Enhancing Pattern Construction by Body Scanning: The Importance of Curves

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Abstract

This paper will discuss the enhancement of trouser pattern construction through the utilisation of 3D body scanning. It will discuss the lower body shapes -pattern -garment relationship. It will focus on the curves that are required to suitably develop trousers from 3D body scans.

It is acknowledged that 3D Body scanning offers more anthropometric data on the body than had been previously possible to collect from traditional methods of measurement. However, there exist differences between these two methods of measurement[1] and limitations within the existing 3D body scanning process at certain locations of the body; namely the armhole curve , the armscye, the bust, the neck curve and the crotch.[2].

This research began with eighteen methods of pattern cutting for trousers [3]–[18], the measurements were taken from a 3D body scanner in order to draft the pattern using Lectra. The data outputs from this were then entered into Excel for analysis and comparison and to see if there were any inconsistencies for ease or arc definition for different morphologies. It was noticed that during the pattern making process traditional linear Euclidian methods of measurement were used, whereas the body is shaped with curves, convex or concave, and these seem not to be given their importance in the pattern construction process within a 3D environment. This necessitated an investigation into a new approach using hybrid calculations using Euclidian and non- Euclidian geometry to incorporate and calculate the curves in 3D.

The increased adoption of technology and environmental issues caused by fast fashion have propelled the concept of mass customisation to the fore. Greater precision in 3D scan data which relates directly to the lower body shape has huge implications for customer satisfaction and the garment manufacturing industry.

Keywords: 3D Body Scanning, Anthropometrics, Lower Body shapes, pattern construction, Hybrid calculation of measurements.

1. Introduction

It is acknowledged that 3D Body scanning offers more anthropometric data on the body than had been previously possible to collect from traditional methods of measurement. However, there exist differences between traditional manual collection of measurements taken based on the individual geography of the body and 3D measurements based on geometry of the surface of the skin and limitations within the existing 3D body scanning process at certain curved locations of the body; namely the armhole curve , the armscye, the bust, the neck curve and the crotch. It is also recognised that not all 3D measurements are defined in ways suitable for pattern cutting and the development of products [19].

This research will investigate 3D body scanning and women's trousers. It is known from the literature that trousers are an extremely popular convenient garment for the modern woman, but they are also problematic. They present to the manufacturers as a major source of returns with 30 % of online clothing purchases being returned[20]. Studies cite [21] the major cause of dissatisfaction for most customers as fit issues. Indeed ,the majority of literature on trousers deals with fit dissatisfaction [22]–[24]. One of the reasons for the paucity in the literature for the construction and development of trouser patterns , according to [1] is that they are such complex garments.

1.1 Aim and Objective

To introduce a new pattern drafting methods for trousers for women, based on the use of 3D body scanning technology, better able to respond to an individual's shape, curve. size and proportion.

To highlight the limitations in the current methods of pattern construction for women's trousers, through an analysis of existing methods of pattern drafting.

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2. Methods

The practical aspect of this research began with the selection of eighteen methods of block pattern drafting methods used in the construction and cutting for women's trousers. Table 1 shows the eighteen case studies for pattern construction.

Table 1: below shows the names, locations, and year of publication of the trouser Patterns Secondary data for the 18 mini-case studies as described by Yin (2014)

