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Research into the Influence of the Ease Coefficient on the Fit of Torso Dresses

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Abstract

This approach offers an alternative method for size selection, one that accounts for the inherent variability in body measurements, thus providing a more tailored and accurate fit for consumers. This study aims to establish a dataset of ease coefficients for torso pattern design across various fabric types and body shapes to ensure proper garment fit. Data were collected from 120 women aged 18–30 in Ho Chi Minh City. Using principal component analysis, K-means clustering, discriminant analysis, and ANOVA via SPSS, participants were classified into four distinct body shape groups. A basic dress pattern was developed based on the average measurements of each group and simulated on different woven fabrics to assess fit and make necessary adjustments. The correlation between body-specific and average-group patterns was analyzed, resulting in a table of ease coefficients for multiple fabric types. Fit evaluations were conducted through 3D simulation and wearer feedback. The study provides ease coefficient data for the bust, waist, and hip areas of Vietnamese women aged 18–30, offering a foundation for the design of dresses and blouses in the fashion industry.

Keywords: ease coefficient, garment, body shape, principal component analysis, Torso

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1. Introduction

The garment fit is a key determinant in customer purchase decisions, alongside design aesthetics and fabric quality. It significantly influences consumer satisfaction and trust in clothing products. Fit is affected by various factors, including fabric properties, body shape, pattern-making methods, and ease coefficients. Variations in fabric characteristics can result in different fitting outcomes. Studies based on 3D simulation images from Modaris 3D Fit have demonstrated the importance of pattern adjustments. Fabric selection also plays a crucial role in optimizing garment fit [1], [2]. Body shape is particularly important. Individuals with identical measurements may have vastly different body contours, leading to distinct fitting challenges. There are several methods for classifying body shapes, with many studies using SPSS for body shape analysis[3], [4], [5], [6]. For instance, one study analyzed 3D anthropometric data from 302 normal-weight women aged 40–59 and classified them into four body shape groups [7]. Another research analyzed 241 Pakistani males and found that a 10° angular difference best identified three body shapes: straight, hourglass, and torch [8]. Additional studies identified three body types based on 53 measurements: heavy with short legs, average with a flat belly, and thin with a prominent belly and flat buttocks [9]. Using the FFIT method, one study classified lower body shapes into three categories based on hip-to-waist differences [10]. Furthermore, waist and hip girths of young women in Northeast China have increased by approximately 1.5 cm and 1.4 cm over the past decade. Research has also classified body shapes based on BMI, which helps in generating virtual bodies that resemble customer body shapes, aiding apparel design [11]. In another study, 107 American and 102 Russian

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female students rated body size and attractiveness using 27 body scan images categorized by BMI and three body shapes: hourglass, rectangle, and pear. During pattern development, designers apply appropriate ease values to ensure comfort and aesthetics [12]. Notably, researchers have proposed design formulas derived from draping techniques, validated through wearer feedback and expert evaluations [13]. A study analyzing 1,389 wedding dress photographs published in Wedding 21 magazine identified 15 bodice designs, 11 sleeve designs based on neckline, and 8 skirt types based on silhouette. These elements were classified and ranked according to their frequency of appearance [14]. The study highlights that selecting fabrics for desirable draping designs is influenced by several factors. These include the drape coefficient, fabric thickness, and the complexity of draping [15]. Technologies and methods in tailoring, along with the integration of flat pattern making and draping, are opening new possibilities for specialists in the field [16]. Research also explores the potential of 3D technology in pattern production. Virtual fashion designing software contributes to improving both efficiency and cost-effectiveness [17]. The ease coefficient, especially at the bust, waist, and hip, is crucial in influencing fit. However, most studies have focused primarily on its effect on the visual appearance of garments [18], [19], [20]. Previous research has examined the impact of structural parameters of knitted fabrics and ease coefficients on mobility and fit in aerobic apparel [21]. However, woven fabrics have been less explored. Some research has explored ease coefficient adjustments for woven fabrics using Modaris 3D Fit software. However, comprehensive analyses across diverse body shapes remain limited [22]. Therefore, investigating the effect of ease coefficients on torso dress designs is essential. V-Stitcher 3D software enables rapid assessment of fit across various body types.

In this study, SPSS software was used to classify the body shapes of Vietnamese women aged 18–30. Based on the average measurements of a common group, 2D basic patterns were constructed for different fabric types. These patterns were simulated across multiple body shape groups to evaluate fit. The findings include correlation coefficients and ease values at the bust, waist, and hip, comparing different body types to the common group. The primary aim of the research is to develop a dataset of ease coefficients to support the design of torso dress patterns, ensuring optimal garment fit.

2. Material & Methodology

2.1. Material

The research subjects of this study are Vietnamese women aged 18 to 30 residing in Ho Chi Minh City. The sample size was determined using the following formula:

$$m = \frac{t \times \sigma}{\sqrt{n}} \Rightarrow n = \frac{t^2 \times \sigma^2}{m^2} = \frac{1.96^2 \times 5.58^2}{1^2} = 119.61$$

n = 120 people

In which: n is the sample size, t is the probability (t=1.96); m is the error (m=1); and σ is the standard deviation (σ=5.58), which has the highest correlation when preliminarily measured on 30 subjects. Based on this calculation, a sample size of 120 participants was selected to ensure 95% confidence.

