Chapter 2: Theoretical Framework

2.1 INTRODUCTION

Fit is clearly a complicated problem that can be approached from different viewpoints. This chapter will attempt to explain the various factors that determine and influence garment fit.

The framework of Susan Ashdown (2002), as presented in **Figure 2.1**, is used as a point of departure in this study. Ashdown views sizing systems as the focus around which all factors concerning sizing and fit evolve.

2.2 SIZING SYSTEMS

For the purposes of the framework, Ashdown (2002) defines sizing systems as a set of sizes derived using common assumptions and methods of development. Size categories within a system will be defined as the various groupings of sizes as they would be presented in a retail situation. The sizing system indicates the difference between sizes, thus how much bigger or smaller the following size must be. Loose fitting styles may have fewer sizes since the intervals between sizes can be bigger. Close fitting styles might need more sizes, because the difference between sizes would be smaller. A sizing system can therefore be as simple as one-size-fits-all or Small/Medium/Large (SML), or as complex as a system that provides a custom fitted garment for every individual (Ashdown, 2002). The sizing system generally used for ready-to-wear in the USA, and also in South Africa, makes use of a base size and a set of sizes proportionately graded from this size. Grading may be defined as the

increasing or decreasing of a pattern according to a set of corresponding body measurements (Handford, 1980:vii). A master pattern is graded up and down to create the other sizes in the range of the particular sizing system (Ashdown, 1998:336). As stated in the previous chapter, pattern making starts with body measurements of an individual from a specific population, and a good pattern is key in obtaining well fitting garments.