Methods	Note
Aldrich, (2015)	This method is used primarily in the UK and is often used as a core book for those learning to draft patterns. The process is a simple number of steps with an accompanying visual outline of the finished pattern. Originally published in 1998, it is a core handbook for those learning to draft patterns. The standard size charts in this book were upgraded in 2016 to take into consideration the current larger size of the "Average woman". The pattern for Aldrich begins with the front crease line, this is where the pattern begins.
Armstrong, (2010)	This is another core book originally published in 1987, it is well known for being clear in its instruction and having clear illustrations. It is mainly used in the USA and is in imperial measurement. From measuring out this pattern manually it can already be seen that this is normal basic trousers. It has wide ankles and knees. It is wider at the back than the front. This includes directions and instruction for measurement (Gill,2009). The focal point and starting point for Armstrong's trousers pattern is the waist descending to the waist descending to the hip and then down, almost in a scaffolding manner.
Beazley and Bond, (2003)	This method was developed in the UK, it is based on Beazley's vast experience of research into Size and Fit (1996, 1998, 1999). The pattern from the Beazley already includes ease. This method is one of the more direct methods of creating a pattern block. Here, measurements and ease are used directly to define the pattern dimensions. Beazley and Bond start with rectangle and design the trousers to fit within this rectangular block they specify firstly centre back and centre front
Bergh, (1995)	This method was developed in France. The process is a simple of steps with visual outline. The pattern for Bergh uses measurement of circumference and proportional for some key location. It is mainly used in imperial measurement.
Bunka,(2009)	This is a basic pattern cutting for Japanese designers. The Bunka college was opened in 1912, the measurements for the trousers are taken from the standard body shape of a Japanese female in her 20s. Bunka (p136). This is important since there is a difference in body characteristics between Asian and Western Women according to Lim and Cassidy (2017). This method has the same starting point as Aldrich
Campbell, (1980)	This is a UK pattern drafting techniques, the measurement for this method were taken from the standard body shape of UK female. The process has simple steps which are described with a visual outline of the finished pattern using proportional measurements for some key location's circumferences. This method starts with hip line. The draft of the pattern at the knee and ankle level similar (back and front). This pattern is based on some measurements being proportional to other measurements
Esmond, (2009)	This is a French pattern drafting techniques based on the work of Professor Alexis Lavigne, who opened the first fashion design School in Paris in 1841. The Technical application of these patterns are based on a "flat pattern design" of the silhouette of the woman, with the volume being put in by the pattern drafter. The method is universal and easy and can be used by sewists and those in the industry including pattern makers, pattern drafters and product managers. There are clear diagrams showing a visual description of the structure and easy steps are described. This method starts with the straight grain, they do not call it crease line
Hagger, (2004)	This method was developed in the UK, the first published in 1961, it begins with clear instructions and visual illustration it is mainly used metric measurement. The process to draft the pattern of trousers used the proportions for some of key locations. This method starts with straight grain provisional side seam.
Holman, (1997)	Made Easy published by Pavilion Books in paperback form has simple easy to use sketches which makes pattern cutting easier for the beginner. However, there is no body measurements chart anywhere in the book. Holman follows the same focus and starting point as Bunka

Khalil, (1985)	This is an Egyptian method, which is easy-to-follow following a set of numbers. Almost like pattern cutting by numbers. There are visual descriptions and numbered step-by-step instructions. There are also descriptions of how to use darts and alter the pattern for irregular or larger sizes, again using a system describing the steps A to Z to be followed. This method follows the same starting point as Beazley and Bond.
Kunick, (1967)	This was a treatise and textbook for those who were involved in the production of women's clothes. This pattern is based on some measurements being proportional to other measurements. This sizing and grading belong to the era before the 1960s, and before CAD or even calculators the process of drafting and grading patterns was totally manual. The starting point for this method is the same as Armstrong
Lo, (2011)	This method was developed in the UK. it begins with clear instructions and visual illustration it is mainly used metric measurement. The process to draft the pattern of trousers used the proportions for some of key locations.
MacDonald, (2010)	This method was developed in the New York. MacDonald presents step-by-step instructions and diagrams, including a representation of the completed pattern. It is mainly used in the USA and in imperial measurement. This method starting with grain provisional side seam.
Shoben and Ward, (1987)	This is a core book is for students at college about to embark on a course to learning basic pattern cutting. The illustrations are basic. However, his book Grading for the Fashion Industry: Theory and Practice 2004 with Patrick Taylor has better illustrations, and a more in- depth approach to grading. This book had the late Phillip Kunick as an advisor. This method is the same as Armstrong for its starting point.
Shoben and Ward, (2000)	This method was developed in the UK. The structurer of drafting the pattern of trousers is different from Shoben and Ward (1987). There are clear diagrams showing a visual description of the structure and easy steps are described. This method starts as the steps of draft the skirt used the scale to calculate the size.
Thatha, (1995)	This method is based on the Profile pattern drafting method from Italy. It is easy to follow and has numerous visual descriptions and explanations. It is used as a textbook for academic purposes in some Arabic countries, including Saudi Arabia, it is printed and used in secondary schools and even at undergraduate level in some of the universities there. Some Arabic countries including Saudi Arabia, it is printed and used in secondary schools and even at undergraduate level in some of the universities there. including Saudi Arabia, the starting point for this method is the same as Bunka
Tuit, (1974)	This method is well known for being clear in its instruction and having clear illustrations. It is mainly used in imperial measurement. There are clear diagrams showing a visual description of the structure and easy steps are described, the process to draft the pattern of trousers used the proportions for width and length. The knee and ankle line in draft is similar.
Whife, (1965)	This method is developed in the UK. The measures and drafting of pattern for slacks. The process is a simple number of steps with an accompanying visual outline. This method used imperial measurement, this pattern starting on crease line

The rationale behind the choice of these selected pattern construction methods is that they are commonly used in the garments and apparel industry and in academia. Previous related research in this field has been done by [24], [27], [28].