Data were processed using SPSS version 26.0. The 2D pattern construction was carried out using Gerber AccuMark 9.0, and the 3D simulations for different body shape groups were performed using V-Stitcher 2024.2.

Three woven fabrics were selected for simulation and garment production, with physical properties tested at the Ho Chi Minh City Textile and Garment Institute. The muslin fabrics included: 100% cotton (Figure 1). Fabric parameters were declared and configured within the V-Stitcher software for accurate simulation.

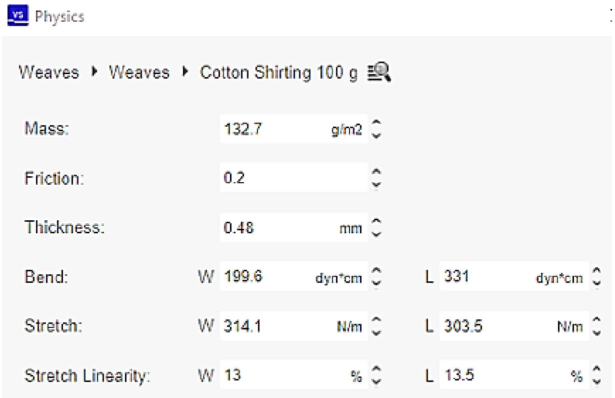


Figure 1. Test results of fabric samples used for draping

2.2. Methodology

Research and document analysis method: This study involved reviewing scientific literature, academic theses, research reports, and specialized publications related to garment fit and its influencing factors. Particular focus was placed on identifying the essential body measurements required for pattern design [23].

Data Collection Method: A cross-sectional statistical approach was employed, with direct anthropometric measurements taken in accordance with the standard posture defined in TCVN 5781:2009 [24] (Figure 2). A total of 32 anthropometric dimensions were collected, including 24 key parameters used to construct the basic torso pattern, following the Hellen Armstrong design method (Figure 3). These were supplemented by two primary measurements: height and weight. Additionally, six indirect angular measurements were extracted from front and side photographs of each subject (Figure 4).

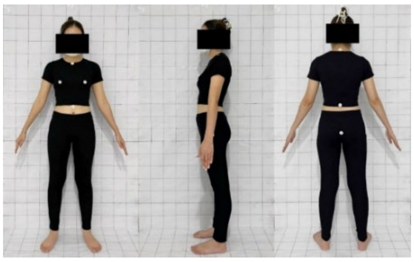


Figure 2. Standard standing posture

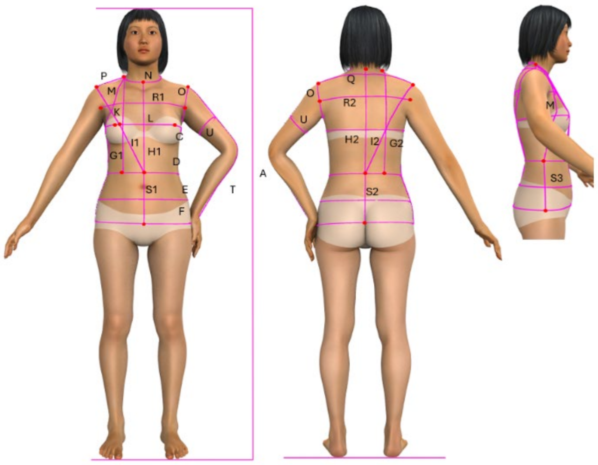


Figure 3. Direct measurement positions on the body

Figure 4. Indirect measurement angles

Body Shape Analysis Method: Utilize SPSS 26 sofware [13], [14] for body shape analysis. This study employed a variety of statistical methods to analyze the anthropometric data and classify body shapes. Principal Component Analysis (PCA) was used as a multidimensional statistical technique to identify the primary measurement components within the set of 32 anthropometric measurements. By reducing the dimensionality of the data, PCA grouped correlated variables, enabling a more manageable dataset while retaining essential variation. To further refine the classification of body shapes, K-means cluster analysis was conducted to group participants based on similarities in their body dimensions, followed by discriminant analysis to validate the groupings and assess the distinguishing characteristics of each cluster. Finally, one-way ANOVA testing was performed to examine the differences in mean measurements across the identified body shape groups, providing statistical evidence for the classification. These combined methods formed the foundation for body shape classification, allowing for a comprehensive understanding of the various body types relevant to garment fit design.

The design process began with 2D pattern creation using Gerber Accumark software, following the design formula by Hellen Armstrong to ensure accurate fitting patterns for different body shapes. Based on the measurements of the identified body shape groups, data were then input into the 3D V-Stitcher software for virtual garment simulation. This allowed for the assessment of how the patterns performed across various body types. To evaluate the effectiveness of the design, measurement parameters from each body shape group were compared with the common group, highlighting any variations in fit. The samples were further assessed using feedback from models, collected through a Likert scale [14], and analyzed with pressure maps generated by the 3D V-Stitcher software to evaluate fit and comfort. Finally, ease coefficients were calculated for different body shape groups at key positions such as the bust, waist, and hip, ensuring that the patterns provided the necessary movement allowance and comfort. This integrated approach provided a comprehensive method for developing well-fitted torso dress patterns suitable for diverse body shapes.

