Cape Peninsula University of Technology

Ergonomic considerations for the design of women's functional protective wear for the local construction industry

by

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DECLARATION

I, Bongiwe Kolisi, declare that the contents of this dissertation/thesis represent my own unaided work, and that the dissertation/thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of Cape Peninsula University of Technology.

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ABSTRACT

This study highlights the preliminary findings of an investigation into ergonomic considerations in the design of women's protective clothing. The study investigates the validity of an assumption that there is a dearth in the product offerings of women's protective wear that are ergonomically designed with a good fit, and offer acceptable levels of comfort for women performing outdoors in the construction industry. The research employs a qualitative research method – including interviews with key actors such as women working in the construction industry, and manufacturers. Pertinent psychological and physiological factors relating to the current protective wear are also interrogated herein. For example, the unique morphological features associated with steatopygia and gynaeoid body types are common in the sub-region, and yet not fully accommodated in the design of context-responsive work wear.

The prevailing attitudes among selected manufacturers and suppliers to motivate them to offer superior products for women in the construction industry are explored. A higher adoption rate of the redesigned women's protective wear could correlate to reductions in downtime associated with general occupational health and safety issues; as well as an impact of low levels of comfort, protection and garment fit. Similarly, the redesigned garments could inform the development of improved protective wear for women, and ultimately facilitate higher productivity in the work environment. Subsequently, a boosted self-confidence and higher levels of motivation occasioned by a positive body image of women workers would validate the efficacy of the intended ergonomic design intervention. Lastly, the thesis discusses socio-technical strategies for generating high fidelity data for applications in new product development for women's protective wear. Furthermore, the findings and recommendations are discussed herein; this is made possible by the data collected.

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DEDICATION

This study is dedicated to my late mother who passed on looking forward to my graduation day. To my mom Nondumiso Kolisi, I say, thank you mom for all the prayers towards my success. It is also dedicated to my father and all my family members for their support during the period of my study.

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GLOSSARY

Terms/Abbreviations **Definition/Explanation**

Aesthetics	The study of human reaction to the non-instrumental qualities of an object or occurrence (O'Neal cited by de Klerk & Lubbe, 2004:2)
Anthropometric Data	"Measurement data on the dimensions of specified body areas of a large sample of the population being studied" (Mullet, Moore & Young, 2009:212).
Anthropometry	The branch of the human sciences that deals with body measure*ments*, particularly with measurements of body size, shape, strength and working capacity (Pheasant, 1996:6).
Block Pattern	"A foundation pattern constructed to fit an average figure" (Aldrich, 2011:15).
Body Image	"The internal representation of one's own outer appearance, the ideas people hold about their appearance" (Fan, 2004:1).
Body Types	"Classification of the specified population that are based on the key length and circumference body measurements" (Mullet, Moore & Young, 2009:213).
Clothing Design	The identifying characteristics of a garment that differentiate it from other garments of the same style (ibid, 2009:213).
Clothing fit	According to Cain (cited by Yu, 2004:32) "fit is directly related to the anatomy of the human body and most of the fitting problems are created by the bulges of the human body".
Construction Industry	Sector of national economy engaged in preparation of land and construction, alteration and repair of buildings, structures and other real property (http:/www.businessdictionary.com).
CPUT	Cape Peninsula University of Technology
Culture	The way people live, the clothes they wear, the food they eat, the stories they tell and the ways they celebrate, the way they show their imaginations through art, music and writing. It is essentially about people's roots (Kalman, 2009:4).
Diversity	It is the variety that exists in race, gender, ethnic or cultural background, age, sexual orientation, religion and physical or mental capability.
Ergonomics/ Human Factors	The science of work: of the people who do it and the ways it is done, the tools and equipment they use, the places they work in, and the psychosocial aspects of the working situation (Pheasant,1996:4).
Fashion	"A current style that is followed by a large number of people at any one time. It is about promoting the new and is concerned with constantly changing aesthetics" (Burke, 2011:11).
Gender	"Socially developed differences between being feminine and being masculine" (Holmes, 2007:31).
Gender Equity	"A set of actions, attitudes, and assumptions that provide opportunities and create expectations about individuals" (http://www.edc.org).

MMH	Manual Material Handling.
Morphology	“The study of form. In medicine, morphology refers to the size, shape and structure rather than the functions of a given organ” (Medical Dictionary, 2008).
Pattern	A diagram of each of the component pieces required for a construction of a garment.
Pattern designing	“Is the adapting and styling of basic foundation blocks to produce any desired design of garment or part thereof” (Defty, 1998:6).
Pattern drafting	“Is the drawing of vertical and lateral lines onto paper or card, of certain dimensions taken on a human figure (or from sizing charts of average figure dimensions” (Defty, 1998:6).
Pattern grading	“The process of systematically increasing and decreasing the size of a master pattern to create a range of sizes” (Mullet, Moore & Young, 2009:1).
PPC	Personal Protective Clothing.
PPE	Personal Protective Equipment.
Prototype	“A garment sample that is made up so that the designer can check and refine both the pattern and the construction of the garment” (Aldrich, 2008:5).
SABS	South African Bureau of Standards.
SANS	South African National Standard.
Size	“The dimensions of a *finished garment* made by garment manufacturers, not the actual dimensions of the person who may wear a particular size” (Defty, 1998:6).
Style	“A general category or classification of garments” (Mullet, Moore & Young, 2009:215).
UoT	University of Technology.

KEYWORDS

- 3D Body Scanning
- Anthropometry
- Body image
- Clothing fit
- Construction industry
- Ergonomics
- Fashion design
- Protective wear
- Sizing

CHAPTER ONE

SCOPE OF THE RESEARCH

1.0 INTRODUCTION

The construction field was previously almost exclusive to men in composition due to the physically demanding nature of the job – the emphasis was on higher levels of bodily strength. Consequently, women have not traditionally been employed in the construction industry because they were not regarded as being strong enough to cope with the physical demands of the job. To ameliorate this situation, an initiative called South African Women in Construction (SAWiC) was founded in 1997 to empower women to gain access to contracts, training, finance and networks in the construction industry (SAWiC, 2008). Due to the important contribution by SAWiC to the development of women contractors, women are now slowly joining the construction industry in South Africa, benefitting from the role that automation and technology plays in this industry, further eliminating the requirement for workers with relatively strong physiques.

Despite the fact that women are slowly joining the construction industry, safety concerns in the industry seem to create barriers for women entering the field. Notwithstanding, women are not perceived as equals by their male counterparts and often have to work twice as hard to be recognised and accepted. As a result, in most construction sectors, women are seen to be more suited to administrative rather than production functions – these sentiments were echoed by a manager of a protective wear manufacturer (Anon, 2013). Further, he concurs with the fact that there are serious limitations in the product offering of protective wear for women, and that there is a potentially large market for its supply.

1.1 MOTIVATION FOR CHOOSING THIS TOPIC

The motivation for this study stems from the observations and preliminary interviews with local suppliers and manufacturers which indicated that because of the prior history of the construction industry, protective apparel mainly focuses on men's product lines and neglects those of women. In particular, with respect to the current *personal protective equipment* (PPE), the focus of the study is "the overall" attire which is the integral part of PPE. Most local suppliers label it as unisex, despite the fact that there is a remarkable difference between male and female morphological structures. This was affirmed by observations when I was driving along the streets of Cape Town, South Africa, during 2009-2010. At that time, the city of Cape Town, South Africa engaged in new road construction and facility upgrades in preparation for the 2010 FIFA World Cup. As a result driving around was not just difficult

due to the regular heavy traffic, road construction in preparation for the hosting of the 2010 FIFA World Cup also contributed to the driving difficulties encountered. It was during this time that I observed female workers taking part in road construction, which used to be a job previously designated for men.

As a clothing designer who pays more attention to the technical aspects of pattern making and clothing construction, I took note of the fact that the protective clothing worn by the women proved to be unflattering and not feminine (see Figure 1.2 in page 3). The concern is that the clothing worn seems uncomfortable and the ill fit was due to the fact that it was designed and manufactured to suit the men's physique. Uncomfortable clothing can impede motion or alter strategies for the accomplishment of the physical task. This may result from the fact that the sector has been male dominated; therefore, appropriate work attire is not readily available for women working in the construction industry. This situation is not only evident in garments but in personal protective equipment (PPE) too. Consequently, a study that was conducted by English, Haupt and Smallwood (2004) on a platinum plant indicated that small enough boots and overall sizes were not available for women engineering recruits.

Figure 1.1: Men's two-piece overall (Source: Cape Town based Research Construction Company, 2013)

Subsequently, during an unstructured interview with a protective wear manufacturer who is based in Cape Town, South Africa, Interviewee 1 (2013) argued that there are work shoes that are designed and made for women (see Figure 1.2 below). This state of affairs was also prevalent with work gloves, women used to wear oversized gloves, which made it difficult for them to work efficiently, and recently, there are gloves available for women construction

workers. With that said, currently, there are no studies that confirm that there are attempts made for the design of protective garments that are ergonomically designed to suit women's physique. This was also confirmed during the interviews with the manager of a protective wear manufacturer.

Figure 1.2: Ladies' work boots (Research Construction Company, 2013)

As part of the construction field duties, workers engage in various demanding tasks which require lifting heavy materials, pushing and pulling, bending arms, bending, squatting and stretching, therefore comfort in the worker's attire is crucial in order to maintain work efficiency. It is also important that the main purpose of wearing protective wear while on the job, which is to reduce the effects of sudden impact forces by means of shock-absorption and pressure distribution, is taken into consideration. Figure 1.3 displays women wearing their own clothing including tight fitting denim pants that are restrictive. During the interviews with a construction site manageress, it was gathered that women prefer to wear their own garments on site because they are not happy with the fit and look of the current protective wear. Regardless of the job type, working in construction sites or in manufacturing plants calls for protective wear that should be designed to embrace comfort, protection, and durability and should allow the employee to execute tasks effectively.

Figure 1.3: Caption of women working in construction wearing their own garments (Captured by the Author, 2013)

The size of a garment and the size of the body are the critical factors in the design of functional protective wear. Clothing which is too loose may get caught during work and that which is too tight may restrict movement. Therefore, it is important that protective clothing is designed with the intended user in mind in order to provide a better fit, comfort and mobility on the job-sites while performing one's tasks. Loose work clothing could have an impact on the health and safety for women; as a result, visual assessment of clothing fit is an essential part of the process when identifying and evaluating problems on a garment.

De Jonge (cited in Black and Cloud, 2008:36) proposed a process for the development of functional occupational clothing that places emphasis on identifying user needs, and focusing more on fit, fabric properties and comfort. De Jonge's study points to the fact that the misfit of male protective wear on a woman's body may give rise to the issue of women's negative view of body image. Body image is how we perceive our appearance and is very important to most people; everyone wants to maintain a pleasing look, regardless of the position held or type of work performed.

Due to the fact that the construction field was previously male dominated, background reading from newspaper articles highlighted that women that are working in the construction field often experience sexual harassment from male co-workers. This state of behaviour could be caused by the way women dress while on the job, where in most cases clothing seems tighter around the hip and bust areas (see Figure 1.4).

Figure 1.4: Women at a construction site wearing men's protective wear (Source: http://www.sawic.org, 2013)

Part of the problem that concerns and encourages the conducting of this specific research study is the observed need for female construction workers' awareness about the physical, as well as psychological qualities that protective wear should encompass in order to complete the aesthetic experience. During a subsequent unstructured interview with a manager of a protective wear manufacturer based in Cape Town South Africa, Interviewee 1 (2013) argued that, "as a manufacturer for protective wear, sometimes I go for site visits with an aim of viewing the dress code and also to receive garment fit feedback from my clients. It has been evident that women in construction are not happy about the way they dress, but do not express their concerns about comfort to their employers because they are fearful of losing their jobs".

1.2 RESEARCH PROBLEM

Against the above background, the problem to be researched within the ambit of this thesis revolves around the designs and fit of the available protective wear that does not adequately accommodate women when performing outdoor activities within the construction industry. The research problem is supported by the fact that evidence of availability of protective wear for men is visible; there is no evidence of the research that has been done on ergonomic design consideration of female protective wear in South Africa.

1.2.1 BASIC ASSUMPTION

The research assumption is that available protective wear is not suitable for the women who are employed in the construction industry. This may possibly result from the fact that, historically, the construction industry was male dominated; therefore, protective wear was designed for the male structure. As the construction industry became more transformed to accommodate women, the design of the protective wear was not changed accordingly. The design of the protective wear did not adhere to the user-centred design theory proposed by Pheasant (see Figure 1.4). The user-centred design theory emphasises that "if an object, a system or an environment is intended for human use, then its design should be based upon the physical and mental characteristics of its human users" (Pheasant, 2006:6).

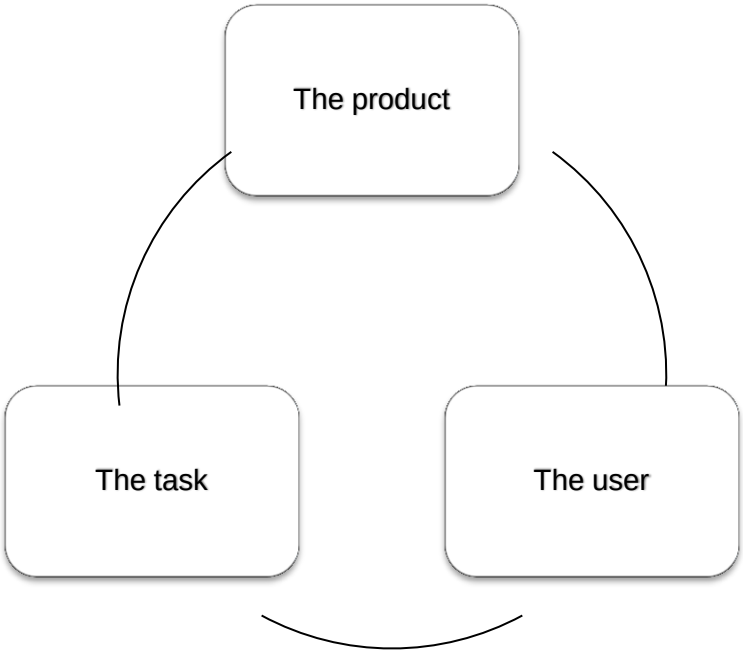


Figure: 1.6: User-centred design: the product, the user and the task (Source: Pheasant, 2006:6)

1.3 RESEARCH QUESTION

The research question of this thesis revolves around "why does design and fit of available protective wear not adequately accommodate women when performing outdoor activities within the construction industry?"

1.3.1 INVESTIGATIVE QUESTIONS

The investigative questions to be examined in support of the research question provide an overview of the following:

- What is the current situation with respect to available women's protective wear in the Cape Town construction industry?

- Why do the current designs and fit in the available protective wear not adequately accommodate women in the construction industry?
- How can relevant ergonomic considerations better inform the design of feminine and more appropriate protective wear for women?

1.4 RESEARCH OBJECTIVES/AIMS

The overall objective of this thesis is to propose practical guidelines for protective wear that is ergonomically designed and made to suit women's physique in order to accommodate women working in the construction industry. To achieve this, the following objectives refer:

- Investigate the availability of protective wear that is specifically designed to suit women's physique;
- Identify the possible limitations in the product offering of protective wear for female construction workers;
- Investigate the practicality and usability of available protective wear designs, their construction, and how suitable the fit is for women; and
- Establish the viability and practicality of designing and manufacturing protective wear that is suitable, comfortable and fit for purpose with respect to women's physique.

1.5 SIGNIFICANCE OF THE RESEARCH

As mentioned in the background of the research, women are increasingly joining the construction industry; therefore, there is a physiological need for the design of protective wear that will be suitable for women, and accommodating their structural difference from that of men. This study is an initial attempt to investigate the validity of this assumption and therefore contribute to such a need by generating a sufficient interest for updates on protective wear that is already offered by manufacturers and suppliers. The study also aims to investigate the range-of-motion and design issues of existing protective wear. Furthermore, the study will add to protective wear manufacturer databases used for quality garment manufacturing and quality improvement.

To construct a well-fitted garment, body measurements should be extremely accurate. To achieve this, the 3D Body Scanner is used to generate new size charts for women. The generation of size charts aids the reduction of downtime due to occupational issues of comfort, protection and garment fit problems. The 3D body scan data can be very helpful to understand better the issues related to mobility and restrictions imposed by the clothing. Uncomfortable protective wear can contribute to lack of productivity in the work place; thus the study contributes to the development of better functional protective wear for women with the intention of improving productivity in the workplace, through boosted self-

confidence/motivation as well as positive body-image of women workers. Below (Fig: 1.4) is an example of a scan that illustrates the difference in shape among women, examples of which will be elaborated in Figure 2.3 of Chapter 2.

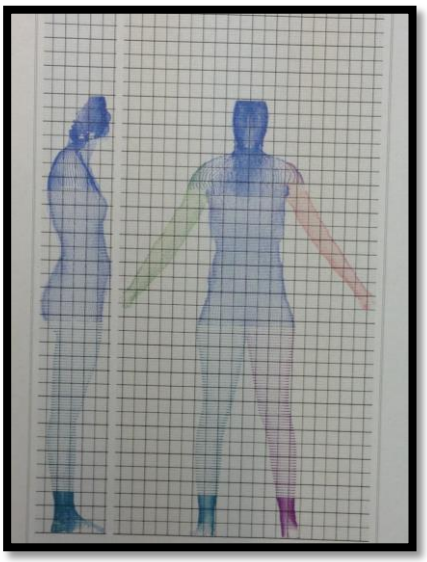


Figure 1.7: Sample of female body scans (Source: Author, 2013)

1.6 STRUCTURE OF THE THESIS

The initial chapters of this thesis study the perception about the fit, styling, construction and availability of women's protective wear working in the outdoor context of the construction industry.

Chapter One provides an overview of the topic under investigation and encompasses issues relating to the research focus, context of the study and the significance of the study. Chapter Two discusses the effects of the deficiency in product offering of protective wear designed specifically to suit women's physique. It also unpacks the challenges that could be faced by women as a result of ill-fitting clothing when performing the anticipated important tasks. The approaches to the investigation process and ways for capturing the data are outlined in Chapter Three in conjunction with research design. Chapter Four contains data collection, all data instruments are clearly defined, inclusive of how the data has been collected. Chapter Five encompasses the analysis of data and interpretation of results gathered from the investigation process. In that process, the validity of the assumption about lack of protective wear suitable for women in the construction industry will be finalised. In the end, the Conclusion (Chapter Six) of the study, recommendations and findings will be outlined and finalised in detail.

1.7 SUMMARY

The construction industry was previously male-dominated and women did not show much interest because of the nature of the job. However, there appears to be women joining the industry benefiting from the role of automation and technology, where not much strong physique is required. Even though there is success in the introduction of automatic equipment and advance in technology resulting in more women joining the industry, as a result of the history of the industry, there is a deficiency in the product offering for protective clothing that is suitable for women's physique, affecting the levels of comfort while performing tasks in the outdoors; therefore, this study investigates the validity of this assumption.

This study hopes to make a significant contribution to the development of size charts that will be used in the construction of protective wear that is suitable for women. This is done by using qualitative methods as a means of data collection, including the 3D Body Scanner that will be used as a tool for taking body measurements accurately. The collection of data requires the involvement of other parties, which might create unforeseen complications that may lead to a prolonged time frame for the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter provides a review of the literature on the ergonomic considerations for protective wear. As indicated in the roadmap to the current status of the research area, (see figure 2.1), the following areas were investigated and are discussed in detail:

- Practical concerns related to protective wear currently offered in the market;
- Challenges that are faced by women within the construction industry
    - Ergonomics/Human Factors
    - Occupational Health and Safety
    - Structural differences of the body and sizing (applied anthropometric data); and
- Importance of garment properties.

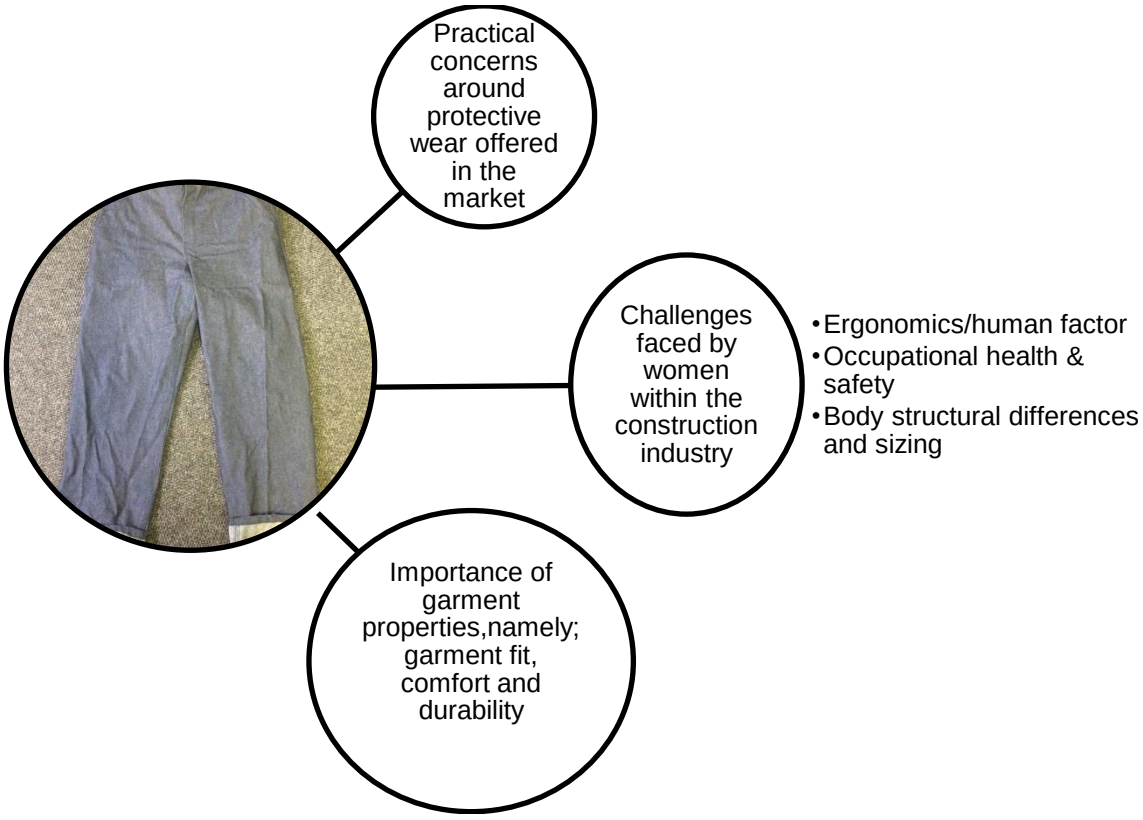


Figure 2.1: Roadmap to the current status of the research area (Author's construct, 2012)

In construction, the degree of the garment fit and being comfortable at work are the key to business success (happy workers equate to productive workers) and the way you dress for work, affects the way you perform. Clothing by its very nature has a restrictive effect on body

movement, therefore, the design and manufacturing processes of protective wear considered the ease of use, dress and removal of the garments. Unlike fashion clothing, which is a product of the designer's creative instincts, the process of designing functional clothing begins and ends with the user specific requirements that include good fit and comfort.

There is always a need for a human body to feel comfortable in a clothing system. Kaplan-Leiserson (cited in Hughes, 2001) argued that "the way you look directly affects the way you think, feel and act". Additionally, Botha and Bridger (1998 cited in Bridger, 2003:79) while carrying out studies of female nurses in Cape Town, noted the need for using "statistical scaling techniques to estimate the required anthropometric data". With respect to designing to suit a range of users, Bridger (2003:79-83) identifies the following strategies:

- Make different sizes – this requires the determination of the minimum number of sizes. Additional considerations include (Bridger, 2003:81):
    - Accommodate as large a percentage of the population as possible with ready-made garments – in the case of the Southern African population, a higher number of hip sizes (compared to waist sizes, crotch depths, and lengths) may be required in view of the unique morphological features associated with steatopygia; and
    - Use as few sizes as possible – this rule of thumb helps to ameliorate the risk of revenue losses, as well as increase profitability for manufacturers.
- Design adjustable products – this approach allows users to adjust the product themselves. Examples include cuff links with extra buttons or Velcro adjustable wrist, neck and waist adjustments; and
- "Fit for use" surveys – this can be achieved by carrying out task analysis by unobtrusively observing people at work. Any discrepancies in fit could be readily observed, and complemented by photo documentation for critical interrogation. A useful statistical technique for facilitating "fit for use" is cluster analysis which is described by Bridger (2003:81) as an approach "used to search for groups, or clusters, of anthropometric variables in the target market".

The design and construction of protective wear would not be possible without accurate body measurements. Traditionally, protective wear focused primarily on structural anthropometry which measures the length of bones between joint centres, with the person measured standing, as opposed to functional anthropometry which records measurements when the body is in motion or engaged in a physical activity (Hedge, 2011:1). Functional anthropometry is deemed to be a more relevant method for designing protective wear. The

latter should be designed and manufactured for a particular purpose because it is mainly used in an outdoor environment where there is ample body movement. This measuring method lends itself to the use of the 3D Body Scanner that provides a greater body measuring range. This will be needed because construction work involves a lot of movements, therefore, during design and manufacturing stages, consideration should be given to the types of work postures or positions required by the job, such as bending over, lifting heavy equipment and looking overhead. Consideration should not only be given to working in the working environment, but focus on the differences in body structure of the user too.

Human beings differ in their anthropometric characteristics, especially with respect to the bodily features of males and females. There are remarkable gender differences between males and females genetically and physiologically (see Figure 2.1). An average male is taller and heavier than an average female. His broad shoulders carry weight on the upper torso and males are over 30% stronger than females, especially in the upper body (Pheasant, 1996). As Grieve and Pheasant (1982 cited in Bridger, 2003:60) argue that “if we take the smallest female and the tallest male in the population, the male will be 30-40% heavier and 500% stronger” – the situation is compounded further in the Southern African region due to the heterogeneous nature of the local population on account of racial diversity and racial admixture. As illustrated in Figure 2.1 the male vertebral column goes straight at the back to the floor. Females, on the other hand, have wider hips than males and their upper torso is smaller than the male torso. Females carry their weight on the lower body and their tail bone curves out to the back. Consequently, body measurements differ significantly when constructing a foundation pattern block.

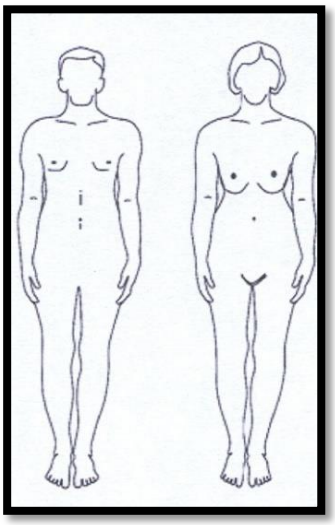


Figure 2.2: Comparative illustration for typical male and female body morphology (Source: http://www.hindawi.com)

Differences in body structure among women must also be considered, because two women can be of the same torso height but differ greatly in other respects. 3D anthropometric measurements will be taken in order to identify the differences in shape between women of different sizes and body proportions. To accomplish this, the researcher has used a Three Dimensional (3D) Body Scanner (see Figure 2.3) (this will be discussed and explained in detail in the Research Methodology section).

The use of 3D Body Scanner hopefully eliminates the possibility of fit problems. Because of its power of about 15 amps (one outlet) the measuring process runs quicker than the manual measuring method and allows for scan views from four different angles and four varying heights. This measuring technology helps to eliminate the concerns about the shape, size and feel of the garment. The use of a body scanner has been supported by Ashdown (2002, cited in Strydom and de Klerk, 2006:82) when highlighting that the development of the 3D Body Scanner has opened up new possibilities for measurement and analysis of the human body. The space inside the body scanning device of about 1.14 metres by 1.68 metres (3.75 feet by 5.5 feet) allows for movement during the body measurement sessions (see Figure 2.3).

After having collected the anthropometric data, there are garment construction processes that must take place in preparation for the development of a prototype. As defined by Aldrich (2008:5), “a garment sample that is made up so that the designer can check and refine both the pattern and the construction of the garment” will be developed in order to test the practicality of the garment while its wearer is performing certain tasks. The garment construction process comprises of the following:

- Body measurements / anthropometric data collection – data collected in preparation for garment construction process. There are two methods that can be used, the manual tape measuring method and body scanning which is a three-dimensional measurement system.
- Design of the intended garment – this is the identifying characteristics of a garment that differentiate it from other garments of the same style.
- Detailed technical drawing – this is a line drawing of garments, drawn to scale using simple clear lines with no exaggeration of detail, and is always drawn from an illustration to make it easy for a pattern maker to read.
- Foundation block draft – “foundation pattern constructed to fit an average figure” (Aldrich, 2011:15).

- Pattern making (rough to final pattern) – “is the drawing of vertical and lateral lines onto paper or card, of certain dimensions taken on a human figure (or from sizing charts) of average figure dimensions” (Defty 1998:6).
- Development of a prototype – after the pattern making process, a garment sample gets made up so that the designer can check and refine both the pattern and the construction of the garment. This is done in order to verify whether the pattern is done properly or not.

A prototype will be constructed from the anthropometric data gathered. It will also be used to ascertain whether the dimensions are accurate, as fit is one of the important characteristics for good garments. Yu (2004:3) indicates in his study that “clothing fit has long been regarded as the single most important element to customers in clothing appearance and that the definitions of fit vary from time to time, and depend on the fashion culture and industrial norm”. A prototype will be developed based on the data collected, in order to ascertain/test the functionality of the product. The American Architect Louis Sullivan (cited in Pheasant, 1996:9) coined the slogan “form follows function” – this suggests an emphasis on functional design. Sullivan (ibid) argued that functional considerations are sufficient to determine the form of an object. With reference to his slogan “form follows function”; protective wear should be made specifically for the targeted gender because of the differences in form. The question regarding protective wear is “whether women in construction are aware of the fact that the clothing they wear was meant for the opposite gender”, or did they simply adapt to what was at hand? This has been addressed in the interview sessions that have been done with female construction workers

Figure 2.3: 3D Body Scanning Machine [TC] ² (Source: http://www.tc^2.com)

2.1 PRACTICAL CONCERNS AROUND PROTECTIVE WEAR CURRENTLY OFFERED IN THE MARKET

As previously argued in the introduction section, women used to be less interested in the construction field; as a result less attention was paid to the production of protective wear suitable for women. However, currently women are developing an interest in the construction field and are left with no choice but to wear small-sized and uncomfortable men's garments that are not suitable for their physique. Design aspects, such as the degree of protection and human needs (fit and comfort while on the job, including work postures) are in question as to whether they are taken into consideration in order to produce women's protective wear. Openshaw (2006:3) argues that an optimal product fit for use in diverse environments could result in "more comfort, higher productivity, and less stress". It is questionable whether the design of protective clothing currently on the market takes into consideration the degree of protection needed and other human needs. This state of affairs is not only evident in clothing but in personal protective equipment (PPE) as well.