Each of the selected published pattern drafting methods varies slightly, consequently this produces different pattern blocks for the same sized body. As can be seen in the diagram below (Figure 1). The instructions within these methods are according to [22] "theoretical statements of concept relationships" (p.154). For the purpose of this study and to create a reference point for each of the respective measurements of the drafts , an expert practitioner with seventeen years experience of pattern construction, constructed each of the respective pattern making methods using common pattern - drafting procedures. Additionally, based on previous research by [29] ,the patterns will only have ISO, BS ISO 8559-1-[30] size designation of clothes size 12.and use the 3D body scan of a size 12 Alvanon Body form. Based on the directions for each of the eighteen case studies the different measurements were entered into MS Excel in order to generate both a comparison between the methods and the 3D body scan size 12 and assess the percentages of difference between the methods at different locations on the trouser. Figure 1 shows all eighteen methods superimposed, in order to highlight the differences between the eighteen pattern construction methods.

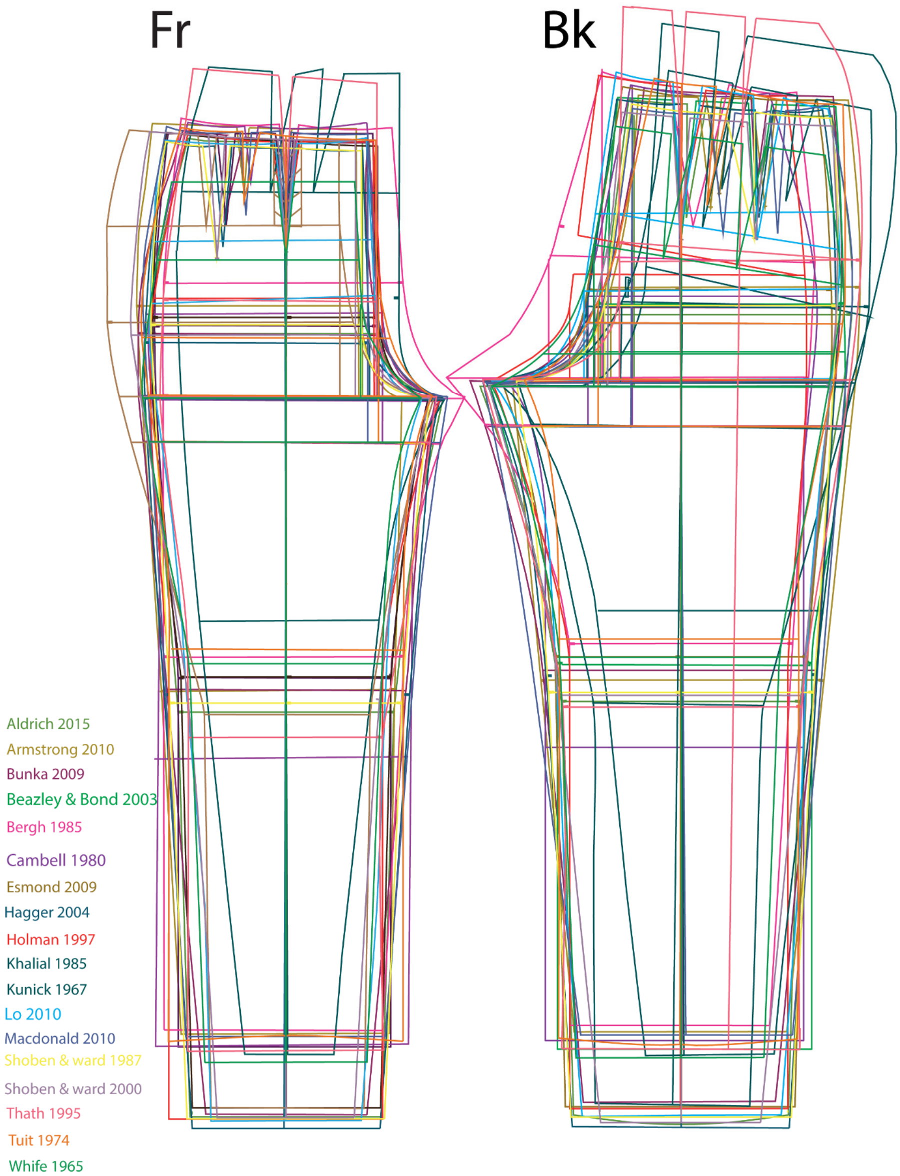

Figure 1: Superimposed images for the 18 pattern methods, zero point is intersection at the Hip line.

3. Results and Findings

