

Proposing a Novel Grading Method for Women's Wear Upper Torso Contour Garments

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I. INTRODUCTION

Women's wear body contour garments are critical in fit and construction due to the considerable number of body curves involved. Fit of the women's upper torso contour garments is affected by the shoulder angle, armscye, sleeve crown, bust and necklines [1], [2]. It becomes more complicated with fabric stretch as fabrics incorporate stretch as a part of their fit and function [3].

Patternmaking theory plays a vital role in achieving perfect fit. Flat pattern creation and fabric draping are the most common methods of patternmaking [4]. Pattern grading is also important in achieving clothing fit. Pattern grading is the process of adjusting a pattern to fit within a range of sizes [3]. An accurate pattern grading method is necessary to ensure accurate garment fit across the sizes. Although there are established pattern grading methods for some garments produced using rigid fabrics, no such grading methods are published or practiced in the industry for garments produced using stretch fabrics.

Incorporation of fabric stretch during grading needs to be considered during to have a proper fit. According to Moore *et al.* [3], reducing ease and darts are necessary to obtain the perfect fit with the stretch fabrics. With the different fabric stretch percentages, it is difficult to determine a common grading rule for each fabric. However, the industry demands a precise guide for stretch-knit pattern grading, to minimize existing problems relevant to the current trial-and-error method.

Establishment of a grading method for stretch-knit pattern grading is useful for the ready-to-wear industry, and this tacit knowledge can be applied in developing an automated pattern development system that can be used in customized clothing production in future. This study aims to examine the grading values of contoured patterns in developing the size set of the women's upper torso garments and develop a relationship between fabric stretch and pattern grading values for the same product type.

This study will examine pattern grading values of women's contour garments, analyze pattern curve shapes and body landmarks, and develop a relationship between fabric stretch and grading values of women's upper torso garments. The proposed method will be validated both digitally and physically.

II. LITERATURE REVIEW

Patternmaking is a fundamental step in apparel development. Base patterns, or slopers, are developed to fit an average figure and can be adapted to various garment styles. The process of creating patterns for different sizes, known as pattern grading, involves systematically adjusting the base pattern dimensions to fit a range of sizes [3]. The grading process ensures garments maintain their fit and proportions as the size changes [3].

Grading involves modifying pattern pieces to fit different sizes by increasing or decreasing dimensions at specific points [3]. The grading process includes creating a base pattern, fitting it on models, and adjusting dimensions based on cardinal points and grade intervals [3], [5].

Two primary grading systems exist: simplified two-dimensional and complex three-dimensional systems. Two-dimensional systems apply size increments in height and girth, while three-dimensional systems also account for body contours [3], [6]. Simplified systems are commonly used due to their ease of application, although they may not maintain garment shape when grading more than two sizes from the base [3], [6]. As [3] recommends, limiting grading to five sizes avoids fit issues.

Grading stretch fabrics differs from grading rigid fabrics due to the fabric's inherent stretch. Patterns for stretch fabrics are typically cut smaller than body dimensions to ensure a good fit. This involves reducing ease and darts and adjusting pattern profiles based on the fabric's stretch percentage [7], [8]. Conversion factors, derived from the fabric's stretch factor, are used to maintain consistency across sizes [3]. Conversion factor (CF) can be determined by either dividing the key width and length measurements of stretch garments by actual body dimensions or using a certain percentage of the stretch factor [3]. For example, using 10% of stretch factor, if the stretch factor of the fabric is 130%, conversion factor can be determined as 87% (1). Therefore, the grade rule should be multiplied with the conversion factor before adding the grading values to the cardinal points [3].

$$CF = 100\% - 130 - 10\% \quad (1)$$

Ziegert and Keil [9] developed a system for designing well-fitting stretch garments using a grid approach. Their method involves measuring fabric stretch, adjusting flat patterns, and applying stretch formulas to achieve a proper fit. They found that each fabric type requires different modifications to ensure consistent fit [9]. Their approach emphasizes the importance of fabric properties in achieving

a good fit. In conclusion, they have identified that the relationship between stretch knit fabrics and body contouring apparel must address the issues of both fabric and form [9].

