664	1	.1	.1	95.3
665	4	.4	.4	95.6
666	2	.2	.2	95.8
667	3	.3	.3	96.1
668	1	.1	.1	96.2
669	4	.4	.4	96.5
670	1	.1	.1	96.6
671	3	.3	.3	96.9
672	4	.4	.4	97.2
673	2	.2	.2	97.4
674	2	.2	.2	97.6
675	1	.1	.1	97.7
676	2	.2	.2	97.9
677	2	.2	.2	98.0
680	2	.2	.2	98.2
682	2	.2	.2	98.4
683	2	.2	.2	98.6
685	1	.1	.1	98.7
688	1	.1	.1	98.7
689	1	.1	.1	98.8
690	5	.4	.4	99.3
695	1	.1	.1	99.4
696	2	.2	.2	99.6
701	1	.1	.1	99.6
702	1	.1	.1	99.7
705	1	.1	.1	99.8
727	2	.2	.2	100.0
Total	1118	100.0	100.0	

Male Hip Breadth Sitting

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
hip_breadth_sitting	1117	246	300	546	381.21	34.719	.924	.073
Valid N (listwise)	1117							

hip_breadth_sitting

N	Valid	1117
	Missing	1

hip_breadth_sitting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	300	1	.1	.1	.1
	302	1	.1	.1	.2
	304	1	.1	.1	.3
	306	1	.1	.1	.4
	308	3	.3	.3	.6
	310	2	.2	.2	.8
	311	2	.2	.2	1.0
	314	2	.2	.2	1.2
	317	2	.2	.2	1.3
	318	2	.2	.2	1.5
	319	2	.2	.2	1.7
	320	1	.1	.1	1.8
	321	3	.3	.3	2.1
	322	1	.1	.1	2.1
	323	3	.3	.3	2.4
	324	2	.2	.2	2.6
	325	2	.2	.2	2.8
	326	5	.4	.4	3.2
	327	4	.4	.4	3.6
	328	2	.2	.2	3.8
	329	3	.3	.3	4.0
	330	5	.4	.4	4.5
	331	1	.1	.1	4.6
	332	5	.4	.4	5.0
	333	6	.5	.5	5.6
	334	6	.5	.5	6.1
	335	7	.6	.6	6.7
	336	3	.3	.3	7.0
	337	5	.4	.4	7.4
	338	6	.5	.5	8.0
	339	10	.9	.9	8.9
	340	6	.5	.5	9.4
	341	7	.6	.6	10.0

342	8	.7	.7	10.7
343	6	.5	.5	11.3
344	10	.9	.9	12.2
345	10	.9	.9	13.1
346	7	.6	.6	13.7
347	8	.7	.7	14.4
348	6	.5	.5	15.0
349	10	.9	.9	15.8
350	10	.9	.9	16.7
351	10	.9	.9	17.6
352	8	.7	.7	18.4
353	11	1.0	1.0	19.3
354	8	.7	.7	20.1
355	13	1.2	1.2	21.2
356	17	1.5	1.5	22.7
357	17	1.5	1.5	24.3
358	13	1.2	1.2	25.4
359	11	1.0	1.0	26.4
360	14	1.3	1.3	27.7
361	14	1.3	1.3	28.9
362	18	1.6	1.6	30.5
363	11	1.0	1.0	31.5
364	12	1.1	1.1	32.6
365	6	.5	.5	33.1
366	18	1.6	1.6	34.7
367	20	1.8	1.8	36.5
368	19	1.7	1.7	38.2
369	13	1.2	1.2	39.4
370	15	1.3	1.3	40.7
371	11	1.0	1.0	41.7
372	13	1.2	1.2	42.9
373	11	1.0	1.0	43.9
374	16	1.4	1.4	45.3
375	11	1.0	1.0	46.3
376	23	2.1	2.1	48.3
377	25	2.2	2.2	50.6
378	15	1.3	1.3	51.9
379	15	1.3	1.3	53.3
380	22	2.0	2.0	55.2
381	14	1.3	1.3	56.5
382	13	1.2	1.2	57.7
383	11	1.0	1.0	58.6
384	9	.8	.8	59.4
385	7	.6	.6	60.1
386	14	1.3	1.3	61.3
387	25	2.2	2.2	63.6
388	11	1.0	1.0	64.5

389	10	.9	.9	65.4
390	14	1.3	1.3	66.7
391	13	1.2	1.2	67.9
392	10	.9	.9	68.8
393	9	.8	.8	69.6
394	16	1.4	1.4	71.0
395	8	.7	.7	71.7
396	12	1.1	1.1	72.8
397	11	1.0	1.0	73.8
398	9	.8	.8	74.6
399	6	.5	.5	75.1
400	8	.7	.7	75.8
401	7	.6	.6	76.5
402	9	.8	.8	77.3
403	9	.8	.8	78.1
404	4	.4	.4	78.4
405	12	1.1	1.1	79.5
406	10	.9	.9	80.4
407	6	.5	.5	80.9
408	9	.8	.8	81.7
409	4	.4	.4	82.1
410	5	.4	.4	82.5
411	9	.8	.8	83.3
412	6	.5	.5	83.9
413	6	.5	.5	84.4
414	9	.8	.8	85.2
415	15	1.3	1.3	86.6
416	11	1.0	1.0	87.6
417	4	.4	.4	87.9
418	3	.3	.3	88.2
419	2	.2	.2	88.4
420	2	.2	.2	88.5
421	7	.6	.6	89.2
422	3	.3	.3	89.4
423	5	.4	.4	89.9
424	5	.4	.4	90.3
425	1	.1	.1	90.4
426	3	.3	.3	90.7
427	4	.4	.4	91.0
428	5	.4	.4	91.5
429	3	.3	.3	91.8
430	2	.2	.2	91.9
431	5	.4	.4	92.4
432	2	.2	.2	92.6
433	1	.1	.1	92.7
434	5	.4	.4	93.1
435	2	.2	.2	93.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	436	4	.4	.4	93.6
	437	3	.3	.3	93.9
	438	2	.2	.2	94.1
	440	1	.1	.1	94.2
	441	4	.4	.4	94.5
	442	1	.1	.1	94.6
	443	2	.2	.2	94.8
	444	3	.3	.3	95.1
	445	2	.2	.2	95.3
	446	5	.4	.4	95.7
	447	3	.3	.3	96.0
	448	1	.1	.1	96.1
	449	2	.2	.2	96.2
	450	2	.2	.2	96.4
	451	1	.1	.1	96.5
	452	1	.1	.1	96.6
	455	2	.2	.2	96.8
	457	2	.2	.2	97.0
	458	2	.2	.2	97.1
	460	1	.1	.1	97.2
	462	1	.1	.1	97.3
	463	1	.1	.1	97.4
	464	2	.2	.2	97.6
	467	1	.1	.1	97.7
	468	1	.1	.1	97.8
	470	2	.2	.2	97.9
	471	1	.1	.1	98.0
	472	1	.1	.1	98.1
	474	3	.3	.3	98.4
	476	1	.1	.1	98.5
	479	1	.1	.1	98.6
	481	1	.1	.1	98.7
	483	2	.2	.2	98.8
	488	2	.2	.2	99.0
	502	1	.1	.1	99.1
	504	1	.1	.1	99.2
	506	2	.2	.2	99.4
	507	1	.1	.1	99.5
	512	1	.1	.1	99.6
	519	2	.2	.2	99.7
	536	1	.1	.1	99.8
	540	1	.1	.1	99.9
	546	1	.1	.1	100.0
	Total	1117	99.9	100.0	
Missing	System	1	.1		
Total		1118	100.0		