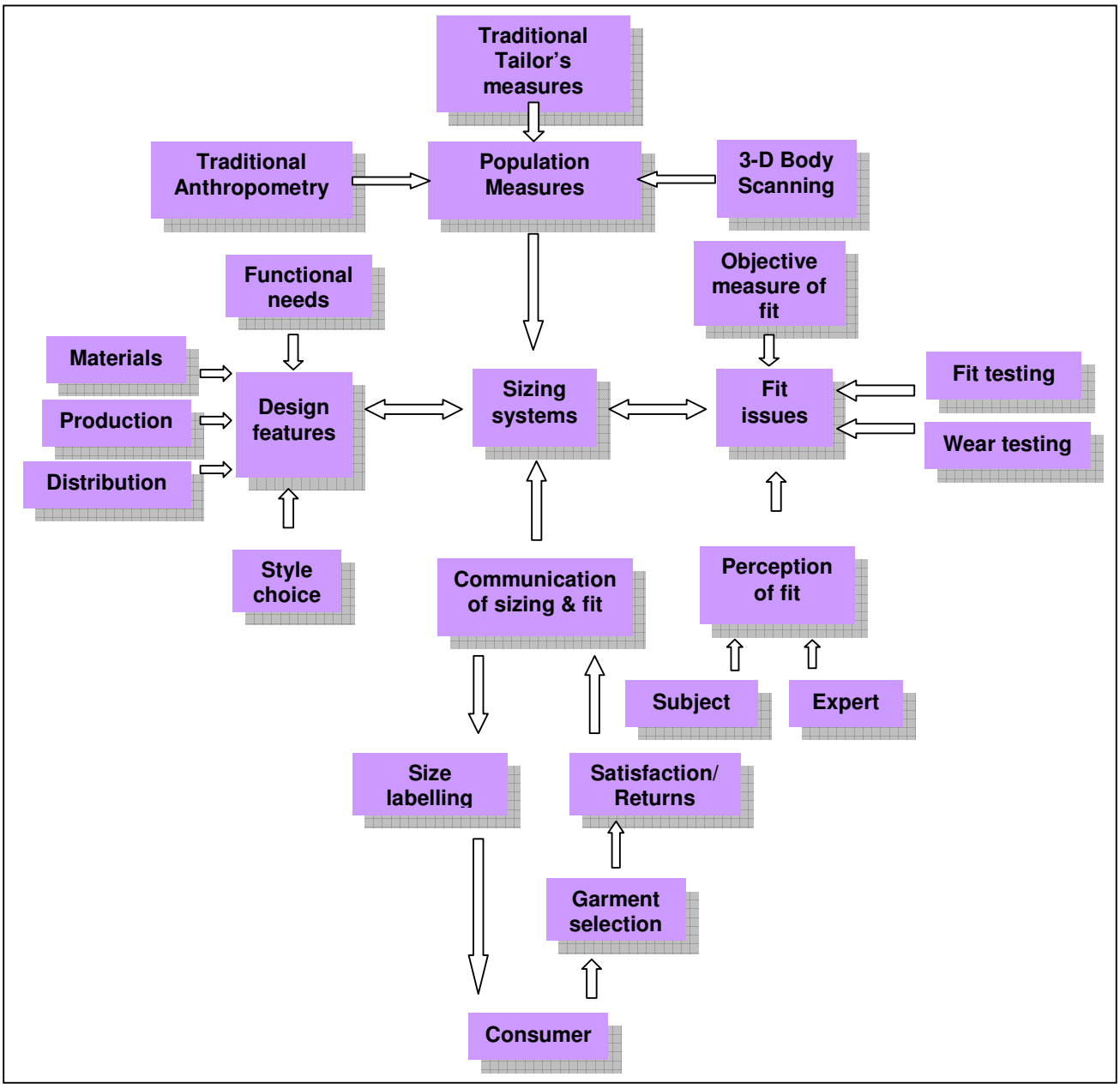

FIGURE 2.1: THEORETICAL FRAMEWORK (Ashdown, 2002)

2.3 POPULATION MEASUREMENTS

The framework in **Figure 2.1** illustrates that the effectiveness of any sizing system depends on the population measurements on which it is based. It is important that these measurements be current, accurate and representative for the population for which the sizing system is being developed. Ashdown (2002) states that population measures can be used to determine the range (smallest to largest), as well as the variation (differences in proportions) of the people in a population. Population measurements are especially important in countries where variations are the result of the population consisting of a variety of ethnic groups, as is the case in South Africa. If population measurements are outdated and inaccurate for a specific population, the best sizing system will not be able to ensure well-fitting garments for that population.

Measurements can be obtained by different methods, namely traditional tailor's measurements, traditional anthropometry or three-dimensional body scanning. The accuracy as well as the representativeness of the population's measurements may be influenced by the measuring methods used. It is therefore necessary to briefly discuss the different measuring methods.

2.3.1 Traditional tailor's measurements

Traditional tailor's measurements refer to measurements taken by hand using a measuring tape. Measurements taken and landmarks are directly related to the garments that are to be made. Most measurements are taken along the contours of the body and not in a straight line between two points. Due to the variability in identifying landmarks and the placement of the measuring tape on the body by different measurers, it is not always possible to repeat measurements. The accuracy of traditional tailor's measurements can be significantly reduced as a result of posture shifts by the person being measured. Although a skilled tailor or dressmaker can take very accurate measurements, methods and measurements can vary considerably among different professionals (Ashdown, 2002).

2.3.2 Anthropometry

Anthropometry literally means the measurement of people (Norgan in Ulijaszek & Mascie-Taylor, 1994:141). It can be defined as the science of measurement. The name derives from *anthropos*, meaning human, and *metrikos*, meaning measuring (Roebuck, 1995:1). It deals with measurements of the physical characteristics of human beings – particularly their sizes and shapes (Pheasant, 1996:3; Norgan in Ulijaszek & Mascie-Taylor, 1994:141). Anthropometric measurement methods and tools have been developed to make valid and reliable measurements of individuals in a population possible. Anthropometric tools include anthropometers (a standing tool that measures straight linear distances), callipers (measures linear depths and widths), and calibrated measuring tapes (Ashdown, 2002). Observer error is the most troublesome source of anthropometric error and includes imprecision in landmark location, subject positioning and instrument applications (Simmons & Istook, 2003). Accuracy is therefore dependent on the person taking the measurements. It is often advised that two people should measure each subject to ensure the least amount of error. Careful and accurate location and marking of landmarks on the body, as well as proper training of personnel can ensure consistency and accuracy of measurements. It is clear that the collection of anthropometric data is a time consuming and expensive process that requires skilled personnel. The development of three-dimensional body scanners has opened up new possibilities for the measurement and analysis of the human body (Ashdown, 2002).

