DOES IT REALLY FIT?

Improve, find and evaluate garment fit

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ABSTRACT
Clothes affect everyone; we wear them for all occasions; they silently communicate on our behalf, and they can enhance our level of confidence and comfort. For the garment to be comfortable, the garment fit has to be appropriate. Appropriate for the intended function and in line with the wearer’s preferences. For the garment to end up as an approved garment in the customer’s wardrobe, it has to be improved and evaluated many times over. The final evaluation to pass is when the customer finds the garment, tries it on and asks: Does it really fit?

The common denominator for the studies included in this thesis is garment fit; the goal is to investigate some methods to improve, find and evaluate garment fit. To improve garment fit, two studies were done. One study is on improving garment fit with the help of a systematic model, based on anthropometric and garment numerical data; this is explored with the help of an experimental set up. The second study is on improving garment fit for the unique figure by offering made-to-measure garments, which is investigated with a structure of action research. An experimental strategy is used to find garments that fit, where the size and fit correspondence is compared between virtual and real garments. To tie everything together, variables for garment fit evaluation are identified with the help of a structured literature review and then analysed within each study.

The result shows that the theoretical garment fit improves by using the systematic model. Both the overall accommodation for the target group increased as well as the fit value. The garment fit is improved for the unique figure; this is achieved through complex body measurements, invasive pattern modifications and garment make-up for fit evaluation. The accuracy for size selection based on virtual garments exceeded the one based on the more traditional key measurements. The variables involved in the garment fit evaluation can be divided into five areas: influencing factors, evaluations focus, resources, evaluators or fitting sessions.

Key words: garment fit, fit value, pattern construction, pattern modifications, virtual, made-to-measure, custom-made, garment, garment simulation
I am on a blessed, fabulous, enjoyable and challenging journey – called life! This thesis is part of that journey and even if only my name is written on the cover, it is a product of a joint effort. All my life, I have been blessed with people and opportunities challenging and supporting me to move forward. I have taken the challenge one step at a time, with the support of others, arriving at this....

Textiles have always been a part of my life. The interest was born in my grandmother's kitchen, where everyone gathered to do some handicrafts, encouraging the children to learn knitting, crocheting, sewing and other textile related crafts. Many thanks to all my extended family, my parents Vanja and Zamo and my sister Zaari for your patience and never ceasing encouragements to achieve all that I want in life.

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Gratefully,
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INTRODUCTION

Clothes affect everyone; they are worn for all occasions and are close to our bodies. For the clothes to be comfortable, the garment fit has to be appropriate, that is, appropriate for the intended function and according to the wearer’s preferences. To achieve this, the garment has to be evaluated and improved many times over. Professionals, test persons and finally the end user all evaluate the garment fit. They do this with different focuses and at different stages of the development. After the product development, the brand can, hopefully, provide, well-fitting garments that match the target group. The next challenge is for the customer to find the fitting garment, either by try-on or by other tools communicating size and fit. However, if the customer or the brand finds it demanding to match the wearer with a standard sized garment, the solution might be a custom-made garment. This thesis explores how garment fit is evaluated by numbers, simulated or tried-on garments as well as in the made-to-measure process.

The product developers bear the responsibility of improving the garment fit for the intended target group. Early in the development, they should analyse the anthropometric data and compare these with the product information. This evaluates the theoretical garment fit; adjustments in measurements improve the garment to match the target group. This should provide a better garment fit. Previously, researchers have compared standard charts and body measurements. Gupta and Gangadhar (2004) evaluated the body size chart, while McCulloch, Pall and Ashdown (1998) evaluated garment measurements. All of them used a method generating fit values but not a clear judgement of misfit. To go one step further, we propose a systematic model that generates the fit value as well as a clear judgement when misfit occurs, Appendix 1. The customer wants to find the best fitting garment. We assume that a suitable garment is available, but how do you find it? First step is usually the size label; this indicates which garments are close to your body size. Second step is to try-on the garment; and finally, you walk out with a suitable garment! However, the demand for evaluating garment fit without try-on is increasing by the day. The growing statistics on returns related to online shopping are costly for everyone. One way to estimate size and fit without try-on is to use simulated garments. Earlier studies investigated how the virtual garment represents the real garment. Kim and LaBat (2013b) asked the general customer, while Song and Ashdown (2015) used a panel of fit experts. The latter used trousers that were custom-made for the test persons, while Kim and LaBat (2013b) used standard sizes. In our study, we wanted to compare the size selection based on the simulated garment versus the real try-on. We also documented and compared the customers’ perception of ease in the simulated and real garment, Appendix 2. The long-term goal is to increase the match between the pre- and real size selection.

When the need is special or the preferences too particular, a custom-made garment might be the solution. The custom-made offers are set up in different ways. One way is the “custom-design”, which offers standard sizes and asks the customer to select from various designs, such as combination of details, fabrics and special monograms. Another way is the “custom-fit”, which offers standard designs in a made-to-measure (mtm) fit, meaning that the measurements of the standard garment are modified in line with the customer’s measurements. Of course, a combination of these custom-made offers is possible. For the brand and manufacturer, the custom-design offer is rather straightforward and is more of a logistic and production set up challenge. In contrast, the custom-fit offer requires additional control of patterns and production quality to be able to deliver garments with the promised measurements. The most common mtm garments offered are menswear, and modifications are usually standard length and width
measurements. To expand and offer garments for unique body shapes, more invasive pattern modifications need to be available. Frost (1987) uses a method based on standard patterns that are modified according to the individual measurements, including largely asymmetrical figures. Part of the goals within the EASYTEX project (1997-2000) was to produce software for automatic measurement and pattern construction. To test the software for pattern construction, we recruited test persons with unique figures. We classified the figure deviations, took complex measurements, made complicated garment constructions and finally evaluated the garment fit, Appendix 3.

The complexity of the garment fit evaluation became evident during the research cases. In retrospect, it would have been beneficial if an accepted standard were available to lean on when evaluating all the garments. This was not and is still not available. However, when revisiting the cases, it is evident that parallel result from the research is available; this by exploring the way we evaluated the garment fit within each case. This is reviewed in the structured literature review, focusing on garment fit evaluation, Appendix 4.

Objectives

Garment fit runs as a red thread throughout the studies included in this thesis. The attempt is to pull all the studies together by their common denominator - garment fit. Two methods of improving garment fit will be explored as well as how well the garment size and fit matches between the simulated and the real garment. These will be tied together with an exploratory overview of garment fit evaluation. The following objectives and questions are set as guidelines to fulfil these goals.

Improve garment fit

- RQ1 To what extent can a systematic model improve garment fit?
- RQ2 How is garment fit improved for the unique figures?

Find a garment that fits

- RQ3 How accurate is the size selection of best fitting garment, when comparing virtual and real garments?

Evaluate garment fit

- RQ4 What variables are involved in evaluation of garment fit?

Structure of Thesis

The structure of the thesis is as follows:

Introduction – This chapter explains the research background for the cases included in the thesis. A brief presentation of previous studies that inspired in identifying the research gap is also provided; this also gives justification for the research scope for the presented cases.

Background – This chapter presents the background for garment fit and the tools used, as well as the previous studies leading up to the studies presented in this thesis.

Scope and Limitations – This chapter gives a condensed presentation of the scope and delimitations of each study.

Methodology – This chapter presents the methodology as a whole and the detailed methods used for each study. The chapter ends with a methodology discussion.
BACKGROUND

This chapter presents the background of garment fit and the tools used, as well as the previous studies leading up to the studies presented in this thesis.

Clothes are important for the wearer's identity and nonverbal communication. The comfort of clothing depends on many social and physical factors. Garment fit affects comfort, and a well-fitting garment increases both appearance and confidence. Many tools and resources are needed to deliver well-fitting garments. Some of these include body measurements, pattern technology and simulation of garment fit. These are implemented in the product development process to improve and evaluate garment fit as well as support the size selection process.

Importance of Clothing

Clothes are not only used to cover and protect our bodies; today, clothes are used to identify oneself (Alexander, Connell & Presley 2005). Clothes communicate personality, stand point, group belonging, etc. (Feather & Jenkins 1993; Jacobson 1994; Ryan 1966) and are essential in the first impression of an individual (Molloy 1988; Thorin 1992). According to Ashdown and O'Connell (2006), clothes that fit well enhance appearance and increase confidence. Even if many authors stress that clothes are a strong communication tool, Feinberg (1992) believes that not all garments give clear and complete signals about the wearer's self-identity, since the interpretation depends on the viewer (Ryan 1966).

Because clothes are of such importance for self-identity and nonverbal communication, it is of great interest for everyone to be able to find suitable and comfortable clothes for every occasion.

Clothing Comfort

Clothing differs from other products on the market. Since they are worn close to our bodies (Ashdown 2014), comfort of the product is important. The definition of clothing comfort is difficult to quantify (Slater 1986) and even difficult to define (Li 2001). The factors involved in clothing comfort are interactive, and the individual evaluations vary, which makes the subject difficult to study (Goldman 2005). In the literature, clothing comfort is described in different ways; they overlap and use different vocabulary, which makes comparison difficult. Despite this, an overview of clothing comfort is given in Figure 1. Sontag (1985) starts by putting comfort in a context where the environment, clothing factors and the individual interact. The environment includes attributes such as climate, people and social norms. Clothing factors involve all physical attributes affecting comfort. The individual relates to, for example, personal values, age, ethnicity, sex, height, weight and physiological aspects (Sonntag 1985). All these aspects are considered when comfort is evaluated. The individual evaluates, consciously or not, both physiological and psychological comfort. The physiological comfort includes, for example, the state of the person's body temperature, lung function, tactile sensation, blood pressure as well as visual and aural stimulation. The psychological comfort includes the environmental attributes related to people and social norms. (Slater 1986)

The social and physical factors influence the evaluation of clothing comfort. Social factors affecting clothing comfort relates to the personal experience and how others respond to the individual. Psychological comfort can be fulfilled if the individual has a feeling of wearing the appropriate dress for a specific occasion (Sonntag 1985). In the literature, there are mainly four physical factor described as having an impact on physiological and psychological comfort: Thermal, sensational, ergonomic and aesthetic (Das & Alagirusamy 2010; Roy Choudhury, Majumdar & Datta 2011).

The thermal performance relates to the balanced state of heat and moisture (Li & Wong 2006). Underlying thermal factors are, for example, fabric thickness, fibre density, number and proximity of layers (Roy Choudhury, Majumdar & Datta 2011). The mechanical aspects of a garment relates to the mechanical touch of the fabric against the skin (Das & Alagirusamy 2010). The ergonomic, also known as the body movement comfort, relates to the ability to move freely without uncomfortable restrictions in movement or pressure against the skin (Goldman 2005; Li & Wong 2006; Roy Choudhury, Majumdar & Datta 2011). This is where the appropriate size and fit of the garment comes in (Das & Alagirusamy 2010). The aesthetics factors relate to, for example, the drape, lustre, creasing and decorative ornaments of the garment. When all these aspects are weighed together into an evaluation of the comfort, many researchers find that individuals have difficulties defining comfort, while describing discomfort is easier (Li 2001; Slater 1986; Watkins 2011).

In the literature, ergonomics are one part in the larger puzzle of clothing comfort. Geršak (2014) stated that wearing comfort is an essential attribute of any garment. In this thesis, the focus is on the garment fit. Influence of other physical or social factors can be limited but not excluded; thus, in this thesis, they are neither registered nor analysed.

Garment Fit

Garment fit is important for the user. A nice design, costly fabric and other features of the garment are of no use if the fit is poor. A well-fitted garment looks better and is more comfortable; on the contrary, a garment with poor fit will not be used and maybe not even sold. (Brown & Rice 2014) The wearing comfort is a interaction of body measurements, fabric properties and pattern construction, including ease allowance (Geršak 2014). The ease allowance is the difference between the garment and body measurements (Wang, Newton, Ng & Zhang 2006); its purpose is two-fold: functional or fit ease for the movements of the body and aesthetical or style ease for the design of the garment (Ashdown & DeLong 1995; Beasley 1999). Incorporated in the ease is the parameters of comfort, function, oversize and fabric properties (Gill 2011). Ease also serves as a buffer when a person's body measurements do not conform to a specific size (Petrova & Ashdown 2008).

In regard to wearing comfort, Song and Ashdown (2010) also mentioned the importance of the wearer's proportions and posture. Good garment fit requires a balance between the garment and the body; the garment follows the silhouette of the body (Ashdown & O'Connell 2006; Brown & Rice 2014; Erwin 1974; Song & Ashdown 2010). In support, Gribbin (2014) stated that garment fit has to do with shape; if the garment represents the three-dimensional body, the probability of
good fit increases. The problem with garment fit stems from insufficient product development, which includes selection of fit model, pattern development, grading and distortion of grain line (Ashdown & O'Connell 2006). Even if ill-fitting garments can stem from poor product development, Brown and Rice (2014) stated that most fitting problems are due to the variety in our bodies, i.e. we all have unique bodies.

In addition to our bodies, perception of garment fit is also unique. Individuals with the same body measurements identify their fit preferences differently (Alexander, Connell & Presley 2005); thus, one likes a tight garment, while someone else likes it loose (Brown & Rice 2014). The variation of case preference is also shown by Lin and Wang (1993). The variation in fit preference varies between individuals, but it also depends on the occasion (Shin & Damhorst 2018), fashion, culture, norms (Zhang, Zhang & Xiao 2011), specific fits that are in fashion and the subjective perception of fit, all this makes it difficult to establish a standard for fit (Ashdown & O'Connell 2006). For the brands to maintain or improve garment fit, they need to use a well-designed sizing system, commit to product development, effective pattern construction and high quality production (Ashdown & O'Connell 2006).

The individual preference of fit is unique and important for the garment fit evaluation; two of the studies in this thesis register and analyse the individual preferences in regard to garment fit.

Means for Product Development
There are different resources used for product development. In this section, a small selection is presented, which has a significant place in the studies within this thesis.

Body Measurements & Shape
Different body measurements are the reason for different sizes available in stores. The body measurements are one way of describing a body; this description is then interpreted to create well-fitted garments (Bye, Labat & Delong 2006). The measurements can be taken manually with a tape measure (Liechty, Rasband & Potthberg-Steineckert 2010) and preferably with identified marks on the body (Roebuck 1995), or with the help of some equipment, for example, a body scanner (Daamen & Ter Haar 2013). To get accurate measures, the measurement should be taken by someone else (Yoon & Radwin 1994), preferably a trained expert. The registration of measurements can be with the purpose of documenting only one individual or a selected group of individuals representing a population. Earlier surveys were conducted manually (Cednäs & Kjellnäs 1977); however, lately they have been conducted with the help of 3D body scanners (Bougourd & Treleaven 2014). With access to larger data set of measurements, statistical analysis can be conducted. The key measurements, chest and hip for the upper and lower body, respectively, are the result of this kind of analysis (Gupta & Gangadhar 2004).

Even if the body can be described via body measurements, it is not a complete description. The traditional circumference and length measurement document the volume and length of the body but not how the underlying shapes are distributed over the body. The most common way of identifying the shape of the body is to compare the silhouette and/or by calculating the difference between specific circumference measurements (Connell, Ulrich, Brannon, Alexander & Presley 2006; Liechty, Rasband & Potthberg-Steineckert 2010). With the help of some photos, one can analyze the body figure from different angles (Farrel-Beck & Pouliot 1983). The body scanner registers the body shape as well as the measurements; within the EASYTEX-project (1997-2000), the body scanner was used to register both measurement and figures of individuals with large deviations from standard bodies (Neuez 2000). Song (2011) used a method based on scanned standard bodies, where new measurements such as depth and angle measurements were implemented in cluster analysis to classify body shape for the lower body.

The measurements and the shape of the body are important aspects when analysing garment fit. Body measurements played an essential role in all studies included in this thesis. In the study Tailoring the Unique Figures, the body shape was analyzed in depth with the help of specific landmarks on the body, body measurements and photos. In the study Size Selection, key measurements were used and the shape of the body registered by a 3D body scanner.

Pattern Construction
Computer generated patterns are used to produce garments in many sizes. For production, they are two-dimensional and include seam allowance and other production information such as grain line, notches and internal marks. There are different ways of creating the initial pattern; a common way of creating new styles is to modify an existing block pattern and add details according to the design (Armstrong 2014; Öberg & Ersman 1999). Creating basic blocks is done by using measurements and a construction plan (Aldrich 2008, Armstrong 2014), or they can be created by draping the garment on a fit stand or real body (Duburg 2014). The draped garment is then dismantled and flattened into a 2D basic pattern. Draping can also take place in a virtual world. Draping the fabric on an avatar creates the block; thereafter, a three-dimensional shape is flattened into a two-dimensional pattern (Huang, Mok, Kwok & Au 2012; Hwan Sul & Jin Kang 2006). Independent of how the basic pattern was created, it is the starting point when adding a size range by grading the pattern pieces (Shoben, Taylor & Taylor 2004).

Different types of graded patterns were used within this thesis; Basic blocks and patterns ready for production.

Simulation of Garments
Garment simulation is used for two purposes: product development and marketing. There are several software companies on the market providing simulation software: Asyst, Browswear, Clo3D, Gerber, Lectra, Otitex, etc. They work in slightly different ways, but the output is the same, i.e. a simulated garment on an avatar. If the output simulation is to be used in marketing, the visual aspects are important and might need some improvement, but how much depends on the limitations of the simulation software.

The working process within apparel simulation software operates in five steps: Avatar, fabric properties, stitching of 2D pattern, placing garment on avatar and finally, the simulation (Song & Ashdown 2015). The avatar available in the simulation software are usually parametric; the avatar’s length, volume and posture can be somewhat modified. However, it is difficult to get the parametric avatar to mirror an individual, including his/her body shape (Jevsnik, Pilar, Stjepanovic & Rudolf 2012). The avatar can also come from a body scanner. This avatar is the best replica of the real body (Kim & LaBar 2013b) and is more realistic than the parametric avatar (Lim & Istoek 2011). The simulation of fabric can be split into two sections: one where the goal is to get a realistic visual result (animations) and the other where the mechanical properties, affecting garment fit and design are important (Kuijpers 2017). To be able to evaluate the garment fit and design, the mechanical properties have to be included in the simulation. To convert the real fabric into usable simulation data, the above companies use Kawabata Evolution System (KES), Fabric Analysis by Simple Testing (FAST) or a set of software specific
The next step in the process is to stitch the pattern pieces, it is done manually and gives the software direction on how the pieces should be assembled. The details of the design have to be incorporated in the stitching to give the garment a realistic look; placement of tucks, darts, ruffles, elastic seams, etc. have to be placed and managed. After the stitching, the garment is placed on an avatar, followed by the simulation, which combines the entered information to generate the virtual garment.

The garment simulation has its limitations as shown in previous research; on the contrary, many companies think that the benefits outweigh the drawbacks (Song & Ashdown 2015). In the garment simulation, the fabric’s mechanical properties and the accuracy of the avatar are very important for the success of the simulation (Jevnik et al. 2012). If the avatar is not a replica of the real person, one cannot expect the virtual and real garment to be similar (Jevnik et al. 2012). The fabric has an overall impact on the simulation (Ancutiene & Sinkевичюte 2011) as well as on the measured ease in the simulated garment (Lage & Ancutiene 2017). It is also reported that mismatches between virtual and real garment are often related to aspects in the fabric simulation (Kim & LaBat 2013a); small wrinkles on the real garment were not noticeable on the virtual garment (Kim & LaBat 2013b; Song & Ashdown 2015). Test persons in other studies found that the simulation depicted the quality of the garment but was not reliable when it came to fit assessments (Lee & Park 2017). In yet another study, test persons found it difficult to see how the garment related to the body, i.e. it was too tight or loose (Kim & LaBat 2013a). The experience of ease among the test persons varied while the feeling of the garment’s strain corresponded between the real and virtual garment (Ancutiene 2014). Despite some of these shortcomings, Shim and Lee (2011) reported that the three dimensional model surpasses the two dimensional photo when it comes to understanding the garment fit. Test persons are also able to rank and sort virtual pants, with an accuracy of +/-1.26 cm, based on waist and hip circumference (Kim 2016). The results in the reported studies vary, and the reason is not clear.

The reason could depend on the possibilities and the limitations of the software used as well as the ongoing development within the software and more powerful computers. Test persons and researchers in previous studies mentioned the limitation of the static avatar; they thought it would be easier to evaluate the garment fit, ease and the strain if the avatar was dynamic (Ancutiene 2014; Bye & LaBat 2005; Kim & LaBat 2013a). With some software programmes, the garment can be transparent, which might also help when accessing how the garment relates to the body. Other possibilities within the software are the pressure and strain mapping of the garment (Hong, Zeng, Bruniau & Liu 2017; Magenat-Thalmann, Kevelval, Volino, Kasap & Lyard 2011; Sayem 2017). Some evaluators would like to use the pressure points to evaluate the ease is distributed (Song & Ashdown 2010). Unfortunately, the preparations for simulation are considered to be labour-intensive; however, technical solutions are developed by researchers to mass produce digital garments (Kim 2012). Future developments and research will hopefully provide time-effective and reliable techniques related to simulation of garment and improved tools for evaluation of size and fit.

Kim and LaBat (2013b) stated in their consumer related study that the accuracy level of the simulation is based on the user's ability to make decisions regarding size, fit evaluation and purchase decisions based on the simulation. This is a guide to what level of simulation we need for our decision-making; specifically, do we need to evaluate garment fit and drive product development or only display products for sale – the requirements of the simulation software are different depending on expected decisions.

**Earlier Initiatives**

Even if the area of research is quite narrow, over the years some research has been done forming the framework for the studies in this thesis. These include different ways of evaluating garment fit, improving the fit for a group or for an individual, and finally how the customer finds the best size and fit.

**Evaluate Garment Fit**

Evaluation of garment fit is an essential step in the product development. The most important step in the product development is the fit session; thus, companies that are successful in maximising this, increase the garment fit and thereby the sale (Bye & LaBat 2005). A more comprehensive evaluation suggests to include four steps: (1) Gathering of anthropometric data for the target group, (2) manufacturing of the prototype, (3) test persons test and evaluate the prototype regarding the fit, comfort and functionality and finally (4) experts evaluate the visual aspects of the garment on the test person (Kohn & Ashdown 1998). However, many companies do not have the resources to gather new anthropometric data, although they might have access to a database from where they can draw target related data. Most companies ask the test person to try-on and alongside the experts to evaluate the prototypes in the basic size (Ashdown 1998); ninety-four per cent of the average garment is evaluated two to three times during the product development (Bye & LaBat 2005). The garments should be fit tested in different sizes; however, this is seldom done due to the complicated process (Watkins & Dunne 2015); the extended size range is usually only checked by measurements (Ashdown & O‘Connell 2006).

The live fit sessions are set up in different ways, and they involve various evaluators. The evaluators look at the garment on a body form and donne on a fit model (Ashdown & O‘Connell 2006; Yu 2010; Zhang, Zhang & Xiao 2011). The fit model is preferred because he/she can evaluate the comfort, feel of fabric and behaviour of the garment, both static and in motion (Bougourd 2007). The evaluators belong to one of the three groups: fit model, experts or end user (consumer). To fully evaluate the garment, the fit model has to be representative in both size and physical capabilities (McConville 1986). An expert panel is often used for fit assessment (Choi & Ashdown 2002); the experts participating in the evaluation are often a designer, merchandiser, product developer and/or pattern maker (Bye & LaBat 2005). During product development in a company, the evaluation is usually finalised during the fitting session, while other methods are used and tested in research. Before the fit session, the criteria for good fit should be defined (Ashdown & O‘Connell 2006). The live fit session and the evaluation can be documented in various ways: photos, videos and text document. Using photos is an excellent way to illustrate the findings (McConville 1986) as well as capturing the fit session on video (Kohn & Ashdown 1998; Schofield, Ashdown, Hethorn, LaBat & Salusso 2006). By using photos and videos, it is possible to re-evaluate and compare the fit between garments (Petrova & Ashdown 2012). This also creates flexibility with maintained reliability; the evaluator can watch the video at different times but still evaluate the exact same session (Ashdown & O‘Connell 2006). In addition to these visual documentations, text-based documentations can be used. The content of the structured document depends on who is evaluating. Several researchers claim that the content and vocabulary have to be different depending on the respondent. (DeLong et al. 1993; Varghese & Thilagavathi 2013) The document for the expert is more technical (Ashdown & O‘Connell 2006).
2006) and uses formal terminology of fit evaluations such as grain, set, line, ease and balance, established by Erwin (1974). These formal terms for evaluation were not used when a focus group evaluated fit; their evaluation is based on how they feel and perceive fit and comfort; there is a gap in the vocabulary between layman and experts when evaluating garment fit (Shin & Damhorst 2018), which should be considered when comparing evaluations.

Another way of evaluating garment fit is based on virtual (simulated) or scanned garments. All test persons are dressed in a selected garment and then scanned; these scans are then analysed and fit evaluated in different sections of the garment (Ashdown, Loker, Schoenfelder & Lyman-Clarke 2004; Zhang, Zhang & Xiao 2011). Another analysing method when using scanned garment is to evaluate the air gap and air volume between the body and the garment (Lu, Song & Li 2014). Yet another way is to compare the reliability of the scanned garment versus a real garment; fit assessments are made on both the real and scanned garment, at different garment locations and then compared (Song & Ashdown 2010). The simulated, virtual garment is used in comparisons between the virtual and real garment. The test person is dressed in the real garment, and the real fit is documented with photos; the same test person's avatar is used in the simulation of the garment; a panel of experts compares the photos from the real garment and the virtual garment (Song & Ashdown 2015). Another way of comparing the virtual and real garment is to have the virtual garment on the individual avatar and then ask the same test person to try on the real garment; the test person then compares the real garment on their bodies to the virtual one (Kim & LaBat 2013b).

The result of garment fit evaluation is not an exact science (Ashdown & DeLong 1995). The evaluation can be subjective or objective. The objective evaluation is measured by instruments with little or no interaction by humans (Slater 1986). There are five objective evaluation techniques when it comes to garment fit: moiré optics, algebraic, waveform, pressure and 3D modelling of pressure (Yu 2004a). To my knowledge, these objective techniques are not widely used in companies or in applied research. On the other hand, subjective evaluations are frequently used in fit evaluations; independent of who is the evaluator, the evaluation is considered subjective; the evaluation is impacted by the evaluator's own perception of fit (McConville 1986; Yu 2004b; Zhang, Zhang & Xiao 2011). The reliability of this fit evaluation is considered to be low because of the subjectivity and lack of clear methodology when it comes to evaluation of garment fit (Ashdown & DeLong 1995). However, the reliability was high over time, that is, when comparing two evaluations conducted two weeks apart with the same evaluation panel and the same garments (Ashdown & O'Connell 2006). Another challenge with evaluation of garment fit is the fluctuation of the result between the evaluating groups. The test persons’ perception of fit varies within the group (DeLong et al. 1993) and differs as well from the experts’ evaluations (Kohn & Ashdown 1998). It seems to be consistent that individual’s preference of fit and comfort varies (Ashdown & DeLong 1995; Bye, Labat & Delong 2006) and therefore is difficult to predict.

As mentioned before, if it is not established how garment fit is evaluated, the outcome depends highly on who is the evaluator (Ashdown & O'Connell 2006). Previous researchers have used evaluation set-ups that might support a more consistent evaluation. The use of expert panels might reduce the risk of bias and individual preferences. Yu (2010) mentioned that the expert evaluators should receive training so they individually can assess the garment fit. Ashdown and O'Connell (2006) trained a set of inexperienced fit evaluators; they were trained by watching videos, including well- and poor-fitting jackets commented on by a fit expert; the effect of the training resulted in no significant difference in the evaluation scores between fit experts and trained fit evaluators. The consistency in fit evaluation during the product development might benefit the customer in the end. However, the final say when it comes to the garment fit rests with the wearer and end user (Gribbin 2014). The garment fit evaluation will be further explored in the structured literature review, Appendix 4, and linked to the different studies used to complete this thesis.
modifications linked to the individual measurements. The foundation of this information is the understanding of how to achieve improved garment fit (DeLong et al. 1993). To offer modifications covering larger figure deviations, more invasive modifications of the patterns are needed. Frost (1987) used a modification method based on standard patterns, which are modified according to the individuals' asymmetrical and warped figures. Part of the goals in the EASYTEX-project (1997-2000) was to improve availability of regular, well-fitting garments for individuals with unique figures. To reach this goal, software for automatic measurement and pattern modifications were developed and tested. The project succeeded in providing improved garments for the unique figures (Berglin & Hernández 1997; Berglin & Hernández 1999). Some researchers created made-to-measure pants to evaluate the similarities between real and virtual fit of the pants (Song & Ashdown 2015). Other researchers show the possibilities to make the process even more automatic; from 3D body scanning to an individual pattern (Dābolīna, Vilumsonė, Dābolīns, Strazdiene & Lapkovska 2018). In order to produce made-to-measure garments, the manufacturer has to get or estimate the individual measurement in some way. Over the years, it has become evident that it is difficult for the customers to take and report their own body measurements in a correct manner (Gribbin 2014). However, avoiding risky unknown measurements, researchers use data known to the customer, namely, age, height, weight and neck circumference; with these four dimensions, the company can provide 95% of the population with fitting shirts (Daanen & Byvoet 2011).

Previous researchers have predicted the aggregate loss of fit. Taking this method one step further, in the study Garment Fit by Numbers, a systematic model was used to improve the theoretical garment fit of a women’s skirt. In the study Tailoring the Unique Figure, invasive pattern modifications were developed to improve garment fit for warped, short/tall stature, prominent and wheelchair users.

**Find a Garment That Fits**

All customers want to find a garment in a suitable size and fit. This is dictated by available sizes, which usually is an excerpt from a sizing system. A sizing system should fulfill three objectives: accommodate a high per cent of the population, give as good garment fit as possible and use as few sizes as possible (McCulloch, Paal & Ashdown 1998). The challenge is especially difficult with the knowledge of the body shape and size variation within the population (Ashdown 2014). The brands are also challenged by the uncertainty of the body dimensions of the unknown customer (Petrova 2007). Independent of the selected sizing system, clarity is important when it comes to the garment size and its dimensions (Labat 2007). However, the size and dimensions of the garments vary between the brands. One reason for this variation is the different target groups (Kim & LaBat 2013a); these groups differ in their lifestyle, income and body shape (Alexander, Connell & Presley 2005), which affect their body dimensions. Another reason for the variation is that some companies implement the so-called vanity sizes, where the size label in the garment decreases but the volume of the garment is the same (Alexander, Connell & Presley 2005; Gribbin 2014).

Unfortunately, the brands seldom test their size system on their customers; this leads to deprived knowledge about the customers’ feedback regarding size and fit (Ashdown & DeLong 1995). This could be the reason as to why customers often say that the measurement of the garment does not correspond to the size label or that they are frustrated because their size is not available (Kasambala, Kempen & Pandarum 2016). Adding to the complexity, the individual can be quite particular and can feel small differences such as 0.5cm at the hip level of a pair of trousers (Ashdown & DeLong 1995). Over the years, the same pattern is reported; the only way to find the appropriate size in a store is to try-on the garments (DeLong et al. 1993; Kasambala, Kempen & Pandarum 2016), often in multiple sizes (Daanen & Ter Haar 2013). Unfortunately, individuals with different body shapes have to select the most satisfactory size available (DeLong et al. 1993), which does not necessarily mean that they are satisfied with the fit.

Different attempts are made to help the customer find the best size and fit. According to Winks (1997), there are four ways for size selection: body mass, age, garment and/or body dimensions; the most common way is based on vertical and girth measurements. A common way is to match a primary measurement to the garment: bust and hip for women, and chest and waist for men (International organisation for standards (ISO) 2017). Researchers support that the bust measurement for women has most influence and is most reliable when selecting the size for an upper garment (Lin & Wang 2016; Song & Ashdown 2010). Another more complex method is to use algorithms, including five body dimensions: stature, across shoulder, arm length, chest and neck circumference, in order to determine the best fitting size of a garment (Ding & Xu 2008). Daanen and Byvoet (2011) did not recommend a size for the customer but proved a made-to-measure garment fitting the customer; the input dimensions were: age, height, weight and neck circumference for men and age, height, weight, bra size, arm length, shape of waist and hip for women. Neither of the above methods take into account the individual preference of garment fit, which is an important parameter from the individual wearer (Gribbin 2014). The wearer might be able to incorporate the individual preference in the size selection if the garment is visualised in some way. Researchers point out the importance of using visualisation technologies to support the pre-purchase information (Ancutiene 2014; Kim & Forsythe 2008). If the virtual model represents the shape of the consumer, it benefits the garment fit decision (Shim & Lee 2011).

Researchers have shown in tests that individuals can rank and sort garments with differences down to 1.25cm in width measurements (Kim 2016). This indicates that they can use the tool to identify different sizes. Experts have compared the real and virtual garments dressed on test persons; the highest correlation is with well-fitting trousers. When differences were indicated, the virtual garment was perceived as being looser than the real garment and with less stress folds shown (Song & Ashdown 2015). In another study, test persons made a size selection, based on the simulated garments and compared how well the selected garment fitted on their virtual and real body, respectively. The results of the study shows that the test persons perceived the virtual pants to be tighter than the real ones and that the fidelity of the simulations is moderately good (Kim & Labat 2013b).

In the study Size Selection, the test persons selected the best fitting size based on both virtual and real garment independently. They also evaluated the perception of ease at different sections in both garments. The experts, on the other hand, only selected the best fitting virtual garment, but no evaluation of ease at different sections.
SCAPE AND LIMITATIONS

This chapter gives a condensed presentation of the scope and delimitations of each study.

The focus is on garment fit through all the studies as well as in the dissertation. Other underlying physical and social factors of comfort will not be explored at this point.

Two methods for garment fit improvements are investigated. In the study Garment Fit by Numbers, we used a systematic model to improve garment fit early on in the product development. The study is limited to numerical analysis and does not incorporate any correlation analysis towards real garments. In the study Tailoring the Unique Figure, we increased the garment fit for the individual with unique figures, such as warped, tall/short stature, prominent and wheelchair user. The study excluded the individual preferences such as colour, design, fabric and functional aspects, and the focus was on garment fit.

In the study Size Selection, we looked at the pre size selection and the real size selection. The test persons evaluated the ease perception of the real and virtual garments’ different sections. The experts made a size selection based on the virtual garments. Due to the response time of the questionnaire, the evaluation of the garment’s sections was eliminated.

METHODOLOGY

This chapter presents the methodology as a whole and the detailed methods used for each study. The chapter ends with a methodology discussion.

Research Approach and Strategies

This research, as a whole, is a mix between applied and basic research. In short, the basic research strives to find and add general value to the society, while applied research aims to gather knowledge and understanding of a particular problem (Saunders, Lewis & Thornhill 2009). Part of the research is applied because it addresses real problems and generates practical outcomes.

However, the exploratory study of garment fit is basic research; the general contribution to the apparel community is to identify the underlying factors of garment fit evaluation.

When investigating a relatively new research area, it is logical to start by mapping the basic variables. By using an exploratory nature of research, one can put light on what variables are included and gain basic knowledge of the field. Moreover, the descriptive research could explain how the variables are connected; and to reach even deeper/higher, use explanatory nature of research to answer why the variables affect each other. (Saunders, Lewis & Thornhill 2009) Based on this reasoning, the exploratory nature of research was used as a starting point for all research questions in this thesis. However, the studies related to improving garment fit for unique figures, and the accuracy in size selection for best fitting garment also uses descriptive research to answer the research questions; how the garment fit is improved as well as how accurate is the size selection.

Two main approaches to research can be taken: the deductive and inductive, as well as a mix of the two. The approach is related to how the research is conducted, from theory to data or from data to theory. In the deductive approach, the research starts in existing theories, and the empirical data relate to these. The inductive approach starts with the data and forms theories. (Saunders, Lewis & Thornhill 2009) All studies in this thesis use the deductive approach.

However, the existing theories and methods are just a starting point. From these, the research design was developed to match the research questions, available resources and time frame.

The time frame of a research often affects how to plan and conduct the research. It can be either cross-sectional or longitudinal. The former refers to one time selection, while longitudinal means surveys executed several times, usually to detect changes in phenomena. (Dwyer & Bernauer 2014) A cross-sectional approach was used in the studies included in the thesis. Even if one study was carried out for many years (Tailoring the Unique Figure), the aim was to catch and analyse the present data to improve garment fit, not to compare the improvements. The chronology of the studies of this thesis is presented in Figure 2.

Figure 2: Research chronological

Experiment

The experiment is a strategy built on as controlled settings as possible. In short, the aim is to see how the independent variables (also called factors) affect the reading of the dependent variables.
(also called response variable) (De Veaux, Velleman & Bock 2012). Jacobs (1961 see (Wang & Groat 2013) describes five elements included in an experiment: independent variable (the variable changing in the experiment), dependent variable (effected by the independent variable and holds the outcome measure of the experiment), treatment unit (the unit receiving treatment in experiment), control unit (unit with no treatment) and focus on causality (focus on cause-effect relationship).

An experiment was used to investigate if a systematic model can improve garment fit (RQ1). The dependent variable is the fit value measuring how well the included theoretical garments fit to the target group. The independent variable is the garment measurements, which were modified between the experimental runs. The unit receiving treatment is the theoretical garment, and the control unit is the original (untreated) theoretical garment. The causality represents the analysis done between each run.

An experimental set up was also used when looking at the accuracy of size selection of best fitting garments (RQ3). The dependent variable is the size selection, and the two independent variables are the method, on which the size selection is based (virtual garment or real try-on) and who is selecting the size (user or expert). The test unit is the individuals for whom the size selection is made. The control unit is the same individuals, but with the size selection made by key measurement. The study focused on the different size selections; thus, at this stage did not analyse the causality.

Survey
The survey is a strategy to collect data from a set of individuals or groups, using questionnaires or interviews. Data collected can be qualitative, quantitative or both. Depending on its form, it reaches the target group via electronic tools, physical distribution or via meetings. (Nishishiba 2014)

Tools like 3D body scanners are other types of tools (other than questionnaires and interviews) that make it possible to gather another type of data. 3D body scanner is a tool for the researcher to gather detailed and large amount of body surface data. (Robinette & Daanen 2003)

A survey was used for quantitative data collection when investigating the accuracy of size selection (RQ3). Two groups of respondents participated in the cross-sectional survey: one via an online questionnaire and the other via questionnaires distributed during two separate meetings. Three questionnaires were used during these two meetings the first was distributed right before the subjects were body scanned, the second one for size selection based on virtual garments, and the third for size selection based on real try-on.

Action Research
Action research is about learning through action and evaluation (McNiff 2013). Saund er et al. (2009) underlines four components in action research: (1) one should focus on action in research (not research about action), (2) collaboration, between all participants, including the researcher and individuals affected and concerned by the research, (3) it is a iterative process and (4) should be somewhat

generalisable. The iterative process includes: diagnosing, planning, taking action and evaluating, Figure 3.

Action research was used to improve the garment fit for the unique figure (RQ2). The context was set within the EASYTEX project, while the researchers and supervisors in the project set the detailed purpose of the action research. The garment construction and making of prototypes represent the action in the research. The test persons and the researchers met regularly to collaborate by evaluating the garment fit. The researcher then made the diagnostics before planning the next version of pattern and garment, Figure 4. A questionnaire was used for registering the evaluation.