Male Weight

Descriptives

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	Std. Error
weight	1118	135.61	45.80	181.41	85.9811	17.55969	1.108	.073
Valid N (listwise)	1118							

weight

N	Valid	1118
	Missing	0

weight

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	45.80	1	.1	.1	.1
	48.75	1	.1	.1	.2
	50.11	1	.1	.1	.3
	51.47	1	.1	.1	.4
	52.61	1	.1	.1	.4
	53.51	1	.1	.1	.5
	54.42	1	.1	.1	.6
	54.88	3	.3	.3	.9
	55.10	1	.1	.1	1.0
	56.01	1	.1	.1	1.1
	56.24	1	.1	.1	1.2
	56.69	2	.2	.2	1.3
	57.37	2	.2	.2	1.5
	57.82	1	.1	.1	1.6
	58.05	1	.1	.1	1.7
	58.28	3	.3	.3	2.0
	58.50	2	.2	.2	2.1
	58.73	1	.1	.1	2.2
	58.96	2	.2	.2	2.4
	59.18	1	.1	.1	2.5
	59.86	1	.1	.1	2.6
	60.09	1	.1	.1	2.7
	60.32	2	.2	.2	2.9
	60.54	2	.2	.2	3.0
	61.00	3	.3	.3	3.3
	61.22	1	.1	.1	3.4
	61.45	1	.1	.1	3.5
	61.68	3	.3	.3	3.8
	61.90	2	.2	.2	3.9
	62.13	3	.3	.3	4.2
	62.36	1	.1	.1	4.3
	62.59	1	.1	.1	4.4
	62.81	1	.1	.1	4.5

63.04	2	.2	.2	4.7
63.27	1	.1	.1	4.7
63.49	3	.3	.3	5.0
63.72	5	.4	.4	5.5
63.95	1	.1	.1	5.5
64.17	1	.1	.1	5.6
64.40	2	.2	.2	5.8
64.63	2	.2	.2	6.0
64.85	6	.5	.5	6.5
65.08	6	.5	.5	7.1
65.31	1	.1	.1	7.2
65.76	3	.3	.3	7.4
65.99	7	.6	.6	8.1
66.21	3	.3	.3	8.3
66.44	8	.7	.7	9.0
66.67	1	.1	.1	9.1
66.89	7	.6	.6	9.7
67.12	2	.2	.2	9.9
67.35	7	.6	.6	10.6
67.57	4	.4	.4	10.9
67.80	4	.4	.4	11.3
68.03	7	.6	.6	11.9
68.25	4	.4	.4	12.3
68.48	15	1.3	1.3	13.6
68.71	4	.4	.4	14.0
68.93	7	.6	.6	14.6
69.16	7	.6	.6	15.2
69.39	5	.4	.4	15.7
69.61	9	.8	.8	16.5
69.84	2	.2	.2	16.6
70.07	8	.7	.7	17.4
70.29	3	.3	.3	17.6
70.52	7	.6	.6	18.2
70.75	3	.3	.3	18.5
70.98	6	.5	.5	19.1
71.20	2	.2	.2	19.2
71.43	4	.4	.4	19.6
71.66	2	.2	.2	19.8
71.88	13	1.2	1.2	20.9
72.11	1	.1	.1	21.0
72.34	4	.4	.4	21.4
72.56	4	.4	.4	21.7
72.79	4	.4	.4	22.1
73.02	7	.6	.6	22.7
73.24	6	.5	.5	23.3
73.47	13	1.2	1.2	24.4
73.70	5	.4	.4	24.9

73.92	9	.8	.8	25.7
74.15	5	.4	.4	26.1
74.38	10	.9	.9	27.0
74.60	6	.5	.5	27.5
74.83	7	.6	.6	28.2
75.06	5	.4	.4	28.6
75.28	14	1.3	1.3	29.9
75.51	5	.4	.4	30.3
75.74	10	.9	.9	31.2
75.96	6	.5	.5	31.8
76.19	7	.6	.6	32.4
76.42	3	.3	.3	32.6
76.64	6	.5	.5	33.2
76.87	12	1.1	1.1	34.3
77.10	5	.4	.4	34.7
77.32	3	.3	.3	35.0
77.55	10	.9	.9	35.9
77.78	8	.7	.7	36.6
78.00	8	.7	.7	37.3
78.23	2	.2	.2	37.5
78.46	8	.7	.7	38.2
78.68	10	.9	.9	39.1
78.91	2	.2	.2	39.3
79.14	6	.5	.5	39.8
79.37	11	1.0	1.0	40.8
79.59	5	.4	.4	41.2
79.82	6	.5	.5	41.8
80.05	4	.4	.4	42.1
80.27	8	.7	.7	42.8
80.50	7	.6	.6	43.5
80.73	10	.9	.9	44.4
80.95	5	.4	.4	44.8
81.18	7	.6	.6	45.4
81.41	5	.4	.4	45.9
81.63	5	.4	.4	46.3
81.86	5	.4	.4	46.8
82.09	13	1.2	1.2	47.9
82.31	5	.4	.4	48.4
82.54	4	.4	.4	48.7
82.77	7	.6	.6	49.4
82.99	5	.4	.4	49.8
83.22	6	.5	.5	50.4
83.45	7	.6	.6	51.0
83.67	12	1.1	1.1	52.1
83.90	7	.6	.6	52.7
84.13	2	.2	.2	52.9
84.35	5	.4	.4	53.3

84.58	6	.5	.5	53.8
84.81	3	.3	.3	54.1
85.03	6	.5	.5	54.7
85.26	3	.3	.3	54.9
85.49	9	.8	.8	55.7
85.71	4	.4	.4	56.1
85.94	6	.5	.5	56.6
86.17	2	.2	.2	56.8
86.39	6	.5	.5	57.3
86.62	7	.6	.6	58.0
86.85	7	.6	.6	58.6
87.07	9	.8	.8	59.4
87.30	5	.4	.4	59.8
87.53	3	.3	.3	60.1
87.76	2	.2	.2	60.3
87.98	6	.5	.5	60.8
88.21	8	.7	.7	61.5
88.44	4	.4	.4	61.9
88.66	17	1.5	1.5	63.4
88.89	3	.3	.3	63.7
89.12	2	.2	.2	63.9
89.34	4	.4	.4	64.2
89.57	5	.4	.4	64.7
89.80	6	.5	.5	65.2
90.02	4	.4	.4	65.6
90.25	3	.3	.3	65.8
90.48	11	1.0	1.0	66.8
90.70	2	.2	.2	67.0
90.93	5	.4	.4	67.4
91.16	6	.5	.5	68.0
91.38	7	.6	.6	68.6
91.61	5	.4	.4	69.1
91.84	3	.3	.3	69.3
92.06	8	.7	.7	70.0
92.29	5	.4	.4	70.5
92.52	3	.3	.3	70.8
92.74	2	.2	.2	70.9
92.97	4	.4	.4	71.3
93.20	5	.4	.4	71.7
93.42	5	.4	.4	72.2
93.65	3	.3	.3	72.5
93.88	8	.7	.7	73.2
94.10	4	.4	.4	73.5
94.33	4	.4	.4	73.9
94.56	6	.5	.5	74.4
94.78	4	.4	.4	74.8
95.01	5	.4	.4	75.2