3. Results and discussion

3.1. Results of Body Shape Analysis

The analysis, following the rotation of 22 main dimension variables, revealed that no strong correlations existed among the variables. Through this process, five principal components with eigenvalues greater than 1 were identified, explaining a cumulative variance of 77.14%. These components play a crucial role in the classification of body shape groups among the study participants. The principal components include key parameters such as horizontal body dimensions, body length, hip area, shoulder and chest area, and height. All of these significantly contribute to the differentiation of body shapes.

To analyze body shape, the study utilized K-means cluster analysis and discriminant analysis to identify differences among subjects. Seven solutions were proposed, dividing the subjects into 3 to 9 groups, with the most suitable grouping determined to be 4 groups based on discriminant analysis results. The distribution chart for this grouping showed no overlap (Figure 5). Further analysis with ANOVA revealed that 28 out of 32 variables had a Sig value < 0.05. The differing variables, which include upper body dimensions such as chest, waist, hip, armhole, ankle, and upper arm circumferences, are crucial for body shape analysis and significantly impact pattern design for Vietnamese women aged 18-30.

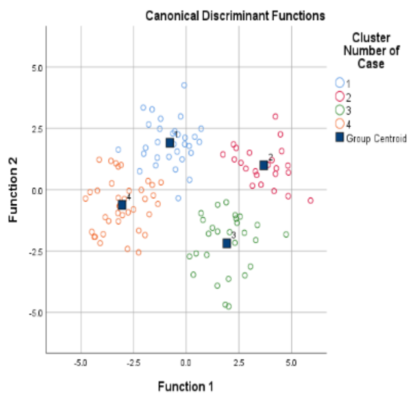


Figure 5. Scatter plot of the four-group solution

In previous studies by various authors, the differences among shoulder, waist, and hip measurements have been identified as one of the body shape classification methods. For instance, in study [5], the author classified body shapes into seven groups. Therefore, it is concluded that dividing the upper body shapes of the 120 research subjects in this study into four groups is the most reasonable approach.

The number of individuals and the corresponding percentage for each group, as well as the average values of the measurement parameters for the four groups, are presented in Table 1.

Table 1. Results of the analysis of the four body shape groups

Measurements	Common group		Group 1	Group 2	Group 3	Group 4	F	Sig
	N=120 (100%)		N=31 (25.83 %)	N=24 (20.00 %)	N=27 (22.50 %)	N=38 (31.67 %)		
	Mean	(SD)	Mean	Mean	Mean	Mean		
Unit: cm								
Height	157.21	5.14	154.35	159.29	160.63	155.9	12.08	0.000
Weight	47.98	5.16	46.76	54.23	51.26	42.71	106.58	0.000
Bust circumference	81.74	4.73	82.21	87.72	83.26	76.51	108.55	0.000
Waist circumference	67.61	5.04	67.26	73.08	70.30	62.51	66.27	0.000
Abdomen circumference	80.82	4.29	80.06	85.81	83.25	76.55	78.70	0.000
Hip circumference	90.29	4.46	89.59	95.24	92.75	85.98	63.88	0.000
Front full length	40.28	2.13	40.11	41.58	40.87	39.18	8.51	0.000
Back full length	40.01	1.96	39.23	41.17	41.09	39.13	12.59	0.000
Front center length	31.93	1.89	31.93	32.93	31.97	31.26	4.13	0.008
Back center length	37.83	2.04	37.12	38.69	38.80	37.17	6.92	0.000
Front shoulder slope	39.98	1.83	39.84	41.18	40.26	39.15	7.34	0.000
Back shoulder slope	39.68	1.96	38.95	41.11	40.92	38.50	20.89	0.000
Bust depth	21.84	1.39	21.82	22.68	22.20	21.07	8.92	0.000
Bust span	8.28	0.55	8.25	8.64	8.34	8.02	7.33	0.000
Shoulder strap	38.85	1.70	38.49	39.90	39.36	38.13	7.70	0.000
Neck circumference	33.68	1.24	33.60	34.50	34.23	32.84	15.14	0.000
Armhole circumference	36.56	1.61	36.62	37.85	37.28	35.18	27.10	0.000
Shoulder length	11.49	0.67	11.40	11.72	11.61	11.33	2.26	0.085
Shoulder width	18.16	0.71	18.02	18.56	18.39	17.86	7.03	0.000
Aross chest	15.39	0.71	15.25	15.86	15.67	15.00	11.58	0.000
Across back	16.60	0.79	16.45	17.18	17.00	16.09	17.31	0.000
Front crotch depth	20.11	1.11	19.73	20.71	20.27	19.92	4.50	0.005
Back crotch depth	19.53	1.07	19.16	20.15	19.76	19.29	5.48	0.001
Hip depth	20.61	1.11	20.21	21.22	20.76	20.43	4.53	0.005
Sleeve length	54.41	2.33	53.77	54.61	55.45	54.07	3.06	0.031
Biceps	25.26	1.09	25.33	26.16	25.58	24.42	20.55	0.000
Unit: degree (°)								
Shoulder down	23.52	2.92	23.71	22.28	24.07	23.75	1.92	0.000
Back bent	27.01	6.83	21.41	29.56	32.22	26.27	19.85	0.000
Full bust	29.26	5.83	33.44	33.78	24.10	26.65	38.28	0.000
Round bust	18.65	5.26	20.13	22.48	16.40	16.63	10.69	0.050
Standing posture	12.29	3.51	13.76	11.45	12.04	11.78	2.69	0.101
Protruding abdomen	9.48	4.79	9.90	9.45	11.00	8.08	2.13	0.000

3.2 Statistical Description of Body Shape Groups

Simulate body shapes based on the measurements of each body group in Table 1. There are 4 groups: rectangular shape 1, rectangular shape 2, triangular shape, and spoon shape (Figure 6). The differences in the shapes of groups 1, 2, 3, and 4 compared to the common group will be clearly seen in Figure 7.