Even if the duration of this research was over three years, it was a cross-sectional study. The aim was not to compare the different phases over time, as in longitudinal studies. The aim was to improve the garment fit for the unique figure (RQ2) using action research.

Sample Selection
The population is the entity relevant for the research. When the entity is large, there is a need for a representative sample, which can be a probability or non-probability sample. The former can be used when the population size is known. The sample size is determined based on the population size, confidence interval and margin of error. Probability sampling can be done using four techniques: simple, systematic, stratified random and cluster (Saunders, Lewis & Thornhill 2009). According to Pickard (2017), probability sampling has to be used if statistical generalisation is required. Even if this sampling method is used, the researcher should always be careful of any bias and misrepresentation of the population (ibid.). When the entity for the research is not known, a non-probability sample should be used. There are four sampling techniques used in non-probability sample: Quota, purposive, volunteer and convenient sampling. Quota is a non-random technique assigning the participant to one specific, predetermined strata/group. The recruitment goes on until the quotas for all groups are filled. When using the purposive technique, the researcher makes the sampling based on his/her judgement. The researcher can select cases that are extreme, heterogeneous, homogenous, critical or typical. When the subjects identify their desire to participate in a sample, this is called self-selection sampling (volunteer) (Saunders, Lewis & Thornhill 2009). The volunteer sampling is often biased in some way or another and cannot claim to be representative of the population (De Veaux, Velleman & Bock 2012). This should be considered when drawing conclusions based on this type of sampling.

Size of the sample depends on many factors. According to Daniel (2012), the researcher has to consider five main points before deciding on the sample size: Objectives of the study, ethical considerations, nature of population, available resources and research design, including design of research, analysis and sample. Research with an exploratory nature, ethical considerations as well
as homogenous and scattered population often use smaller sample sizes. Larger sample size is used when research is qualitative, non-experimental, longitudinal and with a detailed and complex design for analysis (ibid.). The studies presented in this thesis have used non-probability samples. For the Size Selection study (RQ3), we decided to have small samples based on the rather homogenous population, experimental design, simple analysis and limited resources. For this study, volunteer sampling was used (n=42). An invitation to participate as a test person was sent out and announced in different ways without any purposive selections. The invitations to the expert panel were only sent to individuals fulfilling the expert criteria. The researcher used purposive selection for this first selection; thereafter, the expert subjects decided if they volunteered or not (n=24). These samples do not represent the population, but the samples are big enough to draw some explorative and descriptive conclusions.

The sample used in the study Tailoring the Unique Figure (RQ2) was recruited in two steps: first, with a self-selection (volunteer) technique and then with the quota. First, via newspaper ads, individuals with unique body shapes and difficulties finding well-fitting garments were invited to sign up. Based on the first sample (n=16), the total sample was decreased with the use of the sampling technique quota. For the first phase (A) in the study, we needed test persons representing the four different identified categories: Short/long stature, warped figure, prominent figure and wheelchair user (n=8). For the test phases (B & C), we used the wider range of volunteers (n=16).

Data Collection
The data are either secondary or primary data. They are used separately or in combination to enhance and widen the scope of the research.

Secondary Data
The secondary data are data previously collected, for some other purpose than your research. Advantage with this data is that it is already collected and available. It can be used as it is or analysed together with primary data to give a wider scope of the study. On the down side, the secondary data might not contain all information to exactly answer the research question. The quality of the data might be uncertain. (Saunders, Lewis & Thornhill 2009)

Secondary data are the basis for the study Garment Fit by Numbers. The data came from the large database ANSUR, which contains body measurements and data from 2,208 US women. This data set is comprehensive and well documented by Gordon et al. (1989), which is important to know when using secondary data.

Primary Data
Primary data are the data you select for the purpose of your research. The researchers gather primary data by using observations, interviews and/or questionnaires. There are two types of observations: Participant and structured observations. The former aims to observe the meaning attached to the action, and the second focuses on the frequency of the action/s. There are mainly three types of interviews: Structured, semi-structured and unstructured. The first follows a strict protocol, while the semi-structured interview has key areas to cover in a more relaxed interview and maybe a few questions to ask. Unstructured interviews are those that are very informal around a specific topic but usually with no set questions to ask. The questionnaire includes three variables: Attributes, behaviour and opinion. The attribute contains facts such as sex, age, location and income. The behaviour contains facts related to what the subject is doing. The opinion is related to the subject’s feelings, beliefs or what they think about a specific topic. The questions can be structured in different ways, for example, list (select one or many of the options), category (select one category), ranking (rank the presented words/statements), rating (frequently used Likert-style rating, agree – disagree) (Saunders, Lewis & Thornhill 2009) and open-ended questions.

In the studies Size Selection and Tailoring the Unique Figure, we used printed questionnaires for gathering the primary data regarding size selection and/or garment fit evaluation. The participants received the questionnaire during the meeting. The expert participants in the Size Selection study received a link to a survey platform, where they could interact with the material while answering questions. Within the surveys, all variables were used: attribute, behaviour and opinion. The questions were categorical, rating and open-ended questions.

Besides the collection of data through questionnaires, we gathered information about body dimensions and surface data. In the study tailoring the unique, the body measurements were taken manually and documented on a structured form. Figure registration was captured with a Polaroid camera. In the Size Selection study, we gathered primary data through the 3D body scanner as well as few manually documented measurements. The data gathered were the body measurements and the cloud of points, building the actual 3D body image. These data were extracted from the system to be further used in the experimental set-up.

Literature Review
The broader sense of the literature review is to expand the understanding of the research area. It is a way of learning from others, how researchers solved their problems. It is also a way of building a foundation that will help to refine your research topic, and last but not least, being aware of surrounding research and finding the gap to pin point your specific research. (Brown 2006)

To find what variables are used in relation to garment fit evaluation (RQ4), a literature review was conducted. The review was limited to journal articles, books and conference proceedings. Three key terms were used in the search: (1) Garment fit evaluation, (2) fit evaluation AND (garment OR apparel) and (3) garment fit. The search was restricted to finding the key terms within the sources’ title, keywords or abstract and to English sources only without limitations of publication year. First, five databases were searched: Textile Technology Complete, World Textiles, Web of Science, Scopus and Insppec. Second, nine academic journals were searched: Clothing & Textiles Research Journal; International Journal of Clothing Science & Technology; International Journal of Fashion Design, Technology & Education; International Journal of Clothing Science and Technology; Journal of Fashion Marketing & Management; Journal of Textile & Apparel Technology & Management; Journal of the Textile Institute, Textile Progress; and Textile Technology; Journal of Fashion Design, Technology & Education; International Journal of Clothing Science and Technology; Journal of Fashion Marketing & Management; Journal of Textile & Apparel Technology & Management; Journal of the Textile Institute, Textile Progress; and Textile Research Journal. The searches produced 136 hits. After removal of duplicates and a first screening of relevance, based on title and abstract, 35 sources remained, published from 1991 to 2018: 29 journal articles, four conference proceedings, one book and one book chapter. The next evaluation of the sources was based on the full text of the source and based on three points: availability of full text, relevance to garment fit evaluation and empirical study (not mainly an overview of previous studies). One of the selected articles was part one of two; to get a complete understanding, both articles had to be studied, hence the addition of one article. Based on this reasoning, 21 sources remained: 20 journal articles and one book section.
The 21 remaining sources were coded within five areas related to garment fit evaluation: Factors, fitting session, resource, evaluator and focus. The different words included in the areas are categorical words. The words were a guide to code the practice and use within the studies, not necessarily the exact wording. Table 1 shows an overview of the areas and the categorical words used in the coding. The aim was to document how previous researchers have conducted the garment fit evaluation within their studies. What they included when referring to previous studies was not registered, only what variables they actually used. Some studies evaluated garment fit and other areas, for example, design, functional testing and social aspects; these areas were not coded in this review. All relevant sources are presented in Appendix 4 along with the coding.

Table 1: Valuables in garment fit evaluation, divided into five areas

<table>
<thead>
<tr>
<th>FACTOR (influencing garment fit)</th>
<th>FITTING SESSION (method – source)</th>
<th>RESOURCE (type of resource/garment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>measurements and data shape</td>
<td>method: try on calculation</td>
<td>garment measurements</td>
</tr>
<tr>
<td>posture</td>
<td>visual evaluation</td>
<td>scanned garment**</td>
</tr>
<tr>
<td>volume</td>
<td>source: anthropometric data</td>
<td>physical garment**</td>
</tr>
<tr>
<td>pattern methodology</td>
<td>fit stand</td>
<td></td>
</tr>
<tr>
<td>fabric</td>
<td>avatar, standard</td>
<td></td>
</tr>
<tr>
<td>movement</td>
<td>avatar, individual*</td>
<td></td>
</tr>
<tr>
<td>user’s preferences</td>
<td>test person</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVALUATOR (the one evaluating)</td>
<td>FOCUS (evaluation focus)</td>
<td></td>
</tr>
<tr>
<td>output from system</td>
<td>set</td>
<td></td>
</tr>
<tr>
<td>expert/researcher</td>
<td>line</td>
<td></td>
</tr>
<tr>
<td>test person (user)</td>
<td>grain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>line</td>
<td></td>
</tr>
<tr>
<td></td>
<td>grain</td>
<td>pressure/collision</td>
</tr>
<tr>
<td></td>
<td>balance</td>
<td>seam line deformation</td>
</tr>
<tr>
<td></td>
<td>balance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>comfort</td>
<td>wrinkles (strains/folds)</td>
</tr>
<tr>
<td></td>
<td>coverage</td>
<td></td>
</tr>
</tbody>
</table>

* replica (file from 3D body scanner) and customised, parametric avatar modified with individual measurements
** standard and customised

Ethical

The standards of ethics can vary between researchers and between research fields. It does not matter whether one uses qualitative, quantitative or mixed method. Everyone involved in the research has to consider the ethics from their point of view, including research participants, researcher and the one funding the research. The ethics in relation to the participant should consider the following six topics: data collection, informed consent, incentives, sensitive information, risk of harm and maintaining confidentiality. The researcher should avoid bias, relate to and justify provision and deprivation of treatment, as well as avoid inappropriate methodology, incorrect reporting and misuse of information. The sponsors of the research should be careful and justify imposed restrictions on the research as well as the misuse of information. (Kumar 2014)

Ethical considerations were made throughout all the studies. The supporting parties did not impose any restrictions affecting the research. The researchers avoided bias in the research situation and in reporting. The researchers have reported and used the information correctly. Only the necessary information was collected regarding the participants, and they signed a consent form. They were also informed how they could withdraw from the study or get their data erased from the data set. The test persons received incentives in the studies Size Selection and Tailoring the Unique Figure. Within the former study, they received files containing their avatar as well as a film showing their avatar turning around (screensaver). In the other study, they received the final garments produced in the project. The experts in the studies did not receive any incentives. The most sensitive and personal information was in relation to the body measurement and registration of body figure, both manually and scanned data. The scanner creates avatars that could be recognised by a third party. Therefore, the participants were informed that the face/head would be disguised in publications, if there were no other agreements. When using only manual tools, we also took Polaroid pictures of the deviating figures. These were only for internal use and for publications; we used drawings to communicate the various figures.

Regarding the body scanner, the subjects’ were informed in advance that it was a safe laser scanner that was not harmful to the eyes. Concerning the participants’ confidentiality, the scanned and the identification data are stored in separate systems: digital data on a drive and manual data in a safe. The digital and analysed data contain no personal and traceable information. However, we have to be able to link the data to an individual in case they want their data to be removed in the future.

Reliability and Validity of Research

The reliability and validity of the research is important for overall research quality. The reliability relates to the study’s ability to be repeated with the same result (Saunders, Lewis & Thornhill 2009). The validity of the research can be looked at in three aspects: measurement/construct validity (if the tool measures what is intended), internal validity (causality, if x affects y) and external validity (generalisability beyond the studied group). (Bryman 2012)

The action research study, Tailoring the Unique Figure, can be questioned regarding its reliability. Based on the strategy of the research, the researcher is involved and affects the result with his/her knowledge and previous experience. However, if the same process were repeated, including participants with similar but not equal competences, the result would yield an improved fit, which was the aim of the research. So in a process sense, the study is reliable. The construction validity in this study was good. The surveys used, measured the evaluation of garment fit, which was intended, both in the process of improving garment fit and the final evaluation. The internal validity can refer to the garment fit evaluations in the process (cause), which yielded a better garment fit for the individual (effect). The external validity is difficult to evaluate in regard to the specific pattern modifications because the study focused on few participants. However, the process of improving garment fit for the unique figure would probably be generalisable.

Garment Fit by Numbers is a reliable method. As a systematic model was used, replicability is easier to predict. The difference in the output depends solely on the input values and on the analysis between the runs. The validity of the construction is strengthened by the comparison with descriptive statistics. However, further research is needed to prove the validity between the systematic model and the reality. The internal validity is proven based on the causality between the modified measurements and the effected fit value. The external validity is not proven because the study only included one theoretical garment. However, I do not see why the systematic model would not yield an improving result in theoretical fit for other garments.

Reliability is strong in the study investigating the size selection. A standard for fit evaluation could be used to strengthen reliability, once the standard is available. The measurement validity is
rather strong, meaning that the selected data communicated the size selected as well as the garment fit. With the structured questionnaire, it would not be probable to interpret the answers in another way. As the individual evaluations did not deviate too much between the experimental settings (simulated and real garment), the internal validity is high. With such a small sample, it is not possible to make general conclusions regarding the larger population. However, because the strategy is experimental and the population is rather homogenous in regard to size selection, the external validity is somewhat strengthened.

The reliability of the literature review is high, because it was structured and could be repeated by someone else, receiving similar result. The key words used grasped a wide range of research, presenting different methods and angles for garment fit evaluation.

Methods for Analysis
The data gathered in these studies are quantitative, hence, the quantitative analysis. Even if the data sets are not large, some interesting statistics are presented. With the help of quartiles, descriptive, frequency and comparative statistics, we could find logical reasons and were able to answer the research questions. A non-parametric significant test was used to identify which of the evaluations of simulated and real garments were significantly similar.

Overview of Methodology
There are quite a few methodological choices in relation to the different studies; an overview of these is presented in Table 2.

### Table 2: Overview of the methodology choices related to the different studies.

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### Discussion on Methods
There are so many undiscovered facts within this field of research that the biggest challenge was to limit the scope to what was essential for the present study. By using another research method, I could have gathered more data for future studies. However, it was not ethical to expose the participants to a wider data collection than necessary, including more observations, interviews and/or other tests.

When the research questions for the study Size Selection were formulated, we considered planning for a case study. A case study is a research method used in contemporary settings when there is not a sharp distinction between phenomenon and context. The setting is often in the “real-world” and relies on multiple sources of evidence. The research questions often include, but are not limited to, how and why questions. The research tends to be more of a descriptive or explanatory nature over exploratory research. (Yin 2014) After some further investigation concerning methods, we decided against case study, based on collection and analysis of data. The basic data collection concerns the size selected with the help of different methods. In the data analysis, the findings were compared to answer the question regarding the accuracy of the size selections (how accurate). Survey was selected as the only format for collecting data from the participants, and neither observations nor interviews were conducted. Case study was not applicable, as it requires multiple sources of evidence (Yin 2014). The environmental setting of the study was not in the real-world and also did not strive to imitate a live setting. The experimental setting was structured in a way that the appropriate data could be gathered. At this stage of the research, the focus was not on how and why they made their size selection. This might be a question for future studies. Considering the aim of this study, the experimental strategy was better suited.

For the study Tailoring the Unique Figure, the action research fitted the aims for both researchers and the sponsoring party (European Union). The iteration process fitted very well when developing both a process for improving garment fit at the same time as classifying different pattern construction methods for improving garment fit for the unique figure.

The literature review, covering the garment fit evaluation, could be even more comprehensive to include additional literature, to which the currently used sources referred. However, I do not know if that would yield more variables to consider in the garment fit evaluation. It is a quite comprehensive list of variables for garment fit evaluation. A deeper literature review might be something for future studies.
SUMMARY OF THE LITERATURE REVIEW

This chapter summarises the literature review, focusing on variables used when describing garment fit evaluation. The literature review yielded a wide range of variables in relation to garment fit evaluation. In the following section, a summary of the review is given. Building on these findings, the theme “garment fit evaluation” will be the red thread throughout the results in the thesis. Therefore, this section will present the results of the review in a condensed and structured way. These results will be put into context in the Results chapter, together with the presentation of the studies.

The words used when describing garment fit evaluation are similar throughout the literature. There are some cases of interchangeable expressions that will be discussed and clarified as to how they are used in this thesis. An overview of the areas and codes used in the review is presented in Table 1, p.20. The coding in relation to the literature is presented in Appendix 4.

Factors
The factors influencing garment fit evaluation are related to the body or garment.

Measurement & Data: Data connected to the individual, such as gender, age and ethnicity are usually used together with body measurements. The body measurements can be obtained either manually or with the use of a 3D body scanner. The test person can also self-report the measurements and data. However, to ensure validity, most of the time the measurements and data are obtained by the researcher.

Shape: The shape of the body refers to how different body sections are in proportion to each other. One way is to make a visual classification of the body shape, using, for example, hourglass, triangle or rectangle. Shape is also classified by width measurements, for example, the chest – waist ratio.

Posture: The posture is determined by the bearing of the body. It is strongly related to the curving of the spine and also by the position of the shoulders. In the literature, it is seldom mentioned how this is defined but recognised that it has an impact on the garment fit.

Volume: The volume of the garment affects the garment fit. It needs to be in balance with other factors, such as fabric, movement and personal preferences.

Pattern methodology: A pattern needed for cutting the fabric into garment pieces. There are different methods for creating these patterns, for example, by draping, pattern construction (based on body/garment measurements) or modifying an existing block. Within these different methods, there are variants that individually give variation of the fit and balance of the garment. All methods can be implemented manually or with some kind of computer aided tool, semi or fully automatic.

Fabric: The selection of fabric has an effect on other variables affecting garment fit. It is strongly related to the volume of the garment, and the volume may have to be modified depending on the fabric properties. Fabric property is an important variable when doing research with digital tools. The mechanical properties are usually described and measured by tensile, bending, shearing and surface. Non-digital studies, on the other hand, often use only the composition and amount of stretch as description of the fabric.

Movement: The evaluation of fit can change when the body starts to move. All garments for everyday life have to be able to tolerate some movements of the body. There are garments for extreme functional movements related to sports, work-wear or other specific situations. Movement is mentioned in quite a few studies, but they are seldom connected to the evaluation of garment fit.

User's preferences: The preference of the user is important when it comes to fit. This is difficult to manage in a research study because it is highly individual. Studies included in this review seldom considered the user’s preferences for fit.

Fitting Sessions
The fitting session is a combination of method and source. The method is how the evaluation is conducted, and the source is what person or object the garment is hanging on, when being evaluated.

Method
The method explains the ground on which the evaluation is made.

Visual: The visual evaluation is based on what can be noted visually. Often used when the expert is evaluating the garment without personally trying on the garment. Depending on the focus of the evaluation, the test person can also use the visual evaluation, while trying on the garment.

Try-on: The person evaluating the garment has to try-on the garment. This opens up for another type of evaluation beside the visual one.

Calculations: Calculations can be made by the researcher or be an output from a system. This data produces a foundation of data, which can be processed by an evaluator. The literature shows that many researchers use calculations in combination with other methods.

Sources
The source identifies the placement of the garment during evaluation.

Test-person: In the literature, the test-person often commits to be measured and then tries on garments, physically or virtually. Whether the test persons are just objects for trying on the garment or if the researcher records the test person’s evaluation differs between studies.

Fit stand: The fit stand is a very common way to make the first fit evaluation of the product development. However, according to this review, it is not so common in the research field. There was one study using a fit stand, but they did not focus on fit; therefore, it was excluded.

Avatar, standard: The standard avatar represents the target population, usually matching sizes in the used size range. In the literature, this is mainly used when a new system or testing method is investigated.

Avatar, individual: The individual avatar can be created in two ways: individual full body scan, creating a replica of the body, and by modifying a parametric avatar, modifications based on individual measurements. The body scanned avatar reveals asymmetrical features and contains the “cross-sectional” posture of the individual. The parametric avatar is usually symmetric and has a general body figure and posture.

Anthropometric: The individual or the target group can be represented by anthropometric data. This data can be a source against which the measurements of the product can be tested.
SUMMARY OF THE LITERATURE REVIEW

Resource
The resource is the basis for the fit evaluation.

Physical garment: The physical garment can be a bulk, prototype or a custom-made garment, as long as it is presented physically.

Simulated garment: The garment can exist only in virtual or in both the real and virtual world. In the literature, there are two main ways of using simulated garments in relation to garment fit: One to compare the real and the virtual garment and the second to develop new evaluation methods or pattern generating systems. The fabric property is often mentioned as an important parameter when it comes to the reliability of the simulated garments. Another factor is to have a relevant avatar to evaluate the garments.

Anthropometric: Anthropometric data in relation to apparel is often gathered to know the volume of the bodies within a specific target group. The target can be a whole country or a specific workforce.

Scanned garment: The full body scanner can be used to scan the full garment as well. One research found during the literature review used this method, but they were not focused on fit, therefore excluded.

Evaluator
The person or system that makes the evaluation of the garment fit.

Expert: In the literature, an expert panel is often used to evaluate the garment fit. It is often not clear if the researcher is part of this expert panel or not. However, when the researcher is mentioned as an evaluator, he/she is coded as an expert. The level of expertise varies between the studies but is often mentioned in years of experience in the field.

Test persons: Often, a test person represents the random customer. They are available for trying on garments, and sometimes they fill out an evaluation form. In some research, they are required to be within a specific size range but never requested to be a representative for a specific size. It is not usual that specific competence is required from the test person.

Output from system: Based on the calculation method, a system can be an evaluator if a clear evaluation is reported. However, often the output from the system has to be interpreted by the researcher. Within further research, the system may also include interpretations by experts in the system.

Focus
The coding within the focus grasps the focal points of the evaluation. In the literature, they often refer to the fit evaluation consisting of grain, set, line, balance and ease. However, it is often unclear which focal points were used when evaluating the silhouette, overall fit, garment in relation to body, etc. Further research might be able to clarify this.

Grain: Evaluation with the help of grain emphasises the warp and weft in the garment, in relation to the environment’s horizontal and vertical lines.

Set: How well the garment follows and adapts to the body.

Line: How the silhouette and cut lines are harmonised throughout the garment.

Balance: How well balanced the garment is towards the body. A garment in balance should hang evenly from right to left and front to back.

Ease: The difference between the garment and the body. The amount and distribution of ease have to be made according to the design, fabric, functional movements and the body.

Comfort: A number of attributes affect the comfort of the garment. However, in this context the comfort focuses on the garment fit, the feeling when standing still as well as moving within the movement range intended for the garment.

Coverage: Coverage usually relates to quantitative evaluations. It measures, for example, how one or a combination of size ranges accommodates the targeted population. In the literature, this is used in product development to check how well the product will fit the target group.

Tension and Stretch: In the literature, tension and stretch are measured at different areas of the simulated garment. The result is displayed on the garment by showing different colours, representing the variation in the tension and stretch force. However, the tension and stretch values are not available within all simulating software and also require some knowledge to interpret the result.

Mesh deformation: The deformation of the mesh is measured in x, y and the two diagonal directions. The study using this method compared the mechanical properties to the mesh deformation alongside general fit evaluations.

Pressure: Pressure or actually the distance between garment and body is used in some studies to evaluate fit. It is usually visualised on the garment with different colours, representing different pressures/distances. This can be helpful to identify areas of the garment with too much pressure to give a good fit.

Wrinkles: The wrinkles are an indication of misfit and refer to either strain or fold wrinkles. The strain is usually caused by too little fabric, causing a strain, while the fold is the outcome of too much or misplaced material. In the literature, the wrinkles are used to detect general misfit but can also be used to quantify misfit, the more wrinkles, the worse the fit.

Seam line deformation: A way of quantifying the distortion of the seam lines in a garment; the distance between the distorted seam line and the desired placement of the seam line.

Conclusions and Remarks
Based on the literature review, the exploratory study of garment fit evaluation continues. All but a few variables presented above are included in the continuation of the research.

In the literature review, the fitting sessions were divided into: method and source for easier tracking. However, further on, the fitting sessions are combined to better visualise the flow of sessions.

In the literature review, there was only one study using a scanned garment. Based on my knowledge on other research and practices within the field, this is not common; furthermore, it is not used within the studies leading up to this thesis. Accordingly, it is excluded from the upcoming exploratory study.

The literature shows some studies that use system output in their evaluation process. One study claims that their system, in the future, could generate a clear result with no interpretation needed. However, it is more common that the system output needs to be interpreted by an expert in the
field. The literature emphasizes the difference between the objective and subjective assessments. As soon as there is a person evaluating the fit, it is, most of the time, considered a subjective evaluation. This is because the person comes with his/her own preferences and opinions. The truly objective evaluation is made by systems with minimal human intervention. When it comes to different evaluators, the literature recognizes that there is a gap between experts and customers when it comes to expressing garment fit. The terminology between the two groups does not match, and this is something that could be explored in future research.

In the Result chapter, the mesh deformation, tension and stretch will be put together represented by one evaluation focus. This is because their output refers to the deformation of the mesh in the simulated garments. The seam deformation, which is an evaluation of the garment’s lines is included in the evaluation focus on line. The quantification of the deformation can still be done if so desired, but within the focus of line. Regarding the evaluation focus on wrinkles, this will be included in the evaluation focus of ease. The reason for this is that the wrinkles are most of the time a consequence of the amount of ease in the garment (Liechty, Rasband & Pottberg-Steineckert 2010). Of course, wrinkles can be used as a tool to evaluate ease or to quantify misfit, as in the literature.

**SUMMARY OF THE LITERATURE REVIEW**

The literature contains the answer to what extent a systematic model can improve garment fit (RQ 1). Even if the suitable garment is available, it can be difficult to find the suitable size, especially when try-on is not available. Further, the report includes the differences between the virtual and real garment, when it comes to Size Selection and Garment Fit (RQ3). If the suitable garment is not available, a custom-made garment might be the solution. The section Made-to-Measure and Garment Fit summarises the project providing unique figures with improved garment fit (RQ2). To tie all these together and with the literature review as a foundation, the chapter will start by exploring the different variables of garment fit evaluation (RQ 4) and present how they interconnect with each other and finally which variables were active within the different studies.

**Garment fit Evaluation**

Garment fit improves during the product development of the garment. Professionals and test persons (users) evaluate the garment fit within the fitting sessions. Many factors influence the garment fit, which can be evaluated with the help of different evaluation focuses. Fitting sessions, factors and focuses are often presented separately in the literature. Because they all affect each other, I attempt to explore and map out the interconnections between these areas.

**Exploring Influencing Factors & Evaluation Focus**

When the user puts on the final garment, the garment conforms to the user’s body and movements, and can then be evaluated. During evaluation, both professionals and users need to consider the factors influencing garment fit, Figure 6, p. 30.

All the underlying factors influencing garment fit are considered in an overall evaluation. However, the different factors connect to either the body (green) or the garment (blue). When the factors vary, the outcome of the evaluation changes. The professionals (yellow) and the users (pink) evaluate different factors with the help of the evaluation focuses. The professional should evaluate the garment, without personally trying on the garment. This evaluation is usually more...
detailed; it brings up aspects that the user only indirectly evaluates. The professional evaluates
grain, set, line and balance, while the user indirectly evaluates these by assessing the comfort of
the garment. An example is the evaluation of ease where the professional evaluates the actual
amount of ease [cm], while the user notices whether the garment is too tight/loose, short/long in
different areas. Ease highly affects the comfort of the garment, but this cannot be fully evaluated
by the professional (without try-on). Based on the focuses assigned to the professional, an
estimated comfort evaluation can be made but not validated without a real try-on. The
professional could be helped in the evaluation by using system output (grey) in combination with
his/her experience.

**Factors Related to the Body**

Here, the connections between the influencing factors of the garment fit and the evaluation focus
will be further explained and put into context, complimentary to Figure 6. The user’s BODY
MEASUREMENTS influence the garment fit because it is a reflection of the volume and length
of the body’s sections. The proportions of the width measurements identify the BODY SHAPE,
known in the literature as triangular, hourglass, round, etc. A 3D body scan and/or body
measurements can identify the body shape, but in different ways. The latter gives only the
theoretical body shape, while the scan reflects the real shape. When evaluating a garment, based on
the factors, body measurement and theoretical body shape, the focus is on the coverage. In
other words, finding out if the sized garments accommodate the individuals’ body measurements
and shapes. When evaluating body shape, in addition to the coverage, the evaluator pays attention
to the correct amount and distribution of ease. The ease corresponds to the design, function and
the body. The evaluation also covers the silhouette and cut lines through the garment (line) and
the smoothness of the garment in relation to the body (set). The pressure of the garment against
the body can give the evaluator important information concerning the body shape; this is
applicable when evaluating a simulated garment. These focal points are also important
expressions when evaluating the posture.

The POSTURE is the vertical balance of the torso, curvature of spine and the position of
the shoulders, which all affect the garment fit. The posture’s influence on garment fit can be
considered on the 3D body shape and/or by the body measurements. The latter gives only
indications of the theoretical posture. In addition to set, line and ease, the individual’s posture
influences the garment fit through the grain- and crossline in relation to the horizontal and
vertical perception (grain). When evaluating the garment from the hanging point (e.g. shoulder,
waist), there should be equal distance to the body from right to left and back to front (balance).

**EVALUATION OF GARMENT FIT**

**EVALUATION OF GARMENT FIT**

The VOLUME of the garment, which influences the garment fit, includes the garment’s ease for
both function and style. The professional evaluator looks at the set, balance and ease as well as
asking for the overall feeling in relation to the garment’s function (comfort). A system output
regarding pressure and mesh deformation can help the evaluator to make a better-grounded
evaluation. Volume can be evaluated both with numbers (the amount of ease) and the perceived
comfort of the ease.

The methods and principles of construction and grading of patterns affect the garment fit in
many ways. The behind the scene PATTERN METHODOLOGY is evaluated by looking at the
grain, set, line, balance, ease, and if available the simulated pressure. The more up-front factor
influencing the garment fit is the mechanical properties of the fabric such as, stretch, bend, fall,
etc.

The FABRIC PROPERTIES are evaluated by set, ease, comfort and mesh deformation. The set
is influenced by the fabric properties, for example, if a design with many gathers are presented in
a very stiff fabric, the garment will not follow the body in the same way as if the same design was
presented in a smooth, flowing fabric. The fabric properties affect the ease, especially when it
comes to the stretch of the fabric. This is also when the mesh deformation can be of help to
determine how the fabric properties affect the garment fit.

**Movement and Preferences**

The influence of the basic body and the functional MOVEMENTS for the garment fit is
evaluated by set, line, ease and comfort. It is important that the garment and its cut lines work in
harmony and smoothly follow the body’s movements. The final and so far most unpredictable
influence of the garment fit is the INDIVIDUAL PREFERENCES. These preferences connect
mainly to the ease and comfort, perceived by the wearer.

**Exploring Fitting Sessions & Influencing Factors**

The end user makes the final evaluation of the garment when using the garment in its intended
environment. However, to reach a satisfying garment fit, product development includes many
fitting sessions. During these, the factors influencing the garment fit are evaluated, Figure 7, p.32.

The fitting sessions support the garment development from start to finish. Improvement of the
garment fit should be an outcome from each fitting session. The evaluators in these sessions vary;
they are the professionals (yellow), test persons (purple) and the end users (pink). The
professionals evaluate the garment fit objectively, without trying-on the garment. The test
persons (average user) should represent the target group by measurements, shape and by its
statements. The end user evaluates the garment before purchase and while in use. Included in the
fitting sessions are both evaluators and other resources. Resources vary through the garment
development and dictate what can be evaluated within each fitting session. Early in the
development, the available resources are based on numbers (orange), for example, the garment

![Figure 6: Garment fit is influenced by different factors, connected to the body or the garment. These factors are evaluated with different focuses and carried out by professionals and/or user, sometimes with the help of a system output.](image-url)
measurement chart, representing the theoretical framework of the garment. This is followed by garment prototypes (red), which can be either virtual or physical garments. The virtual garment is a development resource and does not replace the physical prototype. The final garment (bright green) can also be a virtual or physical resource. The purpose of the fitting sessions is to evaluate the factors influencing garment fit. Of course, not all factors can be evaluated within all sessions, but a mix of sessions gives a comprehensive evaluation throughout the whole process. The output from the evaluation depends also on who is participating in the evaluation and which resources are available.

** Sessions with numbers as a resource**

The professional carries out the fitting sessions based on numbers, a resource available early in the product development. The most basic sessions are the INDIVIDUAL BODY MEASUREMENTS. The professionals analyse the measurements to determine if available bulk sizes accommodate the individual. The tailor uses measurements to construct a bespoke garment. If a larger group of scans and measurements are available, statistical analysis of the body measurements can be carried out in an attempt to create STANDARD BODY MEASUREMENTS. Examples of usage are pattern construction and workplace design, based on standardised measurements. The fitting sessions including these individual and standard body measurements are influenced by factors such as the measurement of the body/bodies as well as the shape/s and the posture/s. Further statistical analysis and clustering of body measurements can create useful DATA and BODY SIZE CHARTS. These include the basic measurements for size designation, corresponding to a target group. The measurements are quite rough and are therefore only affected by the body measurements in combination with the surrounding data, for example, age, ethnicity and weight. The availability of data for target group/s limits the possibilities to carry out these number-based fitting sessions. However, when carried out, the results should improve the match between the developing garment and the target group. The pattern constructor uses this information to create and grade patterns that accommodate the target group in regard to measurements, body shape and posture.

**Sessions with prototypes as a resource**

In the early stages of product development, the professionals can use 3D SIMULATION to evaluate the garment fit. It is essential that the avatar/s, used in the simulation, represent the target group. The pattern methodology, volume of the simulated garment, fabric properties and movements affect the evaluation, based on 3D simulations. The main take-away from this session is the visualisation of the pattern modifications, which needs to be done. Limitations in this session depend on how well the avatar/s represents the target group as well as how the fabric properties are measured and expressed in the simulation. The scope of the evaluation is also dependent on the avatar’s ability to stand in different poses or be dynamic. If any of these are compromised, there will be limitations in the evaluation.

For the next fitting session, physical garment/s must be available as well as a physical FIT STAND representative of the target group. The fit stand can be in one or many sizes, depending on the depth of the evaluation. The pattern methodology, volume of the garment and the fabric properties influence this session. The limitations in the evaluation relate to the fit stand, including how well it represents the target group, with regard to measurements, shape and posture. The next evaluation step is to involve a physical person/s. The STANDARD person/s should be representative of the target group, that is, one or more sizes. The areas impacting this session are the same as for the fit stand, with the additional influence of movement. It is important that the session is structured; all necessary poses and movements should be considered during the session. The downfall of this evaluation is if the persons do not represent the target group or if eccentric opinions about comfort and ease are generalised. The outcome from both sessions, including physical garments, is how well the pattern construction interacts with the chosen fabric to enhance the garment fit. If the method for product development requires a fitting session with the END USER (bespoke garment), all the influencing factors are considered during the session.

**Sessions with final garment as a resource**

The final garment is evaluated in many situations and is ongoing during the garment’s whole lifespan. The customer makes the first evaluation when buying the garment. We can evaluate garment fit in many different ways. Purchasing channels offer different tools, to help us find the correct and fitting garment. In the fitting session, PRE-SELECTION of SIZE, the customer evaluates the garment fit without try-on, for example, when shopping on the Internet. The volume of the garment influences this session. Photos of the garment and garment measurements (if available) communicate the volume to the customer. The outcome of the session is the customer’s ability to select a size for their purchase. Misleading information about the garment’s volume or misinterpretation of the same can lead to pre-selection of the wrong size.

The final garment can be SIMULATED and visualised for the customer. This simulation should be made on an avatar modified to the customer’s measurements or on the customer’s 3D body scan. This session is impacted by all factors such as individual measurements, body shape, posture, preferences and movements as well as the fabric properties, pattern methodology and the garment’s volume. The outcome from the session is to visualise the garment fit even if the customer is not present for a physical try-on. The same limitations, as for the standard 3D simulation, apply in this session as well as how similar the avatar is to the customer’s body. All aspects of the garment have an impact on the FINAL EVALUATION of the garment. The customer or wearer does the evaluation. There are no limitations in the final evaluation. It is what
it is! If the garment is not to satisfaction for the wearer, this has to be fixed in the early stages of the development. An alternative is to order a customised garment, which hopefully will improve the satisfaction.

**Exploration Overview**

As mentioned before, the garment fit is influenced by different factors (blue & green arrows and ovals) and is evaluated within different fitting sessions (listed to the left). When combining these with the evaluation focus (coloured dots), the model for evaluating garment fit is near complete, as illustrated in Figure 8. The blue and green ovals, representing the factors, include the dots; these indicate which focus areas are used within the specific fitting session. A combination of fitting sessions is needed to fully evaluate a factor that influences garment fit. If possible, the session should include evaluations in both static pose and in motion. To push the garment development forward, the implementation of the evaluation’s output is important. Developers should do changes on a factor-level; most common is to modify the garment and not the target group.

**Garment Fit by Numbers**

A sized garment should accommodate as many targeted individuals as possible. This is easier said than done; however, this can be accomplished with our systematic model. The model compares the garment and the body measurements; it highlights potential misfit and gives the garment a FitValue.

We developed and tested *A Systematic Model for Improving Theoretical Garment Fit*, appendix 1. The model compares the body and garment measurements, and judges them according to the scale: good, decent or poor fit; this becomes the basis for the overall evaluation, scored as the FitValue. The main input data, in the model, was the garment measurements ($n=5$), related to a basic sized shirt, and corresponding body measurements from the target group ($n=2,208$). After each run of the model, the garment measurements were analysed and modified. At the end, the theoretical garment fit had improved dramatically! However, the first output showed that only 13% of the target group fitted into the theoretical garment. For this accommodated group, the average FitValue was 0.82 ($n=277$) and for the whole group 0.10 ($n=2,208$). As long as the garment measurement chart (GMC) included only one length category, the improvements were limited and not satisfying. The GMC with one length category, accommodate, at best 57% of the target group, with an average FitValue of 0.90 ($n=1,260$); average FitValue for the whole target group was 0.51 ($n=2,208$). We could see in the output that the length measurements caused most of the problems. Hence, there was a need to create three length categories at the end. This last output showed that 95% of the target group fitted into the theoretical garments. The average FitValue for the accommodated group was 0.90 ($n=2,102$) and for the whole target group 0.86 ($n=2,208$). In summary, to go from accommodating 13% to 95% is a large increase and would theoretically lead to more satisfied wearers.

**Exploring Garment Fit by Numbers**

The numbers presented in previous section show an increase in both accommodation and FitValue. However, one has to remember that the evaluation is limited by the distance to both the end user and the physical garment; only numbers represent the user and the garment, Figure 9. When exploring the evaluation within this study, we can see the strengths and the limitations of evaluating garments by only numbers. Individual body measurements form the basis of this fitting session, and the resource is the garment measurement chart. Within this study, we looked at the influencing factors of shape and measurements, with the focus on coverage. We can conclude that the evaluation method was the correct one, because we received output related to our questions. However, the systematic model was not used to its full potential. The influencing factor, posture could be included if more detailed measurements were entered in the model.