The ergonomic design process that includes the selection of materials, size and fit determination, pattern making, garment assembly and finishing has to be considered for effective functional wear. Outer wear, particularly overalls, coveralls and jumpsuits, are commonly worn in all kinds of jobs, especially in the world of construction, but they are rarely made to suit women. The issue of ill-fitting protective wear for women is not only evident in outerwear (all-over protection); similar concerns can be raised with regard to all PPE. Improperly fitting work wear can lead to difficulty in doing the job well and will result in less efficient work. Sugerman and Jenkins, (1999:1) highlighted similar issues of fit problems with work gloves and further state that the attitude of one-size-fits-all should not be applied to the development of protective wear. This is because the safety of workers and their ability to work efficiently is of paramount importance.

2.2 CHALLENGES FACED BY WOMEN IN THE CONSTRUCTION INDUSTRY

This section of the research will unpack the challenges that are faced by women working in the construction industry. The areas that will be focused on involve the ergonomics/human factors, which are a significant part of the working conditions. Occupational health and safety will be discussed in detail. The key areas about body structural differences have to be considered during the design process in order to achieve well-fitting garments. This section of the research will also unpack these psychological and physiological considerations in detail, covering the importance of garment fit, comfort and durability in protective wear.

2.2.1 Ergonomics/Human Factors

Ergonomics is described by Pheasant (1996:4) as “the science of work: of the people who do it and the ways in which it is done, the tools and equipment they use, the places they work in, and the psychosocial aspects of the working situation”. Dress code has to be suitable for workplace conditions, job demands and weather conditions. The internal and external stimuli such as extreme cold, heat, rain, sand and snow are the key areas that must be taken into consideration in the process including the ease of use, dressing and removal. Additionally, Gupta (2011:328) argues that “ergonomic considerations dictate that the mechanical characteristics of clothing match the motion, degree of freedom and movement of human joints”. The areas where blood vessels lie are more sensitive to pressure; therefore, consideration has to be given to this fact as disregard can lead to the wearer experiencing unpleasant sensations such as rubbing, pressure development and restriction of movement.

Consideration as to whether products/garments are ergonomically designed must be given at the beginning stage of design and before the production stage. According to Pheasant (1996:8) the term “ergonomically designed” seems to be misused in the marketing stage of products, which can mislead the product end-user. This study adopts a more rigorous stance in applying the term. The terms *human factor* and *ergonomics* are often used synonymously, with human factors applying principles of psychology to designing products and creating environments that boost productivity while minimising safety issues.

2.2.1.1 Anthropometry

As defined by Pheasant (1996:6), “anthropometry is the branch of the human sciences that deals with body measurements, particularly with measurements of body size, shape, strength and working capacity”. Pheasant (ibid) further argues that anthropometrics is a very important branch of ergonomics. For the ergonomic considerations, using 3D Body Scanner to take the necessary measurements of the female construction workers will help in the process of anthropometric data collection because of its accuracy and that it is time consuming. For the accuracy of body measurements, standard anthropometric postures must be maintained. This is echoed by Pheasant (ibid) in stating that “in the *standard standing posture*, the subject stands erect, pulling himself up to his full height and looking straight ahead, with his shoulders relaxed and his arms loosely by his sides”.

2.2.2 Occupational safety and health

Safety at work is one of the key focus areas, especially in the construction industry. Background studies indicate that safety in construction is one of the barriers to women joining the industry, and very little information has been collected on the health and safety concerns of women construction workers. With reference to a study by Sugerman and Jenkins (1999:1), women's health and safety is identified as a growing concern as the number of women joining the trade increases. The issue of inadequate physical protection, work environment and the fact that women make up a small fraction of the workforce are factors that add to women's concerns about the construction industry. This concern is echoed by Hermanus (2007:531) in his observation that "occupational injuries and ill-health have huge social and economic implications for individuals, their families and their communities".

Although health and safety are not the primary focus of this study, such background will benefit the design process of ergonomically designed protective wear and will help in the elimination of psychological factors, namely, gender and sexual harassment and physiological factors that affect women. This state of affairs was also proven by the data collected through interviews with female construction workers where some women agreed that they receive comments from their male colleagues about the way they dress (See table 5.2 on page 50 of the thesis). As for the mental health of female construction workers, background interviews with construction field workers have shown that female construction workers suffer from gender and sexual harassment by their male colleagues.

2.2.3 Psychosocial Factors
2.2.3.1. Gender and sexual harassment

As previously argued in Chapter One, the construction industry was male dominated because of the nature of the job that requires a strong physique, as a result women are still a minority in the construction trade. Consequently, women are faced with health and safety hazards inclusive of sexual harassment. "Sexual harassment in the workplace is not only an equal employment opportunity issue, but it is also increasingly recognised as a health and safety issue" (http://www.osha.gov). This could be prompted by the way women appear in their ill-fitting outfits. As was previously mentioned, women have a different physique from that of men; therefore, men's clothing does not provide space to accommodate women's hip areas, buttocks and bust (refer to data illustrated in Table 5.2). As a result, men's pants on women could be tighter around the waist and seat as are the tops around the bust areas, leading to sexual harassment that violates laws prohibiting sexual harassment in the workplace. Additionally, the high incidence of steatopygia only

exacerbates the situation. Sexual harassment could also be as a result of the history of the construction field, where women were not necessarily employed in the construction industry. Consequently, protective clothing and equipment are among the most important factors that should be given consideration in the construction industry, as the worker's safety and well-being also depend on them.

2.2.4 Physiological Factors

2.2.4.1 Structural differences of the body and sizing (Applied anthropometric data)

Protective wear designed for a man's body does not fit a woman's body comfortably. Considerations about different body dimensions and stature do not only apply when comparing men with women; they apply when comparing different body types among men as well. Differences in body structure/shapes among women (*inter alia* "hour glass", "spoon" and "pear" shape) must be factored into design criteria for women's protective wear (see Figure 2.3 below). As a result of the different body shapes among women, a different approach is essential with regard to selecting the best style of clothes to wear. This factor should not be treated in isolation when designing protective wear as it affects garment comfort. Therefore, taking into consideration the changing migration patterns in which people from different ethnic groups have to be employed in the construction industry, a garment that fits one person well is not necessarily a good fit for another person. Bridger (2003:79) also noted the myriad problems associated with fit "found to be more common in the extreme quartiles" due to heterogeneity, morphological diversity and complexity associated with migrant labour – this single fact limits the usefulness of specific data in most national anthropometric databases.

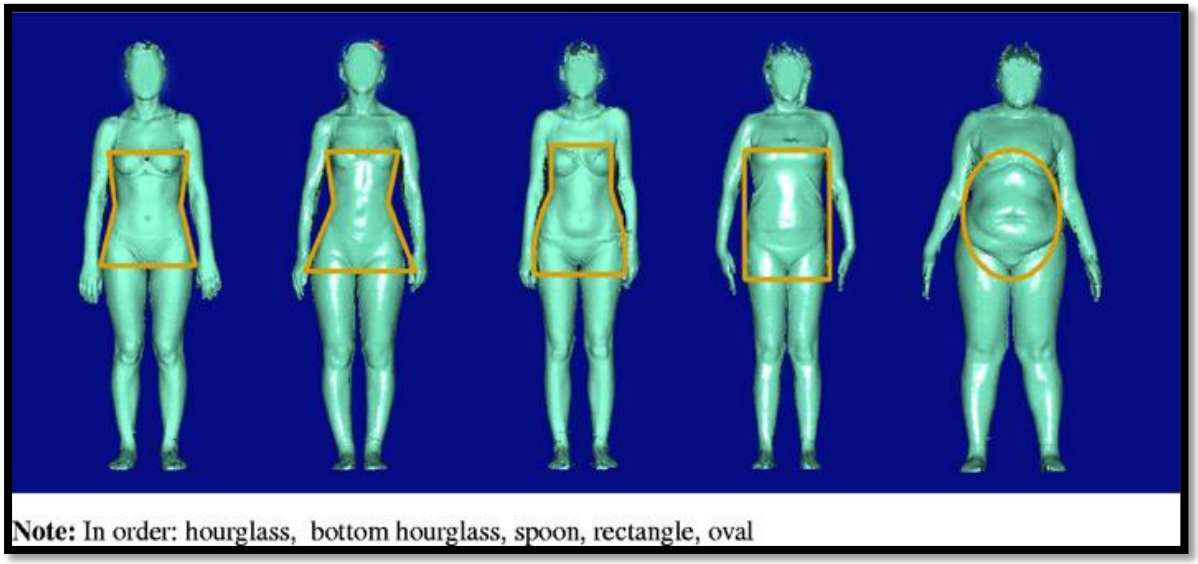


Figure 2.4: Different female body shapes (Source: http://www.translife.com)

2.2.4.2 Body (Morphological) forms

As discussed earlier, body shapes such as gynaeoid body type in Figure 2.4 and proportions vary from person to person; one person can be long-legged and short in the torso, while another can be the opposite. A gynaeoid body is defined as a body with curvaceous hips with a tapered small waist, small to medium shoulders and the chest/breasts vary in size with the hips and thighs curving outwards and weight gain occurs only below the waistline" www.detoxtransforms.com, 2014). An oversight that is sometimes made is to assume that people's dimensions are the same, and that is noticeable in the protective clothing worn by women currently, hence the research. Pheasant (1996:10) indicated that "people come in various shapes and sizes, therefore body structural differences must be given attention at the design stage". Protective clothing should, therefore, be designed and made for the targeted gender, and anthropometric data should be collected accordingly.

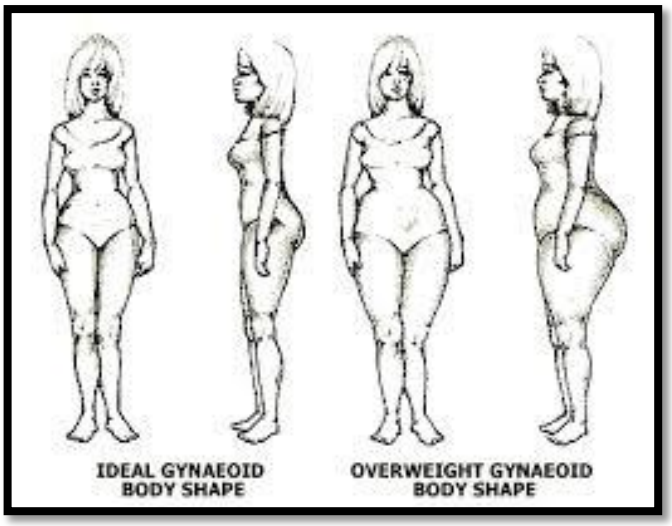


Figure 2.5: Image of gynaeoid body shape (Source: www.detoxtransforms.com, 2014)

As a result of the significant increase in women joining the construction industry, it is of importance that size charts used are accommodative of differences in body shapes and proportions between men and women. Consequently, functional and end-user considerations are essential in protective wear design. Due to the nature of the job, female workers use portable toilets, sometimes sharing them with males. In such a toilet, there is limited space for movement, and it becomes necessary to remove some of the protective equipment, such as gloves and belts, which may be uncomfortable for women. Subsequently, protective wear should be made functional to accommodate such issues and be considerate towards women's body image. To this end, two-piece garments instead of overall garments would be preferable for women to wear, so as to safeguard ease of comfort and functionality in order to maintain their body image and dignity.

2.3 IMPORTANCE OF GARMENT PROPERTIES

Regardless of the job type, working in construction sites or in manufacturing plants calls for protective wear that should be designed to embrace comfort, protection, and durability and should allow the employee to execute her tasks effectively. Textile and clothing designers create fabrics and garments that are both beautiful and functional. Protective wear requires a lot of considerations with regard to the use of materials; consequently, as a clothing designer, it is important to have the intended customer/end-user in mind.

There are various theories that argue why people wear clothing, one being that of *protection,* which argues that man originally clothed himself in order to protect the body against the weather – heat, cold and rain. With that said, protection of the body against weather through clothing requires that a garment comprise good garment properties which will enable the wearer to regard the garment as comfortable. Garment properties, specifically garment fit, durability and comfort, are essential in the production of protective wear as they play a vital role in the performance of the garment.

2.3.1 Fabric selection

Good garment performance is not possible without good quality fabric. As argued by Aldrich (2008:5), the aesthetic qualities of a fabric are often the inspiration that initiates the design. Fabric selection plays a vital role in achieving good garment properties, and that entails a thorough understanding of the influence of fibre properties on the performance of the end product. Aldrich further argues that, in creating a new shape, a designer has to consider five crucial fabric qualities that could realise or destroy the garment. These are weight, thickness, shear, drape and stretch. Compromise on the said garment properties may affect the worker's efficiency on the job and may lead to downtime due to occupational issues of comfort, protection and garment fit problems.

For the development of a prototype, a cotton blend fabric has been considered the fabric of choice, primarily because cotton is known to give a better performance as far as the comfort requirements of fabrics are concerned. Furthermore, cotton fabrics have good properties that qualify to be a good choice for protective wear garments i.e. dyeability and washability. Raj and Sreenivasan (2009:29) state that "after experimenting with synthetics for over four decades there is a general agreement that there is no comparison with cotton as far as comfort is concerned, although better durability and aesthetic look might be achievable in the synthetics''.

As mentioned in section 2.2.1, functional protective wear should be designed with the end-user in mind, therefore, the ergonomic design process that includes the selection of

materials, size and fit determination, pattern making, garment assembly and finishing has to be considered for effective functional wear, hence the use of cotton fabric. As defined by Aldrich (2008:5), the “comfort of cotton originates from the fact that it is a natural fibre. Natural fibres come from vegetable, animal, and mineral plants” (Elsasser, 2007:14). Cotton has a good strength fibre and is also known for its abrasion resistance; therefore it is more ideal to be used in protective wear, as the nature of the job requires a lot of movement that involves lifting heavy materials, pushing and pulling, bending arms, bending, squatting and stretching. Therefore comfort in the worker’s attire is crucial in order to maintain work efficiency. Comfort on a garment cannot be possible without making sure that a garment qualifies to be regarded as a good fitting garment and the choice of fabric influences the fit of the garment.

2.3.2 Garment fit

Fit is one of the subjective factors that are of importance to the product end-user, and affected by the aesthetic behaviour of the fabric such as softness, handle and drape. According to Cain (cited by Yu, 2004:32) “fit is directly related to the anatomy of the human body and most of the fitting problems are created by the bulges of the human body”. Often people use garment fit as a means of evaluating the quality of the garment. This fact has to be considered in protective wear as well, as garments should be designed and made for a purpose and with strong durability in mind. Garment fit is the most important aspect in ensuring the comfort of a garment, because the body, and the way it is clothed and presented, is a primary medium of self-expression. As shown in figure 2.4, some women wear tight denim jeans while on the job and jeans are the difficult-to-use products that are, in general, unsafe and ineffective in the construction industry due to the nature of the job.

Since clothing in general is designed with a range of body proportions in mind, it may fit a large number of people, but it may not always be flattering (Strydom & de Klerk, 2006). The mis-fit of male protective wear on a woman’s body gives rise to the issue of women’s negative body image. The ultimate success of any fit and sizing system sits within the accuracy of body measurements. Therefore, a 3D body scanner has been used for body measurements. This is in view of the fact that body image is how we perceive our appearance and is very important to all people; everyone wants to maintain the same image, regardless of the position held or type of work performed. De Jonge (cited by Black & Cloud, 2008:36) proposed a process for the development of functional occupational clothing that places emphasis on identifying user needs, and focusing more on fit, fabric properties and comfort. According to Obrigkeit (2009:9), women want clothes that fit them, as a better fit means more comfort on the job-sites and mobility while performing one’s tasks.

A study by Ontario's Women's Directorate (2006:2) indicated that "Ill-fitting protective clothing and equipment can also mean that women entering certain 'non-traditional' fields will be unable to perform the given task efficiently". Ill-fitting garments do not provide sufficient protection. For instance, if a female worker wears small men's sized gloves, the fingers are too wide and long, and the palm area too large, therefore, the chance of getting the fingers caught in machinery is high.

Furthermore, badly fitting clothing can also affect perceptions of body image that is of high concern to most people. Grogan (2008:1) argues that there has been a significant increase in the psychology of body image. He further highlighted that body image is not just a perceptual construct, but also a reflection of attitudes and interactions with others. Being comfortable at work is key, and while protective clothing (PC) may help save lives, the use of comfortable and good fitting PC allows people to work in and around hostile environments and at the same time accomplish useful tasks. This research aims to determine the degree of comfort and protection provided to women when wearing protective wear designed for men and how useful it is in the working environment.

2.3.3 Durability and Aesthetics

According to Fan (2004) "clothing durability and aesthetics are the most important aspects of clothing quality, but what is appealing to one person may not necessarily be appealing to the next person". This was also supported by the study conducted by Okur (Ibid) by pointing out that, according to the conducted surveys, garment fit and comfort were viewed to be of importance when making purchasing decisions (Okur, 2007). At the same time, however, Fan (2004:1) notes that, in order to design garments to present the best image of the wearer, it is necessary to understand the perceptions of body attractiveness and body image as well as how the perception of body appearance can be modified through clothing.

Generally, clothes are the first impression people give of themselves. This remains a challenge in the female protective manufacturing industry, as females in construction were never as popular as they are at present and with no female protective wear option this is difficult. Harcourt (2011) argues in her research that the way we feel about our bodies can impact on all aspects of our lives. Therefore, it is important that protective wear designed and manufactured is made according to women's physique so that they can feel good about themselves. There are different garment functional and aesthetic performance characteristics that influence the design and buying choices for clothing. Functional protective wear should provide the user with functional performance characteristics that are

involved with the use and durability of the garment. Furthermore, the garment should be suitable for different purposes, without losing the garment structure and appearance.

2.3.4 Clothing comfort

Physiological and psychological are the key factors that affect the comfort of a garment. As defined by Raj and Sreenivasan (2009), clothing comfort is a pleasant state arising out of psychological, physiological and physical harmony between a human being and the environment. The literature generally classifies clothing comfort into three broad categories, namely, aesthetic comfort, thermo-physiological comfort, and tactile comfort. Aesthetic appeal or psychological comfort is mainly based on subjective feelings and fashion trends that influence customer preferences. On the other hand, thermo-physiological comfort relates to the ability of the fabric to maintain thermal equilibrium between the human body and the environment. Thermal, moisture and air resistance properties of the clothing material collectively contribute to the state of the thermo-physiological comfort of the wearer.

The tactile comfort relates to mechanical interaction between the clothing material and the human body and is an intrinsic and essential performance requirement in clothing. Comfort in protective wear is vital because comfortable garments give the user an assurance that the product is safe and effective; however, uncomfortable clothing can impede motion or alter strategies for the accomplishment of the physical task. Generally, most consumers regard clothing comfort as one of the universal requirements to qualify a clothing piece as good clothing or not.

Style is not regarded as a safety feature, but a range of styles can encourage young male and female workers to be keen on joining the construction industry, especially the younger fashion-conscious generation. With reference to a study by Smith (1991:1), comfort is referred to as becoming increasingly important to users of safety clothing, and style is becoming one of the important features of protective wear. Although the research focus is on functional design rather than fashion design, as fashion is subject to constant change, different styles of protective wear will be considered in order for female protective wear to be feminine and more flattering to women. At the design stage, an ergonomic approach is used, where all relevant critical needs are considered: ease of use, types of work postures or positions that are required by the job, and health and safety issues.

2.4 SUMMARY

In construction, the degree of the garment fit and being comfortable at work can be strong contributing factors to business success – the way you dress for work, affects the way you perform. Clothing by its very nature has a restrictive effect on body movement, therefore, the design and manufacturing processes of protective wear have to consider ease of use, when putting on and taking off of the garments. Because of the unique morphological features associated with steatopygia, there are many areas that require consideration in the development of protective wear that is specifically designed for women.

Areas that involve the psychosocial factors, such as gender and sexual harassment, structural differences of the body, and sizing and body (morphological) forms are the key factors. Clothing production is not possible without taking note of garment properties that include garment fit, durability and clothing comfort, as they affect the appeal and the performance of the end product. These factors play an important role in protective wear, as protective wear users engage in everyday tasks that involve a lot of movement; therefore, the comfort of a garment cannot be possible without a good choice of fabric. Fabric choice influences the final product; therefore, it is essential that prototypes are constructed using the exact same materials which will provide a true sense of the garment performance.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.0 INTRODUCTION

This research has two components, namely, a theoretical component and, secondly, a practical component. The theoretical component investigates mainly the research problem, through the earlier discussed research questions, and its related research areas in-depth. Therefore it also defines the parameters that should guide the design and development process of the practical design. With the utilisation of the findings the design intervention is executed in the form of ergonomically designed protective wear for women in construction.

A research design is a plan or blueprint (Mouton, 2001:55) or structured framework (Babbie & Mouton, 2001:105) of how the researcher intends conducting the research process in order to solve the research problem. The research design also helps in answering the questions posed in the research, achieve the research goal and objectives, and also to prove whether a formulated hypothesis is correct or not.

The research design used to address questions posed in this research describes the methodology employed in achieving the data outlined in Table 3.1. It also provides a description of the sources of data and the methods used in collecting the required data. The research process provides insight into “how” the research is conducted from developing the proposal to submitting the thesis (Remenyi, Williams, Money & Swart, 2002:64-65).

An investigation was conducted by visiting the construction sites, manufactures and suppliers of protective wear. The on-site observations are used in order for the researcher to gather direct views from the subjects and also help gather commentary as it happens, as well as observe the practicality and comfort of the garments worn by women in construction. By conducting site visits the researcher wishes to gain an opportunity to hear female employees speak freely in their own language. During site visits to manufacturing sites, documentation through note transcripts and voice recording has been prepared.

The wearer satisfaction on components of the protective wear currently worn by women has been observed. Blaikie (cited in Flowers, 2006), defines “ontology as the science or study of being and develops this description for the social sciences to encompass claims about what exists, what it looks like, what units make it up and how these units interact with each other”. Blaikie (ibid) further describes [ontology] as “the view of whether claims have, or assumptions on the nature of reality, and specifically, is an objective reality that really exists or only a subjective reality created in one’s mind”. The ontological standpoint adopted in this

study is informed by current protective wear worn by women that performs in the outdoor context of the construction industry, how it affects the body image and how it contributes to their productivity at work. The data has been collected from protective wear manufacturers in order to gain an insight into the availability of protective that is ergonomically designed to suit women's physique. Research design is a plan and framework designed for the collection, analysis and identification of data to answer the research questions.

3.1 SAMPLING METHODOLOGY

3.1.1 Sampling

Babbie and Mouton (2001:164) define sampling as "the process of selecting observations". Additionally, a sample is described by Babbie and Mouton (2001:202) as "a special subset of a population observed in order to make suggestions about the nature of the population itself". The sampling process determines what to observe and not to observe during a research study. It is important to specify how a particular sample was selected from the population of study.

There are two forms of sampling: probability random sampling and non-probability sampling. Babbie and Mouton (2001:173) view probability samples as more representative of the samples from which they are drawn than non-probability samples. Conclusions drawn from probability samples are likely to be the same for other samples that were not selected. This is a basic principle of probability sampling. The second principle of probability sampling is that "the probability sampling theory permits us to estimate the accuracy or representativeness of the sample". The theory of probability sampling will then be applied to the method of probability sampling selected.

Both sampling approaches have various methods, for example, probability sampling methods are: simple random sampling; systematic sampling; stratified random sampling and cluster random sampling (Babbie & Mouton, 2001:202). The methods of non-probabilistic sampling are: reliance on available subjects, purposive or judgemental sampling, snowball sampling and quota sampling (Babbie & Mouton, 2001:166).

3.1.2 The approach used in sample selection

For the purposes of this study, the preceding terms as well as actor, collaborator, interviewee, respondent, and the observed are represented by the single term *subjects* as "used to identify the individuals that a researcher studies" (Schwandt, 2001:126). Given that the study focus area is specifically about women working in the construction field, this study has a specific target population. The population in this study refers to the subjects with

specific characteristics that consist of the total collection of individuals on which the study is carried out (Welman, Kruger & Mitchel, 2008:54).

According to Babbie and Mouton (2001:12) “a sample will be representative of the population from which it is selected if the aggregate characteristics of the sample closely approximate those same aggregate characteristics in the population”. However, it must be expected as well that the chosen sample might not perfectly represent all the characteristics of a bigger population. Given the fact that the study has a target focus, participants are those that work in the construction sites, so that they can share their perception about the fit and availability of protective wear.

A sample selected comprises of randomly selected women that are employed in the construction field and are based in Cape Town, South Africa. Furthermore, randomly selected protective wear manufacturers were approached. Two protective wear manufacturing companies were approached in request of their permission to participate in the study. One of the manufacturers was a local company that is based in Cape Town, South Africa. Protective wear is supplied from across RSA; therefore, a request for participation was extended to a supplier from Durban, South Africa, without neglecting the fact that the study is locally based. The intent was to obtain data from a manufacturer that is located in a different province.

The targeted viewpoints from the manufacturing side, was that of the design and production managers as they play an influential role in the design and manufacturing of protective wear. Both protective wear manufacturers willingly offered participation due to the fact that they are in agreement that there is a need for a study of this nature because of extensive growth in women joining the construction industry. All parties that are participating in the study have different roles to play for the success of the study. The information gathered from the female construction workers will contribute to the research study because it will provide an insight into their state of mind about the current protective wear. The information gathered from the protective wear manufacturers will contribute to the design of protective wear for women.

3.1.3 Anticipated role of female construction workers in the study

Subjects participated in the study following research instruments listed below, with an aim of answering the research questions and furthermore validate the assumptions of the study:

- Focus groups
- Individual Interviews
- Questionnaires
- Anthropometric data collection – Body measurements

3.1.4 Anticipated role of protective wear manufacturers in the study

The aim of involving the manufacturers was to gather information about the design of the current protective wear using the following research instruments:

- Individual interviews – unstructured interviews were between the researcher and the local protective wear manufacturer and are documented.
- Questionnaires – these were issued to both protective wear manufacturers (Cape Town and Durban based).

3.1.5 Selection of subjects

As mentioned in Figure 3.2, a sample of 25 female subjects has been selected from the construction field with an aim of gathering information on psychological and physiological issues regarding the current protective wear. The selected subjects participated during the interview sessions (individual interviews and focus groups), the questionnaire process as well as in anthropometric data sessions. Subjects are in the range of 50th percentile with relatively the same height and weight. Considering the South African labour law, where children under the age of 18 are not allowed to take part in the labour force, age restriction is considered in the selection of female construction subjects.

During the anthropometric data collection process, pregnant women were not considered for participation, as their body measurements would distort the morphological norm. In this study a high degree of privacy was of importance during the data collection to ensure comfort for the participants taking part. Women who participated in the focus group, in-depth interviews and fit sessions were randomly selected on their willingness to participate further in the study. The involvement of the researcher in the anthropometric data process is mainly to record data and not to participate (see the anthropometric data collection sheet in Appendix I).

3.1.6 Description of research methods

The goal of this study is to investigate the availability of protective wear that is ergonomically designed to suit women's physique. Table 3.1 below illustrates the research questions that the study will attempt to answer, the objectives, the methodology and the literature that will be used to answer the stipulated questions. The research methods employed included an investigation of individual and collective views and perceptions of the research problem tackled in this research.

Table 3.1: Research question, sub-questions and objectives (Author's construct, 2012.)

Research problem	Women's structural differences from those of men are not accommodated by the designs and fit of the available protective wear.	
Research question	Why do design and fit of available protective wear not adequately accommodate women when performing outdoor activities within the construction industry?	
Research sub-questions	**Research method(s)**	**Objectives**
What is the current situation with respect to available women's protective wear in the Cape Town construction industry?	• On site observations • Interviews • Questionnaires	Investigate the availability of protective wear that is specifically designed to suit women's physique. Identify the possible limitations in the product offering of protective wear for female construction workers.
Why do the current designs and fit in the available protective wear not adequately accommodate women in the construction industry?	• Literature review • Protective wear manufacturer and supplier visits • Interviews • Focus group	Investigate the practicality and usability of available protective wear designs, their construction, and how suitable the fit is for women.
How can relevant ergonomic considerations better inform the design of feminine and more appropriate protective wear for women?	• Interviews • Focus group • Anthropometric data collection through body measurements	
	• Development of a prototype • Fitting Trials • Videography Establish the viability and practicality of designing and manufacturing protective wear that is suitable, comfortable and fit for purpose with respect to women's physique.	

In order for the above-mentioned goal and objectives to be achieved, the manner in which the research has been conducted is outlined. The design and the methodology to be pursued during the research will assist in answering the research questions outlined above.

The research problem revolves around the designs and fit of the available protective wear that does not adequately accommodate women when performing outdoor activities within the construction industry. As argued in Table 3.1, this research study seeks to investigate the

availability of women's protective wear that is designed to suit women's physique. It also aims to investigate the practicality of the current protective wear designs, construction and fit suitable for women. Therefore an investigation has been done using a qualitative research methodology in order to identify different approaches for collecting and analysing data to answer the research question.

Remenyi, Money and Twite (1995:65) explain that the qualitative research consists of specific phases, which can be applied to a research study. These phases include reviewing the literature, with the aim of finding out what the most widely accepted findings in the field of study are. This was echoed by Wilson (2009) stating that "an inductive approach to gathering, analysing and reporting information seek[s] out the 'why', not the 'how' of its topic through the analysis of unstructured information – for example, interview transcripts, open-ended survey responses, emails, notes, feedback forms, photos and videos". A model of data collection (Table 3.2) outlines how the qualitative methods have been used in order to discover the underlying meanings.

Table 3.2: A model of data collection, (Author's construct, 2013).

Tools and methods used for data collection	**Data analysed by these methods**	**Relevance or use of data analysis methods**	**Subjects/Informants**
a) Literature Review	Theoretical discourse	Familiarising with the construction industry and the design of protective wear	Books and journals
➢ Contextual analysis	Qualitative analysis	To the conceptualisation of protective wear for women	Books, journals and internet
Fieldwork research			
b) Questionnaires in Cape Town, South Africa	Content analysis	Grouping and categorising of data to establish levels of awareness/knowledge about the current protective wear	25 Female construction workers (different age groups) and 2 protective wear manufacturers
➢ One focus group in Cape Town	Conversation	Categorising data and establishing levels of awareness/knowledge about the current protective wear	25 Female construction workers, different age groups.
c) Interviews	Conversation analysis	Establishing the need for protective wear that is ergonomically designed to suit women	Protective wear manufacturers and female construction workers

3.1.6.1 Qualitative research and data collection methods

Visits to the construction sites, manufacturers of protective wear, interviews and documentation in the manufacturing sites have been done. Unstructured and semi-structured interviews were conducted with an aim of gaining new knowledge of and new insight into certain unexplored qualitative aspects of the problem. An interview generally started with the few explicit questions and then followed the individual tangent of thoughts with the interviewer. Therefore, unstructured interviews informed structured interviews as well as questionnaires. Additional aims of conducting the interviews with the personal protective clothing (PPC) manufacturers and suppliers were to gather information on the production methods used in the manufacturing process and also to track whether there are female protective wear production lines that are being produced.