However, the examination of fabric stretch is still lacking despite its notable influence on the fit with the sizing. Our main goal is to investigate how stretch knit fabric reacts to changes in grading parameters for various sizes.

III. MATERIALS AND METHODS

Initially, the fabrics were selected for analysis. It was done according to the garment type and the required fabric stretch variations. Five single jersey knit fabrics containing polyester and elastane were considered. The elastane percentage varied from 10% to 18% with a step of 2%. They were analyzed using the Browzwear fabric analyzer and the digital fabric data was input to Browzwear Vstitcher software. It should be noted that the Browzwear stretch values are calculated in the units of Newtons per meter (N/m). This is the amount of force per unit of length needed to stretch a piece of fabric to stretch twice its length. Therefore, fabrics which stretch more give lower stretch values. To prevent any confusion, the term “maximum stretch values” will refer to 50 N/m and 60 N/m lengthwise stretch and widthwise stretch, respectively. Based on the digital stretch values, the range for lengthwise stretch was selected as 50 N/m to 242 N/m with a step of 64 N/m and for widthwise stretch was selected as 60 N/m to 140 N/m with a step of 20 N/m.

With consideration of the availability of physical dress forms, Aldrich’s maximum stretch patterns for close fitting body blocks [10] was modified to be used with ASTM D 5585-21 size chart [11]. Patterns were drafted in base size: size 12 for the maximum stretch values using Valentina software. Next the digital fit was evaluated using Browzwear Vstitcher and pattern amendments were conducted to obtain acceptable pressure values. Next patterns were created in the sizes 8,10,12,14 and 16, considering combinations of the above-mentioned stretch parameter ranges. Digital fits were assessed, and the pattern amendments were noted.

A data set was prepared for all pattern measurements. Six pattern measurements were selected for further analysis: quarter bust, quarter waist, quarter hip, armhole depth, sleeve cap height and half wrist. Using IBM SPSS software, a multivariate regression analysis was conducted for the pattern measurements to map their relationship with the fabric stretch parameters and the standard measurement values.

Using the developed relationships, pattern measurements were calculated for each size for the stretch parameters of the selected five fabrics. Patterns were created digitally and fitted using Browzwear Vstitcher. Physical samples were sewn, and they were fitted onto physical dress forms of sizes 8,10,12, and 14. It should be noted that some dress forms did not match perfectly the standard, but they were selected to be as close as possible.

IV. RESULTS AND DISCUSSION

After the fabric was tested, the stretch ranges were set using the values obtained from Browzwear Fabric Analyzer. The steps in lengthwise and widthwise stretch values were selected based on the change needed to observe noticeable changes of the pressure maps in digital fit by Browzwear Vstitcher. By developing patterns for different size and stretch parameter combinations, a data set was prepared for all pattern measurements. Six measurements were selected for further

analysis following the guidelines set by Bye *et al.* [2] as shown in Fig. 1. For the multivariate regression analysis, the independent variables were set to the standard measurements, and the widthwise and lengthwise stretch values as given in table I. The developed models are listed below. Each of the models satisfied the conditions for multiple linear regression analysis: independence, linearity, normality, and homoscedasticity [12].

