Shaped to Fit

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Front Cover image:

Weaver, Nina Shaped to Fit.
Swimwear Patterns: Energy,
Reflect, Glam, 2017
Wellington, New Zealand.
Photo: James Weaver,
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And lastly, I thank my parents, Alba and Nick for their legacy of creative illumination.

Abstract

This practise-led project investigates alternative pattern cutting processes for the design and making of a small collection of women's swimwear for recreational purpose. The traditional pattern matrix system used to design patterns has little anatomical relationship to the moving body (Lindqvist, 2013). However there are alternative pattern design practitioners who step outside of this model (Sevin-Doering, 2004, Wang, 2011, Lindqvist, 2013, Cumming, 2015) These methodologies offer benefits to high stretch knit designs, enabling the designer to enhance garment fit by transferring shaping in direct relationship to the body to provide support and aid movement. An investigation of one piece pattern cutting for a close fit using woven and knit fabrics will play an important role in the technical design process. This analysis considers the application of Cumming's method of one piece pattern development for fitted body garments along with an expanded analysis of methods and designs developed from other one piece cutting practitioners and active wear researchers informing the development of recreational swimwear (Sevin-Doering, 2004, Lindqvist, 2013, Cumming, 2015). Methods combining technical research and an iterative design practice including design, toile, sampling processes and motion wear qualitative testing to analyse designs. The use of new pattern cutting methods can improve the fit and comfort and subsequent performance capacity of recreational swimwear without the reliance on high performance materials. The benefits of this method encourage the designer to pattern design to the body shape and utilise fabric properties to meet the gap in the market between the fashion consumer and the elite athlete. Further developments open up opportunities for future developments including smart technologies and complete garment technology applications (Brownbridge, 2016).

Keywords: alternative pattern methodologies, one piece pattern design, direction grainline, high stretch knit, recreational swimwear.

Contents

Introduction

The aim of this practise-led project is to investigate alternative pattern cutting processes for the design and making of a small collection of swimwear for recreational purpose. This research challenges conventional patternmaking practise, by applying alternative pattern methodologies of cutting a single shape of cloth.

During my previous experience in industry, I had begun to develop one piece swimwear patterns for efficient production. However it wasn't until I began assisting Deb Cumming on projects that I could begin to see the challenges of aligning angles of grainline and the associated and varied capacity of stretch to provide increased comfort and performance (Cumming and Weaver, 2016). Cumming proposed that if drape and one piece cutting methods were oriented to patterns for movement of the live body, then there is a closer relationship of pattern development for low and high stretch fabrics (Cumming, 2015). Fabrics containing elastane fibre provide the garment with a close body fit often paralleled to a second skin. However few fashion or recreational swimwear designers fully utilise the potential of high stretch fabric properties, optimising grainline stretch and stability. Arguably, if high stretch fabric was designed to mimic the body's skin or muscular structure, then why not place seamlines with a closer directional relationship to the body to achieve a fit that offers support and comfort during activity? Through technical research and iterative design practise, this research project aims to answer this question by exploring alternative pattern design cutting methods as well as understand how to process complex 2D design shapes into 3D forms approaching design primarily from a technical design application. Alternative pattern practitioners challenge the conventional Patternmaking rules by refraining from using the traditional matrix pattern blocks and instead utilise fundamental properties of soft material to direct the form of apparel design (Vionnet, Sevin-Doering, 2004, Lindqvist, 2013, Cumming, 2015). The pattern practitioner's Sevin-Doering, Lindqvist and Cumming work primarily in woven or low stretch fabrics achieving unexpected one piece pattern shapes in unexpected ways (Sevin-Doering, 2004, Lindqvist, 2013, Cumming, 2015). These singular shapes form around the body, using curved design, balance lines and directional grainlines to achieve movement.

This initial part of this research project builds on Cumming's one piece work to further the comparative analysis of woven to knit pattern shapes and communicate fit and movement with specific characteristics of the one piece singular pattern. This work contributed to the collaborative exhibition works

titled: ‘Nature, energy and movement for new apparel design’ and ‘oneP-active’ that created fashion active wear pattern exhibits. (Cumming and Weaver, 2016).

In the context of fashion, everyday dress is becoming more relaxed as people are drawn to a healthier lifestyle. This is particularly evident on urban streets with apparel designed in low and high stretch knit fabrics and styling positioned somewhere between leisure and active wear. The shift of aesthetic narrows the divide between active wear and fashion. As athleisure blurs the boundaries between high fashion and active wear, more research is needed to attend to design and technical requirements.

The second part of this master’s project develops a swimwear collection for the recreational swimmer based on findings from the oneP-active research. It is important to cater for a range of recreational swimmers with designs that provide an enhanced fit with support and movement, qualities that enhance active wear as well as fashion appeal. Mull, Forrester, Barnes (2013) define recreational pursuits as `a voluntary activity that creates a diversion from work. It is reenergizing, socially acceptable use of leisure time’. Swimwear design for recreational activity has not generated the same level of technical development as the high performance athletes. The sports industry engages in research and development for material and production innovation for high performance swimwear however there is greater capacity to provide for an increasing market that sits between high performance and fashion swimwear. As a designer, I saw the need to satisfy a female market who defined themselves as recreational swimmers. I classified this psychographic as being highly conscious of their individual lifestyle and personal preferences; they are also a group who swims regularly for general fitness and stress release. They have a strong sense of awareness of performance and comfort needs alongside fashion design trends.

The swimwear collection is produced in high stretch knit fabric readily available in the market to allow for close fit and maximum stretch. Fabric grainlines play an important role in the design development process, and this investigation analyses the position of the crucial body points and lines of extension and support for high stretch knit garments. The use of new pattern cutting methods can improve the fit and comfort and subsequent performance capacity of recreational swimwear without the reliance on high performance materials. As well as being technically effective, I have created swimwear designs oriented to three different fashion aesthetics to show the adaptability of this pattern design process for future design outcomes.

1. Context

This research embraces the idiosyncratic challenges synonymous with pattern design in high stretch knit fabric and designing close fitting garments to achieve optimum garment fit for movement to support the female body while performing sporting and leisure activity.

The aim of this literature review is to contextualise the research and to investigate the validity of one piece pattern cutting for contemporary swimwear design. The application of this review informs my direction of analysis and subsequent methodology. This project focuses on swimwear for the purpose of recreational activity. This market can be better provided for through new cutting methods to aid fit and movement.

1.1 Patternmaking for Stretch

Pattern design methodology for knit can be broadly classified into two categories: traditional and alternative. Pattern practitioners, Bray (1978), Armstrong (2013) and Aldrich (2015) can be regarded as traditional patternmakers as they all produce basic pattern blocks (front, back and set in sleeve), by applying a set of vertical and horizontal measurements to simple rectangle dimension, referred to as the tailoring matrix (Lindqvist, 2013). The 2D pattern block is then manipulated into a 3D form. Aldrich (2015) describes the pattern produced from these pattern blocks as 'constructing a constant shape of the body that allows for movement'. However, I would argue that the changing mobile body measures need to be considered earlier in the design process including consideration to change of fabric alignment when the body moves and also relevance of seamlines to the body shape. In the scope of this research, I define alternative pattern designers as those who use pattern methodologies outside the scope of the tailoring matrix and use fabric properties with the body as central to the process.

Preceding 2008, the numerous publications available on the market offering technical instruction in pattern design methods for stretch knit apparel were primarily pitched at a basic level aiming at the domestic sewing market. This may have attributed to the audience having restricted access to specialised machinery for stretch construction. Consequently, there was limited knowledge being disseminated to designers eager to learn advanced patternmaking techniques for stretch apparel. Following 2008, the need for more technical pattern design information is addressed by publications including Richardson (2008), Armstrong (2010, 2013), Nakamichi (2012), and Cole (2016). These practitioners combine traditional flat pattern adjustments and alternative pattern design methods to fit fabric on the form however many require further refinement to accommodate the stretch properties the fabric is designed for. An example is Richardson's (2008) sloper draft or pattern block draft for a full body high stretch garment known as a unitard (Richardson, 2008). The draft uses a tailoring matrix system and applies a set of measurements including a mere reduction of ten (10) percent in the horizontal direction. Armstrong (2013) provides instruction to manipulate low and high stretch designs however does not utilise the fabric stretch properties to transfer seam shaping and instead retains the side seams and shoulder seams in the traditional position. Conversely, Nakamichi (2012) offers shapes for the adventurous patternmaker with draped designs in singular piece patterns and repositioned side seams. These designs are loose fitting, made from low stretch knit with the intention to be worn

for streetwear and are also based on flat pattern manipulations from conventional pattern blocks. Nakamichi (2012), and Armstrong (2013) show variations to the traditional flat 2D patternmaking method by draping stretch fabric on the form to achieve the desired fit.

Richardson (2008) and Cole (2016) use a 2D pattern manipulation to show how to transfer side seam shaping for a high stretch unitard pattern. Richardson's (2008) method removes the side seam shaping by placing the front and back underarm and hip side seam points together. The shaping between the front and back block is measured and the amount transferred to the centre back seam resulting in a one piece pattern (Richardson, 2008). While the manipulation results in a one piece pattern shape and the stretch is not interrupted by seams, Richardson and Cole do not address shaped seams or panel seams to follow the body curvatures, nor do they discuss grainline direction (Richardson, 2008, Cole, 2016). Richardson (2008) includes garment fitting instruction for the high stretch unitard removing excess along vertical side seams and horizontal shoulder seams however there is no information for swimwear shapes. Commonly, in the industry swimwear fittings or development of patterns are carried out on fit models toward the end of the pattern design process, rather than at the beginning with adjustments made to the flat patterns. However there are few systematic processes describing the pattern adjustments. Generally, most pattern observations are for aesthetic reasons with basic consideration for movement and pattern developments are toiled and tested for fit and comfort. The main focus is on achieving a successful prototype that fits and matches the design specifications.

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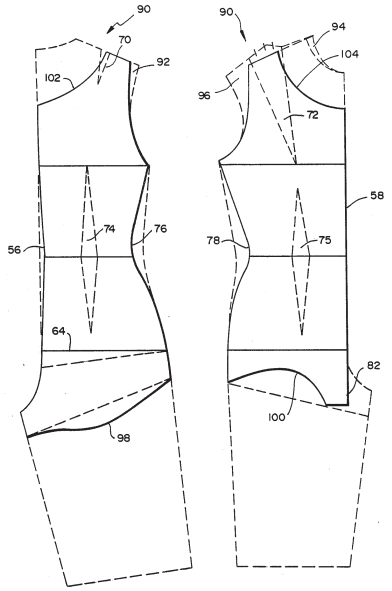
1.2 Comparisons: Woven and High Stretch Knit Patternmaking

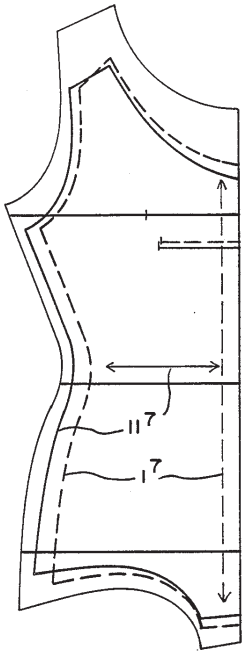
Conventional swimwear pattern developments generally derive from non-stretch pattern blocks. Nearly thirty years ago, Ziegert and Keil (1988) carried out research to analyse and compare pattern shape and size of woven or low stretch fabrics and high stretch knit fabric. At the time, high stretch elastane fabrics had been used for approximately ten years to make women's active sportswear (including swimwear) but little was understood and documented about the quantitative findings of a formula for adapting woven patterns to make an elastomeric knit pattern block (Ziegert and Keil, 1988). Ziegert and Keil pioneered and patented a patternmaking system that measured the stretch fabric properties of two different knit fabric configurations and from the results established a suitable formula to apply to the women's woven darted pattern block with the intention of producing a contoured high stretch knit block (fig.1). A method of how to apply the calculations was also ascertained. Measurements are shown in the vertical and horizontal direction in relation to how the fabric performs when measured on the garment stretch test assembly (Ziegert and Keil, 1990) (fig. 2). The approximate horizontal body measurements are located at: cross back, cross chest, midway between underarm and natural waist, high hip and the approximate vertical body measurements are located at: midway along front and back neckline, midway along shoulder width. The comprehensive study identified the relative differences between stable woven fabric and flexible high stretch elastane knit fabrics. A manual method of patternmaking is chosen to alter the women's darted bodice block into a close fit body wear block even though at the time CAD was considered to be new technology (Ziegert and Keil, 1988). My own previous design and patternmaking industry experience concurred with Ziegert and Keil's grainline identification discussion with their identified differences of fabric stretch qualities in the warp and weft direction and effects of different knit structures on the size and shape of the pattern (Ziegert and Keil 1988). It is important to note that these developments of the knit blocks from the woven are all based on the vertical and horizontal shift of axis. Watkins acknowledges Ziegert and Keil's research and states how little research has been undertaken in high stretch apparel in recent times. Watkins quantitative study updates Ziegert and Keil's research by utilising modern tensile testing equipment to measure fabric stretch in relation to fabric strength (Watkins, 2011). Watkins identifies research undertaken by Harada (1982) which adopts Laplace law to identify the effect of fabric tension on the curvature of the body and makes a valid summation of body circumference to fabric stretch relativeness. Watkins also identifies the levels of garment fit in proximity to the body and the

relevance of shoulder and armhole areas to the fitting process of body contour apparel as well as the crucial shoulder and hip points in relation to movement (Watkins, 2011, Harada (1982) cited Watkins, 2011).

Watkins integrates 3D and CAD technology to devise a mathematical printed grid system on an `action fit' body suit to analyse body movement to determine stretch fit ratio in high stretch knit apparel. However the pattern shapes are still based on the tailored matrix system including side seams, shoulder seams, set in sleeves with conventional shaped armholes. Most research in this area including Watkins, make adjustments to the woven block and diffuse the darts into the knit body block following the notion that the fabric will stretch and form over the body. This is correct for a skimming fit however if a contoured fit is required then darts or bust suppression is required or an alternative method of cutting.