95.24	4	.4	.4	75.6
95.46	15	1.3	1.3	76.9
95.69	6	.5	.5	77.5
95.92	1	.1	.1	77.5
96.15	4	.4	.4	77.9
96.37	2	.2	.2	78.1
96.60	3	.3	.3	78.4
96.83	3	.3	.3	78.6
97.05	5	.4	.4	79.1
97.28	4	.4	.4	79.4
97.51	2	.2	.2	79.6
97.73	4	.4	.4	80.0
97.96	4	.4	.4	80.3
98.19	2	.2	.2	80.5
98.41	2	.2	.2	80.7
98.64	1	.1	.1	80.8
98.87	8	.7	.7	81.5
99.09	6	.5	.5	82.0
99.32	2	.2	.2	82.2
99.55	2	.2	.2	82.4
99.77	2	.2	.2	82.6
100.00	5	.4	.4	83.0
100.23	1	.1	.1	83.1
100.68	4	.4	.4	83.5
100.91	4	.4	.4	83.8
101.13	3	.3	.3	84.1
101.36	1	.1	.1	84.2
101.59	3	.3	.3	84.4
101.81	2	.2	.2	84.6
102.04	2	.2	.2	84.8
102.27	4	.4	.4	85.2
102.49	1	.1	.1	85.2
102.72	2	.2	.2	85.4
102.95	3	.3	.3	85.7
103.17	5	.4	.4	86.1
103.40	4	.4	.4	86.5
103.63	2	.2	.2	86.7
104.08	4	.4	.4	87.0
104.54	4	.4	.4	87.4
104.76	1	.1	.1	87.5
105.22	2	.2	.2	87.7
105.67	2	.2	.2	87.8
106.12	4	.4	.4	88.2
106.35	1	.1	.1	88.3
106.58	4	.4	.4	88.6
106.80	2	.2	.2	88.8
107.03	1	.1	.1	88.9

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	Frequency	Percent	Valid Percent	Cumulative Percent
107.48	2	.2	.2	89.1
107.71	1	.1	.1	89.2
107.94	1	.1	.1	89.3
108.16	3	.3	.3	89.5
108.39	5	.4	.4	90.0
108.62	1	.1	.1	90.1
108.84	2	.2	.2	90.3
109.07	6	.5	.5	90.8
109.30	4	.4	.4	91.1
109.52	3	.3	.3	91.4
109.75	1	.1	.1	91.5
110.20	2	.2	.2	91.7
110.43	1	.1	.1	91.8
110.66	1	.1	.1	91.9
111.11	1	.1	.1	91.9
111.34	1	.1	.1	92.0
112.02	1	.1	.1	92.1
112.47	3	.3	.3	92.4
113.15	2	.2	.2	92.6
113.38	1	.1	.1	92.7
113.61	1	.1	.1	92.8
113.83	1	.1	.1	92.8
114.06	2	.2	.2	93.0
114.29	3	.3	.3	93.3
114.51	1	.1	.1	93.4
114.97	1	.1	.1	93.5
115.19	2	.2	.2	93.6
115.42	1	.1	.1	93.7
115.87	1	.1	.1	93.8
116.10	3	.3	.3	94.1
116.33	3	.3	.3	94.4
117.01	2	.2	.2	94.5
117.23	2	.2	.2	94.7
117.46	1	.1	.1	94.8
118.14	1	.1	.1	94.9
118.82	1	.1	.1	95.0
119.05	1	.1	.1	95.1
119.27	2	.2	.2	95.3
119.73	2	.2	.2	95.4
120.41	1	.1	.1	95.5
120.63	2	.2	.2	95.7
121.09	2	.2	.2	95.9
122.00	1	.1	.1	96.0
122.22	1	.1	.1	96.1
123.13	1	.1	.1	96.2
123.58	1	.1	.1	96.2
124.04	1	.1	.1	96.3

125.40	1	.1	.1	96.4
125.85	1	.1	.1	96.5
126.30	2	.2	.2	96.7
126.53	1	.1	.1	96.8
126.76	2	.2	.2	97.0
127.21	2	.2	.2	97.1
127.44	1	.1	.1	97.2
128.12	1	.1	.1	97.3
129.71	1	.1	.1	97.4
131.29	1	.1	.1	97.5
132.20	2	.2	.2	97.7
132.65	1	.1	.1	97.8
134.47	1	.1	.1	97.9
134.69	1	.1	.1	97.9
134.92	1	.1	.1	98.0
136.28	2	.2	.2	98.2
138.10	2	.2	.2	98.4
139.00	1	.1	.1	98.5
139.23	1	.1	.1	98.6
139.68	1	.1	.1	98.7
140.36	1	.1	.1	98.7
141.50	1	.1	.1	98.8
141.95	1	.1	.1	98.9
143.08	1	.1	.1	99.0
144.22	1	.1	.1	99.1
145.35	1	.1	.1	99.2
146.26	1	.1	.1	99.3
147.85	1	.1	.1	99.4
148.30	2	.2	.2	99.6
150.79	1	.1	.1	99.6
153.97	1	.1	.1	99.7
155.78	1	.1	.1	99.8
156.46	1	.1	.1	99.9
181.41	1	.1	.1	100.0
Total	1118	100.0	100.0	

SURVEY INSTRUMENTS

Survey #1 – Zig Zag *Chair*

Survey on Beauty and Proportion in Chair Design

The purpose of this survey is to find out how the perceived level of beauty and proportion of a classic chair changes when the chair is scaled to fit people in a range of anthropometric percentiles.

You will be presented with 3D renderings of an historical chair design and a series of differing versions of that chair. This is an Occasional Chair that might be found in a reception area and would be sat in for limited periods of time. Please evaluate each chair by answering the questions that follow.

Your responses are confidential and cannot be used to identify you.

Thank you very much for your participation in this project.

Caroline Kelly

Age _____   **Gender** Male   Female

Chair I
Original Design

1)   Are you familiar with this chair?   Yes   No

On a scale of 1 – 10, with 1 being the least and 10 being the most, rate this chair on the following criteria:

2)   How beautiful do you think this chair is?

            1   2   3   4   5   6   7   8   9   10

3)   How well proportioned is this chair?

            1   2   3   4   5   6   7   8   9   10

4)   Which one dimension, if any, of this chair seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

       Seat Height   _____   too high too low
       Seat Depth   _____   too deep too shallow
       Seat Width   _____   too wide too narrow
       Back Height   _____   too high too low
       Back Width   _____   too wide too narrow
       None   _____   this chair is well proportioned

Comments (optional)

Chair I, Redesign 1

5)   How beautiful do you think this chair is?