An additional data collection instrument was questionnaires, as it falls within the broader definition of “survey research” or “descriptive survey” (Remenyi et al,1995). Questionnaires were developed and distributed to protective wear manufacturers and female construction workers. Questionnaires for manufacturers (see Appendix E) encompassed the issues about the design of the current protective wear. A fixed or closed response type questionnaire was drafted where a subject was asked to check the answers that fit the best and alternative answers were given in a multiple choice type and rank order type of questions. Due to the nature of the research where human beings are involved, it is important that participants are assured about their security, therefore, consent forms were designed and distributed to both manufacturers and female construction workers and both research participants willingly signed the forms (see Appendix D).

3.1.7 Questionnaires

As mentioned above, questionnaires were used as a data collection instrument, as it falls within the broader definition of “survey research” or “descriptive survey” (Remenyi et al, 1995). For the protection of human subjects in research, different consent forms had been prepared and distributed to both manufacturers and female construction workers (see Appendix D). The consent process was informative and empowering, with an aim of giving the subjects the information they need to decide whether to participate or not (participation being completely voluntary). The consent process was conducted in a manner that accommodates non-English speaking participants. Both the researcher and participants granting permission signed the forms.

3.1.8 Administering of questionnaires

The use of questionnaires is a valuable method of collecting a wide range of information from a large number of respondents (Antonius, 2003). As previously argued in Chapter Three, questionnaires were designed with protective wear manufacturers and female construction workers in mind. The objective in designing questionnaires was to investigate the practicality and usability of available protective wear designs, their construction, and how suitable the fit is for women. This was done with a view to establishing the viability and practicality of designing and manufacturing protective wear that is suitable, comfortable and fit for purpose with respect to women's physique.

3.1.8.1 Question types

The questionnaires employed the following types of questions:

- Likert scales
- Closed ended questions
- Open-ended questions

These question types are clearly outlined in Chapter 4.1.3.2.

3.2 QUESTIONNAIRE GROUPING

Questionnaires are structured and questions are grouped into sets determined by the objectives of the research. All questions focused on covering the set research objectives as presented in Table 3.1 of the thesis. Due to the fact that surveys are highly structured, questions were prepared and piloted to ensure they reflected a high degree of "validity". For the reason that there are many role players and interested parties in research of this magnitude, it is important that data is collected from all parties involved to ensure a valid research process.

The designed questionnaires were intended for the following participants:

1. **Questionnaire designed for protective wear manufacturers.** The questionnaire encompassed the issues about design of the current protective wear only in view of the fact that the manufacturers are more involved in the design process and the focal point was that of garment fit. In addition, questionnaires aimed at understanding if the manufacturers acknowledge the need for the design and production of protective wear specifically to suit women's physique.

2. **Questionnaires designed for Female Construction workers.** Two different Questionnaires were designed for Female Construction workers. The intent of using

questionnaires as one of the data collection methods is to investigate the two segments of garment quality satisfaction, namely, garment fit and garment design. Garment fit questionnaires aimed at gathering information on whether female construction workers feel comfortable in wearing work wear that is designed to suit men's physique. Secondly, the garment fit questionnaires allowed users to provide suggestions on how to improve on protective wear. Furthermore, garment design questionnaires aimed at discovering whether the design of the current protective wear is suitable for women's physique and also to gather a solution and suggestions on the future design of protective wear for women.

3.3 INDIVIDUAL INTERVIEWS AND FOCUS GROUPS

The aim of visiting construction sites and protective wear manufacturers was to conduct individual interviews and conduct focus group discussions to gain detailed data directly from a participant. Specifically with protective wear manufacturers, interviews were conducted with an aim of gathering information on the production methods used in the manufacturing process and also to track whether there are ranges of female protective wear production lines that are in place. Semi-structured questions were asked during the meeting with the intent of gaining new knowledge of and new insight into certain unexplored qualitative aspects of the problem. An interview generally started with a few explicit questions and then followed the interviewee's individual course of thoughts.

The focus group survey method is also employed in the study; the guidance of the researcher through the interview sessions is of importance in order to direct the group dynamics and also to engage with in-depth discussion of the problem. The group dynamics determine the direction of the discussion and the ways in which participants respond to the group leader and one another. The interaction between participants is one of the advantages of conducting focus groups, due to the influence of participants' opinions and behaviour, which encouraged the formulation of contributions regarding the research problem.

3.4 ANTHROPOMETRIC DATA COLLECTION

To eliminate the fit problems that affect the comfort of the wearer, proper body measurements are essential. Subsequently, a TC² three-dimensional (3D) Body Scanner that scans the whole body in seconds and speedily produces a 3D body mock-up has been used to collect anthropometric data from female construction workers (see specifications as noted in Chapter 2.0). The software is available in the Clothing Technology Station at Cape Peninsula University of Technology (CPUT), Bellville campus and the permission to utilise it has been granted at no cost. The technology station was established to provide innovation

support to the clothing and textile industry to become more competitive. This would directly provide feedback into the teaching, learning and research at the University of Technology (UoT) by engaging staff and students in its programmes and thus UoTs become responsive to industry needs.

Traditionally, during the anthropometric data collection, the process involves three participants that ensure that the process runs smoothly and that the data is well captured, namely:

- The measurer – a participant who takes care of the measuring process, informing the subjects about what the measuring process entails and making sure that the subjects are clearly aware of the process, and who also manually takes body measurements and ensures that the subjects are comfortable.
- The recorder – a person who records the anthropometric data making sure that body measurements are clearly captured and easy to read.
- Subject – a person being measured.

The body scanning process involves a different group of participants, namely:

- The operator – a participant operating the software, capturing body weight and height and, in the process, informs the subjects about the scanning processes and ensures that the subjects are comfortable.
- Non-participant observer – a person who certifies that the process is fair and that ethics are taken into consideration.
- Subject – a person being scanned.

Regardless of the measuring type method, it is important that all the above-mentioned role players are involved during the measuring process and that the data is captured and stored safely.

3.4.1 TC² three-dimensional (3D) Body Scanner

The 3D automatic body measurement software can extract over 400 unique measurements, many of which can be user customized and are capable of providing the body scan data in multiple formats (see Figure 3.2.1). Strydom and De Klerk (2006:82) substantiated this by stating that, “this measurement technology has the potential to enable researchers to collect and process more accurate anthropometric data than ever before”. The use of the automatic body measurement software is proven to be a good approach because it works faster and is time saving as opposed to taking body measurements manually. Strydom and De Klerk (2006:82) support this statement by highlighting that it is ideal to undertake a survey by

using the Body Scanner because more measurements can be obtained in the same time that a traditional anthropometric survey would take to complete. The fact that the 3D body scanner captures the data more quickly than the traditional manual way, where the measuring body is used, was essential in this study as the participants involved are expected to return to their workstations.

As previously highlighted in the introduction section, the 3D body scan data can be very helpful to understand better the issues related to mobility and restrictions imposed by clothing. The data that was collected through the use of the Body Scanner has been applied in the development of size charts, which has been helpful when basic block patterns are drafted, to enable the sample making process.

Figure 3.1: Interior of the TC^2, 3D Body Scanner (Source: http://www.tc^2.com)

3.4.2 The Body Scanning process

A prototype was produced based on the measurement data extracted from the volunteers, and they will wear the garments as models and give feedback on fit and comfort. Fit trials were also conducted with construction workers and feedback on garment fit and comfort has been captured through interviews and questionnaires. A video of women wearing the sample has been taken in order to capture their movement and simultaneously the evaluation of the degree of comfort will take place. Figure 3.2 below displays the research design, with the

order of the qualitative method that the researcher used when gathering the anthropometric data illustrated in detail.

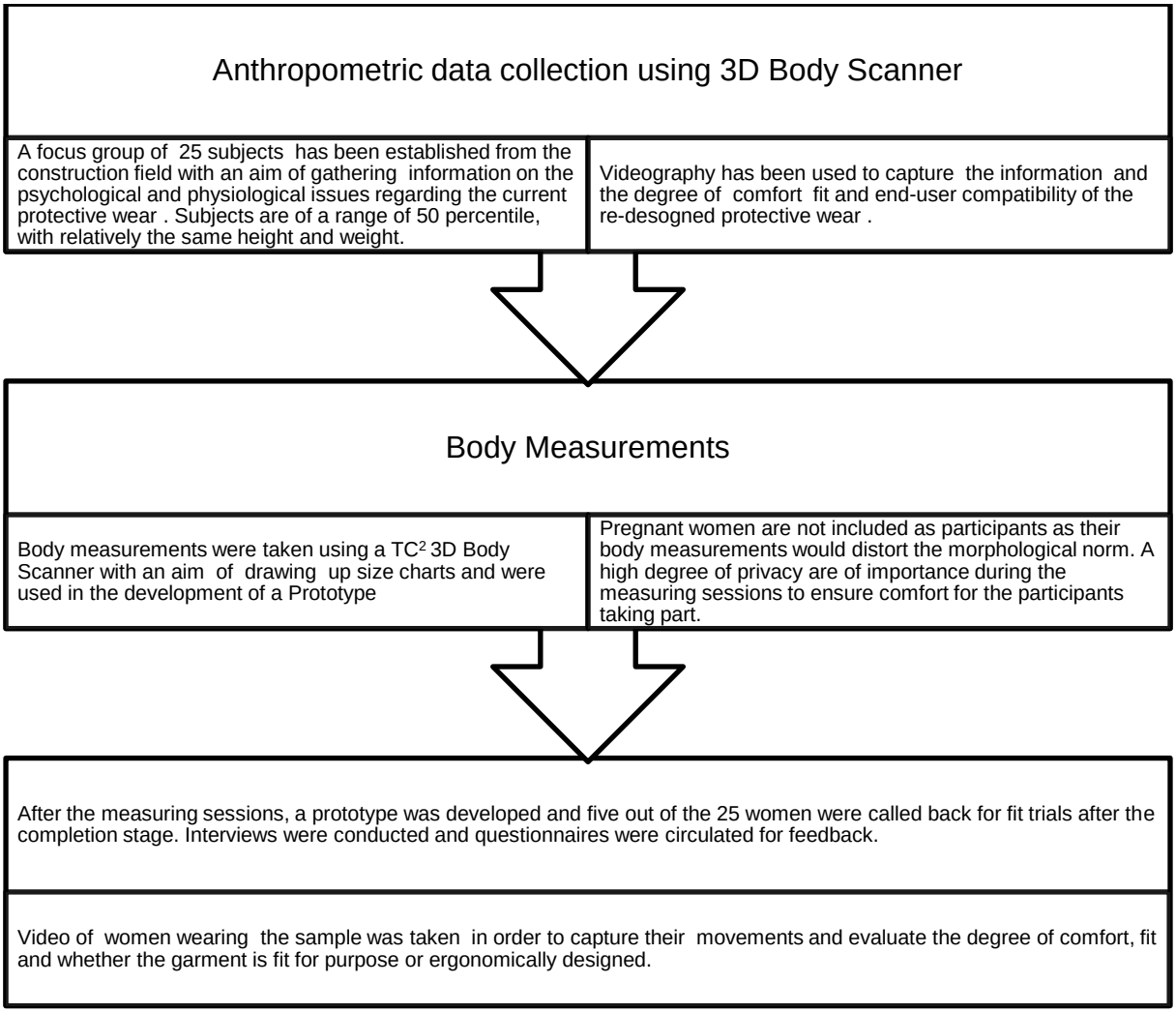


Figure 3.2: Qualitative method for gathering the Anthropometric data (Source: Author's construct, 2012).

3.4.3 Size charts

Fit and function of garments, whether for performance or fashion, is vital, because when not taken into consideration, garments may be uncomfortable. Uncomfortable garments impede the movement of the wearer. It is therefore highly important that accurate sizing methods are used during the clothing pattern making stage. The foundation blocks are based on body measurements/dimensions (manual or electronic) that make it possible to determine dimensions of the garment.

Pattern construction represents the most structured and controlled method of applying dimensions of the garment, and is considered as the first step of the garment. Constructing suitable patterns is not possible without a proper size chart. A size chart is a representation

of the measurements collected during the body measuring stage. Different body dimensions are applied in the construction of block patterns with an aim of drafting clothing patterns. It is very important that different size charts are drafted for each and every garment type, taking note of the targeted population. Studies show that South Africa is using the size charts that are based on the data that was captured in the United States, which could be an influence on sizing problems because of the different body morphology. Therefore it is imperative to establish a more accurate size chart for the planned prototype for PPE.

3.5 ETHICAL CONSIDERATIONS

There are many role players and interested parties in research of this magnitude. It has thus be essential to consider ethical issues relating to each of the participants. These key parties include:

- the participant, or subject – for the purposes of this study, the preceding terms as well as actor, collaborator, interviewee, respondent, and the observed are represented by the single term *subjects* as "used to identify the individuals that a researcher studies" (Schwandt, 2001:126);
- the researcher; and
- the sponsoring body.

Any research must be ethical especially when dealing with personal engagement of subjects involved in the study, whether they are human beings or animals. The following measures were taken to ensure that the study is ethical in relation to the following entities:

3.5.1 Subjects

Female workers are not compelled to participate in the study. A signed consent form was one of the pre-requisites for participation (see Appendix D). Subjects who choose to withdraw from the study and revoke the information they supplied to the investigator are granted their wish without prejudice. Information collected is confidential so as to protect the subjects from any (potential) psychological harm. Information on personal details by subjects was optional and treated with due confidentiality.

Names of the subjects (or their organisations) are not being used in the findings if doing so could harm their reputation or jeopardise their work. Explicit requests are made to subjects to allow their names to be included in this thesis. The subjects are not deceived but are told the truth about the intent of the study. Subjects are not seduced into the research by giving them any incentives to participate in the study. Instead the importance of the study is emphasised to them. After analysis the investigator provided the subjects with the findings so as to clear up any possible misconceptions that may have arisen during the data-collection phase.

3.5.2 Researcher

The researcher commits to being ethical when dealing with the research by taking numerous steps. The investigator endeavoured to ensure that the data collection procedure and interpretation were not biased. Appropriate methodology was used when conducting the study. The researcher ensured that the results of the report are correctly communicated without bias. No information was obtained from the subject in any adverse manner to them.

3.5.3 Sponsoring Organisation

Whereas the primary source of funding for this research study was sought from CPUT, there was no chance of manipulation of the study by the sponsor as this research was not commissioned by, nor conducted for the sponsor – it was initiated at the researcher's prerogative purely for academic purposes. Finally, any unforeseen ethical implications were addressed in consultation with the academic supervisors.

3.6 RESEARCH CONSTRAINTS

The research study is limited to the construction industry in Cape Town, South Africa, and also pertains only to women who are actively engaged in gainful employment in this sector.

3.7 SUMMARY

The aim of this study is to investigate the validity of an assumption that there is lack in the product offering of women's protective wear that is ergonomically designed with good fit and comfortable for women when performing tasks in the outdoor context of the construction industry. The research questions and objectives mentioned in the literature have provided information on data collection strategies. The comparison between the structural anthropometric differences between men and women will be done with an aim of highlighting that their difference in body structure makes it not possible that women dress in men's clothing.

The differences in body structure/shapes among women must be factored into design criteria for female protective wear. The aim of this study was to develop functional protective wear that is suitable for women. The research is based on women's protective wear only, specifically overalls, and is not aimed at disagreeing with the fact that was highlighted by the background studies and preliminary interviews showing that even the current men's protective wear is not ergonomically designed and that fit and comfort is compromised.

CHAPTER FOUR

DATA COLLECTION

4.0 INTRODUCTION

The information that is required in this study is collected through gathering and analysis of primary and secondary data. Babbie and Mouton (2009:76) refer to primary data as the data that will be collected by the researcher and secondary data as the data that already existed when the research began. During the collection of data, the researcher has a degree of control over primary data while s/he has no control over secondary data (ibid). In this study, both primary and secondary data were collected. The use of qualitative techniques helped the researcher analyse data and draw conclusions. The methods used to collect the required primary and secondary data are stipulated below.

4.1 PRIMARY DATA

Primary data as mentioned above refers to the data that is collected by the researcher. In this study, primary data is collected through the use of the following instruments: focus group interviews, questionnaires and anthropometric data. Interviews were conducted through group and individual interview methods. In order for the researcher not to interrupt workers while on the job, group interviews were conducted with construction workers and the individual interviews were possible with manufacturers only.

Interviews and focus groups are typically structured in a manner that clearly defines the aim of investigation, the competence of the researcher. Other factors that are of concern to the researcher are the atmosphere created during a meeting and ethical procedures (see Consent Form provided in Appendix D). As argued by Sapsford and Jupp (1996), conducting focus groups largely relies on group dynamics being understood as either a direct or indirect interaction between members of a given group. The group dynamics determine the direction of the discussion and the ways in which participants respond to the group leader and one another.

4.1.1 Focus group interviews.

The construction company that participated in the focus group interviews is located within Cape Town, South Africa. In preparation for the focus group interviews, the researcher designed a questionnaire/interview schedule to guide the discussions. The researcher also prepared consent forms that were handed out to the subjects (see Appendix D). For the non-English speaking participants, the consent process and forms are provided in the appropriate language and most female construction workers are isiXhosa speaking, which is

also the researcher's home language. Participants willingly signed forms granting permission for their participation.

The prepared open-ended questions guided the discussions in the focus group. The questions posed are open-ended to allow maximum participation from the subjects and gathering as much information as possible. Successively, the interaction between participants is one of the basic advantages of conducting my focus groups due to the mutual influence of participants' opinions and behaviour, which encouraged the participants to engage in a conversation freely and communicate spontaneously. The semi-structured free discussions allowed for the expression of spontaneous and sincere reactions that would have been harder to achieve by way of in-depth personal interviews.

The researcher also requested permission from the participants to record the discussion for later reference. The research participants agreed that the discussion may be recorded and responses were therefore recorded in a notebook through the consent of the participants (this is in possession of the researcher).

4.1.2 Individual interviews

The researcher used semi-structured interviews; the order and ways in which questions were formulated depended on the relation between the researcher and the participant. During individual interviews, I interacted directly with participants in my role as a researcher. At the beginning of the interview, I noticed that participants felt somewhat pressurised, due to the fact that they were interviewed, and that some participants were not English speaking, and that made them feel uncomfortable. Thus, in order to make them feel comfortable, I tried to create a natural and friendly atmosphere. Interviews were conducted in the participants' working space, which also contributed to the comfort levels of the participants.

4.1.2.1 The types of questions used during the individual interviews

The questions used during the interviews consisted of the following:

- Oriented questions, which were usually asked during the initial phase of the interviews or questionnaire in order to familiarise participants with the subject under question.
- Introductory questions, which closely related to the investigated problem in a focused way in order to establish the required details.
- Transitional questions, the asking of which encouraged participants to provide more details.

- Indirect questions, concerned with the respondent's attitude that gave him/her the opportunity to personalise his/her own experience and attitudes indirectly.
- Ending questions, consisting of final statements and conclusions.

4.1.3 Questionnaire

The survey was conducted with 25 women working in the construction field (see questionnaire in Appendix F for garment design and Appendix G for garment fit). Two protective wear manufacturers, one based in Cape Town, South Africa and the second one based in Durban, South Africa were consulted in the study. The researcher visited the local manufacturer in order to have direct contact, and the manufacturer based in Durban was contacted via email.

The study is locally based, but because the supply of protective wear is not locally based only, a request for participation was extended to a supplier that is based in Durban, South Africa. Therefore, questionnaires were distributed to these participants by email. The questions posed in the questionnaire also assisted in acquiring the required information on the achieved results of the research. A copy of the questionnaire is attached as Appendix E.

4.1.3.1 Administering of questionnaires

The researcher designed questionnaires which were circulated to both manufacturers and female construction workers in order for them to decide on whether to participate in the study or not (participation being completely voluntary). The researcher separated and grouped questions into sets determined by objectives. Different sets of questionnaires were designed in order to authenticate the validity of an assumption that there is dearth in the product offering of protective wear gears that suit women's physique. A questionnaire designed for construction workers mainly focuses on two aspects, namely, garment fit and garment design. This was because the researcher wants to gather information about protective wear design separately from that of garment fit. In order to avoid making any suggestions to the participants, my questions were open-ended, to which the respondent supplied his or her own answer without being constrained by a fixed set of possible responses.

4.1.3.2 Question types

Both the questionnaire about garment fit and the one about garment design employed the following type of questions:

- Scaled questions, responses were rated from a scale of 1-5, with 1 indicating "not important at all"; 2 "somewhat not important"; 3 "neither important nor comfortable"; 4 "somewhat comfortable" and 5 "very important". This will provide a greater

understanding of the challenges faced by women in construction as far as their protective wear is concerned.

- Coded questions, responses were coded in such a way that participants could identify the areas of a garment that require improvement. Codes were from 1-8, 1 “bust area”; 2 “Across back”; 3 “Sleeve length”; 4 “Waist”; 5 “Hip”; 6 “Crotch/fly opening”; 7 “Leg length/shape”; 8 “other”.
- Open-ended questions, consisting of questions to which the respondent supplied his/her own suggestion or comments without being constrained by a fixed set of questions.
- Closed ended questions, the answers to which were limited to a fixed set of responses, such as “Yes” or “No”.

4.1.4 Anthropometric data collection

Initially, the aim was to take body measurements from the women who are working in the construction sites, but it has not been easy to find companies that were willing to release workers from their jobs during working hours to the station where the body-scanning machine is situated. The body scanning is not portable, so participants have to be transported to the station. Therefore, body measurements have been taken from a group of 25 women volunteers who are not necessarily working in the construction field. This was done in order to acquire a broader view of the different body types that are available in South Africa i.e. Pear shaped body type, Hourglass, Gynaeoid body shape, etc. Furthermore, such anthropometric data will be used when developing a prototype.

4.2 SECONDARY DATA

Secondary data is data that was readily available before the research commenced. In this research study, secondary data was gathered from the following data sources:

- Books
- Internet
- Protective wear suppliers
- South African Bureau of Standards

4.2.1 South African Bureau of Standards (SABS)

SABS is a leading service to organisations worldwide, offering a range of services for management system certification, product testing and certification, and standardisation. As defined on the official website (www.sabs.co.za), a standard is an agreed, repeatable way of doing something. It is a published document that contains a technical specification or other

precise criteria designed to be consistently a rule, guideline, or definition. It increases the reliability and the effectiveness of the goods and services used by different sectors. In the clothing industry, there are different standards that are available to be used in the design and production of certain garments, with protective wear being one of the selected garments. It is empirical that protective wear designers use specifications as argued in the SABS and ISO 9000. It is also important that protective wear manufacturers are aware of what is required by the targeted industry. Bringing together the experience and expertise of all interested parties such as the producers, sellers, users and regulators of a particular material or product can help in the creation of standards.

In South Africa standards enhance competitiveness and provide the basis for consumer protection, health and safety. This was confirmed during interviews with the representative from SABS branch, based in Rondebosch, Cape Town, South Africa. Interviews were conducted telephonically and some of the follow-up questions were handled via e-mail (these is in possession of the researcher). The researcher aimed at finding out whether there are existing standards that cater for female protective wear. Manufacturers make use of the available specifications and all the specifications on how protective wear must be constructed are outlined in the SABS standard ref code SANS 434:2008. See Appendix A for the outline of the required material and workmanship, Appendix B and C for styling, sizing and garment construction requirements for the current protective wear. Therefore, the researcher has used the SABS standard as a guide for designing prototypes. The design process is explained in Chapter Five of the thesis.

4.3 RECORDING OF DATA

Key word notes were taken during the interview sessions and are in the possession of the researcher. Measurement data recorded are stored in a computer that is attached to the 3D Body Scanning machine for easy access. Pictures of the current protective wear overalls have been captured with an aim of comparing them to the newly developed overall pieces and are stored safely by the researcher. Videography taken during the fit sessions of the researcher's prototypes is in the possession of the researcher and is stored in a DVD rom attached to the thesis.

4.4 SUMMARY

The use of the design, the methodology and methods mentioned above have enabled the researcher to discover whether the available protective wear can comfortably be worn by women. This enabled the researcher to draw conclusions based on the findings of the research. The information sources mentioned above helped in the collection of the primary and secondary data that is required in the research.

The data analysis methods embraced content analysis and measurement techniques (such as the Likert Scale). Once the data has been gathered through the use of these instruments, it needs to be analysed in order for the research questions to be answered. The section below (Chapter 5) indicates how the collected data has been processed and analysed into useful information that can provide the answers.

CHAPTER 5

PRESENTATION AND ANALYSIS OF DATA

5.1 INTRODUCTION

This chapter is dedicated to presenting the results obtained from using the research methods mentioned in Chapter Four. The first section of this Chapter presents the data collected via questionnaires that were distributed to women working in the construction field. The second section presents the interpretation of the data collected via interviews with protective wear manufacturers and supported by questionnaires.

Following the presentation of data collected in this study, the data will be analysed and interpreted in the second section of this Chapter. The information gathered from the presented data will be used to answer the research questions posed in Chapter One of this study. Again, the collected information will inform the conclusions and recommendations that will be made in Chapter Six.

The aim of the research is to propose strategies for protective wear that is ergonomically designed and made to suit women's physique in order to accommodate women working in the construction industry. The research also aims to investigate the validity of an assumption that there is a gap in the product offering of protective wear for women in the construction industry. The focus of the study is to design protective garments that are suitable for women's physique while working in the outdoor context of the construction industry. Additionally, the research should show in an exemplary manner how to implement sustainable design processes within the local construction industry.

Chapter Two discussed the main topics of the research, Chapter Three defined the research design and methodology, and in Chapter Four the strategies that were applied in the collection of data were well defined. The summary made during the research guided the design of a prototype that will be used as an example of the research outputs and findings discussed below. The purpose of this Chapter is firstly to analyse the findings of the research, which should clarify its contribution to the clothing design/manufacturing industry and allow a summary to be drawn. This Chapter further addresses issues and makes recommendations drawn from the research.

The second section of the Chapter analyses the results obtained using the research methodology outlined in Chapter Four.

5.2 PRESENTATION OF DATA

The data was gathered from local female construction workers and protective wear manufacturers through the use of semi-structured interviews and questionnaires as mentioned in Chapter Four of this study. The interviews were conducted with both female construction workers and protective wear manufacturers. However, interviews could only be possible with the local manufacturer and not the manufacturer that is based in Durban, South Africa because of the long distance between the manufacturer and the researcher. Questionnaires were distributed to both manufacturers and female construction workers. Appendix F encompasses a questionnaire that is designed to gather the views of the construction field workers about the garment design of the current protective wear and Appendix G reflects the questionnaires that the female construction workers responded to about garment fit, while Appendix E reflects the questionnaire that the protective wear manufacturers responded to.

In this Chapter, the researcher presents findings in sections. The data was gathered from local female construction workers and protective wear manufacturers in relation to the research objectives. The results of the semi-structured interviews and questionnaires responded to by 25 women working in construction and two protective wear manufacturers are also discussed herein. The data was collected and then processed in response to the problems posed in Chapter One. Two fundamental goals drove the collection of the data and the subsequent data analysis. Those were to verify the validity of the assumption about lack of protective wear suitable for woman in the construction industry, and to verify that there is a gap in the offering of protective wear for women and that there is a need for it to be designed. These objectives were accomplished.

5.2.1 The research findings of the fieldwork conducted with protective wear manufacturers and women working in the construction field.

Before the initiation of the study, the significance, rationale and purpose of the study were provided to subjects. Furthermore, the subjects have also been given assurance that all the data they will give is used for the purpose of the research only and their identities will be confidential. In the report about the body measurements, codes are used instead of the real names in order to keep their identity unknown. In the analysis, the researcher categorised participants into two groups, namely, women working in construction and protective wear manufacturers. Furthermore, the researcher categorised the subjects according to their different dress size codes, in order to allow for the analysis of the different figure types. This is in line with the assumption that there are noticeably body differences among women.

5.2.2 The subject's rationale for garment fit

This part of the thesis will provide an analysis and discussion of the perception of subjects on garment fit based on the Likert scale, where responses were rated from a scale of 1-5. As illustrated in Appendix G, there were only two questions where the Likert scaling method was applied in the interest of gathering the subject's standing in the importance of garment fit. In question 1, the following categories were provided: 1 = not important at all, 2 = somewhat not important, 3 = neither important nor uncomfortable, 4 = somewhat important and 5 = very important. In application of this method in question 4 where the researcher wanted to understand the level of comfort of the current protective wear, the following choices were offered: 1= very uncomfortable, 2 = somewhat uncomfortable, 3 = neither comfortable nor comfortable, 4 = somewhat comfortable and 5 = very comfortable.

Herein, it should be noted that the subjects were given a set of statements through the questionnaire so as to express the importance of garment fit while performing their daily tasks. Closed ended questions, the answers to which were limited to a fixed set of responses, such as "Yes" or "No", were also integrated. Furthermore, subjects had to identify the parts of their work wear which they would like to change in order to improve the comfort of their garments (see Table 5.1). This would provide a greater understanding of how to design protective wear that is meant to fit women.

5.2.2.1 Women working in the construction field

Likert scale method explanation

Question 1

1=not important at all
2=somewhat not important
3=neither important nor not important
4=somewhat important
5=very important

Question 4

1=very uncomfortable
2=somewhat uncomfortable
3=neither comfortable nor uncomfortable
4=somewhat comfortable
5=very comfortable

Table 5.1: Aspects of protective wear affecting women in relation to garment fit

Questions	1	2	3	4	5	No answer			Interpretation
1. How important is to you that your work clothing fits comfortably while performing your daily tasks?			4	5	12	4			Very important
	Yes			No					
2. Are you able to differentiate between a good fitting and an ill-fitting garment?	18			2		5			Yes
	Yes			No		No answer			Interpretation
3. Does the fit of the available protective wear allow you to execute your tasks effectively?	8			12		5			No
	1	2	3	4	5				
4. How comfortable is your work wear in comparison to your everyday wear?	15	4	2	2	5	0			Uncomfortable
	1	2	3	4	5	6	7	8	Interpretation
5. Which parts of your work wear would you like to change in order to improve the comfort of your garment?									
Body dimensions									
▪ Bust area	10								Some are uncomfortable with the bust area
▪ Across back		2							
▪ Sleeve length			2						
▪ Waist				5					
▪ Hip					6				A number of subjects are not happy about the hip area
▪ Crotch/fly opening						10			Some subjects are not comfortable about the comfort of the crotch area
▪ Leg length							15		Many subjects are not happy about the comfort of the leg length
▪ Other comments/suggestions									
	Yes		No			No Answer			Interpretation
6. Do you receive any comments from your co-workers about your current work wear? IF YES, use the diagram below and indicate with an X next to the areas of concern.	7		13			5			No
Body dimensions									Interpretation
	1	2	3	4	5	6	7	8	Question is not relevant to the company in question
▪ Bust area		5							
▪ Across back									
▪ Sleeve length									
▪ Waist									
▪ Hip									
▪ Crotch/fly opening	5								
▪ Leg length							15		
▪ Other comments/suggestions									

5.2.2.2 Interpretation of the feedback

In an aim of answering the sub-questions of this chapter, a set of questions was presented. Table 5.1 above reflects the questions asked and responses to the questions. In response to the question about garment comfort while preforming the daily tasks, the majority of the subjects felt that it is very important that work clothing fits comfortably while performing the daily tasks and those subjects are very much aware of the garment fit. This means that it is very important that female protective wear is made to fit the female structure in order to achieve or satisfy the expectations of the wearer. When asked if the fit of the available protective wear allow the subjects to execute their daily tasks, the response was "uncomfortable" meaning that subjects would welcome change to the garment that would be more accommodating of female structures.