2.3.3 Three–dimensional body scanning

In recent years, researchers have developed three-dimensional body scanners that can capture the outside surface of the human body within a few seconds by using optical techniques. This measurement technique can be non-contact, instant and accurate through the use of laser light or white light and cameras. This technology has the potential to enable researchers to collect and process more accurate anthropometric data than ever before almost instantaneously (Le Pechoux, 2000). Three-dimensional scanning produces a 360 degree replica of a solid object, for example the human body, on a dimensionally accurate computer screen. This image

of the human body can be stored and then viewed, rotated, sliced and measured on the computer screen by using automated measuring procedures whenever information is needed. This makes it possible to analyse body postures and proportions in new ways (Ashdown, 2002). Unfortunately, there are still some shaded body areas that cannot be scanned effectively. For the time being, three-dimensional body imaging has to be used in conjunction with hand measurement.

The use of three-dimensional body scanners can help overcome the constraints in the use of body dimensional data as listed by Laing and Sleivert (2002:4). These constraints include that the data are current, the data reflect the potential user group and that the methods used are comparable and reproducible (Laing & Sleivert, 2002:4). Body scanning is a less time-consuming and therefore also a less expensive method of obtaining body measurements than traditional anthropometric methods. This increases the possibility of repeating body measurement surveys on a regular basis, resulting in more recent body measurement data being available. Information regarding the population being scanned, such as gender, age, ethnic origin, and other relevant data can be collected and stored with the scanned data, since taking the measurements does not take as much time as with traditional anthropometry. Human error is greatly reduced, resulting in the survey data being more comparable and reproducible. Definition of landmarks and clear descriptions of measurements are, however, still a very important requirement to ensure comparability and reproducibility of any body measurement survey, regardless of which measurement method is used.

Three-dimensional body scanners have not been available in South Africa for use by the clothing industry. In general, measurements are taken in the traditional tailor's manner with normal tape measures. It is therefore very difficult to compare measurements used by different companies because of the variation in measurements and methods between different professionals. Anthropometric surveys have been undertaken in the past, but because of the time and financial implications involved the number of measurements have to be limited. These measurements are also not available for use by everybody involved in the clothing industry, but are restricted to the companies involved in undertaking the survey. The use of a three-dimensional body scanner can make body measurement surveys more

accessible to the clothing industry in general. Using less time to scan one person it might be possible to take more measurements on more people in the same time that a traditional anthropometric survey took to complete. Therefore it would be ideal to undertake such a survey by using a 3D-body scanner. It is however necessary to establish how and where measurements are taken on the body, to ensure that critical and useful measurements are taken.

2.4 DESIGN FEATURES

In the process of producing well-fitting garments the design features of the actual garment play a significant role, as indicated in **Figure 2.1**. The relationship between design and fit of clothing is complex because each garment style has its own ideal relationship to the body. It is generally accepted that, the more style ease a garment has, the greater the range of body variations that the garment will fit (Ashdown, 2002). Ease is the difference between the body measurements of the intended wearer and the measurements of the garment (Brown, 1992:265). Ease can be differentiated in movement and design ease. Movement or fitting ease is the amount added to the body dimensions to allow for movement and comfort. Design ease is the amount added to the body dimensions to create a specific style, silhouette or fit. Design ease is added in addition to movement ease (Laing & Sleivert, 2002:6 and Brown, 1992:265,266). The importance of comfort and freedom of movement in clothes was discussed in the previous chapter. Design features may limit or expand the range of dimensions that can be fitted by a style; for example, princess lines on a dress create a more fitted style which will fit a limited number of people in an acceptable way. Sleeves with cuffs, on the other hand, can be adjusted to different wrist sizes and create an acceptable fit for a variety of arm lengths. Ashdown (2002) is therefore of the opinion that the number of sizes needed to fit a population can be reduced by the creative use of design or design features.