               1   2   3   4   5   6   7   8   9   10

6)   How well proportioned is this chair?

               1   2   3   4   5   6   7   8   9   10

7)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly
       proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair I, Redesign 2

8)   How beautiful do you think this chair is?

           1   2   3   4   5   6   7   8   9   10

9)   How well proportioned is this chair?

           1   2   3   4   5   6   7   8   9   10

10)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair I, Redesign 3

11)   How beautiful do you think this chair is?

             1   2   3   4   5   6   7   8   9   10

12)   How well proportioned is this chair?

             1   2   3   4   5   6   7   8   9   10

13)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair I, Redesign 4

14)   How beautiful do you think this chair is?

          1   2   3   4   5   6   7   8   9   10

15)   How well proportioned is this chair?

          1   2   3   4   5   6   7   8   9   10

16)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair I, Redesign 5

17)   How beautiful do you think this chair is?

         1   2   3   4   5   6   7   8   9   10

18)   How well proportioned is this chair?

         1   2   3   4   5   6   7   8   9   10

19)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair I, Redesign 6

20)	How beautiful do you think this chair is?

       1   2   3   4   5   6   7   8   9   10

21)	How well proportioned is this chair?

       1   2   3   4   5   6   7   8   9   10

22)	Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair I, Redesign 7

23)   How beautiful do you think this chair is?

                    1   2   3   4   5   6   7   8   9   10

24)   How well proportioned is this chair?

                    1   2   3   4   5   6   7   8   9   10

25)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly
          proportioned?   – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

        Seat Height   _____   too high too low

        Seat Depth   _____   too deep too shallow

        Seat Width   _____   too wide too narrow

        Back Height   _____   too high too low

        Back Width   _____   too wide too narrow

        None   _____   this chair is well proportioned

Comments (optional)

Chair I, Redesign 8

26)   How beautiful do you think this chair is?

          1   2   3   4   5   6   7   8   9   10

27)   How well proportioned is this chair?

          1   2   3   4   5   6   7   8   9   10

28)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair I, Redesign 9

29) How beautiful do you think this chair is?

        1   2   3   4   5   6   7   8   9   10

30) How well proportioned is this chair?

        1   2   3   4   5   6   7   8   9   10

31) Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

32)   Rate these chairs in order of best to worst proportioned:
       (1-10, 1 being the best, 10 being the worst)

       Chair I, Original Version   _____
       Chair I, Redesign 1   _____
       Chair I, Redesign 2   _____
       Chair I, Redesign 3   _____
       Chair I, Redesign 4   _____
       Chair I, Redesign 5   _____
       Chair I, Redesign 6   _____
       Chair I, Redesign 7   _____
       Chair I, Redesign 8   _____
       Chair I, Redesign 9   _____

Please select one choice for each question and mark with an X

33)   Which chair(s) do you think would have the best **seat height** for you?

       Chair I, Original Version, Redesign 1   _____
       Chair I, Redesigns 2, 4, 5, 6,   _____
       Chair I, Redesigns 3,7, 8, 9   _____

34)   Which chair do you think would have the best **seat depth** for you?

       Chair I, Original Version   _____
       Chair I, Redesign 1   _____
       Chair I, Redesign 2, 4, 7, 9   _____
       Chair I, Redesign 3, 5, 6, 8   _____

35)   Which chair do you think would have the best **back heigh**t for you?

       Chair I, Original Version, Redesign 1   _____
       Chair I, Redesign 2, 6, 8, 9   _____
       Chair I, Redesign 3, 4, 5, 7   _____

36)   Which chair do you think would fit the most people – both adult men and women of varying
       sizes?

       Chair I, Original Version _____   Chair I, Redesign 5   _____
       Chair I, Redesign 1   _____   Chair I, Redesign 6   _____
       Chair I, Redesign 2   _____   Chair I, Redesign 7   _____
       Chair I, Redesign 3   _____   Chair I, Redesign 8   _____
       Chair I, Redesign 4   _____   Chair I, Redesign 9   _____

Survey #2 – *LC2 Chair*

Survey on Beauty and Proportion in Chair Design

The purpose of this survey is to find out how the perceived level of beauty and proportion of a classic chair changes when the chair is scaled to fit people in a range of anthropometric percentiles.

You will be presented with 3D renderings of an historical chair design and a series of differing versions of that chair. This is an Occasional Chair that might be found in a reception area and would be sat in for limited periods of time. Please evaluate each chair by answering the questions that follow.

Your responses are confidential and cannot be used to identify you.

Thank you very much for your participation in this project.

Caroline Kelly

Age _____   **Gender** Male   Female

Studio Instructor   _____

Chair B
Original Design

1)   Are you familiar with this chair?   Yes   No

On a scale of 1 – 10, with 1 being the least and 10 being the most, rate this chair on the following criteria:

2)   How beautiful do you think this chair is?

                    1   2   3   4   5   6   7   8   9   10

3)   How well proportioned is this chair?

                    1   2   3   4   5   6   7   8   9   10

4)   Which one dimension, if any, of this chair seems to stand out the **most** as being badly
        proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair B, Redesign 1

5) How beautiful do you think this chair is?

            1   2   3   4   5   6   7   8   9   10

6) How well proportioned is this chair?

            1   2   3   4   5   6   7   8   9   10

7) Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair B, Redesign 2

8)   How beautiful do you think this chair is?

                1   2   3   4   5   6   7   8   9   10

9)   How well proportioned is this chair?

                1   2   3   4   5   6   7   8   9   10

10)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned?   – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair B, Redesign 3

11)   How beautiful do you think this chair is?

        1   2   3   4   5   6   7   8   9   10

12)   How well proportioned is this chair?

        1   2   3   4   5   6   7   8   9   10

13)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair B, Redesign 4

14)   How beautiful do you think this chair is?

         1   2   3   4   5   6   7   8   9   10

15)   How well proportioned is this chair?

         1   2   3   4   5   6   7   8   9   10

16)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly
         proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair B, Redesign 5

17)   How beautiful do you think this chair is?

               1   2   3   4   5   6   7   8   9   10

18)   How well proportioned is this chair?

               1   2   3   4   5   6   7   8   9   10

19)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly
        proportioned? – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

Chair B, Redesign 6

20)   How beautiful do you think this chair is?

        1   2   3   4   5   6   7   8   9   10

21)   How well proportioned is this chair?

        1   2   3   4   5   6   7   8   9   10

22)   Which one dimension of this chair, if any, seems to stand out the **most** as being badly
        proportioned?   – e.g., the seat width looks too narrow; the seat height looks too low.

Select one dimension and circle the choice that best describes the problem.