There is also a possibility to expand the analysis regarding shape by adding ease to the focus. A flexible design of the systematic model makes different analyses possible, but is limited to the factors included in the evaluation.

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1 The individuals fitting into the garment.
Size Selection and Garment Fit
The brands should help their customers find the most suitable size, even when physical try-on is not available. This is easier said than done; however, by visualising a virtual garment and its fit on the customer’s avatar, the hit rate increases.

In our study, Can Virtual Try-on Help in Selecting the Correct Size?, Appendix 2, we show the hit rate of different size selection methods for a woman’s shirt and trousers. The recruited participants were a group of test persons (n=35) and an expert panel (n=24). The pre-selection methods compared were based on key measurements, virtual (VR) and real (RL) garments. The key measurements were the circumference of the chest and hip for the shirt and trousers, respectively. The test person analysed three sizes of the VR garments; three images per size showed the garment: front, side and back view. The expert panel watched a movie capturing the turns on different sizes of the shirt. Both the experts and the test persons independently selected the best fitting size. The test persons also tried on a range of sizes and picked the most suitable size; we compared all pre-selections to this real, physical size. The goal for the pre-selection method is to match the true size selection. To analyse the result, we looked at the difference between the pre-selected size and the real size. The result indicates that the best pre-selection method for size designation is the one based on VR-garments; this occurs when the wearer them/herself makes the size selection. For the test person, the match between the pre- and the real size selection was 53% for the shirt and 61% for the trousers. The panel’s size selection showed that only 37% matched the real size for the shirt. Pre-selection based on key measurements gave 40% for the shirt and 39% for the trousers. In summary, the size selection based on VR-garments gave, in this study, a higher hit rate than the more commonly used key measurement.

A person makes the most reliable evaluation of the garment fit when the garment is tried on. However, when the physical garment is not available, alternative methods can be valuable. In our study, Appendix 2, we compared the evaluation of the VR and RL garment in order to establish if the evaluation based on VR is reliable. The test persons evaluated their selected size in both VR and RL. With this study, we have an indication that some areas are more difficult to pre-evaluate than others. The key measurements, hip and chest circumference, are frequently evaluated similarly, 78% for the shirt and 89% for the trousers. The overall evaluation of the width measurements indicates that the VR garment, to some degree, matches the RL-garment, the shirt in 53% of the cases and the trousers in 72%. When looking at the mismatch, it seems that the VR-shirt’s combined circumference (all width measurements) is perceived as being smaller than the RL-garment. However, the VR trousers’ combined circumference does not indicate any tendency because the results are evenly distributed between too small and too large.

We can state that the VR garment can be of help when pre-selecting the size. However, the match between VR and RL is not that convincing when it comes to the test person’s own fit evaluation.

Exploring Size Selection and Garment Fit
In this study, two types of evaluators assessed the garment fit: The professional and the end user. Both groups of evaluators assessed the garment fit within the fitting session “3D simulation - end user”, Figure 10, p. 37. In addition, the test person also used the fitting session’s “final garment”.

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3 This means that the same size is selected even when using different selection methods.
4 The subject selects one size before (pre-) selecting the size based on physical try-on.
selected garment. In both cases, they used the focus of ease to evaluate the width and the length of the garment.

**Made-to-Measure and Garment Fit**

It is a privilege to find a suitable garment, according to the personal preferences. This is easier said than done; however, creating your own designed and fitted garment is possible with today’s apparel technology.

In the research *Tailoring the Unique Figure*, Appendix 3, we explored the possibilities and challenges when it comes to manufacture made-to-measure (mtm) garments. The objectives relate to the pattern construction and its process, both within mtm garments. The test persons in the study all had body shapes deviating from the standard, divided into four categories: Short/tall stature, warped figure, prominent deviation and wheelchair user. The process to create mtm garment was the same, independent of the uniqueness of the body. As a starting point for the pattern construction and for the process, basic and style patterns in different sizes were used. The styles used were skirt, trousers and fitted jacket/coat. The first step is to document the test person’s body shape with placement of landmarks, manual measurements and photos. To continue, the size of the garment was selected based on the measurement and figure analysis. By analysing the measurement and figure, the pattern could be individualised. In short, everything comes down to adding and subtracting volume and/or length of the appropriate places on the pattern. In phases A and B, prototypes were sewn to evaluate the pattern construction. To end the first development circle, the test persons came back to evaluate the garment; further, modifications were noted, which improved our construction analysis. In phase C, the individual style pattern was sent directly to the manufacturer, without any test garments verifying the garment fit. Finally, the manufactured, customised garment was evaluated; the majority of the test persons judged the overall comfort as excellent. For all combinations of unique body shapes, we used the same process.

**Figure 11: Fitting session with final garment as a resource, the user is the evaluator.**

**Figure 12: Test persons and professionals covers almost all variables in garment fit evaluation.**
REFLECTIONS AND FUTURE WORK

This chapter contains reflections and discussions from the presented work as well as suggestions for future research and development.

Evaluate Garment Fit

The garment fit evaluation is complex; in the overview, the focus is on influencing factors, evaluation focus, resources, evaluators and fitting sessions. All these five aspects are identified in the literature, Appendix 4. The literature review could have been more comprehensive, looking up secondary sources for a more in-depth overview. However, I am doubtful as to whether other aspects or content would have surfaced, but a quantification of the terms could have been of interest. For the purpose of this overview, the existing review was comprehensive enough to cover the concepts used in the studies included in the thesis.

As mentioned before, it would have been supportive to have an existing standard for garment fit evaluation. Researchers have already established that different vocabulary terms have to be used, depending on the respondent (DeLong et al. 1993; Shin & Damhorst 2018; Varghese & Thilagavathi 2013). The experts use more technical terms (Ashdown & O’Connell 2006), while the layman probably use terms related to how they feel, perceive fit and comfort. It would be of great interest to establish recommendations on how to ask about garment fit depending on the respondent.

The use of simulated garments in the evaluation is quite new and will be improved in the future. The five main steps in simulations are: Avatar, fabric properties, stitching of 2D pattern, placing garment on avatar and finally, the simulation (Song & Ashdown 2015). There are two main avatars: the parametric and the scanned. The latter being more realistic (Lim & Istoik 2011). The parametric depends on input values from the individual, and records show that it is difficult for customers to report correct body measurements (Gribbin 2014). And finally the test persons preferred to see simulated garment on their own avatar (Kim & LaBat 2013a). Based on these facts, the preferred and most reliable avatar is the scanned version. Future developments are needed for accessible equipment and software for body scanning or for services to be available for creation of realistic individual avatars; however, a challenge here is the reliability of the input data.

The fabric properties have an impact on the simulation (Ancutienė & Sinkevičiūtė 2011; Kim & LaBat 2013a; Lage & Ancutiene 2017). Today, the input values come from Kawabata Evolution System (KES), Fabric Analysis by Simple Testing (FAST) or a set of software specific instruments. There is no standard for mechanical properties in relation to simulations. In the future, there should be a standard that could be used by the fabric producers to supply the buyer with the digital file for fabric simulation. This could benefit the online sales of fabric because the potential buyer can simulate different fabrics for their upcoming collection.

In the simulation, all the input values come together for visualisation in the virtual garment. In this research, the avatar was in a static pose and the garment was shown with and without transparency to facilitate evaluation of garment volume. Test persons and researchers alike indicate that there is a limitation with the static avatar, and they would prefer to have a dynamic avatar to evaluate the fit, ease and the strain (Ancutienė 2014; Bce & LaBat 2005; Kim & LaBat 2013a). Other tools within some software are pressure and strain mapping (Hong et al. 2017; Magnenat-Thalmann et al. 2011; Sayem 2017). These tools might be of help to evaluate ease (Song & Ashdown 2010) in combination with fabric properties (Lage & Ancutiene 2017). Maybe these new simulation-related tools lay the foundation for additional objective fit evaluation methods in the future. Future research would be of great interest, testing which tools are preferred for fit assessment, depending on the evaluator, layman or expert.

Thoughts for the future

In the future, I would like to see the customer evaluate garment fit on their own avatar with interactive possibilities to change details, fabric properties, accessories and of course, change colour, all according to one’s preferences; in addition, visualise fit modifications of the garment corresponding to the scanned avatar. To evaluate the garment properly, movement should be incorporated in the avatar, i.e. movements that are relevant for the function of the garment. With or without the interactive design, modifications of fit or moving avatars, there is an interest in finding easy assessable evaluation tools for the consumer to use within their shopping experience. This does not only opt for tools facilitating fit evaluations without try-on but also for quality control to ensure delivery of products corresponding to the promised virtual product. When we try-on real garments, we can try on different sizes and find the one that fits the best. For the customer, it does not matter if the garment deviated from the planned garment or not, as long as the garment is made to satisfaction. In the future, improved visual evaluation tools are available, and the customer evaluates and orders the suitable garment based on the virtual garment and without real try-on. The visual tool is probably developed on the basis of the approved patterns and specification of the garment. This means that if the garment production deviates from the approved pattern or specification, the real product will not reflect the visual garment the customer selected; this will jeopardise the customer’s satisfaction level. Will the consequence be that only higher quality garments are sold with the help of visual evaluation tools, assuming that higher quality garments have lower tolerance for variance.

Improve Garment Fit

In this thesis, two ways of improving garment fit are studied. One, used early in the product development based on anthropometric and garment related numbers. Second, enhancement of fit for the individual with a unique figure, focusing on the process and pattern construction of individual patterns.

Garment Fit by Numbers

In the study Garment Fit by Numbers, the theoretical evaluation of garment fit is based on anthropometric data and garment measurements. The garment measurements include the ease, which is balanced in relation to the garment’s comfort, function, size, fabric (Gill 2011) and design (Ashdown & DeLong 1995; Beazley 1999). Ease also serves as a buffer when it comes to garment fit, and the individual does not match the standard body (Petrova & Ashdown 2008). Previous analysis regarding measurements and sizes are usually focused on the body measurements (Celinska & Kjellnas 1977; Daenen & Reiffelrauth 2007). By using the garment measurements instead of only body measurements, we argue that we come closer to the true garment fit, including properties related to comfort, fabric, design and fit buffer even if the evaluation is limited to only numbers. Further studies regarding theoretical fit analysis could compare the results from theoretical fit analysis conducted with different methods.

The result shows that it is possible to improve the theoretical garment fit with the help of the systematic model as well as to clearly indicate when a made-to-measure garment is needed. As an inspiration for the systematic model, we used the framework presented by McCallloch, Paul and Ashdown (1998). Based on our understanding, they used a continuous formula to indicate the
aggregate loss of fit for each evaluated measurement; the average of these measurements was then presented as the aggregate loss of fit. There was no clear limit for poor fit; consequently, poor fitting measurements can be covered up in the average of all measurements. In our systematic model, this fit range controls this. The fit range clearly indicates the values for good, decent and poor fit for each measurement. If one measurement has a poor fit, the whole garment is judged as poor fitting and might be subject to a made-to-measure garment. In our model, the fit ranges are of great importance, which could be a subject for future research. However, the fit ranges are influenced by, for example, the ever-changing fashion; thus, it would be difficult to generalise the ranges for different garment types and over time.

As mentioned earlier, the systematic model can indicate when the individual needs a made-to-measure garment. With this information early on in the product development, the bulk and single garment production can be modified for convenience or cost-effectiveness. For example, the manufacturer has committed to supply a set of individuals with uniforms; with a maximised stock of sizes, only a few are in need of a made-to-measure garment. If the stock is slimmed down and includes only the core sizes, there will be a greater need for made-to-measure garments. The right balance in sizes is important to equalise the production cost (Petrova 2007). With the complete cost for bulk and individual garments, the manufacturer can estimate the optimal balance between bulk and made-to-measure. It is not only the cost that is important, the supply time should also be considered. Obviously, this would be of great interest for future research, finding the correct balance of bulk and made-to-measure in relation to variables in different settings.

**Made-to-Measure and Garment Fit**

In the study Tailoring the Unique Figure, body and figure registration was of great importance. Both traditional measurements as well as innovative ones were taken with the help of specific landmarks. The specific marks made it possible to link the measurements to specific positions on the body. The measurements were complimented by a series of photos; these served as a reminder as well as an analysing tool throughout the pattern modifications. In the literature, it is well established to take measurements by hand (Liechty, Rasband & Poettberg-Steineckert 2010) with identified landmarks (Roebuck 1995). The standard body shape is often registered by the silhouette or with notes of the differences between girth measurements (Connell et al. 2006; Liechty, Rasband & Pottberg-Steineckert 2010). This is not possible to use when the figure deviates from the standard. With the help of the body scanner, both measurements and body figures can be registered at once (Daanen & Ter Haar 2013; Neuez 2000). A body scanner was used in the Easytex project; however, at the early stages of the project when the figure registration took place, the software for the scanner was not up for the challenge to consistently register measurements of very unique figures. For future studies, it would be interesting challenge to use scanning software with the large figure deviations. This could be done with traditional body scanners or with upcoming new technologies for easy measurement and figure registration.

With the measurement and figures documented, the invasive pattern modifications could take place. A combination of different modification techniques was used to achieve the individual pattern and test garment. Within the Easytex project, the made-to-measure software FitNet was tested; therefore, the modifications had to be structured in a clear way that was understandable for the software. In the literature, one can find traditional modification of patterns (Aldrich 2008; Armstrong 2014; Liechty, Rasband & Poettberg-Steineckert 2010; Öberg & Ersson 1999) as well as more invasive modifications (Frost 1987). Researchers also pointed out the importance of understanding how improved garment fit is achieved (DeLong et al. 1993). All combinations of pattern alterations were entered into the software, and the individual patterns were automatically generated from the software after entering the desired modification values. For future studies, it would be interesting to challenge the automatic concept, from body scanner to manufactured designed garment. Expanding on the concept described by Dăboldina et al. (2018) but use production patterns and include individuals with large figure deviations.

Ashdown and Delong (1995) pointed out that the made-to-measure garment has to be better than ready-to-wear garment. This was clearly fulfilled in the project; the evaluation of the final garment showed satisfied test persons: During the course of the project, we had several meetings with the test persons. A limitation of the study could be that we developed a report with the test person. This might have influenced his/her evaluation of the garment. It could be interesting for future studies to have anonymous participants. A body scanner registers the body measurements and shape and after delivery of individual garment, an anonymous evaluation of the final garment.

**Find a Garment that Fits**

When a person tries on the garment, the real size is selected. A reliable pre-selection method is the one that matches the real size selection. In this study, the most reliable pre-selection was based on the virtual garment; this was so when the test person him/herself selected the size; when the expert made the selections, the match to the real garment was lower. One factor unknown to the experts is the individual’s preference for fit. Researchers established the individuality when it comes to preferred fit (Alexander, Connell & Presley 2005; Brown & Rice 2014; Lin & Wang 2016); the preference also depends on the occasion (Shin & Damhorst 2018), fashion, culture and norms (Zhang, Zhang & Xiao 2011). The experts did not know any of these facts, but the wearer knows his/her preferences and can include this when pre-selecting the size; hence, the higher match with the real garment. Further research is suggested to find ways to grasp the individual preference for fit; this should benefit the customer service when the brand wants to recommend size and fit for the customer.

The test person evaluated the perception of ease; the key measurements (hip and chest) were most frequently evaluated the same; areas indicating a low match were inside leg length of the trousers, and the circumference of the waist, bicep, length of sleeve and the centre back of the shirt. The key measurements are considered reliable and often used for size designation (International organisation for standards (ISO) 2017; Lin & Wang 2016; Song & Ashdown 2010). It is interesting to notice that these key areas have the highest match between virtual and real evaluation. Maybe because these areas are the primary areas for size designation, and the other areas play a secondary role in the size designation. There is a low match in the evaluation among the length measurements, inside leg, sleeve and centre back. In this study, the virtual evaluation was based on a static avatar, which poses a clear difference from the dynamic real evaluation. Previous researchers indicated that there is a limitation with the static avatar; they proposed a dynamic avatar to be able to better evaluate garment fit, ease and strain (Ancutiene 2014; Bye & LaBát 2005; Kim & LaBát 2013a). The length of the garment that seems too long in a static pose might be evaluated as good when the subject moves and realises that the length is needed for comfortable movement; this applies also for the sleeve length. Similar reasoning might be true for the inside leg length; the virtual static garment seems good but when starting to move, the length is perceived as being too short. Further research is needed to find tools to increase the match between the virtual and the real garment; the benefit should be to increase the reliability of the pre-selection of size based on virtual garments.
When analysing the mismatch of all areas evaluated in relation to the circumference, the result indicated that the virtual shirt is perceived as being smaller than the real garment, while the tendency for the trousers was evenly distributed and did not indicate smaller or larger. Previous researchers also conducted comparisons between virtual and real garments. Even if the setup of the experiments is not the same as ours and leaves room for lurking variables to affect the result, it is interesting to consider the indications. Kim and LaBat’s (2013b) study implied that the virtual garment was smaller than the real one, while Song and Ashdown’s (Song & Ashdown 2015) study indicated the opposite. These variations in results strongly suggest the need for further research to find the best practice to communicate garment fit with the wearer.

The expert panel in our research was experienced in evaluating real garment fit; only a few had experience with virtual apparel software. They came from a variety of companies and did not receive any pre training for the evaluation in this study. Previous research suggested training for the evaluators (Yu 2010) as well as presenting the criteria for good fit (Ashdown & O’Connell 2006). However, this was consciously not done in this study because we wanted to register the size selection based on their experience, without any influence. It is interesting to include and compare the perception of fit between experts and the user. The final say concerning fit rests with the end user (Gribbin 2014), but the expert is the one developing the garment. Researchers showed that the results between the evaluating groups fluctuate (DeLong et al. 1993; Kohn & Ashdown 1998). The interest for future research is to investigate if the cause for the variation is due to the individual preferences of fit (Ashdown & DeLong 1995; Bye, Labat & Delong 2006), to the different use of vocabulary between the groups (Shin & Damhorst 2018) or other lurking variables affecting the evaluation. This should support the product development towards a more satisfied customer.

CONCLUSIONS

This chapter holds the core conclusions based on the presented studies.

Garment fit is the common denominator for this thesis and ties the studies together with the help of the structured literature review focusing on garment fit evaluation. Improving garment fit was explored in two ways: by a systematic model based on anthropometric and garment data, and by developing made-to-measure garments for unique figures. How to find a garment that fits was investigated by comparing the size and fit correspondence between virtual and real garments.

To what extent can a systematic model improve garment fit?
The systematic model generated a higher accommodation rate and increased fit value for the target group. The theoretical garments judged as misfit decreased from 87% to 4.8% (n=2,208) at the same time as the average fit value for the group increased from 0.10 (run 1:1) to 0.86 (run 3:3) (n=2,208).

How is garment fit improved for the unique figures?
The garment fit is improved for the unique figure in three main steps: registration of complex body measurements including quantification of the warped and prominent disfigurements, invasive pattern construction and garment make-up for evaluation. The result shows that the majority of the test persons evaluated the final garments as having excellent fit.

How accurate is the size selection of best fitting garment, when comparing virtual and real garments?
The accuracy of the size selection based on the simulated garment is 53% for the shirt and 61% for the trousers. This exceeds the more traditional key measurement, which scored 44% for the shirt and 39% for the trousers.

What variables are involved in evaluation of garment fit?
In the structured literature review focusing on garment fit evaluation, a set of variables was identified. These variables belonged to one of the five areas: influencing factors, evaluation focus, resources, evaluator’s or fitting sessions.
REFERENCES


APPENDICES

Overview of the appendices.

Appendix 1 (Paper I)


Accepted for publication

**Author’s contribution:** The author conducted the experiments independently and wrote the main text for the article with suggestive comments and guidance from supervisors.

Appendix 2 (Paper II)


28th February 2018, comments received for revision of manuscript for a second review.

**Author’s contribution:** The author took the initiative, planned and collected data for the article. The author wrote the main text for the article with suggestive comments and guidance from supervisors.

Appendix 3 (Licentiate Thesis, monography)


Defended and approved June 2000, Gothenburg University

Appendix 4

Overview of structured literature review focusing on garment fit evaluation.

ARTICLE I


Accepted for publication.
A Systematic Model for Improving Theoretical Garment Fit
Hernández, N., Mattila, H. & Berglin, L

Structured Abstract

Purpose – The purpose of this study is to use a systematic model for detecting misfit between the garment and the target group.

Design/methodology/approach – Using an empirical-analytical methodology, the systematic model was tested. The input data were run through the model to generate the output data, which was analysed, including basic statistics. The purpose of the analysis was to detect misfit and improve the garment measurement chart. This procedure was repeated until a clear result was reached.

Findings – The result of this study is an optimised garment measurement chart, which considers the garment’s ease, different sizes/proportions in relation to a target group. The results show that it is possible to use a systematic model to define the shortcomings of a garment’s range of sizes and proportions.

Research limitations/implications – Further studies are needed to verify the results of the theoretical garment fit and their values in relation to real garment fit.

Practical implications – If the systematic model is implemented to improve the theoretical garment fit, this may have effects on the available garment sizes and its proportions, resulting in increased theoretical garment fit for the target group.

Originality/value – The paper presents a systematic model for detecting and eliminating theoretical fitting; the model includes both garment ease allowance and defined points of misfit.

Keywords: Garment fit, garment measurement chart, evaluation of fit, fit value

Article Type: Research paper
Clothing that fits well is critical to garment suppliers. Consumers should be able to rely on checking how the population is distributed over the sizes (Daanen and Reffeltrath, 2007). An assortment of size ranges should be produced. Fit mapping is one way to ensure this, i.e. Daanen and Reffeltrath, 2007, Cednäs and Kjellnäs, 1977). McCulloch et al. (1998) developed the analysis is usually done with various sets of two body measurements with low correlation and based on this, different sizes can be identified (McCulloch et al., 1998, 2006) and the variation in the evaluation makes it difficult to establish a standard for good garment fit. In line with this, ease is included in the measurement evaluations in this study.

Garment fit is highly influenced by personal preferences (Alexander et al., 2005, Bye et al., 2006) and the variation in the evaluation makes it difficult to establish a standard for good garment fit. In line with this, ease is included in the measurement evaluations in this study.

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Theoretical garment fit includes the judgements based on numbers and does not include personal preferences of fit.

Fit is often defined as how well the garment conforms to the body (Brown and Rice, 2014). Garment fit is highly influenced by personal preferences (Alexander et al., 2005, Bye et al., 2006) and the variation in the evaluation makes it difficult to establish a standard for good garment fit. In line with this, ease is included in the measurement evaluations in this study.

Usually one or two main measurements with correlation to other dimensions are used when the wearer selects a particular size for fitting (Winks, 1997). It is common to use the chest and hip circumference as key measurements, because they have the highest correlation for other width measurements of the upper and lower body (Gupta and Gangadhar, 2004, Zakaria, 2014). The size is only a guideline for the consumer for finding a fitting garment. Many other aspects influence the wearer’s perception of comfort, such as material, design, culture (Hu et al., 2008) and individual preferences (Bye et al., 2006).

Live fitting sessions of prototypes are usually done only with the basic size, as they are time consuming (Ashdown and O’Connell, 2006, McConville, 1986). For better result, the fit of different sizes should be tested. This, however, is seldom done (Watkins, 2015). The garment is usually evaluated by analysing the garment’s grain, set, line, balance and ease (Erwin, 1974, Liechty et al., 1994, Brown and Rice, 2014). A protocol for the evaluation can be used for structural purposes (Petrova and Ashdown, 2012) but no standards are available. A more efficient method is needed for evaluating the fit of the rest of the sizes. Based on the idea outlined by McCulloch et al. (1998), a new systematic model was developed for predicting the range of sizes and their proportions for a garment meant for a particular target group. Input values, such as measurement charts and fit intervals, are used by the model for generating a set of output values that can be used for determining how well the garment fits the target group. By analysing a garment measurement chart with the systematic model, better garment fit and coverage of the target group can be achieved in the early stage of product development. Furthermore, those individuals who need made-to-measure service can be identified.

The systematic model was designed to evaluate the fit of a complete garment (including ease) against the body measurements of a target group. The objective was neither to create a general sizing system based on body measurement charts, nor to develop parameters to be applicable for the general population. Rather, the study sought answers to the following research questions:

RQ1: How does a systematic model improve the garment fit?
RQ2: Can a systematic model indicate when made-to-measure service is needed?
RQ3: What data are needed to operate the systematic model?

**Model and Methodology**

The model, presented in Figure 1, is divided into three interconnected parts: input data, calculations within the model and finally, analysis of the output data. Based on analysis of the output data, the garment measurement chart can be modified and then run through the model again to get a new evaluation of the fit. This can be repeated until a satisfactory level of coverage and garment fit value have been reached for the target group. The calculations were carried out by using Microsoft Excel 2010, together with Visual Basic module for easy programming.

![Figure 1: Based on the model's input data the size selection (Z) is made and the individual garment measurement chart (G) is created. The model then compares the standard (S) and the individual (G) garment measurement charts and judges the fit value by the fit ranges. The output data is then analysed to find modifications to improve theoretical garment fit.](image-url)
The input data are derived from four main sections: individual body measurements \( (b) \), size chart \( (s) \), garment measurement chart \( (g) \) and the fit ranges. The anthropometric individual body measurements are based on the US military ANSUR study (Gordon et al., 1989). Size charts are from the Swedish standard chart for women, comprising sizes from C32 to C54 (Johansson, 1987). Garment measurement chart (sizes 32 to 54) contains selected garment measurements (including ease). Experience-based fit ranges define the intervals of good, decent and poor fit of the garment. The date of the input data set is not relevant because the aim is to see if the model can indicate how the garment measurement chart should be modified to match the anthropometric data.

Based on the input data, separate charts were extracted to prepare for the calculations within the systematic model. The charts contained the ease allowance \( (e) \), size selection \( (Z) \) and the individual garment measurement chart \( (G) \), see overview in Figure 1. The ease allowance chart \( (e) \) indicates the difference between the garment measurement chart \( (g) \) and the body size chart \( (s) \) for each measurement \( (i) \) and size \( (z) \). In this study, the size selection \( (Z) \) was based on the closeness between the chest (key) measurements in the standard body measurement size chart \( (s_z) \) and the individual body measurement chart \( (b_i) \). If the individual body measurement was exactly between two sizes, the larger size was selected. The individual garment measurement chart \( (G) \) was then created by adding the ease allowance \( (e) \) for each measurement \( (i) \) to the individual body measurements \( (b) \). For example, if the individual body chest measurement \( (b_i) \) is 93 cm and the ease for chest \( (e_i) \) is 10 cm, then the individual garment chest measurement \( (G_i) \) becomes 103 cm, as demonstrated in Table 1. With the input data, selected size \( (Z) \) and the individual garment measurement chart \( (G) \) at hand, the systematic model compares the standard \( (g) \) and individual \( (G) \) garment measurement charts, Figure 1.

Also part of the input values a rating scale of good, decent or poor fit was used in this study for determining how well a garment conforms to the individual body. The interval for good fit lays around the general fit for this type of garment while poor fit is when the garment is not possible/comfortable to wear at all. Decent fit is the bridge between good and poor fit. These intervals provide the garment’s fit range that will later be transformed into a fit value for the garment. The borders of these intervals are based on the authors’ general experience from garment fittings in combination with the complex interaction of different variables such as the amount of ease, comfort and fabric properties. The borders for each interval are identified with \( p_1 \), \( p_2 \) (plus-values) and \( m_1 \), \( m_2 \) (minus-values). The values for the plus-intervals \( (p_1, p_2) \) are usually set tighter than the minus-intervals \( (m_1, m_2) \); this is done because the garment fit is, from experience, more forgiving when slightly too large than too tight. The theoretical perfect fit is found where the developer determines the relation between the body and garment measurements are in balance. However, if the individual deviates from the standard body, a made-to-measure garment is needed to achieve acceptable theoretical fit. If the deviations are not too far from the standard, the individual might be able to fit into the standard sized garment but with the consequence of decreasing garment fit. To find the fit value for each measurement, the systematic model compares the individual garment chart with the standard garment chart, with the earlier mentioned fit rating good, decent or poor. For example, the garment’s waist measurement \( (g_2) \) for the standard size 40 \( (Z_{40}) \) is 89 cm. The calculated individual garment’s waist measurement \( (G_2) \) is 93 cm. The difference between the two waist measurements is +4 cm, which is less than the plus value \( (p_1) \) for the waist \(+6 \text{ cm}\). This means that the fit for the waist measurement is judged as good fit. If the individual garment’s waist measurement had been 96 cm, this would have given a difference of +7 cm, which leads to a judgment of only decent fit, as demonstrated in Table 2.

![Table 1: Example of an individual garment measurement chart (G)](image)

<table>
<thead>
<tr>
<th>[cm]</th>
<th>(v)</th>
<th>(s)</th>
<th>(G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>93</td>
<td>10</td>
<td>103</td>
</tr>
<tr>
<td>Waist</td>
<td>78</td>
<td>15</td>
<td>93</td>
</tr>
<tr>
<td>Hip</td>
<td>99</td>
<td>6</td>
<td>105</td>
</tr>
<tr>
<td>Back length</td>
<td>37</td>
<td>25**</td>
<td>62</td>
</tr>
<tr>
<td>Sleeve length</td>
<td>58</td>
<td>7**</td>
<td>60</td>
</tr>
</tbody>
</table>

* \( b \) = individual body measurement, \( e \) = ease allowance, \( G \) = individual garment measurement
** added length to the body measurement to create the style

With the input and extracted data at hand, the estimation of the fit value could be calculated with the model. The fit value indicates how well the individual garment measurement chart \( (G) \) conforms to the standard garment measurement chart \( (g) \). An overview of symbols and abbreviations can be found in Table 3. For calculation purposes, the different judgements (good, decent, poor) are transformed into a numerical fit value \( (v) \), good = 1, poor = 0 and decent proportionate value between zero and one \((0 – 1)\). The calculation to find the individual value for decent fit was divided into two parts: the first was to find the value of \( P_1, P_2, M_1 \) and \( M_2 \) for each measurement for the selected size. This was done by adding/subtracting the border value \( (p_1, p_2, m_1, m_2) \) from the standard garment measurement \( (g_Zi) \) as defined in Equations (1) and (2). For example, the garment’s waist measurement for standard size is 89 cm, and the plus borders \( (p_1, p_2) \) for decent fit are +6 cm and +10 cm, see Table 2, which gives an interval between 95 cm and 99 cm on the plus side.

\[
P_{1Zi}, P_{2Zi} = g_{Zi} + p_{1Zi}, p_{2Zi}
\]

\[
M_{1Zi}, M_{2Zi} = g_{Zi} - m_{1Zi}, m_{2Zi}
\]

![Table 2: Fit ranges for the garment’s good, decent and poor fit. The borders between fit ranges marked with \( m_1 \), \( m_2 \) (minus) and \( p_1 \), \( p_2 \) (plus); output/fit value of each range is marked at the bottom (grey area).](image)

Table 3: Overview of the abbreviations

<table>
<thead>
<tr>
<th></th>
<th>Individual body measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>Individual body measurements</td>
</tr>
<tr>
<td>z</td>
<td>Body size chart</td>
</tr>
<tr>
<td>e</td>
<td>Garment measurement chart</td>
</tr>
<tr>
<td>G</td>
<td>Individual garment measurement chart</td>
</tr>
<tr>
<td>v</td>
<td>Fit value</td>
</tr>
</tbody>
</table>

4.

APPENDIX 1

5.

APPENDIX 1
The decent fit value ($v$) for the individual garment measurements ($G_i$) is calculated with equation 3. This was done by subtracting the individual garment measurements ($G_i$) from the defined border values, $P_1$, or $M_1$, and then dividing the difference with the spread of the decent fit interval ($M_1$ - $M_1$ or $P_2$ - $P_2$). Finally, this quotient is extracted from integer one (1), as presented in Equation (3). For example, the individual garment waist measurement ($G_i$) is 100 cm, the lower border value ($P_1$) for plus decent fit is 99 cm, the difference between the two is 1 cm. The upper border value for plus decent fit is 103 cm, which gives a spread value of the interval plus decent fit ($P_2$ - $P_1$) of 4 cm (103-99cm). The individual difference divided by the spread value (1/4) gives a value of 0.25, which has to be subtracted from the integer one (1). The final fit value for this individual’s waist measurement was 0.75.

$$v_i = 1 - \frac{(P_1 - M_1) - G_i}{(M_1 - M_1) or (P_2 - P_1)}$$  
(3)

The fit value for each measurement needed to be further calculated to show the individual fit value for the whole garment. The values of fit ($v$) for each measurement ($i$) were summed up and divided by the number of measurements ($I$) used in the model. This gave the average fit value for the whole garment. However, if one of the fit values was zero (0), the garment was regarded as total misfit. This is so because if the garment has a poor fit in any of the areas, then a good and/or decent fit in other areas cannot compensate for the poor fit and make the garment seem to fit the individual. With the judgment of misfit or a fit value at hand, further analysis could take place to identify shortcomings of the standard garment charts or to identify the need for customisation.

The output from the systematic model was the input for the analysis of garment fit. A combined fit value is shown for each measurement and individual included in the model. The fit value, which was used in the analysis, had two goals: one was to identify mismatches between garments and the target group and the other, to evaluate the individual garment fit for a selected garment and size.

Mismatches between the garment and target group were identified with the help of the output data. To get useful information from the output data, various statistical calculations were used, e.g. median, mean and quartile values. With the statistical information at hand, the garment measurement chart was modified to better fit the target group. To verify if the modifications improved the theoretical garment fit, the garment measurement chart was run through the model again. This was repeated until the best coverage was reached.

The model generated data needs to be further analysed to pin point modifications needed in th garment measurement chart for achieving a better fit value for the target group. The analysis can be divided into three main steps; indication of misfit, location of misfit and modification values. Analysing steps presented below:

1. Indication of misfit anywhere in the garment
   a. Number and percentage of individual garment measurement charts containing at least one measurement with the values of misfit (fit value = 0)
   b. The distribution of misfit over the available sizes, in relation to selected sizes.
2. Location of misfit
   a. Statistical overview of which measurements caused misfit (fit value = 0).

b. To determine if there were misfits due a grading problem (which is not covered in this paper) an additional analysis could be conducted in the same way as 3a–b, but with the average calculated per size.

3. Modification value
   a. For each measurement, causing misfit (2a), the average measurement value for all individuals (n=2208) and the sized standards garment measurement chart (p) were compared and analysed.
   b. Further analyses were conducted with the average measurement value for only the individuals with a fit value equal to zero (n=1a).
   c. If the location of the misfit was identified to be a grading problem (2b), the modification value had to be based on further analysis on a more detailed (size) level.

### Garment Fit Analysis

The goal was to find the best theoretical garment fit for the target group and to do this with as few garment measurement charts and sizes as possible. To identify misfit and potential for improvements, the output from the systematic model together with additional calculations were used in the analysis. In this study, the systematic model was tested with a target group (n = 2,208). A women’s basic shirt was used, and five measurements were selected: chest, waist, hip, centre back and sleeve length as indicated by Figure 2. This gave 11,040 individual values for comparing to the standard garment’s measurements (five selected measurements x 2,208 individuals from the ANSUR database). From the selected measurements, the chest measurement was used as the key measurement.

Misfit of a garment can be caused by a single measurement or by a combination of two or more measurements. The misfit of a measurement can either spring from a misfit in the basic size that correlates to the whole span of sizes or it can be a problem related to the grading. This can be determined by analysing the calculations based on the output data. However, a certain number of misfits can always be expected within any target group.

Further calculations are done by identifying and locating the misfit and finally modifying the value of the garment measurement chart to prepare for the next run through the model. Based on the output from the first run, 87% (n=2,208) of the individuals have at least one measurement judged as misfit (fit value=0). Further analysis showed that the sizes, including measurement/-s with misfit distributed evenly over the used sizes, Figure 3. The distribution of ill-fitting garments in relation to selected sizes indicates that the main problem lies in the basic size and not in

**Figure 2:** Measurements included in the systematic model.

**Figure 3:** Correlation between sizes used and detected misfit. The output of the systematic model shows the distribution of the misfit (n=1,931) over the sizes. This was then compared to the selected sizes for the whole target group (n=2,208).
specific sizes or range of sizes. As many as 81% of the individuals (n=2,208) suffered from poor fit in relation to the sleeve length, 26% for the centre back length, 19% for the hips and less than 0.5% for the waist area. A combination of all three identified areas causing misfit is possible in an individual profile. The main misfit of the garment seems to be that it is too long at both the centre back and sleeve but too tight at the hip area.

Further analysis of the output values was carried out with the goal of identifying the value of misfit and improving the theoretical garment fit. Table 4 gives an overview of the output data from the runs with the systematic model as well as calculations in relation to the upcoming analysis. Analysis is carried out after each run, and the final modifications for each run are also presented.

Table 4: An overview of the five runs made with the systematic model, also listing the calculations used in the analysis for each measurement, causing misfit in the first run.

<table>
<thead>
<tr>
<th>Run No.</th>
<th>1st run (1:1)</th>
<th>2nd run (1:2)</th>
<th>3rd run (1:3)</th>
<th>4th run (1:4)</th>
<th>5th run (1:5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Modifications in g-chart*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20.0</td>
<td>7.2</td>
<td>-3.1</td>
<td>-1.2</td>
<td>-0.8</td>
</tr>
<tr>
<td>2</td>
<td>13.2</td>
<td>-1.3</td>
<td>-1.1</td>
<td>-2.2</td>
<td>-0.9</td>
</tr>
<tr>
<td>3</td>
<td>15.3</td>
<td>-2.5</td>
<td>-3.1</td>
<td>-3.2</td>
<td>-0.7</td>
</tr>
<tr>
<td>4</td>
<td>17.4</td>
<td>-1.8</td>
<td>-2.1</td>
<td>-3.4</td>
<td>-0.4</td>
</tr>
<tr>
<td>5</td>
<td>19.5</td>
<td>-1.4</td>
<td>-1.9</td>
<td>-2.3</td>
<td>-0.6</td>
</tr>
</tbody>
</table>

* total increase/decrease in relation to Original garment measurement chart (g) (1:1). ** ID's classified with fit values >m2 and <p2, table 2. *** ID_F+ (G-chart with value above p2), ID_F- (G-chart with value below m2), table 2. ****The value shows how far into the poor fit the G-chart is, the distance from m2/p2, table 2.

To find the best fitting garment measurement chart (g) for the target group, a few runs using the model had to be carried out, with modifications of the garment measurement chart (g-chart) between the different runs as presented in Figure 4. The first run (1:1) showed that 87% (n=2,208) of the individuals in the target group had one or several measurements judged as poor fit. The fit value for the remaining 13% containing good and decent fit was 0.82 (n=277); the average fit value for the whole target group was 0.10 (n=2,208), as in 87% (n=2,208) of the individuals in the target group had one or several measurements.