Considering the response, there is a need for the design of protective wear that is suitable for women's physique, which will enable them to execute their tasks comfortably. During the unstructured interviews with the subjects, most of the subjects were aware that the clothing they wear at work is mainly designed for men, which explained why the majority of the subjects answered that the garments are uncomfortable. The questionnaire granted the subjects an opportunity to highlight the areas in which the subjects would like to have the current protective wear changed in order to improve the fit. Subjects seemed to be very passionate about this question, in so much that some of them selected more than one area of concern.

Seven out of fifteen subjects selected leg length as the area of concern. During the interviews the subjects mentioned that the leg length appears to be too long, they always have to spend money by taking their pants to a tailor for the adjustment of the leg. The problem is either that the leg is too long or that it is too wide. A leg that is too long can be hazardous as it could be trapped while preforming the tasks. This is not only hazardous but costly and counterproductive as women spend considerable time taking care of their clothes during working hours. A leg that is too wide can impact on the appeal of the wearer.

Six out of fifteen subjects selected the hip as an area that requires improvement. It was highlighted that the hip area of the current protective wear seems to be too tight. Pants that are too tight around the hip area can be the actual cause of discomfort and minimise wearer mobility, especially if the job requires bending and squatting movements. This confirms that the clothing that was constructed for men fits differently on women because of the body structure especially in the hip and bust areas. Furthermore, as mentioned in Chapter Two of

this thesis, protective wear designed for a man's body does not fit a woman's body comfortably or as it should do.

Furthermore, five out of fifteen subjects selected the bust and crotch/fly opening as another area of concern. Some mentioned that the garments are too loose in the bust area and some mentioned that they are too tight. This could be because the men's chest is sometimes bigger than that of women. A size 34 men's top garment fits differently on women because of the difference in chest and bust measurements. In response about the crotch/fly opening, it was mentioned that the crotch is too long and that creates bulk in the front area. For the success of a good garment, it is important that garment fit and garment design are always related, as the success of a garment depends on the two aspects. Table 5.2 below demonstrates the responses from the female construction workers in relation to garment fit.

5.2.3 The subjects' rationale for garment design

Table 5.2: Aspects of protective wear affecting women in relation to garment design

Questions	Coveralls		Work suits					Interpretation
	Yes	No	Yes	No				
1. From the current range of protective wear, which one do you prefer?	3	1	10	1				Majority prefer work suits
	Yes	No	Yes	No				
2. Are you happy about the style of your coverall and work suits?	3	3	7	2				Majority prefer work suits
	1	2	3	4	5	6	7	8	Interpretation
3. Which parts of your work wear would you like to improve?									
Body dimensions									
▪ Bust area	3								
▪ Across back		3							
▪ Sleeve length			3						
▪ Waist									
▪ Hip					2				
▪ Crotch/fly opening						6			Crotch/fly opening requires improvement
▪ Leg length							7		Leg length requires improvement
▪ Other comments/suggestions									
	Yes		No						Interpretation
4. Do you receive any comments from your co-workers about your current work wear? IF YES, use the diagram below and indicate with an X next to the areas of concern.	3		12						No comments, this not an area of concern
Body dimensions	1	2	3	4	5	6	7	8	Interpretation
▪ Bust area									
▪ Across back									
▪ Sleeve length									
▪ Waist									
▪ Hip					2				

▪ Crotch/fly opening									
▪ Leg length							1		
▪ Other comments/suggestions									

5.2.3.1 Interpretation of the feedback

Protective wear should ideally provide maximum comfort and protection for the wearer; the design and fit of a garment are factors that can affect both the protective aspects of a garment as well as its comfort, therefore, garment design is one of the areas of concern in this research. A questionnaire on garment design was drafted to enable the researcher to gather information that will help in the development and design of a prototype. In response to the question about the type of preferred work wear by women working in construction, the majority (ten out of fifteen) of the subjects prefer a two piece overall.

During the interviews, it was mentioned that, previously, the research company used to use one-piece overalls as work wear, but when women joined the company they requested that the uniform be changed because of the restrictions that were experienced when wearing one piece overalls. One of the subjects argues that “I felt that my dignity was lost, especially when I had to use the toilet, because the construction of the one piece coverall required me to take it down all the time and it was time consuming due to buttons on the centre front”.

In response to question 3 where the subjects were given an opportunity to identify the areas that require the design improvement, the response was similar to that of garment fit. Seven out of fifteen subjects highlighted that the leg length is indeed an area that requires improvement. The subjects highlighted that they would prefer an adjustable leg, as it would not be possible that each employee receives a tailor made garment because of bulk production of the garments. Repeatedly, crotch/fly opening had most scores as an area that requires design improvement. This is because a man’s crotch is always designed to be longer than that of a woman, and ease is added in order to accommodate the different bodily structure of a man to that of a woman.

As mentioned in the background to the research section of this thesis, sexual harassment has been proven to be a concern in the construction field. But, as a result of the strict rules and regulations laid by the research construction company, in response to the question where the subjects were asked if they had received any comments from their male co-workers about the current work wear, it appeared that it is not really a concern.

5.3 THE BODY SCANNING PROCESS

A successful garment cannot be possible without a set of body measurements; therefore, as mentioned in Chapter Three of this thesis, a 3D body scanner was used as another means

of collecting the data. The data collected enabled the researcher to gather the information used as a means of constructing sizing charts. To maintain confidentiality, as promised to the subjects during the body measurement process, a coding method has been used to identify the subjects in order for them to remain anonymous.

Furthermore, the aim of using a body scanner as a data collection method is to verify the assumption that there are structural differences within women besides the differences between men and women and also to draft a size chart that will be used in the development of a prototype. The first set of data collection was based on different age groups in order to classify the difference in height, weight and dress size (see Appendices J – Q for detailed information) among women who participated in the body measuring process. Appendices J – Q outline the results of the body scanning process with all the different body parts measured illustrated through the use of graphs.

During the body measuring process, there was no specific age group targeted, as the body scanning process was done entirely on a voluntary basis. The anthropometric data was collected from women of different ages, height, weight and dress size. It therefore demonstrated through the use of charts as illustrated in Tables 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9 and 5.10 below. An analysis of charts is clarified in Table 5.4.1 below. Waist, hips, inseam and thigh are the main focal points of the body measuring process, and the said measurements will be used during the construction of the basic foundation blocks in preparation for pattern making.

Table 5.3: Anthropometric data collection chart

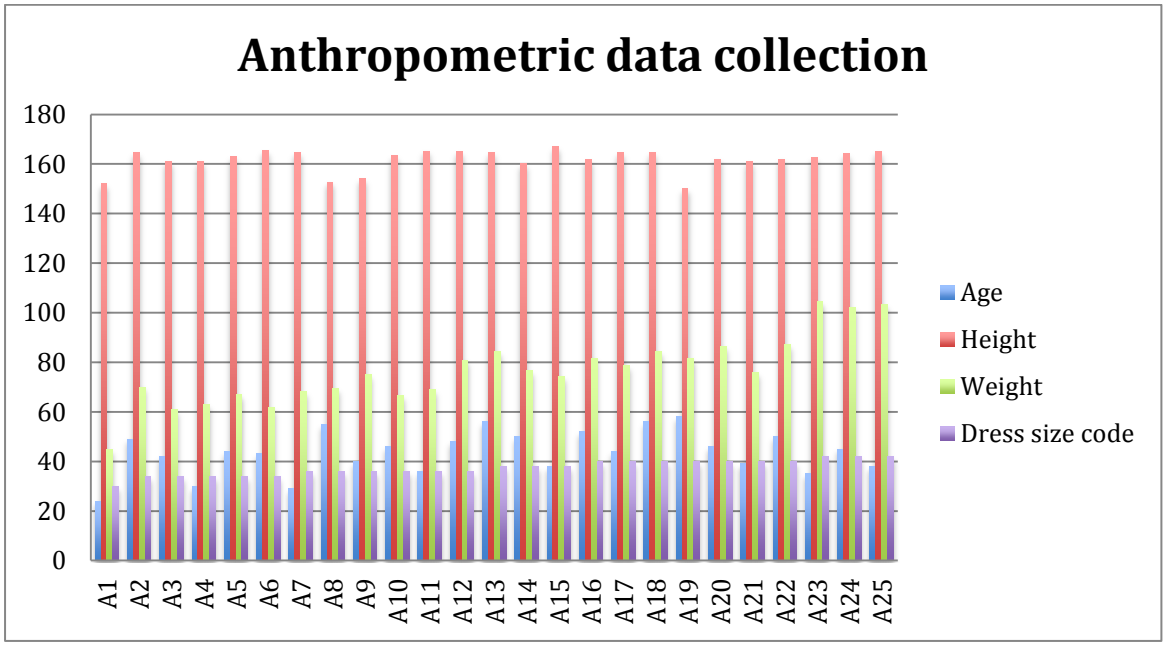
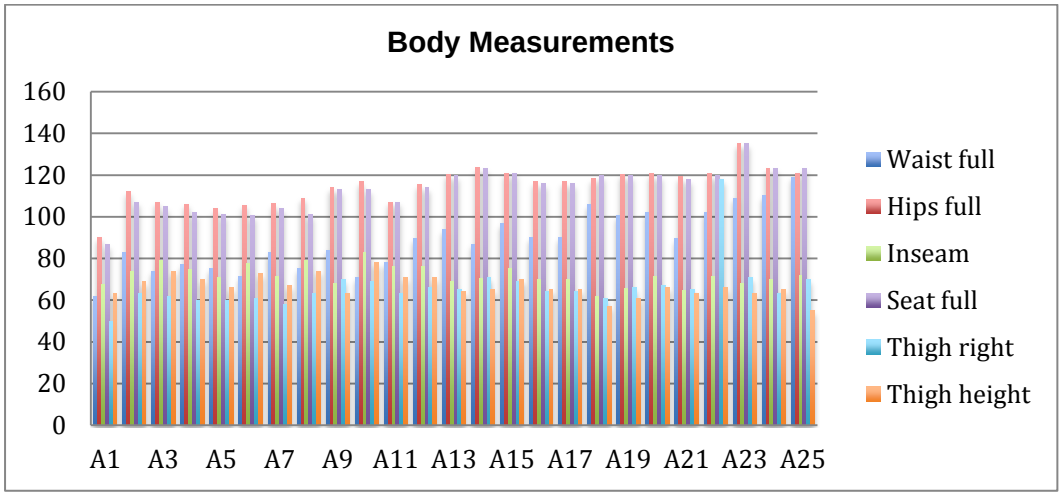


Table 5.4: Coded body measurements chart



The data was collected from 25 women of different ages as illustrated in Table 5.3 above. Below is an analysis of 3D scanning anthropometric data from size 30 to size 42.

Table 5.5: Bust Category: Dress size Cross tabulation

Count

		Dress size						
		30	34	36	38	40	42	Total
Bust Category	< 85	2	0	0	0	0	0	2
	85.01 - 95	0	5	3	0	0	0	8
	95.01 - 105	0	0	1	2	0	0	3
	105.01 - 115	0	0	1	2	3	0	6
	115.01 - 125	0	0	0	0	4	2	6
Total		1	5	5	4	7	2	25

Table 5.6: Bust Category: Bar chart

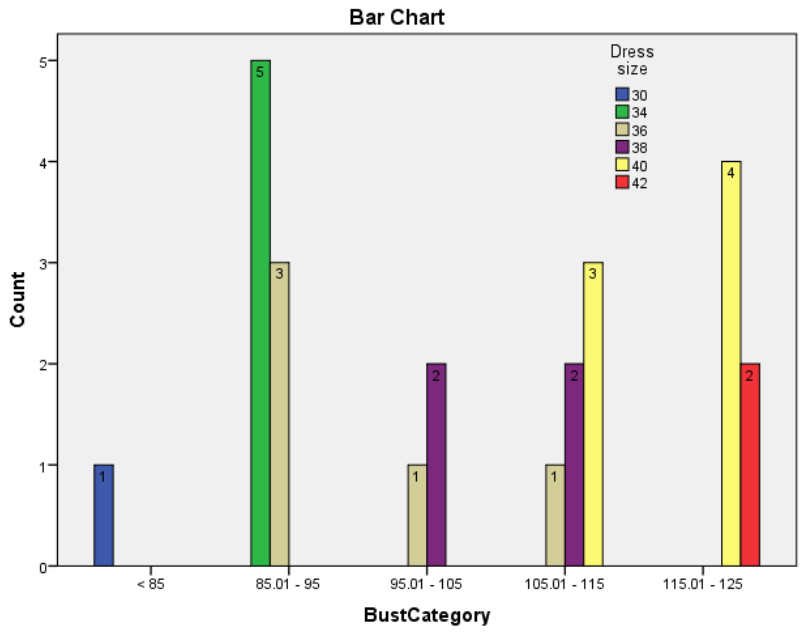


Table 5.7: Waist Category: Dress size Cross tabulation

Count

		Dress size						
		30	34	36	38	40	42	Total
Waist Category	< 80	1	4	3	0	0	0	8
	80.01 - 90	0	1	2	2	2	0	7
	90.01 - 100	0	0	0	2	1	0	3
	100.01 - 110	0	0	0	0	4	2	6
	110.01 - 120	0	0	0	0	0	1	1
Total		1	5	5	4	7	3	25

Table 5.8: Waist Category: Bar Chart

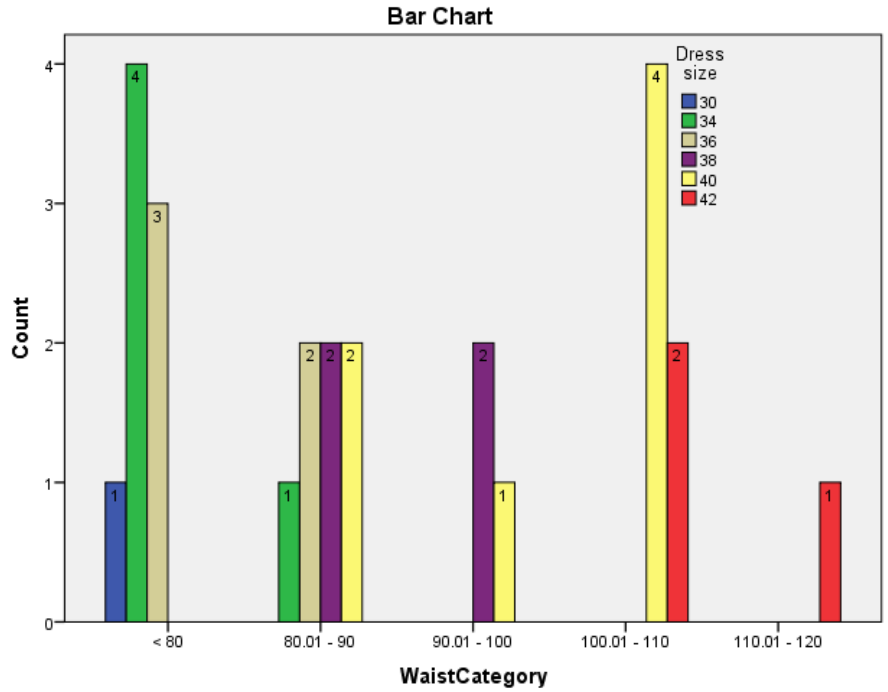
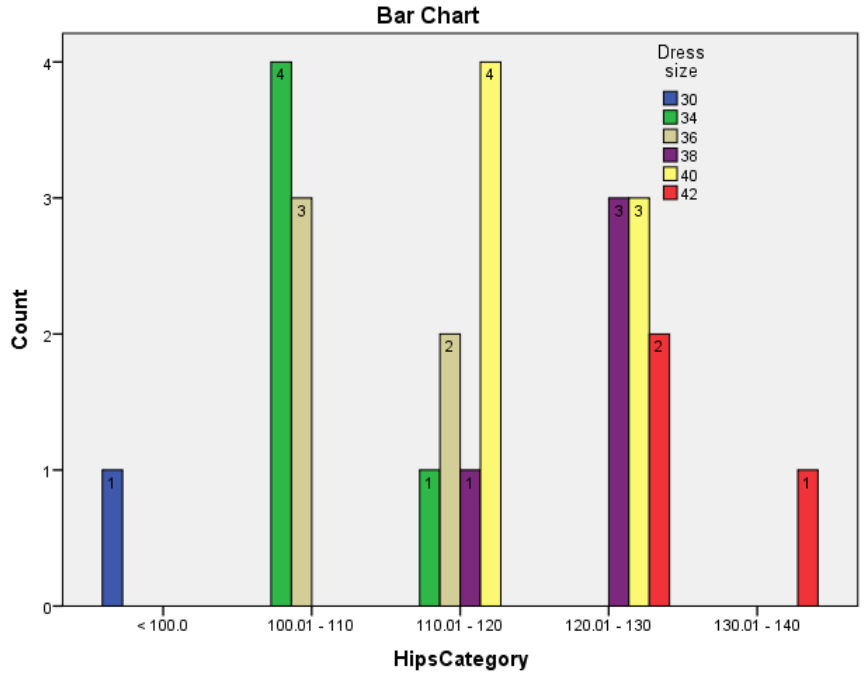


Table 5.9: Hips Category: Dress size Cross tabulation

Count

		Dress size						
		30	34	36	38	40	42	Total
Hips Category	< 100.0	1	0	0	0	0	0	1
	100.01 - 110	0	4	3	0	0	0	7
	110.01 - 120	0	1	2	1	4	0	8
	120.01 - 130	0	0	0	3	3	2	8
	130.01 - 140	0	0	0	0	0	1	1
Total		1	5	5	4	7	3	25

Table 5.10: Hips Category: Bar Char



5.3.1. Protective wear manufacturers' rationale for garment design

Table 5.11: Factors affecting the protective wear manufacturers

Questions	**Manufacturer 1**	**Manufacturer 2**	**Interpretation**
1. What influences the design of the current protective wear?	1. The environment in which the garments are to be worn. 2. Customer requirements	1.The environment that the garment is made for. 2. Customer specification 3. Durability of garment 4. Costing	It is important that the end-use and user of the product is considered.
2. Are the current designs suitable for both male and female?	**Yes**	**No**	**Interpretation**
	The company manufactures garments that would be accommodative to both male and female.	Men's sizing is different to that of women. We always have to physically go to the client for fittings, which is time consuming. Some women fit on the tops but have to change or alter pants, which is time consuming.	Currently, there are no garments that are designed specifically for women. Manufacturers interpret the existing protective wear as unisex.
3. In your opinion, is it necessary to have protective wear that is specifically designed for women, in view of the increased number of women joining the construction industry?	**Yes**	**No**	**Interpretation**
	Manufacture1: Yes, presently, manufacturing unisex garments is quite difficult, due to structural differences between men and women.		There is a huge need for protective wear that is specifically designed to suit women's physique.

	Manufacture 2: Yes definitely, this will help the business grow, as we will be supplying both men's and women's wear.		
4. What challenges do you anticipate in designing protective for women?	From a manufacturing point of view, the volume of demand would not be economically viable.	Getting the health & safety act to change the current specifications and include the needs of the women. The existing standards are only meant for the manufacturing of menswear.	**Interpretation** Marketing of women's protective wear will be essential.

5.4 ANALYSIS OF 3D SCANNING ANTHROPOMETRIC DATA

A. Overall Data (n=25):
The total population sample size is 25 women. The 9 parameters/sizes measured include:

- Dress
- Bust (full)
- Waist (full)
- Hips (full)
- Inseam
- Seat (full)
- Thigh (right)
- Thigh height
- Out seam (maximum)

B. Dress size analysis:
- 4% of the women have a dress size of 30
- 20% have a dress size of 34
- 20% have a dress size of 36
- 16% have a dress size of 38
- 28% have a dress size of 40
- 12% have a dress size of 42

Summary:
- the *minima* (least measurement) for the subjects measured was size 30
- the *maxima* (or highest measurement) recorded was 42
- the *median* bust measurement is size 38 – this is the middle size of the subjects measured
- the *mode* (the most frequently occurring) bust size is 40
- the *mean* (or average) bust size for the sample population is 37.52 - the closest commercially available size is thus 38
- for purposes of testing, bust sizes 40 (closest to statistical *mode*), 38 (closest to statistical *mean* and median), and 34 (occurring in more than 20% of the measurements)
- the standard deviation for the data set is 3.12

C. Bust (full) size analysis:
- 4% of the women have a bust size of 71-80
- 4% have a bust size of 81-90
- 32% have a bust size of 91-100
- 28% have a bust size of 101-110
- 24% have a bust size of 111-120

- 8% have a bust size of 121-130

Summary:
- the *minima* (least measurement) for the subjects measured was 78
- the *maxima* (or highest measurement) recorded was 121
- the *median* bust measurement is size 104.68 – this is the middle size of the subjects measured
- the *mode* (the most frequently occurring) bust size is 91
- the *mean* (or average) bust size for the sample population is 103.46 – the closest commercially available size is thus 100
- for purposes of testing, bust sizes 90 (closest to statistical *mode*), 105 (closest to statistical mean and *median*), and 120 (occurring in more than 20% of the measurements)
- the standard deviation for the data set is 12.18

D. Waist (full) size analysis:
- 4% of the women have a waist size between 61-70
- 28% have a waist size of 71-80
- 24% have a waist size of 81-90
- 16% have a waist size of 91-100
- 20% have a waist size of 101-110
- 8% have a waist size of 111-120

Summary:
- the *minima* (least measurement) for the subjects measured was size 61.79
- the *maxima* (or highest measurement) recorded was 119.00
- the *median* waist measurement is 89.48 - this is the middle size of the subjects measured
- the *mode* (the most frequently occurring) waist size is 71-80
- the *mean* (or average) waist size for the sample population is 88.77 – the closest commercially available size is thus 90
- for purposes of testing, waist sizes 90 (closest to statistical *mode*), 80 (closest to statistical *mean* and median), and 110 (occurring in more than 20% of the measurements)
- the standard deviation for the data set is 14.39

E. Hips (full) size analysis:
- 4% of the women have a waist size between 91-100
- 28% have a hip size of 101-110
- 32% have a hip size of 111-120
- 32% have a hip size of 121-130
- 4% have a hip size of 131-140

Summary:
- the *minima* (least measurement) for the subjects measured was size 61.79
- the *maxima* (or highest measurement) recorded was 119.00
- the *median* waist measurement is 117 - this is the middle size of the subjects measured
- the *mode* (the most frequently occurring) waist size is 71-80
- the *mean* (or average) waist size for the sample population is 114.85 – the closest commercially available size is thus 115
- for purposes of testing, waist sizes 90 (closest to statistical *mode*), 115 (closest to statistical *mean* and median), and 110 (occurring in more than 20% of the measurements)
- the standard deviation for the data set is 8.96

As mentioned in 5.2.4.1 above, the focal points during the measuring process, was that of the dress size, bust, waist, hip, inseam and sit area. These areas are known as the areas where the difference in bodily structure is evident. This information is presented in the charts below (see Table 5.1 for Anthropometric data collection and Table 5.2 for body measurements data). The measurements that the researcher used in the construction of basic foundation blocks are that of the bust, waist, hip and leg length. Below are the charts that show that difference.

5.5 BACKGROUND TO THE DESIGN AND CONSTRUCTION OF PROTECTIVE WEAR FOR WOMEN

During the collection of data, restrictions in age, height, weight and dress size were not considered as the researcher wanted to get a wide variety of points. The data was collected from women aged between 24-58, height of 152-165, weight of 45-103 and dress size of 30-42 (see Appendix J). Scans were taken from the side and front view that made it easier for the researcher to gather clear and detailed information required (see Appendix H). As stated in Chapter Three of the study, the aim was to take body measurements while the subject is in movement; however, the available machinery only allowed for the measurements to be taken with the subject standing still.

As mentioned in Section 1.4, the aim of the study is to contribute towards the generation of new size developments for women by collecting body measurements through the use of the 3D Body Scanner. This will enable the development of better functional protective wear for women in order to enhance productivity in the workplace, through boosted self-confidence and motivation. The garment manufacturing process requires the use of size charts in the development of basic foundation blocks; therefore, the data collected during the body scanning process is used to develop a size chart. A size chart will be used in the development of foundation blocks for two-piece overalls (tops and bottoms). In the development of bodice and pants basic foundation blocks, the researcher uses a Metric pattern book as a guide. The basic foundation block stage is the first stage of the garment construction process and is drafted manually. Body measurements used are gathered from the data collected through the 3D Body Scanner, therefore the measurements used are customized. Sizes drafted are from size 34-40.

5.6 SABS REQUIREMENTS FOR THE CONSTRUCTION OF PROTECTIVE WEAR

According to the South African Bureau of Standards (SABS), there are guidelines that must be followed when constructing protective wear. Therefore, the design, pattern making and garment construction process has followed the South African Bureau of Standards (SABS)

guidelines that are outlined in the South African National Standard (SANS 434:2008) edition 4.2, see Appendix A, B and C.

5.6.1 The ergonomic design and garment construction process

As mentioned in the background of the research chapter, the researcher aims to design and produce protective garments that are ergonomically designed to suit women working in the construction field, taking garment comfort, fit, and women's body image into consideration. Therefore, the researcher has observed the existing protective garments worn by women while on site and considered the feedback acquired during data collection.

The design and manufacturing processes applied involve methods that will contribute in user-friendliness of the garments, easy movement and adjustability. The illustrations below (Figure 5.1) are the first drafts of the design process, and all the design considerations are specified in detail through the use of annotations through detailed technical drawings that are attached in Appendices and are constructed using a Corel Draw graphics drawing program in order to ensure accuracy and well-proportioned technical drawings (See Style 2).

5.6.2 Ergonomic design considerations for pants

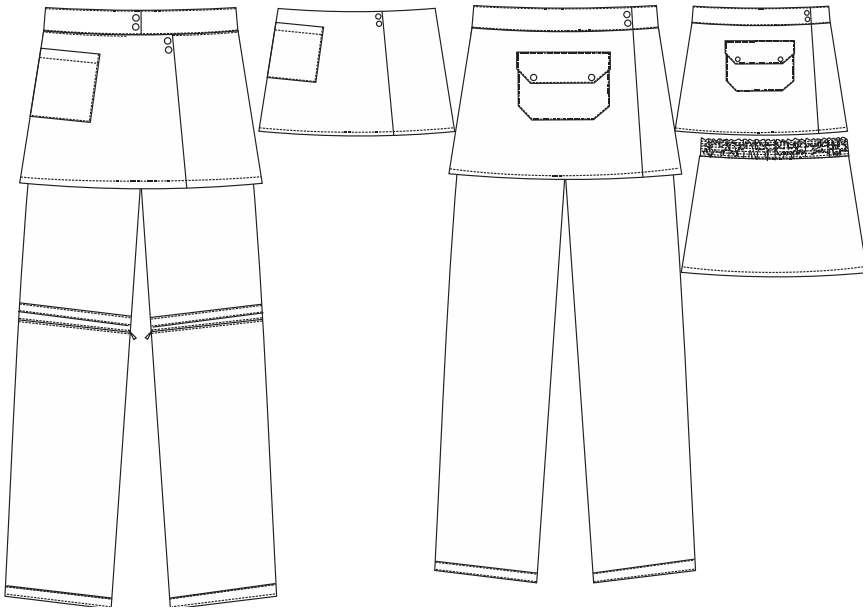


Figure 5.1: Pants and skirt front (skort) and back first draft drawings (Style 1 and 2) Features on Pants: skirt with side pocket (Source: Author's Construct, 2014)

During the interview sessions, it was evident that some of the women working in construction are married, and are not comfortable in wearing pants because of traditional, religious, and personal choices. Therefore, the use of a wrap over skirt (skort) attached to pants, covering the seat, crotch and hip areas back and front will help with respect to comfort and confidence

while on the job (see Figure 5.1). A skort originated in the 1950's and is defined as a blend of skirt and shorts (www.oxforddictionaries.com, 2014).

The designs have both detachable and stitched on skirts (skort) in order to offer different and useful options in order to accommodate women with different choices. A wrap over skirt will be attached from the front waist, sandwiched in-between the pants waistband and pants, and the left front part will flip open for easy access to the crotch.

Patch pocket design: the inspiration for the design of pockets stems from the Xhosa tribe's tradition which specifies that a married woman should be dressed in a long skirt with an apron with front pockets big enough for easy storage of the equipment used in the kitchen during the cooking process inclusive of a cell phone. Therefore, pockets will be useful on-site too, to store small working equipment and cell phones safely especially when working outdoors. Side pocket width is about 15cm as argued in SANS 434:2008. This will help with the storage of cell phones for convenience and other personal belongings while on site.

Pants leg designs

SANS 434:2008 stipulates that legs must be kept plain; however, due to the findings of the research where it was clearly stated by the subjects that comfort is important, the researcher has added a functional open-end zip on the knee area. The idea was raised by observations in the construction field where women had to roll long pants up in order to execute the tasks comfortably. Therefore, the aim for adding the zip feature is to offer a wearer an option of wearing pants as ¾ pants in summer and also when working outdoors in wet areas, therefore instead of rolling pants up which looks untidy and not appealing (see Figure 5.2), one can easily zip off the bottom part of the pants. To add on to the functional feature, a zip will act as a design feature of the pants as well, which will help boost the confidence of the wearer.

Figure 5.2: Caption of a female construction field worker with rolled up pants

Knife pleats on pants: the aim of the researcher is to provide comfort to the wearer; therefore, the option provided is that of pants with knife pleats on the front, which will add allowance or fullness which will enable the wearer to bend the knee easily without any restriction, thus executing the tasks easily and comfortably.

Figure 5.3: First draft of the designs for pants with knife pleats on the front knee

(Source: Author's construct, 2014)

Elasticated back waistband: Elastic helps adds more stretch to the desired area, therefore adding it in the back waistband will add comfort to pants, and will also keep pants in the desired position while performing tasks that require squatting and bending positions. This is inspired by the comments made by construction field workers during the interview sessions, where it was mentioned that the centre back of the current protective wear appears to be low, as a result, underwear tends to show when bending and squatting. To eliminate this problem further, during the basic foundation block stage, the researcher also raised the centre back area by 3.5 cm for more ease and comfort on pants. Furthermore, an elasticated waist will also provide comfort to pregnant women during the first trimester of their pregnancy period, and the same pants will be used with no fit problems after birth.

Reflective tape: Safety in the construction site is very important, therefore a reflective tape is added on for the safety of women while on the job. This is in consideration of the working environment of the construction site, conditions where workers execute their daily tasks in the dark because of working times and different weather conditions, namely, road construction and mining.