Seat Height	_____	too high too low
Seat Depth	_____	too deep too shallow
Seat Width	_____	too wide too narrow
Back Height	_____	too high too low
Back Width	_____	too wide too narrow
None	_____	this chair is well proportioned

Comments (optional)

23)   Rate these chairs in order of best to worst proportioned:
        (1-7, 1 being the best, 7 being the worst)

        Chair B, Original Version   _____
        Chair B, Redesign 1   _____
        Chair B, Redesign 2   _____
        Chair B, Redesign 3   _____
        Chair B, Redesign 4   _____
        Chair B, Redesign 5   _____
        Chair B, Redesign 6   _____

Please select one choice for each question and mark with an X

24)   Which chair do you think would have the best **seat height** for you?

        Chair B, Original Version   _____
        Chair B, Redesign 1   _____
        Chair B, Redesign 2   _____
        Chair B, Redesign 3   _____
        Chair B, Redesign 4   _____
        Chair B, Redesign 5   _____
        Chair B, Redesign 6   _____

25)   Which chair do you think would have the best **seat depth** for you?

        Chair B, Original Version   _____
        Chair B, Redesign 1   _____
        Chair B, Redesign 2   _____
        Chair B, Redesign 3   _____
        Chair B, Redesign 4   _____
        Chair B, Redesign 5   _____
        Chair B, Redesign 6   _____

26)   Which chair do you think would have the best **back height** for you?

        Chair B, Original Version   _____
        Chair B, Redesign 1   _____
        Chair B, Redesign 2   _____
        Chair B, Redesign 3   _____
        Chair B, Redesign 4   _____
        Chair B, Redesign 5   _____
        Chair B, Redesign 6   _____

27)   Which chair do you think would fit the most people – both adult men and women of varying
        sizes?

        Chair B, Original Version   _____
        Chair B, Redesign 1   _____
        Chair B, Redesign 2   _____
        Chair B, Redesign 3   _____
        Chair B, Redesign 4   _____
        Chair B, Redesign 5   _____
        Chair B, Redesign 6   _____

APPENDIX C

Raw Data Zig Zag Survey

Questions	Subj 1	Sub 2	Sub 3	Sub 4	Sub 5	Sub 6
Age	38	23	22	22	23	22
Gender	F	F	M	F	M	M
Instructor	UNG -GRAD	RIAN - GRAD	LYNN	LYNN	LYNN	LYNN
INAL CHAIR						
1	Y	Y	Y	N	Y	Y
2	2	8	6	4	5	5
3	2	8	9	2	6	5
4a	SD1	BH1	N	SD1	SD1	SD1
4b	1	1	0	1	1	1
REDESIGN 1						
5	3	5	5	4	8	5
6	8	4	4	3	8	6
7a	SH2	SD2	SD2	N	BH1	BH1
7b	2	2	2	0	1	1
REDESIGN 2						
8	6	4	5	4	6	4
9	8	4	7	5	6	5
10a	SD2	BH1	N	N	BH1	SH1
10b	2	1	0	0	1	1
REDESIGN 3						
11	3	7	8	4	7	5
12	6	8	9	4	7	6
13a	SH2	N	N	SW1	BH1	SW1
13b	2	O	0	1	1	1
REDESIGN 4						
14	3	7	6	4	9	5
15	8	7	6	4	9	6
16a	SW2	SW2	N	SW1	SD2	SH1
16b	2	2	0	1	2	1
REDESIGN 5						
17	3	4	4	4	8	5
18	6	2	3	2	8	4
19a	SD2	SD2	SD2	SD2	SW1	SD2
19b	2	2	2	2	1	2
REDESIGN 6						
20	2	2	4	4	5	5
21	2	1	3	2	4	4
22a	SD2	SD2	SD2	SD2	BH1	SD2
22b	2	2	2	2	1	2
REDESIGN 7						
23	3	7	5	6	5	5
24	4	7	2	6	6	6
25a	SH2	SH2	SH2	SD1	SH2	SH2
25b	2	2	2	1	2	2
REDESIGN 8						
26	1	4	5	5	4	5
27	2	3	3	5	4	5
28a	SD2	SD2	SD2	SD2	BH1	SH2
28b	2	2	2	2	1	2
REDESIGN 9						
29	2	8	6	7	7	5
30	6	7	6	7	7	4
31a	SH2	N	N	N	BH1	SD1
31b	2	0	0	0	1	1
GENERAL						
32						
RANK 1	4	3	O	9	4	1
2	3	0	3	7	5	3
3	2	7	2	5	1	4
4	1	4	4	3	3	7
5	7	1	9	4	9	8
6	0	9	1	1	2	2
7	8	2	5	0	7	0
8	6	3	6	6	0	9
9	5	6	8	2	8	5
10	9	8	7	8	6	6
33	2	3	1	3	3	1
34	3	3	3	4	1	2
35	1	3	1	3	3	3
FIT MOST 36	4	3	4	7	3	7

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Sub 7	Sub 8	Sub 9	Sub 10	Sub 11	Sub 12	Sub 13
22	21	24	23	23	23	22
F	M	F	F	F	F	F
LYNN	CHUDEK	LYNN	RINGHOLZ	RINGHOLZ	RINGHOLZ	RINGHOLZ
N	Y	N	Y	Y	Y	Y
8	4	6	6	6	7	7
9	6	4	3	8	4	6
N	BH1	SW1	SD1	SH2	BH	SD1
0	1	1	1	2	1	1
6	4	5	7	6	5	5
6	5	4	5	8	4	5
SD2	BH1	SD2	BH1	SD2	SD2	SD2
2	1	2	1	2	2	2
8	4	7	5	6	6	5
7	6	8	6	9	5	6
SH1	BH1	NA	BH1	N	BH1	BH1
1	1	NA	1	0	1	1
8	5	5	9	6	4	6
7	6	4	9	9	4	7
SH1	N	SW1	N	N	SD2	SH1
1	0	1	0	0	2	1
9	5	3	8	6	5	7
10	5	6	7	7	6	7
SH1	BH1	SD2	SH1	SD2	SD2	SH1
1	1	2	1	2	2	1
5	3	5	4	6	4	4
3	4	3	3	5	5	3
SD2	SD2	SD2	SH1	SD2	SD2	SD2
2	2	2	1	2	2	2
3	4	5	2	6	3	5
2	4	4	1	5	4	4
SD2	SH1	SD2	SD2	SD2	SD2	SD2
2	1	2	2	2	2	2
10	6	6	5	6	6	8
10	6	6	7	5	4	8
SH2	BH1	SH2	SH2	SH2	SH2	N
2	1	2	2	2	2	0
2	6	5	2	6	5	5
1	5	4	1	6	4	5
SD2	BH1	SD2	SD2	SH2	SD2	SD2
2	1	2	2	2	2	2
7	4	6	6	6	7	8
5	4	9	4	7	6	8
SH1	SH2	N	SH1	SH2	SH2	N
1	2	0	1	2	2	0
7	7	9	3	2	3	9
4	4	2	4	3	4	7
0	9	1	2	1	9	4
2	6	4	0	0	7	3
3	3	0	1	4	1	2
9	0	3	7	9	2	0
1	2	6	8	8	5	6
5	5	7	5	5	6	8
6	8	5	9	6	8	1
8	1	8	6	7	0	5
1	3	2	2	2	2	3
3	3	3	3	3	1	4
3	3	3	3	3	3	1
O	2	9	4	3	9	9