This research shows that there is a huge variation between the methods of pattern cutting, even when starting from the same body/figure. This pattern data allows an exploration of the body-to-pattern shape relationships and body curves, particularly the relationship of the body curves and the pattern curves and the crotch. This relationship between the pattern curves and the body curves is of key importance for the crotch extension. Furthermore, the ultimate suitability and applicability of these patterns for 3D applications in a mass customisation process will be explored. Upon identifying the processes that cause inconsistencies within the pattern construction methods, suggestions for an improved patternmaking system can be proposed in order to advance apparel mass customisation.

3.1 Side Seam and Uplift

The side seam (SS)and darts create a 3D shaping for the trousers in order to deal with the curves, particularly in larger and plus sizes. Some of the pattern methods are longer at the back than the front, when compared at the side seam. The amounts for the uplift of the side seam is an area under consideration since the different methods vary greatly. The image (figure 2) shows the concept of uplift, which is inconsistent within the methods analysed.

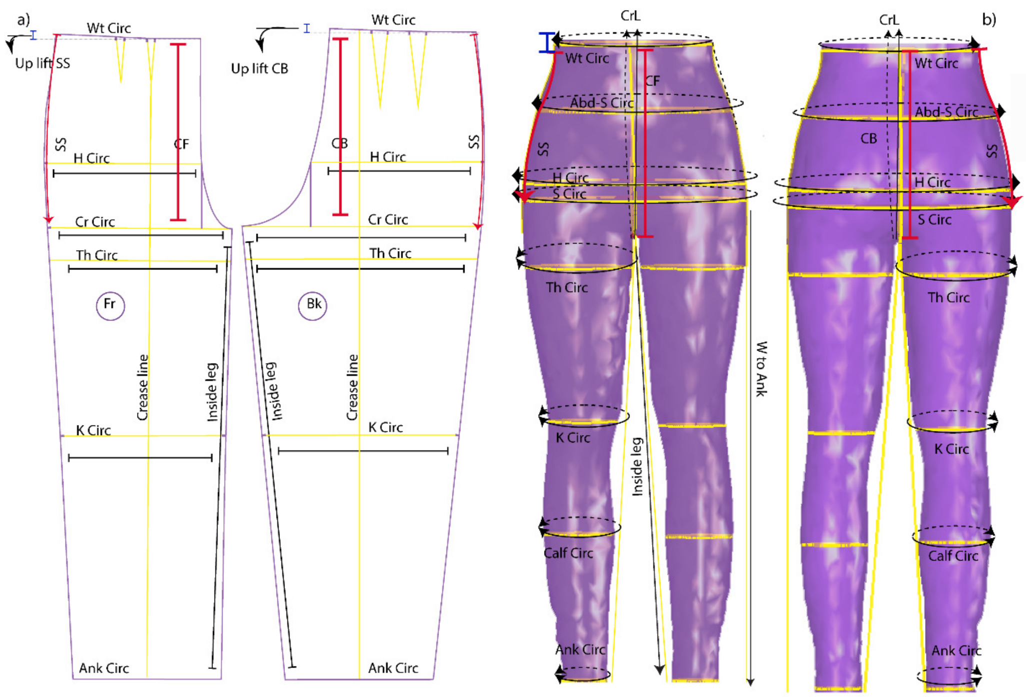

Figure 2: This show the relationship between the 3D body Scan and pattern for lower body at Uplift CB, and SS.

Again, there is no formula, nor theory and little understanding of the relationship between the pattern and body shape as can be seen. The relationship of the body to the pattern around the centre front and centre back of the lower torso, between the legs, is unique to bifurcated garments. None of the methods provide theories that would help within the necessary steps to digitize methods of construction and firmly exploit data from body scanning.