2.4.1 Functional features

When designing functional features, the needs of the wearer and the expectations for the garment have to be considered. According to Laing and Sleivert (2002:7), garment sizing is more critical for work and sports garments than for fashion garments. Poor fit can compromise the protection offered by a specialised garment, and as a result the safety of the wearer. Movement, interaction with the environment, specialised fabrics and thermal properties are other factors to consider when designing functional garments. The fit and performance of a functional garment may be significantly affected by decisions taken during the design process (Ashdown, 2002).

2.4.2 Materials

Regarding materials, Solinger (1980:55) indicates that it is vital that the pattern maker considers the drape and stress characteristics of the fabric to be used for the garment. Stress characteristics are the tendencies of the fabric to stretch, shrink, and/or distort under body stress induced during wear. Drape characteristics are the fabric's tendencies to change constructional dimension when the orientation of the grain structure of the fabric is changed with respect to gravitational forces (Solinger, 1980:55). These characteristics of the fabric often influence and dictate style choices and the amount of ease needed in the design process. Stretch fabrics will extend and move with the body and will need less ease to be comfortable. A stretch fabric can therefore be fitted more closely to the body than fabrics with less stretch. According to Ashdown (2002), material properties affect the way a garment fits on a body. It can also impact how many people of different shapes and sizes can be fitted with one garment size; for example, if a garment is made from a stretch material, it will be possible to fit more people with a variety of body shapes into one size.

2.4.3 Production

The precision of garment sizes can be affected by methods such as spreading, cutting, sewing and pressing, used during the production phase. Inaccurate cutting and sewing as well as shrinkage due to heat and steam from pressing, could result in identical garments being labelled with the same size but having completely different physical dimensions. According to Hudson (1980:113), it is possible to destroy a well-fitting pattern through inaccurate, inconsistent sewing practices. The introduction of unit production or modular production systems increased the number of sizes that can be handled by one manufacturer and as a result the number of sizes that can be accommodated in a sizing system. Modern technology even makes it possible to produce custom-made garments economically (Ashdown, 2002). Quality control during the production process is of the utmost importance in order to maintain consistent size of garments.

2.4.4 Distribution

Distribution goes hand in hand with production, as the number of sizes in a system are dependent on warehousing, retrieval and shipping issues (Ashdown, 2002). Distribution involves the selection of the appropriate styles and numbers of each size to be sold at each store location to a particular target market. Stock keeping units are one style made in one colour and one size (Glock & Kunz, 1995:77), and is currently based on what has sold in the past. This usually included fewer garments in the smallest and largest sizes. The optimised sizing system has the advantage that the number of individuals who fit into each size are more evenly distributed across the range of sizes. An added advantage is that if each retailer has an accurate database of their customers it would be possible to calculate the number of the different sizes necessary to accommodate the population in that area (Ashdown, 1998:338). Retailers will thus be able to offer their consumers a better selection of styles and sizes.

2.4.5 Style choices

The designer's style choices can affect the overall fit of a garment, because structural seams and darts incorporated into the design of a garment will influence how the garment will fit the consumer. Fashion is an important consideration, since it is a design aspect of apparel. It is the distinct look that is being created and is identifiable by the silhouette produced. The achievement of the intended silhouette in the finished garment is a function of fit, and is determined by pattern making and the amount of ease added. Length of sleeves, pants, skirts, jackets, coats and dresses; placement of waistline; shoulder shape; neckline and collar shape have to be considered (Hudson, 1980:109). Consumer perception of the fit of the garment is influenced by these style features of the garment.