Sub 14	Sub 15	Sub 16	Sub 17	Sub 18	Sub 19	Sub 20	Sub 21
21	21	21	21	20	25	22	22
F	F	F	F	F	F	M	M
RINGHOLZ	LYNN	FLORIAN	LYNN	CHUDEK	RINGHOLZ	RINGHOLZ	RINGHOLZ
Y	Y	Y	Y	Y	Y	Y	Y
5	8	4	7	8	8	9	7
4	8	6	5	9	7	9	7
SD1	N	SH1	BH1	N	BW1	BH1	SH1
1	0	1	1	0	1	1	1
4	6	4	7	6	6	5	7
4	6	3	6	4	6	5	7
SD1	SD2	SD2	BH1	SD2	SD2	SD2	SH1
1	2	2	1	2	2	2	1
3	7	4	7	7	9	3	7
3	7	3	5	9	10	3	7
BH1	BH1	BH1	BH1	N	N	SD2	SW2
1	1	1	1	0	0	2	2
5	8	4	7	7	8	8	7
4	8	7	6	6	9	8	7
SD2	N	N	SW1	SD2	SD2	SD2	SW1
2	0	0	1	2	2	2	1
3	6	4	7	6	9	5	7
3	5	6	7	6	8	5	7
SH1	SW2	SH1	SH2	N	SD2	BH2	NA
1	2	1	2	0	2	2	NA
5	5	4	6	3	6	3	7
4	4	4	5	3	5	4	7
SD2	SW2	SD2	SD2	SD2	SD2	SD2	SD2
2	2	2	2	2	2	2	2
4	3	4	6	NA	5	4	NA
3	2	4	5	NA	3	4	NA
BH1	SD2	BH1	SD2	SD2	SD2	SD2	NA
1	2	1	2	2	2	2	NA
3	3	4	6	8	8	8	NA
2	3	7	5	8	10	8	NA
SH2	SD2	N	SH2	N	SH2	N	NA
2	2	0	2	0	2	0	NA
3	2	4	5	5	7	3	6
3	2	5	5	4	5	3	6
SH2	SD2	SD2	SH1	BH1	SD2	SD2	SD2
2	2	2	2	1	2	2	2
3	8	4	7	6	9	5	7
3	7	6	7	7	9	5	7
SH2	SD	N	SW1	N	BH1	SH2	BH1
2	2	0	1	0	1	2	1
1	0	NA	3	O	0	1	0
2	7		4	3	2	3	2
3	4		9	4	9	7	9
4	3		5	9	1	8	3
5	1		7	7	3	9	5
6	9		2	1	7	4	1
7	8		5	2	4	2	7
8	2		8	5	6	5	8
9	6		0	8	8	6	4
0	5		1	6	5	8	6
1	1	3	2	3	3	3	3
3	3	3	3	3	3	1	4
2	2	3	3	3	3	3	2
4	4	9	3	2	7	7	8

Sub 22	Sub 23	Sub 24	Sub 25	Sub 26	Sub 27	Sub 28
21	22	22	27	22	26	24
M	M	M	M	M	M	M
RINGHOLZ	RINGHOLZ	RINGHOLZ	RINGHOLZ	MCJUNKIN	ENGLUND	OLZ - GRAD
Y	Y	Y	Y	Y	Y	Y
6	4	7	7	8	7	5
8	4	7	8	9	8	7
SH1	SD1	SD1	NA	N	BH	BW1
1	1	1	NA	0	1	1
4	4	7	7	6	7	5
6	5	7	7	5	7	5
SD2	SW2	SH2	SH1	SD2	SD2	SD2
2	2	2	1	2	2	2
4	2	5	7	7	7	5
5	3	4	8	8	6	6
BH1	BH1	SH1	SH1	BH1	SH1	BH1
1	1	1	1	1	1	1
7	5	8	7	8	8	5
8	5	8	8	8	9	8
SD2	SD2	N	N	N	NA	N
2	2	0	0	0	NA	0
8	2	5	7	7	7	5
9	2	5	8	6	7	8
SD2	SD2	SD2	SH1	BH2	NA	N
2	2	2	1	2	NA	0
5	2	4	7	4	5	5
4	2	1	5	5	3	4
SD2	SD2	SD2	NA	SD2	SD2	SD2
2	2	2	NA	2	2	2
4	2	1	6	4	4	5
3	2	1	5	4	4	4
SD2	SD2	SD2	NA	BH1	SD2	NA
2	2	2	NA	1	2	NA
8	6	8	8	7	6	5
9	6	10	8	7	6	5
N	N	N	N	SH2	NA	SH2
0	0	0	0	2	NA	2
5	2	3	6	5	5	4
4	2	3	5	4	4	4
SD2	SD2	SD2	NA	SD2	SD2	NA
2	2	2	NA	2	2	NA
7	7	8	8	8	6	5
8	7	8	7	8	8	5
BH1	N	N	BH1	N	NA	SH2
1	0	0	1	0	NA	2
7	9	7	NA	0	9	4
9	7	9		9	0	3
4	8	4		1	7	7
0	6	0		3	1	9
3	0	5		7	3	2
1	3	1		4	2	1
2	1	3		5	4	8
5	2	2		2	8	5
6	5	8		6	5	6
8	4	6		8	6	7
3	3	3	3	3	3	2
3	3	3	3	4	4	1
3	3	3	3	2	3	3
7	9	9	NA	1	1	4

Sub 7	Sub 8	Sub 9	Sub 10	Sub 11	Sub 12	Sub 13	S
22	21	24	23	23	23	22	
F	M	F	F	F	F	F	
LYNN	CHUDEK	LYNN	RINGHOLZ	RINGHOLZ	RINGHOLZ	RINGHOLZ	RINGI
N	Y	N	Y	Y	Y	Y	
8	4	6	6	6	7	7	
9	6	4	3	8	4	6	
N	BH1	SW1	SD1	SH2	BH	SD1	
0	1	1	1	2	1	1	
6	4	5	7	6	5	5	
6	5	4	5	8	4	5	
SD2	BH1	SD2	BH1	SD2	SD2	SD2	
2	1	2	1	2	2	2	
8	4	7	5	6	6	5	
7	6	8	6	9	5	6	
SH1	BH1	NA	BH1	N	BH1	BH1	
1	1	NA	1	0	1	1	
8	5	5	9	6	4	6	
7	6	4	9	9	4	7	
SH1	N	SW1	N	N	SD2	SH1	
1	0	1	0	0	2	1	
9	5	3	8	6	5	7	
10	5	6	7	7	6	7	
SH1	BH1	SD2	SH1	SD2	SD2	SH1	
1	1	2	1	2	2	1	
5	3	5	4	6	4	4	
3	4	3	3	5	5	3	
SD2	SD2	SD2	SH1	SD2	SD2	SD2	
2	2	2	1	2	2	2	
3	4	5	2	6	3	5	
2	4	4	1	5	4	4	
SD2	SH1	SD2	SD2	SD2	SD2	SD2	
2	1	2	2	2	2	2	
10	6	6	5	6	6	8	
10	6	6	7	5	4	8	
SH2	BH1	SH2	SH2	SH2	SH2	N	
2	1	2	2	2	2	0	
2	6	5	2	6	5	5	
1	5	4	1	6	4	5	
SD2	BH1	SD2	SD2	SH2	SD2	SD2	
2	1	2	2	2	2	2	
7	4	6	6	6	7	8	
5	4	9	4	7	6	8	
SH1	SH2	N	SH1	SH2	SH2	N	
1	2	0	1	2	2	0	
7	7	9	3	2	3	9	
4	4	2	4	3	4	7	
0	9	1	2	1	9	4	
2	6	4	0	0	7	3	
3	3	0	1	4	1	2	
9	0	3	7	9	2	0	
1	2	6	8	8	5	6	
5	5	7	5	5	6	8	
6	8	5	9	6	8	1	
8	1	8	6	7	0	5	
1	3	2	2	2	2	3	
3	3	3	3	3	1	4	
3	3	3	3	3	3	1	
O	2	9	4	3	9	9	