5.6.3 Ergonomic design considerations for tops/blouses

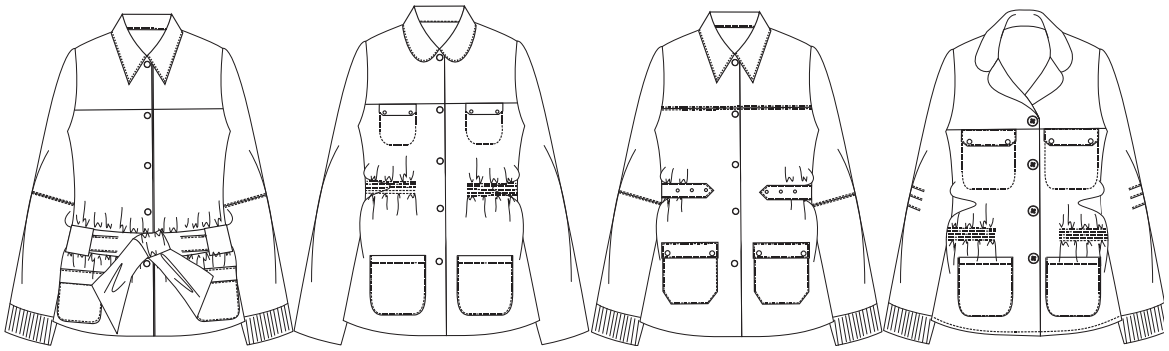


Figure 5.4: First draft of the designs for blouses/tops. (Source: Author's construct, 2014)

With great consideration of the specifications argued in SANS 434:2008, based on the feedback gathered through interview sessions with female construction workers and protective wear manufacturers, some changes are applied. The aim of the researcher is to ensure that the female protective wear is ergonomically designed, ensuring high levels of comfort to the wearer of the garments. Changes include adjustable tabs, elasticated waist, functional zips on sleeves and waist belts with a reflective tape. Aims for applying the said changes are stipulated in detail below.

Adjustable Side Tabs (see style 3) will help with comfort, and will help with an extension of the garment around the waist in case of weight gain. Lifestyle conditions are also

considered; adjustable side tape will also be accommodative to pregnant women during the first trimester of the pregnancy period and will be used after birth.

Elasticated waist (see style 2 and 3). Comfort in protective wear is a key factor; therefore elasticated waist will provide the wearer with more comfort. Taking into consideration that women go through different natural life stages, elasticated waist will also provide comfort to pregnant women during the first trimester of their pregnancy period and they will still be able to use the same tops after giving birth.

Set in sleeves with functional open-end-zip (see style 1 & 3). The aim for attaching zips on the sleeves is to provide a wearer with dressing options that will be functional and convenient while on the job. The design is inspired by the interview feedback from female construction workers. The caption below (Figure 5.5) shows a female construction worker wearing a long sleeve t-shirt underneath her working blouse because of the cold weather. When asked if she feels comfortable in the way she is dressed, she answered, “This blouse is not accommodative of the cold weather conditions because of the sleeve length, and for that reason, I had to wear a t-shirt underneath. I am well aware that it is not relative to my uniform and the colour is different; however, it provides warmth preventing me from staying away from my job because of health conditions” (Interviewee 2: 2014).

Zipping the sleeves off to ¾ sleeves can shorten the designed sleeves; this will help the wearer during the seasonal weather changes and will be convenient while performing the tasks.

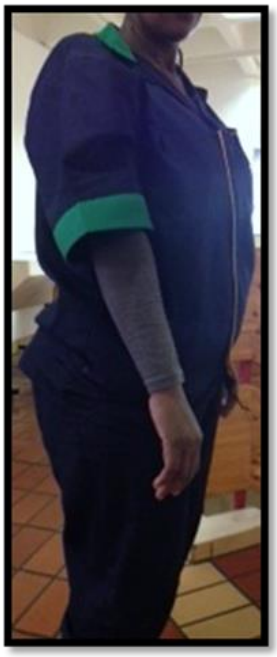


Figure 5.5: Caption of a female construction field worker wearing a long sleeve t-shirt underneath a ¾ sleeve work blouse (Source: Author’s construct, 2014)

Pleated sleeves (see style 4) will help with comfort, and will help with an extension of the garment around the sleeve on the elbow area when performing tasks that requires bending the arm.

The researcher used videography as means of demonstrating the functions of the garment features. Video clips are stored in the attached DVD- ROM.

5.7 DRAFTING OF THE BASIC BLOCKS AND MOCK-UP TESTING

In ensuring good fitting quality garments, the basic foundation blocks for pants and tops were drafted manually, using the customised measurements taken through the 3D Body Scanner (See Appendix J). The basic sizes drafted were from a size 34-40 (See Step One in the attached DVD-ROM). To ensure good fitting prototypes, mock-ups were constructed using the foundation blocks. Mock-ups or test garments were cut directly from the basic blocks in order to test the fit of the basic foundation blocks using 100% cotton fabric, which is of similar weight to that of the prototypes. This ensured that the blocks fitted perfectly before making the patterns that will be used to cut the final garments or prototypes.

After the manufacturing process, the test garments got fitted by construction field workers and the fit was good for some women. The problem encountered was that of women with smaller upper bodies than lower bodies. As a result, the said women ended up fitting in a size 34 blouse and a size 38 pants. Furthermore, the researcher made a few adjustments to the waist of the tops and pants because of the different bodily structure. This problem will be eliminated through elasticated waist on pants and around the waist on tops, inclusive of adjustable tabs.

During the fit sessions the models were asked to demonstrate the functionality of the garments through various bending and squatting positions. The feedback was that women felt comfortable because the back of the pants was sufficiently high and the tops covered the seat area which was a major concern with the current protective wear. After the fit sessions, the researcher adjusted the basic foundation blocks accordingly taking note of the feedback from the models.

During the pattern- making process, Accumark, which is used for grading patterns, digitising pattern pieces or basic foundation blocks into the computer, is used. As defined by Sharp and Elssasser (2007:2), digitising is the process of entering the shape and details of a pattern into the computer. Subsequently, blocks were plotted into the computer in order to construct patterns electronically using the Gerber pattern making system.

The pattern making process took place using the technical drawings constructed through the use of Corel Draw graphics drawing program in order to ensure accuracy and well-proportioned technical drawings. After the pattern making stage, patterns were graded up from a size 34-40 (See Step Two in the attached DVD-ROM)using the customised size chart that was developed for the measurements gathered from female construction workers through the 3D Body Scanner. Sharp and Elssasser (2007:20) define grading as the process of changing the size of a sample pattern, scaling it up and down to create a range of sizes. Thereafter, the functionality of the patterns was tested through mock-ups that encompassed all the design details that will be visible on the final garments. The aim of constructing mock-ups was to test the accuracy of the patterns and the functionality of the new designed features of the two-piece overalls.

5.7.1 The garment production process

In the production process of the prototypes, four different designs are produced following the technical drawings illustrated by the researcher. A standard size 34 is produced out of four different tops and three pants. Pants and tops are designed in order for them to be worn as a suit or separately. Sizes 36, 38, 40 are graded from size 34 and the graded screen shots are stored in the attached CD-ROM for easy viewing.

Considering the construction field environment where workwear easily get dirty therefore garments require frequent wash, the researcher used navy field dress canvas fabric with contrasting light grey reflective tape. The fabric is very easy to work with during the sewing process and the colour and texture does not change after the washing process.

5.7.2 Fitting of the prototypes

After the production process, the researcher conducted fitting session of the prototypes with the subjects. The aim of the fitting is to check the level of comfort of the pants with regards to fabric reaction, functionality of the garments and fit.

The process was deemed to be successful as the subjects were satisfied with the fit and comfort levels of the garments. The ergonomically designed features of both pants and tops seemed very useful and effective. Models were pleased with the fit and comfort of the garments; they made a comment that they feel feminine and they will confident to wear the garments in public. Models were generally pleased with the skirt that is worn over the pants because it covers their private parts of the body (see pants Style One and Two) which make them feel more comfortable when conducting jobs that require bending movements.

In the process, videos were captured with movements in order for the researcher to grasp the level of comfort and practicality of the garments. Furthermore, various photos were taken and are stored in the attached CD-ROM together with the video clips, graded patterns and detailed technical drawing of the garments. Full view and close-up pictures can also be viewed in the attached CD-ROM. The photo-shoot and videography was conducted in the construction site so as to provide a true sense of the garment on the body.

5.8 SUMMARY

The data collected suggests that the current protective wear fits uncomfortably; as a result it restricts movement when performing the daily tasks. The two protective wear manufacturers who participated in the research echoed this, by mentioning that men's sizing is different to that of women, therefore there is a need for the design and manufacturing of protective wear mainly for women. Consideration must be given to the environment in which the garment is manufactured as well as to the product end-user right from the design stage of the product.

The results of the preliminary investigation show strong support for the research. The data collected has indicated that there are huge gaps in the product offering for women's protective wear in South Africa. Questionnaires and interview answers to the questions about the garment fit and design proved that there is an excessive need for the design of protective wear that is ergonomically designed to suit women's physique. The participating clothing manufacturers believe that women also need clothes that suite the work roles they undertake but most importantly those that embrace their femininity in their daily lives.

This was evident explicitly in the interview and questionnaire response from both female construction workers and the two protective wear manufacturers in answering questions about both garment fit and garment design of the current protective gears. Based on the interviews carried out in this study, it became evident that women put on the protective wear to be effective at work, and to fit into the work environment, rather than being comfortable and enhancing their femininity.

To accommodate this, the researcher developed prototypes with design features that are accommodative of the different working conditions and better fitting because they are ergonomically designed to suit women's physique. The garment manufacturing process that involved the intended client helped the researcher in testing the functionality of the garments and to gather immediate feedback timeously.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

6.0 INTRODUCTION

The research reveals that on-site work wear has largely remained male wear ignoring the women body physique. This is attributed to the fact that previously such work was considered physically demanding and could only be handled by men – the emphasis was on higher levels of bodily strength. Consequently, women were not traditionally employed or involved in such work such as the construction industry because they were not regarded as being strong enough to cope with the exacting physical demands of the job. This mind set is likely to have made the clothing designers not to come up with on-site work wear that takes care of women's body physique.

As time goes on, the change in living dynamics and new technology has made women to undertake duties that were previously men's dominion. This necessitated providing for appropriate work wear for women. Although women were and may still not be easily accepted in some work roles, different women pressure groups are pushing for equality in the job market.

The aims of the study were to look into why design and fit of available protective wear do not adequately accommodate women when performing outdoor activities within the construction industry. The research methodology used for the investigation of the study has aided the researcher throughout the research process and based on the information, the researcher could draw conclusions.

In my investigation, the following research questions were interrogated and the said research methods were used in order to answer the questions.

6.1 What is the current situation with respect to available women's protective wear in the Cape Town construction industry?

6.2 Why do the current designs and fit in the available protective wear not adequately accommodate women in the construction industry?

6.3 How can relevant ergonomic considerations better inform the design of feminine and more appropriate protective wear for women?

6.1 REVISITING OBJECTIVES/AIMS OF THE RESEARCH

The overall objective of this research is to propose practical guidelines for protective wear that is ergonomically designed and made to suit women's physique in order to accommodate women working in the construction industry. To achieve this, the following objectives refer:

1. Investigation of the availability of protective wear that is specifically designed to suit women's physique. The data collected indicates that there are huge gaps in the product offering for women's protective wear in South Africa. As a result, some of the manufacturers and suppliers pronounce the current protective wear as unisex with no consideration of the fact that measurements and basic foundation blocks used during the pattern construction stage are meant to suit men's physique which proves to be different from that of women due to different bodily structure.

2. Identification of the possible limitations in the product offering of protective wear for female construction workers. The information drawn from the collected data suggested that the manufacturers recognize the need for designing protective wear that is meant to suit women. However, they displayed business related fears in starting the product line, as it will be the first experiences in the production of women's protective wear. The fear is that the product line will not be sold as much as the existing protective wear which is worn by both men and women.

3. An investigation of the practicality or functionality of available protective wear designs, the garment construction, and how suitable the fit is for women. The data collected suggests that the current protective wear fits uncomfortably; as a result, it restricts movement when performing the daily tasks. The two protective wear manufacturers who participated in the research echoed this, by mentioning that men's sizing is different from that of women, therefore there is a need for the design and manufacturing of protective wear mainly for women.

4. Establishing the viability and practicality of designing and manufacturing protective wear that is suitable for women. It is evident that protective wear should be designed to be comfortable and fit for purpose with respect to women's physique. Consideration must be given to both the environment in which the garment is manufactured and the product end-user right from the design stage of the product. Therefore the researcher has designed four different designs for tops and bottoms and made prototypes. Prototypes are designed based on feedback gathered from the interviews and questionnaires.

6.2 GENERAL CONCLUSIONS AND PROPOSED GUIDELINES

The data was collected predominantly in Cape Town; however, to enrich the study, data collection was extended to Durban, Kwazulu Natal, through the use of telephonic interviews and questionnaires that were distributed via email.

In answering the first research question, data revealed strong support for the research in assuming that there is a gap in the product offering of protective wear that is ergonomically designed to suit women. It was also evident that women who wear protective wear are not aware that they wear men's garments. Additionally, some of the suppliers and manufacturers pronounce the garments as unisex regardless of the fact that there are remarkable differences between men and women in body structure.

In response to the second question, the results show that there is no protective wear for women in the market. This stems from the previous state of affairs in the construction field where women were not regarded as strong enough to execute the tasks. Currently, the PPC manufacturers only produce ranges for men or ranges labelled unisex. On investigation, these two products seem to be produced from the same foundation block pattern, thus confirming a need for the manufacturing of protective clothing that is ergonomically designed to suit women's physique. Women have developed interest in the industry, therefore there is a huge need for protective wear that is produced with women in mind, and women's size charts must be drawn accordingly.

The South African National Standard (SANS: 2008) requires that construction workers be provided with PPE. Although the SANS for protective wear have styling details, specifications and size charts clearly indicated, it does not indicate whether the standard is intended for men only or for both men and women. This indicates that the South African government has to be considerate of the fact that the construction industry is no longer an industry that is male dominated; therefore, there should be an introduction of legislation that specifies standards for women's protective wear.

Currently, legislation calls for appropriate general safety clothing, but provides no specific standard for women's wear. The exclusion of women in the act about PPE is evident for work wear, including work boots, and gloves. It was confirmed that there are plans for improvement though the development of working shoes and gloves for women but no improvements for garments. The current standard used for the manufacturing of protective wear is not considerate of women. Therefore, the South African government should consider the fact that women's interest in joining the construction is increasing rapidly, and therefore launch legislation and standards that will be accommodative of women too.

In answering the third research question, the data revealed support for the assertion that there is a dearth of product offerings of women's protective wear that is ergonomically designed. This state of affairs includes garments with good fit and that are comfortable for women when performing specific occupational tasks in the construction industry. The validity of this assumption was enriched by the feedback from the manufacturing companies and informal interviews with suppliers of protective wear agreeing that there is a deficiency in the product offering protective wear that is suitable for women's physique. With this in mind, the researcher recognizes a need for protective wear that is ergonomically designed to suit women's physique.

Using the information gathered from protective wear manufacturers and women working in the construction field, I have produced size charts and prototypes based on the needs of women in construction. Fit, comfort, and user friendliness of the garments were the main aspects of the design and production process. The evidence from the respondents indicates that the current design of the protective wear is not suitable for women's physique. Moreover, most women users feel protected working in their overalls but inconvenienced by its design.

Fundamentally, work wear is good working attire if it could be customized to the body physique of women. I suggest that the stereotypical thinking of work isolation which hinders the design of work wear friendly to women's body physique should be discarded. I further suggest that regardless of the type of job one is undertaking, working in any practical environment requires a work wear that suits one's body physique and one that enables freedom of movement and allows creativity. It is important that protective clothing is designed with the body physique of the intended user in mind in order to provide a better fit, comfort and mobility on the site. The question regarding protective wear is whether women in construction are aware of the fact that the clothing they wear was meant for the opposite gender or whether they simply adapted to what was at hand.

6.3 CONTRIBUTIONS TO KNOWLEDGE

The study set to generate sufficient interest for updates on protective wear that is already offered by clothing manufacturers and suppliers. For the reason that the available database and standards for protective manufacturing are suitable for men only, the study aims to add to the protective wear manufacturer database used for quality garment manufacturing and quality improvement. Furthermore, it aims to contribute towards the generation of new size developments for women. This will extend the possibility of the development of better functional protective wear for women, which will enhance productivity in the workplace,

through boosted self-confidence and motivation. The development of better functional protective wear will hopefully reduce downtime due to occupational issues of comfort, protection and garment fit problems. Lastly, the study contributes towards a positive body-image of women workers via the improved protective wear.

6.4 LIMITATIONS OF THE RESEARCH

Since the study is primarily a practical research study, the success of the data collection depended on people who are in the business sector, and expected to reach the required daily targets. Additionally, there is admittedly the possibility of skewed data due to a relatively small sample size. The process also identified complications that made it difficult to collect the required data. Complications encompassed the following:

Time constraints and the availability of data. Clothing manufacturers are one of the participants in the study. In the manufacturing industry, time is money; consequently the time that was allocated to the researcher to conduct interviews was very limited. Therefore, not all the intended questions were asked during the allocated time. For the reason that the manager was not readily available, questionnaires had to be distributed via email, and participants took almost a month to answer questionnaires and that interfered with the researcher's time plan. The language barrier could have been a problem, especially if participants are not English speaking; therefore this necessitates the development of two sets of questionnaires, one written in English and another in a language that will accommodate the non-English speaking participants. IsiXhosa was the principal secondary language used.

Limited participation in the research. Limited research knowledge of participants has led to the misconception of the purpose of the research; as a result participants could view the research as a way of disclosing information about the company and refuse to disclose such information. The researcher had to assure participants that information will remain confidential and will be in the possession of the researcher and consent forms were signed for more assurance. Data collection was taken during lunchtime or after working hours, therefore some participants were not willing to participate, fearing the utilisation of their spare time.

Moving the subjects from their workstations for anthropometric data collection. The anthropometric data which is defined by Mullet, Moore and Young (2009:212) as the "measurement data on the dimensions of specified body areas of a large sample of the population being studied" was collected via a non-mobile 3D Body Scanner that is situated

at Cape Peninsula University of Cape Town (CPUT), Bellville campus. Some participants were not willing to move to the venue where the scanner is located.

6.5 SUMMARY

Although protective wear gives the necessary protection of one's body and other garments, the design of the current protective wear infringes on the women's body physique. During data collection, respondents were concerned, for example, with the crotch and centre back height of the current work wear that was not relevant to the women's body. Regarding the crotch, most of them were concerned that on most new sites, there is limited privacy in respect of washrooms. In most cases men and women share the same places of convenience; whereas men easily manoeuvre and take advantage of their body physique and the crotch/fly, it is more inconvenient to a woman because one needs more time to remove the pants irrespective of her intentions to visit the washroom. Regarding the centre back, most women felt that current pants are not accommodative to a female structure where women appear to be broader than men around the hip and back areas. As a result they feel uncomfortable when performing tasks that require bending and squatting because such positions reveal their underwear and that makes them feel uncomfortable.

The data also revealed that community perception of women in protective wear was not supportive of their profession. In most cases when women put on work wear, they are equated to their male counterparts and usually not respected as ladies or sometimes referred to as gentlemen because of their dress code. That the SABS has no specifications that take care of pregnant women and as such one has to put an oversize overall to accommodate one's pregnancy, the researcher designed protective wear that will also be accommodative to pregnant women.

Generally, protective wear is good working attire – it just needs adjustments and to be customized to the body physique of women and for it to serve the women on site. Most women users feel protected working in it but inconvenienced by its design. Due to the information gathered, I further suggest that regardless of the type of job one is undertaking, working in any practical environment requires a work wear that suites one's body physique and one that enables freedom of movement and allows creativity. It is important that protective clothing is designed with the end-user of the product in mind.

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APPENDIX A: Materials as specified in SANS 434:2008

1. Fabric types	Reference Code	Description
• Woven cotton and similar apparel fabrics	• SANS 1397-10	
• Pocketing - This shall consist of outer material, or a warp-knitted pocketing that complies with the approved code.	• SANS 1008	Warp-knitted pocketing
2. Outer material		
The outer material shall be a fabric that complies with the relevant requirements. • **Elastic webbing** - Minimum width of 30mm and must comply with the requirements for type 1 of the relevant requirements.	• SANS 1261-3 item 3, or SANS 1387-2, OR SANS 1387-3 • SANS 142.	Woven cotton and similar fabric Narrow elastic and strip
3. Fasteners		
• Buttons – Acceptable four-hole, dyed plastic buttons of minimal diameter 15mm and of a colour that is an acceptable match to that of the fabric with which they are used.	• None	None
• Press-studs – Intrinsically corrosion-resistant metal press-studs of male and female ring type, and shall have a smooth finish. The inside diameter of the hole in the female section shall be at least 4mm.	• None	None
• Interlocking slide fasteners -	• Class C slide fasteners of	Slide fasteners

Slide fasteners shall comply with the relevant requirements for performance	SANS 1822 ,	
• If metal fasteners are used, they shall be of an intrinsically corrosion-resistant metal (other than brass or aluminium). The colour of the stringers of a fastener shall be an acceptable match to that of the fabric with which the slide fastener is used.	• None	None
• Hook and loop fasteners - these shall have nominal width 25mm and shall comply with the requirements. The colour of the fasteners shall be an acceptable match to that of the fabric with which they are used.	• SANS 1823.	Touch and close fasteners
• **Sewing thread:** a polyester-and-cotton core-spun thread or a staple polyester thread. Ticket No 80. • **Overlocking thread:** a crimp-textured polyester thread, the colour of the threads shall be an acceptable match to that of the material with which they are used.	• None • Ticket No 80. • Ticket No.140.	None

APPENDIX B: Design and garment construction as specified in SANS 434:2008

Garment Parts	SABS Specification
• **Cuffs**	**Plain cuffs** - plain cuffs with a hem. **Ruched cuff** - ruched with elastic. **Open cuffs** - faced with outer material on the inside of the cuff. The facing shall be of width 12cm at the opening, tapering to 50mm at the forearm. The opening shall be a slit at the position of the hind arm for the insertion of the opening cuff and shall be of length 10cm. The opening shall be securely bar-tacked across at the top end. Open shall fasten with a button and buttonhole or with a press stud. **Shirt type cuffs** - a folded length of outer material of finished width 65mm. The opening shall be a slit at the position of the back arm, and shall be bound with outer material or turned in and stitched and finished at the top with a dart. Alternatively at the back arm, a gap of 40mm may be left between each end of the cuff.
• **Front fastening**	The bottom of the opening shall be securely bar-tacked. All raw edges shall be overlocked or bound, or turned in and stitched. The opening shall be one of the following : **1. Fly-fronts:** a fly-front shall fasten with at least six buttons or with a slide fastener. 1.2 The slide fastener shall have one or two sliders, and shall be secured with two rows of stitching. 1.3 The front shall be lined with outer material and stitched down at least 35mm from the front edge. 1.4 The fly-facing shall be grown on or sewn on, shall be faced with outer material, and shall be of finished width at least 20mm. 1.5 A button fly shall be securely tacked between each buttonhole.

• **Pockets**	The finished width and depth of a pocket shall be measured from the edge to edge on the outside of the pocket. A rule pocket shall be optional. **1. Breast, hip and rule pocket:** these shall be patch pockets, with rounded, blunted or square corners. The side and bottom edges of a pocket shall be turned in **9mm** and stitched down with two rows of stitching (or only one row on lighter weight polyester-and-cotton garments), the first row being positioned at a maximum of **2mm** and the second row at a maximum of **8mm** from the turned in edge. The mouth of the pocket shall be hemmed and each end of each pocket mouth shall be securely bar-tacked. **1.1 Rule Pockets -** shall be sewn in with the side seam on the back panel, approximately **70mm** below the level of the bottom of the hip pocket on the right-hand side. **1.2 Side Pockets -** the side pocket shall have a slanted mouth opening of finished length 18 cm and shall be an inside patch pocket of outer material. Each end of each pocket mouth shall be securely bar-tacked.
• **Pocket flaps**	**Breast pocket flaps** - shall be mitred or square and shall be lined with outer material and shall fasten in the centre with a button and buttonhole, or with a press stud, or with a hook and loop fastener. All flaps shall be of depth at least **50mm,** and a mitred flap shall taper at least **30mm** at the ends. A flap shall be of such length as to overlap the pocket width on each side and shall be positioned **10mm** above the pocket mouth and shall be adequately secured at each end.
• **Buttonholes**	Buttonholes shall be large enough to accommodate the buttons and shall be as follows: **For all riveted buttons**, or for buttons that have a shank. For four-hole plastic buttons, a shirt type buttonhole may be used.

• **Buttons**	Buttons shall be securely sewn or reverted in positions that correspond to those of the appropriate buttonholes.
• **Hanger**	A hanger of outer material folded double, or of an acceptable tape, of finished length **70mm** and finished width **6mm**, shall be securely sewn in with the collar at the back on the inside.
• **Bottoms**	The bottoms of the legs shall be plain and hemmed.
• **Hems**	Hems (except breast pocket hems) shall be of minimum width **10mm,** and the edge shall be turned in 5mm and stitched 2mm from the turned-in edge.

Pocket sizes

Pocket types	**Width, min - mm**	**Depth, min - mm**
Breast	140	150
Hip	150	180
Rule	80	230
Side (swing and patch)	170	150

APPENDIX C: Designing of work wear suits as specified in SANS 434:2008

Jacket	
The jacket shall have a collar or a plain V-neck. The front shall be an open type with fastenings, or a closed front (pull over type). **The jacket bottom** shall have a plain hem, with or without side vents or a waistband. **Pockets** shall be with or without flaps. **Sleeves** shall be one-piece of two pieces, long or short, and set-in, and except for short-sleeved jackets, and shall have any cuff as required.	
• **FRONTS**	Front edges shall have sewn-on or grown-on facings of width **50mm** and the inside edges of a facing shall be turned in and neatly stitched down or overlocked.
• **Slide fastener fronts**	The fronts shall fasten with a slide fastener that extends to within **100mm** of the bottom hem.
• **Button fronts**	**A button front** shall have at least four buttons or press studs as required and shall have a fly that is lined with outer material and sewn down at least **35mm** from the front edge. **A fly** shall be securely tacked between each buttonhole. The inside edges of a fly shall be overlocked or turned in and neatly stitched down.
• **Closed fronts**	**A closed front** shall have yokes that extend to the level of the front sleeve pitch. At the centre front, the yokes shall overlap each other by at least **30mm.**
• **BACK**	The back shall be plain (no centre back seam) or shall have yoke of depth at least **80mm.** The pleats shall be of depth at least **10mm** and shall be positioned at least **80mm** and the steps shall be at least **35mm** long.
• **Collars**	**Collars** shall be of the open-neck step collar type. **The under-collar** shall be of outer material. The shape shall be of such to be acceptable, the width at the centre back shall be **80mm** and the steps shall be at least **35mm** long.

• **Jacket bottom finish**	**The bottom** of a jacket shall be finished with a plain hem with side vents or a waistband, **Plain Bottom:** the bottom of a jacket shall have a finished width **15mm.** **Plain bottom with vents:** the bottom of a jacket shall have a hem of finished width **15mm** and vents at the side seam that are of finished length at least **100mm.** **Waistband bottom:** the waistband shall be of outer material that is folded along the bottom edge to form a self-lining and shall be of finished width at least **30mm**. The front shall fasten with a button and buttonhole or with a press stud. **Adjustment tabs:** adjustment tabs shall be of acceptable size and shape shall fasten with a button and buttonhole, or with a press stud, or with a hook and loop fastener. Shall be attached at the side seams on the waistband or above the side vents, and shall give an adjustment of **50mm** on each side.
• **TROUSERS**	
• **Fronts**	Shall be inserted in the right front waistband seam.
• **Backs**	The backs shall be plain, and shall have one or two hip pockets and a rule pocket if required.
• **Fly**	The fly shall be lined with outer material and shall be stitched at least 35mm from the front edge. The closure shall be by means of a slide fastener or at least four buttons.
• **Fly-facing**	The fly catch shall be sewn on or grown on and shall be of finished width at least 30mm.
• **Waistband**	The waistband shall be sewn or grown on. The back shall be ruched from side to side. A finished waistband shall be of width at least 40mm unless otherwise specified. Each pair of trousers shall have five belt loops on sizes with a waist measurement not exceeding 83cm, and seven belt loops on larger sizes. The belt loops shall be of width of 10mm and of such length as to accommodate the belt used with the trousers.

APPENDIX D: Questionnaire conducted with female construction workers
(Author's Construct 2012)
Consent form

Study Title	Ergonomic considerations for the design of women's functional protective wear for the local construction industry.
Investigator	Ms Bongiwe Kolisi
Name of the Institution	Cape Peninsula University of Technology (Cape Town Campus).
Supervisor	Ms Annadine Vlok (Cape Peninsula University of technology)
Co Supervisor	Prof. Mugendi M'Rithaa (Cape Peninsula University of Technology)

Ms Kolisi is a master's candidate, studying the availability of the protective wear designs that adequately fits and accommodates women's body structure when performing outdoor activities within the construction industry.

Contribution of the study

- Study will generate sufficient interest for updates on protective wear that is already offered by manufacturers and suppliers.
- It will add to protective wear manufacturer database used for quality garment manufacturing and quality improvement.
- Study will contribute towards the generation of new size developments for women by making use of the 3D Body Scanner.
- It will reduce downtime due to occupational issues of comfort, protection and garment fit problems.
- Possible developments of better functional protective wear for women will enhance productivity in the workplace, through boosted self-confidence/motivation.
- Study will contribute towards positive body image of women workers.

The study supervisors and other appropriate authorities at Cape Peninsula University of Technology (CPUT), in the Western Cape Province, have approved the study and its procedures.
The study procedures involve no foreseeable risk or harm to you. The procedures include:

1. *responding to a questionnaire about your response to design for Protective Wear for women in the construction industry,* and
2. *participation in interviews conducted by Ms Bongiwe Kolisi with an aim of collecting the data that will be used in the study.*

Participation in this study will take approximately 20 (twenty) minutes of your time.
Please feel free to ask any questions about the study or about being a participant/subject and you may call Ms Bongiwe Kolisi via the following information:

Contact Details
Office Tel Number : 021-4603453
Mobile Number : 083 4693 656
Email Address : KolisiB@cput.ac.za

Ref	CT	0	0	1

Bongiwe Kolisi _ date ……

The study data will be coded so they will not be linked to your name. Your identity will not be revealed while the study is being conducted or when the study is reported or published unless you give explicit consent for the same. To ensure anonymity and confidentiality, all study data will be collected by Ms Kolisi, stored in a secure place, and not shared with any other person without your permission.

I have read this consent form and voluntarily consent to participate in the study:

Signature of Participant/Informant …….
Date……

Signature of Witness……...
Date……..
I have explained this study to the above subject and have sought his/her understanding for informed consent:

Signature of Investigator……
Date……

Bongiwe Kolisi _ date .....

Ref	CT	0	0	1

APPENDIX E: Questionnaire conducted with protective wear manufacturer (Author's Construct 2012)

Garment Design

Q 1. What influences the design of the current protective wear?

_____

_____

_____

Q 2. Are there any specifications that influence the design process?

_____

Q 3. Are the current designs suitable for both male and female use?

1. Yes ☐ 2. No ☐

Q 4. If No, were there any previous attempts to design and produce protective wear particularly to suit women's physique?

_____

Q 5. If yes, please provide detailed information

_____

_____

Q 6. In your opinion, is it necessary to have protective wear that is specifically designed for women, in view of the increased number of women joining the construction industry?

_____

_____

Q 7. What challenges do you anticipate in designing protective wear for women?