(fig. 1)
Ziegert & Keil U.S. Patent (1990) Comparative analysis between Woven & stretch knit block



(fig. 2)
Ziegert & Keil U.S. Patent (1990) Comparative analysis of high stretch knit pattern blocks

1.3 Pattern Practise for Movement

i) Alternative Patternmaking

In this research project, I chose to explore the potential of one piece (singular) pattern design methods and systems as an alternative to conventional processes for swimwear production (Sevin-Doering, 2004, Lindqvist, 2013, 2015, Cumming, 2015, 2016).

Most published design practitioners, who engage in draping fabric to the moving form, work with primarily woven fabrics or low stretch knit, resulting in nett fitting measurements (Sevin-Doering, 2004, Lindqvist, 2013, Cumming, 2015). Early innovators, Madeleine Vionnet and Genevieve Sevin-Doering are most relevant to this project as they investigate drape for movement and the body is central to their methodologies (Kirke, 2012, Sevin-Doering, 2004). In the years, 1912-1939, Vionnet attributed her drape technique to observing the fabric grainline and specifically cutting garments on the bias grainline. She created designs that emulated the body shape and the bias cutting allowed her garments to move (Kirke, 2012). Vionnet's method included draping fabric on the form, using convex and concave shapes and transferring fabric shapes to patterns (Kirke, 2012). Costume design artist, Sevin-Doering (Sevin-Doering, 2012) practised a similar method to Vionnet although she purposely draped the cloth from directional points of the body and designed for the moving body. Genevieve Sevin-Doering developed `methode de coupe en un seul morceau' in 1969 using the live body to systematically create one piece patterns (Sevin-Doering, 2012). The patterns are cut as one piece with the intention for the final shapes to be considered as art pieces (fig. 3). Sevin-Doering methods are based on cutting from a pre-tailoring period (middle-ages in Europe) before blocks and mannequins were used (Lindqvist, 2013).

Much of Rickard Lindqvist research is based on Sevin-Doering's practice after spending two weeks with this artist and carrying out reverse engineering of her patterns (Lindqvist 2013). Lindqvist formalised a system called the `Kinetic Garment Construction Theory' (Lindqvist, 2015). Lindqvist's system begins with a single piece of cloth but this is not consequential to his research. Both Sevin-Doering and Lindquist consider the body should be the starting point in garment construction (Sevin-Doering, 2004, Lindqvist, 2013). Lindqvist's garment construction process is developed from Sevin-Doering's, `methode de coupe en un seul morceau' promoting working outward from the body and not inward as Lindqvist describes the tailoring matrix method of patternmaking (Lindqvist, 2013).

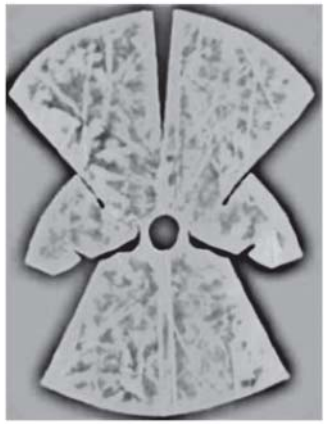
Lindqvist questions the industry patternmaking methods that use the tailored matrix and discusses

that this system bears no relation to the curvatures of the body or the moving body (Lindqvist, 2013). Alternative pattern practitioners Lindqvist, Wang and Cumming have published work that identifies points on the body that are essential to design patterns for the moving body. Lindqvist identifies a complex system of biomechanical directional points and curved balance lines denoting them in `Kinetic Garment Construction Theory' (2015). These biomechanical points on the body are referred to as `fundamental points' to indicate gravitation drape and directional movement (fig. 4) (Lindqvist, 2015). Wang (2011) takes net measurements of the exact body size with 3D body scanning technology (Wang, 2011). Wang's anatomical points (fig. 5) are within close proximity to those identified on Cummings oneP-foundation bodice that were derived from analysing drape points of curvature on the body. Cumming's identifies the points on the oneP-foundation as upper body pivot points (Cumming, 2015) (fig. 6).

The body points identified by these three alternative pattern practitioners have inform my decision to ascertain which points are relevant to high stretch apparel.

It is interesting to note that in Wang's research the intended types of fabrications are considered after measurements are taken and the block is drafted contrary to fundamental processes working with the fabric and its inherent qualities to enhance movement, as seen in practitioners using Drape. Wang researched pattern cutting for high performance running gear, positioning seams for movement and even though the patterns were not one piece, the multiple pattern shapes were cut to the curvatures of the body and consideration to the moving body (Wang, 2011).

Cumming's work looked to drape methodology to create one piece pattern shapes inspired by the minimalist aesthetic of patterns created by Vionnet, Sevin Doering and Lindqvist and new possibilities for production. Similar to the afore-mentioned designers, Cumming creates design pattern shapes utilising grainline for inherent movement and strength to achieve the desired fit and ease. Like Sevin-Doering and Lindqvist, vertical and horizontal matrix lines are ignored. Crucial body points and curved body lines from the live body inform the shapes and internal cut lines. In some of her work, laser cutting treatments provide functional aspects of folds and fit in the one piece pattern shapes (Cumming, 2015). Of interest to my project is Cumming's research in fitted womenswear. By observing fabric grainlines and directional drape principles, Cumming establishes the points on the body where fabric wraps and falls away to facilitate increased movement (Cumming 2015). This identifies where to place the particular grainline to provide strength which aids fit and flexibility for the arm and upper body movement while retaining



(fig. 3)
Famille Porte feuille Sevin-Doering (1981)
Famille du Collant Sevin-Doering (1972)

a close body fit in woven or low stretch fabric (Cumming, 2015).

In addition, Cumming is researching the relationships of one piece pattern methodology and processes for varied fabric types, including non-woven, low and high stretch fabrics. This investigation plays an important role in the beginning stages of this project.

In this literature review, I did not find other pattern cutters who referred to fundamental body points or applied radical pattern methods to enhance movement. In industry most pattern designers rely on stretch and new developments in fabric for performance. There are new technologies such as new CAD software and body scanning equipment with heightened capabilities to analyse movements of the body and motion exercises but pattern system changes are not evident yet. Sevin-Doering, Lindqvist and Cumming are design-orientated practitioners and their alternative approach is qualitative in nature. Quantitative research has the capacity to contribute to high performance developments using biomechanical engineering (Wang, 2011, Watkins 2011, Li, Zhang and Dai, 2006).

Linqvist Fundamental points:

- cb 7th cerival at vertebra
- front arm point
- back arm point
- cb waist point

Gravitational drape lines:

- cb neck through front arm point around to cb waist,
- cb to back arm point through scapulae,
- cb waist point to front crotch.

(fig. 4)
Fundamental points, (Lindqvist,2015)

Wang Anatomical points:

- Base of 7th cervical vertebra
- point of halfway between the front upper and lower scye levels
- point of halfway between the back upper and lower scye levels
- Front point of armscye depth
- Back point of armscye depth
- Under point of armscye point of scapulae

(fig. 5)
Anatomical points of upper torso (Wang, 2011)

Cumming Body pivot points:

- back scapulae
- each side of top shoulder area
- elbow
- body front arm points
- back arm points
- upper centre front
- bust
- front waist
- back waist

(fig. 6)
Body pivot points (Cumming, 2015)

ii) Biomechanical engineering

Li, Zhang and Dai (2006) defined clothing biomechanical engineering as ‘the application of a systematic and quantitative way of designing and engineering apparel products to meet the biomechanical needs of the human body and to maintain an appropriate pressure and stress distributions on the skin and in the tissues for the performance, health and comfort of the wearer’.

In his comprehensive quantitative study, Wang analysed body movement and fabric response to develop apparel for high performance activity (Wang, 2011). Even though Wang’s quantitative research is very specific to high performance running wear, the methodologies applied to analyse fabrication, body motion, and functional design are all applicable when designing apparel for recreational swimming including crucial seam line positioning, evaluation of directional grainline and wear testing of the garments to assess design, fit and comfort. Wang observed the body in static and moving states to identify the optimum fit during movement for thermal comfort and support. Wang (2011) refers to the result of fit as the `dynamic fit‘ and considers the close fit of the body suit to be similar to that of the pattern structure of skin following the curves of the body (Wang, 2011).

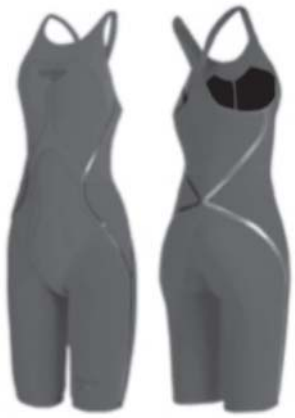
Hatch (1993) (cited in Ashdown, 2011) calculated from a variety of high stretch fabrics and active wear garments that `the appropriate range of percent elongation’ changes between 35-50%. This range and freedom of movement hinges on the pattern being cut to fit like a second skin: affirming the importance of designing with consideration of the body for a close fit. The anisotropic (different properties in all directions) and isotropic (retaining identical properties in all directions) qualities of skin are also discussed by Lindqvist in pattern applications (Lindqvist, 2015). Lindqvist’s qualitative research regards fabric grainlines in relation to fit and movement, and presents his developing work of the co-relationship between the directional drape lines and mapping lines of human skin from Langer (cited in Lindqvist, 2015). While skin property analysis is outside the scope of this project, it is acknowledged in respect of directional stretch on the body and relational seamline direction.

1.4 Developments in Industry

i) High performance Swimwear

In the high performance swimwear market, renowned market leaders as Speedo, Arena, Adidas undertake extensive research and developments that are commonly protected by intellectual property (Speedo, www.speedo.com, Arena, www.arenawaterinstinct.com, Adidas, www.adidas.co.uk). Consequently, there is limited literature published by the sports industry and academics in pattern design for high performance and biomechanical engineering (Watkins, 2011, Wang, 2011, Watkins and Dunne, 2015, Hayes, Venkatraman et al, 2016). These generally include new fabric developments, integration of human ergonomics in product design and new production methods to enhance performance.

In the specialism of high stretch apparel, there is an intrinsic relationship between fabric performance and response. Published works (Ziegert and Keil, 1988, Wang 2011, Watkins 2011) and companies Speedo and Arena all show the inherent association of analysing fabric weight and stretch capability to the apparel form before and during the design stage. It appears to be common practice for quantitative researchers undertaking pattern design research to test two to five different fabrics to determine the most appropriate denier (thickness), stretch and recovery properties for the study (Ziegert and Keil, 1988, Wang, 2011, Watkins, 2011). Wang (2011) refers to Kirk and Ibrahim (1996) 42% skin elasticity capability and applies the correlation to high stretch knit fabric used in sportswear design. This parallel can be integrated by utilising fabric stretch properties to achieve a close fit as well as using fabric grainlines that follow the same directional pattern as the muscle structure of the body. Muscle mapping provides information to the designer to observe the parts of the body requiring support during movement. Panel lines on the running suit Wang developed explored the correlation between skin and fit (Wang, 2011). Wang applies the directional skin lines to the fabric grainline of the running suit which simulates the same stretch properties and the strength /support allowing a fit to accommodate maximum body extension and contraction (Wang, 2011). Erwin and Kinchen (1974) (cited in Wang, 2011) refer to five criteria (ease, line, grain, balance and set) as guidelines to determine how a garment sits on the body. Wang (2011), like Zeigert & Keil (1988), Watkins, (2011) analyses the stretch properties of the high stretch knit to establish fit in relation to movement.



(fig. 7)
Speedo® Fastskin® LZR Racer X Closed Back swimsuit

Sabir & Wood present an informative evaluation of fabrics and garments designed for performance clothing (Sabir & Wood, 2016). This includes a discussion of the advanced technical knit fabric, Fastskin, developed by Speedo in 1996 for the elite athlete / high performance market. The Fastskin fabric simulates the skin structure of a shark and is shown to improve the athlete's performance (Sabir & Wood, 2016).

In 2008, Speedo developed another product for the high performance swim athlete (Sabir & Wood, 2016). The LZR Racer range, including the Fastskin LZR Racer X closed back and the LZR X, is manufactured from a high stretch, lightweight fabric of woven structure. The fabric pieces of the LZR Racer range high performance swim suit are cut out using laser technology and joined together with high stretch seam sealing tape which prevent the fabric from fraying and also reduces seam thickness. The tapes strategically provide strength and support during activity from side front to side leg and back underarm to centre back waist (fig 7). This increases comfort for the athlete by significantly reducing chaffing during high performance movement. Specific areas of the suit provide the body with support using either double fabric layers or a higher density fabric weight (Sabir & Wood, 2016). However, Sabir and Wood (2016) also highlight one of the problems of the Speedo LZR range swimsuit is the length of time it takes for the athlete to don and doff the high tech garment due to the firmness of fabric and the garment fit. I would suggest this anomaly is not acceptable to the recreational swimmer nor is the high price point of these suits.

ii) Fashion and Recreational Swimwear

Even though, the fashion sector is considered as the trend setter for swimwear, it appears little research is carried out to improve the customer's experience of swimming. The fashion swimwear market is designed for a high season turn around with a wide price range between economic and luxury swimwear brands (fig 8). The lower priced fashion swimwear brands often have a minimal design aesthetic and use readily available plain or patterned fabric. Whereas the luxury swimwear brands often include poolside designs made from expensive fabrics not intended for regular water immersion (Schmidt, 2012). This price variance is directed by the label driven consumer who follows brands that demand a high price aesthetic. There is a smaller price variance within the recreational swimwear labels largely due to less focus on fashion orientation and lower fabric costs. The design aesthetic often focusses on sporty styling including cut away straps and slight alteration to vertical seam line positioning. These design elements have no relevance to directional grainlines or curved seamlines. It is more economical to signature the recreational product with surface interest rather than invest in product design development for specific purpose.