The question that emerged was whether it was possible to decrease the misfit further if a modification was done based on the value for the average ID_F+ (which had the highest number of misfits) (row 9, Table 4). The third run (1:3) showed that most of the misfits came from the length measurements, centre back and sleeve length. The hip measurement was probably at the best level, based on the distribution of the misfit, (rows 6 & 8). However, to make sure, the modification value lying between runs 6 and 8 was tested in the upcoming run. The fourth run (1:4) gave a higher misfit than the third run, and the best value for hip measurement was identified as +8 cm (1:3). Compared to the third run, this run also gave lower misfit values for the length measurement (row 1). The sleeve length did not reach satisfying values in the fourth run either. The misfit was divided between the ID_F+ and the ID_F+ (rows 6 & 8), which indicated that for this target group it was necessary to have a garment with at least two different sleeve lengths, one short and one long. This will be covered later in the paper, but at this point - was the value that gave the lowest misfit for sleeve length. The fifth run (1:5) was carried out to check the fit value for the centre back length with a different measurement value. The results showed that the misfit of the measurement decreased and was distributed between the ID_F+ and ID_F- (rows 6 & 8). This should be taken into consideration when developing different g-charts to accommodate the target group concerning the sleeve length. When summarising the analysis conducted in the different stages, the best fitting g-chart was the one with modifications of the centre back -4 (1:5), hip +8 cm (1:3) and sleeve -5 (1:4) (row A, Table 4). With this selected g-chart for the target group, the garment still did not accommodate 43% of the group. The best fit with the use of one g-chart for the target group in the case study gave a 43% misfit (n=2,208). The fit value for the remaining 57% containing good and decent fit was 0.90 (n=1,260); the average fit value for the whole group also increases. In order to reach such high coverage for the target group, three garment measurement charts (small, normal, long) are needed.
fit value for the whole target group was 0.51 (n=2,208), Figure 5.

Same style – different measurement charts

The low accommodation for a target group can be solved partly by creation of different garment measurement charts (g) for the same style. This should maintain the same expression and design; thus, only the g-chart was modified to meet the variations within the target group. The main area still causing misfit was the sleeve length with 42% (n=2,208) with an almost even distribution of misfit between poor- (ID_F-) and poor+ (ID_F+), 442 and 475, respectively. As the length measurements of the sleeve will be modified, the length of the centre back needs to be altered accordingly in order for the garment to be more proportional, and to improve the fit value for the centre back length and the whole garment.

The initial measurements of sleeve and centre back length were the mean values of the two groups (n=2,208), Figure 6. The values used in the first run with two g-charts were: sleeve N(normal) -3, sleeve S(short) -8, centre back length N -2 and S -6, all in comparison to the first run (1:1). The analysis between the runs (2:1-4) was the same as previously, and the results are presented in Figure 4 and Figure 5. The conclusion drawn from these runs was that two different lengths for the g-charts are not enough. The best run (2:3) still generated 14% misfit due to the sleeve length. Three different lengths seemed to be needed to cover the target group’s variation in length measurements. The three different lengths for the initial run (3:1) were based on the values found when dividing the target group into four even groups, Figure 6. Based on this, different g-charts were created and compared to the original g-chart with centre back S -5, N -4 and L (long) -3 and sleeve S -7, N -5, L -3. Further runs (3:2-4) were carried out to find the best combination of g-charts for the target group. Figure 4 shows the changes in the different g-charts and Figure 5 the results of the runs. The third run gave the lowest misfit out of all the runs. Only 4.8% (n=2,208) of the garments were judged as poor fit. The individuals falling within these 4.8% would have to order made-to-measure garments or accept a garment with poor fit in one or more sections of the garment. The fit value for each g-chart, excluding the individuals judged with poor fit were: S 0.91 (n=537), N 0.91 (n=1,101) and L 0.89 (n=464); the average for all three g-charts was 0.90 (n=2,102). The average fit value for the whole target group was 0.86 (n=2,208).

The output from the systematic model and the additional calculations suggest which g-charts should be used to cover the target group. Further studies are needed to verify the suggested g-charts and their values in relation to virtual and/or real garment fit, as analysis of theoretical garment fit is not adequate.
Future research should be carried out both by using different garments and target groups but also by analysing the value of fit (numbers) against the virtual and/or real evaluation of the garment fit.

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ARTICLE II


February 28th 2018, comments received for revision of manuscript for a second review.
Can virtual try-on help in selecting the correct size?
Hernández, N., Mattila, H. & Berglin, I.

Abstract
If physical try-on is not possible, selecting the correct garment size may be difficult. Researches indicate that virtual try-on could be helpful. Within this study, test persons and an expert panel were presented with a virtual garment of different sizes, simulated on test persons’ individual avatars. Both the test persons and the expert panel selected the best fitting virtual size independently, and the results were compared to the selection made by the test persons when the garments were physically tried on. The results show that the size selection based on a virtual garment was more accurate compared to selection with key measurements. Furthermore, the test persons were able to carry out more accurate pre-selection compared to the expert panel. Further research is needed in regard to virtual techniques and set up in order to enhance the accuracy of pre-selection by consumers.

Keywords: garment, apparel, fit, evaluation, virtual, simulation, virtual try-on
Can virtual try-on help in selecting the correct size?

Hernández, N., Mantilla, H., & Bengín, I.

To ensure the selection of the correct size, customers feel that they have to physically try on many sizes in order to find the one that fits them the best (Daanen & Ter Haar, 2013; Kasambala et al., 2016). This poses a problem when it comes to Internet shopping where physical try-on is not possible (Daanen & Ter Haar, 2013; Kim & LaBat, 2013a). The fashion shopper often has difficulties in selecting the correct size because the measurements of a particular size are not equal from the various brands (Gribbin, 2014). A sizing system should be consistent, be equal in the measurements and dimensions of a garment (Labat, 2007), as well as indicate which size fits well (Ashdown & O’Connell, 2006). The sizing system should help the consumer to find and select the correct size. However, researchers show that customers do not believe that the garment measurements correspond to the size marking, and they do not trust that the selected size will fit them (Kasambala et al., 2016). Alternative methods for finding the correct size are needed when try-on is not possible. In this study, we want to explore the possibility of using virtual images for pre-size selection and compare this with a real size selection.

Literature review

The most traditional way to select a size (without try-on) is to use the vertical and girth body dimensions (Winks, 1997). The primary measurements for women are bust and hip girth and for men, chest and waist girth (International organisation for standards (ISO), 2017). Another way to make size selections is to use algorithms and databases to pick the most appropriate size based on the customers’ self-reported measurements (Gribbin, 2014). Daanen and Byvoet (2011) found that with information pertaining to a woman’s stature, weight, age, and bra size, in combination with the body shape identifications, such as the size of the waist, hip, and length of the arms, they can provide a well-fitting garment. Today, it is also possible to select the size on the basis of a virtual model (Kim & LaBat, 2013b). Regardless of the way in which the size selection is made, the goal is always to find the size that makes the wearer feel satisfied.

Garment fit is a subjective and highly individual matter. It is influenced by fashion, social, and cultural norms (Petrova & Ashdown, 2012) as well as individual preferences (Alexander et al., 2005; Ashdown & O’Connell, 2006; Bye et al., 2006). Different views in perception of fit make it difficult to establish a standard (Ashdown & O’Connell, 2006). One factor affecting fit and comfort is the amount of ease. The amount of ease that is perceived as being good in a garment’s different areas has previously been studied; the conclusion is that the preferred amount of ease is highly individual (Ancutiene, 2014; Ashdown & DeLong, 1995; DeLong et al., 1993; Lin & Wang, 2016). Perception of the overall garment fit also varies between brands (Ashdown & O’Connell, 2006) and individuals (Alexander et al., 2005; Kohn & Ashdown, 1998; Gribbin 2014) argues that it is only the wearer that can be the true judge concerning the fit and comfort of the garment; therefore, all attempts to select a size on behalf of the customer contain the uncertainty of the customer’s agreement.

Evaluation of garment fit is made by experts, test persons, and finally by the end user (Ashdown & O’Connell, 2006; Watkins, 2015). The experts evaluate the garments on a body during a live fitting session (Bye & LaBat, 2005) or by looking at photos (Petrova & Ashdown, 2012), videos (Ashdown & O’Connell, 2006; Choi & Ashdown, 2002; Kohn & Ashdown, 1998; Petrova & Ashdown, 2012; Schofield et al., 2006), or illustrations of 3D simulated garments (Ancutiene et al., 2014; Song & Ashdown, 2010). The structure of the fitting session is enhanced when a protocol of multiple evaluations is carried out (Petrova & Ashdown, 2012). The consistency of the expert panel increases if the criteria for good garment fit are reviewed with them before the evaluation (Ashdown & O’Connell, 2006; Yu, 2010). The individual wearer’s evaluation is usually considered subjective (Connell et al., 2006; Pisur & Jo Connell, 2007) and focuses on the visual and tactile (Ashdown & DeLong, 1995) as well as comfort and satisfaction (Ashdown & O’Connell, 2006) part of the evaluation. The most important and the final say in the fit evaluation always comes from the end user of the garment.

Three main techniques for virtual apparel fitting are discussed by researchers: (a) 3D to 2D, where the simulated 3D garment is flattened into a 2D pattern (Huang et al., 2012), used mainly for small garments such as basic garments, (b) garment is scanned or measured on a body, and then the visual correspondence with the real garment is analyzed (Bye & McKinney, 2010; Song & Ashdown, 2010; Zhang et al., 2011); and (c) where 2D patterns are placed, curved, and simulated on an avatar and later evaluated against the similarities to a real garment (Kim & LaBat, 2013a, 2013b; Song & Ashdown, 2015), or simulated sizes are ranked and sorted according to size (Kim, 2016). When using 3D to 2D (a) or simulation of a garment (c), the avatar is of great importance. It is possible to either create an avatar based on the measurements or use a 3D body scanner to get a replica of the body (Gribbin, 2014; Kim & LaBat, 2013a; Lim & Istoook, 2011; Stjepanović et al., 2012). With the simulation technique (c), most detailed research has been conducted by investigating the effect of mechanical properties (Ancutiene et al., 2014), grain line (Koo & Suh, 2009), wrinkles (Kang & Lee, 2010), and ease amount (Lin & Wang, 2016). Apart from the technical findings and the similarities of the virtual and real garment, another research area is how the user/customer perceives the virtual garment in a shopping scenario (Kim & LaBat, 2013a, 2013b; Kim & Fosythe, 2008).

Researchers point out several challenges with the virtual techniques. The most frequent problem is related to the fabric, where its properties (Ancutiene & Sinkvičiūtė, 2011), structure, or wrinkles do not correspond to reality (Kim & LaBat, 2013a, 2013b; Song & Ashdown, 2015). Other challenges are the communication of the amount of ease and its effect on the garment fit (Ancutiene, 2014) as well as the interaction between the garment and the body (Volino et al., 2005). Moreover, the type of body/avatar used in the simulation affects the final simulation, and researchers show that the scanned avatar gives a more realistic simulation compared to a parametric avatar (Kim & Istoook, 2011a; Lim & Istoook, 2011a; Simona Jevane, 2012). Researchers also indicate that a dynamic avatar that moves better facilitate the evaluation of strain, ease, and fabric characteristics (Ancutiene, 2014). Others would like to see pressure points to evaluate the distribution of ease (Magenart-Thalmann et al., 2011; Song & Ashdown, 2010).

Kim and LaBat (2013b) studied the perception of virtual and real garment using garment fit experts, test persons, and simulated on different sizes in an avatar and later evaluated the garment fit. Individual simulations were created of each test person with their avatar dressed in the appointed size of the garment. The photos were then compared to the virtual garment, and the experts evaluated the garment fit and fidelity of the virtual simulation. (Song & Ashdown, 2015) Yet another study reports on the respondents’ ability to successfully rank and sort a set of sized virtual pants (Kim, 2016). When looking at the results from the above studies, the results point in different directions. The fidelity was higher when the garment fit was good; when the fit was poor, the experts reported that the virtual (VR) garment was looser than the real (RL) garment (Song & Ashdown, 2015). In another study, Kim and LaBat (2013b) show that the identified differences between the VR and the RL garments were related to the fabric presentation. The researchers also reveal that the test persons, on the basis of a virtual garment, had a tendency to select a size that was larger than what they normally wore, for example, the VR garment was perceived as being smaller than the real size (in contrast to the previous study). In yet another study, Kim (2016) showed clearly that the respondents
could rank and sort the virtual trousers and detect differences down to +/-0.5 inches. A summary of these results indicates that when evaluating only the VR garment, the consistency of the responses is better than when the evaluation is made between the VR and RL. Even if the fidelity of the simulated garments was only moderately good and the technique had some challenges, virtual garments are better than photos when it comes to demonstrating the garment fit (Jyeon & Forsythe, 2009; Kim & Labat, 2013b; Shim & Lee, 2011). This underlines the previous researchers’ demand for further software development and research within the field.

Objectives of this study
Researchers discuss garment fit, in terms of comparing the fit of a virtual presentation and the fit of a real garment. However, we find a research gap when it comes to the reliability of the pre size selection, based on the virtual image and a real size selection. We also find it important to explore the difference between the experts and test persons when selecting a suitable size. Together, the test persons and a panel of fit experts made a virtual size selection, and the results were compared to the test persons' size selection based on the physical try-on. The test persons also evaluated both the virtual and the real garment at different sections. With this research focus, we attempt to answer the following questions:

RQ1: How correctly can test persons and a panel of experts select the best fitting size when the selection is based on illustrations of virtual garments?

RQ2: Which garment areas are most difficult to evaluate when it comes to garment fit visualized in 3D?

Method
The data for this study were collected from two connected but different studies. The data for the first study were collected during two appointments, while the second was an online survey. For the first study, 124 females were invited by e-mail, out of which 42 signed up and 39 attended the first session; three out of the 39 did not attend the second session. Some of the responses were not complete, so the final number of participants was 35, where 34 filled-in the questionnaires for the shirt and 33 for the trousers. For the second online survey, 61 individuals with different kinds of experience with apparel and garment fit were invited, and 24 completed the survey. The garments used in the study were obtained from a local manufacturer who provided both 2D-patterns and real garments of a semi tight casual blouse (100 % cotton) and close fitting trousers.

Evaluation of the real garments: The test persons tried on the same sizes as previously illustrated as virtual garments and selected the most suitable size. They evaluated the selected size at the same areas and with the same scale as when evaluating the virtual garment.

Data collection – test persons
The test persons were body scanned during the first visit. During the second visit, they evaluated the garment fit based on both the virtual garment and by trying on the real garment.

Scanning: For the body scanning LS3, a laser scanner from Human Solutions was used. Each participant signed a consent form agreeing to the use and storage of the scanned data.

Evaluation of virtual garments: Simulated garments on individual avatars were displayed in a front, back, and side view. The garment was illustrated with and without transparency in order for the participant to see the distance between the body and the garment, as presented in Error! Reference source not found.. Each test person evaluated her own avatar dressed in different sizes and selected the best fitting size. The fit of the selected size was then evaluated in different areas of the garment. For the shirt, there were seven areas, that is, circumference of the bust, waist, hip, bicep, placement of the waist, length of the center back and the sleeve. For the trousers, six areas were used, that is, circumference of the waist, hip, thigh, placement of the waist, crotch and finally, the inside leg length. To register the evaluation, a Likert-type scale (five options) was used: much too tight/low/short (1), too tight/low/short (2), good fit (3), too loose/high/long (4), and much too loose/high/long (5). The virtual evaluation was completed and handed in before entering the evaluation of the real garments.

Data collection – panel
A survey platform was used to present the questions and gather the responses from the garment fit expert panel.

Video: The avatar with the simulated garment was individually displayed in a movie, showing the avatar turning around 360°, although the avatar was fixed in the same posture.

Survey design: The respondents were asked to analyze the videos, and based on their evaluation of the size selection and garment fit, select the one with the best overall fit. The respondents were also asked about their experience within the field of garment fit and apparel.

Survey analysis
General analysis was carried out to study and visualize the results. When appropriate, a Sign test within SPSS was used for statistical analysis.

Results
The results in this study are based on the findings from two successive studies. The first study recruited 35 test persons, aged between 21 and 56 (Mean = 40.2, SD 11.9). First, they were body scanned; later, they made size selections and evaluations based on both simulated and real shirts.

Figure 1: Sample of illustrations shown to a test person. The upper row illustrates a transparent garment for evaluation of the distance between the body and the garment.
and trousers. The second study included a panel of 24 respondents, all with experience in product development and garment fit. Sixty-three percent of the respondents had worked for more than 10 years with product development in apparel. The panel evaluated the overall garment fit of the simulated shirts.

**Size selection**
In many situations, it is necessary to make a size selection based on other facts than real try-on. The goal for the alternative selection method is to be as accurate as possible, for example, to match the real try-on. The alternative size selection based on other facts than the garment was actually tried on.

One established method for pre-selection of size is to use key measurements. In this study, we tested an alternative way, which is to use visualization of the garment in 3D. Error! Reference source not found., gives an overview of the findings related to this issue, indicating that the most accurate pre-selection method is based on viewing illustrations of a simulated garment; this when the wearers themselves make the pre-selection. For a test person, the match between the pre- and the real size selection when using virtual images was 53 % for the shirt and 61 % for the trousers. The panel also selected the best fitting size based on the simulated shirt; however, with their selections, only 37 % matched the size actually selected by the wearer, as illustrated in Error! Reference source not found..

Size selection based on the key measurements had a match to the real size selection, with 44 % for the shirt and 39 % for the trousers. Size selection based on the key measurements has a tendency to appoint a larger size than desired by the test persons, in 50 % of cases for the shirt and 55 % for the trousers. This may indicate that the size chart of the garment does not fully match this group of individuals. If these garments were ordered online without trying on, the garment would have been perceived by the wearer as being too large, unless the users actually wanted to have a so-called vanity size garment (Alexander et al., 2005; Gribbin, 2014).

The results of this test seem to indicate that size selection made with the help of 3D-visualization gives a better result compared to selection made with the key measurements only, that is, when selection is done without an actual try-on.

**Garment evaluation**
The most reliable evaluation of a garment fit is done when the garment can be tried on. Simulated illustrations can serve as an alternative evaluation tool. This study also compared the evaluations of various garment sections based on virtual (VR) and real (RL) garments. To be able to analyze how the evaluation of the VR-garment reflects the RL-garment, the evaluation had to be based on the same size. Therefore, a dataset was picked out so that there was a match between the pre- and the real size selection, in 18 cases for the shirt and in 19 for the trousers. The findings in this study indicate that some areas are more difficult to pre-evaluate than others. An overview of the areas and results of the shirt and the trousers’ evaluations are illustrated in Error! Reference source not found., respectively. The results show that the key measurements having a high match between the pre- and the real evaluation were chest for the shirt (78 %) and hip for the trousers (89 %).

According to the Sign test, the areas that showed a significant match include the hip circumference (p=0.039), crotch placement (p=0.004), sleeve (p=0.002), and the center back length (p=0.004). The hip area of the shirt is perceived as being tighter on the VR-garment than on the RL-garment. The placement of the crotch is perceived as being hugger (further down) on the real garment. At the center back length, the virtual garment is perceived as being shorter than the real garment, while the length of the virtual sleeve is perceived as being longer; even the RL-sleeve is judged to be too long (avg. RL-sleeve 3.39).

The overall evaluation of the width measurements indicates that the VR-garment, to some degree, matches the RL-garment, the shirt in 53 % of the cases and the trousers in 72 %. When looking at the mismatch, it seems that the VR-shirt’s combined circumference (all width

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**APPENDIX 2**

![Figure 2: The difference between the real selected size and the pre-selections; one size up means that the pre-selection is one size too big in relation to the real size selection. Pre-selections of size are based on the key measurement and virtual simulations and the real size selection is done by try-on of the real garment.](Image 222x433 to 423x582)

![Figure 3: The test persons (n=34) and an expert panel (n=120, 24 experts * 5 questions) conducted the size selection based on the virtual simulations of the shirt.](Image 273x148 to 408x310)

![Figure 4: The difference between the evaluation scores given when evaluating the shirt, 3D simulations (VR), and the real garments (RL). This analysis includes only the data sets with the same size selected for the pre and the real size selection (n=18). Percentages may not total 100 due to rounding.](Image 654x154 to 900x327)

![Figure 5: The difference between the evaluation scores given when evaluating the trousers, 3D simulations (VR), and the real garments (RL). This analysis includes only the data sets with the same size selected for the pre and the real size selection (n=19). Percentages may not total 100 due to rounding.](Image 661x437 to 907x611)
measurements) is perceived as being smaller than the RL-garment. However, the VR trousers’ combined circumference does not indicate any tendency because the results are evenly distributed between too small and too large.

**Discussion**

Pre-selection of the size based on a simulated garment gives a slightly better match (57%) than the more traditional key-measurement based selection (42%), when compared to the selection done with real try-on. These were the results when the wearers themselves selected the size. Other individuals, such as the fit experts, got a lower match for size selection, 37% (shirt). One reason for this could be that the panel members are not aware of the individual wearers’ preferences regarding how they like the garments to fit: tight, medium, or loose.

Even though the statistical analysis in our study does not show a significant result in all of the measured areas, interesting findings can be observed from the output. When evaluating the different areas of the virtual garment (VR) and the real (RL) garment, the lowest match between the two is with the inside leg length for the trousers, and the circumference of the waist, bicep, length of sleeve, and the center back for the shirt. Both the VR- and RL-sleeve lengths are perceived as being too long (avg. 3.94 and 3.39, respectively), but the VR-sleeve length is perceived as being the longest. The results might have been different if the avatar could move, as the evaluator could have noticed that some of the length that looks bulky when standing still is needed when moving the arms. The same reasoning might be true for the inseam of the trousers, where the VR garment is perceived as being longer than the RL garment. It is noted that the highest match, for both the shirt and the trousers, is the ones for the key measurements, chest and hip, with scores of 78% and 89%, respectively.

Fit evaluations of garment sections in previous research are conducted with a slightly different purpose and scale. Several researchers investigate the fidelity of the simulated garment, using scales ‘disagree/different’ and ‘agree/similar’ (Kim & LaBat, 2013b; Song & Ashdown, 2015). Kim and LaBat (2013b) evaluated the fit with the terms ‘poor’ and ‘excellent fit’. These two sets of evaluation terms are not used in our study. Instead, we used terms like ‘tight/low/short’ and ‘loose/high/long,’ similar to the terms used by Song and Ashdown (2015). Even if it is not possible to compare the studies due to these differences, we can conclude that the results are not equal. When looking at the fit of the trousers, Kim and LaBat’s (2013b) study indicated that the VR-trousers were smaller than the real garment (based on the interview), while the study by Song and Ashdown (2015) indicated the opposite (based on the width measurements). In our study, we had a 72% overall match between the VR and the RL for the width measurements, but when looking at the mismatch it is evenly distributed between tighter and looser, 14% on each for the width measurements. These differences in research results indicate that further studies are needed and, if possible, more standardized methods should be used.

The trousers have a higher match between the pre- and the real selection than the shirt. The higher match for the trousers might be an effect of the fabric stretch, which increases the span of good fit on the real garment; for example, the same circumference of a garment can accommodate a wider range of body measurement, thanks to the flexibility inherent in the stretch material.

Some of the experts in our study indicated that it was difficult to select the size; hence, they only evaluated the overall fit. One garment could be better in one area, while another size was better in another area. The experts did not receive any training in how to conduct the evaluation, as was the case in the previous research. We wanted them to draw from their own experiences of garment fit and assess the size selection from that perspective. The results also seem to point out that the experts and the test persons have a different perception of fit.

The virtual tool to be used by consumers needs to be further developed in order to find parameters, which make the fit outlook of a virtual garment match the real garment in a more consistent way. Further research is needed to identify which additional virtual information could be helpful, and how to visualize different kinds of ease, movement of garment, properties of fabric such as stretch, texture, and strain, in order to increase the matching between the virtual and the real fit evaluations.

**Conclusions**

The results of this research indicate that pre-selection of size based on simulated garments exceeds the accuracy of the size selection based on the key measurements, especially when it is the wearer who makes the pre-selection of the size. If an expert makes the size selection, the accuracy is not as high, probably because the second person is not aware of the fit preferences of the wearer.

The most difficult areas to evaluate are the inside leg length (trousers), the circumference of the waist, bicep, length of the sleeve, and the center back (shirt), as reflected by the mismatch percentages between the evaluation of the VR and the RL garment. Interesting to note is that the key measurements for the shirt and the trousers (chest and hip, respectively) scored the highest match for each garment.

It is evident that further research is needed to develop the tools that can be used in the simulation of garments. This is especially true in relation to the material properties, display of ease and strain, avatar creation, and possible movement of the same. Parallel with the technical development, research should continue within the area of consumer studies to find out how, when, and in which way the tools are best used.

**References**


LICENTIATE THESIS


Defended and approved June 2000, Gothenburg University
Preface and acknowledgements

I am glad to see that the technical equipment needed for mass customisation is available today. The industry can use it to gain more satisfied customers, which would benefit everybody. Tailors could use it in order to speed up the process of making a high quality suit and keep their close contact with the customers. The know-how to adapt a pattern for a unique figure is important to master even if we have technical equipment that facilitates and speeds up the process. Through this study I have learned about the variations of the body figures and a lot about how to make an individual pattern that gives a well-fitting and comfortable garment.

This study has been finalised in a short and intensive period. I have lived closely with these chapters and not had much time over for other things. First of all I want to thank my dear, wonderful, and supportive husband Jaime Hernández for all the excellent dinners he cooked and fortified me with. Always welcoming me home with a smile and a kiss – even if it was late!

There are many people that have helped me through this work. Marianne Thorén who encouraged me to enter the field of research while working in the EASYTEX project. When it comes to pattern construction I want to thank my mentor Inger Öberg who has been my discussion partner all through this process. My supervisor Jan Paulsson, who has spent many hours reading and coming up with great suggestions to improve the material. Helena Shanahan who has always been there to answer my questions. In the EASYTEX project we struggled and supported each other side by side, Helene Berglin and Camilla Svensson. Extra thanks to Helene Berglin who has given this report the great illustrations of the unique figures.

Last but not least, thanks to the EASYTEX project and to all the test persons who volunteered for the benefit of this research.

Göteborg May 2000

Niina Hernández
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To find clothes in a retail store is a problem for quite a lot of individuals. The problem always exists because we wear clothes all the time. It is a very widespread problem, which can effect anyone, all depending on their figure, the supply of clothes in the stores, and the individual’s demands. However, there are many individuals within the categories elderly, impaired, and/or disabled who have exceptional problems with finding suitable clothes.

There are individuals who have unique figures, which do not always fit into the standard sizes that are available in the stores. There is a gap between the stores’ supply and the demands from the customers. The more the figure diverges from the standard figure the more difficult it is to find suitable clothes in retail stores. It is almost impossible for an individual with a hunched back to find suitable garments. The customer demands a more flexible market when it comes to clothes, a market that can provide them with suitable garments.

Before garments were produced in large quantities clothes were produced by tailors, seamstresses, and/or by a family member. The garments were automatically individualised according to the customer. Now there are very few tailors and seamstresses and they have difficulties to compete with the manufacturer’s low prices. The retail stores can attract more buyers due to greater quantities, lower prices, and more advertisement. Most people buy their clothes from retail stores.

It is impossible to estimate how many people are effected by not finding suitable garments. The individuals that have this problem are not registered anywhere. No statistic is available in the matter either. The effected are spread out over the whole community. One group asking for made-to-measure might have a disfigurement of some sort. Another group might have rather high demands on the garment, which makes it difficult to find suitable clothes according to their desire.

Today, it is possible to offer customers a garment to order according to their desires and body figure. The new, more automatic, equipment and software make the process faster and possible to realise. However it is important to have the basic knowledge about how to adapt the patterns according to the many variations of figures that exists. Pattern construction for unique figures is covered in this study. The report begins with a background to the problem concerning finding suitable garments, followed by earlier initiatives. The main body of the study contains three main sections: body figure registration – including measurements, single pattern adaptations, and individual patterns.
Importance of dress

The environment has certain expectations on how to dress in certain situations. The way of dressing depends on the environment and the willingness of the individual to adapt to the environment’s expectations. Clothing has both a functional value and a symbolic value to the human being (Rosenblad-Wallin 1983). There are innumerable ways of dressing, there are certain dress codes depending on in which country, society, social status, circumstance and group we find ourselves. With the way we dress we communicate things about us as individuals e.g. our personality, what we stand for, to what group we belong etc. (Feather & Jenkins, 1993; Ryan, 1966).

There is an oversupply of clothes on the market in the industrialised countries. People have more clothes than they actually need for the protection of the physical body. “Everyone enjoys wearing clothes that are comfortable, pleasant to the eye, and that make them feel self-confident.” (The Disabled Living Foundation, 1994, p.1). The style and colour advisers, whose numbers have increased over recent decades, also give witness in how important it is to dress the so-called correct way. It is important for our wellbeing that we feel attractive, “Beauty provides feelings of serenity, well-being and happiness, and lessens feelings of tension, anger, hostility, and depression.” (Hoffman 1979, p.36). Attractive and comfortable clothing leads to the feeling to be a part of a group, e.g. social integration (Hallenbeck 1966; Kratz 1996).

Jacobson (1994) describes how important dress is for the personal development and which signals the dress sends. The dress plays an essential role when establishing the individual’s position in various groups, e.g. work-mates, friends etc. It also builds self-confidence, recognition and influence, which are all included in developing a social position. Our dress declares our position and what we stand for (Jacobson, 1994). Dress has become of such importance for the personal development and social establishment because it is used everyday, most of the time in a public display and it is easy to manipulate (Feinberg, Mataro, & Burroughs, 1992).

Dress plays an essential role in how the first impression of an individual will be (Ryan 1966; Molloy 1988; Thorén 1992). “Appearance is an index to what people think of themselves and what they strive for.” (Feather, 1993, p.1). A person’s dress usually gives the viewer clues about the person on meeting. The sex, age, occupation, attitudes and personality are some of the information we might get by observing the dress (Ryan 1966). Dress communicates the identity better than the verbal conversation, due to the fact that the dress often guides the succeeding verbal communication (Roach-Higgins & Eicher, 1992; Ryan, 1966).

There are many authors that underline the importance of dress used as a strong communication tool at the first meeting. Feinberg (1992) gives a counterweight to this discussion. He means that not all garments give the same clear signals of the wearer’s identity. Consequently the dress can reflect other things than identity or simply reflect nothing. The communication signals sent by a unique dress might not be understood as the message is intended. How the observed individual is perceived depends highly on the viewer (Ryan 1966). It is difficult for the viewer to “read” the signals of the dress if it is generally acceptable among many cultures, groups and social levels e.g. jeans wear. Feinberg (1992) also underlines that even though their dress reflects the wearer’s self-identity it is impossible for the dress to reflect all aspects of the individual and therefore it is not totally reliable.

For the physically disabled individual the attractiveness of clothing is very important. The observer should not be immediately aware that a person is disabled/impaired, person but should see a well-dressed person and maybe after that the disadvantage or disfigurement (Hoffman 1979). “The disabled person does not want to appear different from others in his social group, irrespective of his age, sex or financial circumstances.” (Gamwell 1966, p.18). The importance of clothing is a highly individual experience for the impaired, disabled or disfigured person. However, active individuals, i.e. the ones who meet a lot of people seem to think that clothing is of great importance (Thorén 1992). It is therefore most important that an individual is free to chose clothes according to his/her own style and through that establish various personal priorities (The Disabled Living Foundation, 1994).

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1 “surroundings and circumstances affecting a person’s life” (Elliott, 1997, p.249)
2 Dress “Clothing, esp. whole outfit” (Elliott, 1997) The dress includes the whole out-fit, both modifications of the body and supplements to the body are included in the definition dress. (Roach-Higgins & Eicher, 1992)
3 To modify and change something, e.g. the pattern. Synonyms are adjust and alter.
4 Clothes “Things worn to cover body and limbs”(Elliott, 1997). Clothing, which is a combination of various garments, is a general word for articles of dress.
5 protection and comfort (Rosenblad-Wallin, 1983)
6 self-esteem, appearance, and decency (Rosenblad-Wallin, 1983)
7 A style is created when style lines and details such as collar, button stand, pockets etc. are added to the block pattern. Also design.
8 “Article of dress” (Elliott, 1997) The combination of garments creates the clothing.
9 “... a disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being” (WHO, 1990, p.28).
10 “... an impairment is any loss or abnormality of psychological, physiological, or anatomical structure or function” (WHO, 1980, p.27).
11 A disfigurement is a spoiled or deformed appearance. In dictionaries this word is explained from a negative angle. In this study the word “disfigurement” simply means a kind of larger figure deformity which does not fit within the parameters of a standard body figure.
Problems with clothing

Thus it is important to be able to select the clothing we wish to wear. However, this is not a possibility for everybody. The reasons can vary and have different impact. Groups, that have the greatest problems with finding well-fitting garments, are the elderly, and disabled and/or impaired adults and children. Nevertheless, a person might not fit into one or more of these categories but still have difficulty in finding clothes, depending on their figure. Bergenheim (1986) states that a person is handicapped if he/she does not fit into the standard sized garments.

There are individuals who can not find suitable garments in today’s stores. There is a problem and dissatisfaction among consumers concerning the inconsistency in sizing of the off-the-peg garments (Caldwell & Workman, 1991). Customers have for a long time wanted more individualised fit of the garments they are about to buy (Hey, 1998).

Cednäs (1973) made a survey of women’s satisfaction with off-the-peg garments available in the stores. She found that it is difficult to find suitable clothes for the short (<162cm) and tall (>170cm) and for those with a bust circumference over 100cm. The problem with finding suitable clothes also increases with age (Cednäs, 1973).

A survey among elderly persons showed that this group has problems with the standard sizes because their shoulders and bodice are too narrow in relation to the waist and hips. They might also have a disability and/or impairment, which effects the garment’s fit (Kernaleguen, 1978). The biggest problem is to find garments in the larger sizes, 46-48, within the 20-series. Women seem to have greater difficulties than men in finding clothes (Rosenblad-Wallin, 1977). One of the reasons might be that made-to-measure garments are not as common in ladies wear as in men’s wear (Thorén, 1992). Another reason might be that in

12 The problem of finding suitable clothes seems to exist in some countries. The studied literature in this chapter mainly form Sweden and Great Britain, but there is also literature from USA, Canada, and Finland.

13 Garment fit: The way the garment forms to the body in the matter of tolerance and harmony with the covered body parts.

14 Person who is 65 years old or older (Cednäs & Kjellnäs, 1977; Kernaleguen, 1978).

15 The external form/outline of the human body, includes the posture. Also body figure.

16 A handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual” (WHO, 1980, p.29).

17 The survey was done together with a measurement survey. The participators were 664 women living in different parts of Sweden and between 16-65 years of age.

18 No large survey of this kind has been carried out in Sweden since this time. Even if this is for a long time ago some of the problems seem to remain. However, nowadays some companies have their own collections supplying the plus sized women with clothes, ranging from C40 up to C54. It varies quite a bit from company to company. Hennes & Mauritz has sizes from C32-C46, their collection for the plus sized starts on XS (38/40).

19 Kappahl has sizes C34-C46, they carry some trousers in the 20-series. Their plus sized collection includes the sizes C42-C52. Lindex has the largest range of sizes between these three companies. The sizes available range from C34-C48, they carry trousers and skirts in the 20-series, D18-D24. They also have variety of inside seam length of the trousers. Their collection for plus sized includes C46-C54.

20 20-series is made for woman with full length as 160 cm +4 cm.

21 Rosenblad-Wallin divides the analyses into two main sections each with subcategories. “Problem’s characteristics: (1) Why is it a problem?, (2) What causes the problem?, (3) How did the problem arise?, (4) What can affect the problem?, (5) Under which conditions does the problem exist?, The user and the user situation: (1) Who are affected by the problem?, (2) Who are the affected?, (3) How many are affected?, (4) Where are the affected?, (5) Do these have any specific qualities? (Rosenblad-Wallin, 1983, p.25-26) the author’s translation.

22 The criteria for the interviewees was to have a great variety with respect to the type of disability and/or impairment, age, sex and living locality, N=66 (Thorén, 1992).

23 The standard figure is illustrated by the ID-dummy, size C38, which should be considered as a standard figure.

24 The areas which were scaled were: “neck, shoulders, armscye, upper arm, lower arm, bust, shoulder blades, midriff, abdomen, hip, buttocks, crotch, thigh, calf, lengths of waist to knee and ankle, and back and arm lengths” (LaBat & DeLong, 1990, p.45).

25 Details added to a garment, usually in order to enable/facilitate dressing e.g. Velcro instead of buttons or zippers, zippers along the sides of the trousers etc.
design and colour because the garment fit is just what we want or the opposite. Individuals with disabilities, impairments and/or disfigurements might ignore quite extensive inappropriate aspects of the garment in order to get any clothes at all. Rosenblad-Wallin (1983) says that we satisfy our purchase instead of maximising it. For the impaired, disabled, and/or disfigured the off-the-peg garment usually has to be altered26 in order to fit the figure and to facilitate/enable dressing (Ernström, 1981; Gamwell, 1966). The altered garment is more comfortable than the off-the-peg garment and contributes to the ease of movement and the individual’s social activity (Kratz, 1996; Lodge, 1989). Until today there have been three main ways for the individual with special needs to get suitable clothes; Off-the-peg garments that have been altered, specially designed garments for a specific target group27, and individual garments made at a tailor’s shop, dressmaker or by a family member (Hoffman 1979).

Among the individuals in need of special garments there are very few that are interested in sewing or altering their own clothes. They want to be able to buy the ready-made clothes as everybody else (Gamwell, 1966; Thorén, 1994). The clothing should not differ too much from the off-the-peg garments available in the stores (Bergenheim, 1986). The accessibility, selection of garments, fabrics, designs, and prices are important factors for individuals with special needs (Thorén 1994). These individuals desire attractive clothes that do not stigmatise their image (Lamb & Kallal, 1992). The garments should call attention to the attractive parts, camouflage the bad ones and above all give a psychological lift to the wearer (Kernauguen 1978).

There is a lot of published material presenting technical solutions for garments in order to facilitate/enable dressing (Kernauguen 1978; Benktzon 1980; The Disabled Living Foundation, 1994). Individuals with functional impairments need individually designed garments (Kratz 1996). Nevertheless, we can not forget the individuals who need individually made garments because of a fitting problem and are not in need of technical solutions (Kärholm 1976). Only 7 percent (N=666) state that the openings are unsuitable to enable them to get dressed. Small companies that manufacture clothing for individuals with special needs or disfigurements, have made the wrong priorities. They often put the function of the garment foremost and address the design and material secondly. It is very important for the disabled/impaired individual to decide the style themselves, the function of the garment is secondary. (Thorén 1992)

There are many aspects that should be taken into consideration when buying clothes especially if we want to maximise our purchase instead of just satisfy it. According to Hoffman (1979) there are six major factors that a customer wants to be satisfied with in the garment; fashion, design, comfort, fit, and cost. Clothing can be a complex matter. The actual garment can be summed up in three areas; the pattern construction, the anatomical structure, and the fabric (Caldwell & Workman, 1991). Gamwell (1966) expressed the categories in a slightly different way. She mentions fabric, design, comfort, and fit as four main components of a garment. Thorén (1992) adds the importance of delivery and service quality.

What causes the disadvantage?
The problem with finding clothes depends for example on the individual’s figure, the need for technical solutions, the market’s supply of clothes, and the material/immaterial resources the individual has access to.

The environment is an important variable when determining how extensive a disadvantage is going to be. There are three main environmental factors, with reference to clothing; the existing sizing system, the supply in the stores, and people’s expectations regarding the importance of dress. The importance of dress and people’s expectations have been discussed in previous chapters. The focus of this chapter is on the other two factors; the sizing system and the supply in the stores.