Sub 29	Sub 30	Sub 31	Sub 32	Sub 33	Sub 34	Sub 35	Sub 36	Sub 37
21	21	26	24	31	24	23	26	22
M	M	M	M	M	NA	M	F	M
FLORIAN	FLORIAN	LYNN	MCJUNKIN	FLORIAN	RINGHOLZ	RINGHOLZ	CHUNG	CHUDEK
Y	Y	Y	Y	Y	Y	Y	N	N
7	7	6	6	8	3	8	7	7
5	6	6	8	6	5	7	4	3
SD2	SH1	SD2	N	SH1	SW1	N	SW1	SH2
2	1	2	0	1	1	0	1	2
6	4	7	5	7	3	8	6	7
5	4	4	6	7	3	5	7	7
SW2	SH1	SD2	SH1	SH1	NA	SD2	SH1	BH1
2	1	2	1	1	NA	2	1	1
7	7	5	5	6	5	8	7	8
6	7	4	4	6	4	6	6	9
SD2	SH1	BH1	BH1	BH1	SH1	SD2	SH1	N
2	1	1	1	1	1	2	1	0
8	7	8	5	7	3	NA	7	6
8	7	NA	6	8	5		5	7
N	SH1	BH1	SH1	SH1	SD2	na	SH1	BH2
0	1	1	1	1	2	na	1	2
8	6	7	5	6	4	7	7	8
7	6	7	5	6	4	5	6	7
N	SH1	SH2	SW2	SW2	NA	BH2	SH1	NA
0	1	2	2	2	NA	2	1	NA
8	4	5	4	5	1	NA	6	5
5	4	3	3	5	1		7	3
SD2	SD2	NA	SD2	SD2	SD2	na	sh1	SW2
2	2	NA	2	2	2	na	1	2
7	4	7	4	5	1	5	6	3
4	3	3	3	4	1	4	6	3
SD2	BH1	NA	SD2	SW2	SD2	SD2	SH1	SW2
2	1	NA	2	2	2	2	1	2
8	5	8	4	8	5	NA	7	8
4	8	7	3	9	5		8	8
SH2	N	NA	SH2	N	N		SW1	N
2	0	0	2	0	0		1	0
7	5	6	4	6	2	7	6	2
4	4	4	3	4	2	7	9	1
SD2	SD2	SD2	SW1	BH1	SD2	SD2	SH1	SW2
2	2	2	1	1	2	2	1	2
8	7	7	3	8	4	6	8	9
6	8	5	2	8	4	8	7	7
N	N	BH1	SW1	N	N	NA	SD1	SW2
0	0	1	1	0	0	NA	1	2
4	7	NA	1	7	7	NA	7	2
3	9		5	9	9		8	9
7	0		6	0	0		6	4
8	2		4	1	4		5	3
2	3		8	3	3		9	7
1	4		9	2	2		4	0
9	1		2	4	1		1	1
0	8		3	8	8		3	6
5	5		0	5	6		2	5
6	6		7	6	5		0	8
3	3	3	1	3	3	1	3	3
3	3	4	1	3	3	3	4	3
3	3	1	1	1	2	3	3	1
4	0	9	1	7	7	0	7	4

APPENDIX D

Raw Data *LC2* Survey

		1	2	3	4	5	6
Age		26	21	23	22	20	22
Gender		m	f	m	m	f	m
Instructor		Lynn	Lynn	Lynn	Lynn	Lynn	Lynn
1		y	n	n	y	y	y
Original 2		8	7	6	4	8	8
3		7	3	3	4	10	6
4a		sd1	sw1	bh1	sh2	sw1	bh1
4b		1	1	1	2	1	1
Redesign 1 5		7	6	4	4	7	8
6		6	3	2	3	7	8
7a		sd	sh1	sw1	sw1	sd1	none
7b		2	1	1	1	1	0
Redesign 2 8		5	7	6	3	6	7
9		5	5	na	3	6	6
10a		sh2	bh1	bh1	bh1	sd1	sw2
10b		2	1	1	1	1	2
Redesign 3 11		5	4	5	3	7	7
12		4	5	2	3	5	6
13a		sh2	sw1	sh2	sd1	sd1	sd1
13b		2	1	2	1	1	1
Redesign 4 14		4	4	4	3	5	7
15		4	3	2	3	3	6
16a		sh2	sh2	sh2	sd2	sd2	sh2
16b		2	2	2	2	2	2
Redesign 5 17		3	3	3	3	4	7
18		2	3	2	3	5	6
19a		sd2	bh2	bh2	bh2	bh2	bh2
19b		2	2	2	2	2	2
Redesign 6 20		4	3	3	3	5	7
21		3	1	1	2	3	6
22a		sh2	sh2	sh2	sh2	sh2	sh2
22b		2	2	2	2	2	2
23	Original	3	5	1	1	1	1
	1	1	3	2	3	3	3
	2	5	2	3	2	4	2
	3	2	1	5	4	2	5
	4	4	6	4	6	7	4
	5	6	4	6	5	5	6
	6	7	7	7	7	6	7
Seat Height 24		4	1	4	orig	orig	orig
Seat Depth 25		2	1	orig	orig	1	orig
Back Height 26		3	2	5	1	1	orig
Most 27		3	1	orig	orig	2	orig