To keep costs down, most the recreational swimsuits on the market are manufactured in the same Nylon /elastane fabrics as fashion swimwear however recently more specialist fabrics including chlorine resistant, Aquablast, fabric are being introduced to the consumer. The Speedo Pinnacle swimsuit has a number of technical design elements for comfort and support including `light compression' to enhance fit, intentionally placed tape lines to follow the muscular structure of the body, spherical support around the bust, cross over shoulder straps and forward positioned side seams. However these seamlines remain in a vertical position and do not follow through from the tapelines (fig 9). In 1929 the Australian company, Speedo released the Racer back swimsuit: designed to hold the straps between the shoulder blades for comfort while swimming (Schmidt, 2012) (fig 10). Close to one hundred years later it remains a functional design element of Speedo and other swimwear design companies.

The swimwear sports label, Zogg integrated a variation of the racer back design: the action back (fig 11). The second Zogg swimsuit is cut from specialised Aquablast fabric to resist chlorine and is fully lined with a shelf bra for bust support. This swimsuit has adjustable cross over straps attached at the front underarm although these are too narrow to give under bust support during repetitive arm movement. The side seam is positioned toward the back pant section to reduce bulk at the intercepting seams however the height of the side back waist is low and could affect the comfort element during twisting (fig 12).

(fig. 8)
Product analysis and price positioning

(fig. 9)
Speedo Fit Pinnacle X-Back Swimsuit

(fig. 10)
Speedo racerback swimsuit

While all of these contemporary swimsuits are examples of close fit, they have had only minor seam alterations to the pattern block and none of the designs are cut to optimise the high stretch properties of the fabric that it was designed for.

(fig. 11)
Zoggs active sport action back swimsuit

(fig. 12) Zoggs starback swimsuit

1.5 Fit, Comfort, Movement Evaluations

It is important to include testing and evaluation in this study as it is standard procedure in industry to have consumer wear testing or, more recently, body scanning to create a 3D computer image or avatar (Gill, 2016). Gill and Prendergast acknowledge existing quantitative research focuses on the engineered fit of high performance sportswear and state there are further research opportunities which centre on designing apparel for the non-competitive sportsperson (Gill and Prendergast, 2016). The observations by Gill and Prendergast, (2016) and Ashdown (2011) confirm recreational sportspersons are interested in buying apparel designed with technical aspects that attribute to body fit and comfort during specific performance movement. Gill and Prendergast (2016) identify that the dynamics of a well-fitting pattern shape are reliant on certain fit criteria which they list as `fabric, function, sensorial comfort, performance expectations and ease determination, especially regarding their numeric application in terms of the pattern'. These criteria are paramount during the design and development stage of high stretch knit apparel. Gills and Prendergast (2016) and Ashdown (2011) suggest the designer needs to observe the moving body and design the garments orientated to the particular sporting activity and evaluate fit. Brownbridge (2016) classifies four categories of garment comfort in relation to seamless knitted garments (produced with complete garment technology). The four categories are sensorial, ergonomic, thermophysiological, and psychological comfort (Brownbridge, 2016). For this study, I identify a) sensorial comfort and b) psychological comfort as the most relevant. Sensorial comfort is particularly applicable to the one piece pattern shapes in respect to the strategically placed design lines that follow muscle structure and contribute to garment fit, flexibility and stability.

Sensorial comfort is `the subjective evaluation the wearer makes about how the garment feels against the skin….'This is clearly advantageous for sports garments, particularly those worn next to the skin, such as base layers and swimwear (Magnus et al., cited in Brownbridge, 2016).

Psychological comfort speaks to design aesthetic and the `feel good' aspect of design: an element essential in design both of which is fundamental to this project.

`Psychological comfort relates much more to how someone feels in a garment and will be more influenced by factors such as styling, colour, fashion and aesthetics. When relating psychological comfort to sportswear, garments that are perceived to look and feel as if they will provide high performance may also provide the wearer with higher levels of psychological comfort' (Brownbridge, 2016).

There is a distinct gap in the market for recreational swimwear with a need for fashion appearance and fashion developments to enhance the user experience and performance capability.

2. Methods and Creative Process

Alternative pattern practitioners, Sevin-Doering, Lindqvist and Cumming, show the benefits of extending traditional patternmaking methods to achieve new and exciting pattern shapes. Their one piece pattern and methods commonly include body related curved balance lines, pivot points and directional grainlines to assist fit and provide comfort and movement. The one piece pattern shape has the capacity to encompass all of these aspects and there is opportunity to apply these pattern methodologies to high stretch knit fabric and bring the relationship between fabric and the body even closer. I was interested in the close fit of Cumming's woven foundation for the female body and the integration of specified pivot points and directional lines related to grainline behaviour to assist movement (including the arms) without disrupting the fit of the body (Cumming, 2015). Cumming's drape method on the live body is different from my 2D to 3D practise of using the flat body wear pattern blocks and I was keen to develop one piece pattern design skills without the use of conventional pattern blocks as a base. As previously mentioned, Athleisure is an ever-increasing market (Gill and Prendergast, 2016) and designers can respond with alternative methods that bring fashion and leisure closer together in design, wearer appreciation and new production methodologies. This process can obscure the formal margins between knit and woven fabrics methodologies from many perspectives.

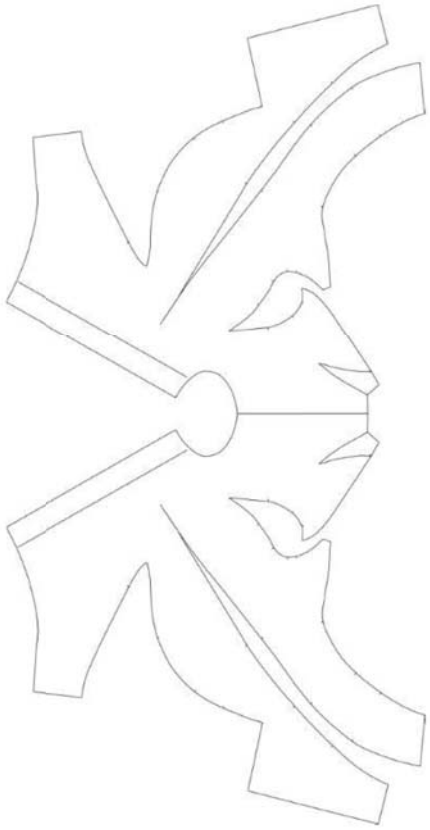
My initial research applies alternative one piece pattern methodology using Cummings the non-stretch oneP-foundation bodice pattern as a basis (Cumming, 2015). This contributed to a collaborative collection of low and high stretch knit apparel, `oneP-active' in exhibitions Nature Now CTANZ (Cumming and Weaver 2016) and End of Fashion (Cumming and Weaver 2016) (see Appendix: Part A). Preliminary research discusses the development of patterns for the high stretch components.

2.1 Understanding a Pattern Method

i) oneP-foundation Bodice (Cumming, 2015)

The one –P foundation was draped with a completely different starting point to the standard practise of creating a sleeved bodice. Cumming began with draping a cape-like garment with a front line running down the centre of the standing live figure, cutting away a circular neckline and letting the fabric settle on and around the shoulders to form a bias grainline at a cut centre back line. Marking the centre back neck point, front shoulder (forward of the high shoulder point) and front arm body crease line (made by pivoting the arm forward), she drew a connecting line, and cut from the perimeter of the fabric up through this line close to the centre back neck point (an approximate bias line). Another line was drawn from the back scapula to the back arm body pivot point (derived from moving the arm back and forwards) and again cut from the fabric perimeter up though this line. These two cut lines created a bias rectangular shape. It was this shape that Cumming then wrapped around the arm like a shawl. In order to create a close fit on a forward moving arm Cumming cut a third bias line in the middle of this bias rectangle extending to the back shoulder (slightly back from the top shoulder position). The grainline, shaping of these lines and displacement of exterior joining points provides a fitted spiralling tube and forward placed curvature for the arm and bent elbow. An additional shape was accommodated in the curved line on the front sleeve to allow a forward lift movement for the arm. The body of the garment was then shaped from the back scapula under the arm around the front torso using the flexible grainline to return to a more stable line towards the centre front under the bust. This horizontal line corresponds to the forward body bending of the abdominal area and the back bias extended in one to the front to provide fit and movement. These lines are informed by heightened breaks of body curvature, fabric grainline observation and curved seam lines and function follows the form with internal cut lines and exterior shaping of the draped piece (Cumming, 2015).

Cumming draped a single piece of woven cloth with minimal stretch on the live body and used the directional grainline of the fabric, then strategically placed curved body lines with pliable bias grainline which corresponds to body movement and provides the close fit of the garment. The principles provide the garment with defined areas of flexibility and stability for a body in motion. Cumming's upper body pivot points are located at the back scapulae, each side of top shoulder area, elbow, body front and back arm points, upper centre front, bust, front and back waist. The oneP-foundation bodice, cut in one piece, has suppression removed along the curved seam lines and bust darts (fig. 13).



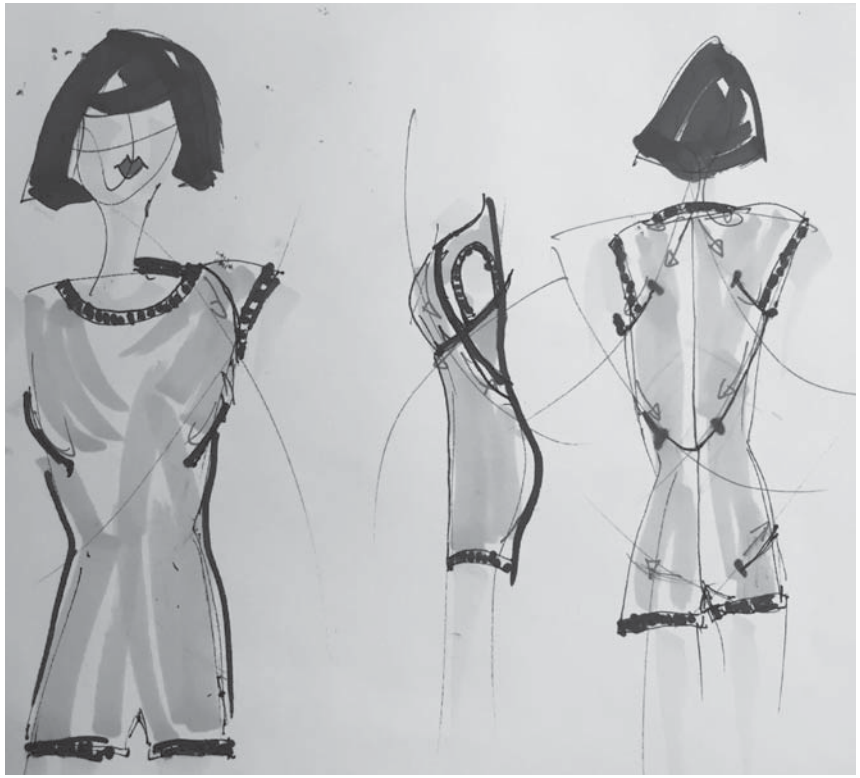
(fig. 13)
oneP-foundation bodice
(Cumming, 2015),
Courtesy of Deb Cumming

ii) Design Development from oneP-foundation bodice

To comprehend Cummings pattern design methodologies, I reflected on my own practise of Patternmakingswimwear in relation to grainline and curved balance lines. I identified points on the body where fabric stretches between points and draw directional arrows onto my design sketches (fig. 14). I also considered the position of grainlines, body curves and crucial body points and areas of stability and stretch. High stretch knit grainline direction can significantly alter the fit of a garment depending on where the strongest structure of the knit fabric is positioned on the body. This is also inherent with Cummings work with the bias grainline providing suppleness and the linear grainlines providing strength.

To fully understand the methods employed by Cummings I worked on a collaborative one piece active wear pattern collection that comprised of high stretch active wear (bodysuits, crop top, tights). These were developed alongside low stretch active wear jackets that Cummings resolved. The first part of this project contributed to a collaborative exhibit with Cumming titled ‘Nature, energy and movement for new apparel design’ and ‘oneP-active’ (Cumming and Weaver 2016) (see Appendix: Part A). In this exegesis, I discuss the technical design and development of the high stretch Cap sleeve body, Racer back body and the crop top as these are the basis to my swimwear collection. For the oneP-active garments, I selected polyester and elastane fabric for the sampling and prototyping as this is widely available and commonly used in active wear.

An iterative design process is integral to my technical design practise and is used to develop the one piece pattern shapes for the oneP-active and the swimwear collections. To realise the 3D design concept, the designs are manipulated into eighth (1/8) scale pattern shapes which provides an estimate shape of the final designs and ascertains the pattern success in full scale size. It also aids efficiency: the physicality of working on these smaller patterns enables more design ideas to formulate and more efficiency in annotating process (fig. 15).



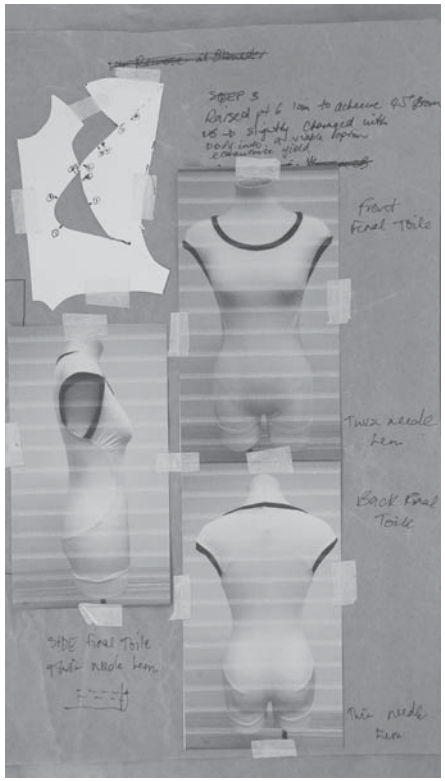
(fig. 14)

Weaver, Nina. Shaped to Fit.