Standard sizing system

Before standard sized garments were available on the market all garments were produced for a specific individual. The tailor was very important. His work was the foundation of a garment’s good fit. During the 17th century the tailor measured his customer with a paper strip28. He cut notches in the strip in order to mark the individual’s dimensions. He used the tailors’ greatest trade secret, the paper pattern, which was tried out in order to give the right model and fit—these were sometimes referred to as “gods” (Kindwell, 1979). When ordering a suit form a tailor one could not get it right away. The customer had to be measured, the garment had to be cut, and then sewn. Not all customers, such as sailors for example, could wait for the suit to be produced. Garments in standard sizes could therefore be found at busy ports during the 17th century. Tailors had a stock of standard sized garments for their maritime customers (Hulme, 1946).

The drafting-systems for patterns, developed during the 19th century, were time-saving for tailors and dressmakers. When using such a system it was not required to have as much knowledge within the field of cutting as was needed before. A drafting-system reduced the cutting errors and was the foundation for the sizing system which followed. Three main drafting-systems developed; one based all body measurements being proportional to one single body measurement. Another system used direct body measurements and the third was a hybrid drafting system29. While these systems developed and were used, tailors found that the human body was not shaped according to any set formula. Few individuals have a similar figure, each individual is unique. Even though the systems didn’t work for all figures, a system was better than no system at all (Kindwell 1979).

Throughout the world there are many sizing systems suitable for each country’s population. The latest sizing system for women in Sweden is the one compiled during the 1970’s. This system was meant to facilitate sizing for the industry, the retail store, the consumer, and for the trade education. Better fit, fewer sizes, and ease in finding the right size were among the things that would be improved by a new sizing system (Cednäs & Kjellnäs, 1977). The

26 To modify and change something, in this case the ready-made garment. Synonyms are adapt and adjust.
27 Ready-made garments for a specific target group are garments that are produced, in smaller quantities, in order to supply a specific group’s need (Bergenheim, 1986).
28 The yardstick was not used until the end of the 18th century (Kindwell, 1979).
29 The hybrid drafting system was a combination of the proportional system and the one using direct measurements. This is the system that has most in common with our drafting system today. We use direct measurements with ease, for example the bust measurement. In addition to this we calculate certain measurements, for example 1/10th - 1/8th of the bust girth is usually the armscye width.
system includes four length classes\(^3\), three variations of relation between bust and waist/hip\(^4\), and two age groups, 16-65 years old and 65 years and over (65+). For the elderly (65+) there are only two length classes\(^5\) and only the medium relation between bust and waist/hip are included. This is the official standard system for women’s clothing available in Sweden at the moment. The standard figure is illustrated by the IP-dummy\(^3\), size 38C, which should be considered as a standard figure.

For the moment, a standard sizing system is being developed within the European committee for standardisation. Four topics are addressed within this research: (1) Where and how the measurements are going to be taken on the body. (2) What name the sizes should have. (3) Which measurements are important for certain garment types. (4) Which intervals are suitable between the sizes (Lundgren, 1999). So far, only the first topic has been presented in a draft by the European committee for standardization (1998).

There are measurement charts for different disfigurements. Individuals with Down’s syndrome have similarities of the body figure, and research has been carried out in order to standardise this figure and create a measurement chart for this target group (Tam & Harwood, 1993). Similar research has been done with the target group, of short stature (Kohvakka, 1993). Similar research has been done with the target group, of short stature (Kohvakka, 1996). The elderly might be in need of specially designed garments to suit the physiological changes and the consequences of various diseases common within this category. The changes and consequences are mapped out and considered in the design of the elderly woman’s dress in the Rosenblad-Wallin’s study (1977).

Body measurements and the proportions of the figure are continuously changing (Cednäs & Kjellnäs, 1977). The standard sizing system in use today is from the 70’s. Based on previous references the proportions of today’s Swedish women have probably changed slightly. Even if the standard sizing system from the 70’s were updated there would still be people who do not fit into the system (Thorén, 1994). These people have unique figures, they probably do not fit into any standard system.

**Market supply**

The reason why women who are short, tall and/or have a large circumference have difficulty in finding suitable off-the-peg garments is that stores supplies are limited when it comes to sizes (Cednäs, 1973). If stores had all the sizes that exist in the standard sizing system, more individuals would be able to find suitable clothing. The clothing companies do not manufacture all the sizes, because it is too expensive and consequently the stores do not carry them. The stores do not have a large assortment of sizes for women clothing (Rosenblad-Wallin, 1977). This has also been established in later reports concerning available clothing for a special target group such as plus-sized or short women. Some stores have special collections for plus-sized women and some carry a few garment types in the 20-series (Bloom, 1998; Nyman, 1999).

Cednäs (1977) made various classifications according to age, full length, bust circumference, and relation between bust and hip girth. By using six of Cednäs’ classification combinations 83 percent of the population would be represented. The sizes available in the stores come from the classification C32-C52, which represents only 22 percent of the population, Figure 1.

![Figure 1: The share of the market for the different sizes (Cednäs,1977, p.14)](image)

However, most women find clothes. The manufacturers solve the problem by changing the measurement chart so that it suits their target group, which might be, for example, middle-aged women. This means that more than 22 percent of the population might find clothing that fit even if their bodies do not fit into the standard chart. The manufacturers do not always follow the standard measurement charts, which leads to that the standard sizes can vary from company to company, this makes it more difficult to find the suitable size when shopping (Rosenblad-Wallin, 1977).

Manufacturers tend to offer a small range of sizes. One reason for this is that it is usually more expensive to produce few garments per size compared to many garments per size. A further limitation in size range is the system with small, medium and large. This tends to favour the manufacturer more than it favours the customer. The one-size-label, which is supposed to fit everyone limits the supply even more (Lundgren, 1999).

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\(^{3}\) For women with full length as 160 cm (20-series), 164 cm, 168 cm (40-series), and 172 cm.

\(^{4}\) B for thin waist and hip, C for medium waist and hip, and D for fuller waist and hip.

\(^{5}\) 160 cm and 168 cm

\(^{33}\) This tailor’s dummy is produced and sold by IP datamönster in Borås, Sweden, +46 (0)33-444480.
A conceptual framework for clothing studies

It is sometimes said that we all can be more or less handicapped when it comes to clothing and its fit. It might surprise some to be classified as handicapped. Therefore I want to discuss some basic concepts concerning what causes a handicap but also concepts in relation to pattern construction for the unique figure. A model gives an overview of clothing studies within the areas of design and making up.

Impairment, disability, and handicap

What kind of and degree of handicap an individual has depends on the impairment and/or disability and on the environment. The impairment and/or disability can be the consequences of a disease or a disorder. Which disease or disorder that are the cause does not matter when classifying the impairment and disability.

WHO, World Health Organisation, is now revising the manual from 1980. I will refer mostly to this official manual, but will bring up some interesting definition changes from the revised manual (WHO, 1999).

“… an impairment is any loss or abnormality of psychological, physiological, or anatomical structure or function” (WHO, 1980, p.27). The impairments that will be of interest when studying the garment fit are the ones that cause disfigurement of the outward body – the anatomical structure such as, dwarfism, spinal curvature, and gigantism (WHO, 1980).

“… a disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being” (WHO, 1980, p.28). It does not matter which impairment causes the disability, only the activity is considered when classifying the disability. A disability that effects clothing is the decreased ability in dressing/undressing. If clothes were altered or adapted for a specific disability the degree of the handicap would decrease, as well as if the proper aids were used to facilitate/disable dressing. The other disability effecting clothes is the inability to walk; the need for a wheelchair for mobility. The sitting position causes problems with clothing, both in garment fit and in the sitting comfort of the garment.

The environment includes the material society, the man-made artefacts, as well as the social and cultural context, e.g. the family members and friends. The environment plays an essential part in how extensive the handicap is going to be for a specific individual with an impairment and/or disability. WHO (1980) defines handicap as follows “…a handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual” (p.29). In the revised manual of classification they call this category for participation restrictions. It is defined as follows; “Participation Restrictions are problems an individual may have in the manner or extent of involvement in life situations.” (WHO, 1999, p.14). One individual can be handicapped/disadvantaged in one group but not in another (WHO, 1980). It is the individual’s experience that decides how extensive the handicap is going to be (Hallberg, 1992).

When a person can not dress properly or as normally expected, it can be to his/her disadvantage. They can not mix in with the group in the matter of clothing – They experiencing a disadvantage with regard to clothing. It is a psychological need to feel attractive and not set apart from the group by the clothes one wears. (Hallenbeck 1966). The policy goals are that all individuals are going to be a part of the society. The society should not be handicap friendlier but human friendlier. Everybody’s needs should be met. When changing something in order for the individual with impairments or disabilities to be able to take part in society, it benefits more people than just the individual experiencing a handicap (Kohlström, 1996). The degree of the handicap, in relation to the disability or impairment, also depends on the values the society stands for. In the Western world the values are “…health, youth, beauty, and effectiveness…” (p. 41). The outward appearance has a high value, which makes individuals with visible impairments and disabilities severely handicapped (Kohlström, 1996). The individual can feel embarrassment and shyness because of defects of the self-image caused by disfigurement, impairment and/or disability. This can cause the individual to avoid participation in social activities (WHO, 1980). Clothes are an essential part of the outward appearance. If the individuals, who are disadvantaged in the matter of clothing could get clothes that fit them, both in style and fit, it would improve their participation in life situations. If an impaired or disabled individual does not have any problems finding well-fitting clothes there is no disadvantage.

Concepts concerning garments and pattern construction

Adapt, Adjust, Alter
To modify and change something, e.g. the pattern. These words are sometimes used as synonyms to each other.

Block pattern / Block
The block pattern is a foundational pattern constructed to fit the average individual or a unique figure. “The designer uses the foundation pattern (block) as a basis for making the pattern for a design.” (Aldrich, 1982, p.8).

Body figure / Figure
The external form/outline of the human body, including the posture.

Clothes
Clothes “Things worn to cover body and limbs” (Elliott, 1997). Clothing, which is a combination of various garments, is a more general word for articles of dress.

Deformed
The shape is not conformed to the standard form.

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33 When the measurements or figure falls outside the defined standard measurements or defined standard figure it is considered a unique figure.
34 Dwarfism includes short stature. Spinal curvature includes scoliosis, lordosis, kyphosis. Gigantism is extremely tall stature (WHO, 1980).
35 The concept disability is not used in the same way in the revised manual from WHO. The new concept is activity limitation and is defined as follows “Activity limitations are difficulties an individual may have in the performance of activities” (WHO, 1999, p.14).

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17“Participation is an individual’s involvement in life situations in relation to Health Conditions, Body Functions and Structure, Activities, and Contextual factors.” (WHO, 1999, p.14)
Design, Style
A design is created when style lines and details such as collar, button stand, pockets etc. are added to the block pattern.

Disfigurement
A disfigurement is a spoiled or deformed appearance. In the dictionaries this word is explained from a negative angle. In this study the word “disfigurement” simply means a kind of deformity which does not fit within the parameters of a standard body figure.

Dress
“clothing, esp. whole outfit” (Elliott, 1997). The dress includes the whole out-fit, both modifications of the body and supplements to the body are included in the definition dress. (Roach-Higgins & Eicher, 1992)

Fit
Se garment fit
Garment
“Article of dress” (Elliott, 1997). Is a single piece, a combination of garments creates the clothing.

Garment fit
The way the garment forms to the body in the matter of tolerance and harmony with the covered body parts.

Tolerance
The tolerance is the difference between the body measurement and the garment’s measurement. For example, bust girth: 88cm the garment bust width is 102cm, the tolerance is in this case 14cm over the bust.

Individual pattern
A pattern that is made to fit only one individual.

Landmark
Points on the body that are essential for the measurements.

Made-to-measure garments
A garment made according to the individual measurements; produced by the clothing industry.

Mass customisation
A new concept within the clothing industry. The manufacturer offers the customer to design their own garment by selecting from a predestined range of details and fabrics.

Posture
The way a person carries themself, the back and shoulders are in focus.

Standard figure
The standard female figure is illustrated by the IP-dummy, size C38, which should be considered as a standard figure. This tailor’s dummy is produced and sold by IP datamönster in Borås, Sweden, +46 (0)33-444480.

Standard measurement
The standard measurements are the ones included in the official standard measurement chart, in this study the Swedish one (Johansson, 1987).

Style
See design.

Unique figure
We all are unique creations with individual body figures. When the measurements or figure fall outside the defined standard measurements or defined standard figure it is considered a unique figure.

Perspectives
Linked to a model, the importance of dress has been studied in various ways. Anttila (1995) gives an overview in her model for studies within the areas of designing and making up. Figure 2. The individual sits at the top with both the personal and social environments. Forming the pyramid are the four pillars springing from the different environmental aspects; ecological, cultural, economic, and technological environments. The technological environment symbolises the production of clothing, including the patterns, fabrics, machines etc.

Clothing has previously been studied from many different perspectives, here follows some examples. Dress is important for the communication between individuals and groups. The individual can send signals about their personality, social status, sex, career, opinion etc. (Feather & Jenkins, 1993; Jacobson, 1994; Molloy, 1988; Roach-Higgins & Eicher, 1992). The way we use our body language is closely associated with what signals we send to the individuals we meet (Broby-Johansen, 1953). The garment’s function and meaning throughout various historical epochs has also been studied (Centergran, 1996). Clothing from a social-psychological perspective (Ryan, 1966). The social meaning of clothes (Kaiser, 1997; Nagasawa, Hutton, & Kaiser, 1991) and how important clothes are for self-perception (Liskey-Fitzwater, Moore, & Gurel, 1993). The design and making up process for exclusive haute couture garments have been studied (Koskennurmi-Sivonen, 1998). Technical studies carried out are; functions of clothing such as protection, mobility, fastenings, possible body

Figure 2: Studies within the areas of designing and making up (Anttila, 1995, p.50)

38 Includes for example colored skin, pierced ears, coiffed hair etc. (Roach-Higgins & Eicher, 1992).

39 “The results can be evaluated in terms of economy of natural resources, recycling or reproduction.” (Anttila, 1995, p.51).

40 “… includes aesthetic, historical, ethnological, fashion and tradition related criteria.” (Anttila, 1995, p.51).

41 “… production and products are evaluated in terms of economic inputs and outputs, economic profits, marketing, and consumption.” (Anttila, 1995, p.50)
Earlier initiatives

To find clothing in the regular retail market has been a great problem for a long time for individuals with special needs and/or disfigurements. Some regular retail stores do offer, for a fee, to alter ready-made garments e.g. shortening of the sleeves and trousers and increasing/decreasing of the waist. Today, there are a few companies selling clothing to a specific target group such as wheelchair users e.g. Sitting Feathers, and Combino. These companies supply a part of the market with products. The garments are not individualised and therefore not all wheelchair users are able to find well-fitting garments at these companies. Because of the relatively small market for these companies they can not have as many variations of designs as are available in the regular retail store.

The elderly are a large and growing group of people who are in great need of specially designed garments. They would not be in need of individualised garments if the stores carried clothing designed according to the size chart for elderly women. Suitable garments for the elderly were designed within Rosenblad-Wallin’s (1977) product development project. Both the garment fit and the technical solutions to facilitate/enable dressing were identified (Rosenblad-Wallin, 1977). In yet another study, women with osteoporosis were the target group. Garments were developed to fit the needs of this target groups with regard to fit and comfort (Benktzon, 1993). A different project was carried out in Finland aiming to design and make garments for individuals of short stature. A spring/summer collection was developed for this target group (Kohvakka, 1996). As said before, a sizing chart has also been developed for women with Down’s syndrome (Tam & Harwood, 1993).

The new special sizing charts cover a great number of individuals with a specific figure e.g. short stature and Down’s syndrome. However, there will always be individuals who do not fit into any standard system. They have such unique figures that it is impossible to gather them as a group and create a size chart. They are in need of a individual garment. Frost (1987) has developed a system for measuring the disfigured body and then creating a suitable basic pattern. The measurements are taken both on right and left side of the body, in order to register the difference between the two body halves. A mean value is calculated and then used when constructing the symmetrical block pattern. With the symmetrical pattern as a base the differences between right and left side are made by increasing/decreasing the pattern at appropriate places, see Appendix A. The individual block pattern is the starting point when creating the desired design (Frost, 1987). Klädverkstán [Clothing workshop] was a project that taught how to make garments for individuals with disfigurements. Interested seamstresses, family members and the disfigured individuals could participate in the workshop. Frost’s method was conceived and practised for individual garment construction (Lejring, 1996).

Patterns for various disfigurements and disabilities have been developed, and many sewing courses have been held for the concerned individuals and their families. In spite of all efforts,
it seems that the affected individuals do not feel as though they have been helped in the matter of getting suitable clothes (Thorén, 1992). Many projects have finished without consequent activities to carry on with the results produced by the project (Bergenheim, 1986). One reason is the high costs inherent in the development of clothing for special target groups (Stenström, 1997).

Bergenheim (1986) finds that documentation is missing on the designs, materials, patterns, colours and structures that should be used in order to camouflage a disfigurement. However, Lodge (1989) maps out which clothes are suitable for specific impairments, disabilities, and handicaps. Information to the manufacturers and the retailers is essential. Further training is needed in the areas of pattern construction and ergonomics with regard to clothing (Benktzon, 1980).

Thörn (1992; 1994) identified and attempted to solve the clothing problem for the target group impaired, disabled, and/or disfigured individuals. She used the product development method created by Rosenblad-Wallin (1983). This method works in steps, from the identification of the problem all the way through to the evaluation of the final product, see footnote 21, page 11. The process is used in order to increase the user value of the product. Within Rosenblad-Wallin’s study, the end users were always a group of individuals. The clothes were developed for the groups; elderly, different categories of workers, military etc. (Rosenblad-Wallin, 1983). Thörn’s (1992) identification and analyses of the problem has been covered in previous chapters. Thörn presents three steps, which could solve the problem of finding suitable clothes for impaired and disabled individuals. (1) The methods for getting the measurements from analysis of photos need to be further tested. (2) Rationalisation of made-to-measure and/or altering of ready-made garments needs to be done. (3) Finally, an improvement of software for pattern construction and education of specialists within this field is needed (Thörn, 1992). The possibility of sending information between the different production sites increases when the pattern construction is computerised. However, this was not tested within the project. The made-to-measure for individuals with large disfigurements was carried out with experts within the clothing industry. Frost’s method for creating individual patterns was used, but it was computerised46. When the individual pattern was evaluated the fitted jackets were sewn at Oscar Jacobson47. Even though the pattern construction was computerised it was still time-consuming and not without problems. It takes longer time to cut one single garment compared to regular production. The production of the fitted jackets was time-consuming (Thörn, 1994).

It is difficult to make an accurate two-dimensional garment pattern to fit comfortably and stylishly on the complex three-dimensional human body (Roebuck, 1995). The hardship is greatly increased when a disfigurement is included. The pattern construction is the difficult part of the made-to-measure concept (Thörn, 1994). Draping is another method of creating a individual pattern. In draping the garment is formed directly on the person by smoothing the fabric over the body. The individual figure is taken into account and the design of the garment is created directly on the individual body (Heisey, Brown, & Johnson, 1988).

Made-to-measure is becoming more and more common in the industry thanks to better computer software available for this purpose. The concept of mass customisation has been developed and improved over the recent years. Today, made-to-measure is most common within men’s wear, e.g. suits and shirts. However, the manufacturers offering made-to-measure in Sweden today mainly produce uniforms and working clothes. Their customers are companies, for example bus and airline companies, and not the single consumer. The share of made-to-measure garments these companies produce is about ten percent of the standard production. The percentage depends on the type of garment and the company’s demands on the garment fit48. Of the made-to-measure garments produced 20 percent are returned because they do not fit the individual (Eriksson, 1999). The procedure, how the made-to-measure garment is ordered and produced, varies between the different companies. It is becoming more and more common to offer the customer the service of more or less made-to-measure. Some companies only adjust off-the-peg garments while others use the whole concept of made-to-measure garments, the garment is not produced until it has a buyer.

Classification of body shape

Surveys on the outward human body have taken place earlier. Sheldon (1940) made a large survey involving 4000 students, all of whom were classified. He used somatotyping49 in order to classify the individuals. Sheldon found three main figure types50 within this group of students. No large disfigurements were represented within the studied group. Dysplasias51 became a problem when classifying the whole human body. In order to classify the body he discovered that he had to divide the body into five regions52 and analyse each part separately. Sheldon wrote that it was difficult to find a technique to classify people because they tend to differ in almost innumerable ways (Sheldon, 1940).

Cednäs (1977) has measured the human body and created standard measurement charts for the Swedish woman. She grouped the measured women into two age categories, in addition to that, she created four length categories and three width categories, see the chapter Standard sizing system.

Farrel-Beck & Pouliot (1983) used Sheldon’s method of studying the body shapes but applied it to the female figure. Two photos were taken one from the back and one in profile53. The figures were studied and the body angle and body proportions were determined. This determination was used together with traditional measurements of length and circumference in order to establish which alterations are needed to achieve a good fit. The body shape analysis gave a better fit of the trousers in four critical areas54. When analysing the lower part of the female bodies they found five figure variations. “… round hip, pear-shaped hip, average hip, weight in front, and weight in back” (Farrel-Beck & Pouliot, 1983, p.95).

46 The pattern construction was carried out at Lectra System AB in Borås, Sweden.
47 Oscar Jacobson is a manufacturer of men’s suits, in Borås, Sweden.
48 An airline company has higher demands on the garment fit than a bus company. A bus company usually chooses a uniform, but more loose-fitting uniform (Eriksson, 1999).
49 Somatotyping has three main steps. Photographs, three views (front, back and profile) are taken of the individual. Measuring the diameters of the different body parts on the negative. Calculating with a formula to get the percentage of the stature.
50 *Endomorphy* – round and soft, *mesomorphy* – muscles and bones make a compact impression and *ectomorphy* – thin and fragile (Sheldon, 1940).
51 Dysplasias is when the body’s different parts belong to different categories, (Sheldon, 1940).
52 Head, face and neck make the first region. The thoracic and the abdominal trunk make the second and forth region respectively. The third region includes arms, shoulder and hands. Legs and feet make the fifth region.
53 The profile photo helped to identify if the person had a figure with weight-in-front or a figure with weight-in-back. The photo taken from the back helped to identify if the person had round or pear-shaped hips. Both views were needed in order to identify the average/normal figure. (Farrel-Beck & Pouliot, 1983).
54 The four areas were; (1) waist placement in front, (2) sizes of darts in front, (3) curve of the back crotch, and (4) horizontal grain.
Ilmola (1996) categorised the female figure according to three different relations of the body\textsuperscript{57}. This analysis was used as a starting point when developing basic patterns suitable to the different categories.

The dysplasias problem, which Sheldon had, was also faced in the EASYTEX project. In the project the body was divided into two main sections, upper part of the body and the lower part of the body. Garments for the upper part of the body are, for example, fitted jackets, blouses, shirts, dresses.\textsuperscript{56} Garments for the lower part of the body are trousers and skirts.

The classification of body shapes has been an ongoing process in the EASYTEX project. First, an identification of the disfigurements which cause problems in the matter of finding well-fitting clothes was mapped out\textsuperscript{57}. Another approach was used in the next step. The classification was made according to how the pattern adaptations would be done, Table 1 page 34. Neither the disability, nor the impairment or the handicap was of interest for the classification. Only the outward/visual disfigurement and its impact on the garments were taken into account. The five categories were; short/ tall stature, warped figure, prominent figure, wheelchair user and elderly. The category elderly was later included in the other four categories because this age group was not more homogeneous than any other age group.

The dysplasia problem, which Sheldon had, was also faced in the EASYTEX project. In the EASYTEX project, the body was divided into two main sections, upper part of the body and the lower part of the body. Garments for the upper part of the body are, for example, fitted jackets, blouses, shirts, dresses. Garments for the lower part of the body are trousers and skirts.

The EASYTEX project EASYTEX is a project financed by the European Commission, carried out January 1997 – June 2000. It aims to improve the living conditions concerning textiles and clothing for the elderly, disabled, and impaired individuals. Five countries participate in EASYTEX. Great Britain\textsuperscript{58}, Greece\textsuperscript{59}, Finland\textsuperscript{60}, France\textsuperscript{61}, and Sweden\textsuperscript{62}. The project is to produce a database, equipment and software for automatic measurements, and software for automatic pattern construction.

The EASYTEX project task for the Department of Home Economics at Göteborg University (GU) was to collaborate with Lectra Systèmes in order to develop the software FitNet\textsuperscript{63} used for production of made-to-measure garments see box below. The software had to be tested to check if it could handle large disfigurements such as those represented among the impaired, disabled, and elderly. The software uses various alteration files in making an individual garment. These files contain data of how to alter a pattern when a certain value is entered. These files were created by GU.

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\begin{table}[h]
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\hline
\textbf{The tasks carried out at Göteborg University (Commission of the European communities directorate general XIII, 1998, ANNEX 1 p.24)}  \\
\hline
\textbullet T3.1 Analysis of different adaptations of clothing needed for disabled people. A study of people with scoliosis, kyphosis, shortsatured, people in wheelchairs, with deformed arms and legs, paraplegies or other deformations of importance to garment design.  \\
\textbullet T3.2 Definition of special pattern adaptations not available in software products for clothing. Produce a list of relevant transformations regarding basic garment + a list of relevant measurements lines.  \\
\textbullet T3.3 Development of Lectra’s software programs in order to include adaptations for the disabled; Integration of Body Click with Modaris. Integration with the 3D measurement system. Modification of Body Click/Modaris for asymmetrical bodies. Development of the manual alteration method. Data management by order to follow an order.  \\
\textbullet T3.4 Validation of the software for individual pattern-construction in the initial phase at GU. Later on validation on site of the previous step in production.  \\
\textbullet T3.5 Validation of garment construction within this project regarding styles, fitting and cost. Validation in production at the demonstration site.  \\
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The research started with finding out which alterations are suitable for specific disfigurements. This research was carried out in close collaboration with the test persons. The test persons have large disfigurements and difficulties with finding suitable clothing in a retail store. Each test person was deeply involved, from figure analysis all the way to the evaluation of the final garment. With the help of newly developed software, this procedure was made

\textsuperscript{57} The three categories were: (1) figure type according to the relation between the bust and waist; hip/waist (2) figure type according to bust and back relation (3) figure type according to relation between the bust/abdomen and between back/buttocks.

\textsuperscript{58} A dress covers both the upper and the lower part of the body but it has most of the contact points on the upper part of the body.

\textsuperscript{59} Short stature, tall stature, low weight, heavy weight, warped body, prominent deformity, wheelchair user, other technical aid, and other (Berglin & Hernández, 1997c).

\textsuperscript{58} De Montfort University, Leicester: database

\textsuperscript{59} Clotefi, Athens: properties of materials

\textsuperscript{60} VTT, Tamerfors: Co-ordinator and properties of materials

\textsuperscript{61} Lectra Systèmes, Bordeaux: Development of software for pattern construction and made-to-measure. Telmat, Strasbourg: Automatic 3D measurement

\textsuperscript{62} Chalmers, Gothenburg: Collaboration with Telmat

\textsuperscript{63} FitNet is a software used to speed up the process of made-to-measure. It is a Netscape based program. A user-friendly order form guides the user through the process of creating the individual garment. The style, basic fabric, details, contrast fabric, and adjustments for a better garment fit are selected. When the order is complete it is sent to production, see also Appendix B.
quicker than the previous attempt in making individual patterns on the computer. However, while working with the software some needed improvements and changes were noted and documented in the deliverables within the project, see box below.

The reports delivered by Göteborg University for the EASYTEX project

<table>
<thead>
<tr>
<th>Report</th>
<th>Comments</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviations in body constitution and adaptation of patterns (1997b)</td>
<td>The purpose was to get acquainted with various disfigurements and documented pattern adaptations.</td>
<td>Hernández N.</td>
</tr>
<tr>
<td>Datoriserad mönsterkonstruktion: en beskrivning av Modaris version 2.1 (Computerised pattern construction: a description of Modaris version 2.1) (1997a)</td>
<td>This report was done in order to document what was possible to do in the software Modaris version 2.1.</td>
<td>Berglin &amp; Hernández</td>
</tr>
<tr>
<td>Special adaptations to clothing needed to be done for the disabled user: deliverable 3.1 (1997c)</td>
<td>The first official deliverable within the EASYTEX project</td>
<td>Berglin &amp; Hernández</td>
</tr>
<tr>
<td>Definition of automated pattern adaptations not available in software products for clothing: primary report Deliverable 3.2 (1998)</td>
<td>Individuals with large disfigurements are presented along with the automatically adapted patterns.</td>
<td>Berglin &amp; Hernández</td>
</tr>
<tr>
<td>Special adaptations to clothing needed to be done for the disabled user: deliverable 3.1 (1997c)</td>
<td>Continuation of previous deliverable.</td>
<td>Berglin &amp; Hernández</td>
</tr>
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The technique needed for the mass customisation concept is now available on the market. The made-to-measure concept was presented at the final conference, The made-to-measure concept available to everybody, November 23, 1999. The concept presents one way of how a manufacturer could use the made-to-measure system in the future, Appendix B.

The manufacturer has to decide which fabrics, details, and alterations to offer to the customer, Figure 3, page 27. The system has to be built up in such a way that errors are prevented, as far as possible. When it comes to large disfigurements, a greater know-how is needed both for the building-up process and for the entering of the alteration values according to the customers body figure. The computer stores and mediates the information but the computer does not have the human knowledge.

The section that demands most knowledge from the manufacturers is the building-up of the alteration files. The manufacturer has to know how, where, and with which restriction values the alterations should be created. When it comes to smaller alterations, such as moderate lengthening/shortenings and smaller increasing/decreasing of circumferences the alterations files are not that difficult to create. When it comes to larger alterations for specific

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64 Especially errors connected to alterations, their values, and the combination of large alterations.
Objectives of this study

In order for an individual to obtain an esthetical and well-fitting made-to-measure garment the technical solutions have to be available. But there must also be know-how of how to adapt the patterns in order to obtain an esthetical and well-fitting garment.

The empirical work and the development of alteration methods has been done within the EASYTEX project. The purpose of our part of the project was to use and develop software for mass customisation in collaboration with Lectra Systèmes. In order to make realistic tests of the software, real garments were used and altered for individuals with extensive disfigurements. This gathered data forms the base of this study.

This study looks at clothing from a technological perspective, it deals with links in the chain of making the made-to-measure concept available to everybody. The approach is problem oriented and explorative. The objectives are to report and to discuss the experience of how to alter a pattern to fit a disfigured body. The alteration methods are not tied to a specific disability/impairment but are developed to fit various and extensive disfigurements, regardless of the cause. Methodology and experience are discussed with two main areas in focus:

- **THE INDIVIDUAL PATTERNS – PROCESS**
  By which steps are the individual patterns developed? Is it possible to follow the same process for all combinations of disfigurement?

- **THE PATTERN CONSTRUCTION**
  In what way does the pattern have to be adapted in order to obtain a well-fitting garment for the individuals with large disfigurements?

Delimitation of this study

When producing an individual garment there are many aspects to consider, Figure 10, page 40. However, the focus of this study is on the figure registration and the individual pattern and not on the other links in the chain such as designing, the making-up process and the delivery. The evaluation is used in order to check if a comfortable and well-fitting garment was produced.

A garment is created of many elements and attributes such as design, fabric, comfort, and fit. In addition to these, specific technical solutions can be essential for the user with special needs. These technical solutions will not be considered in this piece of research. Many reports have already presented technical solutions in order to decrease a specific handicap.

The goal of the EASYTEX project has always been to be able to apply alteration information, using software for automatic made-to-measure. Here is the clearest distinction between a garment created by a tailor and one produced by a manufacturer\(^6\). The alterations should be identified only by measurements and figure analysis. Small alterations, which can only be discovered when testing the garment, are not considered.

Clothes designed for a particular impairment, disability, or disfigurement are not specifically covered in this research. The garments used within the EASYTEX project are standard garments, which could be sold off-the-peg at any retail store. The focus is on the garment fit and not on special designs suitable for a specific target group.

The automatic made-to-measure software, FitNet was developed and used within the project. This software will not be explained or illustrated in detail. The alteration methods can be applied either in a made-to-measure program, “manually” in the computer, or when making the pattern without the assistance of the computer. The same is true for the measurements, they can be obtained manually or automatically. The presentation of the measurements focuses on the manual way of obtaining measurements but to some extent the automatic method will be discussed. How the body scanner that obtains the automatic measurements works will not be covered in detail\(^6\).

The evaluations, filled in by the test persons, include questions that were of interest for the EASYTEX project but not particularly for this study. These answers will not be reported in this study.

\(^6\) More information can be found in the licentiate report *Range camera imaging with application to human body measurements*, by Gaël Nueze, PhD student at Department of Signals and Systems, Chalmers, May 2000.
Methodology and procedures

Not many studies have been carried out within the area of pattern construction in order to handle large disfigurements on a general basis. The more extensive studies have mainly been based on Frost’s (1987) method for creating individual basic blocks. In this study a combination of conventional knowledge within the field of pattern construction and explorative research has developed the methods of adapting patterns for individuals with large disfigurements.

Methods

Frost (1987) has developed a method for creating an individual basic pattern, Figure 4. The method starts with the process of measuring the disfigured body and after that the constructing of a suitable basic block. The measurements are taken on both right and left side of the body. This is done in order to register the difference between the two body halves. A mean value is then calculated and used when constructing the symmetrical basic pattern. With the symmetrical pattern as a base the differences on right and left side are applied by increasing/decreasing the pattern at appropriate places, Appendix A shows a slashed pattern piece. The individual basic block later becomes the starting point when creating the desired design (Frost, 1987).

Previous projects have used Frost’s method and, but outcome of those does not present a complete and ongoing solution for the disfigured individuals’ problem in finding clothes. The method was tested, both manually and by computer and the main shortcomings is that it is too time-consuming. This is because a basic block is first created to be followed by the making of the designed pattern (Thorén, 1994).

Roebuck (1995) outlines how to prepare the different aspects of the measuring procedure. He mentions three main points; (1) imagine in what way the measurements are going to be used, (2) perform an analysis of the future data, and (3) ask potential users what data they need. When these aspects are analysed the number of measurements can be limited. In order to carry out the measurement plan Roebuck mentions a number of practical things to think about; facilities, equipment, checking the software and the procedures, personnel, training, scheduling, and administrative concerns.

Johansson (1987) presents the Swedish standard measurement charts for women. She includes the basic measurements long with explanations of how the measurements should be taken.

Vigede (1988) presents a way of registering the body constitution by using set drawing presented on paper. These drawings illustrate a number of variations in posture and the outline of shoulders and abdomen. When registering the figure, the drawings illustrating the subject’s body figure just have to be marked.

Method discussion

Registering the variations in body constitution by using set illustrations was presented by Vigede (1988). This was not applicable within this study because variations of the disfigurements are so many, both in shape and size. However, a body illustration was necessary in order to register the measurements of highly unique disfigurements, such as hunchback.

The three aspects of the measuring procedure presented by Roebuck (1995) are used within this study. However, the measurers and the users of the measurements have been the same team and therefor there has not been a clear dividing line between the three aspects. Right from the start it was clear that the measurements were not going to be used for anything else than to determining how a standard block patterns should be altered to create an individual pattern. The measurements presented by Johansson (1987) were used as a starting point when deciding which measurements to use. In addition to these basic measurements some special measurements were needed in order to register larger disfigurements. These special measurements were at the start obtained according to Frost’s (1987) method. At the beginning many measurements were registered in order not to be without an important measurement when later on creating the individual pattern. During the process the measurements were limited to only the useful ones. Some measurements were ignored and some were modified in order to mediate clearer information about the body figure in connection with the pattern

Figure 4: The process of creating an individual basic pattern with Frost’s (1987) method

**APPENDIX 3**

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68 The facility: A practical room where the measuring can take place and a place to store instruments and supplies. Equipment: The equipment has to be available for each measuring team. Checking the software and the procedures: It is essential that the procedures are clear so that human errors are eliminated as far as possible. It is also important that computer software is checked. Personnel: Each measuring team should include at least two persons, one to conduct the measurements and one to record them. Training: It is important that all measurers uses the same equipment and techniques when measuring. Scheduling: When measuring for long periods the measurer and the recorder should alternate tasks in order to keep focused. Administrative concerns: Administration such as payment for the subjects, renting of facilities, scheduling both the measuring teams and the measured individual etc. (Roebuck, 1995).

69 It is essential that the procedures are clear so that human errors are eliminated as far as possible. It is also important that computer software is checked. Personnel: Each measuring team should include at least two persons, one to conduct the measurements and one to record them. Training: It is important that all measurers uses the same equipment and techniques when measuring. Scheduling: When measuring for long periods the measurer and the recorder should alternate tasks in order to keep focused. Administrative concerns: Administration such as payment for the subjects, renting of facilities, scheduling both the measuring teams and the measured individual etc. (Roebuck, 1995).

67 Except for measurements such as length of garment centre front and centre back (Frost, 1987).

68 A project lead by Thorén (1994) and the project Klädverkstan (Lejrings, 1996).
construction. The final measurements are presented in the chapter Registration of the body figure.

The practical measurement preparations described by Roebuck (1995) have been used within the project. However, many of his concerns were automatically taken care of, as we were fortunate enough to be stationed in one facility all the time. It was not necessary to clear the space for upcoming activities. The measuring was shared by all four experts throughout the project. Most of the time one was taking the measurements and one writing down their values.

The measurement method used by Frost (1987) has the purpose of registering measurements needed for the construction of an individual block pattern. A lot of measurements are registered and many are taken both on the right and the left side of the body. This is not necessary for symmetrical parts of the body. Within this study the number of measurements was limited to only the ones necessary and therefore the right/left measurements were only registered when needed. As far as possible only the total circumference of each measurement was registered.

The pattern construction method used by Frost (1987) has been evaluated in previous studies and shown to be very time-consuming (Thorén, 1994). Instead of drawing the individual block pattern from scratch, a standard block is altered to create the individual block pattern. When using a block pattern as a starting point the proportions of the designed garment are already evaluated. The individual proportions of course have to be added but they should just make the garment harmonise with the body figure, not change the design. Even more knowledge is needed when drawing an individual basic block from scratch for such disfigured bodies.

Empirical data

The empirical data has been gathered in three phases, A, B and C, Figure 5. The different phases have been in successive time periods. The experimental method has differed in each phase. A more detailed explanation and overview of the three phases will be given further on.

Test persons

Test persons have been recruited at different times during the project. In order to inform individual and get them to sign up at the beginning of the project an information meeting was held (February 26, 1997) and later on an advertisement was placed in a newspaper (September 5, 1999). Key persons and test persons who had participated in previous projects and conferences were invited to the information meeting. From this, the information spread and 43 individuals signed up. The advertisement was placed in Göteborgs Posten, a widely read newspaper in this region, and 41 test persons signed up after the advertisement. In total 84 signed up and 29 of these were selected to participate in the research, the distribution between the phases is illustrated in Figure 6. Everybody that participated in phase A, also participated in phase B. One of the test persons in phase C participated partly in phase B. The final test persons were all women. The reason for focusing on women’s clothing is because the know-how about women’s clothing was greater in the EASYTEX-project than for men’s clothing and the lack of made-to-measure garments available for women.