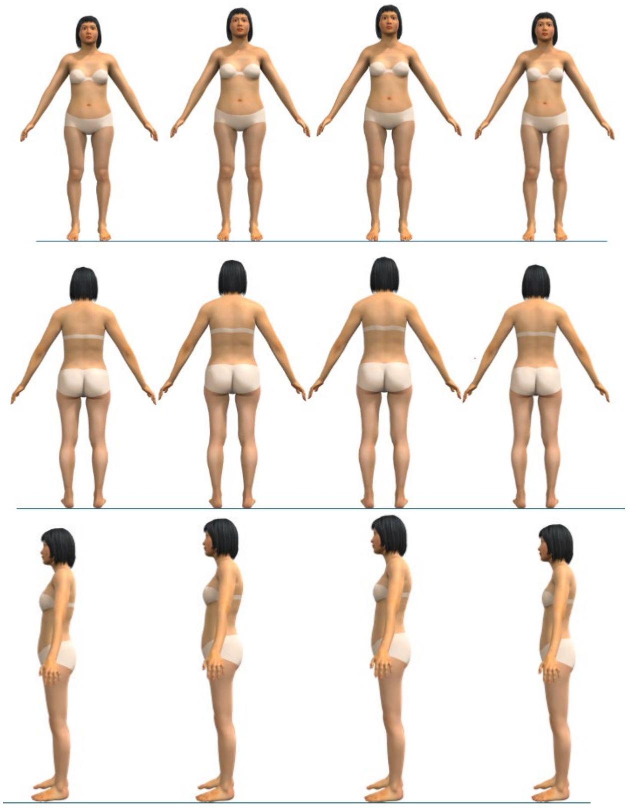


Figure 6. The figures of the body shape's four

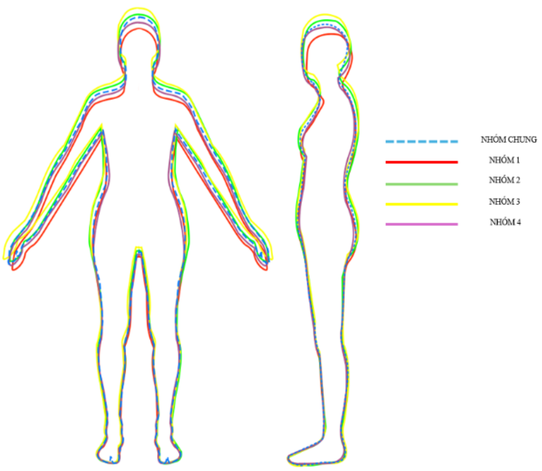


Figure7. Differences in the shapes of the groups compared to the common group.

3.3 Designing patterns of the Torso dress

The measurements of the common group are used to design a 2D basic pattern following the design method of Hellen Armstrong and this basic patten is then simulated for the 4 body shape groups (Figure 8). After designing, the pattern is simulated and checked against the avatar of the common group using raw fabric material. Using the adjusted basic pattern, simulations are conducted successively for Denim fabric and Poplin fabric. After adjustments, we obtain the basic pattern for Denim and Poplin fabrics.