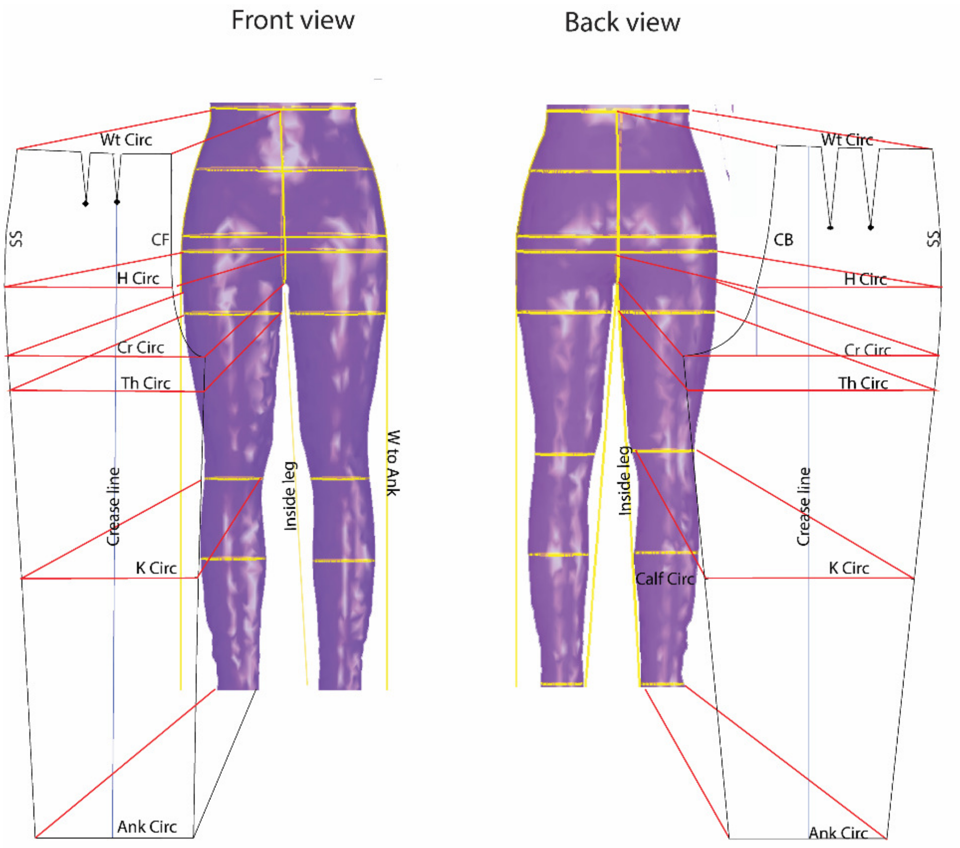

Figure 3: The Key Locations of Body-to-Pattern Relationship for Trousers.

3.2 The crotch curve and crotch extension

The crotch measurement is a complex part of pattern construction for trousers, in reality many are sensitive or embarrassed about being measured there, and the area isn't always fully captured by some 3D body scanners. The image below shows the relation of the crotch curve to the 3D body and its relationship to the eighteen case study methods of pattern construction is measured transversely through the body

If we take the crotch from the side seam as being an X and Y axis, it shows the crotch point. However, if we superimpose these 18 methods based on the hip line and combine them this will also show the Z axis. This highlights the differences between the eighteen pattern methods and their relationship to the body. This also demonstrates that there is no unified theory underpinning the pattern methods and body relationship. This has major implications for the fashion and apparel manufacturing industry and the ability to integrate body scanning into existing system solving complex fit problems.