2.5 FIT ISSUES

Fit issues represent another set of factors related to sizing systems that should be considered to eliminate fit problems. According to Le Pechoux (2000), fit is a function of sizing. Fit affects comfort, as well as wear life or durability of a garment. "How well a garment fits" is based on individual perceptions of comfort, fit and fashion. To complicate matters, the designer, the pattern maker and the consumer each has a very different concept of fit. Since individual perceptions differ regarding tolerance, it is an important factor concerning fit issues. It is imperative to know how much tolerance is acceptable to the consumer before he/she regards the garment as ill-fitting. The fit threshold is the smallest difference in fit that can be sensed. Information regarding fit thresholds can be useful when developing increments between sizes (Ashdown & DeLong, 1995:48). Since fit is one of the aspects used by consumers to evaluate quality, consumers' perceptions of fit is an important consideration when trying to improve the fit, as well as the quality of garments.

2.5.1 Perceptions of fit and the objective measure of fit

Subject or wearer responses to the fit of garments are important in assessing the success of a garment or a sizing system. Such responses can however be difficult to interpret. The subject's perception of fit is shaped by past experiences with the fit of clothing and by their own personal preferences. It is essential that informed subjects who can analyse and communicate garment function and fit are used for fit testing and also for testing sizing systems (Ashdown, 2002).

Methods to subjectively measure fit through visual analysis by experts have been developed by researchers in the apparel field. These methods rely on the expert's visual inspection of garment wrinkles and seam placement of the garment as it is worn by a subject. Expert fit testing methods can increase the quality of fit in a garment. It is necessary that members of an expert panel be trained specifically for the study or test of fit, because the ability to repeatedly assess a garment in the same way, as well as a common understanding among the panel members are necessary for good results from such a panel (Ashdown, 2002).

Since individual perceptions – regardless of whether they are made by the wearer or by an expert – are mostly subjective, it is also necessary to be able to objectively analyse fit. Fit is clearly a complicated concept because every individual has his/her own idea of what it entails. Garment quality depends on the fit and therefore a thorough and objective understanding of what is meant by good fit is crucial. Most of the objective methods to analyse fit are only suitable to answer simple questions about fit, but cannot address the many interactions that occur in the complex system of the clothed body. The body scanner however does show possibilities for the development of more objective measures of fit (Ashdown, 2002). A person can be scanned wearing a garment and the relationship between the garment and the body can then be studied objectively. The difference between the body and the garment can for example be measured, or the silhouette observed without any subjective influence such as personal preference of the wearer or the observer.

2.5.2 Fit testing

The way a garment fits and wears can also influence the perception of fit and the actual fit. To minimise negative effects, fit and wear tests should be conducted. Fit testing is critical to reveal key problems with the fit or functionality of a garment. This can result in a better product. To conduct a fit test it is important to understand exactly what information is needed. Careful planning is needed on how to collect, record and analyse data since data from fit tests may be conflicting and difficult to interpret (Ashdown, 2002).

2.5.3 Wear testing

Wear testing is necessary to address issues of durability, garment performance and fit or changes in fit over time. Subjects wear the garment for a period of time in order to observe the garment's response to normal handling. The lengths of time are specified, with cleaning at specified intervals using appropriate methods. Wear tests occur over time in uncontrolled circumstances and rely on subjective reporting of results from the wearer. Wear tests can however provide important information regarding the success of a garment under actual wearing conditions (Ashdown, 2002).