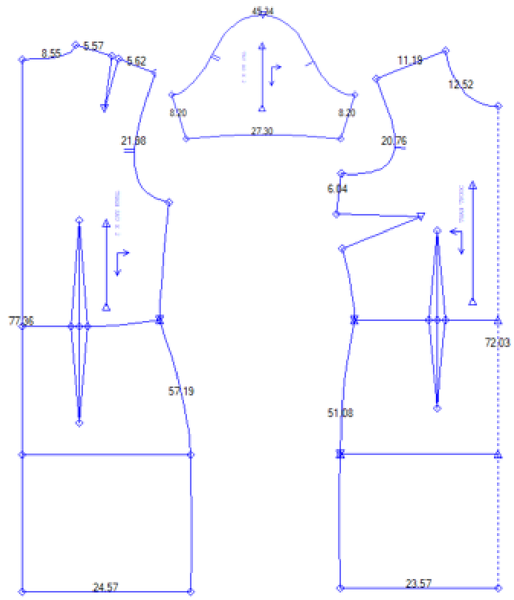
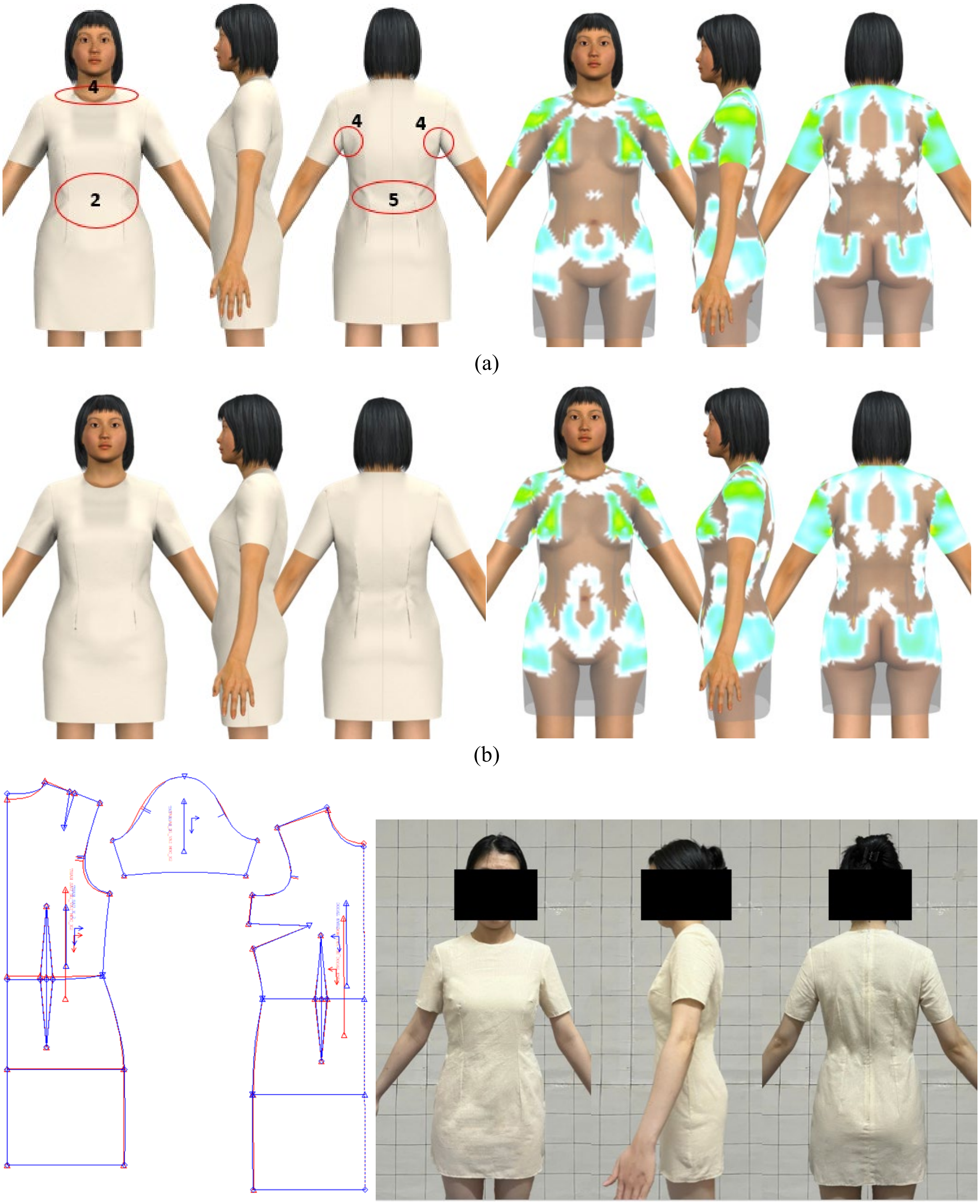


Figure 8. Torso pattern for muslin fabric

3.4 Evaluation Results of Simulated and Actual Samples

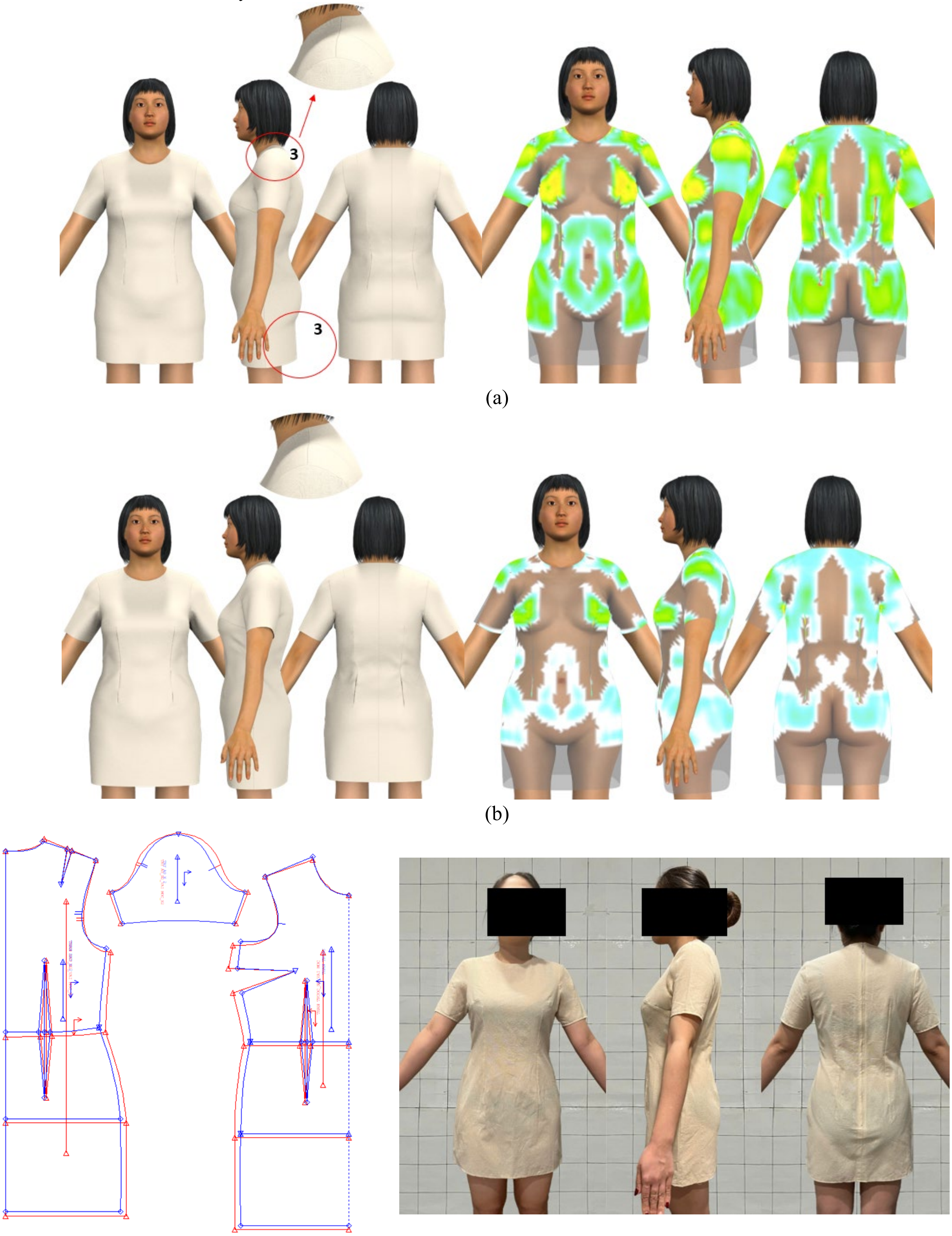
Group 1 has a rectangular shape 1. Compared to the common group of this study, group 1 has a larger bust; smaller waist; smaller hips and buttocks; straight back; and shorter back center length. These differences lead to errors in the simulated sample before adjustments, including a tight fit in the bust area; excess fabric at the waist; wide hips and buttocks; tight back neck; wide front neck and excess fabric at the back armhole; the back body is too long. To correct these errors, adjustments are needed to increase the front bust width, widen the side seams, reduce the hip width, curve the hip line, lower the back neck, reduce the front neck drop, shorten the front neck length, increase the back neck length, and curve the neck. Additionally, adjust the curvature of the back armhole and reduce the length of the back body (Figure 9).