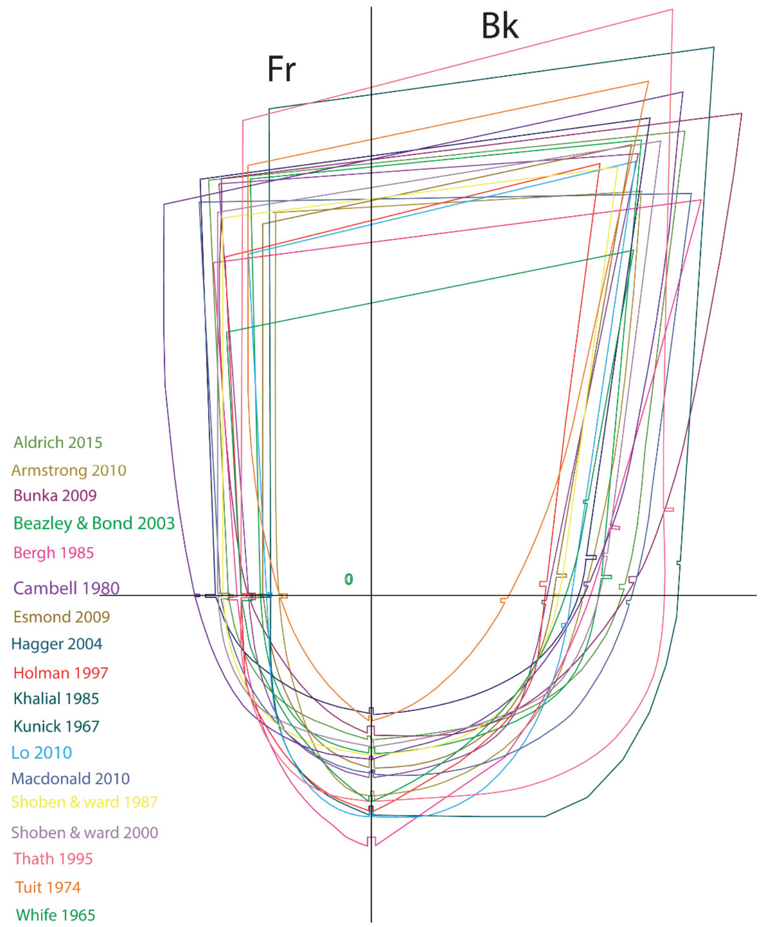

Figure 4: shows the crotch shapes based on the hip line.

The graph in Figure 5 shows the percentages and the numerical values of the front and back crotch extension from the actual depth, this was to investigate the location of the crotch point in each case study, as this is complex with different styles of trouser and different shaped bodies. Again, focusing on crotch extension Campbell (1980) produce a ratio of 58.10% at back 41.90% at the front which highlights that this method produces the crotch curve that is irregulate and uneven. Bergh generated 62.09% at the back and 37.91% .

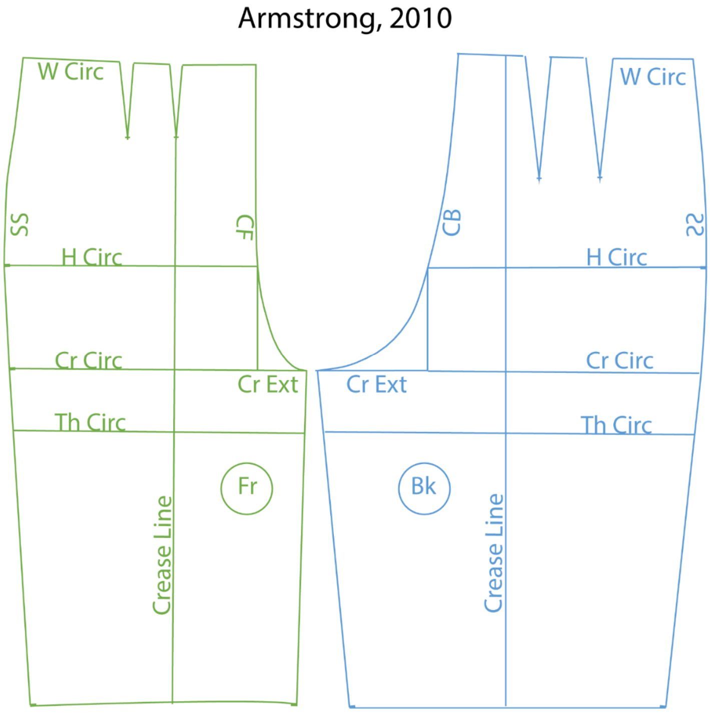

Figure 5: The relationship between the image and diagram in figure 22 below for Crotch Extension.