_____

_____

Q 8. Kindly add other comments or suggestions you might have:

_____

_____

Thank you for your time and valuable input.
Do you grant me permission to cite you in my research?
1 .Yes ☐ 2. No ☐

Official use only		Interviewer's Name : **Bongiwe Kolisi**					Signature				
Date		Start time					End Time				
Scrutinized		Yes	1	No	2	by(name)		Signature			
Questionnaire Serial Number							CT	0	0	2	

APPENDIX F: Questionnaire conducted with female construction workers
(Author's Construct 2012)

Garment Design

Q 1. From the current range of protective wear, do you prefer?

a) Coveralls

1. Yes ☐ 2. No ☐

b) Work suits

1. Yes ☐ 2. No ☐

Q 2. Are you happy about the style of your coverall or work suits?

a) Coveralls

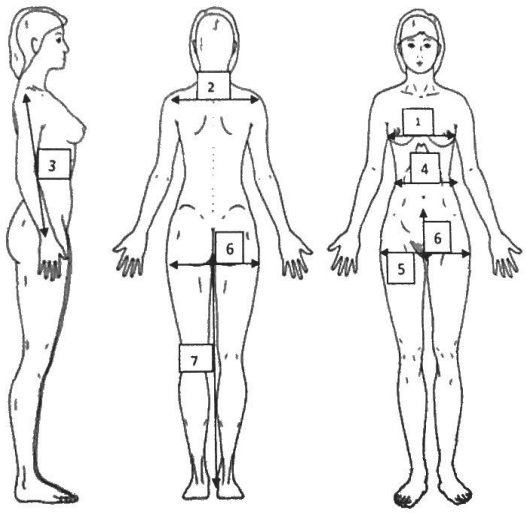
Yes ☐ 2. No ☐

b) Work suits

Yes ☐ 2. No ☐

Q 3. Which part of your work wear would you like to improve?
(Please base your answer on the information listed on the diagram below by indicating with an X next to the Body Dimensions provided below).

Body Dimensions	Code
Bust	1
Across back	2
Sleeve length	3
Waist	4
Hip	5
Crotch/fly front	6
Leg length/shape	7
Other	8



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Q 4. Do you receive any comments from your co-workers about your work wear?

1. Yes ☐ 2. No ☐

If yes, use the diagram below and indicate with an X next to the areas of concern.

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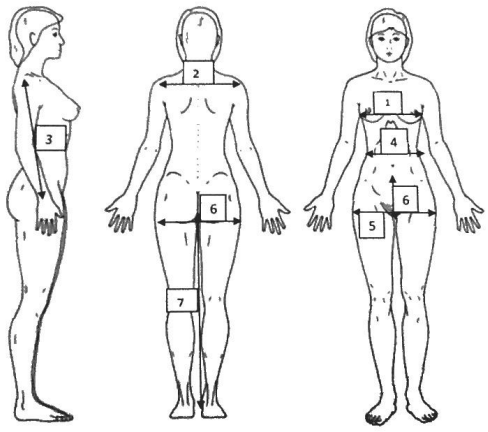
Body Dimensions	Code
Bust	1
Across back	2
Sleeve length	3
Waist	4
Hip	5
Crotch/fly front	6
Leg length/shape	7
Other	8



Q 5. Kindly add other comments or suggestions you might have about the current protective wear:

Thank you for your valued time and input.

Do you grant me permission to cite you in my research?

1. Yes ☐ 2. No ☐

Official use only		Interviewer's Name : **Bongiwe Kolisi**						Signature			
Date		Start time						End Time			
Scrutinized		Yes	1	No	2	by(name)		Signature			
Questionnaire Serial Number								CT	0	0	3

APPENDIX G: Questionnaire conducted with female construction workers (Author's Construct 2012)

Garment Fit

Q 1. How important is it to you that your work clothing fits comfortably while performing your daily tasks?

1. Not important at all	2.Somewhat not important	3. Neither important nor unimportant	4.Somewhat important	5. Very important

Q 2. Are you able to differentiate between a good fitting garment and an ill-fitting garment?

1. Yes ☐ 2. No ☐

Q 3. Does the fit of the available protective wear allow you to execute your tasks effectively?

1. Yes ☐ 2. No ☐

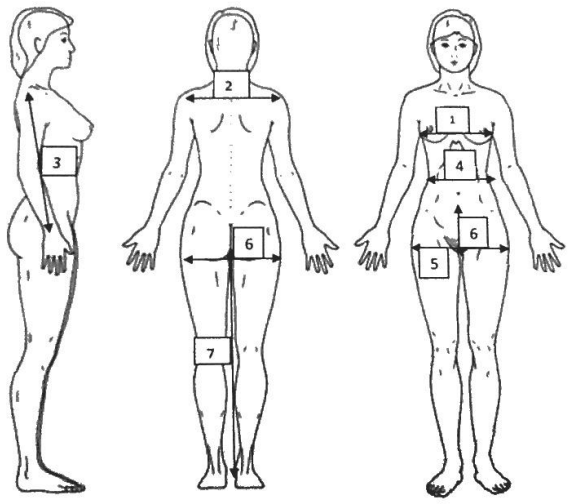
Q 4. How comfortable is your work wear in comparison to your everyday wear?

1.Very uncomfortable	2.Somewhat uncomfortable	3.Neither comfortable nor uncomfortable	4.Somewhat comfortable	5.Very comfortable

Q 5. Which parts of your work wear would you like to change in order to improve the comfort of your garment?
Please indicate an area that you feel should be improved via an X next to the options provided below.

Jackets and Pants

Body Dimensions	Code
Bust area	1
Across back	2
Sleeve length	3
Waist	4
Hip	5
Crotch/fly front	6
Leg length/shape	7
Other	8



Page 1of 2

Q 5. Kindly add other comments or suggestions you might have:

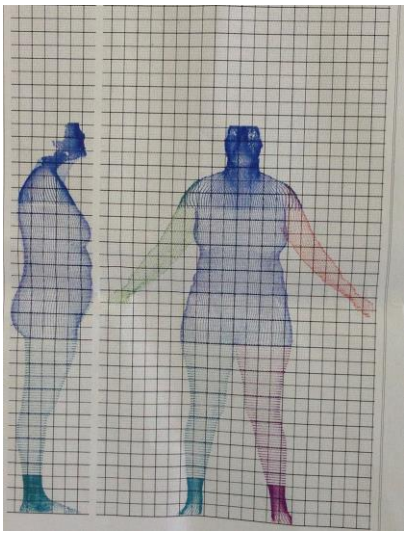
Thank you for your time and valuable input.

Do you grant me permission to cite you in my research?

2. Yes ☐ 2. No ☐

Official use only		Interviewer's Name : **Bongiwe Kolisi**							Signature		
Date		Start time							End Time		
Scrutinized		Yes	1	No	2	by(name)			Signature		
Questionnaire Serial Number									CT	0	0	4

APPENDIX H: Female Body Scan Samples of size 34 and 40 (Captured by author: 2014)



APPENDIX I: Anthropometric data collection sheet (Author's Construct 2013)

Group Details							
Group Name				**CPUT Student Volunteers**			
Date				**26/10/13 & 16/11/13**			
#	**Subject code**	**Permission**	**Date of birth**	**Age**	**Height**	**Weight**	**Dress size code**
1	A1	✓	**22/08/89**	**24**	**152.0**	**44.9**	**30**
2	A2	✓	**26/09/64**	**49**	**164.6**	**70.0**	**34**
3	A3	✓	**13/06/71**	**42**	**161.0**	**61**	**34**
4	A4	✓	**02/05/83**	**30**	**161.0**	**63.0**	**34**
5	A5	✓	**27/09/69**	**44**	**163.0**	**67**	**34**
6	A6	✓	**09/09/70**	**43**	**165.5**	**61.8**	**34**
7	A7	✓	**25/06/84**	**29**	**164.5**	**68.1**	**36**
8	A8	✓	**03/05/58**	**55**	**152.7**	**69.6**	**36**
9	A9	✓	**13/02/73**	**40**	**154.0**	**75**	**36**
10	A10	✓	**14/11/67**	**46**	**163.5**	**66.5**	**36**
11	A11	✓	**13/02/77**	**36**	**165.2**	**69**	**36**
12	A12	✓	**27/12/64**	**48**	**165.0**	**80.9**	**36**
13	A13	✓	**30/08/57**	**56**	**164.5**	**84.3**	**38**
14	A14	✓	**10/12/62**	**50**	**160.0**	**76.5**	**38**
15	A15	✓	**15/02/75**	**38**	**167**	**74.1**	**38**
16	A16	✓	**02/02/61**	**52**	**161.7**	**81.7**	**40**
17	A17	✓	**07/07/67**	**44**	**164.5**	**78.8**	**40**
18	A18	✓	**30/08/57**	**56**	**164.5**	**84.3**	**40**
19	A19	✓	**17/01/55**	**58**	**150**	**81.4**	**40**
20	A20	✓	**14/10/67**	**46**	**162**	**86.5**	**40**
21	A21	✓	**01/10/74**	**39**	**161.0**	**75.9**	**40**
22	A22	✓	**17/08/62**	**50**	**162**	**87**	**40**
23	A23	✓	**30/09/78**	**35**	**162.7**	**104.4**	**42**
24	A24	✓	**02/03/68**	**45**	**164.2**	**102.1**	**42**
25	A25	✓	**21/06/75**	**38**	**165**	**103.2**	**42**
Measurer & Operator's signature					**: Date**		
Researcher's signature					**: Date**		

APPENDIX J: Body Measurement Sheet

Group Details									
Group Name						**CPUT Student Volunteers**			
Captured by :						**Ms Bongiwe Kolisi**			
Dates Captured :						**26/10/13 & 16/11/13**			
Subject Code	**Dress size**	**Bust full**	**Waist full**	**Hips full**	**Inseam**	**Seat full**	**Thigh right**	**Thigh height**	**Outseam max**
A1	30	78.02	61.79	90.13	67.63	86.8	50.21	62.63	96.15
A2	34	90.85	82.65	111.82	73.79	106.95	63.17	68.79	113.45
A3	34	90.50	74.03	106.10	78.89	105.12	61.88	73.89	106.70
A4	34	93.34	77.15	106.11	74.66	101.88	59.72	69.66	107.32
A5	34	92.47	75.02	104.37	70.68	101.18	60.30	65.68	102.70
A6	34	90.57	71.36	105.65	77.72	100.68	60.72	72.72	107.21
A7	36	102.69	82.76	106.39	71.61	104.17	58.25	66.61	106.86
A8	36	94.35	74.93	107.78	79.14	101.41	62.54	74.14	108.73
A9	36	107.58	84.42	113.60	67.96	112.73	69.67	62.96	103.01
A10	36	89.54	70.97	116.97	83.04	113.29	68.68	78.04	116.14
A11	36	91.71	78.15	108.94	76.10	107.29	62.64	71.10	101.17
A12	38	112.46	89.48	115.43	76.17	113.85	65.94	71.19	110.26
A13	38	107.58	94.05	120.51	69.21	119.68	65.15	64.21	102.0
A14	38	101.73	86.89	123.46	70.18	122.30	70.63	65.18	105.82
A15	38	100.73	96.54	120.76	75.3	120.54	69.44	70.21	104.34
A16	40	106.67	90.05	116.88	70.07	115.57	63.76	65.07	106.63
A17	40	106.67	90.05	116.88	70.07	115.57	63.76	65.07	106.63
A18	40	116.85	106	118.45	61.93	120.4	61.37	56.93	70.46
A19	40	120.51	100.64	120.54	65.77	120.44	66.1	60.77	99.45
A20	40	118.25	102.31	120.56	71.55	120.17	66.93	66.44	104.5
A21	40	110.14	89.54	119.46	64.84	118.45	64.76	62.84	97.75
A22	40	118.25	102.31	120.56	71.44	120.17	117.88	66.44	104.51
A23	42	125	109.41	135.44	67.97	135.44	71.32	62.97	100.39
A24	42	119.46	109.69	123.29	70.35	122.81	63.00	65.35	96.60
A25	42	120.5	118.71	120. 80	71.50	123.0	70.11	55.4	101.23

APPENDIX K: Descriptive Statistics

	Dress size	Bust full	Waist full	Hips full	Inseam	Seat full	Thigh right	Thigh height	Outseam max
N	25	24	25	25	25	25	25	25	25
Mean	37.52	103.46	88.7732	114.8452	71.9112	113.1812	66.36	66.56	103.20
Median	38.00	104.68	89.4800	117.0000	71.4400	116.0000	64.00	66.00	105.00
Std. Error of Mean	.625	2.486	2.87779	1.79233	.97644	2.08168	2.347	1.062	1.683
Minimum	30	78	61.79	90.13	61.93	86.80	50	55	70
Maximum	42	121	119.00	135.00	83.00	135.00	118	78	116
Std. Deviation	3.124	12.180	14.38896	8.96165	4.88218	10.40838	11.736	5.308	8.416
Variance	9.760	148.343	207.042	80.311	23.836	108.334	137.740	28.173	70.833

APPENDIX L: Descriptive Statistics - per Dress Size

Dress size		Bust full	Waist full	Hips full	Inseam	Seat full	Thigh right	Thigh height	Out seam max
30	N	1	1	1	1	1	1	1	1
	Mean	78.02	61.7900	90.1300	67.6300	86.8000	50.00	63.00	96.00
	Median	78.02	61.7900	90.1300	67.6300	86.8000	50.00	63.00	96.00
	Std. Error of Mean	.	.	.	.	.	.	.	.
	Minimum	78	61.79	90.13	67.63	86.80	50	63	96
	Maximum	78	61.79	90.13	67.63	86.80	50	63	96
	Std. Deviation	.	.	.	.	.	.	.	.
	Variance	.	.	.	.	.	.	.	.
34	N	5	5	5	5	5	5	5	5
	Mean	91.58	76.1020	106.9520	75.2760	103.1120	61.20	70.40	107.40
	Median	91.00	75.0000	106.1100	74.6600	101.8800	61.00	70.00	107.00
	Std. Error of Mean	.498	1.95959	1.35283	1.41656	1.23641	.583	1.435	1.600
	Minimum	91	71.36	104.00	71.00	100.68	60	66	103
	Maximum	93	83.00	112.00	79.00	107.00	63	74	113
	Std. Deviation	1.114	4.38178	3.02502	3.16754	2.76469	1.304	3.209	3.578
	Variance	1.242	19.200	9.151	10.033	7.644	1.700	10.300	12.800
36	N	5	5	5	5	5	5	5	5
	Mean	97.34	78.1520	110.6780	75.5220	107.6340	64.60	70.60	107.20
	Median	94.00	78.0000	109.0000	76.0000	107.0000	63.00	71.00	107.00
	Std. Error of Mean	3.434	2.41394	2.07043	2.64698	2.38746	2.205	2.619	2.615
	Minimum	90	71.00	106.39	68.00	101.00	58	63	101
	Maximum	108	84.00	117.00	83.00	113.00	70	78	116
	Std. Deviation	7.678	5.39773	4.62962	5.91882	5.33852	4.930	5.857	5.848
	Variance	58.951	29.136	21.433	35.032	28.500	24.300	34.300	34.200
38	N	4	4	4	4	4	4	4	4
	Mean	105.69	91.8550	120.1000	72.6400	119.5000	67.75	67.50	105.50
	Median	104.66	91.7650	120.7550	72.5900	120.5000	67.50	67.50	105.00

	Std. Error of Mean	2.694	2.26533	1.68515	1.72837	1.93649	1.377	1.756	1.708
	Minimum	101	86.89	115.43	69.21	114.00	65	64	102
	Maximum	112	97.00	123.46	76.17	123.00	71	71	110
	Std. Deviation	5.388	4.53067	3.37029	3.45673	3.87298	2.754	3.512	3.416
	Variance	29.028	20.527	11.359	11.949	15.000	7.583	12.333	11.667
40	N	7	7	7	7	7	7	7	7
	Mean	113.95	97.2643	119.0643	67.9429	118.5714	72.14	63.29	98.71
	Median	116.85	100.6400	119.4600	70.0000	120.0000	65.00	65.00	105.00
	Std. Error of Mean	2.205	2.68642	.62141	1.41843	.71903	7.676	1.248	4.980
	Minimum	107	89.54	116.88	61.93	116.00	61	57	70
	Maximum	121	106.00	120.56	71.55	120.00	118	66	107
	Std. Deviation	5.834	7.10759	1.64410	3.75281	1.90238	20.310	3.302	13.175
	Variance	34.040	50.518	2.703	14.084	3.619	412.476	10.905	173.571
42	N	2	3	3	3	3	3	3	3
	Mean	120.00	112.6667	126.3333	70.0000	127.0000	68.00	61.00	99.33
	Median	120.00	110.0000	123.0000	70.0000	123.0000	70.00	63.00	100.00
	Std. Error of Mean	1.000	3.17980	4.37163	1.15470	4.00000	2.517	3.055	1.202
	Minimum	119	109.00	121.00	68.00	123.00	63	55	97
	Maximum	121	119.00	135.00	72.00	135.00	71	65	101
	Std. Deviation	1.414	5.50757	7.57188	2.00000	6.92820	4.359	5.292	2.082
	Variance	2.000	30.333	57.333	4.000	48.000	19.000	28.000	4.333
Total	N	24	25	25	25	25	25	25	25
	Mean	103.46	88.7732	114.8452	71.9112	113.1812	66.36	66.56	103.20
	Median	104.68	89.4800	117.0000	71.4400	116.0000	64.00	66.00	105.00
	Std. Error of Mean	2.486	2.87779	1.79233	.97644	2.08168	2.347	1.062	1.683
	Minimum	78	61.79	90.13	61.93	86.80	50	55	70
	Maximum	121	119.00	135.00	83.00	135.00	118	78	116
	Std. Deviation	12.180	14.38896	8.96165	4.88218	10.40838	11.736	5.308	8.416
	Variance	148.343	207.042	80.311	23.836	108.334	137.740	28.173	70.833

APPENDIX M: FREQUENCIES VARIABLES = Dress size

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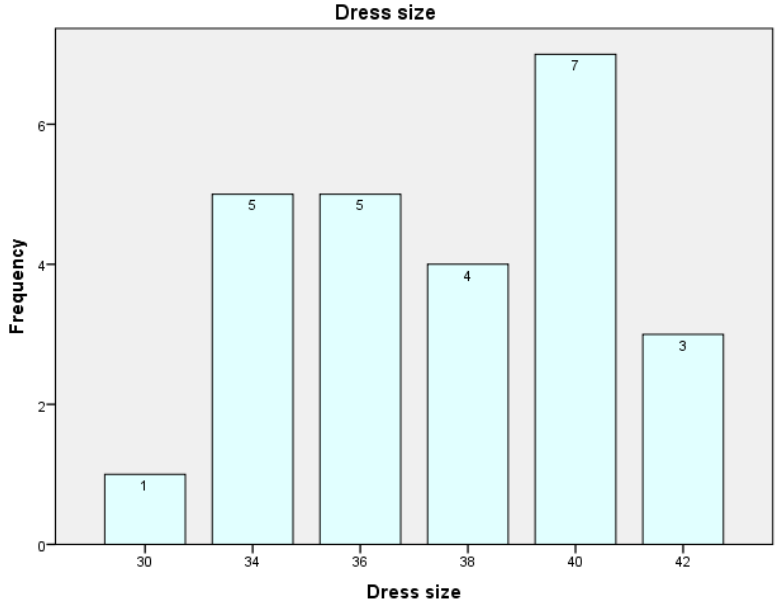
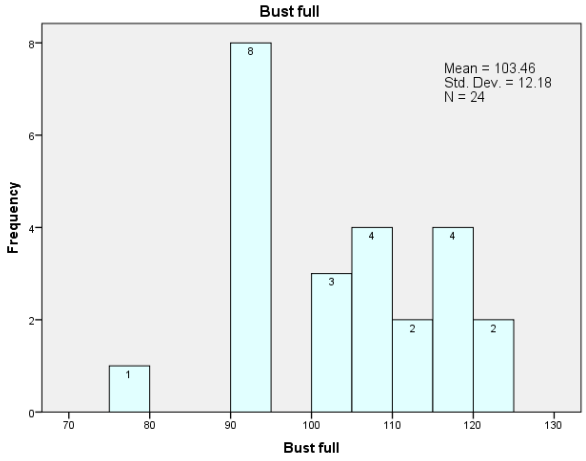
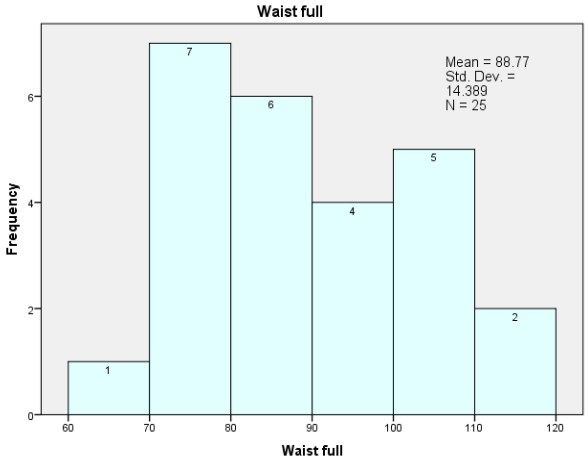
ORDER=ANALYSIS.

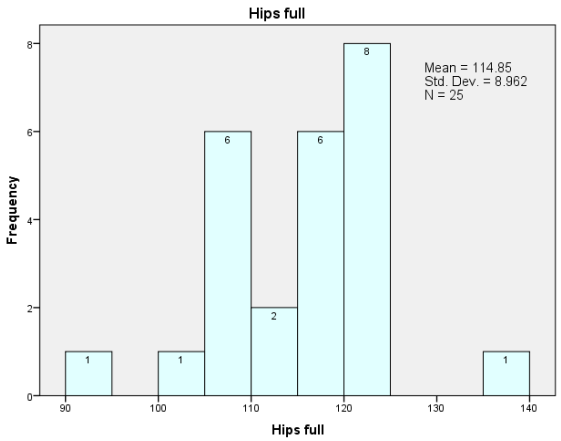


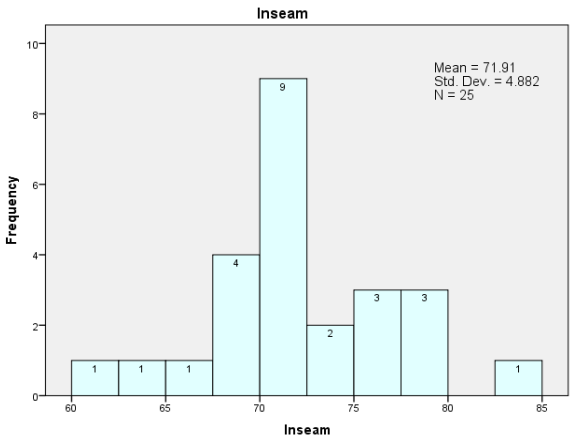
APPENDIX N: FREQUENCIES VARIABLES = Bust full Waist full Hips full Inseam Seat full Thigh right Thigh height Out seam max

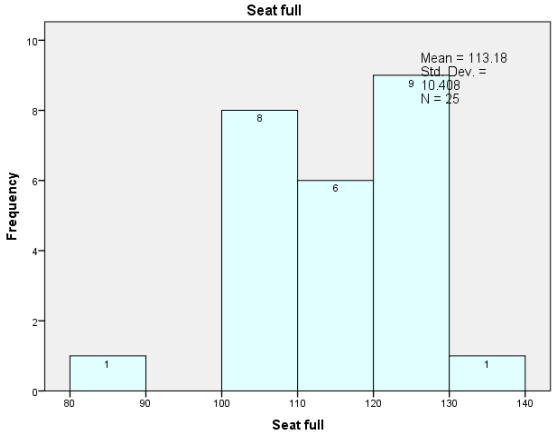
FORMAT=NOTABLE
HISTOGRAM
ORDER=ANALYSIS.

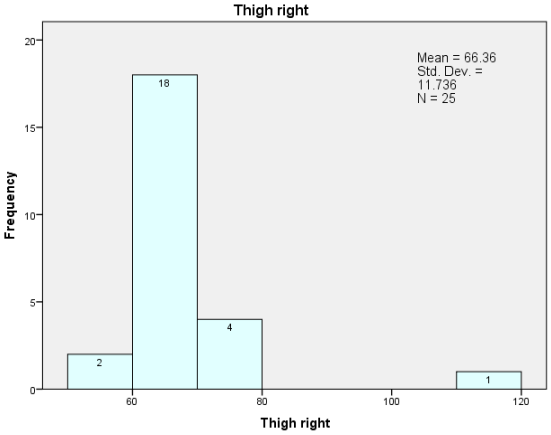


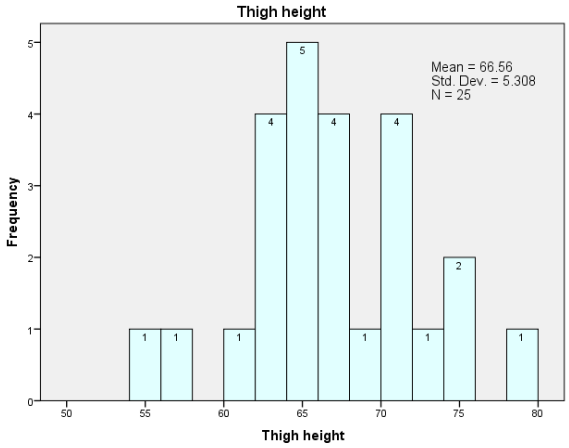



Hips full
Mean = 114.85
Std. Dev. = 8.962
N = 25
Frequency
Hips full


Inseam
Mean = 71.91
Std. Dev. = 4.882
N = 25
Frequency
Inseam


Seat full
Mean = 113.18
Std. Dev. = 10.408
N = 25
Frequency
Seat full


Thigh right
Mean = 66.36
Std. Dev. = 11.736
N = 25
Frequency
Thigh right


Thigh height
Mean = 66.56
Std. Dev. = 5.308
N = 25
Frequency
Thigh height

APPENDIX O: FREQUENCIES VARIABLES (Per Size)= Bust full, Waist full, Hips full Inseam, Seat full, Thigh right, Thigh height, Out seam max

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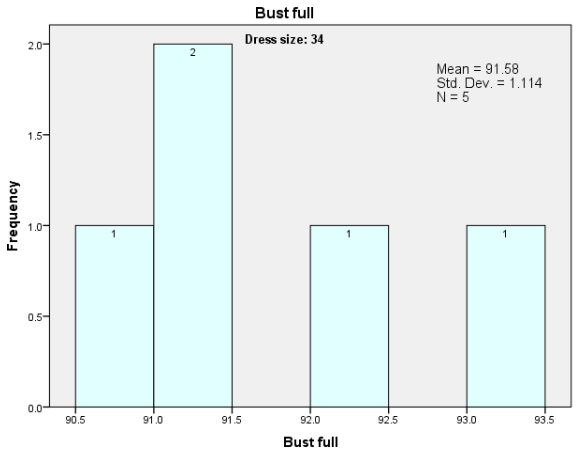
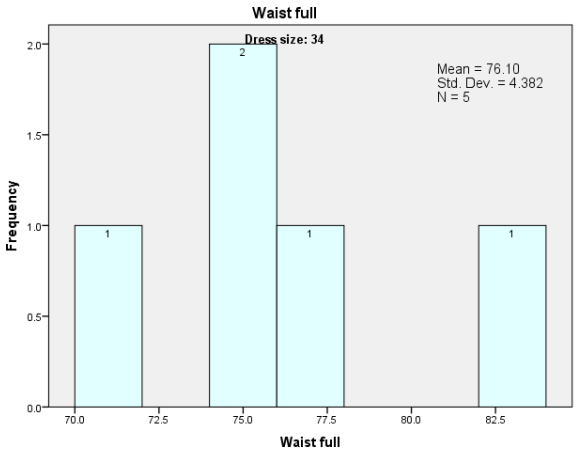
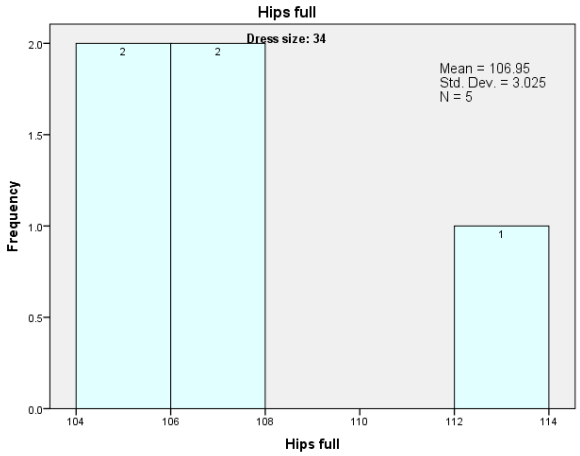
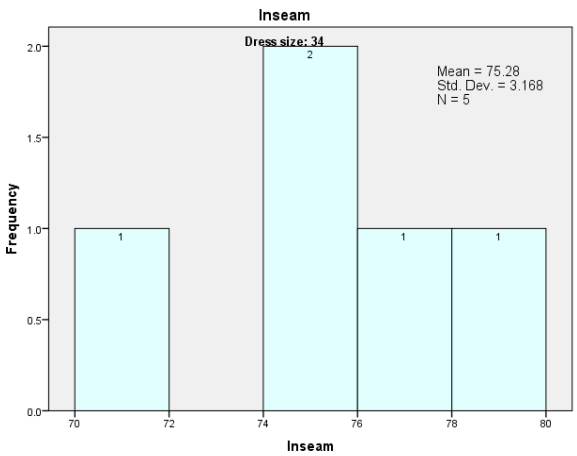
ORDER=ANALYSIS.