7	8	9	10	11	12	13	
22	20	22	20	21	22	24	
f	f	f	f	f	na	f	
Lynn	Lynn	Lynn	Lynn	Lynn	Lynn	Lynn	Cl
y	y	y	y	y	y	y	
10	7	9	6	7	3	8	
7	4	8	5	6	9	5	
sd2	sd2	none	bh1	sh2	none	sh2	
2	2	0	1	2	0	2	
8	6	9	6	7	3	9	
8	6	8	6	9	4	9	
bh1	sw1	sw2	none	none	sh2	none	
1	1	2	0	0	2	0	
9	7	9	7	7	3	7	
8	4	7	6	6	2	5	
bh1	sd2	sh1	bh1	sd2	sh1	bh1	
1	2	1	1	2	1	1	
7	4	8	7	5	3	5	
7	8	6	6	5	1	4	
sd1	sd2	sd1	sw1	sw1	sw2	sd1	
1	2	1	1	1	2	1	
6	6	6	5	3	3	6	
4	4	5	4	5	1	6	
sd2	sh2	sd2	sd2	sd2	sd2	sd2	
2	2	2	2	2	2	2	
3	3	7	6	2	3	6	
3	3	5	5	3	1	4	
sd2	bh2	sd2	bh2	sh2	sh1	bh2	
2	2	2	2	2	1	2	
3	3	6	5	3	3	4	
2	2	5	4	3	1	4	
sh2	sh2	sh1	sh2	sh2	sh2	sh2	
2	2	1	2	2	2	2	
2	5	2	3	1	1	2	
3	2	1	4	3	2	1	
1	1	5	2	2	3	3	
4	3	6	1	5	4	4	
5	4	3	5	4	5	5	
6	6	7	6	7	6	6	
7	7	4	7	6	7	7	
1	3	orig	4	orig	orig	1	
2	3	4	1	1	orig	1	
1	3	orig	3	orig	orig	1	
orig	1	1	4	2	orig	orig	

14	15	16	17	18	19	20	
27	22	24	22	25	21	24	
m	m	na	m	m	m	m	
andan	Applewhite	na	Chudek	Reeder	Vollmer	McJunkin	E
y	y	y	y	y	y	y	
7	7	6	8	8	6	8	
8	8	5	8	7	7	6	
bh1	sd1	sh2	bh1	bw1	bh1	sh2	
1	1	2	1	1	1	2	
7	7	6	9	8	7	7	
7	7	5	9	7	7	7	
none	bh1	sh2	none	sh1	sh1	sw1	
0	1	2	0	1	1	1	
6	5	5	8	6	6	6	
6	6	4	8	5	6	5	
sw2	sw2	sh2	bh1	sw2	bh1	sh2	
2	2	2	1	2	1	2	
5	7	7	7	8	6	5	
4	8	7	7	8	5	7	
sd1	none	sw2	bw2	none	sd1	bh2	
1	0	2	2	0	1	2	
6	5	3	7	6	5	4	
7	5	3	7	3	4	4	
sd2	sd2	sd2	sd2	sh2	sd2	sh2	
2	2	2	2	2	2	2	
6	6	3	8	5	3	4	
5	6	3	8	3	3	3	
bh2	sh2	sd2	sd2	bh2	bh2	bh1	
2	2	2	2	2	2	1	
6	6	3	8	5	2	3	
7	5	3	8	3	2	2	
sh2	sh2	sh2	sh2	sh2	sh2	sh2	
2	2	2	2	2	2	2	
2	2	2	1	2	1	1	
3	5	1	2	3	2	3	
1	4	3	4	5	4	5	
7	3	4	5	1	5	4	
4	1	5	6	4	3	2	
5	6	6	7	6	6	6	
6	7	7	3	7	7	7	
4	3	1	1	3	orig	orig	
1	3	2	1	orig	orig	2	
orig	1	3	1	5	3	3	
1	3	2	1	orig	orig	orig	

21	22	23	24	25	26	27
20	19	21	26	20	21	22
f	m	m	m	m	f	f
⌐land	England	England	England	England	Lynn	Reeder
y	n	n	y	y	y	y
10	7	4	8	8	7	7
8	4	7	8	7	5	8
sw1	sh2	bw2	bh1	bh2	bh1	na
1	2	2	1	2	1	na
10	7	4	6	6	6	6
10	8	7	4	5	6	6
bh1	sw1	none	sd1	bh1	sw1	na
1	1	0	1	1	1	na
8	7	4	7	9	7	4
8	5	6	8	9	7	3
sw1	bh1	none	bh1	sh2	sh1	na
1	1	0	1	2	1	na
7	7	3	4	4	5	5
7	3	5	2	3	7	4
bh1	sd1	sd1	sd1	sd1	sd1	na
1	1	1	1	1	1	na
5	7	4	6	7	6	6
3	5	4	5	8	4	5
sh2	sd2	sd2	sh2	sh2	sh2	na
2	2	2	2	2	2	na
4	7	3	3	9	3	5
4	6	2	2	9	4	4
sw1	sh2	sh1	sd2	none	sd2	bh2
1	2	1	2	0	2	2
2	7	3	5	3	5	5
2	5	2	4	2	4	3
sh2	sh2	sh2	sh2	sh2	sh2	sh2
2	2	2	2	2	2	2
1	3	1	2	2	3	1
5	1	3	3	6	1	2
3	2	2	4	7	4	3
4	7	5	1	3	2	5
6	4	4	7	4	5	4
2	5	6	6	1	7	7
7	6	7	5	5	6	6
orig	4	orig	3	5	1	1
4	orig	orig	orig	orig	2	3
5	3	orig	5	3	3	1
orig	1	2	orig	5	2	1

28	29	30	31	32	33	34	35	36
20	29	21	23	21	21	25	24	45
m	m	m	f	f	f	f	m	f
gland	McJunkin	England	Reeder	Reeder	Ringholz	Sprigle	Dobbins	Applewhite
y	y	y	y	y	y	y	y	n
8	8	8	3	7	7	6	5	6
9	7	9	8	8	7	6	6	8
bh1	sw1	bh1	sd1	bh1	sw1	bh1	bh1	sh2
1	1	1	1	1	1	1	1	2
8	6	6	4	6	7	7	5	6
9	8	7	8	8	9	7	6	6
none	sh1	sh1	none	sd1	sw1	sd1	sh1	sd1
0	1	1	0	1	1	1	1	1
8	6	7	3	5	4	4	5	6
9	7	9	7	5	3	3	4	6
none	sw2	none	sw2	sh1	sh1	sw2	bh1	bh1
0	2	0	2	1	1	2	1	1
8	9	5	3	4	3	2	4	5
8	9	3	7	4	2	5	3	5
bh2	none	sd1	sd1	sw1	sd1	sw2	sd1	sd1
2	0	1	1	1	1	2	1	1
7	5	6	4	6	5	1	4	5
9	6	4	8	6	7	1	4	5
sh2	sh2	sd2	sh2	sd2	none	sh2	sd2	sd2
2	2	2	2	2	0	2	2	2
5	4	3	3	2	1	3	4	5
8	4	2	6	1	1	2	5	5
sh2	na	bh2	sh1	sd2	bh2	bh2	sh1	sh1
2	na	2	1	2	2	2	1	1
6	3	7	3	2	3	1	5	5
8	3	5	6	1	3	1	6	5
sh2	na	sh2	sh2	sw1	sw1	sh2	bh1	sh2
2	na	2	2	1	1	2	1	2
4	3	2	2	1	2	na	4	3
3	4	3	1	3	1	na	2	1
5	5	1	4	4	6	na	7	4
1	2	4	3	5	5	na	6	2
2	1	6	6	2	3	na	5	5
6	6	5	5	7	7	na	1	7
7	7	7	7	6	4	na	3	6
4	4	orig	5	4	3	na	orig	2
3	5	1	1	orig	orig	na	4	orig
5	5	orig	3	3	3	na	3	3
3	1	orig	1	orig	2	na	2	2

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