Workbook: oneP-active: Direction lines 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver



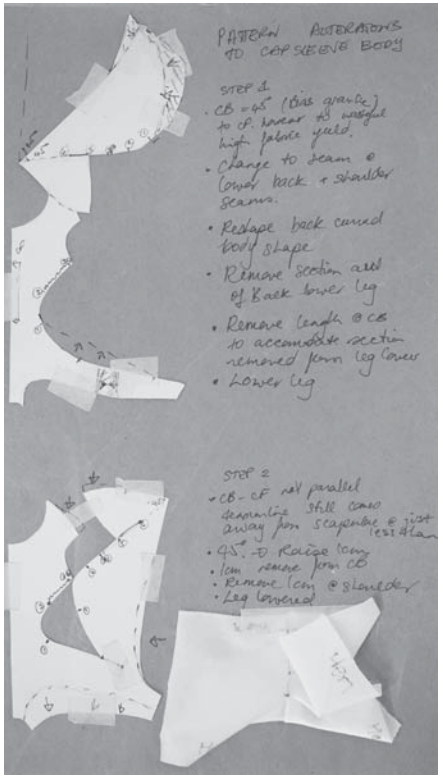
(fig. 15)

Weaver, Nina. Shaped to Fit.

Workbook: Cap sleeve 1/8 scale pattern development

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver



The Cap sleeve body pattern is made by combining the oneP-foundation bodice shape with the hip and leg line shaping of my high stretch body pattern blocks. The centre front lines are placed on top of each other with the waist lines matching. The centre back of the high stretch body block is placed parallel as it is 2cm wider than the oneP-foundation bodice. The position of the crucial pivot points are transferred from the woven foundation pattern to the high stretch blocks. The crucial body points applicable to the designs are located at the centre back neck, scapulae point (45 degrees or bias grainline below centre back neck point), the body front arm point and the highest point at the gluteus maximus. The grainline directions on the oneP-foundation bodice pattern determine areas of stability and stretch and then these are also applied to the high stretch body blocks. The crucial body points are applied to the design drawings which help to establish the points of origin for movement and grainline positioning. The Cap sleeve body seam lines are then designed to the smooth curvature line following the scapulae muscle group (back shoulder blade), through to the body front arm point, front torso and back to the gluteus maximus. The singular pattern is designed to circle the body and fit like a second skin, aiding support during movement by targeting specific muscle groups. It is intended the wearer experiences a continuum: a sense of fluidity.

iii) Analysis of the Low and High Stretch Patterns

With the first pattern iteration completed, I wanted to make a comparison to ascertain the size difference between the oneP-foundation bodice, the high stretch body blocks and the cap-sleeve body pattern. This requires an investigative analysis, following the principles of Ziegert and Keil (1988) and Wang (2011), to study the pattern shape and size as well as fabric stretch and pliability. An observation is made to assess the co-relation between crucial body points, curved seamlines and grainline direction between Cummings close fit low stretch oneP foundation pattern and the high stretch knit body wear blocks. To identify the key points of the oneP foundation, cap sleeve body and high stretch body blocks, the pattern shapes are placed on top of each other in the same way as the first pattern iteration with the shoulder points, centre front edges, and front waists matching. The centre back of the high stretch blocks and the cap sleeve body are positioned on top of each other however as the oneP-foundation bodice is narrower it is placed parallel. The back body arm points are all located at the same level. The patterns are traced around marking in all chronological notches, grainlines and crucial body points: centre back neck point at the seventh vertebrae, the scapulae point, body front arm point. The curved seam lines are also marked in.

My experience of comparing conventional high stretch and low stretch pattern blocks usually shows significant size variances. I came to the conclusion this was due to the difference in ease required between these blocks when they are based on the tailored matrix with side seams and shoulder seams. This study demonstrates that when the pliable grainline of low stretch fabric is strategically curved around the body it gains similar stretch characteristics comparable to the stretch in knit fabric and there are significant dimensional similarities between the low stretch oneP-foundation bodice and the high stretch body pattern and blocks. The oneP-foundation pattern was narrower through the back by 2cm however this is within an acceptable tolerance considering the high stretch pattern and block is stretched both vertically and horizontally around the body. On all three patterns and blocks, the line starting at the apex of the centre back neck and angles through to the scapulae is on the same 45 degree angle or bias grainline and provides different strength and flexibility to all subsequent oneP-active and swimwear designs. There are expected variances between the front body arm points of the high stretch pattern and blocks and the oneP-foundation because the latter front is raised as it wraps around to meet up with the back body arm point. I was intrigued by the results of the investigative analysis and concluded that the results were due to the grainline positioning and alternative methodology (fig. 16).

oneP-foundation bodice Pattern	Cap-sleeve Body Pattern	High stretch Body Blocks
Shoulders	Shoulder points match with oneP-foundation	Shoulder poits match with oneP-foundation
Centre front neck point	Neckline design variances	Shoulder poits match with oneP-foundation
Centre front line & straight grainline	Aligned to CF of oneP-foundation bodice	Aligned to CF of oneP-foundation bodice
Body front arm Points	Front arm point of oneP-foundation is lower because front lifts around to join to back arm point	Front arm point of oneP-foundation is lower because front lifts around to join to back arm point
Centre back neck point (apex)	Wider than oneP- foundation by 2cm but parallel	Wider than oneP- foundation by 2cm but parallel
Centre back line & bias grainline	Wider than oneP- foundation by 2cm but parallel	Wider than oneP- foundation by 2cm but parallel
Scapulae & 45deg from cb	Aligned with oneP-foundation	Aligned with oneP-foundation
Body back arm point	Aligned with oneP-foundation	Aligned with oneP-foundation
Waistline: front 90deg to cf	Waistline sits on top of oneP-foundation	Waistline sits on top of oneP-foundation
Waistline: back 90deg to cb	Back waistline sits higher than oneP-foundation because off vertical and horizontal stretch around body	Back waistline sits higher than oneP-foundation because off vertical and horizontal stretch around body
Below waist: front	N/a use hip and leg shaping of pattern	N/a use hip and leg shaping of pattern
Below waist: back	N/a use hip and leg shaping of pattern aligned	N/a use hip and leg shaping of pattern

(fig. 16)
Findings of Comparative pattern study. 2017. Wellington, New Zealand. Photo: James Weaver. Courtesy of Nina Weaver

2.2 Design Development of oneP-active Capsule Collection

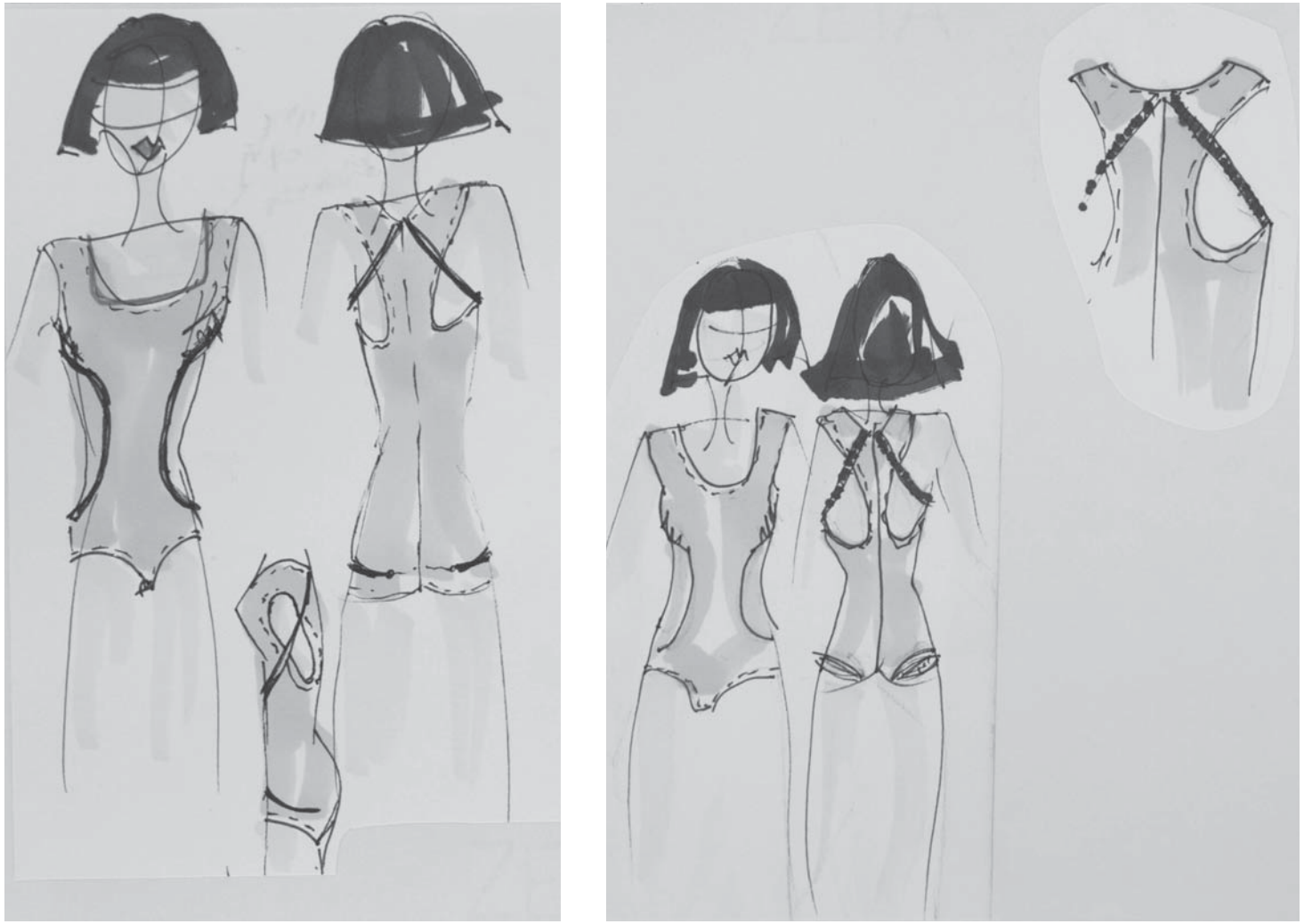
From this point on, the front and back high stretch body wear blocks are not used in the pattern design process as these were only reference points for comparative purpose. Instead, the oneP-foundation pattern and the curved seam lines and grainlines are referenced to complete the Cap sleeve body pattern and the subsequent Racer back body and Crop top pattern.

The principles of method were integral to the design development of the oneP-active designs including one piece pattern shapes, curved seamlines that connect crucial pivot points with consideration to high curvature points to provide areas of strength and stretch during bending and moving action. Horizontal grainlines are used for support and vertical and bias grainlines and optimise fabric stretch for the moving body (fig. 17, fig. 18, fig. 19).

Full scale patterns were then made and toiles were fitted on the live body to evaluate fit for comfort and movement. If adjustments are required during this process, then a visual and tactile assessment is done to calculate how much fabric needs to be added or removed. Directional lines are also drawn on the toile fabric in response to proportion and aesthetic. Where possible consideration is given to fabric yield, for example, the first pattern iteration of the cap-sleeve body has a high fabric yield so the front and back sections are joined at the side body area (fig. 15). This retains the one piece pattern shape and utilises directional grainlines and fabric stretch. The seam over the shoulder follows the balance line from the centre back neck. Consideration is also given to seam angles, for example the Racer back body is designed with a strap / seam from the centre back apex that follows through to the scapulae on a 45 degree angle to the front body arm point (fig. 20).

A Fit model is used to test specified movements relevant to the activities. This process adheres to the applicable ergonomic principles as discussed by Branco (Branco, 2015).

Once the oneP-active wear patterns are finalised, the patterns are digitised into the CAD system and 1/8th scaled patterns are printed off for the design and pattern process of the oneP-swim collection. A print design for the oneP-active collection was developed on Illustrator to show the process with the crucial pivot points, drape and grainline directions and curved seam lines (`Nature, energy and movement for new apparel design' In Nature Now CTANZ (Cumming and Weaver 2016).



(fig. 20)

Weaver, Nina. Shaped to Fit.

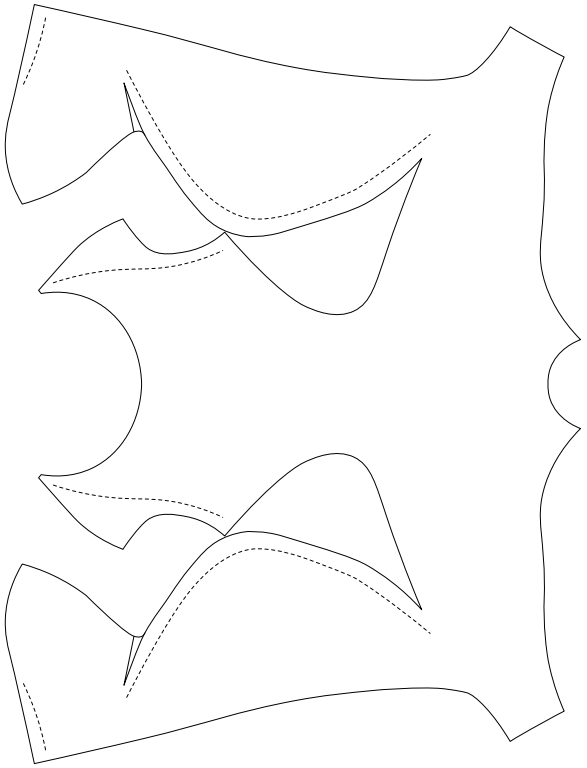
Workbook: Racer back design detail 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

Cap sleeve Body

Aesthetic	Cap sleeve Body design has the functional design elements: print indicating curved muscle bodylines, action neckline, fully enclosed back, elite athlete leg line, under bust gathers. Suitable for cross training, swim, gymnastics, yoga, dance.
Support Seam lines:	Close fit body support from curved seam line following muscle structure passing through crucial curvature points: • Seam starts at high scapulae point at back, through forward side body, to gluteus maximus • Seamline gives support at side under bust and gathers provide bust shaping, provides suppression at waist seam shaping (convex), provides shaping as well as close fit through hip (concave) • Seam through gluteus maximus and seam shaping helps to hold long leg line in place during repetitive leg movements. • Seam from upper centre back across trapezius to deltoideus (forward shoulder /arm position) provides shoulder support from centre back • Centre back seam provides strength through the back.
Support Grainlines: (Horizontal / crosswise / Weft)	• Horizontal stable grainline in torso section: across front under bust, front waistline, top edge of upper centre back section. • Horizontal stable grainline across long leg line from front to back is parallel giving muscle support and some compression
Movement: Stretch lines optimised	• The full front body (from neckline to crotch) has uninterrupted fabric stretch optimising vertical stretch during forward bending and backward movements, arm reach and arm swing movements.
Stretch Grainlines: (Vertical / straight / Warp)	• Grainline through centre front to centre back also has vertical (maximum) stretch through lower section of gluteus maximus providing maximum stretch, stretch and helps to synchronise body with movements. • Low leg line design and shaping through gluteus maximum ensures back leg line stays in place during repetitive leg movements.
High curvature points:	• Scapulae, gluteus maximus
Pivot points:	• Body front arm point



(fig. 17)

Weaver, Nina. Shaped to Fit.