(c) (d)

Figure 9. Simulated sample before adjustment (a), simulated sample after adjustment (b), adjusted pattern (c), and fitting sample on a real person (d) of Group 1

Group 2 has a rectangular shape 2. Compared to the common group of this study, Group 2 has significantly larger bust, waist, and hip measurements. It also has a larger neckline, greater back bent, and larger armholes and biceps. These differences lead to errors in the simulated sample before adjustments. These errors include a tight fit in the dress body, a tight neckline, and the back body being lifted with the shoulder tilted back. Additionally, the sleeve cap is tight, and the sleeve body is also tight. To correct these errors, adjustments are needed to increase the bust, waist, and hip measurements. The front and back necklines should be adjusted, and the neck should be curved. The length of the front and back bodies should be increased, and the curvature of the front neck should be reduced while increasing the curvature of the back neck. Additionally, the body armhole should be lowered, and the sleeve armhole width and cap height should be increased. The sleeve and body armhole should then be curved, and the length of the sleeve opening should be increased (Figure 10)



(a)

(b)

(c)

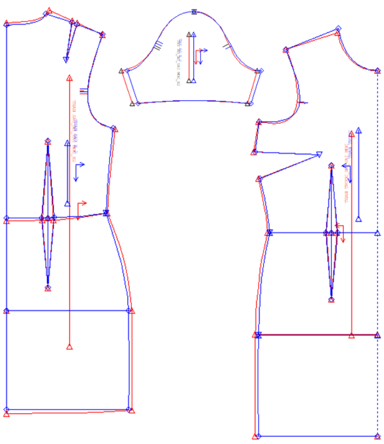
(d)

Figure 10. Simulated sample before adjustment (a), simulated sample after adjustment (b), adjusted pattern (c), and fitting sample on a real person (d) of Group 2.

Group 3 has a triangular shape. Compared to the common group of this study, Group 3 has larger bust, waist, and hip measurements. It also has a larger neckline, greater back bent, and larger armholes and biceps. These differences lead to errors in the simulated sample before adjustments. These errors include a tight fit in the dress body, a tight neckline, and the back body being lifted with the shoulders tilted back. Additionally, the armhole is tight, and the sleeve body is also tight. To correct these errors, adjustments are needed to increase the bust, waist, and hip measurements. The front and back necklines should be adjusted, and the neck should be curved. The length of the front and back bodies should be increased, and the curvature of the front neck should be reduced while increasing the curvature of the back neck. Additionally, the length of the armhole curve and sleeve armhole width should be increased, along with the length of the sleeve opening (Figure 11).