2.6 COMMUNICATION OF SIZING AND FIT

A sizing system can only be regarded as successful when satisfaction with fit is achieved. This conclusion was already reached at the end of the fifties by Emanuel, Alexander, Churchill and Truett (1959:39) while developing a height-weight sizing system for flight clothing. They state that "…a sizing system can be considered successful only after it has been used in the design of one or more garments and these garments have proved, from a functional and comfort standpoint, to fit the individuals for whom they were intended". Once a successful sizing system is developed, it is important to communicate this to the consumer. According to

Ashdown (2002), retailers should communicate any sizing problems that are encountered by consumers back to the manufacturer, but this seldom happens.

2.6.1 Size labelling and the consumer

The size label is a way to communicate sizing information to the consumer. The size label should assist the consumer in selecting the appropriate size garments. Brown (in Chun-Yoon & Jasper, 1993:32) indicates that retailers and manufacturers use the size label as a marketing tool. Consumers however use size labels to find out the garment size before they actually try on a garment (Chun-Yoon & Jasper, 1993:31). A labelling system should enable consumers to find their correct garment sizes easily without trying on too many garments, even if manufacturers use different body measurements for the same size code. Clear size labelling will reduce manufacturers' and retailers' costs because of frequent returns and damage to garments caused by customers frequently trying them on (Chun-Yoon & Jasper, 1993:36). It will also simplify garment selection which is important, since the modern consumer is more pressed for time and not willing to spend time trying on multiple garments in order to find a good fit. Effective communication is therefore essential for the consumer and for the clothing industry.

2.7 CONCEPTUAL FRAMEWORK

The aim of this study is to investigate and describe how the South African clothing industry ensures well-fitting garments for their target consumers. With Ashdown's model (2002) as point of departure and the objectives of the study in mind, the following conceptual framework was developed for this particular study. A model of this framework is represented in **Figure 1.1**. Following Ashdown's framework, it is clear that accurate body measurements of a population form the basis of any sizing system. This means that sizing systems cannot be revised or improved without an up-to-date and representative anthropometric database of a target population.

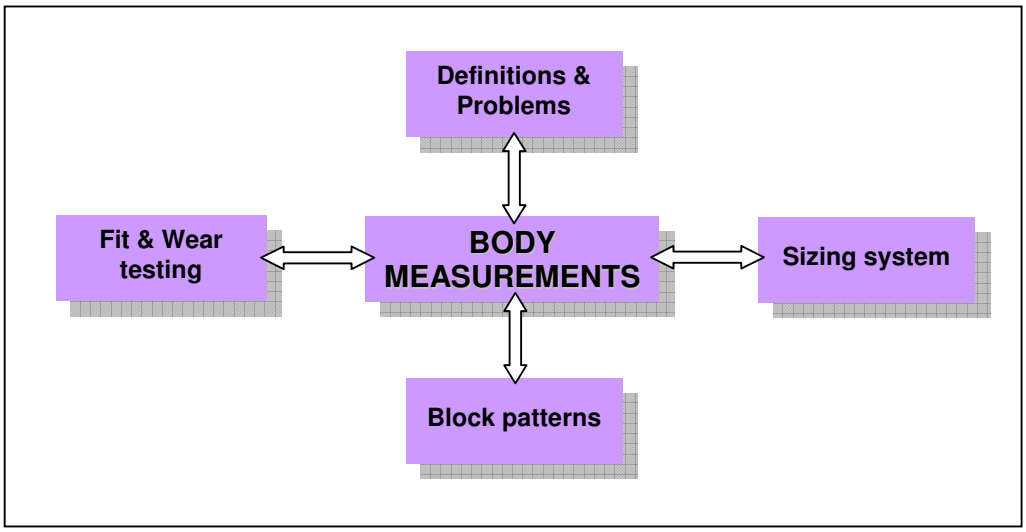

FIGURE 1.1: CONCEPTUAL FRAMEWORK

2.7.1 Body measurements

Figure 1.1 clearly indicates that body measurements are the central focus of the conceptual framework because without body measurements there can be no sizing systems, and no block patterns. Tamburrino (1992b:56) identifies three requirements for anthropometric data to be of practical use. Firstly, such data must be current. Secondly, the data must reflect the distribution of the population's body measurements by geographical area. Manufacturers and retailers need local data of the customers, not general data about the entire country. Sampling of anthropometric data from selected areas needs to be a continuous process in order to satisfy the commercial needs of the apparel industry. Thirdly, the anthropometric data must satisfy the technical requirements of apparel manufacturers. Data must therefore be collected following uniform and standard criteria.