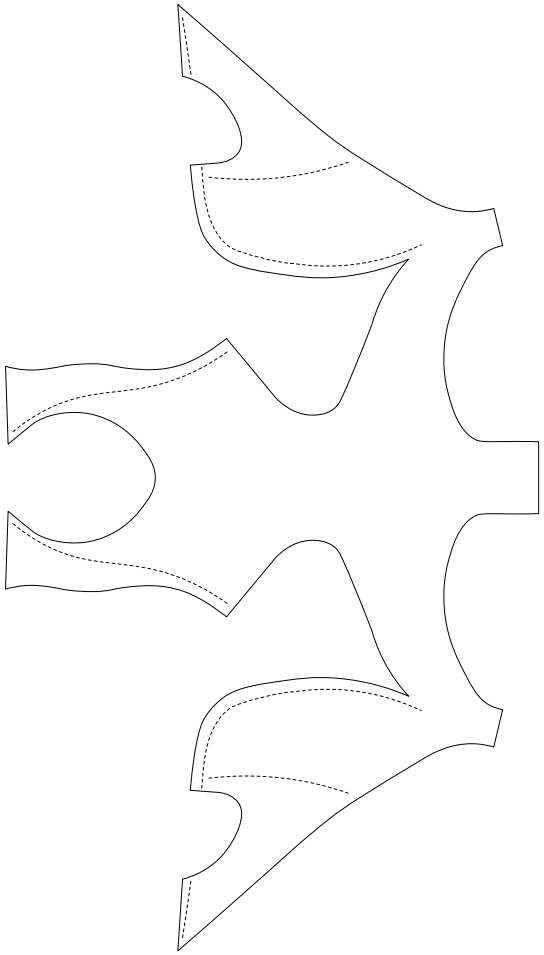
oneP-active: Pattern Analysis of Cap-sleeve body, 2017.

Wellington, New Zealand.

Photo: Deb Cumming, Courtesy of Deb Cumming and Nina Weaver

Racer Back Body

Aesthetic	Racer Back Body design has the functional design elements: stream lined silhouette, action neckline, sport muscle-back, free movement cut away, sport leg line, curved muscle bodylines, under bust gathers. Suitable for cross training, swim, gymnastics, yoga, dance
Support Seam lines:	Close fit body support from curved seam line following muscle structure passing through crucial curvature points: • Seam starts at centre back neck, at a 45 degree angle through the scapulae (including additional strap), front side body, to gluteus maximus • Seamline gives support at side under bust and gathers provide bust shaping, provides suppression at waist seam shaping (convex), provides shaping as well as close fit through hip (concave) • Seam from upper centre back to high point of scapulae connects front shoulder section to back; providing shoulder support from centre back over to body front arm point. • Centre back seam provides strength through the back. • Seam through gluteus maximus and seam shaping helps to hold low leg line in place during repetitive leg movements.
Support Grainlines: (Horizontal Weft)	• Horizontal stable grainline in torso section: across front under bust, front waistline, top edge of upper centre back section, scapulae seam edge of side back section where side back attaches at body front arm point. • Horizontal stable grainline across front leg line.
Movement: Stretch lines optimised	• Side bust / armhole cut to pass through front arm body point, attaching to under bust seam for side bust support. • Additional strap from centre back to top of scapulae, through scapulae picking up front arm body point allows for ease of arm movement as well as snap back after arm movement. • Cut out section at scapulae balances body coverage and facilitates movement.
Stretch Grainlines (Vertical Warp)	• The full front body (from neckline to crotch) has uninterrupted fabric stretch optimising vertical stretch. • Vertical grainline runs along armhole edge from front to back, side back curved seam providing maximum stretch. • Grainlines along curved lower seam at gluteus maximus provide maximum stretch. When the upper seam edge (vertical grain) sews to the lower seam (bias grain) the seam has flexibility and synchronises with body movements. • Low leg line design and shaping through gluteus maximum ensures back leg line stays in place during repetitive leg movements.
High curvature points:	• Scapulae, gluteus maximus
Pivot points:	• Body front arm point



(fig. 18)

Weaver, Nina. Shaped to Fit.

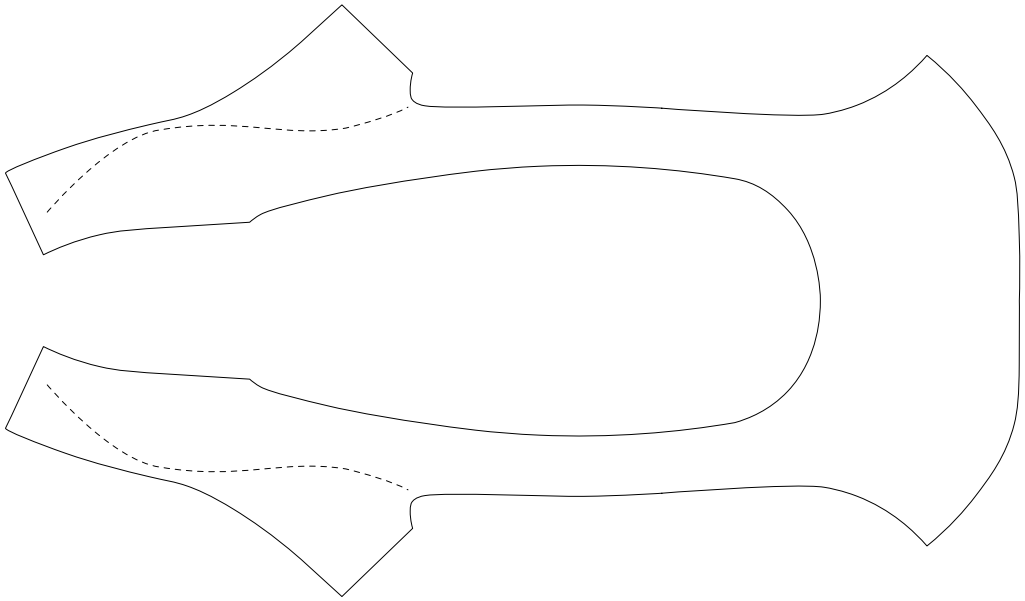
oneP-active: Pattern Analysis of Racer back body, 2017.

Wellington, New Zealand.

Photo: Deb Cumming, Courtesy of Deb Cumming and Nina Weaver

Crop Top

Aesthetic	Crop Top design has the functional design elements: stream lined silhouette, action neckline, support seam at under bust, bust gathers for shaping, cross over support back extends into front torso section, free movement cut away, curved muscle bodylines. Suitable for cross training, swim, gymnastics, yoga, dance
Support Seam lines:	Close fit body support from curved seam line following muscle structure passing through crucial curvature points: • Seam starts at body front arm point to front torso section • Seamline gives support at side bust and gathers provide bust shaping • Seam at centre front of front torso section and at centre back both provide vertical strength through seam
Support Grainlines: (Horizontal Weft)	• Horizontal stable grainline in torso section: across front neckline and bust line
Movement:Stretch lines optimised	• Front armhole passes through front arm body point, attaching to torso section for side bust support. • Cross over back strap follows scapulae line and connects to body front arm point through to centre front of torso section provides increased under bust support and movement • Cut out section below scapulae facilitates movement.
Stretch Grainlines (Vertical Warp)	• Vertical grainline runs from front bust section through armhole front edge, through shoulder strap to centre front of torso section
High curvature points:	• Scapulae
Pivot points:	• Body front arm point



(fig. 19)

Weaver, Nina. Shaped to Fit.

oneP-active: Pattern Analysis of Crop top, 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Deb Cumming and Nina Weaver

2.3 Wear testing of oneP-active

The oneP-active pattern designs are the basis for the swimwear designs therefore it is necessary to have the Cap sleeve body pattern, Racer back body and the Crop top pattern wear tested to assess fit in relation to comfort and movement and also to identify the preferred design elements. The wear test study of the oneP-active garments includes five (5) women participants that vary in chronological age. It is considered important not to limit the consumer market to any particular age group. The participants have previous and current involvement in a range of leisure and high performance activities including classical dance, gymnastics, yoga, pilates, swimming, gym classes, running and walking. A Massey University ethics application has been carried out and anonymity of names and physical evaluations are adhered to. The participants were asked to carry out specified movements and respond to questions relating to fit, comfort and movement (see Appendix: Part B).

The majority of active wear and swimsuits on the market have conventionally placed shoulder and side seams hence the inclusion of a basic maillot in the wear test study to set a base analysis for the participants. The participant's responses were recorded and analysed with relevance to project aims.

The following common responses for the active wear are summarised for analysis and to aid the development of new pattern designs for swimwear.

Findings from Wear test participants:

- Front neck depth good for a number of activities.
- Leg line stays in position and does not ride up.
- The curved seam starting at the scapulae and ending at the gluteus maximus provides stability to the upper back area as well as encouraging upright posture for the wearer to engage in a variety of activities.
- The curved seam is conducive to the shape of the body and allows for easier forward bending and twisting movements in both the Cap sleeve and Racer back body and also encourages the body to snap back into position after arm rotations.
- The shoulder width of the Cap sleeve body hinders arm movements although this style has the benefit of stability through the upper back during front breast stroke.
- The seam located under the bust offers support during twisting motion however the fit at the side of the bust and the strap from the scapulae contribute to under bust support. This result is expected as there is vertical stretch at the side bust on both styles along with stability from the curved seam coming from the scapulae.
- The curved seam provides shaping through the gluteus maximus and this helps to keep the garment in place during knee lift, leg swings, and bend forward and bend backward motions.
- The curved seam line running from the scapulae to the gluteus maximus is favoured in comparison to the conventional maillot.
- The lower leg line on the strap body is preferred for swimming activities.
- The narrower shoulder of the Racer back body is preferable for ease of arm movements.
- Both the closed back of the cap-sleeve body and the open back of the strap body are considered acceptable for swimming activity.

2.4 Design Development: Swimwear

The second part of this research creates three swimwear pattern designs for the recreational swimmer. The patterns are formulated using the one piece pattern methodology and data collected from the oneP-active wear testing. The designs aim to offer the wearer a comfortable fit that supports the body and aids movement during recreational swimming activity. For the swimwear prototypes, I intend to use a selection of plain tonal colours so I chose Nylon/elastane fabric for the dye fast properties. Nylon/elastane fabric also adheres to sensorial comfort and high stretch capacity and is commonly used to manufacture fashion and recreational swimwear (Venkatraman, 2016). The Aquafil Company has developed the ECONYL regeneration system to sustainably produce Nylon 6 polymers used to make yarn for swimwear fabric from post-consumer waste, such as discarded fishing nets from the ocean floor and pre-consumer waste including bi-product scrapes from processing Nylon 6 (www.aquafil.com). The elastane component, Invista LYCRA® is sustainably produced by Koch industries and enhances the close fit of high stretch apparel (www.invista.com). For the swimwear collection, I managed to source Eclipse Nylon / elastane fabric produced by Carvico (www.eclipsetextiles.com.au retrieved 20/12/16, www.carvico.com).

Design Profile:

I chose to create three design variants based on three different psychographic/personality profiles. The intention is that they would appeal to different consumers and show the expanded scope of the one piece pattern methodology for a variety of designs. The designs are referred to as Energy, Reflect and Glam and are outlined in the corresponding Design profiles (fig. 21, fig. 22, fig. 23).

(fig. 21)
Design Profile: Energy

i) Design Profile: Energy

Energy is designed for the personality who is:

- Energised
- Single minded
- Determined
- Focused
- Strong
- Sport

Design development elements: stream lined silhouette, action neckline, sport muscle back, free movement cut away, elite athlete leg line, curved muscle bodylines

The **Energy** swimsuit has the following technical design elements:

- Full back with centre back seam for stability and close fit shaping and a circular cut out mid-way down the back for temperature comfort.
- Rounded mid height neckline, minimal front aesthetic
- The front shoulder strap follows over to upper back to top of scapulae at a 45 deg angle (bias) to a strong muscle back design lines with sufficient width for strength, seam added through straps for stability. The cut of the back armhole facilitates arm freedom. The front side body follows through to an under bust seam for stability ending 6cm from the centre front with small gathers for bust fullness for shaping. The seam curves downwards to the gluteus maximus facilitating strength for lift.
- Change of grainline as seam curves around the body providing support and stability during twisting movements.
- The leg line is lowered, designed to support the upper leg.

(fig. 22)
Design Profile: Reflect

ii) Design Profile: Reflect

Reflect is designed for the personality who is:

- Confident
- Calm
- Mindful
- Reflective
- Zen

Design development elements: organic design lines, circular continuity of panels, gentle curvatures, open cut away, modest leg line, composed cross over front.

The **Reflect** swimsuit has the following technical design elements:

- Deep cross-over front neck following over front shoulder to back
- Active style back strap that passes through scapulae, body front arm point, side body to low back waistline designed for ease of movement and comfort to gluteus maximus.
- The combination of vertical and horizontal grainline provides support and stability during movement.
- Low leg line is shaped to the thigh line at the top of the leg.