(a)

(b)

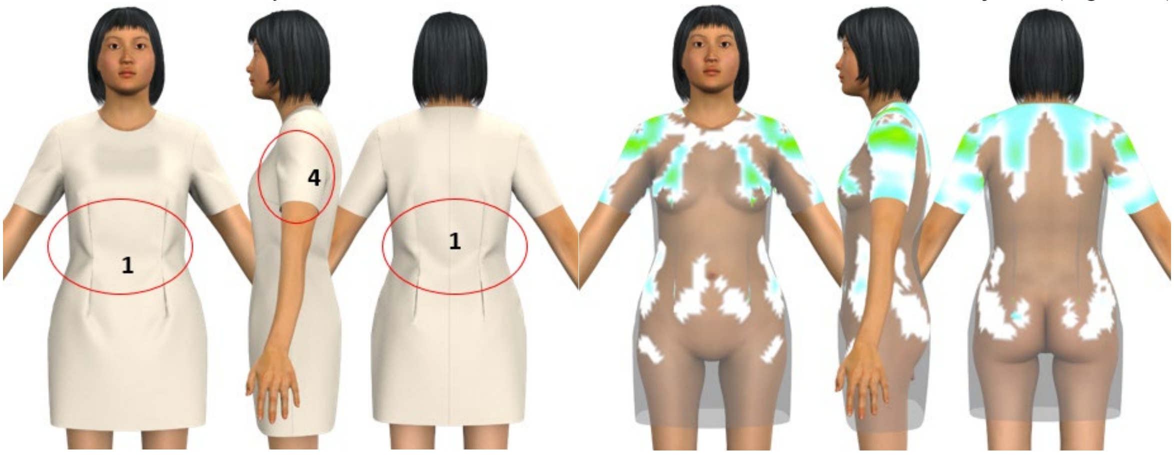


(c)

(d)

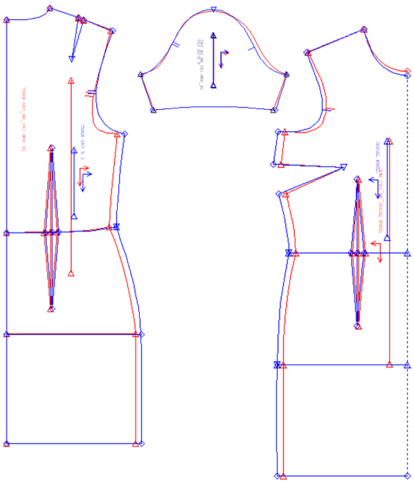
Figure 11. Simulated sample before adjustment (a), simulated sample after adjustment (b), adjusted pattern (c), and fitting sample on a real person (d) of Group 3.

Group 4 has a spoon-shaped figure. Compared to the common group of this study, Group 4 has smaller bust, waist, and hip measurements. It also has a smaller neckline, smaller shoulders, and smaller biceps. These differences lead to errors in the simulated sample before adjustments. These errors include a loose fit in the dress body, a wide neckline, wide shoulders, and a wide sleeve body. To correct these errors, adjustments are needed to reduce the bust, waist, and hip measurements. The front neckline should be lowered, and the shoulder width should be reduced. Additionally, the sleeve opening length and armhole width should be decreased, and the front armhole curve should be adjusted (Figure 12).



(a)

(b)



(c) (d)

Figure 12. Simulated sample before adjustment (a), simulated sample after adjustment (b), adjusted pattern (c), and fitting sample on a real person (d) of Group 4

3.5 Assessment of Movement Coefficient Results for Each Group

Based on the analysis results shown in Table 1, group 1 has dimensions closest to the common group. As a result, the adjustments made to the pattern resulted in the least change compared to the other groups. Group 2 has significantly larger dimensions than the common group, leading to the most noticeable changes, followed by group 3 and then group 4. The ease coefficients for the muslin fabric in relation to the common group indicate that the dimension adjustment parameters vary between groups (Table 2). The increase or decrease in the ease coefficients of the fabrics is based on the color images of the Pressure Map chart. These images are generated in the V-Stitcher simulation software. Additionally, the evaluation of the ease coefficients was conducted based on the fit on the model. The results indicate that the products have a good fit.

Table 2. Ease coefficients for each group for muslin fabric (Unit: cm)

Measurements	Design formula	Ease coefficient to calculate				Ease coefficient to design			
		1	2	3	4	1	2	3	4
Bust circumference	measurements + 8	8.47	13.98	9.51	2.77	8.5	14	9.5	2.8
Waist circumference	measurements + 5	4.66	0.48soo	7.69	-0.1	4.7	10.5	7.7	-0.1
Hip circumference	measurements + 6	5.3	10.95	8.46	1.69	5.3	11	8.5	1.7
Aross bust	measurements + 2	2.23	3.78	2.1	0.7	2.2	3.8	2.1	0.7
Across back	measurements + 2	2	2.99	2.37	0.76	2	3	2.4	0.8
Front waist arcross	measurements + 1.5	1.34	2.89	2.16	0.22	1.3	2.9	2.2	0.2
Back waist arcross	measurements + 1	0.96	2.38	1.71	-0.26	0.9	2.4	1.8	-0.2
Front hip arcross	measurements + 1.5	1.33	2.69	2.11	0.37	1.3	2.7	2.1	0.4
Back hip arcross	measurements + 1.5	1.33	2.74	2.14	0.5	1.3	2.7	2.1	0.5

3.6 Discussion

To evaluate the feasibility and practical application of the developed torso dress patterns, the author selected four individuals. These individuals had body measurements that closely matched the key dimensions representative of each of the four classified body shape groups. These individuals had previously participated in the anthropometric measurement process. Therefore, they were familiar with the study's objectives. They were invited to try on the corresponding sample garments developed for their body group. This allowed for a comprehensive assessment of garment fit from both objective and subjective perspectives.