Using the developed models, pattern measurements were calculated by inputting the stretch parameters of the available fabrics. These were used to create patterns for verification of the models. Digital fit verification was done for all five fabrics in all five sizes. While physical garment samples were sewn in all sizes for all five fabrics, only four sizes were fitted onto physical dress forms due to the unavailability of a size 16 dress form. As seen in Fig. 2, both digital and physical fits showcased approvable fit.

$$Q_B = -2.861 + 0.252 S_B + 0.006 W + 0.007 L \quad (2)$$

$$Q_{WA} = -2.579 + 0.266 S_{WA} + 0.007 W + 0.002 L \quad (3)$$

$$Q_H = -6.266 + 0.255 S_H + 0.007 W + 0.009 L \quad (4)$$

$$D_{AH} = -11.324 + 1.631 S_{AH} + 0.004 W + 0.003 L \quad (5)$$

$$D_{CH} = -5.659 + 1.025 S_{AH} + 0.005 W + 0.002 L \quad (6)$$

$$H_{WR} = -5.051 + 0.847 S_{WR} - 0.001 W + 0.003 L \quad (7)$$

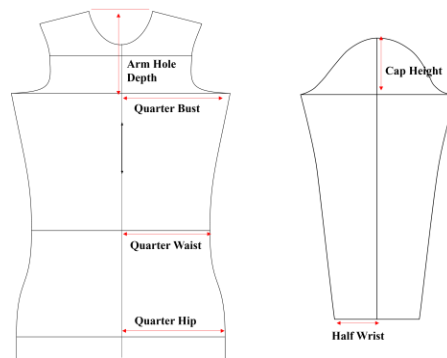
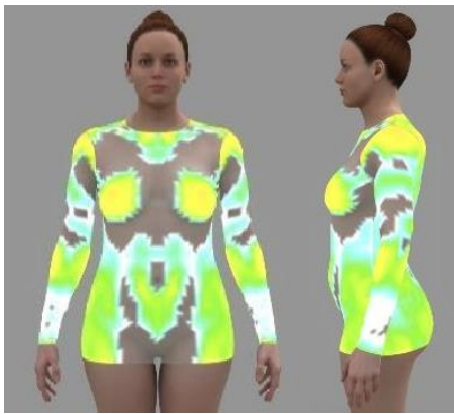


Fig. 1. Selected pattern measurements

TABLE I. INDEPENDENT AND DEPENDENT VARIABLES USED

Dependent Variables	Independent Variables		
Quarter bust measurement (cm) – Q_B	Standard bust measurement (cm) – S_B	Widthwise Stretch (N/m) – W	Lengthwise Stretch (N/m) – L
Quarter waist measurement (cm) – Q_{WA}	Standard waist measurement (cm) – S_{WA}		
Quarter hip measurement (cm) – Q_H	Standard hip measurement (cm) – S_H		
Armhole depth measurement (cm) – D_{AH}	Standard Armhole depth measurement (cm) – D_{AH}		
Sleeve cap height measurement (cm) – D_{CH}	Standard Armhole depth measurement (cm) – D_{AH}		
Sleeve wrist measurement (cm) – H_{WR}	Standard wrist measurement (cm) – H_{WR}		



(a)



(b)

Fig. 2. Fit validation of Size 14 of 18% Elastane fabric (a) Digital fit (b) Physical fit.

As the size increased, it was noted that the fit reduced around the waist and chest areas of the digital fit due to the requirement of additional ease in those areas to be wearable. Some slight looseness was noticed around the back waist area in some of the physical fits due to variations of the dress forms with the ASTM D5585-21 size chart [11]. Nevertheless, the fit of both digital and physical garments was acceptable, which validates the developed method.

V. CONCLUSION

The research explored the relationship between fabric stretch and pattern grading values of women's upper torso garments. It found that existing methods for stretch fabric grading were insufficient. The study developed a new method that considers both fabric type and stretch direction. Base size patterns were created and digitally fitted. Stretch values were adjusted using Browzwear Vstitcher software and found the optimally fitted patterns.

Data collected from this process was used to develop a model to predict pattern measurements based on changes in stretch

values. The results showed that lengthwise stretch primarily affects widthwise measurements (bust and waist), while widthwise stretch significantly impacts sleeve cap height. This research provides valuable insights for garment manufacturers in developing accurate sizing for stretch fabrics.

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