(fig. 23)
Design Profile: Glam

iii) Design Profile: Glam

Glam is designed for the personality who is:

- Playful
- Girly
- Feminine
- Glamourous

Design development elements: playful front and back twists, lavish gathers, clinched waist, retro cross over straps, exposed lower back, sweetheart panelling and leg line

The Glam swimsuit has the following technical design elements:

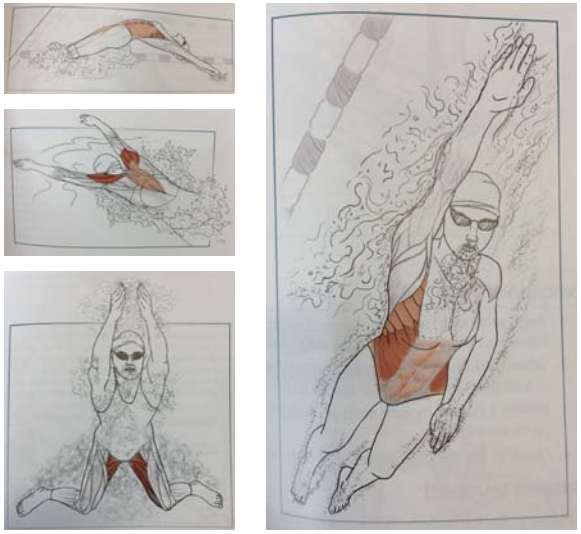
- V-neck front bust section flows over shoulder into back strap and diagonally crosses to scapulae attaching onto under bust section picking up body front arm point. The two fronts connect with a double twist at centre front. The back pant section connects at a 45deg angle to front side body to gluteus maximus.
- The combination of vertical and horizontal grainline provides support and stability during movement.
- Front panels twist together to provide stability along curved seam, concealment over the stomach area with added benefit of psychological comfort and more retro-glam aesthetic.
- Curved seam and cross over back strap provide under bust and torso support
- Low back neckline provides temperature comfort.
- Scalloped shaped low leg line design sits in place during movement.
- Front leg line continues around from the back leg and joins onto the torso section.

2.5 Design to Pattern Process: Swimwear

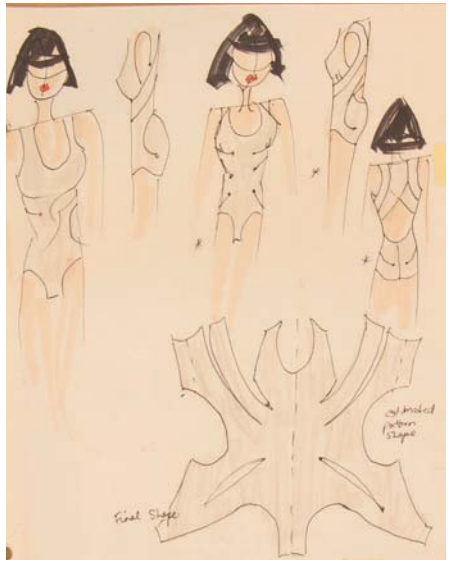
The design profiles informed the design lines and characteristics as an integrated process of one piece pattern methodology. The swimwear pattern design process begins by manipulating the 1/8 scale oneP-active pattern shapes clarifying design feasibility before making the full scale patterns.

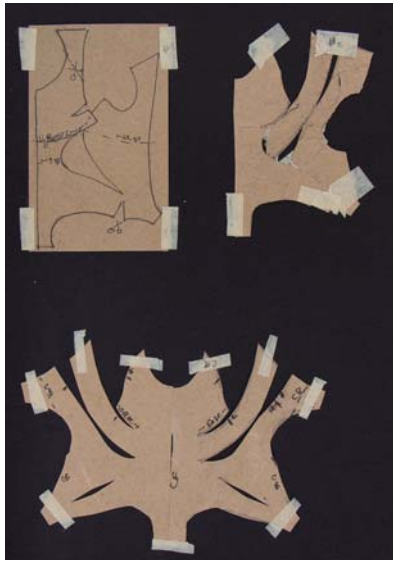
The one piece pattern shapes of oneP-active form the basis to develop the patterns for Energy, Reflect and Glam swimwear. The findings from the wear testing the oneP-active garments indicated that the Racer back body and the Crop top were the most successful for the swimming activities. The pattern of the Racer back body establishes the size and shape of the swimwear patterns, crucial points of curvature and also the curved seam lines. The Crop top is a combination of the oneP-foundation and the Racer back with under bust seam for support and cross over back straps for ease of movement. The Crop top pattern is referenced for the cross over strap and the under bust seam position on the three swimwear designs.

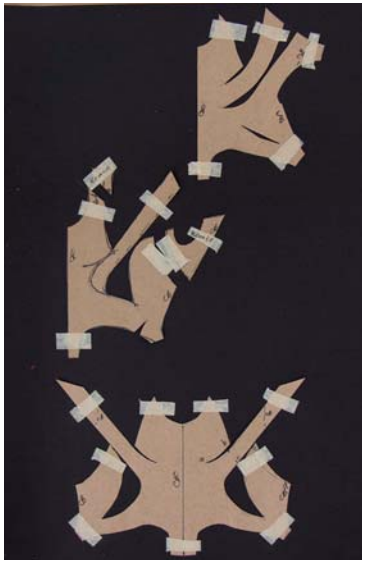
During the pattern design process, I am constantly being guided by the directional grainlines and fabric stretch properties. Areas requiring maximum stretch (through the torso) are placed in the vertical position and areas requiring stability (across the body and leg lines) are placed in the horizontal position. The bias grainline gives flexibility and comfort as it opposes the other grainlines positioned with curved seaming circulating the body. The curved seam lines are repositioned to maximise grainline properties and follow contoured lines of the body's muscle structure. This also provides strength and support during swimming actions (fig. 24). Sections that map muscle structure (scapulae to gluteus maximus) are cut slightly shorter in length than the corresponding section to provide additional support. The shorter length through the scapulae to side body encourages the body to return to position during and after repetitive motions such as front crawl arm movement in Energy, Reflect and Glam (fig. 25).

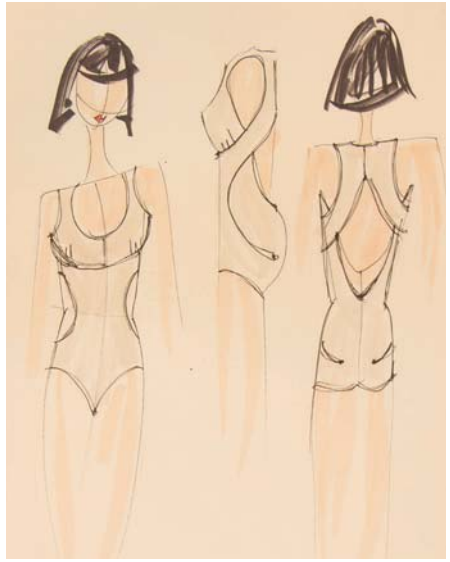


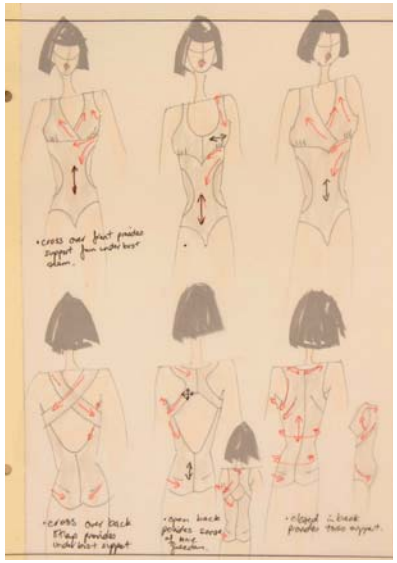
(fig. 24)
Swimming actions relevant to Wear Test exercises (McLeod, 2010)

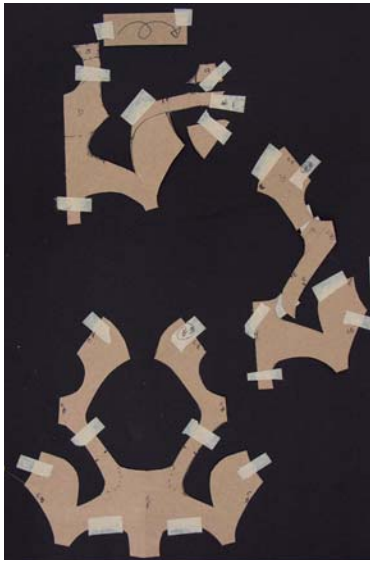












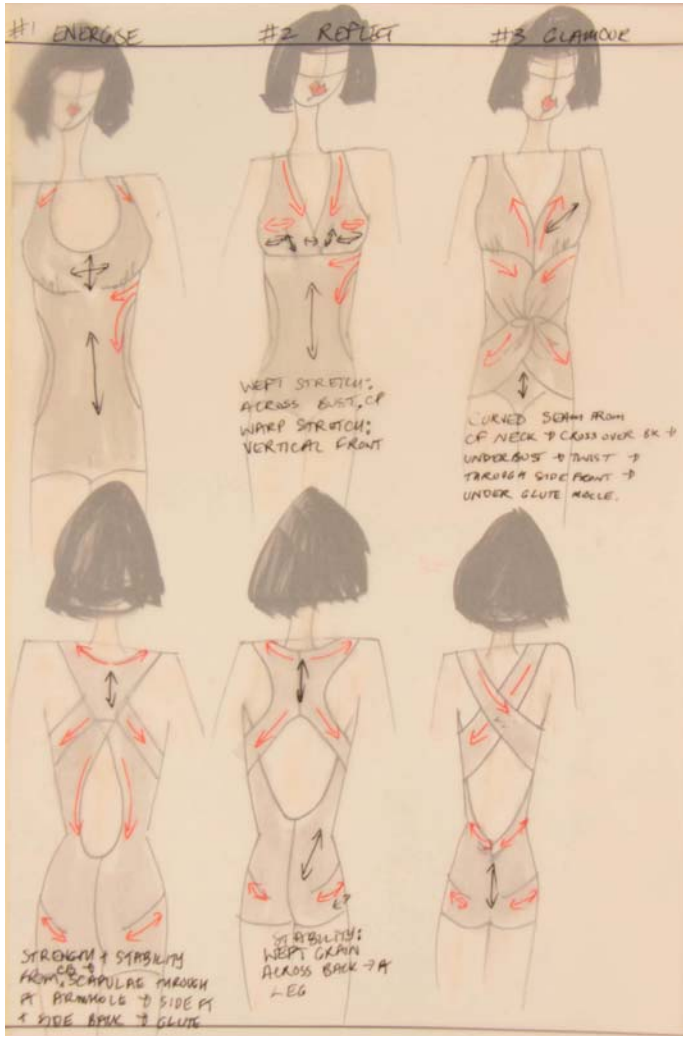
(fig. 25)

Weaver, Nina. Shaped to Fit.

Examples of workbook design and pattern development: Energy, Reflect, Glam. 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver



(fig. 25)

Weaver, Nina. Shaped to Fit.

Examples of workbook design and pattern development: Energy, Reflect, Glam. 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

Pattern and Toile Iterations

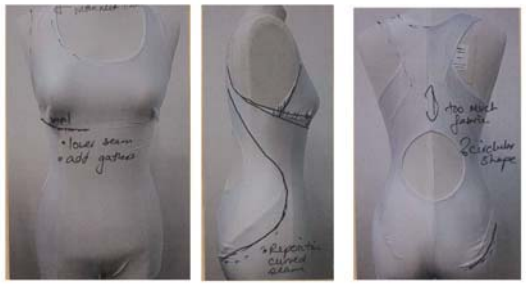
The pattern iterations are toiled in fabric with the same percentage of stretch as the final fabric and the garment fit is assessed on a size 12 dress form. Photographs record any fit anomalies and the changes are recorded on a new sketch with annotations. If any design variations occur during the process, these are also sketched and evaluated. Most designs have three to five toile iterations before the fit of the garment is tested on a live model (fig 26), (fig 27), (fig 28).

i) Pattern and Toile Iterations: Energy

Iteration **One**

- Raise underbust dart
- Reduce side bust width to allow for free arm movement.
- Reloate gathers at side body.
- Remove excess at centre back.
- Reshape and lower leg hem edge to long leg line to utilise stable crosswise grainline for muscle support during leg action.
- Consider cut out through back torso for sensorial comfort.

Iteration **Two**

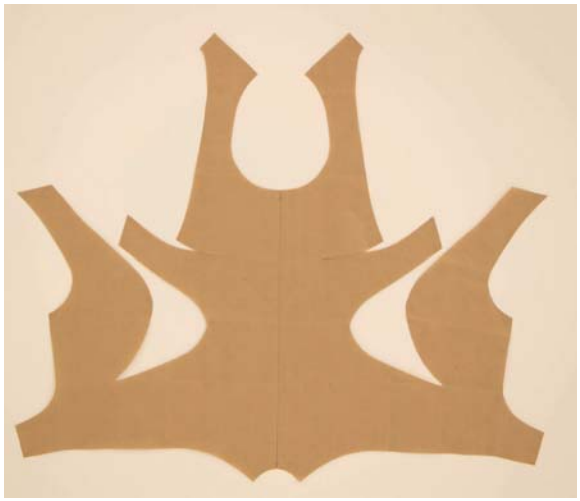


- Raise under bust dart point.
- Move bust gathers closer to under bust. Realign side bust
- Remove gathers at side body.
- Curved balance lines were repositoned to start at the scapulae, flow through the side front and sit closer to the gluteus maximus.
- Consider back strap to cross over.

Iteration **Three**

- Reshape side bust
- Remove excess from back strap.
- Seam at centre back of upper back section
- Back strap cross over for more movement during arm reach movements.
- Eliminate seam at shoulder area, joining back onto front. Bias grainline allows for improved support and stretch.

Iteration **Four**



(fig. 26)
Weaver, Nina. Shaped to Fit.
Swimwear Pattern Iterations: Energy 2017.
Wellington, New Zealand.
Photo: James Weaver, Courtesy of Nina Weaver

ii) Pattern and Toile Iterations: Reflect

Iteration **One**

- Reduce side bust width.
- Lower back, remove excess on curved seam at side panel to be in closer proximity to side body muscule structure, relocate side back point to correspond with new side bust to give illusion strap crosses over bust/torso section.
- Shorten back strap to provide suport through scapulae.