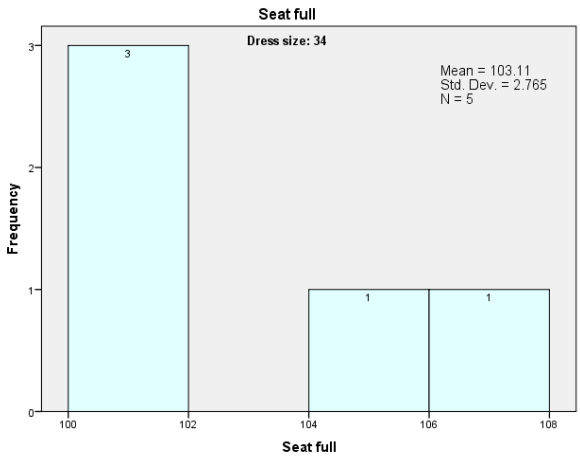
Frequencies

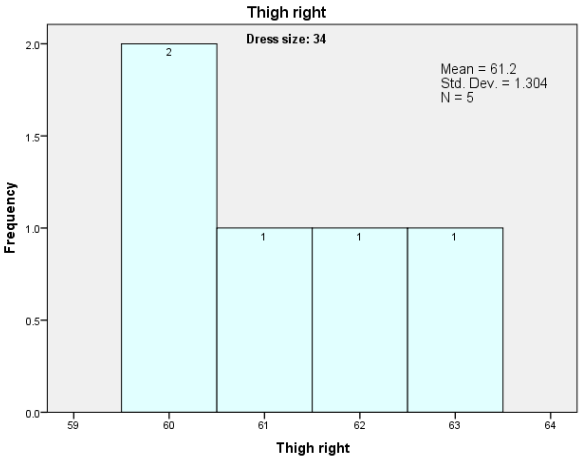


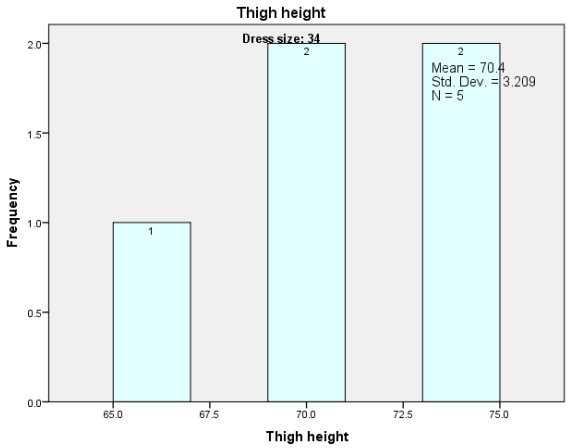


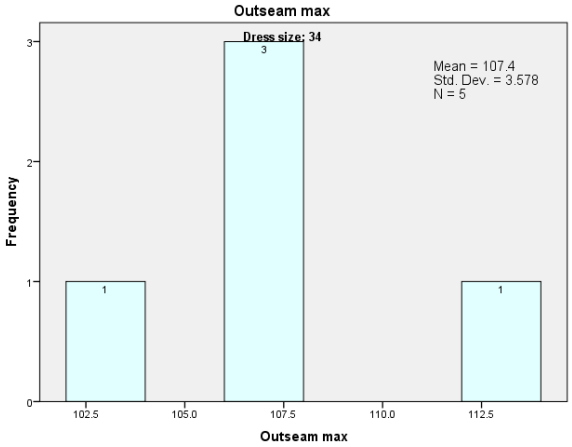


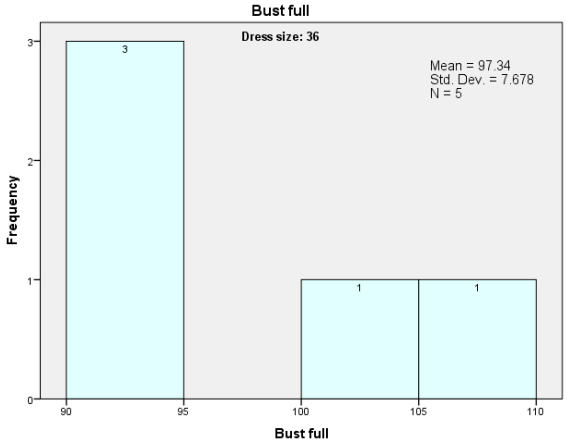


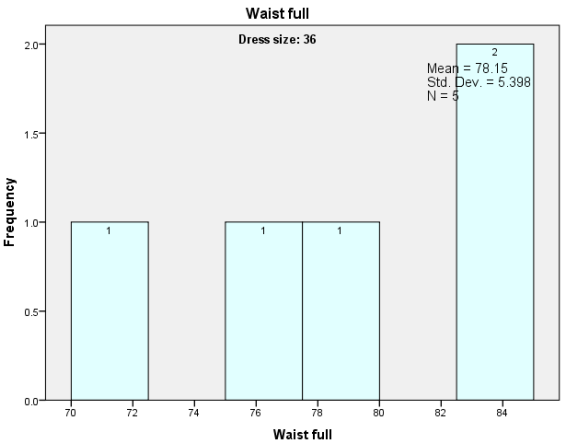


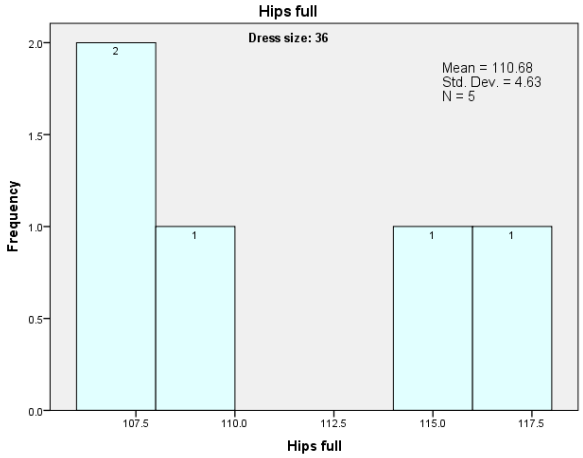


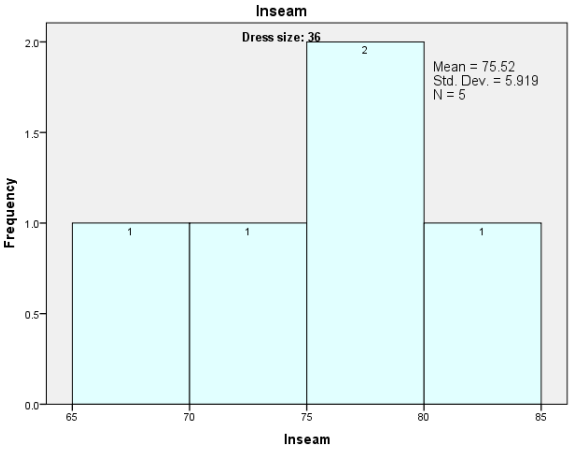

Thigh height
Dress size: 34
Mean = 70.4
Std. Dev. = 3.209
N = 5
Frequency
Thigh height

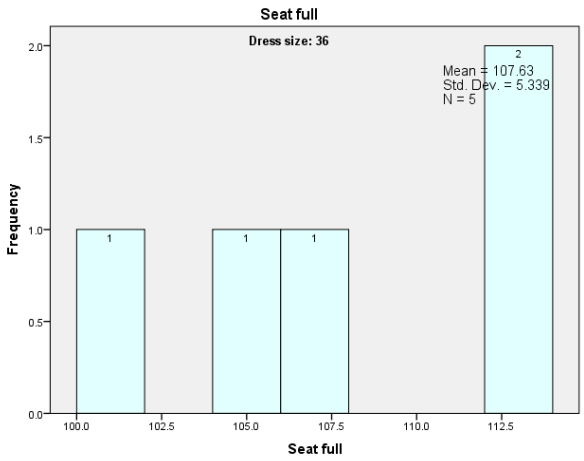

Outseam max
Dress size: 34
Mean = 107.4
Std. Dev. = 3.578
N = 5
Frequency
Outseam max

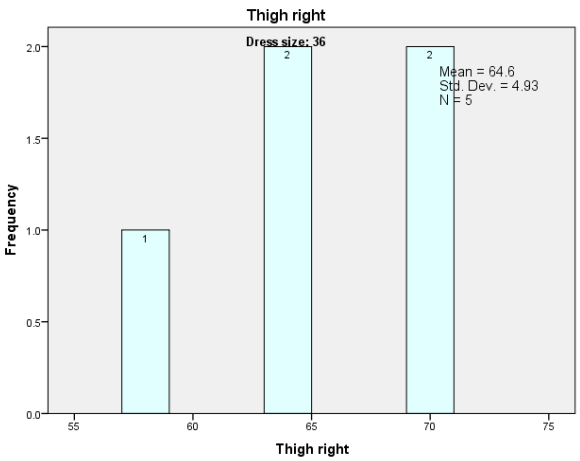

Bust full
Dress size: 36
Mean = 97.34
Std. Dev. = 7.678
N = 5
Frequency
Bust full


Waist full
Dress size: 36
Mean = 78.15
Std. Dev. = 5.398
N = 5
Frequency
Waist full

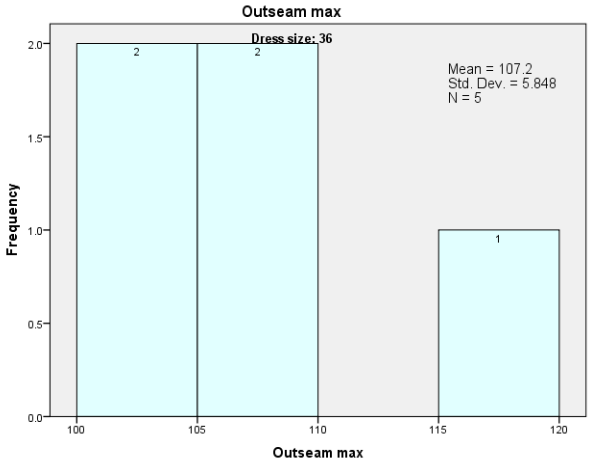

Hips full
Dress size: 36
Mean = 110.68
Std. Dev. = 4.63
N = 5
Frequency
Hips full

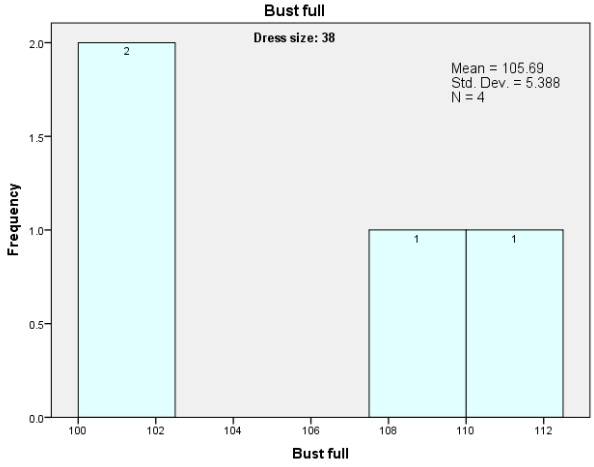

Inseam
Dress size: 36
Mean = 75.52
Std. Dev. = 5.919
N = 5
Frequency
Inseam

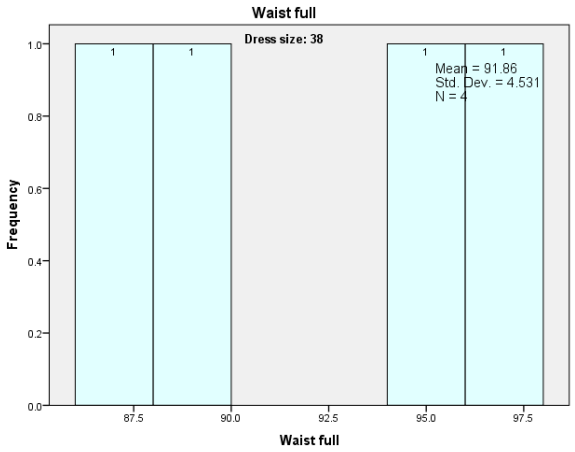

Seat full
Dress size: 36
Mean = 107.63
Std. Dev. = 5.339
N = 5
Frequency
Seat full

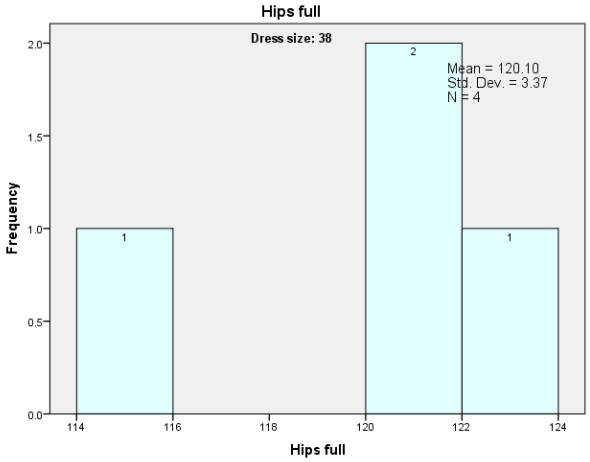

Thigh right
Dress size: 36
Mean = 64.6
Std. Dev. = 4.93
N = 5
Frequency
Thigh right

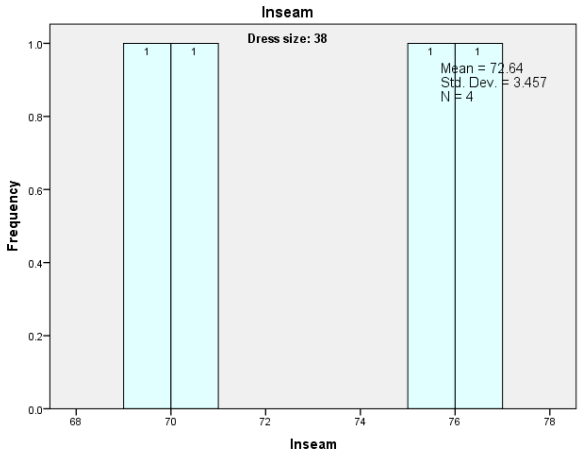

Thigh height
Dress size: 36
Mean = 70.6
Std. Dev. = 5.857
N = 5
Frequency
Thigh height

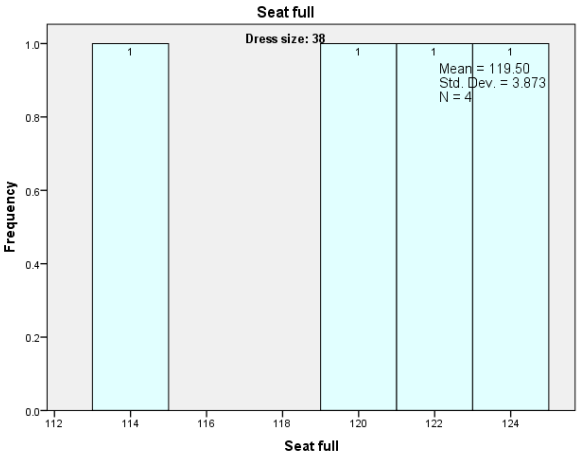

Outseam max
Dress size: 36
Mean = 107.2
Std. Dev. = 5.848
N = 5
Frequency
Outseam max

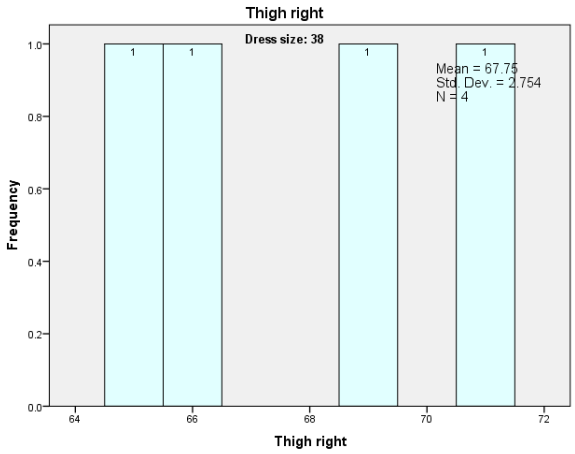

Bust full
Dress size: 38
Mean = 105.69
Std. Dev. = 5.388
N = 4
Frequency
Bust full

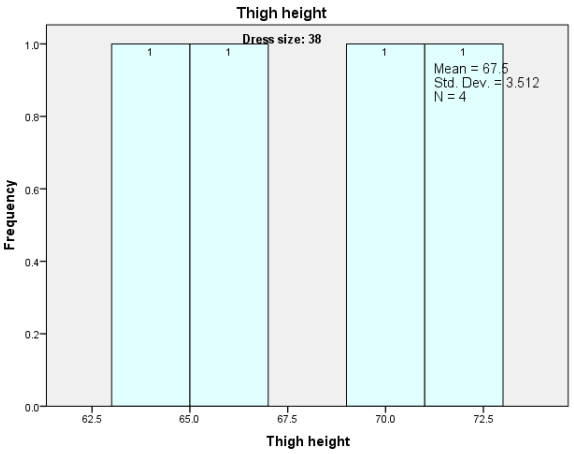

Waist full
Dress size: 38
Mean = 91.86
Std. Dev. = 4.531
N = 4
Frequency
Waist full

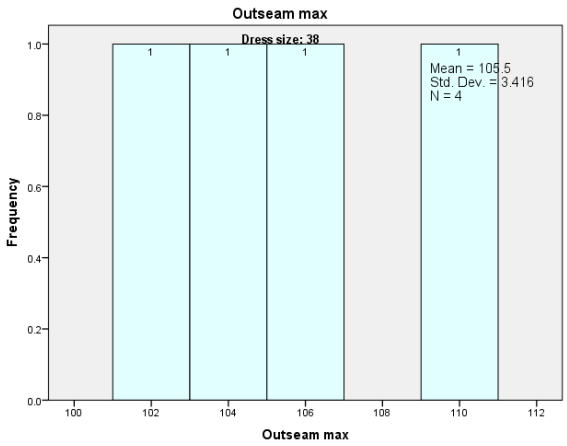

Hips full
Dress size: 38
Mean = 120.10
Std. Dev. = 3.37
N = 4
Frequency
Hips full

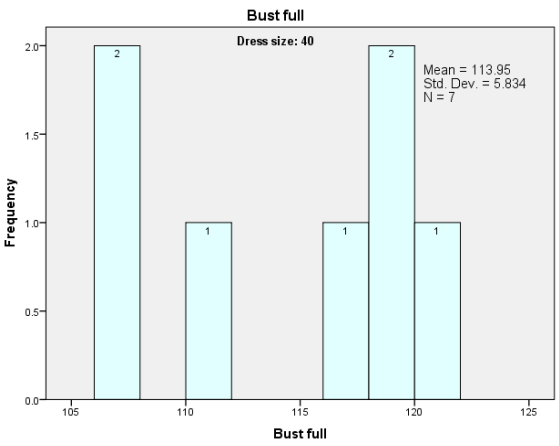

Inseam
Dress size: 38
Mean = 72.64
Std. Dev. = 3.457
N = 4
Frequency
Inseam

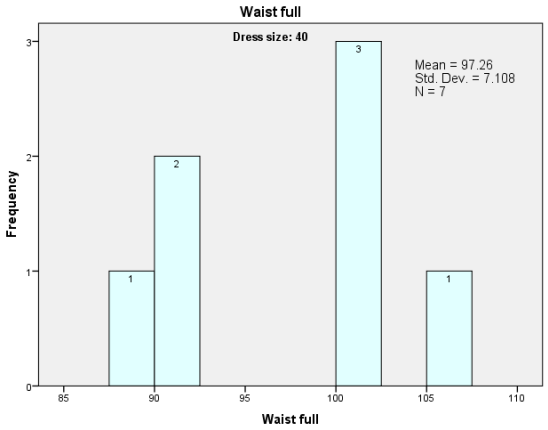

Seat full
Dress size: 38
Mean = 119.50
Std. Dev. = 3.873
N = 4
Frequency
Seat full

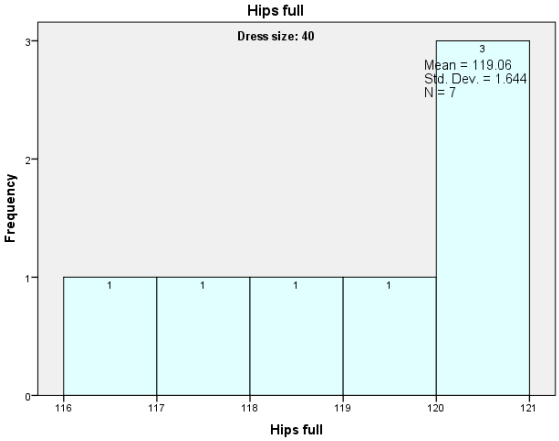

Thigh right
Dress size: 38
Mean = 67.75
Std. Dev. = 2.754
N = 4
Frequency
Thigh right

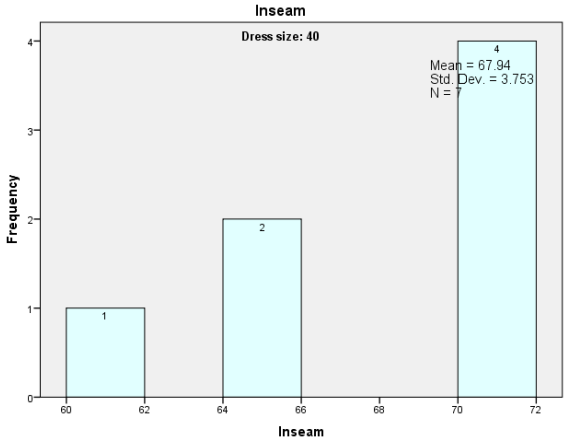

Thigh height
Dress size: 38
Mean = 67.5
Std. Dev. = 3.512
N = 4
Frequency
Thigh height

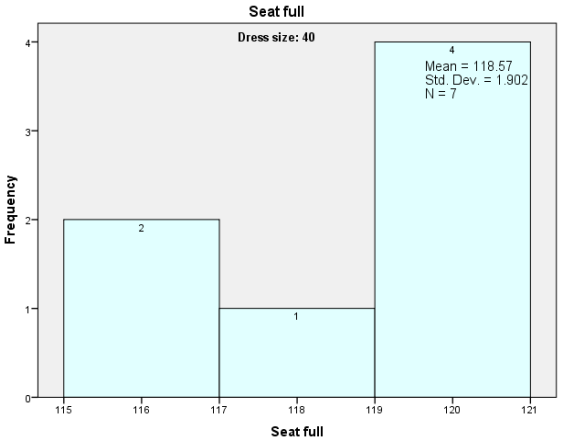

Outseam max
Dress size: 38
Mean = 105.5
Std. Dev. = 3.416
N = 4
Frequency
Outseam max

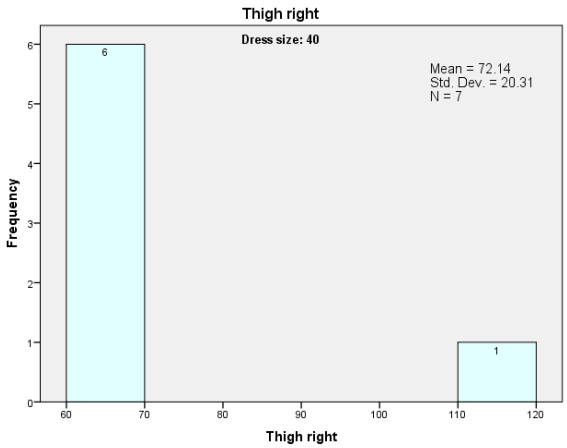

Bust full
Dress size: 40
Mean = 113.95
Std. Dev. = 5.834
N = 7
Frequency
Bust full

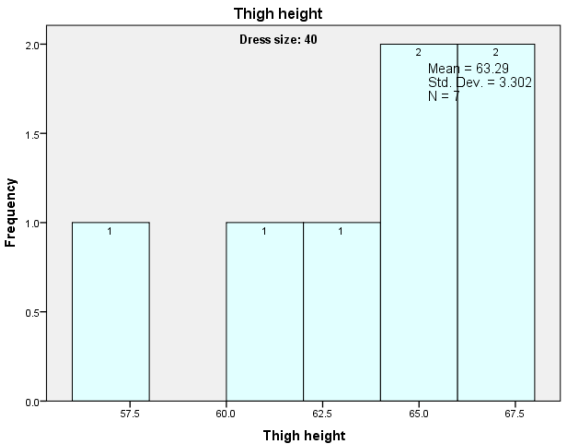

Waist full
Dress size: 40
Mean = 97.26
Std. Dev. = 7.108
N = 7
Frequency
Waist full

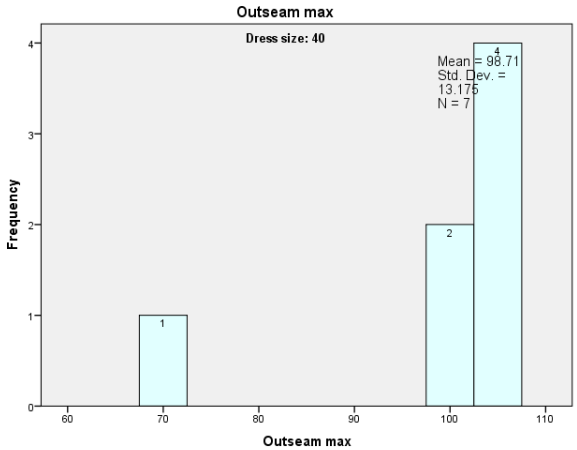

Hips full
Dress size: 40
Mean = 119.06
Std. Dev. = 1.644
N = 7
Frequency
Hips full

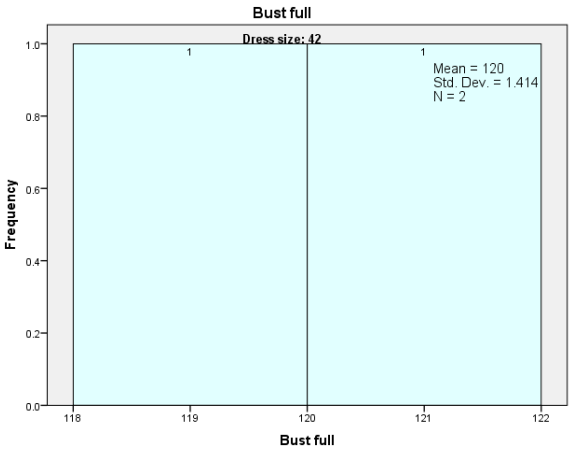

Inseam
Dress size: 40
Mean = 67.94
Std. Dev. = 3.753
N = 7
Frequency
Inseam

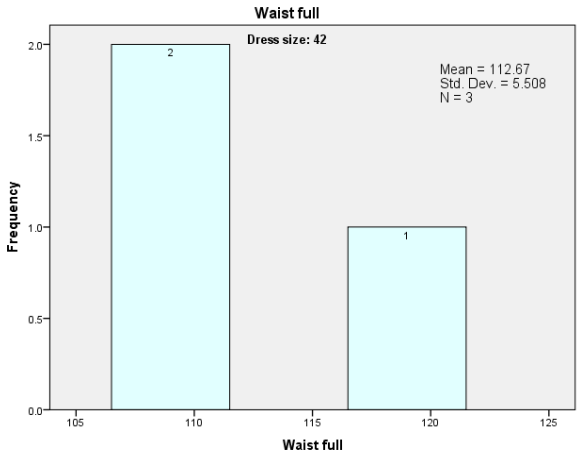

Seat full
Dress size: 40
Mean = 118.57
Std. Dev. = 1.902
N = 7
Frequency
Seat full

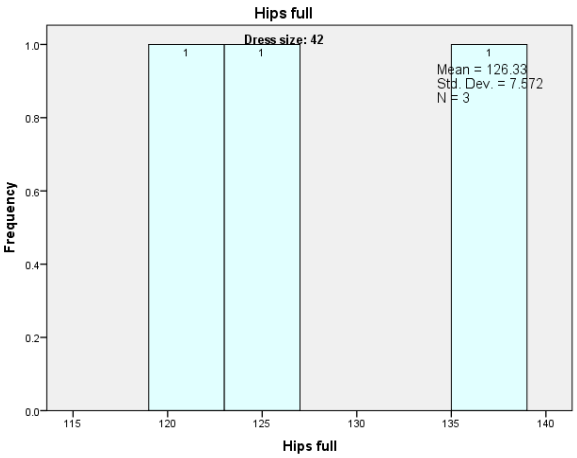

Thigh right
Dress size: 40
Mean = 72.14
Std. Dev. = 20.31
N = 7
Frequency
Thigh right

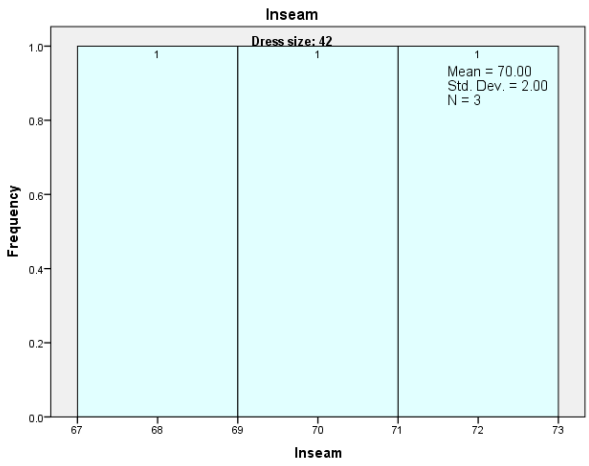

Thigh height
Dress size: 40
Mean = 63.29
Std. Dev. = 3.302
N = 7
Frequency
Thigh height

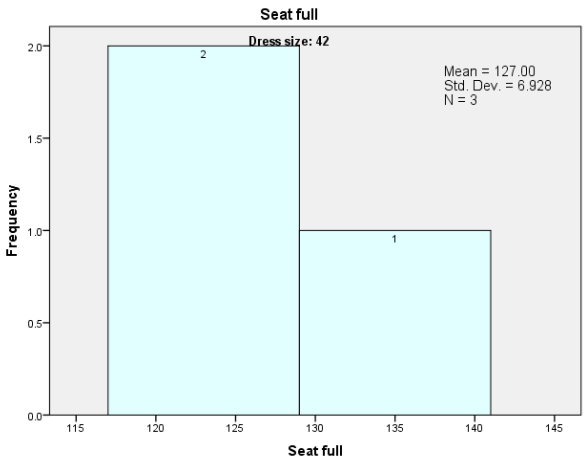

Outseam max
Dress size: 40
Mean = 98.71
Std. Dev. = 13.175
N = 7
Frequency
Outseam max

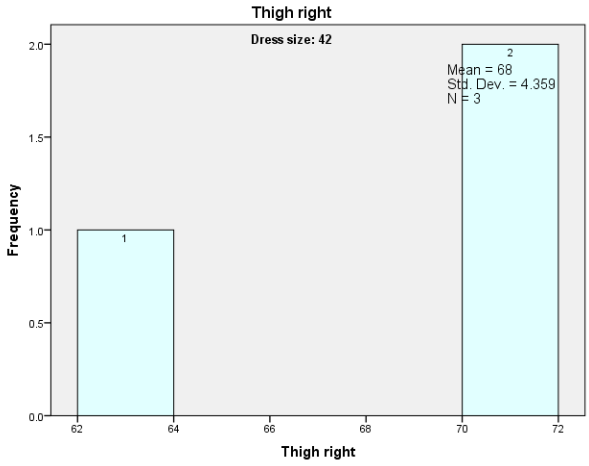

Bust full
Dress size: 42
Mean = 120
Std. Dev. = 1.414
N = 2
Frequency
Bust full


Waist full
Dress size: 42
Mean = 112.67
Std. Dev. = 5.508
N = 3
Frequency
Waist full

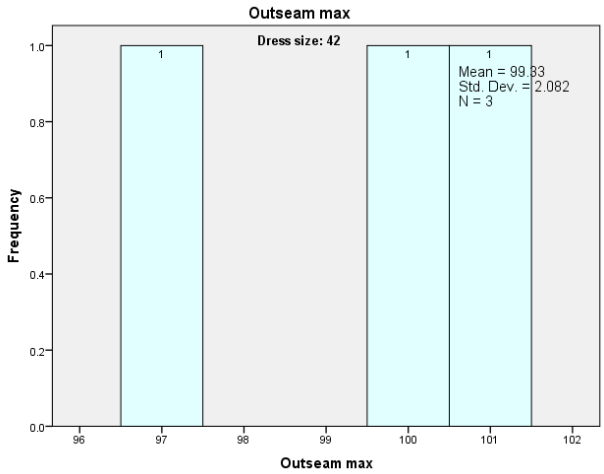

Hips full
Dress size: 42
Mean = 126.33
Std. Dev. = 7.572
N = 3
Frequency
Hips full