Measurement guidelines are necessary to ensure that a South African anthropometric database is relevant and accurate. This will involve decisions regarding the scope of the number of measurements that should be taken and accurate descriptions of exactly where they are to be taken (definitions). Since three-dimensional body scanning technology does not restrict the measurement process to

only a few measurements, it is possible to include the widest spectrum of measurements.

The above procedures are in line with prescriptions suggested in the literature. The planning of an anthropometric survey involves the decision of which parts and attributes of the human body are to be measured (Roebuck, 1995:10).

According to Roebuck (1995:7), a fundamental requirement when selecting measurements and measurement methods is to plan ahead for future applications or uses of the data. A very important future application of the data in a South African anthropometrical database should be the development of revised sizing systems. A clear description and understanding of the current South African sizing systems will be necessary before developing new sizing systems or revising sizing systems currently in use.

2.7.2 Sizing systems

As has already been stated, sizing systems are generally based on a selection of dimensions from an anthropometric study of the population for which the sizing system is designed. Key dimensions are used to divide the population into size groups (Ashdown, 1998:325). Various statistical methods are used to identify key dimensions from which sizing systems can be developed. Most sizing systems are based on two to four key dimensions (Chun-Yoon & Jasper, 1993:34). However, sizing systems created using an optimisation methodology make use of any number of dimensions (Ashdown, 1998:328). Therefore it is necessary to evaluate the different methods used to identify key dimensions in the process of structuring a sizing system. Salusso-Deonier, DeLong, Martin and Krohn (1986:38) state: “Receiving little attention but also critical to assuring apparel sizing adequacy is the classification methodology used to structure a database into sizing systems.” Le Pechoux (2000) also states that “…the statistical models used to derive sizing systems need to be redesigned to better account for the wide variation between individuals”. The above statements clearly indicate the importance of investigating and evaluating different methods for structuring a sizing system. First, the currently

used sizing systems should be described and understood. The success of any sizing system lies in the accuracy of the body measurements that it is based on. Evident from **Figure 1.1** is the fact that any problems experienced with body measurements will also be transferred to the sizing system derived from those measurements. The origin and functioning of the South African sizing system is vague and should therefore be investigated before any structuring of new or revised sizing systems can be undertaken.

2.7.3 Block patterns

Figure 1.1 clearly indicates the interaction and interdependence of body measurements with sizing systems, block patterns and fit and wear testing. Sizing systems are derived from the body measurements of a population. The sizing system then prescribes the set of body measurements relevant to a specific size, which are then used in the drafting of the block patterns for the specific garment size. If the pattern maker starts off with inaccurate body measurements, no matter how accurate all other aspects of the production of a garment up to labelling and fit and wear testing are executed, it will be nearly impossible to create a good fit. Hudson (1980:109) confirms that fit is determined by pattern making.

During pattern making, body measurements are used together with specific amounts for ease of movement and design ease to create a specific silhouette or garment styling. The combination of body measurements together with the correct amounts of ease will result in garment measurements appropriate for the given body measurements. It is not possible to create suitable garment measurements without an applicable set of body measurements as a starting point. It is thus clear how inaccurate and outdated body measurements can result in block patterns that do not fit.