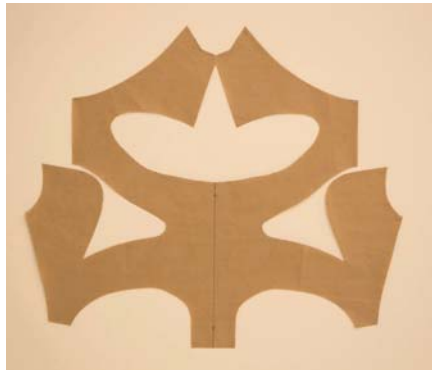
Iteration **Two**

- Add gathers to bust section.
- Add and raise bust seam
- Reposition curved seam at side body.
- Remove excess at upper and lower centre back seam.
- Raise back waist edge.
- Reshape back strap at the scapulae for better support and free arm movement.

Iteration **Three**

- Variations of bust suppression are trialled including gathers, asymetrical cross over and deep tuck darts folded away from the centre front for illusion of box pleat.
- Under bust seam raised
- Curved seamline adjusted at side body
- The vertical (maximum stretch) grainline is located through the centre front and upper centre back strap. The bust section is also on the vertical grainline as the pattern becomes perpindicular to the centre front torso.
- Back strap/neckline iterations improvements provide upper back support with the back strap on the bias grainline(weft grain stability and warp grain stretch)

Iteration **Four**



(fig. 27)

Weaver, Nina. Shaped to Fit.

Swimwear Pattern Iterations: Glam 2017.

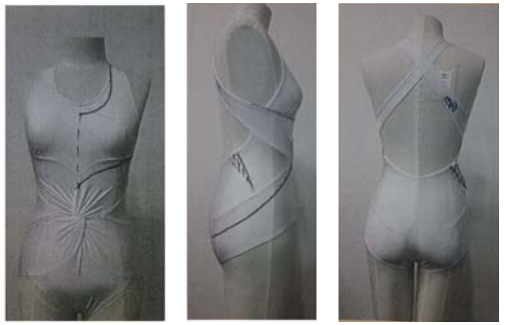
Wellington, New Zealand. Photo: James Weaver, Courtesy of Nina Weaver

iii) Pattern and Toile Iterations: Glam

Iteration **One**

- Front neckline is shaped and lowered to keep in proportion to the bust section.
- Under bust panel section is raised to the underbust line.
- Reduce side bust width to allow for free arm movement.
- Extra fabric added into mid-torso twist section to provide sufficinet fullness and more vertical body length.
- Reshape front pant section including leg line.
- Reshape back leg line.
- Add length onto back strap.
- Remove excess out of centre back seam and reshape back waist.

Iteration **Two**



- Front neckline reshaped.
- Underbust section repositioned.
- Reshape curved seam line.
- Add more length onto back strap.
- Remove excess farbic out of back hip.
- Back twist detail added to connect front to back and also to tighten the front and back waist line.

Iteration **Three**

(fig. 28)

Weaver, Nina. Shaped to Fit.

Swimwear Pattern Iterations: Glam 2017.

Wellington, New Zealand. Photo: James Weaver, Courtesy of Nina Weaver

3. Pattern Analysis of Final Prototypes: Swimwear

All final designs were underpinned with aspects of one piece pattern design methodology using crucial body points, directional grainlines and curved seam lines. These provided the defined areas of fit, comfort and movement for the specific sport activity. The designs were led by these functional attributes alongside the aesthetic that consider the design profile: Energy (fig 29), Reflect (fig 30) and Glam (fig 31).

i) Pattern Analysis: Energy

Aesthetic	Energy design has the functional design elements: stream lined silhouette, action neckline, sport muscle back, free movement cut away, elite athlete leg line, curved muscle bodylines, under bust seam with gathers. Colour: The darker grey portrays the persona of a focussed recreational swimmer along with a narrow strip of reflective tape to highlight the direction of the curved seam indicating muscle structure.
Fit: Stability Crosswise Grainline	• Across front under bust dart section and across front torso at waistline; providing stability during twist and forward bending movements. • Across long leg line from front to back is parallel with horizontal stable grainline giving muscle support during repetitive leg action.
Seam line Strength	• Seam through middle of strap and curved seam line follows muscle structure: starting at scapulae, front side body, to gluteus maximus providing close fit body support through torso during forward bending, twisting and arm motion. • Opposing grainlines along curved lower seam at gluteus maximus provide maximum stretch. When the upper seam edge (bias grain) sews to the lower seam (weft grain) the seam has stability with some flexibility.
Areas of added Fullness	• Gathers at under bust allow for bust shaping. • Curved shaped seam provides suppression at waist line and added shaping on each side of the seam provides fullness at the hip.
Comfort: Degree of Cut away	• Front armhole is cut to pass through front armhole point, attaching to under bust seam for side bust support during over arm, back stroke and breast stroke action. • Cut out section at back waist area provides wearer balance to percentage of body coverage and for ease of movement during activity. • Mid height of back waist provides a sense of freedom during forward bending and twist action.
Degree of Cover	• The full front body (from neckline to crotch) has uninterrupted fabric stretch optimising vertical stretch during forward bending and twist action. • Upper back strap from centre back to top of scapulae provides shoulder and cross back support controlling shoulder strap position during over arm, breast and back stroke swim action. • Low leg line and shaping through gluteus maximum ensures back leg line stays in place during repetitive leg movements.
Movement: Flexibility Vertical Grainline	• Vertical grainline runs along armhole edge from front to back providing maximum flexibility during overarm movement. • Centre front torso, centre back of upper and lower torso are also placed on vertical grainline providing maximum stretch during forward bending, twist and body stretching motion. • Cut out back section allows ease of forward and circular arm motion, • Cross over strap detail at centre back allows for ease of arm movement as well as snap back after each rotating arm movement. • Strap width (4cm) allows free forward, over arm, breast and back action.

(fig. 29)

Weaver, Nina. Shaped to Fit.

Swimwear Pattern Analysis:
Energy 2017.

Wellington, New Zealand.
Photo: James Weaver, Courtesy
of Nina Weaver

ii) Pattern Analysis: Reflect

Aesthetic	Reflect design has the functional design elements: organic design lines, circular continuity of panels, gentle curvatures, open cut away, modest leg line, composed cross over front. Colour: A peaceful white was selected for the recreational swimmer who participates in swimming activity for relaxation and mental well-being.
Fit: Stability Cross wise Grainline	• Bust section from the vertical edge of the bust dart to front neckline; providing stability over bust during forward bend and arm movements. • Along under bust seam for a close body fit during twist and forward bending movements. • Across front torso at waist line; providing stability during twist, stretch and forward bend movements.
Seam line Strength	• Along under bust seam for additional stability during over arm actions. • Curved seam line follows muscle structure: starting at scapulae, front side body, to gluteus maximus providing close fit body support through torso during forward bending motion. • Opposing grainlines along curved lower seam at gluteus maximus provide maximum stretch. When the upper seam edge (bias grain) sews to the lower seam (weft grain) the seam has stability with some flexibility.
Areas of added Fullness	• Gathers give bust shaping and suppression at under bust. • Straight edge of front neckline helps to keep bust section close to body during forward bending motion and arm swings. • Curved shaped seam provides suppression and fullness at the waist line as well as fullness at the gluteus maximus.
Comfort: Degree of Cut away	• Bust sections cross over at the centre front for a feminine neckline. • Front armhole is cut to pass through front armhole point, attaching to under bust seam for side bust support during over arm, breast and back stroke actions • Back torso is cut away for ease of movement during twist action. • Mid height of back waist height provides a sense of freedom during forward bending and twist action.
Degree of Cover	• Upper back strap from centre back to top of scapulae provides shoulder and cross back support controlling shoulder strap position during over arm, breast and back stroke action. • Low leg line and shaping through gluteus maximum ensures back leg line stays in place during repetitive leg movements.
Movement: Flexibility Vertical Grainline	• Centre front torso, centre back of upper and lower torso are placed on vertical grainline providing maximum stretch during forward bending, twist and body stretching motion. • Vertical grainline is also positioned across bust section giving optimum fit and coverage over the bust.

(fig. 30)

Weaver, Nina. Shaped to Fit.

Swimwear Pattern Analysis: Reflect 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

iii) Pattern Analysis: Glam

Aesthetic	Glam design has the functional design elements: playful front and back twists, lavish gathers, clinched waist, retro cross over straps, exposed lower back, sweetheart panelling and leg line, curved panel line that twists at centre front accentuating the body curve. Colour: A platinum shade of grey was chosen for Glam to convey the persona who the swimsuit was designed for.
Fit: Stability Cross wise Grainline	• Stable grainline across lower back neckline to side back point provides a firm fit through waist area. • Stable grainlines also occur in various sections of the pattern.
Seam line Strength	• Most stability is provided by seam lines that circle the body, following the muscle structure starting at bust section, over the shoulder, crossing through the scapulae and picking up along the under bust seam. The front sections twists together and follow through to the gluteus maximus. The stability along the seam line provides a close fit body through torso during forward bending and twist motion and free arm action.
Areas of added Fullness	• Various directional fullness occurs from the twist feature provides support across front torso at waist line; providing stability during twist, stretch and forward bend movements. • Gathers at bust provide fullness across bust. • Extra fabric at the front waist twist section provides sufficient fullness to achieve effect and provides additional body length. • Opposing grainlines along curved lower seam at gluteus maximus provide maximum stretch. When the upper seam edge (bias grain) sews to the lower seam (weft grain) the seam has stability with some flexibility.
Comfort: Degree of Cut away	• Mid to low front neckline is proportional to the bust section. • Front armhole is cut to pass through front armhole point, attaching to under bust seam for side bust support during over arm, breast and back stroke action. • Cross over back straps provides wearer with a sense of snap back during rotating arm movement. • Back torso is cut away for ease of movement during twist action
Degree of Cover	• Low leg line and shaping through gluteus maximum ensures back leg line stays in place during repetitive leg movements
Movement: Flexibility Vertical Grainline	• Vertical straight grainline is located at centre back and centre front of lower pant sections to provide flexibility during forward bending, twist and body stretching motion.

(fig. 31)

Weaver, Nina. Shaped to Fit.

Swimwear Pattern Analysis: Glam 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

4. Final prototypes for Swimwear

4.1 Energy

(fig. 32)

Weaver, Nina. Shaped to Fit.

Swimwear Prototype: Energy 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

4.2 Reflect

(fig. 33)

Weaver, Nina. Shaped to Fit.

Swimwear Prototype: Refflect 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

4.3 Glam

(fig. 34)

Weaver, Nina. Shaped to Fit.

Swimwear Prototype: Glam 2017.

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

5. Conclusion

The primary aim of this practise-led project was to investigate alternative pattern cutting processes for the design and making of a small collection of recreational swimwear. This research challenged existing high stretch patternmaking practises by applying alternative pattern methodologies to enhance fit, comfort and movement. Through technical research and iterative design practise, I have demonstrated how to process complex 2D design shapes into 3D forms by approaching design primarily from a technical design perspective.

This research demonstrated close fit women's wear patterns can be cut from a single piece of cloth utilising grainline to provide areas of uninterrupted stretch and stability as the fabric wraps around the body to respond to the wearer's movements. The one piece pattern design shapes were informed by the crucial body points and lines that determine the particular grainlines and seam lines most beneficial for the fit of the garment and provide the sports person with comfort and support during recreational activity. Despite one piece pattern method originating from the draping of woven fabric, there was comparatively small alteration required for the high stretch knit active wear and swimwear designs.

All final designs were underpinned with one piece pattern design methodology including the aspects of directional grainlines, curved balance lines and crucial body points which attribute to the wearer's response to fit, comfort, support and movement. These attributes along with dynamic aesthetic were discussed in the final patterns of Energy, Reflect and Glam. While there were design variances, there were commonalities in functional characteristics of the organic curved seamlines that provided strength in specific areas and provided a close fit from the scapulae, side front to the gluteus maximus high point. The opposing grainlines provided strength and flexibility; the horizontal gave stability and the vertical and bias allowed the increased stretch. For example, the greater vertical grainline stretch through the torso allowed ease of movement and the horizontal grainline allowed the wearer stability around the torso, across leg lines and lower gluteus maximus during forward bending, twisting and repetitive leg movements. Areas of free movement were exaggerated with the varied degree and positioning of cut away and areas of cover provided stability for light compression.

The three swimwear prototypes, Energy, Reflect and Glam showed there is scope to offer design variations using this method as consumers are increasingly looking for new designs that fit their lifestyle choices. The designs were led by the

functional attributes alongside the aesthetics that speak to design profiles; for example, Energy exhibits elements of streamlined silhouette, elite leg line and sporty muscle back, Reflect shows gentle curvature and composed cross over front and Glam shows playful twist, lavish gathers and romantic leg and neck line.

Swimwear covers a wide market: from the poolside to the high performance athletic swimmer (Schmidt, 2012) and while companies producing swimwear for high performance carry out research and development in house, these new findings are protected by intellectual property and not disseminated into the public arena. However what can be concluded from the high performance products on the market is that most research and development focuses on materiality and construction methods to enhance the athlete's performance. The pattern shapes are still relatively conventional negating variances from the traditional positioning of side seams and shoulder seams. Even though, the fashion sector is considered as the trend setter for swimwear, it appears little research is carried out to improve the customers experience of swimming in a costume designed for movement. The need to produce garments with a quick market response also limits time for investigating alternative pattern methodologies that optimise fabric stretch to fit and support the contoured body. The neglected recreational swimmer, who sits in between the high performance athlete and the social consumer, must settle on a product designed outside of their needs. The highly technical fabrics developed by high performance companies may not be available to those outside of the company and often the cost of the high tech fabric makes these garments not viable for the recreational swimmer. This psychographic would instead greatly benefit from time invested in the design of alternative pattern shapes. This investigation affirmed there are gaps in the recreational swimwear market for design and technical development.