Inseam
Dress size: 42
Mean = 70.00
Std. Dev. = 2.00
N = 3
Frequency
Inseam


Seat full
Dress size: 42
Mean = 127.00
Std. Dev. = 6.928
N = 3
Frequency
Seat full


Thigh right
Dress size: 42
Mean = 68
Std. Dev. = 4.359
N = 3
Frequency
Thigh right


Thigh height
Dress size: 42
Mean = 61
Std. Dev. = 5.292
N = 3
Frequency
Thigh height


Outseam max
Dress size: 42
Mean = 99.33
Std. Dev. = 2.082
N = 3
Frequency
Outseam max

APPENDIX P: Frequencies, Frequency Table and Bust Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	< 85	1	100.0	100.0	100.0
34	Valid	85.01 - 95	5	100.0	100.0	100.0
36	Valid	85.01 - 95	3	60.0	60.0	60.0
		95.01 - 105	1	20.0	20.0	80.0
		105.01 - 115	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
38	Valid	95.01 - 105	2	50.0	50.0	50.0
		105.01 - 115	2	50.0	50.0	100.0
		Total	4	100.0	100.0	
40	Valid	105.01 - 115	3	42.9	42.9	42.9
		115.01 - 125	4	57.1	57.1	100.0
		Total	7	100.0	100.0	
42	Valid	115.01 - 125	2	66.7	100.0	100.0
	Missing	System	1	33.3		
	Total		3	100.0		

Waist Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	< 80	1	100.0	100.0	100.0
34	Valid	< 80	4	80.0	80.0	80.0
		80.01 - 90	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
36	Valid	< 80	3	60.0	60.0	60.0
		80.01 - 90	2	40.0	40.0	100.0
		Total	5	100.0	100.0	
38	Valid	80.01 - 90	2	50.0	50.0	50.0
		90.01 - 100	2	50.0	50.0	100.0
		Total	4	100.0	100.0	
40	Valid	80.01 - 90	2	28.6	28.6	28.6
		90.01 - 100	1	14.3	14.3	42.9
		100.01 - 110	4	57.1	57.1	100.0
		Total	7	100.0	100.0	
42	Valid	100.01 - 110	2	66.7	66.7	66.7
		110.01 - 120	1	33.3	33.3	100.0
		Total	3	100.0	100.0	

Hips Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	< 100.0	1	100.0	100.0	100.0
34	Valid	100.01 - 110	4	80.0	80.0	80.0
		110.01 - 120	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
36	Valid	100.01 - 110	3	60.0	60.0	60.0
		110.01 - 120	2	40.0	40.0	100.0
		Total	5	100.0	100.0	
38	Valid	110.01 - 120	1	25.0	25.0	25.0
		120.01 - 130	3	75.0	75.0	100.0
		Total	4	100.0	100.0	
40	Valid	110.01 - 120	4	57.1	57.1	57.1
		120.01 - 130	3	42.9	42.9	100.0
		Total	7	100.0	100.0	
42	Valid	120.01 - 130	2	66.7	66.7	66.7

		130.01 - 140	1	33.3	33.3	100.0
		Total	3	100.0	100.0	

Inseam Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	65.01 - 70	1	100.0	100.0	100.0
34	Valid	70.01 - 75	3	60.0	60.0	60.0
		75.01 - 80	2	40.0	40.0	100.0
		Total	5	100.0	100.0	
36	Valid	65.01 - 70	1	20.0	20.0	20.0
		70.01 - 75	1	20.0	20.0	40.0
		75.01 - 80	2	40.0	40.0	80.0
		80.01 - 85	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
38	Valid	65.01 - 70	1	25.0	25.0	25.0
		70.01 - 75	2	50.0	50.0	75.0
		75.01 - 80	1	25.0	25.0	100.0
		Total	4	100.0	100.0	
40	Valid	< 65	2	28.6	28.6	28.6
		65.01 - 70	2	28.6	28.6	57.1
		70.01 - 75	3	42.9	42.9	100.0
		Total	7	100.0	100.0	
42	Valid	65.01 - 70	2	66.7	66.7	66.7
		70.01 - 75	1	33.3	33.3	100.0
		Total	3	100.0	100.0	

Seat Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	< 95	1	100.0	100.0	100.0
34	Valid	95.01 - 105	4	80.0	80.0	80.0
		105.01 - 115	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
36	Valid	95.01 - 105	2	40.0	40.0	40.0
		105.01 - 115	3	60.0	60.0	100.0
		Total	5	100.0	100.0	
38	Valid	105.01 - 115	1	25.0	25.0	25.0
		115.01 - 125	3	75.0	75.0	100.0
		Total	4	100.0	100.0	
40	Valid	115.01 - 125	7	100.0	100.0	100.0
42	Valid	115.01 - 125	2	66.7	66.7	66.7
		125.01 - 135	1	33.3	33.3	100.0
		Total	3	100.0	100.0	

Thigh Right Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	< 65	1	100.0	100.0	100.0
34	Valid	< 65	5	100.0	100.0	100.0
36	Valid	< 65	3	60.0	60.0	60.0
		65.01 - 80	2	40.0	40.0	100.0
		Total	5	100.0	100.0	
38	Valid	< 65	1	25.0	25.0	25.0
		65.01 - 80	3	75.0	75.0	100.0
		Total	4	100.0	100.0	
40	Valid	< 65	4	57.1	57.1	57.1
		65.01 - 80	2	28.6	28.6	85.7
		110.01 - 125	1	14.3	14.3	100.0
		Total	7	100.0	100.0	
42	Valid	< 65	1	33.3	33.3	33.3
		65.01 - 80	2	66.7	66.7	100.0
		Total	3	100.0	100.0	

Thigh Height Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	60.01 - 65	1	100.0	100.0	100.0
34	Valid	65.01 - 70	3	60.0	60.0	60.0
		70.01 - 75	2	40.0	40.0	100.0
		Total	5	100.0	100.0	
36	Valid	60.01 - 65	1	20.0	20.0	20.0
		65.01 - 70	1	20.0	20.0	40.0
		70.01 - 75	2	40.0	40.0	80.0
		75.01 - 80	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
38	Valid	60.01 - 65	2	50.0	50.0	50.0
		65.01 - 70	1	25.0	25.0	75.0
		70.01 - 75	1	25.0	25.0	100.0
		Total	4	100.0	100.0	
40	Valid	< 60	1	14.3	14.3	14.3
		60.01 - 65	4	57.1	57.1	71.4
		65.01 - 70	2	28.6	28.6	100.0
		Total	7	100.0	100.0	
42	Valid	< 60	1	33.3	33.3	33.3
		60.01 - 65	2	66.7	66.7	100.0
		Total	3	100.0	100.0	

Out seam Category

Dress size			Frequency	Percent	Valid Percent	Cumulative Percent
30	Valid	90.01 - 100	1	100.0	100.0	100.0
34	Valid	100.01 - 110	4	80.0	80.0	80.0
		110.01 - 120	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
36	Valid	100.01 - 110	4	80.0	80.0	80.0
		110.01 - 120	1	20.0	20.0	100.0
		Total	5	100.0	100.0	
38	Valid	100.01 - 110	4	100.0	100.0	100.0
40	Valid	< 80	1	14.3	14.3	14.3
		90.01 - 100	2	28.6	28.6	42.9
		100.01 - 110	4	57.1	57.1	100.0
		Total	7	100.0	100.0	
42	Valid	90.01 - 100	2	66.7	66.7	66.7
		100.01 - 110	1	33.3	33.3	100.0
		Total	3	100.0	100.0	

FREQUENCIES VARIABLES =Bust Category, Waist Category, Hips Category, Inseam Category, Seat Category, Thigh Right Category, Thigh Height Category, Out seam Category
BARCHART FREQ
ORDER=ANALYSIS.

Frequencies
Frequency Table
Bust Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 85	1	4.0	4.2	4.2
	85.01 - 95	8	32.0	33.3	37.5
	95.01 - 105	3	12.0	12.5	50.0
	105.01 - 115	6	24.0	25.0	75.0
	115.01 - 125	6	24.0	25.0	100.0
	Total	24	96.0	100.0	
Missing	System	1	4.0		
Total		25	100.0		

Waist Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 80	8	32.0	32.0	32.0
	80.01 - 90	7	28.0	28.0	60.0
	90.01 - 100	3	12.0	12.0	72.0
	100.01 - 110	6	24.0	24.0	96.0
	110.01 - 120	1	4.0	4.0	100.0
	Total	25	100.0	100.0	

Hips Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 100.0	1	4.0	4.0	4.0
	100.01 - 110	7	28.0	28.0	32.0
	110.01 - 120	8	32.0	32.0	64.0
	120.01 - 130	8	32.0	32.0	96.0
	130.01 - 140	1	4.0	4.0	100.0
	Total	25	100.0	100.0	

Inseam Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 65	2	8.0	8.0	8.0
	65.01 - 70	7	28.0	28.0	36.0
	70.01 - 75	10	40.0	40.0	76.0
	75.01 - 80	5	20.0	20.0	96.0
	80.01 - 85	1	4.0	4.0	100.0
	Total	25	100.0	100.0	

Seat Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 95	1	4.0	4.0	4.0
	95.01 - 105	6	24.0	24.0	28.0
	105.01 - 115	5	20.0	20.0	48.0
	115.01 - 125	12	48.0	48.0	96.0
	125.01 - 135	1	4.0	4.0	100.0
	Total	25	100.0	100.0	

Thigh Right Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 65	15	60.0	60.0	60.0
	65.01 - 80	9	36.0	36.0	96.0
	110.01 - 125	1	4.0	4.0	100.0
	Total	25	100.0	100.0	

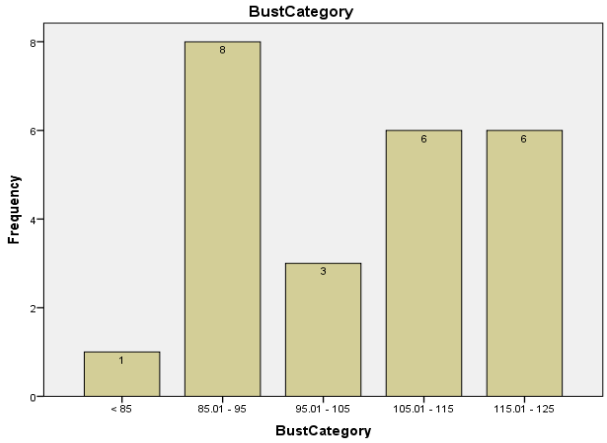
Thigh Height Category

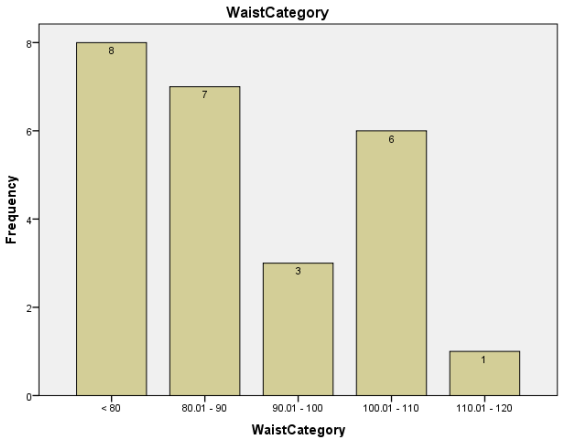
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 60	2	8.0	8.0	8.0
	60.01 - 65	10	40.0	40.0	48.0
	65.01 - 70	7	28.0	28.0	76.0
	70.01 - 75	5	20.0	20.0	96.0
	75.01 - 80	1	4.0	4.0	100.0
	Total	25	100.0	100.0	

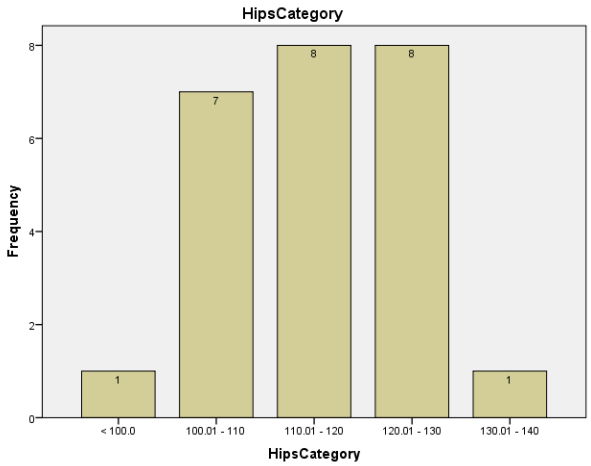
Out seam Category

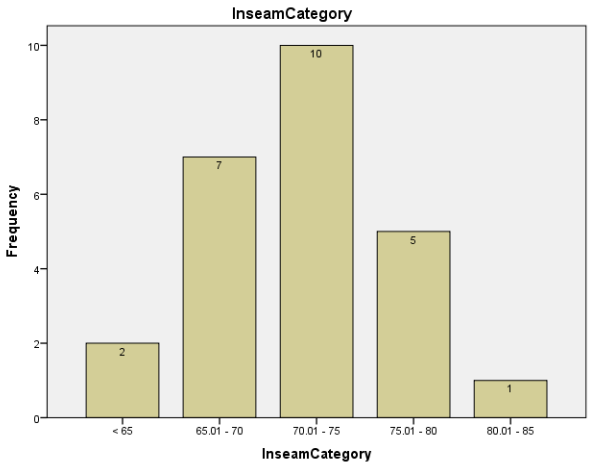
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 80	1	4.0	4.0	4.0
	90.01 - 100	5	20.0	20.0	24.0
	100.01 - 110	17	68.0	68.0	92.0
	110.01 - 120	2	8.0	8.0	100.0
	Total	25	100.0	100.0	

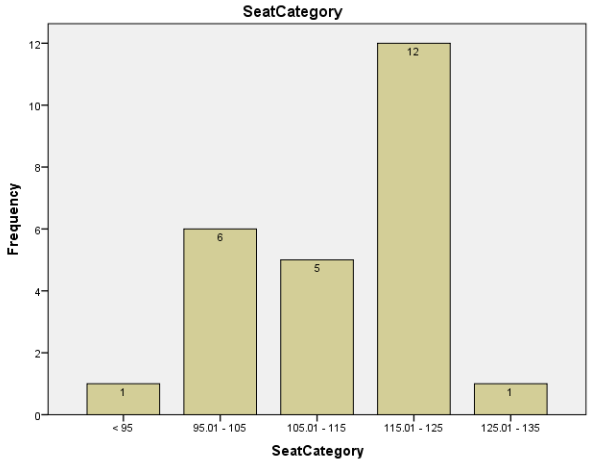
Bar Chart

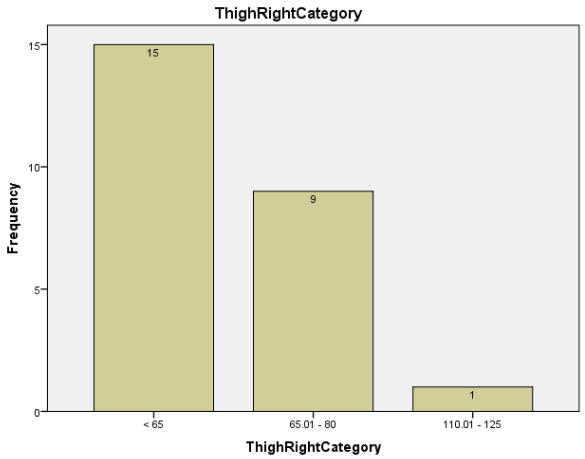


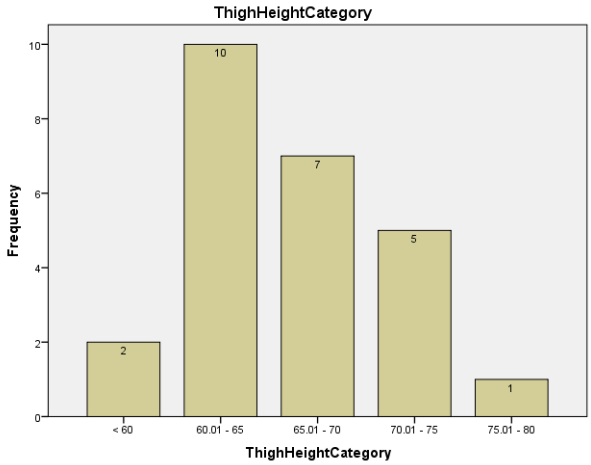


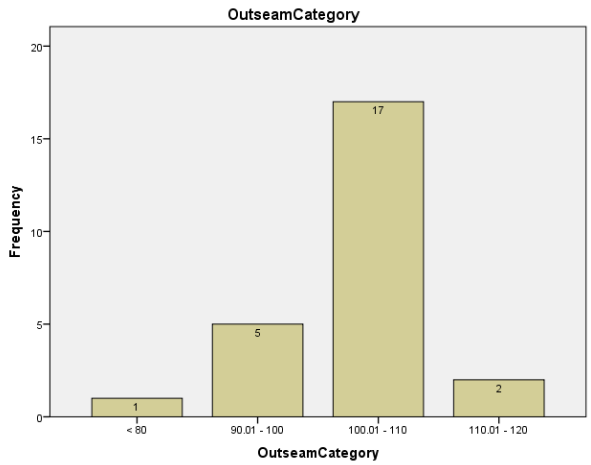





SeatCategory
Frequency
12
10
8
6
4
2
0
1
6
5
12
1
< 95
95.01 - 105
105.01 - 115
115.01 - 125
125.01 - 135
SeatCategory


ThighRightCategory
Frequency
15
10
5
0
15
9
1
< 65
65.01 - 80
110.01 - 125
ThighRightCategory


ThighHeightCategory
Frequency
10
8
6
4
2
0
2
10
7
5
1
< 60
60.01 - 65
65.01 - 70
70.01 - 75
75.01 - 80
ThighHeightCategory


OutseamCategory
Frequency
20
15
10
5
0
1
5
17
2
< 80
90.01 - 100
100.01 - 110
110.01 - 120
OutseamCategory

APPENDIX Q: CROSSTABS

TABLES=Bust Category, Waist Category, Hips Category, Inseam Category, Seat Category, Thigh Right Category, Thigh Height Category, Out seam Category, BY Dress size
FORMAT=AVALUE TABLES
CELLS=COUNT
COUNT ROUND CELL
BARCHART.

Crosstabs

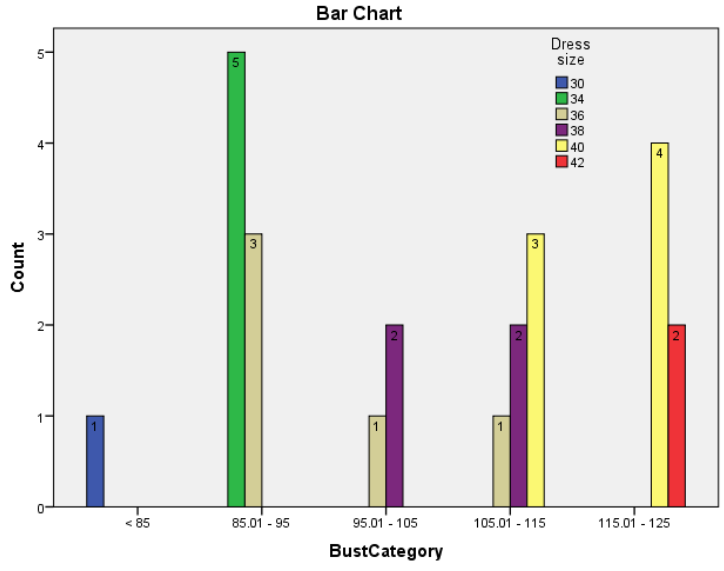
Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Bust Category * Dress size	24	96.0%	1	4.0%	25	100.0%
Waist Category * Dress size	25	100.0%	0	0.0%	25	100.0%
Hips Category * Dress size	25	100.0%	0	0.0%	25	100.0%
Inseam Category * Dress size	25	100.0%	0	0.0%	25	100.0%
Seat Category * Dress size	25	100.0%	0	0.0%	25	100.0%
Thigh Right Category * Dress size	25	100.0%	0	0.0%	25	100.0%
Thigh Height Category * Dress size	25	100.0%	0	0.0%	25	100.0%
Out seam Category * Dress size	25	100.0%	0	0.0%	25	100.0%

Bust Category * Dress size Cross tabulation

Count

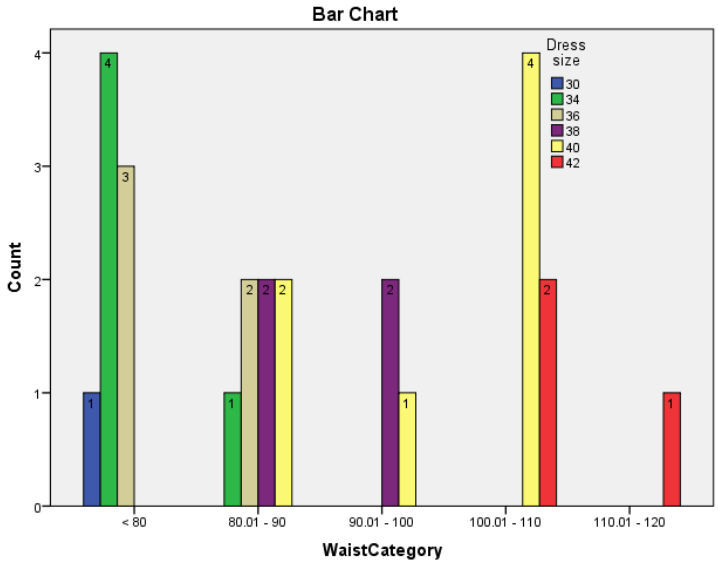
		Dress size						
		30	34	36	38	40	42	Total
Bust Category	< 85	1	0	0	0	0	0	1
	85.01 – 95	0	5	3	0	0	0	8
	95.01 - 105	0	0	1	2	0	0	3
	105.01 - 115	0	0	1	2	3	0	6
	115.01 - 125	0	0	0	0	4	2	6
Total		1	5	5	4	7	2	24



Waist Category * Dress size Cross tabulation

Count

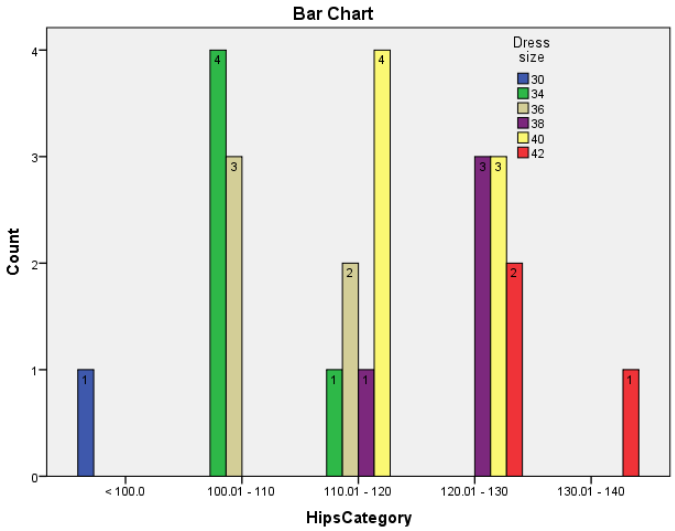
		Dress size						
		30	34	36	38	40	42	Total
Waist Category	< 80	1	4	3	0	0	0	8
	80.01 - 90	0	1	2	2	2	0	7
	90.01 - 100	0	0	0	2	1	0	3
	100.01 - 110	0	0	0	0	4	2	6
	110.01 - 120	0	0	0	0	0	1	1
Total		1	5	5	4	7	3	25



Hips Category * Dress size Cross tabulation

Count

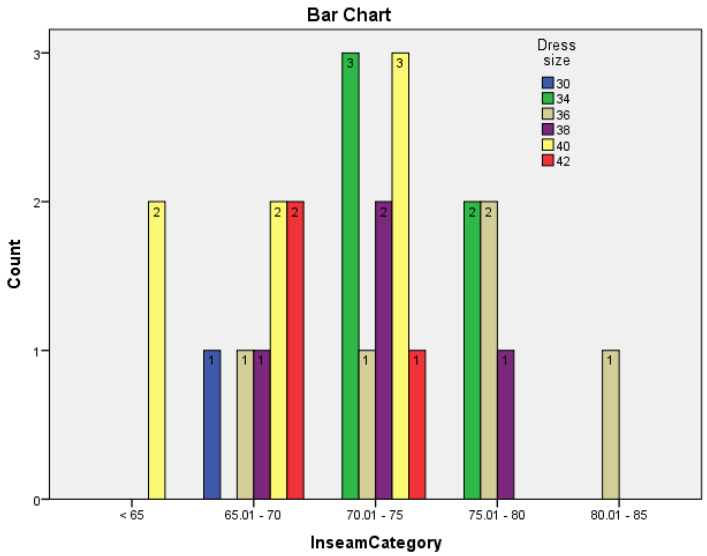
		Dress size						
		30	34	36	38	40	42	Total
Hips Category	< 100.0	1	0	0	0	0	0	1
	100.01 - 110	0	4	3	0	0	0	7
	110.01 - 120	0	1	2	1	4	0	8
	120.01 - 130	0	0	0	3	3	2	8
	130.01 - 140	0	0	0	0	0	1	1
Total		1	5	5	4	7	3	25



Inseam Category * Dress size Cross tabulation

Count

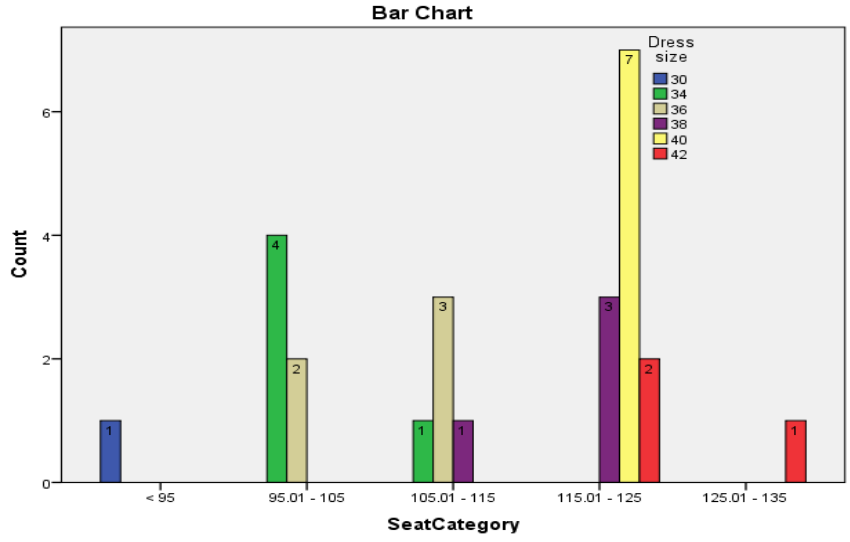
		Dress size						
		30	34	36	38	40	42	Total
Inseam Category	< 65	0	0	0	0	2	0	2
	65.01 - 70	1	0	1	1	2	2	7
	70.01 - 75	0	3	1	2	3	1	10
	75.01 - 80	0	2	2	1	0	0	5
	80.01 - 85	0	0	1	0	0	0	1
Total		1	5	5	4	7	3	25



Seat Category * Dress size Cross tabulation

Count

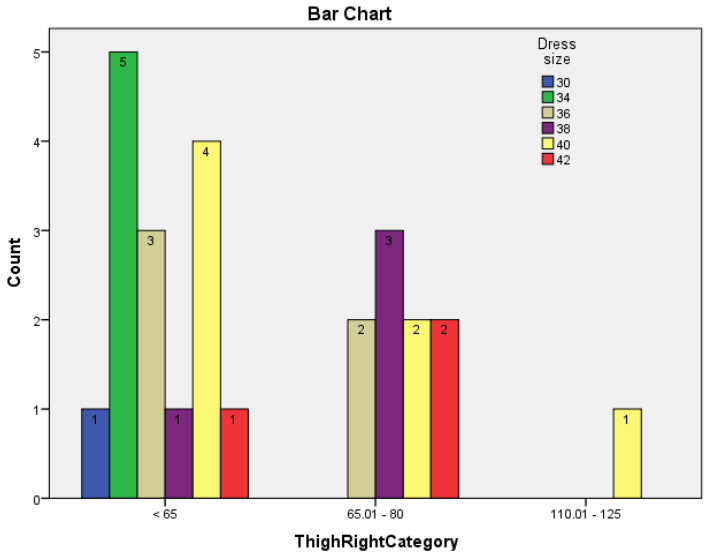
		Dress size						
		30	34	36	38	40	42	Total
Seat Category	< 95	1	0	0	0	0	0	1
	95.01 - 105	0	4	2	0	0	0	6
	105.01 - 115	0	1	3	1	0	0	5
	115.01 - 125	0	0	0	3	7	2	12
	125.01 - 135	0	0	0	0	0	1	1
Total		1	5	5	4	7	3	25



Thigh Right Category * Dress size Cross tabulation

Count

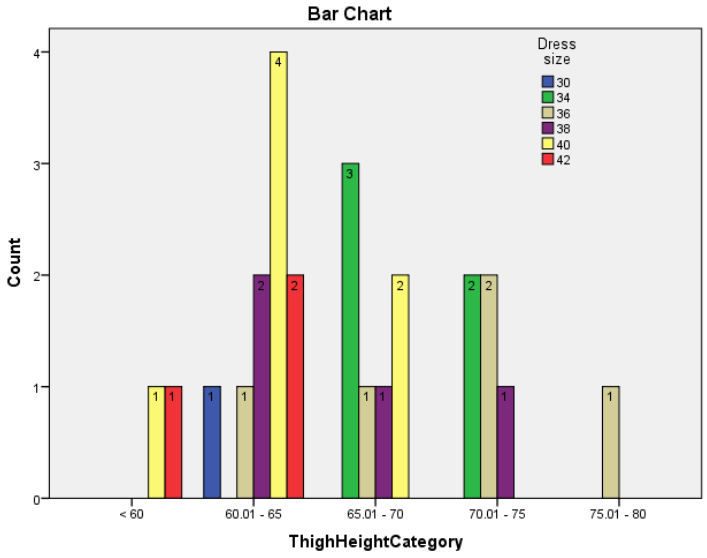
			Dress size						
			30	34	36	38	40	42	Total
Thigh Category	Right	< 65	1	5	3	1	4	1	15
		65.01 - 80	0	0	2	3	2	2	9
		110.01 - 125	0	0	0	0	1	0	1
Total			1	5	5	4	7	3	25



Thigh Height Category * Dress size Cross tabulation

Count

			Dress size						
			30	34	36	38	40	42	Total
Thigh Category	Height	< 60	0	0	0	0	1	1	2
		60.01 - 65	1	0	1	2	4	2	10
		65.01 - 70	0	3	1	1	2	0	7
		70.01 - 75	0	2	2	1	0	0	5
		75.01 - 80	0	0	1	0	0	0	1
Total			1	5	5	4	7	3	25



Out seam Category * Dress size Cross tabulation

Count

		Dress size						
		30	34	36	38	40	42	Total
Out seam Category	< 80	0	0	0	0	1	0	1
	90.01 - 100	1	0	0	0	2	2	5
	100.01 - 110	0	4	4	4	4	1	17
	110.01 - 120	0	1	1	0	0	0	2
Total		1	5	5	4	7	3	25