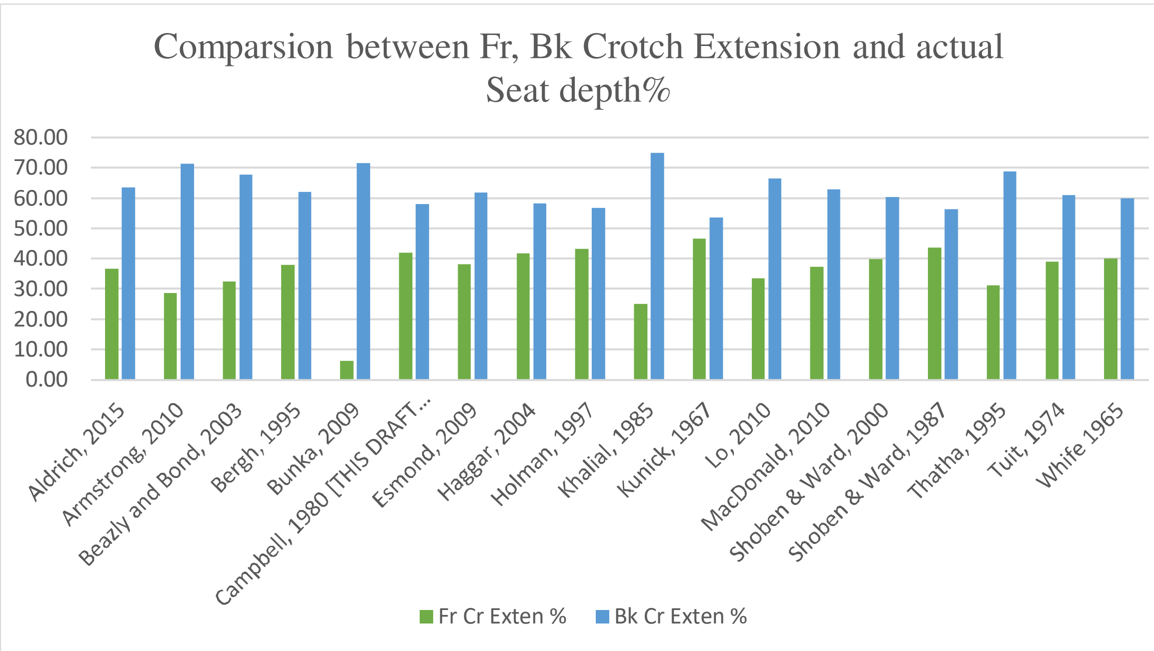

Figure 6: Percentage of distances between the Fr, Bk Crotch extension and Actual seat Depth

The graph above in Figure 6 give a numerical representation of the measurements at different key locations on the trouser pattern. This allows for calculations to be made and offers a mechanism to make comparisons between each of the pattern methods in relation to the body. This will enable researchers to generate theory to underpin pattern construction and 3D body scanning, using advanced technology.

3.3 Curvatures for the Lower body

Issues of curves and curvature. The issues of curves and curvature arose when doing this research and how most of the measurements from 3D body scanners were parametric linear measurements using Euclidian geometry which can measure accurately between two straight lines. However, linear measurements are unable to fully capture the body shape in 3D, it cannot accurately record the curves or arcs of the body and this has presented modern fashion pattern making with numerous problems. For example, the curvature of the crotch and variations in rise, and depth of the seat and curvature lower body shape. The crotch curve as shown in figure 5 indicates that there is little consistency between the methods of pattern construction and the body to pattern shape either in terms of measurement or shape, yet trousers depend heavily on the crotch curve for a proper fit. Poor fitting trousers are a major source of returns for online shoppers

In using 3D body scans to map the body we must take into consideration all the curved surfaces of the body and their measurements. In measuring the body accurately and completely one must recognise that the different areas of the body have different curvatures and consequently different geometric shapes , different geometric properties and are governed by different mathematical rules.

Conclusion

In this paper the analysis found that each of the pattern types produces a different method for the same sized body-form, in terms of shape and measurement. It also became evident that none of these methods were underpinned by pattern cutting theory. None of these eighteen methods showed an understanding of the body/ body shape to pattern relationship, the style and fit of trousers are dependent on the pattern drafting procedure of each method. As such they are not suitable for use in a mass customisation process. New methods of pattern drafting must be developed, based on the relationships between the body measurements and body shape and the extracted data from the 3D body scans. Simple Cartesian or Euclidian methods of calculation in our era of 3D technology are insufficient, other methods of calculations, including the X,Y,Z axes and hybrid forms of mathematical calculations must be explored.

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