Future applications of this pattern study could integrate smart technologies into the one piece pattern shapes utilising the curved seamlines and directional grainlines to guide positioning. Smart technologies could be embedded into specific areas of the textile for applications to include new developments in scanning, body mapping and nanotechnology (Cho, 2010). Garments are designed now with advanced technical body mapping to contour the high performance sportswear however further research is required in the complete garment technology software before the high stretch performance garments can be produced using complete garment technology. (Brownbridge, 2016). With these advancements one piece pattern shapes could aid the process of complete garment

technology by knitting the garment to shape and negating the aspect of fabric waste. This research concurs with Brownbridge (2016) that garment development extends beyond the traditional placement of the matrix seam placement with side, shoulder and set in sleeve seams (Brownbridge, 2016).

(fig 35)

Weaver, Nina Shaped to Fit.

Swimwear Patterns: Energy, Reflect, Glam, 2017

Wellington, New Zealand.

Photo: James Weaver, Courtesy of Nina Weaver

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Appendix: Part A

Exhibitions: In Nature Now

Cumming, D. and Weaver, N. (2016) Nature, energy and movement for new apparel design (Design Exhibit) In Nature Now symposium Costume and Textile Association New Zealand, Massey University and Museum of New Zealand Te Papa Tongarewa, Wellington

`In this research, pattern design process and outcome is derived from the organic lines of nature, energy and movement of the body. The research practice aims to create apparel that enhances movement in alignment with the natural and high performance action of the body. Curved garment balance lines draw the fluid design lines in pattern shaping and print, exposing this new pattern process as the design itself. The resulting design reinforces the ethos of apparel design and pattern being an integral practice. The digital print displays a series of static pulse points formed into rhythmic lines of movement. This was created using the balance lines of the drape process in synchronization with the dynamic body form in a one-piece pattern'. `Nature, energy and movement for new apparel design' In Nature Now CTANZ (Cumming and Weaver 2016)

oneP-design: 'nature, energy and movement'

Photo: Yoshino Maruyama
Photo of model: Amber Griffin
http://costumeandtextile.co.nz/
retrieved 12/12/16

End of Fashion

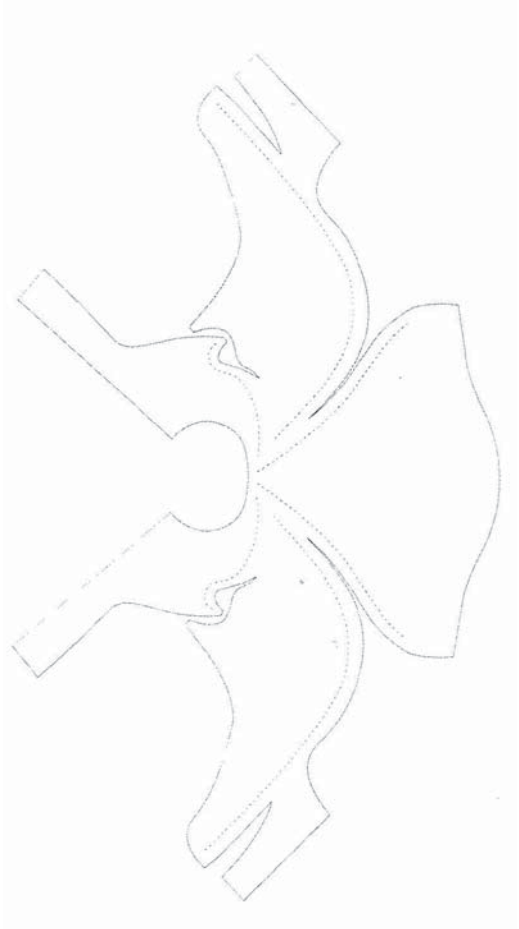
Cumming, D. & Weaver, N. (2016) `oneP-active' (Design Exhibit). In End of Fashion symposium, Massey University, Wellington

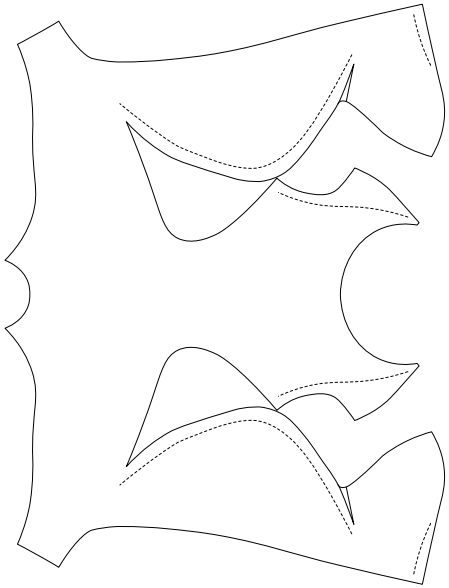
`Digitisation is rapidly impacting on traditional modes of fashion design creation. With developing use of fashion software avatars to simulate pattern designs, alternative developments in pattern and garment methodologies are radically altering current methods practiced in fashion industry. The predominant 2D processes of flat pattern cutting with corresponding front and back pattern blocks derived from a set of measures based on vertical and horizontal axis is shifting to spherical 3D views of virtual bodies and garment pattern design. Yet digitisation software tools are still yet to acquire the nuanced translation of shaping manipulations and fabric behaviours on the live body.

The designs in this exhibit expose the skilled craft of draping on the dynamic body, highlighting curved balance lines in synchronisation with fabric grain-lines and performance. The one-piece pattern shapes are created to wrap the moving body and inform new applications for digital pattern design developments. Reducing manufacturing and production that can provide uninterrupted surfaces to allow for print and smart textile injection.

This design work displays an alternative method of design development resulting in a one-piece pattern shape, which views the dynamic body and fabric behaviour as an implicit and integral practice. Curved garment balance lines draw the fluid design lines in pattern shaping and print, exposing this [pattern process as the design itself.' `oneP-active' In End of Fashion symposium, (Cumming and Weaver 2016)

‘oneP-active’
Print research assistant: Megan Stewart,
Photographer: Amber Griffin
Model: Holly Cumming





Appendix: Part B

Wear Test: oneP-active

Wear Test results: oneP-active

Zones:	Activity/ Exercise:	Comments/ questions		Maillot	Cap sleeve body	Strap back body	Crop Top
Torso (Body)	Static /Bend forward & back	Comments on the level of stretch in body length?		Good. Skin move up at back	More freedom	Bit short in body length, leg hem tight	Good
				Could be longer in body, firm upper area, not moving too much	Back wrinkles at centre back waist, bending forwards it sits in place	Back strap looser, slightly tighter straps	Good
				Length good	Looser at back than strap & maillot, loose at back neck, tight on leg.	Bit tight in leg, enough length in body	Comfortable

Zones:	Activity/ Exercise:	Comments/ questions	Maillot	Cap sleeve body	Strap back body	Crop Top
Upper Torso (Body)	Twist at waist side to side:	**Comments on the level of stretch or stability in the torso.**				
		Do you feel **stretch when twisting side to side?**	Pull at front leg	Twists freely.	Same twist as Cap sleeve body	Twists freely.
				Twist & staying next to skin, stability	Yes	Twist & staying next to skin, stability
		Are you feeling more **freedom Or stability** at the **back shoulder/ blade area?**	Tight back shoulder	More form fitting, holds you, feel supported, holds you.	Position of strap	More form fitting, holds you, feel supported, holds you.
			Upper shoulder stable	Good stability	Tighter outer edge at back, between scapulae is very supportive.	Freedom
			Tighter at back lower armhole	More freedom	Straps more support at back, stability	Freedom
		Do you feel the **back design** (eg straps or filled in back) provides **added support or strength?**	Get back support	Holds shoulder blades, no wrinkles with twisting	Back strap – yes support	Back strap – yes support
				Good, bit loose	Back strip tighter???	Back strap – yes support
			Stable	Looser at back		Back strap - yes support
		Does the seam under the bust provide any added **support/ stability?**	N/A	No extra support. seam at waist is in place	Same as cap, strap little more stability	Support
			N/A	Stability side of bust, tighter through centre front	Good along curved seam	Good along curved seam
			N/A	Stability under side bust	Well supported at seam	Support
		Any general comments you would like to make about **fit and comfort?**	Shoulder straps tight, vertical/length of body	Seam brings your body back, for performance makes you feel like you want to move.	Same comfort, stretch & pull, pull back	Very Comfortable
				Lower back: more twist	Outer edge strap a bit tight.	Good straps
					Outer edge strap a bit tight.	Move freely

Zones:	Activity/ Exercise:	Comments/ questions	Maillot	Cap sleeve body	Strap back body	Crop Top
Upper Torso (Body and Arms)	**Front breast stroke**		**Comments on the level of stretch or stability in the torso / arms**			
		Are you feeling more **freedom or stability** at the **back shoulder/ blade area?**		Front armhole holds but restricts forward movement. Back feels good	Bit more at back but uncertainty of back strap	Freedom
			Feel shoulder width	Cap sleeve problem with restricting movement & rides up onto shoulder	More stretch than cap sleeve, more open & stretch than maillot	Easy to move
			Little tight at back underarm area	Freedom apart from shoulder riding up	More stability	Freedom
		Does the **seam under the bust** provide any **added support/ stability?**	N/A	Bust no difference	Good, a little better with strap	Yes
			N/A	Maillot moving more (not as much support), can't feel side seams	Doesn't change	Great
			N/A	Adds support	Not noticeably	Yes
		Do you feel the **back design provides** added **support or strength?**		Adds support / makes you stand upright / straight posture. feels like a t shirt, more free open at armhole.		Support
				Seam at scapulae provides support		Support and stretch
					Adds support	Support
		Any general **comments** you would like to make about **fit and comfort?**	Very comfortable: material & good stretch	Great ?? fit. Tight on thighs		Great fit
						Easy to move
				Not as much support , cap sleeve digging in.		Good fit

Zones:	Activity/ Exercise:	Comments/ questions	Maillot	Cap sleeve body	Strap back body	Crop Top
Upper Torso (Body and Arms)	**Arm rotation, front and back**		**Comments on the level of stretch or stability in the torso/arms.**			
		Are you feeling more **freedom or stability** at the back shoulder/ blade area?		During backwards movement, back feels fine, forwards: pulls more & hugs at front.	Total freedom	Total freedom
				Cap sleeve rolls back onto shoulder	Free movement	Free movement
			Free back & front	Cap sleeve rides up	Slight snap back at scapulae	Feels good can feel some snap back with this style again
		Does the **seam under the bust** provide any added **support/ stability?**		During backwards movement, back feels fine, forwards: pulls more & hugs at front.	Total freedom	Total freedom
				Cap sleeve rolls back onto shoulder	Free movement	Free movement
			Free back & front	Cap sleeve rides up	Slight snap back at scapulae	Feels good can feel some snap back with this style again
		Do you feel the **back strap** provides added **support or strength?**	Back …? good support		Yes	Yes
					Yes	Yes
				Less supportive than strap		Good
		Any general **comments** you would like to make about **fit and comfort?**	Lower body good	Easier to go backwards		Really comfortable

Zones:	Activity/ Exercise:	Comments/ questions	Maillot	Cap sleeve body	Strap back body	Crop Top
Torso (Body / Legs)	**Bend forwards/ bend backwards**		**Comments on the level of stretch or stability in the lower body/legs.**			N/A
		Do you feel **stability** across the **glute muscle on the back?**	Good	All good, more stability with length	Holds glut muscle in place	
			Not too tight		Stayng in place more than maillot	
			Stable		Tight at leg	
		Do you feel **sufficient stretch** across the **glute muscle?**	Back leg rides up			
				Yes	More stretch than maillot	
		Comment on the **lower boy leg line- tightness? / ride-up?**	Risers a bit at back leg	Boyleg is too tight	No ride up. moves a bit but not excessively, stays in place: grabs skin	
			Back pulls up, leg rides up a bit	Boy leg is a bit tight		
					Legline not as tight as cap sleeve	
Torso (Body / Legs)	Knee Raisers		**Comments on the level of stretch or stability in the lower body/legs.**			
		Do you feel **stability** across the **glute muscle on the back?**	Back leg pulls up	Back : good movement	Yes	
					Not as noticeable	
					More stable than maillot	
		Do you feel **sufficient stretch** across the **glute muscle?**	Stretch good		Yes	
			Not too tight, stretch		Seam helps not to ride up as much as maillot	
		Comment on the **lower boy leg line- tightness? / ride-up?**	Yes. rides up	Lower leg & not a raise due to ???off		
			Rides up, pulling up		Seam helps not to ride up as much as maillot	
			Rides up a bit	Tight on hem of leg		

Zones:	Activity/ Exercise:	Comments/ questions	Maillot	Cap sleeve body	Strap back body	Crop Top
Torso (Body / Legs)	**Leg swings**		**Comments on the level of stretch or stability in the lower body/legs.**			N/A
		Do you feel **stability** across the **glute muscle on the back?**			Yes	
				Yes		
				Quite stable		
		Do you feel **sufficient stretch** across the **glute muscle?**		Good	Yes	
				Yes		
				Yes		
		Comment on the **lower boy leg line- tightness? / ride-up?**	Good except rides up abit		Up movement: digs into front leg	
			No good		Tightened leg is a bit restricting	

	Comments/ questions	Maillot	Cap sleeve body	Strap back body	Crop Top
Final questions / Comments:	Can you make **comparisons between the four garments in terms of design / general fit?**	Bust more hold	Prefer cap sleeve: better around body, Cap bust is looser-more for easier ?? movement. Seam holds butt in place. If triathlon; like boyleg, stretch with muscles.If gym; prefer strap, cap tighter more workout gear/compression around knees. Cap sleeve: sticks to body at legs (great for gymnastics)If swim; strap at back. Beachwear: one piece swimsuit you are able to do things on beach, no strapping ?? likely to do anything.	Prefer strap for more freedom. Prefer cap at waist area, like cap bottom and strap top together. Strap & Cap helps with posture	Really like the under bust support and the cross over strap
			Prefer cap sleeve lower leg & upper back.Cap sleeve has support at front side	Prefer a swimsuit for swim activity: prefer strap of strap body for more movement & lower body (legine) of cap sleeve for modesty	Sort of like the Racer back swimsuit
			More supportive in upper body compared to maillot: a little more comfort.	More supportive in upper body compared to maillot: a little more comfort. Prefer the strap back: supportive at back, more comfortable. Across back is a bit looser & legline.	Like the Crop top For support