Not all 84 individuals who signed up were of interest for the study. The individuals with small deviations from the standard figure were sorted out. The remaining number of test persons were grouped according to how the pattern adaptations would be done, Table 1, page 34. The four categories were; short/tall stature, warped figure, prominent figure, wheelchair user. The ambition was that the test persons should be well distributed between the different categories. An effort was also made in order to get a large age range among the test persons. However, they had to have passed puberty so that their bodies would have developed a female figure.

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70 The four experts were individuals with qualifications within pattern construction, design, and textile.
71 These measurements are necessary when the individual has an asymmetrical body.
72 FitNet, the made-to-measure software, creates the individual block from a standard block pattern on which the needed adaptations are applied.
73 Including proportions between different details and tolerances of different parts of the garment.
74 Project leaders from previous project.
75 One of them, Klädverkstän (1992-1995), taught how to make garments for individuals with disfigurements.
76 A conference was held in order to present the results from klädverkstän, May 3 1994.
77 More people contacted us after the final selection of the test persons needed. They wanted to be a part of the test person team, but we had enough test persons. They are not included in this number.
The 29 test persons selected to participate in the research were spread out over the categories, as Figure 7 illustrates. An individual could be placed in two different categories if their upper and lower parts of the body had different disfigurements. The classification was therefore made according to the individual’s upper and lower parts of the body respectively. Not all test persons are represented with both their upper and lower parts of the body. The grouping of the test persons was always made according to the largest disfigurement.

![Figure 7: The categorising of the test persons](image)

All selected test persons were living in the western part of Sweden at the time of the project. They could not be anonymous, it was not practical due to the many appointments. They were not given any remuneration. They were informed that if the final garment fitted them and they would like to keep it they could do so without any cost.

### Evaluation of made-up garments

In order to evaluate the results of the pattern construction the experts as well as the test persons evaluated each final garment. The experts evaluated the garment in detail while the test persons were asked about a few specific areas of the garment in addition to the overall comfort of the garment. The evaluation forms include more questions than what is relevant for this particular study. The questions dealing with the fit and comfort of the garment will be considered in this report as well as how frequent they have used the final garments will be mentioned. The other information was of interest for the EASYTEX project and for possible further studies within the field of style selection for individuals with disfigurements.

In phase A the expert evaluated the test garments. In phase B 37 final garments were evaluated. About a total of 30 garments will be made-up and evaluated in phase C. Due to lack of time and delays from the commissioned seamstresses only 10 garment are evaluated and included in this study. There was also a follow-up evaluation filled in by all test persons in phase B. The evaluation form for the follow-up evaluation was mailed, along with a letter, to all 15 test persons in phase B about 4-6 month after the first evaluation. The test persons had the chance to use the clothes and then evaluate them once more. All evaluations sent out were filled in and sent back without the need for any written reminders. The used forms and the cover letter are presented in Appendices C – I.

### Implementation

The procedure of making an individual garment can be divided into five main sections; figure registration, individual pattern, test garment, making-up, and evaluation. The implementations within these sections are described in this chapter. The needed equipment and material will be mentioned along with the different sections.

#### Figure registration

The figure registration was performed by the experts. Most of the time at least two experts were present when taking the measurements, one measuring and one registering the values. The procedure when measuring an individual is illustrated in Figure 8, page 36. The subject is measured while wearing underwear or close fitting garments. If the subject normally uses shoes with different heel heights, they have to wear them when being measured. In order to get as accurate measurements as possible certain landmarks should be marked out on the body. This was done with small round stickers, which marked the neck point, shoulder point and the 7th cervical vertebra. If the test person had a prominent disfigurement it was necessary to define landmarks on this projection as well. The waist was marked with a cotton band. The measurements were taken with a tape measure, graded in centimetres. A set square was used in order to facilitate the obtaining of certain measurements. A horizontal surface or a stool was used for the individual to sit on when obtaining the measurement in the sitting position. All measurements were registered on a form, Appendix J. If required, a body illustration was used in order to register measurements around a large disfigurement such as a hunchback or any other prominent body part, Appendix K. As a final registration, a few

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78 12 fitted jackets, 13 skirts, and 12 trousers
79 5 jackets, 1 skirt, 3 trousers, 1 dress
80 The goal is to produce the garment without any test garment in the process.
81 This was done by appointed manufacturers and seamstresses.
82 If they did not wear the shoes they would become more warped in the body than they would be when, later on, wearing the garment.
83 Points marked on the body that serve as guidelines to where specific measurements should be taken.
84 The cotton band has a width of 15mm.
photos were taken with a Polaroid camera in order to visually illustrate the test person’s figure. From one to six photos were taken depending on how the disfigurement looked. Sometimes the individuals were photographed with more clothes on than during the measuring procedure. The measurements and the figure illustrations are when making the figure analysis included in the next step - individual pattern.

Individual pattern

The garments used in all phases are the ones where fit is of great importance, such as trousers, skirt, and fitted jacket. The patterns differed between the phases. In phase A, graded block patterns for skirt, trousers and fitted jacket were used. Note that these patterns do not have any details - no designs were added, Appendix L. The designs available for phase B and C were ready for production, Appendix M. The patterns ranged in sizes from C32 through C54.

Individual patterns are created by figure analysis, style selection, selection of size, and applied adaptations, Figure 11, page 41. There was no style selection in phase A, only a selection of the garment type. In phase B style selections were possible between two trousers and the length of the skirt – short or long. The fitted jacket was available in just one design. In phase C the selection was made between a coat and a fitted jacket for the upper part of the body. For the lower part of the body a pair of trousers, and a skirt short/long were available. A dress in the selection was made between a coat and a fitted jacket for the upper part of the body. For the lower part of the body a pair of trousers, and a skirt short/long were available. A dress in size L/1 was ready for production, Appendix M. The patterns ranged in sizes from C32 through C54.

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Evaluation of made-up garments

A systematic evaluation was used with different evaluation forms for the different phases. The expert panel was present at every evaluation and made direct observations. The experts worked in rotation with at least two of the four present at each evaluation. The experts used an objective evaluation form, when evaluating the test garment, Appendix C. This evaluation was to establish how to adapt a pattern in order to obtain a good garment fit. The focus was therefore on which adaptations were used and what results those gave. The first evaluation of the final garment took place when the test persons tried on the garment for the first time. When evaluating the final garments two different forms were used, a subjective evaluation form for the test person to fill in, Appendix D (phase B) and Appendix E (phase C), and an objective evaluation form for the expert to use, Appendix E (phase B) and Appendix G (phase C). These evaluations focus on the end result. The criteria and the scale for this evaluation are described in Table 2, page 38. If the evaluation was marked as fair an explanation was asked for in order to be able to examine the cause. This is why the evaluation was not anonymous, it was necessary to be able to analyse the answers relation to the unique figure and the individual patterns. A photo taken at the evaluation registered the final result in phase B and C.

with the help of software, which made the process much faster. The adjustments were always made on a standard block; a new basic block was never drawn from scratch.

Test garment

The test garments were sewn in a cotton fabric. For the fitted jackets a rather compact fabric was used but the skirts and trousers were made of a more flexible fabric. The test garments were sewn in a way so that the garment fit could be evaluated in the best way. All the skirts and the trousers had a waistband and material was added along the centre front to facilitate closure of the garments. Various thicknesses of shoulder pads were used for the fitted jacket, all according to the requirements of the disfigurement in combination with the pattern adaptations. The designed garments in phase B were sewn as a test garment but not all the details were fully sewn on this garment, only marked in some way.

Making-up

This section of the process of making an individual garment will not be covered within this study. A manufacturer and seamstresses were commissioned to do the making-up of the final garments. Fabric and haberdashery were needed for the final garment in phase B and C, but will not be brought up here.

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The software Modaris, FitNet, Diamino, and Vigiprint were used in the production of individually made garments. The software was provided by Lectra System, Bordeaux, France.

It is better to use patterns with a design because the tolerance, details, and the balance in the garment is already developed and tested (Thorén, 1994). Another reason of why standard blocks were used as a starting point is that the made-to-measure software FitNet is based on using standard garments available for regular customers.

Except for one evaluation of the test garments and at one evaluation in phase C, were only one expert was present.
Table 2: Criteria used when evaluating the final garment

<table>
<thead>
<tr>
<th>Evaluator</th>
<th>Criteria</th>
<th>Evaluation scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>The experts’ objective evaluation</td>
<td>Ease allowance at various parts of the garment[^91] too small, excellent or too large</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Harmony of the garment, does the garment harmonise with the disfigured body[^92]</td>
<td>fair or excellent</td>
</tr>
<tr>
<td></td>
<td>Details and style lines of the garment</td>
<td>fair or excellent</td>
</tr>
<tr>
<td>The test person’s subjective evaluation</td>
<td>Comfort of the garment</td>
<td>fair, good or excellent</td>
</tr>
<tr>
<td></td>
<td>- in general</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- at specific areas[^93]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall impression of the garment</td>
<td>fair, good or excellent</td>
</tr>
</tbody>
</table>

The follow up evaluation, Appendix H, was mailed to the test persons participating in phase B. This evaluation was built up, and evaluated the garment, in a similar way as in the previous evaluation made by the test persons. A couple of questions were asked on behalf of the EASYTEX project covering areas not in focus in this study.

Summary

As previously stated, the empirical data has been gathered in three phases. The overall purpose of the different phases has been to produce garments with a good fit. This has been done in different ways in the three phases, figure 9, page 39. Phase A was a learning period where the individual garments were block patterns, with no design added. During this phase the basic methods of pattern adaptations for large disfigurements were established. At the evaluations in phase A modifications were noted, and a second test garment was sewn if large modifications were needed in order to obtain a good fit. If only minor modifications were needed these were noted but no second test garment was sewn. During phase B the alterations were made on fashionable styles. Test garments were still sewn in order to evaluate the garment fit before the garment went into customary production. When phase C started the methods for adapting patterns for large disfigurements had been tested quite extensively so this phase was carried out without any test garments[^94].

[^91]: Critical areas: Bust, waist, hip and sleeve.
[^92]: Critical areas: Shoulder, scye, sleeve, waist and hip.
[^93]: Waist, hip, crutch, shoulders, armhole, neck, bust, and sleeve.
[^94]: Except for when the test persons have difficult combinations of disfigurements. Test garments are sewn for them.
Made-to-Measure garments

A well-fitting garment starts with a well-made pattern and of course a suitable design. It can either be a pattern in various standard sizes or an individually made pattern. The standard sizes are produced before they actually have a buyer, while made-to-measure garments are produced only when an order is placed. With the technical solutions available today, the made-to-measure garments originate from a designed standard block pattern. The adaptations needed in order to get an individual pattern are added to the block pattern. The unique garment is made-up and delivered to the individual. Figure 10 illustrates the different steps to go through when creating a unique garment. The section test garment is marked with a dotted line because this step does not exist when the industry makes a made-to-measure garment. However, within this study the test garments have been sewn in order to develop reliable adaptation methods for large disfigurements.

The individual garment has to be in harmony with the individual body shape. Nevertheless the disfigurement should not be more visible than necessary. It is the interplay between the body shape and the final shape of the garment that gives a suitable dress. The garment should not be changed more than necessary, on the other hand it has to be altered enough in order to feel comfortable for the wearer and harmonise with the body shape. Within this interplay certain accessories can be used in order to fill the difference between the disfigured body and the garment. An extra shoulder pad can easily be used in order to compensate a low shoulder. The garment would look more symmetrical and would still harmonise with the body shape and give a good fit and comfort. If accessories such as shoulder pads are necessary this has to be already taken into account when adapting the pattern.

The actual creation of the individual pattern is one of many links in the process of making a made-to-measure garment. There are a lot of factors that influence the outcome of the individual pattern. Figure 11 gives a description of the different decisions needed and what influence them. The individual measurements and figure illustrations describes the body shape. The garment should form to this shape but of course with some tolerance. This tolerance makes the garment more flexible and certain disfigurements are hidden simply because of the tolerance of the garment. Due to this, not all disfigurements need to be taken into consideration when altering the pattern. Neither are all body measurements used exactly according to the measured value. The goal is to create a garment that is esthetical and has a good fit, harmony in style lines and designed shape. Finding a balance between the body shape, the designed style, and the necessary adaptations accomplishes an individual pattern.

The designed shape is of great importance for the final result. Certain designs are more suitable to certain body shapes than others. When making individual garments for individuals with large disfigurements it is important that the garment has the correct style lines. If the garment pattern does not have enough style lines, the adjustment of the garment could be impossible to make. The style lines make it possible to form the garment in accordance with the body shape. The garment pattern should be available in many sizes, preferable C32- C54. It is important to select the correct size as a starting point for the individual garment. The fewer and smaller adjustments needed on the pattern the more certain the final garment

40 Hasvén (1992) describes the same goal as tackled by tailors of not revealing the disfigurements. Instead, they used artefacts such as shoulder pads to hide the disfigurements in order to give the impression that the individual had the ideal figure.

41 The body measurements are one of two sets of data that are used in pattern development, the other data is the visual assessment of the body figure, done by the trained eye (Gazzuolo, DeLong, Lohr, LaBat, & Bye, 1992).

42 The identification of the problem is the beginning of the design (Lamb & Kallal, 1992). Both the kind and degree of disfigurement of the body have to be determined by the analyst (Heisey, Brown, & Johnson, 1988).

43 It is a benefit if a basic pattern includes more tolerance (more than Frost’s method with +6cm for the bust) since this minimises the adaptations and their values. Also individuals with disfigurements rarely wear garments that conform closely to the body (Thorén, 1994).

44 The body and the garment are not identical to each other. Therefore, the body measurements can not be used directly to create a garment. The body measurements should therefore be used primarily as guidelines and approximations (Gazzuolo, DeLong, Lohr, LaBat, & Bye, 1992)

45 These are the sizes for women with a total length of 168–4cm tall (40-series). If patterns for the shorter length class 160–4cm (20-series) were available one would think that it should result in fewer alterations. However, Nyman (1999) shows that when adapting a pattern for a short individual the number of alterations were as many when she used the pattern from the 40-series as when she used the patterns from the 20-series. The values were, however, smaller. (Nyman, 1999).
will be. The hip and bust circumferences are the most common guidelines when selecting a size. In addition to these measurements the disfigurement has to be taken into consideration. If an individual has a hunch on the right side of the back it probably would be more suitable to select one size smaller than indicated by the bust circumference. An adaptation will be added to the pattern in order for the garment to have a good fit over the hunch. If the larger size would have been selected the final garment would have been too large.

The altering of the pattern is divided into two categories; measurement deviation and body shape disfigurement. The measurement deviation includes small adaptations such as shortening/lengthening of trousers/skirt, increasing/decreasing of hip circumference. The body shape disfigurement includes larger adaptations for disfigurements such as, prominent figure, warped figure, and balance between front/back etc. The measurement deviations are always used when making an individual garment. These are, however, small modifications, which are conventional knowledge among pattern constructors. These will not be explained in detail but used when combining the adaptations on a whole body figure in the chapter, Individual patterns.

Registration of the body figure

In this section my experience, gained from this study, when it comes body figure registration is reported. Literature, concerning body figure registration, was studied and used as a starting point. These references are mentioned and discussed along with the experience gained. In this chapter, the references are in footnotes in order to facilitate reading of the text.

Registration of the body figure includes measurements and photos/figure illustrations. The whole process takes about 30-45 minutes, depending on the number of measurements and if the individual needs to rest during the measuring. In this study the purpose of registering the body figure is to determine how a garment should be adjusted in order to give a good fit. To decide how to improve the garment fit it is necessary to analyse both the measurements and the illustrations of the figure. Whether it is a single measurement or several analysed together they always need to be connected to the figure illustration.

Reliability of measurement depends on the experience of the measuring person. Practice is needed in order to measure consistently. The first step to consistent measuring is, however; to be clear on how and where the measurements should be taken. This is of great importance, especially if there are many persons who are going to measure the individuals. It is an advantage to have two persons measuring, one measures and the other assists by registering the values.

The photos are usually taken from the front, the back, and from the sides. The number required depends on the disfigurements. The purpose of the photos is to register the body figure and especially the parts of the body that are disfigured. It is important that the photos show the relation between different body parts.

Preparations

The individual who will be measured is dressed only in their underwear or in some close fitting clothes. Underwear especially can change the body form. However, it is essential that the body form is the same when measuring as it will be when wearing the planned garment. The subject should stand erect, with the feet slightly apart, relaxed shoulders, arms and abdomen, and looking straight ahead. The posture should be the same as it will be when wearing the planned garments. If the subject normally uses shoes with different heel heights, they have to wear them when being measured. If the shoes are not worn the posture and body figure change and the individual will usually be more warped than if measured with the shoes.

Preparations

101 For garments such as skirts and trousers.
102 For garments such as fitted jackets, blouses/shirts, and dresses.

103 (DeCosse, 1998a; Huxley, 1996; Öberg & Ersman, 1999)
104 (DeCosse, 1998b; Huxley, 1996; Lewin & Svensson, 1975; Liechty, Pottberg, & Rasband, 1994)
**Landmarks**

In order to measure as correctly as possible different landmarks are placed on the body. These landmarks serve as guidelines to where specific measurements should be taken. Each landmark is placed according to the anatomy - the skeleton and the muscles are important in order to locate the proper location of the landmarks.\(^{105}\)

The waistline is marked with a cotton band.\(^{106}\) The waist is usually the narrowest circumference of the abdomen. It is located between the lowest rib and the top of the pelvis.\(^{107}\) It is very important that the subject relaxes the abdomen and breaths normally.\(^{108}\) Sometimes it is difficult to determine where the waist is located, in this event the test person is asked to place the band where she would like to have the waist band of a skirt.

Some of the landmarks are marked with small round stickers; they are placed on both sides of the body. Figure 12 illustrates the placement of the landmarks. The neck point (NP) is located at the intersection between the base of the neck and the shoulder. The shoulder point (SP) is located at the utmost part of the acromion. The 7th cervical vertebra (CV), also called nape, is also marked. If the individual has a hunch, this needs to be marked. The highest point of the hunch is marked with a landmark called hunch1 (H1), the landmark located vertically above H1 on the shoulder line is called hunch2 (H2), see Figure 12.

The landmarks make it easier to find the correct locations when measuring. The measurer can concentrate more on all other aspects of measuring.

![Image of landmarks](Image)

**Measuring**

All measurements are taken with the upcoming pattern construction in mind. The measurements that are not necessary when deciding how to alter a pattern are therefor not measured. Most of the measurements listed in the next chapter need to be registered for all individuals, while some are just for individuals with specific disfigurements, such as the measurements 21-23, page 52. The goal is to measure only the measurements necessary to determine how the garments should be altered. The circumference of the body halves are just registered if necessary, otherwise only the total value is registered. This measuring should therefore not be seen as a detailed figure registration. Each measurement is not directly connected to a specific pattern alteration. Most of the time it is necessary to analyse a few measurements and in combination with a figure illustration in order to determine the adaptations needed.

The measurements is taken with a tape measure following the body figure without being too tight or too loose. It is important that the measuring is done consistently and in such a way that it decreases the possibility of incorrect measurements. If possible the measurements should be measured successively, for example, the shoulder and arm length should be measured at the same time without moving the tape measure at the shoulder point. The shoulder measurement is registered as well as the total length value at the wrist. The shoulder value is subtracted from the total value, the remainder is the arm length. When measuring the left/right or front/back part of a circumference it is extremely important to measure them successively in order to avoid errors of measurement.

Whether the measuring is done manually or automatically does not really matter. The measurements presented need to be taken in a way that relates to the pattern construction. Some measurements are easier to take automatically\(^{111}\) and some are easier to take manually\(^{112}\). The body scanner Symcad\(^ {113}\) has been used in the EASYTEX project to register the automatic measurements.

The systems that measure the human body automatically can be built up in different ways. Existing techniques for 3D body measurements include conventional passive video cameras, active range cameras based on structured light, acoustic, infrared emissive and possibly other innovative approaches. Because of the need for accuracy, a system that is safe and fast must be considered. The structured light principle satisfies these criteria. Based on this principle, Symcad provides accurate 2D&3D measurements at predefined landmarks such as chest, waist, hips, etc.\(^ {114}\)

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105. (Roebuck, 1995)
106. The cotton band has a width of 15mm.
108. (European Committee for Standardization, 1998; Landroy, 1949; Telmat Industrie, 1998)
109. The stickers come of very easy so they do not cause any discomfort for the individual.
110. The necessity is judged by the expert’s trained eye.
111. For example: height off shoulder point and height of neck point.
112. For example: inside leg length. Sometimes the thighs do not separate all the way up to the crutch. The automatic measurement is taken from the floor up to the landmark where the legs intersect. Additional software makes it possible to modify this landmark in order to measure all the way up to the anatomical crutch.
113. Manufactured by Telmat Industries in France.
114. However, the Telmat/Symcad system is optimised for measuring individuals with normal body shapes and cannot be used for individuals with large disfigurements, without significant software modifications. Therefore, an interface, based on data provided by Symcad, has been developed at Chalmers university of Technology in Sweden. With this interface, it is possible to modify and add landmarks/measurements, according to needs.
Measurements

The measurements used, and described further on, are either a circumference\(^{115}\) or a linear measurement – including width\(^{118}\) and length\(^{117}\) measurements. There are measurements that follow the outline of the body\(^{118}\), those that only measure the distance without including the outline of the body\(^{119}\), and those combining the outline of the body and the distance\(^{120}\). Some measurements are taken as control measurements; they are only used to check that the width/circumference of the garment is large enough at that particular area. All measurements have been taken with a tape measure but sometimes with the help of other tools such as a set square. Most of the measurements are body measurement but sometimes it is good to measure garment measurements, for example to decide the length of the skirt. This is usually registered when the designed garment is picked out. In this chapter only body measurements are presented. They are described according to how they are generally measured, which tools are suitable to use, and how they are used in the pattern construction. In addition, the experience of measuring individuals with large disfigurements is added. The measurements are presented in the order they were usually measured. The measurements are numbered, and shown in the illustrations in Figures 13-18.

When measuring individuals with large disfigurements one has to be inventive and think about what is necessary to know in order to handle the upcoming adaptation of the pattern. It might be necessary to take some more measurements in order to register the disfigurement.

1. Height

The height, Figure 13, is the vertical measurement from the top of the head to the soles of the feet\(^{121}\). It can be either measured with an anthropometer\(^{122}\) or against a wall with a set square, a tape measure. This was not always measured; the test person could usually give this information.

The height is not used in direct connection to any alteration but serves more as an information of the subjects proportions when comparing with other length measurements.

2. Bust circumference

The bust circumference, Figure 13, is taken with a tape measure over the most prominent part of the bust, under the arms, and vertically at the back while the subject is breathing normally\(^{123}\). Some authors write that the bust circumference should be measured horizontally\(^{124}\). This is not possible when measuring individuals who do not have an erect and straight posture of the upper body. It is most common to register the total circumference but it is also possible to register the left and right value of the circumference\(^{125}\). This is used when the difference between left and right circumference is significant.

The garment size for the upper part of the body is usually selected according to this measurement. A small alteration might be necessary in order to harmonise with the bust circumference of the individual.

3. Waist circumference

The waist, Figure 13, is measured with a tape measure at the narrowest circumference of the abdomen, marked with a waistband. More details about the location of the waist are given in the chapter Landmarks. As with the bust measurement, some authors emphasise that the waist measurement should be taken horizontally\(^{126}\). Often this is not possible when measuring an individual with large disfigurements. If necessary the left and right side of the waist circumference are registered.

Most of the time, especially with trousers and skirts, it is necessary to alter the waist in order to make it fit comfortably. How the alterations should be carried out depends also on how the figure looks around the high hip and hip.

4. High hip circumference

The high hip, Figure 13, is measured with a tape measure over the most projecting part of the hipbone/iliac crest\(^{127}\). About 10cm below the waistline\(^{128}\) or between the waist and hip, but slightly closer to the waist. The measurement should be horizontal\(^{129}\) but as said before this is not possible when measuring large disfigurements.

The high hip measurement is mostly for controlling that the pattern is not too small/tight over this area. The waist and hip 13

\(^{115}\) For example; bust, waist, hip etc.

\(^{116}\) More or less horizontal measurements, for example shoulder width and back width.

\(^{117}\) More or less vertical measurements, such as sleeve length, inside leg length etc.

\(^{118}\) For example; bust point, waist circumference, and thigh circumference.

\(^{119}\) For example the inside leg length.

\(^{120}\) For example; bust circumference, nape to waist – front, outside leg length etc.

\(^{121}\) (Cednäs & Kjellnäs, 1977; DeCosse, 1998a; European Committee for Standardization, 1998; Lewin & Svensson, 1975; Shoben & Ward, 1987)

\(^{122}\) (Cednäs & Kjellnäs, 1977) An anthropometer is a straight vertical bar on which a horizontal measurement arm slides up and down (Lewin & Svensson, 1975).

\(^{123}\) (Landroy, 1949; Shoben & Ward, 1987; Öberg & Ersman, 1989; Öberg & Ersman, 1999).

\(^{124}\) (Cednäs & Kjellnäs, 1977; European Committee for Standardization, 1998; Morris & McCann, 1997; Telmat Industrie, 1998; Zieman, 1994; Öberg & Ersman, 1989)

\(^{125}\) (Frost, 1987)

\(^{126}\) (Gaarder, 1995; Zieman, 1994)

\(^{127}\) (Lewin & Svensson, 1975; Shoben & Ward, 1987)

\(^{128}\) (Shoben & Ward, 1987; Taylor & Shoben, 1984; Öberg & Ersman, 1999)

\(^{129}\) (Öberg & Ersman, 1999)
are the guidelines, the pattern lines have to be smooth and therefore the high hip measurement can not be strictly considered.

5. Hip circumference
The hip, Figure 13, is measured horizontally at the fullest part of the hip including the buttock/glutaeus maximus, about 18-23cm\(^{130}\) below the waistline depending on the height of the subject. It is important to include a protruding stomach\(^{131}\). The tape measure should not be so tight so that it is pulled in under a protruding stomach. If the subject is confined to a sitting position the hip measurement can not be taken horizontally. Instead the hip is measured diagonally from the buttoc to the groin\(^{132}\). If necessary the left and right side of the hip circumference are registered.

The garment size for the lower part of the body is usually selected according to this measurement. A small alteration might be necessary in order to harmonise with the hip circumference of the individual.

Two additional measurements might be necessary if the subject has prominent buttocks. The hip circumference should be measured in halves; the front and the back. Measure from side to side, imagine a side seam straight down from the side of the waistline and measure according to these “seams”. These measurements are used in order to determine how the hip width has to be rearranged between the front and back piece.

6. Neck circumference
The neck circumference, Figure 13, is taken with a tape measure, placed on edge, at the base of the neck, it goes through the landmark for the 7th cervical vertebra\(^{133}\) and through the neck point\(^{134}\). The measurement should correspond to a plain basic neckline.

Small alterations might be necessary, especially if the garment has a high buttoned collar.

7. Nape to waist back
The nape to waist, Figure 14, is an outline measurement from the 7th cervical vertebra, measured along the projections of the back down to the waist. The projections should include the outline of the shoulder blades/scapula\(^{135}\).

This measurement is primarily used to identify the length of the garment, from the neck down to the waist. It is important to bear in mind that this measurement can include a large hunchback. In this case the measurement includes information that should be used when deciding how the garment should be lengthened/shortened but also information about how the garment should be altered in order to get the correct balance between front and back.

8. Back width
The back width, Figure 14, is measured with a tape measure across the back: between the right and left arm crease and over the shoulder blades/scapula. About 2.5cm above the arm hinge\(^{136}/10cm\) down from the nape\(^{137}\). If it is necessary the left and right side of the back width is registered\(^{138}\).

If the subject does not have a hunchback on one side of the back, the back width is considered a control measurement. It is measured in order to check that the back width does not get too small. If the subject has a hunchback it is necessary to analyse the difference between left and right side in order to be able to enlarge the garment at the prominent side.

9. Bust point
The bust point, Figure 15, is an outline measured from the 7th cervical vertebra, around the back neck through the neck point, and down to the bust point\(^{139}\). The location of the bust point can vary depending on if and how a bra is worn. This measurement has a great number of variations in the literature\(^{140}\).

If a garment has a dart pointing toward the bust it is important that the point of the dart is at the correct level.

10. Nape to waist front
The nape to waist front, Figure 15, measurement is successive to the bust point measurement. It is measured from the 7th cervical vertebra, around the back neck, through the neck point, over the bust point, and straight down to the waist.

This measurement is used in combination with nape to waist back to determine if alterations are needed in order to achieve a good balance between the front and back.

11. Shoulder width
The shoulder width, Figure 13, is measured with a tape measure between the neck point and the shoulder point. This measurement is usually taken on both the left and right side of the body. It can also be useful to take a control measurement between the uttermost part of the left and right shoulder point\(^{141}\).

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\(^{129}\) (DeCosse, 1998a; Öberg & Ersman, 1999)
\(^{130}\) (Frost, 1987; (Liechty, Potthberg, & Rasband, 1994)
\(^{131}\) (Bergenheim, 1986)
\(^{132}\) (European Committee for Standardization, 1998; Telmat Industrie, 1998)
\(^{133}\) The intersection between the base of neck and the shoulder.
\(^{134}\) (Telmat Industrie, 1998; Öberg & Ersman, 1999)
\(^{135}\) (DeMont, 1994).
\(^{136}\) (Frost, 1987; Öberg & Ersman, 1999).
\(^{137}\) Measure from the waist up to the bust point (Huxley, 1996; (Liechty, Potthberg, & Rasband, 1994). Measures from the bust point to the centre front/neckline and from bust point to the outside of shoulder/acromion (DeMont, 1994).
\(^{138}\) (Corke, 1996; Huxley, 1996; Liechty, Potthberg, & Rasband, 1994)
APPENDIX 3

The pattern is altered according to this measurement. If the left and right shoulder are of different widths the aim should be to make the shoulders harmonise with the shoulders of the individual but the garment should look as symmetrical as possible. In reality this usually means not to alter the shorter shoulder as much as the measurement indicates.

12. Arm length
The measurement arm length, figure 13, is also called sleeve length, which actually is a garment measurement. In the literature both terms are used. In this report the term arm length will be used.

The arm length is measured with a tape measure in succession to the shoulder measurement, over a slightly bent elbow - approximately 120°, and down to the wrist just below the prominent wrists bone. This measurement is usually taken on both the left and the right side of the body. When the proportions of the arms are very different from standard, it is sometimes necessary to ask the subject which full sleeve length she would prefer.

The alteration to shorten/lengthen the sleeve should be made both above and below the elbow, approximately half of the alteration value on each side of the elbow.

13. Upper arm circumference
The upper arm, Figure 13, is measured around the fullest part of the upper arm, around a relaxed biceps and triceps.

This is mainly used as a control measurement, to check that the sleeve not will be too tight fitting.

14. Wrist circumference
The wrist circumference is measured around the wrist, over the prominent wrist bone.

This measurement is also used as a control measurement.

15. Waist to floor – front & Waist to floor – back
The waist to floor – front, Figure 15, is measured with a tape measure from the centre front/back waistline, following the contour of the stomach/buttocks, and then vertically down to the floor.

These measurements are taken for comparison, in order to determine if a balance adjustment between the front and back is necessary. It should be noted that if the waistline is sloping toward the front or the back it would affect the measurements and later on the judgement of the pattern adaptations.

16. Outside leg length
The outside leg, Figure 13, is measured with a tape measure from the waistline on the side, following the side contour down to the hip level, and from there vertically down to the floor. This measurement is usually taken on both the left and the right side of the body.

These measurements show clearly if the subject has a warped waist. Sometimes the measurements can also indicate if one side of the body is more prominent than the other. A figure analysis is necessary to identify the disfigurements. The measurements also serve as control measurements in combination with measurements for the inside leg length and the body rise.

17. Body rise – centre front
The body rise measurement, Figure 15, is taken with the help of a set square and a tape measure. The subject stands close to a wall with the feet slightly apart. The set square is placed between the subjects legs right below the crotch, and at a right angle toward the wall. The distance between the centre front waistline and the horizontal set square is measured.

The measurement of the body rise does not indicate if the subject is warped or if the subject has a prominent body part on either side of the body. These facts are included in the outside leg length and the body rise measured on the subject’s sides. This measurement indicates the body rise without including a warped waist or a prominent body part.

18. Inside leg length
The inside leg length, Figure 15, is measured in succession to the body rise – centre front. From the horizontal set square the inside leg length is measured vertically down to the floor. If the subject is confined to a wheelchair the set square is placed between the legs just in front of the crotch. The inside leg length is then measured with a tape measure along the inside of the leg, following the angle at the knee.

Illustration Helene Berglin

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142 (European Committee for Standardization, 1998; Huxley, 1996; Lewin & Svensson, 1975; (Liechty, Potberg, & Rasband, 1994; Telmat Industrie, 1998)
143 (Aldrich, 1980; Kindwell, 1979; Yoon, 1994; Öberg & Ersman, 1999)
144 (Telmat Industrie, 1998)
145 (Lewin & Svensson, 1975; Liechty, Potberg, & Rasband, 1994; Shoben & Ward, 1987)
146 (Frost, 1987; Huxley, 1996; Liechty, Potberg, & Rasband, 1994)
147 (Frost, 1987; Liechty, Potberg, & Rasband, 1994)
148 (Telmat Industrie, 1998)
149 (Cednäs & Kjellnäs, 1977; Telmat Industrie, 1998)
This measurement determines the trouser leg length. The alteration to shorten/lengthen should be done both above and below the knee, approximately half of the alteration value on each side of the knee.

The body rise, Figure 16, is measured with a tape measure, with the subject sitting on a horizontal surface. It is measured from the waistline on the side following the contour down to the widest part of the hip, and then vertically down to the horizontal surface. This measurement, along with outside leg length, indicates if the subject is warped in the waist. The garment is usually made to look best when standing; in consideration of this the outside leg length should be the more important because it is measured in the standing position. When measuring a subject confined to a wheelchair the measurement outside leg length is not measured. In this case the body rise is the only measurement that indicates if the subject has a warped waist.

20. Thigh circumfernece
The thigh, Figure 13, is measured around the fullest part of the leg above the knee, approximately 5cm below the crotch.

This measurement is mainly used as a control measurement in order to check that the garment will have enough tolerance.

21. Height of neck point - front & back
The height of neck point, Figure 17, is measured with a tape measure and the front and back measurements are obtained in succession. In the literature the height of neck point is measured down to the waistline. This does not work well when measuring a subject with a warped waistline. When measuring down to the waistline the height of neck point includes the disfigurement of a warped waistline as well. This makes it more difficult to determine what the value actually describes. Instead, it should be measured from a horizontal line below the waist. Measure from the horizontal line in the back, through the landmark of the neck point, and down to the horizontal line in the front.

\[ H2 \]

\[ H2 \]

This measurement shows if the subject has a large difference between the height of the neck points of the left and right side. It is not an easy measurement to “read” because many factors can affect the value, for example asymmetrical disfigurements such as hunchback, different sizes of bust etc. A figure analysis is necessary to determine if a specific alteration is needed to modify the level of the neck points.

22. Height of shoulder point – front & back
The height of shoulder point, Figure 17, is measured with a tape measure, and the front and back measurements are obtained in succession. In the literature this measurement is taken from the side of the waistline, through the shoulder point, and down to the waistline. This causes the same problem as described under height of neck point. Instead, it should be measured from and to a horizontal line. The subject can be standing beside a low table and the measurement starts and ends at this horizontal surface. This measurement is used to identify if and how warped a subject is in the shoulder area. If the subject is warped in this area the first move is to compensate with different shoulder pads. If this is not enough, the pattern has to be adjusted.

23. Location and size of a hunch
How these measurements are taken in detail depends on what the hunch looks like, this should be seen as just an example. The purpose is, however, to determine the location and the size of the hunch. The size of the hunch has to some extent already been registered by other measurements. The back width taken on the left and right sides of the back registers the hunch widthways. The hunch also has to be registered lengthways. This is done by measuring from the landmark \( H2 \), through the landmark \( H1 \), and down to a horizontal line placed approximately at the waistline. Figure 18. The location of the landmark \( H1 \) should also be registered. The location of \( H2 \) is registered by measuring from the neck point to \( H2 \). These are the most important measurements in order to be able to adjust the pattern to fit the individual with a hunchback. It might be necessary to add some more measurements in order to get enough information about the hunch. In that case it is important to also register the

\[ H1 \]

\[ H1 \]

\[ H2 \]

\[ H2 \]
location of the measurement is also registered.

These measurements are used in order to determine how much additional length is needed around the prominent part. This can be done by comparing the measurement taken on the projection with the measurements taken on the other side of the body or it can be determined by measuring the pattern.

Figure analysis

The figure is registered by measurements and by photos. The photo is a reminder of how the individual actually looked and is essential when analysing the measurements. The figure illustration is extremely important in order to understand what information the measurements are giving. Two highly individual body figures can both have a bust circumference of 100cm. It would not be possible to determine where the largest volume is present on these body figures by only looking at the bust circumference. When analysing the photo it is easily seen where the volume is present. One individual might have a large bust while the other has a hunchback – but their bust circumference may be the same. Other measurements which need a clarification by figure illustrations are for example; hip circumference, waist to floor front & back, outside leg length and body rise, height of neck point.

In is important to analyse the body figure from different points and to use all means possible in order to make the best judgement getting to know the body figure by analysing the measurements and the figure illustrations!

Pattern adaptations

The adaptations presented in this study are not easy and most of the time not possible to make when the garment is already produced. The presented adaptations increase or rearrange the length or the width of certain parts of the garment, which should be done on the pattern, before the pieces are cut.

When making an individual pattern many combinations of adaptations are usually needed. How and with what value an adaptation will be used is related to the individual figure, the design, and the other adaptations used. These three considerations are based on various information, see Figure 19. The size selection is a separate judgement done before deciding which adaptations are needed. The measurements of the selected size are compared strictly mathematically with the individual measurements. All aspects have to be considered when deciding which adaptations are going to be applied to the pattern. The adaptations and their values have to be used in a way that does not draw attention to the disfigurement. It is important to find a balance between camouflaging the disfigurement and creating a garment in harmony with the individual figure.

156 How the volume is distributed between front and back.
157 Is the measurement indicating prominent buttocks/stomach or is it indicating a sloping waistline?
158 Is the measurement showing a warped waistline or is it a prominent body part on one side?
159 Is the measurement indicating warped shoulders or a prominent body part?

All the examples of adaptations given in this report are taken from the EASYTEX project. The individuals presented have been examined thoroughly, in the matter of body figure in relation to pattern construction. It is important to see them as examples. Before using these examples it is important to study and really understand how the different adaptations are related to various disfigurements. This is essential if correct combinations of adaptations with the right value are to be used on the individual pattern.

It is difficult to distinguish each adaptation if presented in combination with others. Therefore the adaptations will first be presented separately in a general presentation – in the chapter...
Single adaptations. Further on they will be presented in combination with each other, applied on two unique body figures – in the chapter Individual patterns. The alterations are applied to a basic skirt, trousers, and fitted jacket160. The reason for not using patterns with a specific design and details is that it would make it more difficult to see the individual alterations. In this study the alterations are in focus and have to be presented as clearly as possible. This is why the outline of the pattern cuts into the darts instead of just marking the dart with notches and a point. The adaptations affecting the darts are illustrated more clearly when the outline cuts into the darts. The tolerances of the garments are an important factor when deciding how to alter a pattern. In Table 3 the tolerance of the basic garments skirt, trousers, and fitted jacket are presented.