Evaluation using 3D simulation software: The fit quality of the garments was first examined using V-Stitcher, a 3D simulation software widely employed in the apparel industry. The evaluation utilized several indicators, including the pressure map, axis deviation, and horizontal balance. The pressure map revealed that key fitting areas, such as the shoulders, chest, waist, hips, and upper arms, were predominantly shown in green. This color indicates a balanced and appropriate level of tension in these regions. This indicated a balanced and appropriate level of tension in these regions. The bust area exhibited orange tones, suggesting a slightly snug but acceptable fit. Meanwhile, white areas in less critical regions indicated that the fabric lightly rested on the body without creating pressure. The axis deviation and horizontal balance assessments confirmed that the garments were symmetrical and well-aligned when worn. This finding supported the visual observations from the color-coded pressure map.

Wearer Feedback: In addition to the digital evaluation, subjective feedback was gathered from the wearers. This helped validate the fit quality under real-world conditions. The assessment was based on three key criteria. These included ease of wearing and removal, freedom of movement during typical body motions, and overall perception of garment fit. Each participant completed a standardized survey after the fitting session. According to the results presented in Table 3, all evaluation criteria received average scores exceeding 3.5 on a 5-point scale. This indicates that the sample garments not only achieved a satisfactory technical fit. They also met the comfort and usability expectations of the wearers. Such findings reinforce the potential of the developed patterns and ease coefficients. They can serve as reliable tools in future garment design and customization processes.

Table 3. Evaluation results of the sample wearer

Evaluation criteria	Wearer 1	Wearer 2	Wearer 3	Wearer 4
Easy	5	4.5	5	5
Arm can be easy horizontal	4.5	4.5	5	4.5
Arms can be raised forward to a 90° angle	4	3.5	4	4
Arms can be raised forward to a 45° angle	5	4.5	5	5
Neck fit	5	5	5	5
Bust Fit	5	4.5	5	5
Waist width	4.5	4.5	5	4.5
Hip it	4.5	4.5	5	4.5

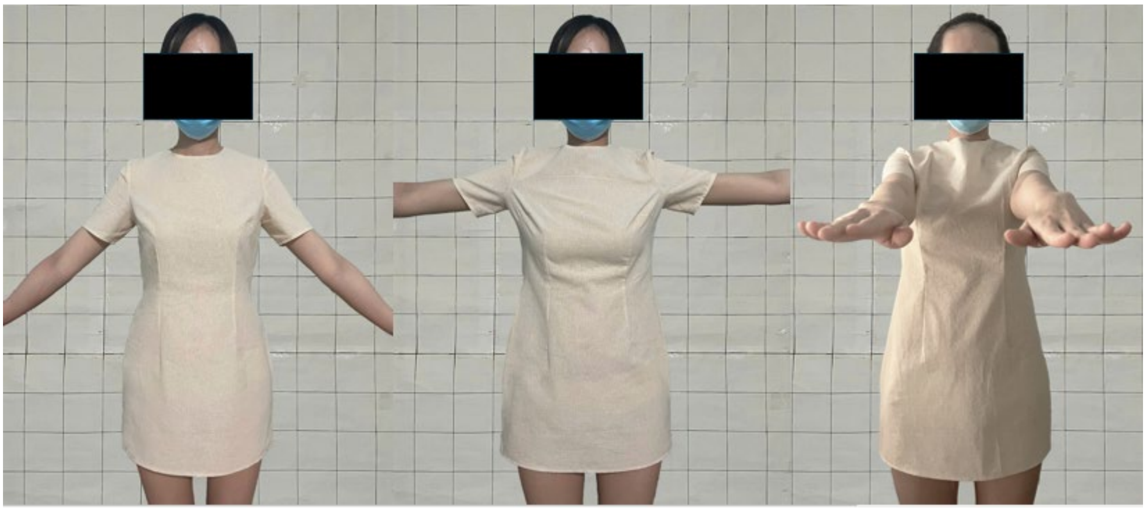


Figure 13. Basic hand movements

4. Conclusion

This study conducted a survey on the body measurements of women aged 18-30 living in the southern region of Vietnam, collecting 120 anthropometric data points. The data was analyzed using SPSS software through principal component analysis, K-means clustering, discriminant analysis, and ANOVA. As a result, four female body shape groups were identified according to the FFIT standard: rectangular shape 1, rectangular shape 2, triangular shape, and spoon shape. The base torso pattern was designed using Gerber AccuMark software. It was then simulated on the four body shape groups in V-Stitcher, where adjustments were made to achieve the best fit. A table of correlation coefficients was created for design positions. Changing these parameters allows for generating different body shapes across the various groups. The increase or decrease in the ease coefficient across different fabric types was evaluated based on the color of the pressure map in V-Stitcher. The weight and composition of the fabric were also considered to evaluate color changes in the V-Stitcher software. Fabrics containing spandex resulted in a more comfortable simulation, showing more areas of blue and white. The adjusted patterns for the four body shape groups, using different fabrics, will be sewn into samples. These samples will then be evaluated through wearer feedback. Results indicate that these products have a good fit. This research outcome can serve as a useful dataset for ease coefficients in garment design. It helps ensure the fit of the Torso pattern and contributes to building a virtual model library in 3D design software. Future directions for this study include expanding the experimental research to fabrics with higher shaping characteristics. It will also extend to stretchable materials, such as knit fabrics. The study could also explore body shapes of postpartum women or further develop the ease coefficient research for various types of clothing.

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Conflict of interest

The authors confirms that there is no conflict of interest to declare for this publication.

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