2.7.4 Fit and wear testing

Before any pattern goes into production, a sample garment is made. The sample is evaluated in terms of fit to ensure that it meets the requirements of the company involved. Yu (in Fan, Yu & Hunter, 2004:33) states that a live model or a dress form (dummy) can be used to verify whether a garment fits the measurement specifications. Choice of a live model and/or an appropriate dummy, is based on the body measurements prescribed by the sizing system for the sample size of garments.

As discussed earlier, wear testing is necessary to address issues of durability, garment performance and fit or changes in fit over time (Ashdown, 2002). Garments are worn for a continuous period and cared for in the prescribed manner. This can be done in controlled (Laing & Sleivert, 2002:11) or uncontrolled conditions. The assumption is that in the industry, wear testing is mostly done in uncontrolled conditions. The choice of people to take part in wear testing is again based on the body measurements that the garment is supposed to fit.

Improving garment fit before mass production is undertaken is necessary to ensure garment quality and consumer satisfaction, and also to avoid unnecessary expenses due to the production of unsuitable garments. Fit and wear testing are the means to improve garment fit before mass production. The South African situation regarding fit and wear testing will thus be investigated.

2.7.5 Definitions and problems regarding body measurements

The correct set of body measurements related to the specific product will determine the relevance of the database. The importance of clear definitions is confirmed by Pargas, Staples and Davis (1997:161): “A key in the successful use of measurements obtained from body scans will be in the clear definition of where and how the measurements were taken.” This view is also confirmed by Laing and Sleivert (2002:4) in their discussion of the use of body measurement data. This applies to any method, for example traditional tailor’s measurements, traditional anthropometry or three-dimensional body scanning, used for taking the

measurements. It is therefore necessary to determine which measurements are important and useful to the South African clothing industry and how and where these measurements should be taken.

A clear understanding of the problems experienced with body measurements will also be useful. As illustrated in **Figure 1.1**, measurement problems together with vague descriptions of where and how the body measurements should be taken, will ultimately result in inaccurate body measurement data. This leads to the development of inaccurate sizing systems, which causes inaccurate block patterns to be created, and unsuitable fit and wear testing to be done.

2.8 CONCLUSION

Databases of the South African population's body dimensions are not readily available. In most cases they are developed for the exclusive use of specific clothing manufacturing and/or retailing companies. The South African Standard Code of Practice for Definitions for and measurement of body dimensions (SABS 0184-1982) contains only fifteen measurements. The origin of anthropometric data used for key dimensions and sizing systems in South Africa is also vague. Since the anthropometric database provides the foundation on which a sizing system that would function optimally (that is, provide the option of well-fitting garments for the majority of the population), would be based, it is important to ensure that measurements are accurate and reliable.

When looking at Ashdown's framework in **Figure 2.1** as compared to the conceptual framework for this study in **Figure 1.1**, it is clear that design features and communication of sizing and fit are not included in this study. The reason for this is that body measurements do not have such a direct influence on design features, choice of materials, production and distribution. Even in the case of size labelling (communicating with the consumer), especially in the case of ladies wear, size designation has become abstract numbers with no direct relation to any body dimension. According to Le Pechoux and Ghosh (2002:11), women do not know what

their measurements are and most probably do not know how to measure them correctly. This researcher is of the opinion that the aspects regarding design features and production, and their effect on fit, as well as communicating sizing and fit to the consumer, as illustrated in **Figure 1.1**, are areas to be investigated in separate studies.

The problem that will therefore be addressed in this study is how the South African clothing industry ensures well-fitting garments for their customers.

Subproblems that arise are the following:

- ✓ Which measurements should be included in a South African database?
- ✓ How are these measurements described by the industry?
- ✓ How do these descriptions compare with international descriptions?
- ✓ What are the problems regarding body measurements?
- ✓ What is the origin of the South African sizing system?
- ✓ How do the sizing systems currently used in South Africa function?
- ✓ How are block patterns generated?
- ✓ How is fit testing done?
- ✓ How is wear testing done?

A strategy to address the above problems will be discussed in the following chapter.