Table 3: The tolerances of the plain basic garments

<table>
<thead>
<tr>
<th>Location</th>
<th>Garment type</th>
<th>Trousers</th>
<th>Skirt</th>
<th>Fitted jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bust</td>
<td></td>
<td></td>
<td></td>
<td>+14</td>
</tr>
<tr>
<td>Waist</td>
<td>+4</td>
<td>+4</td>
<td>+12</td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>+4</td>
<td>+4</td>
<td>+9</td>
<td></td>
</tr>
<tr>
<td>Upper sleeve</td>
<td></td>
<td></td>
<td></td>
<td>+9</td>
</tr>
</tbody>
</table>

The measurements for each adaptation will be presented and discussed. In many cases the body measurements do not correspond exactly to the individual garment161. An alteration plan is made on a basic pattern. On this plan all adaptations used are marked out with their values. These alterations are then applied to a pattern in the software FitNet. The final adapted pattern is presented on top of the basic pattern in order to illustrate the differences. The pattern outlined with a thick line is the altered pattern and the one with the thin line is the standard sized pattern. The patterns will be placed in a way that illustrates the differences as clearly as possible. In order not to take up too much space on the pages, only the pattern pieces including the main adaptations are presented.

Key to the adaptation plan

In order to understand the alteration plans some symbols have to be explained. The unit of measurement is the centimetre and it is always prefixed with plus or minus sign if it is a positive or negative value. If the waist circumference has to increase the adaptation values around the waist are all positive. Notice that a positive value marked at the dart indicates that the waist will be increased by decreasing the size of the dart. If the value has a circle around it the adaptation is meant to be vertical – without a circle the adaptation is horizontal. Sometimes a value will be marked between two pattern pieces placed pretty close to each other. In these cases the value is meant to be adapted on both pattern pieces. When it comes to the sleeves the same adaptations are often done on both the right and the left side, but the value might be different. In these cases the adaptation plan shows only the left sleeve but both the right and the left value are illustrated.

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160 Same block patterns, without a design added that were used in phase A.
161 As said before, not all body measurements are used exactly according to the measured value, see chapter Made-to-Measure garments.
Short/tall stature

Individuals with a short or tall stature have problems with the length of the garment. The garment is either too long or too short or maybe a combination of both but in different parts of the clothing. Some adjustments are possible to make on the produced garment, such as small shortenings of sleeves or trouser legs. This can, however, be difficult if the garment has details in the areas where the shortening needs to be done. The adaptations needed for individuals with a short or tall stature is simply a shortening or lengthening of the pattern. This can be done in different places on the pattern pieces, depending on the proportions of the individual.

![Figure 20: Individual with short stature](image)

Illustration Helene Berglin

![Figure 21: Individual with tall stature](image)

Illustration Helene Berglin

Short stature

The test persons with a short stature can have a proportional body figure, Figure 20, page 58. However, it is also quite usual that they have a disproportion between the extremities and the torso. The short individual has problems with the length of the ready-made garments, Figure 22. Smaller alterations are possible to make on the ready-made garment but larger alterations create bad proportions, for example, by shortening the length of the jacket only at the hemline. It is necessary to shorten the pattern for a fitted jacket between the waist and the armpit in order to get the waist at the correct place. The adaptations have to be made on the garment pattern.

The main measurement indicating a short stature is the height of the individual. In addition to this, other length measurements are necessary to study in order to learn about the proportions of the figure. For the lower part of the body the body rise and the inside leg length are essential. For the upper part of the body the nape to waist and the arm length are the important measurements. In this example it is clear that the extremities\(^{162}\) are very short, -14cm for the arms and -27.5cm for the legs. The torso on the other hand is only -5.5cm shorter, all compared to the standard C38, Table 4.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Height</td>
<td>137</td>
<td>168</td>
</tr>
<tr>
<td>Nape to waist</td>
<td>35.5</td>
<td>41</td>
</tr>
<tr>
<td>Arm length</td>
<td>46</td>
<td>60</td>
</tr>
<tr>
<td>Inside leg length</td>
<td>50.5</td>
<td>78</td>
</tr>
<tr>
<td>Body rise</td>
<td>23</td>
<td>26</td>
</tr>
</tbody>
</table>

The trousers will be shortened both according to the inside leg length and in relation to the body rise, Figure 23, page 60. It is important to consider that the length and width of the trousers legs are proportionate. In this example only the length is considered due to the single adaptation presentation. The trousers legs and the body rise are shortened according to the measurement, -27cm and -3cm respectively. The darts are shortened -1.5cm. If a designed pair of trousers are adapted one have to know if they have a waistline that is cut low, in this case it is important not to make the trousers too low especially at the back.

\(^{162}\) Extremities are the legs and arms.

![Figure 22: Fitting problems caused by the short stature](image)

Illustration Helene Berglin
The nape to waist and the arm length are the most important measurements when deciding how to adapt the fitted jacked according to a short stature. The bodice will be shortened according to two measurements, the nape to waist and the body rise. As it is illustrated in Figure 24, page 61, the nape to waist is shortened in two places, totally –5.5cm. The shortening in the scye has to be done with great care. A little bit of the shortening is placed in this area in order not to make the armhole depth too deep and cut too close to the waist. The goal is to keep the proportions of the garment. On the other hand it is important not to get a too small/tight scye. If the scye is too tight it affects the comfort of the garment. When adapting the scye the sleeve head has to be adjusted as well.

In addition to the shortening according to the nape to waist the total length of the garment is also shortened at the hemline, –4cm. The body rise measurement serves as a guideline but it is important that the lengths of the different parts of the garment are proportionate as well as harmonising with the individual figure. The sleeves are shortened according to the measurement. It might be necessary to adjust the width around the wrist when shortening the sleeve, in this example that is not done.

Figure 24: Fitted jacket for the short individual

Tall stature
An individual with a tall stature, Figure 21, page 58, would need to have the patterns adjusted at the same places as an individual with a short stature, but of course with increasing values instead of decreasing.
Warped figure

The individuals with warped figures have a balance problem with standard garments. The balance between right and left side of the garment does not harmonise with the figure. This can lead to a down-slanting hemline or uncomfortable gathers of fabric.

Figure 25: Body figure with warped shoulders
Illustration Helene Berglin

Figure 26: Body figure with warped waist A
Illustration Helene Berglin

Figure 27: Body figure with warped waist B
Illustration Helene Berglin

Warped shoulders

An individual with warped shoulders does not have the shoulders aligned horizontally, Figure 25, page 62. This gives problems with the garment fit of a standard jacket. One side of the jacket is pulled up in relation to the other side, which creates a down-slanting hemline, Figure 28.

The measurements indicating warped shoulders are first of all, height of shoulder points, and secondly height of neck points. The measurement used in this example, height of shoulder points, does not have a standard measurement to be compared with. The measurements from the left and right side of the body are compared, here the difference is 8cm, Table 5.

Table 5: Measurements that indicate the warped shoulders

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Height of shoulder point front</td>
<td>50</td>
<td>58</td>
</tr>
</tbody>
</table>

The garment needs to be adjusted in order to get a straight hemline. On the other hand the shoulders should not look as warped as they actually are. The lower shoulder is built up by adding a 2cm thick shoulder pad. When a shoulder pad is added the inner circumference of the scye becomes smaller, Figure 29, and needs to be compensated. Enlarging the scye depth with half of the shoulder pad’s thickness solves this. The sleeve head has to be modified in order to fit into the scye. In addition to the extra shoulder pad the garment has to be warped, Figure 30, page 64. The right side seam will be shortened -3cm. In total 5cm out of the 8cm in difference is considered. This adaptation also affects the centre front and back. These are moved in order to keep them aligned with the grain line.

Figure 28: Fitting problems caused by the warped shoulders
Illustration Helene Berglin

Figure 29: Inner circumference of scye
Warped waist
The individual with a warped waist does not have a horizontal waist line, Figure 26 & 27, page 62. The warped waist usually creates problems with the standard trousers and skirts. The trousers usually create an uncomfortable gathering of material on the lower side, Figure 31. When it comes to standard skirts the down-slanting hemline is the most visible. The balance between right and left side of the garment has to be adjusted.

The measurements indicating a warped waist is the outside leg length and sometimes the body rise. If the body rise value is added to the inside leg length value their sum should approximate to the outside leg length. In this example the sum does not add up exactly to the outside leg length. However, the measurements, along with the figure illustration, show that the left side is quite a bit lower than the right side. As usual, not the whole value will be used when the adaptation value is decided. The difference between left and right is about 6-8cm, Table 6. Two ways of adapting the trousers to fit the warped waist will be presented.

Table 6: Measurements for indicating a warped waist

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Outside leg length</td>
<td>105</td>
<td>97</td>
</tr>
<tr>
<td>Inside leg length</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Body rise</td>
<td>26</td>
<td>20</td>
</tr>
</tbody>
</table>

Alternative one
The height of the right side will be kept while the left side is lowered -4.5cm, Figure 32A+B. The whole difference will not be taken into consideration because it would create too warped a waistline. This alternative should be used if the individual wants to have the waistband in the anatomical waist. Otherwise it is preferable to use alternative two.

Figure 30: Fitted jacket for the individual with warped shoulders

Figure 31: Fitting problems caused by the warped waist
Illustration Helene Berglin

Figure 32A: A pair of trousers for the individual with a warped waist, alternative 1
Alternative two

The height of the left side will be lowered according to the body rise, -6cm, Figure 33. In order to avoid a very warped waistline the right side is lowered by -3cm along the side seam. The right side of the waist will not be placed in the defined anatomical waist but lowered towards the high hip. The new placement of the waist in the right side demands a larger circumference. This is why the waist is lowered along the side seam instead of straight down with the same waist circumference. It is important to be aware of the waist and hip tolerance of the garment. Usually the hip has more tolerance than the waist, this has to be taken into consideration when moving the waist along the side seam. The waist circumference is not allowed to increase too much.

The two alternatives have the practical action of warping the garment pattern in common. The two front and back garment pieces are put together along the centre front and the centre back respectively. The waist is warped according to the planned value. The front and back pieces are separated and the adaptation is finished.

Prominent disfigurements

Individuals with a prominent disfigurement have problem with the garment fit because the projection does not fit into the garment. Usually they have to select a garment with a larger size. The projection might fit into the garment but the larger size makes the garment too big in other areas. The adaptations need to enlarge the pattern over the prominent body part without enlarging the whole garment. The increase of the pattern can be made either lengthways, widthways, or with a combination of both.
**Arched back**
An individual with an arched back has a long back and a shorter front, Figure 34, page 67. The vertical measurement of the trunk is shorter because the spine has changed from straight to very curved. The problems with fit are that a standard jacket pulls up in the back and is too long and baggy in the front. The balance between the front and back needs to be adjusted.

The measurements nape to waist and nape to waist front indicate that the balance between front and back is not according to the standard measurements. The back has to be lengthened while the front has to be shortened, Table 7.

**Table 7: Measurements indicating the arched back**

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Nape to waist back</td>
<td>42</td>
<td>41</td>
</tr>
<tr>
<td>Bust point</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>Nape to waist front</td>
<td>42</td>
<td>52</td>
</tr>
</tbody>
</table>

The front has to be shortened -10cm and the back lengthened +1cm, according to the actual body measurements. However, the total balance difference of 11cm will not be taken into consideration. A difference of 9cm will be enough to give the garment a good fit and comfort. The length of the back will be kept while the front will be shortened -9cm, Figure 37A+B. Note that the bust dart is made smaller when shortening the front. The length of the scye front and back is rearranged, the front is shortened and the back is lengthened. This affects the sleeve as well. The shoulder notch has to be moved in order to match with the shoulder seam, in this case 2cm to the front.

**Figure 37A: Fitted jacket for an individual with arched back**

**Figure 37B: Fitted jacket for an individual with arched back**
Prominent stomach
An individual with a prominent stomach is illustrated in Figure 34, page 67. This disfigurement usually leads to problems, with for example a skirt. The prominent stomach makes a standard skirt pull up at the front, which causes a hemline that is not horizontal as desired. The front piece of the skirt has to be lengthened and formed considering the stomach. Another way of handling the prominent stomach is to enlarge the waist of the skirt so that the waistband does not go all the way up to the anatomical waistline in the front. This is preferred if the disfigurement is quite small.

There are no clear measurements indicating this disfigurement. However, the balance between the measurements waist to floor - front and waist to floor - back can be used as a guideline, but only as a guideline. Otherwise, it is important to analyse the figure illustrations from the side view. The two measurements presented in Table 8 can not be compared with standard measurements. The difference between the front and the back indicates that there is a prominent stomach and/or rather flat buttocks. When studying the figure illustration it is confirmed that a prominent stomach gives the large value for the waist to floor front. As said before these measurements can only be compared and used as guidelines.

Table 8: Measurements that can be used a guideline for the prominent stomach

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Waist to floor front</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Waist to floor back</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

The centre front of the skirt will be lengthened +2cm, Figure 38. This has to be done without lengthening the side seam. The centre front is lengthened and a dart is added along the waistline. This lengthens the piece and adds more form to it as well. The alteration shown here does not change the circumference of the waist. However, it would be suitable to give the waist of the garment more tolerance than usual. This would prevent the prominent stomach from being emphasised and makes the garment more comfortable. Note that the side seam of the front piece does not have much form. This has to be considered when adding other alterations to this area of the pattern.

Figure 38: Skirt for the individual with prominent stomach

Prominent buttocks
The condition of having prominent buttocks is considered to exist when the largest volume around the hip area is placed at the back, Figure 35, page 67. The individual with prominent buttocks usually has problems with the garment fit when it comes to the relation between the seat and the waist. The individual has to select the garment according to the hip measurement. The waist on the garment is then usually too large, especially at the back, Figure 39. Prominent buttocks in combination with a flat stomach also create an S-formed side seam. The width of the trousers has to be rearranged, increasing the back piece and decreasing the front piece. The waist usually has to be decreased as well.

The measurements indicating prominent buttocks would be the hip circumference measured at the front and at the back. The difference between the front and the back hip measurement is 8cm, Table 9.

Table 9: Measurements indicating the prominent buttocks

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Front</td>
</tr>
<tr>
<td>Hip circumference</td>
<td>96</td>
<td>44</td>
</tr>
</tbody>
</table>

When planning this adaptation it is very important to know the proportions of the standard garment. The standard garments presented here have the hip circumference divided evenly between the front and the back piece of the garment\(^{\ref{163}}\). In this case, and according to the measurements, the front pieces need to decrease, -4cm and the back pieces need to increase, +4cm around the hip area, Figure 40, page 72. The increasing/decreasing value marked at the waist relates exactly to the rearrangement value. However, the increasing/decreasing will not be as large at the hip area due to the zero value at the hemline. Note that this adaptation, in addition to the rearrangement of the width also decreases the waist circumference of the garment, in this example, -4cm in total. The crutch length is increased on the back piece.

\(^{163}\) There are, for example, skirts where the front piece is larger than the back one.
Hunchback

A hunchback is a projection of the back, Figure 36, page 67. The test persons with hunchback in this study have the main projection on either the left or the right side of the back. The individual with a hunchback has problems with a standard garment because it is not large enough over the actual hunch. The garment pulls up at the hunch and it is usually too tight widthways, Figure 41. The pattern has to be increased over the hunch without increasing other parts of the garment. This has to be done in a way that does not draw attention to the hunch.

When an individual has a hunchback, extra measurements are taken in order to determine how large the hunch is and where it is placed, see the chapter Measurements. The style used as a starting point has to have style lines on the back piece, from the shoulder seam and down. This is necessary in order to form the back piece around the hunch without adding too many darts, pointing toward the projection. The style lines keep down the number of darts or pleats necessary for the good fit.

It is important to select a smaller size than indicated by the bust circumference. The extra width needed due to the hunch is indicated by the back width. By comparing the right and left side of this measurement the approximate size of the hunch widthways is determined. The extra width needed should be subtracted from the total bust circumference, the remainder is the circumference that should serve as a guideline when deciding the size of the standard garment. In this example the bust circumference is 92.5cm - 4.5cm = 88 → size C38, Table 10.

The measurements tell us quite a bit, but it is important to analyse these in combination with the figure illustrations. In this example the hunch is placed on the right side of the back. The back width indicates that the right side of the back is approximately 4.5cm larger than the left side. Lengthways, the right side is about +4.5cm longer than the left side and the nape to waist is 1cm longer than the standard pattern.

Table 10: The measurements indicating the hunchback

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Bust circumference</td>
<td>92.5</td>
<td></td>
</tr>
<tr>
<td>Back width</td>
<td>40.5</td>
<td>22.5</td>
</tr>
<tr>
<td>Nape to waist</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>H2 to waist through H1</td>
<td>47.5</td>
<td></td>
</tr>
</tbody>
</table>
The pattern has to be increased both lengthways and widthways, Figure 42. The increase is not as large as the measurements indicate. +3.5 cm will be added both lengthways and widthways. In order to get an acceptable form of the pattern pieces a dart is added along the shoulder seam and a fold is placed on the seye line. The dart and the folds prevent the seam over the hunch from being too curved. It is possible to change the dart to a fold and visa versa. The right pattern piece is increased by +2 cm at the hemline, which gives a looser fit around the waist under the hunch. This is to decrease the visible difference between the projection and the waist. The pattern pieces on the left side are altered very little, not only to compensate for the longer nape to waist but also to smoothen the contour of the back from the hunch on the right side over to the flatter left side.

Wheelchair user

Wheelchair users, Figure 43, have specific fitting problems with garments for the lower part of the body. Their problems for the upper part of the body are more concerned with the design of the garment. The jacket should not be too long because it can be uncomfortable and unpractical to sit on the garment. Another design detail is that the sleeves wear out by constantly touching the wheels, reinforcement might be the solution. These two example problems are not taken care of by only adjusting the garment according to the individual figure. The standard garment first has to be designed to fit the user demands. With that garment as a base, modifications can be made according to the figure in order to get a better garment fit. The trousers on the other hand have to be adapted in order to get a good garment fit.

Figure 42: Fitted jacket for the individual with a hunchback

Figure 43: Individual confined to a wheelchair
Illustration Helene Berglin

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164 It could also be suitable to modify the design and include the darts in a yoke.

165 They might be in need of individual garments for the upper part of the body as well but then it deals with disfigurements that are not specific for the wheelchair user, such as warped shoulder, hunchback etc.
The trousers available in the regular retail stores are made for a standing position. To fit the sitting position the balance between the front and the back needs to be rearranged, decreased at the front and increased at the back, Figure 44.

There are no measurements that indicate how much the balance needs to be rearranged. In this study the opportunity was given to try out how the adaptation should be applied on standard trousers. It is important to study the profile view of the individual. The adaptations and values presented here are for an individual with a rather horizontal waistline. If the waistline is sloping either forward or backward other adaptation values might be necessary. The balance between the front and back of the trousers is rearranged. The crutch is increased at the back, Figure 44. In total the crutch length is also lengthened. Note that the side seam of the front piece has much form. This has to be considered when adding other alterations to this area of the pattern.

![Figure 44: Fitting problems caused by the sitting position](image)

Illustration Helene Berglin

Other adaptations

The adaptations presented above are examples of adaptations which change the pattern according to a body shape disfigurement. Adaptations, which are common knowledge among pattern constructors, were not to be brought up here. However, a frequently used adaptation is the decreasing of the waist circumference. This can be carried out in many ways with and without additional darts. A couple of words should be said about this adaptation.

The hip circumference is usually used to identify the garment size suitable for the lower part of the body. Due to this the hip circumference usually corresponds quite well with the circumference of the garment. Adjustments are usually needed in the waist area. A larger decrease has to be done by adding extra darts along the waistline. A figure analysis is necessary in order to determine where the extra darts should be placed. By looking at the relation between the hip and waist area it is possible to determine where the decrease should be placed. If the largest difference between the hip and waist is at the back, the decrease should be added on the back piece. If the largest difference is at the front the extra darts should be placed on the front piece. However, it is as common that the decrease is evenly divided around the waist.

Individual patterns

The goal with altering patterns is to achieve well-fitting garments for individuals with various disfigurements. In this chapter single adaptations will be combined to fit a unique figure. The small measurement deviations and the larger adaptations according to the body shape disfigurements are both included in these individual patterns.

Each individual pattern will be presented according to the process presented in the chapter Made-to-Measure garments\(^{166}\). The style selection will not however be brought up in detail because the adaptations will be presented on the basic blocks without any styles added\(^{167}\). The measurements necessary for the specific garment and the individual body figure are presented and discussed. The presentation of the adaptations will be done in the same way as in the chapter Single adaptations. The adaptation plan illustrates the placement and values of the adaptations, this is done on a standard C38 block. The adapted pattern on the other hand will be compared with a standard block of the selected size, for example size C42.

The two individuals exemplified here are selected because they have disfigurements, which need various combinations of adaptations in order to get a well-fitting garment. The two test persons are called A and B.

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\(^{166}\) figure analysis → Style selection → Size selection → Needed adaptations

\(^{167}\) As said before, the reason for not using patterns with a specific style and details is that it would make it more difficult to see the specific alterations.
APPENDIX 3

Test person A

The most obvious disfigurements when analysing the figure of test person A are the arched back in combination with a prominent stomach, Figure 46. The buttocks are rather flat and almost aligned with the lower back. The hipbone on the left side is slightly prominent. Due to an operation on one of the hipbones she was not able to sit down for the measurement body rise. Instead the warped waist was determined only by the outside leg length.

The garments that will be presented here are the fitted jacket and the trousers. There were only a limited amount of styles within the project from which to choose. However, when selecting a style there are a couple of things to think about when it comes to this kind of body figure represented by test person A. Because of the prominent stomach it would be most suitable to select a fitted jacket that does not have a narrow emphasised waist. The fitted jacket has to have at least one seam on the back piece. Due to the arched back it is necessary to give the back piece more form than the standard jacket has. Considering the warped waist it would be more comfortable if the waistband had a little section of elastics168.

PATTERN ADAPTATIONS

Trousers

The size selection for the trousers is done according to the hip circumference that is exactly in-between two standard sizes. The larger size, C42, was selected in order to make the adaptation for the waist circumference a little smaller, Table 11.

Table 11: The needed measurements for test person A’s trousers

<table>
<thead>
<tr>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurements</td>
<td>Total</td>
</tr>
<tr>
<td>Height</td>
<td>154</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>85</td>
</tr>
<tr>
<td>High hip circumference</td>
<td>98</td>
</tr>
<tr>
<td>Hip circumference</td>
<td>100</td>
</tr>
<tr>
<td>Waist to floor – front</td>
<td>103.5</td>
</tr>
<tr>
<td>Waist to floor – back</td>
<td>97.5</td>
</tr>
<tr>
<td>Outside leg length</td>
<td>99</td>
</tr>
<tr>
<td>Inside leg length</td>
<td>72</td>
</tr>
</tbody>
</table>

The individual measurements related to the trousers are listed in Table 11. A few adaptations are needed in order to get a well-fitting pair of trousers. The measurement deviations are the hip and waist circumference, and the inside leg length. The prominent stomach and the warped waist will be considered according the single adaptations prominent stomach and warped waist alternative I explained in the chapter Single adaptations. The waist will be increased +7cm, as seen in Figure 47, page 80; some of the increase is done at the back darts but nothing at the front ones. This is because the flat buttocks do not need as much form as the prominent stomach169. The warped waist is adapted according to the outside leg length measurements. The whole difference is used because A’s warped waist is an ageing disfigurement, which probably will increase in the near future. In Figure 48, page 80, the adapted pattern is illustrated and compared with the standard size C42 trousers. Extra darts are added along the front waistline in order to give the length and form needed for the prominent stomach. The final pair of trousers are illustrated in Figure 51, page 83.

168 The right and the left waist measurements were not obtained at the start. The decision to add more width to the left side of the waist was taken after an evaluation of the test garment.

169 Elastics were available on some of the garments offered in the project and the outcome was more comfort and ease in obtaining a good fit around the waist.

Figure 46: Figure illustration of test person A
Illustration Helene Berglin
The size selection of the fitted jacket is done according to the bust circumference, Table 12. With size C44 as a starting point the measurement deviations are quite small. The arched back is the disfigurement on the upper part of the body that affects the garment fit the most. This is indicated by the measurements nape to waist back and nape to waist front.

Table 12: Needed measurements for test person A’s fitted jacket

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Height</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Bust circumference</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Hip circumference</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Neck circumference</td>
<td>41.5</td>
<td>39.3</td>
</tr>
<tr>
<td>Nape to waist back</td>
<td>42.5</td>
<td>41.6</td>
</tr>
<tr>
<td>Back width</td>
<td>37</td>
<td>38.8</td>
</tr>
<tr>
<td>Bust point</td>
<td>35.7</td>
<td>37.7</td>
</tr>
<tr>
<td>Nape to waist front</td>
<td>45.1</td>
<td>54.1</td>
</tr>
<tr>
<td>Shoulder width</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Arm length</td>
<td>60.6</td>
<td>60.6</td>
</tr>
<tr>
<td>Upper arm circumference</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Wrist circumference</td>
<td>16.5</td>
<td>18</td>
</tr>
</tbody>
</table>

The individual measurements related to the fitted jacket for test person A are presented in Table 12. The figure illustration and the measurements show that there are a few adaptations needed in order to get a well-fitting garment. Figure 49, page 82, illustrates how the measurement deviations for the bust, hip, shoulder width, arm length, and wrist are all adapted according to the difference value of each measurement. The waist measurement indicates that no adaptation is needed. However, due to the prominent stomach the waist of the garment has to be enlarged by +3cm. The neck measurement should be enlarged according to the measurement. When analysing the figure illustration this does not seem reasonable. The measurement was probably taken too loosely or the illustration lies. Due to the type of garment – a fitted jacket it is not critical to consider this measurement deviation. The arched back is altered according to the single adaptation archback explained in the chapter Single adaptations. The length of the nape to waist will be kept while the nape to waist front will be shortened -9cm. The shortening of the armpit depth of the front piece also takes care of the adaptation needed for the bust point. The length of the garment from the waist to the hemline is not adapted because the proportions were nice as they were.
In Figure 50 the adapted pattern is illustrated and compared with the standard size C44. The back piece is lengthened considerably, the larger shoulder dart gives more form to the back along with the formed centre back seam. The front piece is shortened and the bust dart is smaller.

The final result of test person A’s fitted jacket and trousers are shown in Figure 51, page 83. In order to get a balance between upper and lower part of the body test person A should wear a fitted jacket, cardigan, or blouse that covers the waist, as shown in the illustration to the right.
Test person B

When analysing the figure of test person B, the most visible disfigurement is the warped waist, Figure 52. The crooked spine compensates the warped waist and the shoulders are almost horizontal. The right and left sides of the back are not symmetrical. The right side is just a little prominent while the left side is rather flat. B’s neck is quite short, which should be considered when selecting the garment for the upper part of the body. The waist circumference is quite large when compared with the hip circumference.

When selecting a style there are a few things to think about when it comes to this kind of body figure. The garment for the upper body should be quite a straight design, without a narrow waist. This style is suitable considering the large waist circumference in relation to other body circumferences. The fitted jacket should have a collar and lapel and not a centre front that is buttoned all the way up. A collar and lapel fits better around a short neck. If the difference in the back width is going to be considered it is preferable if the garment has style lines from the shoulder and down on the back pieces. A pair of trousers should not be too wide in the lower part of the legs. Test person B has thin elegant legs, which look very nice in a short skirt. It is suitable and comfortable to have a little bit of elastic in the waistband due to the warped waist.

Skirt

The size selection for the skirt is done according to the hip measurement. The closest size in this case is C46, Table 13. The largest disfigurement for the lower part of the body is the warped waist, 7-10cm difference between left and right side of the body.

Table 13: Needed measurements for test person B’s skirt

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Height</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>Waist circumference</td>
<td>96</td>
<td>49</td>
</tr>
<tr>
<td>Hip circumference</td>
<td>108</td>
<td>53.5</td>
</tr>
<tr>
<td>Outside leg length</td>
<td>84.5</td>
<td>53.5</td>
</tr>
<tr>
<td>Inside leg length</td>
<td>62.5</td>
<td></td>
</tr>
<tr>
<td>Body rise</td>
<td>20</td>
<td>27</td>
</tr>
</tbody>
</table>

The useful measurements for the skirt are listed in Table 13. There are few adaptations needed in order to get a well-fitting skirt. There are some measurement deviations to consider in addition to some larger adaptations needed to compensate for the disfigurements, Figure 53, page 86. The waist and hip are adjusted according to the total difference value of each measurement. More width is added on the right side of the waist, indicated by the waist measurement. The warped waist is compensated according to the body rise measurement by using the single adaptation for warped waist alternative 2 explained in the chapter Single adaptations. The right side is shortened, -7cm and the left side is shortened –4cm and along the side seam, which increases the waist and places the waistband on the hip instead of in the anatomical waist.

If the garment measurement skirt length is not taken the skirt could be adapted in proportion to the inside leg length. If it is a long skirt it is shortened according to the inside leg length. On the other hand for a short skirt; to the knees – half of the leg – only half of the adaptation for the inside leg length is used. By doing so the length of the skirt will have approximately the same proportions on the test person as on a standard figure. However it is best is to have the desired garment measurement. This skirt, for test person B, is altered according to the inside leg length. It is a short skirt so half of the value will be used, -8cm. Due to the large size and the length of the test person the width of the lower skirt is decreased in order to get nice proportions between width and length. In Figure 54, page 86, the individual pattern is presented and compared to the standard size C46. The final skirt is illustrated in Figure 57, page 89.
Fitted jacket

The size selection for the fitted jacket is made according to the bust circumference, Table 14. C46 is the most suitable size for test person B.

Table 14: Needed measurements for test person B’s fitted jacket

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Individual measurements</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Right</td>
</tr>
<tr>
<td>Height</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>Bust circumference</td>
<td>106</td>
<td>104</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>96</td>
<td>49</td>
</tr>
<tr>
<td>Hip circumference</td>
<td>108</td>
<td>53.5</td>
</tr>
<tr>
<td>Neck circumference</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Nape to waist back</td>
<td>29</td>
<td>41.8</td>
</tr>
<tr>
<td>Back width</td>
<td>40</td>
<td>21.5</td>
</tr>
<tr>
<td>Bust point</td>
<td>35</td>
<td>37.5</td>
</tr>
<tr>
<td>Nape to waist front</td>
<td>44.5</td>
<td>43</td>
</tr>
<tr>
<td>Shoulder width</td>
<td>12.5</td>
<td>12</td>
</tr>
<tr>
<td>Arm length</td>
<td>50.5</td>
<td>49.5</td>
</tr>
<tr>
<td>Upper arm circumference</td>
<td>30.5</td>
<td>30</td>
</tr>
<tr>
<td>Wrist circumference</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Body rise</td>
<td>20</td>
<td>27</td>
</tr>
</tbody>
</table>

The measurements that need to be studied are presented in Table 14. These measurements reveal that there is a need for some adaptations to be added to the pattern in order to get a well-fitting garment. All adaptations are presented in Figure 55, page 88. The bust, waist, shoulders, sleeves, neck, and wrists are all altered according to the measurement values. The nape to waist back needs to be shortened with almost -13cm while the nape to waist front needs a shortening of only -11cm, according to the average value. The shortening of the nape to waist is done in two places, with the total value of -11cm. Increasing the centre front with +1cm compensates it, the nape to waist front is shortened -10cm in total. The lengthening of the centre front increases the bust dart, which adds more form to the garment. The total length of the garment is also shortened according to the average body rise measurement, -4cm. The back width is altered, the left side is decreased by -1cm, while the right side is increased by +1.5cm. In Figure 56, page 89 the adapted pattern is illustrated and compared with the standard size C46. The final result of test person B’s fitted jacket and skirt are shown in Figure 57, page 89.
Figure 55: Adaptation plan for test person B’s fitted jacket

Figure 56: Test person B’s adapted fitted jacket

Figure 57: Test person B’s final garments

Illustration Helene Berglin
Evaluation of made-up garments

The evaluations of the test garments aimed to establish how to adapt a pattern for a certain disfigurement in order to obtain a good fitting and comfortable garment. This evaluation was done by the experts only. When evaluating the final garments the end result was in focus. If the criteria fair was marked the cause was studied in relation to the figure analysis, style of the garment, size and used adaptations. An explanation to the evaluation fair evaluation was usually found. Sometimes the individual had lost/gained weight, which affected the measurements. The different sections of the final garments were usually evaluated as excellent. In phase B there were 25 different evaluation points to be judged by the experts. Thirty-seven garments divided between the 15 test persons were evaluated, the experts marked 94 percent of all evaluation points as good (N 294). The experts evaluated 10 garments for five test persons in phase C. Each section were evaluated and the experts marked 85 percent of the points as good (N 95).

The evaluations have two purposes. The first is to evaluate the adaptations of the garment, e.g. point out possible improvements of the single and the combined adaptations. The second one is to evaluate the final made-to-measure garment. The individuals using the garments are the only ones who can evaluate the comfort of the garment. The test persons evaluated critical areas of the garments, such as waist, hip, shoulders etc. The evaluation of these critical areas was used in the process of improving the adaptation methods. The test persons were also asked to evaluate the overall comfort of the final garment. Figure 58 shows that the majority of the test persons in phase B marked the overall comfort of the garment as excellent.

A follow-up evaluation was done among the test persons who participated in phase B. The test persons reported how many times they have used the garment, Figure 59. Most of the test persons had used their garments 1-5 times or more. The test persons who have answered that they had never used their garments explain why. Some of the explanations are; the waist is too big due to loss of weight, the colour is too light and gets dirty too easy, the details are not as desired, and the trousers are too thin to wear in the winter time.

The comfort of the garments was evaluated after the test persons had a chance to use their garments, Figure 60. The skirt shows the largest evaluation difference compared to the first evaluation.

The evaluation of phase C is not completed and can not fully be reported and analysed in this study. Only ten garments have been evaluated in phase C. Six of these garments were evaluated, by the test persons, to have a good overall comfort and 4 were marked to have an excellent overall comfort.

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171 Thirteen evaluation points for the fitted jacket, six for the skirt and the trousers respectively. See Appendix 5.
Reflections

Clothes are an important part of our everyday and social life. Everyone wants to feel a part of a group and be able to find clothes that are significant for that group. Clothing is important for personal development and the first impressions are greatly affected by the clothes. This has been established by previous research with various perspectives. The perspective of this study has been technological but also esthetical. In order for individuals with large disfigurements to get well-fitting and esthetical garments it is necessary to continuously develop the pattern construction methods.

Finding suitable clothes

Unfortunately there are individuals that cannot select their clothes according to their desire. Impaired, disabled and elderly have largest difficulties with finding suitable garments include. They have to select garments that they can fit into or that are possible to alter. It is most important for them to be able to select the garments according to their desires, the function of the garment comes in second place. Agility and social integration are improved for the disabled/impaired when they have adapted/suitable garments, they became less handicapped/disadvantaged.

The problem of finding suitable garments for the disabled/impaired is first of all affected by the disfigurement and secondly by the lack of technical solutions e.g. Velcro instead of zipper or buttons. The companies offering garments for a specific target group e.g. wheelchair users, offer garments for a sitting position in combination with technical solutions. They seem to focus too much on the technical solution. Among the test persons who participated in this study there were only a few that would need special technical solutions. There are many individuals who are in need of made-to-measure garments but do not necessarily need other technical solutions than those offered on standard clothes. The garment fit and the technical solutions should be available separately or in combination if necessary.

The latest sizing system for women in Sweden was compiled during the 1970’s. The new system was intended to facilitate the situation for the industry, the retail store, the consumer, and for education in the trade. Better fit, fewer sizes, and making it easier to find the right size were among the things that would be improved by a new sizing system. I think it is a contradiction to suggest that fewer sizes would improve garment fit and make it easier for the consumer to find the right size. It is an improvement when all manufacturers use the same sizing system and labelling. But I do not understand how fewer sizes could offer a better garment fit. The more variation in sizes that garments are produced the more people with figure variations can find suitable garments.

![Figure 10](image)

Figure 10, page 40, illustrates the process of creating an individual garment. The EASYTEX project has dealt with all steps without the making – up and the delivery of the final garments. Within this study the focus is on the individual patterns and the associated figure registration. However, there are quite a few steps within the whole process that could be studied, explored and improved as well.

Today there are some manufacturers that produce made-to-measure garments. Most of them produce garments for uniforms. Of all the garments 20 percent are returned, which is a pretty large percentage especially when considering that people in uniform probably do not have that many large disfigurements. It would be interesting to know why the return rate is so high. Is it the figure registration that is made incorrectly or is it the adaptations? Or maybe the customers have high demands?

Different measurement charts have been developed for specific groups, such as Down’s syndrome, and for individuals with a short stature. Clothes could be mass-produced in “standard” sizes according to these special charts. This would help the individuals that come within the sizes in these specific charts. However the problem in producing garments for such a small target group would be the small potential market. There might be a large number of such people in the whole world, but it would be difficult and costly to reach them all. Within the small target group the way of dressing and the styles preferred, probably varies as much as it would between individuals with a standard figure. Studies have shown that the impaired and disabled want to select their clothes from the regular supply in the retail stores.

With the perspective of the whole clothing market the target group with large disfigurements is rather small. If this target group could be included in the regular market it would be more attractive for the manufacturers. If the clothing industries offered mass customisation the variety of supplies would increase. Garment fit could also be improved by modifying the garment according to the individual figure. This would make it possible for the customer to maximise the purchase instead of just satisfying it. The mass customisation would benefit not only the individuals with disfigurements but also the customers with high demands on the different aspects of the garment. The retail stores and the manufacturers should offer what the customer wants to buy. The customer should be able to buy what they really want instead of just buying what the retail stores offer. The factor that might stop individuals from buying

172 (Thorén, 1992)
173 (Cednäs and Kjellnäs 1977)
174 Companies commissioned to make – up the garments did this.
175 The garments were not delivered. The test persons came to the university in order to evaluate them and pick up the garments.
customised garments is the price\textsuperscript{176}. It might also be a disadvantage for some that the garment has to be produced after the order is placed. It would not be possible to take the garment home right away.

Possibilities with newly developed solutions

Today, the hardware and software are available for the industry to offer mass customisation. They must put these new technical solutions into use in order to give better service to their customers. Other mass production means such as the car industry, have changed in order to give their customers the possibility to compose the product according to their individual desires. According to Hoffman (1979) there are six factors that the customer would like to have satisfied in a garment. By using the available software it is possible to offer customers to maximise their purchase within these areas. (1) Fashion – selection of a fashionable garment in the retail store, available for mass customisation. (2) Design – possibility to select desired details in the garment. (3) Colour – selection of fabric and along with that the selection of colour. (4&5) Comfort & Fit – the garment is modified according to the individual measurements and body figure. (6) Cost – with the software and automated equipment the cost for the customised garment is kept down. The clothing industry has to choose the direction; standard sizes only, made-to-measure, mass customisation, or a combination of these. Mass customisation not only benefits the customer. The manufacturer does not have to decide how many garments of each design/colour/style should be produced. Overproduction should be limited. The store does not have to keep as many sizes and variations in stock. This decreases the needed area in the stores, which affects the costs. But all this is another study!

Today most made-to-measure garments are produced for high quality men’s wear. This is probably because the type of garments, e.g. jackets, trousers, and shirts do not change that much from season to season. Fashions in women’s clothing change often. More preparations are needed in order to offer made-to-measure garments when the designs are replaced quickly.

It is interesting how clothing production has changed over the decades. Clothes used to be made-up at a tailors shop or at home, and were automatically customised. The standard sizes came into the picture when the customer could not wait for the garment to be made-up. When the standard sizes garment were accepted and the sewing machine entered the market the manufacturers took over most of the clothing production. However, there were some customers that still wanted customised garments. The technical development has continued and it is now possible to get customised garments from the manufacturers.

The tailors should take advantage of the new techniques and apply it to their traditional businesses. They could build up the system with the knowledge they have in producing the tailored garments and save some time.

The necessary know-how

It is great that the technique is developed in order to be able to offer better service and products to the customers. However, one has to remember that the technique is only an aid, to perform what the human being wants it to do. The knowledge about figure analysis and pattern construction is still essential. The larger disfigurement the system is programmed to handle, the more knowledge is needed to build it up and run it. The main reason for this study is, therefore to document the adaptations necessary for certain large disfigurements.

Method

The unique figures within this study are short/tall, warped figure, prominent figure, and wheelchair user. These were created according to how the pattern is adapted, Table 1, page 34. This can be taken one step further. The disfigurements can be divided into three categories instead. The warped figure and the wheelchair user can be put in the same category. The pattern is adapted in order to adjust the balance of the garment. For the warped figure the balance of the garment needs to be adjusted according to the left and the right side of the body. The pattern adaptation for the wheelchair user adjusts the balance between the front and the back of the garment.

The uneven distribution between the upper and lower parts of the body, Figure 7, page 34, within each category has its explanation. When an individual has a warped lower part of the body it seems as though the body usually tries to compensate it, the upper part of the body e.g. the shoulders are not necessarily warped.

The largest projections seem to be around the shoulder blade/scapula and around the ribs. There are some projections to the lower part of the body but usually they are much smaller. Wheelchair users all need the garment adjustments according to the sitting position, but the upper part of the body may have other disfigurements, which fit into the other categories, or no disfigurement at all.

The methods used for the different steps will be discussed, along with the discussion of the result.

Figure registration

Figure registration was done by taking measurements and by photos. These are then used for the figure analysis, which is important in order to create an individual pattern. As said previously, the measurements were modified as the study proceeded. The experience gained while working with various body figures, led to another way of measuring and analysing the information in certain areas. Now, when analysing the data once more another connection between the measurements and the pattern construction has been discovered. Some of the measurements would have been easier to obtain with an anthropometer, for example the inside leg length. It would have been better to obtain certain measurements with an anthropometer because it measures distances without including any outward projections of the body, for example the height of neck point and the height of shoulder point. Some measurements would have been better measured both with an anthropometer and with a tape measure, for example outside leg length. For the study this measurement was taken with a tape measure. This measurement determines if the subject has a warped waist and if there is a projection on either side of the body. To determine if the waist is warped the outside leg length should be measured with an anthropometer in order to exclude any outline projections of this part of the body. Ideal measurements only indicate one thing per measurement.

During the measuring, the subject moves when the different measurements are taken or in order to sit down and take a rest. The skeleton and the body mass might shift around and

\textsuperscript{176} A study made within the EASYTEX project showed that only about one third of the test persons were willing to pay the calculated price for the made-to-measure garments: fitted jacket 2500skr/300€, trousers 1450skr/168€, and skirt 1350skr/162€.
could give illogical measurements. If the measurements are taken with a body scanner the procedure takes only a couple of minutes and the subject moves just once. The measurements are obtained when the subject is standing in only two positions. It is important to instruct the subject not to move the body in unusual ways, such as pulling in the stomach or moving the shoulders upward or forward etc. When measuring manually the subject is reminded not to move if doing something unusual which changes the position in different ways.

One of the advantages of automatic measurement is that it is possible to go back and check how the landmarks are placed and how the measurements are obtained. This would have been useful in the case of test person A in order to control how the actual neck circumference is taken. The measurement seemed to be too large when analysing the figure illustration. The neck circumference was not adapted even if the measurements indicated that the circumference should be increased. This could be done because a test garment was sewn and there was a chance to modify the circumference if necessary. It might not be wise to “ignore” an adaptation like this if the order goes directly into production, without any test garment. This example illustrates once more that the measuring procedure is extremely important in order to make the right decisions when later doing the pattern construction.

The garment measurements are sometimes useful, for example to obtain the length of the skirt. The main reason to take this measurement is, of course, to make the length of the skirt according to the individual’s desire. It is better to have an actual measured value of the length instead of talking about short or long skirt. The length of a “short” skirt might vary quite a bit from person to person. The same could be said for the sleeve length. In addition to the arm length it might be a good idea to register what sleeve length the individual feels comfortable with. Note that the length of the actual sleeve on a fitted jacket with shoulder pads should always be longer than the sleeve length measured on the body, due to the thickness of the shoulder pads.

The photos would have been easier to analyse if they had been taken with the individual standing in front of a large grid. This would have made it easier to analyse the figure in relation to the horizontal and vertical lines. Sometimes it was awkward to take the photos, especially when the individual did not wear a bra or because of the personality/shyness. Not all the photos were taken with the subject just in underwear. This is not desirable because disfigurements do not usually show clearly with clothes on. When arranging the appointment with each subject an information letter should have been sent out in order to inform them what was going to happen. This would have made them more prepared and the situation would not have been as awkward.

It is important to analyse the measurements and the figure illustration in order to decide which adaptations should be applied to the garment. This applies when the measurements are taken as presented in this report. It would be interesting to see if it is possible to get a stronger connection between measurements and the pattern adaptations. The measurements probably need to be of another character than the measurements obtained in this study. The vertical and horizontal measurements should be combined with outline measurements. Because of the complexity of the measurements they should be obtained with some type of reliable body. New connection between the measurements and the pattern adaptation could probably be explored by an extensive statistic survey. However, this should probably not include larger disfigurements such as those exemplified in this study.

Made-to-Measure garments

The process of making the individual patterns has followed almost the same routine throughout the study. However, there has been some differences between the phases, Figure 9, page 39. In phase C there were almost no test garments sewn. However in some cases when the disfigurements are extensive it is better to sew a test garment in order to control if the correct adaptations are applied. The same process can be followed when making an individual garment, but depending on the disfigurements it might be suitable to sew a test garment and sometimes it is possible to go directly to the making-up.

When the individual garment is created there are many factors affecting the outcome of the garment. One of the aspects is to make the garment comfortable for the wearer. This is quite difficult to incorporated in the individual garment, especially if the individual has not been able to try at least a standard size of the designed garment. This is usually not possible for individuals who diverge greatly from the standard figure. The tolerance over for example the bust varies between individuals. Individuals with large disfigurements might also need larger tolerance in their garments in order to allow freedom of movement. For example an extremely short individual climbs stairs in a different way to a taller person. The legs of the short individual have to be able to swing to the sides and then forward instead of just being lifted up and forward. It is difficult for the subject to know or imagine exactly how the finished garment will feel. This risk is always present when producing an individual garment, whatever method is used. The risk might be a little less when the garment is tried out during the making up process; then it is possible to do small modifications. It is important that the individual gets correct guidance when selecting the garment type and design. It should be according to the individuals style, but also according to the body figure – it has to be possible to adapt the pattern for this figure.

In this study the garments have always been according to the 40-series. The test persons have usually been shorter than 168cm in height, which is the average for the 40-series. The reason for not using 20-series (160cm ±4cm) for example was simply because well-developed patterns for the 40-series were available. However, by using the 20-series it would not have decreased the number of adaptations, only the applied value. Of course it is better to adapt a pattern with as small values as possible but the length difference between the 40-series and 20-series is so small that it would probably not matter so much when adapting patterns for large disfigurements, which is done in this study.

The smallest size of garment used in the study was C32. In a couple of cases it would have been better to use one size smaller as a starting point. The smallest size in the chart is C32, so C30 is officially not available. However, it would have been suitable because it would have decreased the number of alterations.

177 Telmat’s body scanner Symcad needs two photos from the front/back and from the profile.

178 (Nyman, 1999)

179 It is always preferable to alter the tried-out, standard garment as little as possible. Small alterations give a more reliable individual garment pattern.
Measurements and adaptations

The methods to measure and adapt patterns have been modified and improved along the way. Some small adaptations applied to the patterns in the beginning would not have been applied if the patterns had been made later on in the study.

It is very important to place the landmarks on the correct locations of the body. If the anatomical waist is difficult to find the subject is asked to place the cotton hand where the waistband should be placed, which usually is lower than the anatomical waist. When measuring, for example, the body rise – centre front it should be noted that the waist is not placed at the anatomical waist. This measurement can not be compared with the standard body measurement, it has to be compared with the garment measurement of the centre front. If the measurement is compared with the standard body measurement it will indicate that this distance should be lowered on the trowsers, which would lead to the waistband being place too low on the garment. Another important aspect is where the individual would like to have the waistband. It can vary quite a lot between individuals.

The goal was to obtain only the measurements necessary to determine how the garments should be altered. The right and left sides of the body were only measured when judged as necessary by the experts. In order to control exactly whether there is a difference between the right side and left side of the body the body halves should always be measured. However, if there is a small difference between the halves, not noticed by the eye, it does not matter for the outcome of the garment fit. In the beginning of the project there were subjects whose right and left sides of the body were not obtained separately. The adjustments according to the left and right sides of the waist for example had to be adjusted after the first test garment. This is exemplified on the trousers for test person A. Consequently, the measurer has to decide if the specific measurements should be obtained or not. If not certain, it might be better to register the left and right sides of the body, especially if no test garment will be sewn. One of the advantages of automatic measurement is that all such measurements can be taken without extending the time required for the measurer or the “customer”.

The height measurement was not always taken; the test person was instead informed about the value. Now, when analysing all measurements once more, this measurement should have been obtained as well, in order to be sure of the correct value. Using an anthropometer would have been suitable. Having this measurement did not affect the outcome of the garment fit but it is confusing when studying the height in relation to other length measurements. When studying the short stature, page 58, the height difference does not correspond with the other length differences. The length adaptations, related to the total height, are inside leg length -27.5cm, body rise -3cm, and the nape to waist back -5.5cm. All these negative values add up to -36cm, in comparison with the total height, which indicates a total shortening of only -31cm. Before starting to analyse the reason for the different values it should be said that the final garments, skirts, trousers, and fitted jacket, had an excellent fit. This indicates that the inside leg length, the body rise, and the nape to waist back have the correct values. Three explanations could be possible. (1) If the height is correct the distance from the nape to the top of the head must be 5cm longer than that of a standard individual with a height of about 168cm. This does not seem reasonable when analysing the figure illustration. (2) There might be small errors in the individual measurements obtained, they must, however, be small errors that did not affect the outcome of the excellent garment fit. (3) The last possible error is that the height of the individual is incorrect. The true explanation might be a combination of all three suggested.

The nape to waist back should maybe be measured as a vertical distance measurement as well as an outline measurement, particularly if the back has a large disfigurement. The distance measurement would give the vertical measurement without the disfigurement. It would be easier to know what has to be adapted on the pattern according to the distance value and what needs to be adapted in relation to the disfigurement.

The nape to waist back and the nape to waist front can indicate the balance between the front and back. When adapting the pattern according to these measurements, for example arched back page 68, the adaptations are placed from the waist and up and not along the waistline.

When analysing how this measurement is taken and how it is used in the pattern it might be better to taken these measurements on a horizontal line. Sometimes the waistline is not at the same level in the front and in the back. The waist on a fitted jacket should however always be horizontal in order to look the best. An example: If the waist is not horizontal, it might be lower in the back in relation to the front. The nape to waist front will be measured to a higher level than the nape to waist back and therefore the balance between the front and the back is not clearly indicated. The measurements include both the balance difference and the sloping waistline, which makes it more difficult to analyse the measurements.

The shoulder width is always taken on both the left and the right sides of the body. If the shoulders are of different widths the aim is to make the garment’s shoulders to harmonise with the individual shoulders but at the same time the garment should look as symmetrical as possible. The whole difference between the right shoulder and left shoulder might not be considered when adapting the pattern. The shorter shoulder might not be shortened as much as the measurement indicates. In this case it is important to make sure that this shoulder has support so it does not sag and gives a poor garment fit in this area. The support does not have to be a thick shoulder pad, it can be a flat shoulder pad with good stiffness180.

By using the inside leg length and the outside leg length the body rise can be controlled. It might not be necessary to measure the body rise measurement, at least not when measuring a standing person. When studying the measurements used when adapting the skirt for test person B, page 85, a difference of 10cm was indicated between the left and right sides of the outside leg length. Comparing the left side to the right side of the body rise the difference is only 7cm. The reason for the different values are not studied here but it might be because the measurements are obtained when the subject is in two totally different positions, standing up and sitting down. This might change the position of the skeleton and shift the body mass around, which could explained the different values. In the case of test person B the explanation could also be different leg lengths, which makes the pelvis more warped when standing up then when sitting down. In another case the largest difference was obtained by the body rise. So in those cases the difference can not be explained by difference in leg length. In the last case something must have happened when the position was changed. This should be studied further before excluding the body rise measurement.

Test garment

The goal of the EASYTEX project was to make the process of made-to-measure as similar as possible to real manufacturing. This meant that the test garments had to be eliminated in the

180 A shoulder pad with good stiffness but without thickness is easy to create with a piece of fabric and some layers of interlining.
final part of the study. When working with large disfigurements in many combinations it is advisable to sew a test garment and/or to try out the garment during the making up. When testing the garment, small modifications can be noticed which are impossible to discover when making only a figure analysis. The work method, depends on how extensive the disfigurements is, what kind of garment it is, and the experience of the pattern constructor.

Making-up
The making-up process has not been followed in this study. It would however be interesting to study the whole process of producing mass customisation of garments within the industry. There are many aspects to think about. The manufacturer has to have a stock of fabric in order to be able to produce the garments quickly. The colour of the thread needs to correspond to the fabric, which can be difficult if there are made-to-measure garments of different colours. The single garment has to be held together all though the making up process. There has to be a larger amount of garments produced before this kind of study can be made.

Evaluation of made-up garments
More than half of the women in a survey could not find suitable trousers. This can be because many areas of the body affect the fit of the trousers as another study shows; hips, buttocks, thighs, crotch, and length of trousers are noted as giving the least satisfaction. These quoted studies underline the fact that the evaluation results for trousers are excellent in this study, Figure 58 and 60, page 90.

The evaluation was not anonymous and that could affect the answers given by the test persons in their two evaluations. However, it was important to be able to study some of the answers in relation to the figure analysis, style of the garment, size and used adaptations. As said before it was not practical to have the study done anonymously due primarily to the many face-to-face meetings between the experts and the test persons.

The overall impression and the comfort and fit of the garment are evaluated by the test persons. This might indirectly include an evaluation of the type and design of the garment and also the type of fabric and the colour. Because the test person did not have so many designs to select from, especially in phase B, they could not avoid a design or detail that they did not like. This might affect the evaluation in a negative direction. When mass customisation is available on the market the assortment will be larger and the customer will have more to choose from.

The evaluation done by the test persons concerning the comfort of the garments were quite positive. When evaluating the comfort of these garments they could compare them with the comfort of other garments they use. The garments they usually wear might not be adapted so much, which leads to a poorer fit. On the other hand they might never have used a fitted jacket before and therefore they are not used to the feeling and restriction of movement this type of garment gives. They might indirectly compare the comfort of a fitted jacket with a cardigan, which is not comparable.

The first evaluation, Figure 58, page 90, done by the test persons is quite positive. They answered the questions while they had the garment on. It might be difficult to fully evaluate the comfort without using the garment a couple of times.

All the garments in phase C were not all evaluated when this report was completed. The ten garments that were evaluated so far indicate that it is possible to make made-to-measure garments without a test garment sewn before making-up. However, the conclusion concerning this matter should not be made until more garments are evaluated.

The follow-up evaluation was interesting to make, the idea was to find out what the test persons thought about the garments and, primarily for this study, what they thought about the comfort when they had used the garments for a while. It might have been better to do this follow-up evaluation after a year. Some garments are used in certain seasons depending on the design and on the type of fabric and the colour. If the evaluation had been done after a year the individuals would have had the chance to use the garments in the correct season. The amount of times the garments have been used depends on many factors, for example the season, style, design, details, fabric, colour, comfort, fit etc.

It is interesting to see that the evaluation of the comfort of the trousers and the fitted jacket is quite good. The skirt evaluation on the other hand shows more of a spread regarding the comfort. It is much easier to get a good comfort and fit in a skirt than to get it in a pair of trousers or a fitted jacket.

Conclusion
The process of how an individual garment is created has been explored in this study. The main focus has been on the individual pattern and, in relation to that, the figure registration.

The same procedure for making individual patterns can be used for different kinds of disfigurement. However, if the disfigurement is large and/or in many combinations it is best to sew a test garment.

The most important conclusion drawn from this study is that it is possible to create individual garments to fit individuals with large disfigurements. The measurement and adaptation methods presented in this study should be further improved in order to contribute to continuous development of the knowledge within these areas.

I look forward to continuously expanding my knowledge within the field of pattern construction and other related areas in the future.

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181 (Cednäs, 1973)  
182 (Labat & DeLong, 1990)
Sammanfattning


Tidigare forskning visar att det finns framför allt tre områden som måste förbättras för att det skall bli möjligt att tillverka kläder till dem med avvikande figurer. För det första måste metoderna för hur man kan erhålla nödvändiga kroppsmått genom fotoanalys utforskas vidare. Dessutom måste rationellare metoder för att individanpassa mönster tas fram och i anslutning till detta måste programvaror för måttbeställning utvecklas samt även specialistkunskap inom området.


De tekniska hjälpmedel som finns tillgängliga idag gör det möjligt för industrin att erbjuda kunderna ett individanpassat estetiskt tilltalande och välsittande plagg. Men det mäste också finnas en kunskap om hur man förändrar ett standardmönster för att uppnå samma mål. Denna studie syftar till att utforska och utveckla metoder för hur mönster skall förändras när den enskilda figuren har stora avvikelser från standard. Metoder och erfarenheter diskuteras med två områden i fokus:

- DET INDIVIDANPASSADE PLAGGET – PROCESSEN
- MÖNSTERKONSTRUKTIONEN

På vilket sätt måste ett mönster förändras för att ge ett välsittande plagg för individer med stora figuravvikelser?

Det empiriska materialet till denna studie har samlats in inom projektet EASYTEX. Totalt valdes 29 kvinnliga provpersoner ut att delta i projektet. De delades in i fyra kategorier: kort/lång, sned, puckel eller liknande samt rullstolsburen.


APPENDIX 3


Den främsta slutsatsen av denna studie är att det är möjligt att utforma metoder för att individanpassa mönster även för individer med stora figuranalys.

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diagram index and appendix in English/ (Stencil 45). Göteborg, Sweden: Institutionen för anatomi & Avdelningen för handikappforskning [Department of anatomy & Department of handicap research].


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Appendix A: Pattern adapted according to Frost’s method (1987, p.30)
Appendix B: From order to complete garment
Illustration Helene Berglin

Appendix C: Evaluation of test garments

Avprovning av plagg [Testing of garment]

Kundnummer: [Customer number]  Datum: [Date]
Namn: [Name]
Typ av plagg: [Type of garment]

Helhetsintryck [Overall impression]:

- Ändringar som gjorts [Applied adaptations]

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<th>Kommentar [Comment]</th>
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**Kundnummer [Customer number]: ____________**

### Ändringar som ej gjorts [Adaptations not applied]

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### Kontrollmått [Control measurement]

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<th>Typ av mätt [Type of measurement]</th>
<th>Mått [Measurement]</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Om något ej är bra – vad beror det på? [If something is not good – what is the cause?]

Felaktiga ändringar [Wrong adaptations] ________________________________

Måttfel [Measurement errors] ________________________________

Modellen ej bra [The style not suitable] ________________________________

### Övriga åsikter [Other opinions]

<table>
<thead>
<tr>
<th>Modellförslag [Style suggestions]</th>
<th>Diverse [Other]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

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**APPENDIX 3**

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**APPENDIX 3**

---

**TEST PERSONENS ÄSIKTER [TEST PERSON'S OPINION]**

**Namn:**

[Name]

Vilka plagg använder du helst? [Which type of garments do you prefer?]

Byxa

[Trousers]

Kjol

[Dress]

Skjorta/Blus

[Shirt/Brous]

Klänning

[Dress]

Jacka

[Jacket]

Kavaj

[Fitted jacket]

(annat [other]) __________________________

Hur får du vanligtvis bra passform på kläder i dag? [How do you get clothes with a good fit today?]

Skräddare

[Tailor]

Konfektion

[Ready-made]

Ändrar konf. [Alter ready-made]

Syr själv

[Sew myself]

(annat [other]) __________________________

**BKVÄMLIGHET [COMFORT]**

Hur bekvämt är plagget? Detta måste bedömas i förhållande till vilket plagg det är, en storskjorta kan inte kännas på samma sätt som en figursydd kavaj. [How comfortable is the garment? This has to be judged in relation to what type of garment it is, a shirt can not have the same feeling as a fitted jacket.]

Kryssa i nedan vad du tycker om bekvämligheten. [Mark what you think about the comfort.]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Midja [Waist]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gren [Crutch]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midja [Waist]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
<td></td>
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</tr>
</tbody>
</table>

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Appendix D: Test person’s valuation of final garments, phase B

116
### fortsättning BEKVÄMLIGHET [continuation COMFORT]

|----------------------------------|------------------|------------|------------------------|

Om Du svarade Mindre bra på någon fråga under BEKVÄMLIGHET vad var det som ej var bra? [If you have answered Fair on any of the questions under the headline COMFORT what was it that was not good?]

### ÖVRIGT [VARIOUS]

Vi har alla olika stil och trivs i olika sorters kläder. Hur tycker du att dessa kläder stämmer överens med din känsla? [We all have different styles and feel comfortable with different sorts of garments. How do you think these garments agree with your clothing style?]

|--------------------------------------------|------------------|------------|------------------------|

Om Du svarade Mindre bra på någon fråga vad var det som ej var bra? [If you answered Fair on any of the questions, what was it that was not good?]

Vi tackar för Din medverkan och Ditt engagemang!! [Thanks for you participation and you commitment!!]
**APPENDIX 3**

**Appendix E: Expert’s evaluation of final garments, phase B**

### VÅR OBJEKTIVA BEDÖMNING [OUR OBJECTIVE EVALUATION]

<table>
<thead>
<tr>
<th>Provperson:</th>
<th>Kategori:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Test person]</td>
<td>[Category]</td>
</tr>
</tbody>
</table>

#### PASSFORM KAVAJ [FIT OF THE FITTED JACKET]

Bedöm plaggets passform främst utifrån dess helhet. Följande tre kategorier bedöms; rörelsevidd, form i harmoni med kroppen samt sömmer/skärningar/detaljer. [Evaluate the garment fit primarily from its total fit. Following categories are evaluated; tolerance, shape in harmony with the body figure and seams/style lines/details.]

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Byst [Bust]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midja [Waist]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm [Sleeve]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axlar [Shoulders]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ärmhål [Scye]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armar [Sleeves]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krage [Collar]</td>
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</table>

#### PASSFORM BJÖRKA [FIT OF THE SKIRT]

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Midja [Waist]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Längsgående söm fram/bak [Longitudinal seam front/back]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopp [Zipper]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ärm [Sleeve]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axelsöm [Shoulder seam]</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fickor [Pockets]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krage [Collar]</td>
<td></td>
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</tbody>
</table>

#### PASSFORM BYXA [FIT OF THE TROUSERS]

Bedöm plaggets passform främst utifrån dess helhet. Följande tre kategorier bedöms; rörelsevidd, form i harmoni med kroppen samt sömmer/skärningar/detaljer. [Evaluate the garment fit primarily from its total fit. Following categories are evaluated; tolerance, shape in harmony with the body figure and seams/style lines/details.]

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Midja [Waist]</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Längsgående söm fram/bak [Longitudinal seam front/back]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopp [Zipper]</td>
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<tr>
<td>Ärm [Sleeve]</td>
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<tr>
<td>Axelsöm [Shoulder seam]</td>
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</tr>
<tr>
<td>Fickor [Pockets]</td>
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<tr>
<td>Krage [Collar]</td>
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</tbody>
</table>
**APPENDIX 3**

<table>
<thead>
<tr>
<th>Test person’s evaluation of final garments, phase C</th>
</tr>
</thead>
</table>

**TEST PERSONENS ÅSIKTER [TEST PERSON’S OPINION]**

- **Namn:** [Name]

- **Vilka plagg använder du helst? [Which type of garments do you prefer?]**

  - Byxa [Trousers]
  - Kjol [Skirt]
  - Skjorta/Blus [Shirt/Bouse]
  - Kläning [Dress]
  - Jacka [Jacket]
  - Kavaj [Fitted jacket]

- **Hur får du vanligtvis bra passform på kläder i dag? [How do you get clothes with a good fit today?]**

  - Skräddare [Tailor]
  - Konfektion [Ready-made]
  - Ändrar konf. [Alter ready-made]
  - Själv [Sew myself]

- **Övriga kommentarer. [Other comments.]**

**AVVIKELSE [DISFIGUREMENT]**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Allmän känsla [Overall comfort]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midja [Waist]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
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</tbody>
</table>

**BEKVÄMLIGHET [COMFORT]**

<table>
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</thead>
<tbody>
<tr>
<td>Allmän känsla [Overall comfort]</td>
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<tr>
<td>Midja [Waist]</td>
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<tr>
<td>Stuss [Hip]</td>
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</thead>
<tbody>
<tr>
<td>Gren [Crutch]</td>
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<td></td>
</tr>
</tbody>
</table>
### ÖVRIGT [VARIOUS]

Vi har alla olika stil och trivs i olika sorters kläder. Hur tycker du att dessa kläder stämmer överens med din klädstil?

[We all have different styles and feel comfortable with different sorts of garments. How do you think these garments agree with your clothing style?]

Är det något du vill kommentera angående till exempel material, detaljer?

[Is there something you would like to comment, for example the fabric, details?]

Hur upplever du dessa plagg, med tanke på passformen, jämfört med dina nuvarande plagg?

[How do you feel about these garments, in the matter of fit in comparison with the garments you usually have?]

Övriga kommentarer från Dig som provperson.

[Other comments from you as a test person.]

---

### HELHETSINTRYCK [OVERALL IMPRESSION]

Helhetsintrycket är viktigt när vi klärs oss. Kryssa i nedan vad du tycker om helhetsintrycket för de olika kombinationerna. [The overall impression is important when we dress. Mark what you think about the overall impression for the different combinations.]

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Allmän känsla [Overall comfort]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Byst [Bust]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midja [Waist]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allmän känsla [Overall comfort]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axlar/Armhål/Hals [Shoulders/Scye/Neck]</td>
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<td></td>
</tr>
<tr>
<td>Övervidd [Bust]</td>
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</tr>
<tr>
<td>Ärmar [Sleeves]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midja/Stuss [Waist/Hip]</td>
<td></td>
<td></td>
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</tbody>
</table>

Om Du svarade Mindre bra på någon fråga under BEKVÄMLIGHET vad var det som ej var bra? [If you have answered Fair on any of the questions under the headline COMFORT what was it that was not good?]

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### fortsättning BEKVÄMLIGHET [continuation COMFORT]

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<tbody>
<tr>
<td>Byst [Bust]</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Midja [Waist]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuss [Hip]</td>
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</tbody>
</table>

Om Du svarade Mindre bra på någon fråga under BEKVÄMLIGHET vad var det som ej var bra? [If you have answered Fair on any of the questions under the headline COMFORT what was it that was not good?]
APPENDIX 3

Appendix G: Expert’s evaluation of final garments, phase C

**VAR OBJEKTIVA BEDÖMNING [OUR OBJECTIVE EVALUATION]**

<table>
<thead>
<tr>
<th>Provperson:</th>
<th>Kategori:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Test person]</td>
<td>[Category]</td>
</tr>
</tbody>
</table>

**PASSFORM KAVAJ [FIT OF THE FITTED JACKET]**
Bedöm plaggets passform främst utifrån dess helhet. Följande tre kategorier bedöms; rörelsevidd, form i harmoni med kroppen samt sömmar/skärningar/detaljer. [Evaluate the garment fit primarily from its total fit. Following categories are evaluated; tolerance, shape in harmony with the body figure and seams/style lines/details.]

|-------------|-----------------------|------------|---------------------|

**HARMONI [HARMONY]**

**SÖM & DETALJ [SEAM & DETAIL]**

**PASSFORM BYXA [FIT OF THE TROUSERS]**
Bedöm plaggets passform främst utifrån dess helhet. Följande tre kategorier bedöms; rörelsevidd, form i harmoni med kroppen samt sömmar/skärningar/detaljer. [Evaluate the garment fit primarily from its total fit. Following categories are evaluated; tolerance, shape in harmony with the body figure and seams/style lines/details.]


127
**PASSFORM KLÄNNING [FIT OF THE DRESS]**
Bedöm plaggets passform främst utifrån dess helhet. Följande tre kategorier bedöms; rörelsevidd, form i harmoni med kroppen samt sömmar/skärningar/detaljer. [Evaluate the garment fit primarily from its total fit. Following categories are evaluated; tolerance, shape in harmony with the body figure and seams/style lines/details.]

<table>
<thead>
<tr>
<th></th>
<th>För liten [Too small]</th>
<th>Bra [Good]</th>
<th>För stor [Too large]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Byst [Bust]</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Midja [Waist]</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Stuss [Hip]</strong></td>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mindre bra [Fair]</th>
<th>Bra [Good]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Byst [Bust]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Midja [Waist]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stuss [Hip]</strong></td>
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</tbody>
</table>

**HARMONI [HARMONY]**

<table>
<thead>
<tr>
<th></th>
<th>Mindre bra [Fair]</th>
<th>Bra [Good]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Byst [Bust]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Midja [Waist]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stuss [Hip]</strong></td>
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</table>

**AVVIKELSE [DISFIGUREMENT]**
Har vi lyckats anpassa plagget till avvikelsen? [Have we succeeded with adapting the garment according to the disfigurements?]

<table>
<thead>
<tr>
<th>Vilken är den största avvikelsen? [Which is the largest disfigurement?]</th>
</tr>
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<tr>
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</tbody>
</table>

Är plagget korrekt ändrat/sytt i anslutning till avvikelsen? [Is the garment correctly adapted/sewn in relation to the disfigurements? If not describe what.]

<p>| |</p>
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</table>

Övriga kommentarer. [Other comments.]

<p>| |</p>
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</table>
**APPENDIX 3**

**APPENDIX H: Test person’s follow up evaluation of final garments, phase B**

INDIVIDANPASSAD KONFEKTION - UPPFÖLJNING

<table>
<thead>
<tr>
<th>Namn [Name]:</th>
<th>«Förnamn» «Efternamn»</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ev. Adressändring:</td>
<td></td>
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</tbody>
</table>

**ANVÄNDNING [USE OF THE GARMENT]**

Hur ofta har Du använt plaggens som syddes upp till Dig inom EASYTEX-projektet? (Bortsett från modevisningen.) [How often have you used the garments that were made for you in the EASYTEX project? (Except for the one time at the fashion show)]

Svara genom att sätta kryss för vart och ett av plaggen. [Mark the correct alternative for each garment]

|-----------------|---------------|------------------------|--------------------------|

Om Du svarade att Du aldrig använt plagget - var vänlig förklara varför. [If you answered that you never used the garments – please explain why.]

**BEKVÄMLIGHET**

Vad anser Du om plaggens bekvämlighet och trivsel. [What do you think about the comfort and fit of the garment?]

Svara genom att sätta kryss för vart och ett av plaggen. [Mark the correct alternative for each garment]

|-----------------|-------------------|------------|-----------------------|

**PRISSÄTTNING [PRICING]**

Westerlind AB, de som sydde upp Dina plagg, har gjort en uppskattning av vad dessa individanpassade plagg skulle kosta ute i handeln. Skulle Du vara villig att betala det angivna priset för ett individanpassat plagg? Svara genom att sätta kryss för vart och ett av plaggen. [Westerlind AB, the company making-up your garments, has estimated what these made-to-measure garments would cost in the retail store. Would you be willing to pay the set price for the individualised garments?]

<table>
<thead>
<tr>
<th>Byxa [Trousers]</th>
<th>1450:-</th>
<th>Ja [Yes]</th>
<th>Nej [No]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kjol [Skirt]</td>
<td>1350:-</td>
<td>Ja [Yes]</td>
<td>Nej [No]</td>
</tr>
<tr>
<td>Kavaj [Fitted jacket]</td>
<td>2500:-</td>
<td>Ja [Yes]</td>
<td>Nej [No]</td>
</tr>
</tbody>
</table>

Om Du svarade att Du ej var villig att betala det angivna priset - var vänlig skriv vilket pris Du skulle kunna acceptera. [If you have answered that you were not willing to pay the price – please write down the price you could accept.]

<table>
<thead>
<tr>
<th>Byxa [Trousers]</th>
<th>________ kr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kjol [Skirt]</td>
<td>________ kr</td>
</tr>
<tr>
<td>Kavaj [Fitted jacket]</td>
<td>________ kr</td>
</tr>
</tbody>
</table>

**ALLMÄNT [OTHER]**

Vi värdesätter Dina åsikter och undrar om Du har ytterligare några kommentarer angående något av plaggens (tex. lättåskåla, skrynklar inte, lagom varmt, bra färg osv.). [Your opinion is important to us. Do you have any further comments about any of the garments (for example, easy care, wrinkles easily, gives a comfortable temperature, nice colour etc.)]

Tack än en gång «Förnamn» för att Du har ställt upp för oss och projektet EASYTEX!! [Thanks once more «First name» for your participation in the EASYTEX project!!]
Appendix I: Covering letter attached to the follow up evaluation

Appendix: Covering letter attached to the follow up evaluation

25 October 2000

«Förnamn» «Efternamn»
«Gatuadress»
«Postnummer» «Postadress»

Hej «Förnamn»

Hoppas att allt är väl med Dig, «Förnamn».


Det är nu viktigt att individanpassade kläder blir tillgängliga på marknaden och att Du då kan få möjlighet att få kläder som passar Din kropp direkt från industrin. Det skulle väl vara något det?!!!

För att fortsätta undersökningen vad beträffar individanpassade kläder är det viktigt att höra vad Du anser. Jag gör en enkätundersökning för att samla in ytterligare viktig information för framtida arbete.


Hälsningar genom

_________________________
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http://www.ped.gu.se/ihu/hushome.html
### Appendix J: Registration of individual measurements

**INDIVIDUELLA MÅTT**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Sela mätet (total measurement)</th>
<th>höger (right)</th>
<th>vänster (left)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kroppslängd (Height)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Byssvidd (Bust circumference)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midjevidd (Waist circumference)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Höftvidd (Hip circumference)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stussvidd (Hip circumference)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halvidd (Neck circumference)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livlängd bak [Nape to waist back]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ryggbredd [Back width]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yttre axelspets – Yttre axelspets [Shoulder point – Shoulder point]</td>
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<td></td>
</tr>
<tr>
<td>Byshöjd (mb-byx) [Nape to bust point]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livlängd fram (mb-midjau) [Nape to waist front]</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Axselbredd [Shoulder width]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armlängd [Arm length]</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Överarmovärd [Upper arm circumference]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handledovärd [Wrist circumference]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hellängd bak (midja-golv)* [Waist to floor – back]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hellängd fram (midja-golv)* [Waist to floor – front]</td>
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<td></td>
</tr>
<tr>
<td>Kjollängd/Klännig [Skirt length]</td>
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<tr>
<td>Sidlängd (midja-golv)* [Outside leg length]</td>
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<tr>
<td>Byshöjd, mitt fram [Body rise – centre front]</td>
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<tr>
<td>Nasebenlängd* [Inside leg length]</td>
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<tr>
<td>Sitthöjd [Body rise]</td>
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<tr>
<td>Lårvidd [Thigh circumference]</td>
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<tr>
<td>Ex. högsta klacken [Lowest heel]</td>
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</table>

**Specialmått för vissa kategorier**

<table>
<thead>
<tr>
<th>Measurement</th>
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</thead>
<tbody>
<tr>
<td>Stussvidd-inre axelspets bak [Height of neck point – back]</td>
<td></td>
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<tr>
<td>Yttre axelspets-stussvidd fram [Height of neck point – front]</td>
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<tr>
<td>Stussvidd-yttre axelspets bak [Height of shoulder point – back]</td>
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<td></td>
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<tr>
<td>Yttre axelspets-stussvidd fram [Height of shoulder point – front]</td>
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<tr>
<td>Sidhöjd (midja-armhåla) [Side (waist- arm pit)]</td>
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</tr>
<tr>
<td>Midja fram/bak [Waist front/back]</td>
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</tr>
<tr>
<td>Stuss fram/bak [Hip front/back]</td>
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</tbody>
</table>

* Drag ev. av klackens höjd [Subtract any height of heel]
Appendix L: Standard garments

Skirt with darts both on the front and on the back piece of the garment.

Fitted jacket with darts forming the garment to the body figure.

Trousers with darts both on the front and on the back piece of the garment.

Appendix M: Garments used in phase B & C

Phase B

Classic trousers
Illustration Helene Berglin

Classic trousers with a elastic section on the waistband
Illustration Helene Berglin

Skirt with a slit in the back. The skirt comes in a short and a long variant.
Illustration Helene Berglin

Fitted jacket with cuts form the shoulders both in form and in back.
Illustration Niina Hernández
To find clothes in a retail store is a problem for quite a lot of individuals, especially for those with extensive body disfigurements. Today, information technology brings the industry the aids to produce and offer mass customised garments to a greater variety of customers. Thus, part of the problem is solved. Consequently, the knowledge of how to adapt garment design and patterns in order to obtain esthetical and well-fitting garments becomes fundamental. This thesis reports and discusses the methodology and experiences in research work, with two main areas of focus; the work process and pattern construction in the development of individual garments for persons with large disfigurements.

The thesis describes how an innovative figure registration can be carried out, including the measuring procedure and the figure illustrations, both necessary for the figure analysis which is essential for the creation of the individual pattern. The different adaptations needed for various large disfigurements are presented in two sections; first a general presentation of single adaptations according to specific disfigurements, followed by, adaptations in complex combinations creating individual patterns.

This study has been undertaken within the framework of the EASYTEX project, the overall aim of which is to improve living conditions for the elderly, the disabled, and impaired individuals. The EASYTEX project, which is financed by the European Commission started January 1997 and runs through to June 2000.

Keywords:
pattern construction, pattern adaptation, figure registration, body measurement, disfigurement, clothes, garment, made-to-measure, mass customisation

Research report 30, 2000
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Department of Home Economics
Göteborg University
2000
Overview of structured literature review focusing on garment fit evaluation

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<th>Fitting session</th>
<th>Factor (influencing garment fit)</th>
<th>User's perception</th>
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<td>Visual evaluation</td>
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Table entries marked with an 'x' indicate the presence of information from the mentioned references.