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Fittability and Appearance of Brassiere Taking into Account Individual's Verge Line of Bust in Pattern Making

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Abstract

To investigate the effect of the verge line on the appearance of brassieres, the difference in the verge lines of individuals with the same brassiere size was examined. A new method for designing a brassiere was proposed, taking into account the individual's verge line using a computerised pattern-making system. Three different brassieres were made by changing the verge line of three dummy models (nine different brassieres in total). It was found that the verge line of the bust could differ even for the same bust size. Brassiere patterns and brassieres were made using the proposed design method and it was found that the verge line affected the bust cup shape and the appearance of the brassiere.

Keywords: Brassiere; Verge Line; Bust; Appearance; Individual

1 Introduction

Women commonly wear brassieres for cultural reasons and to modify the aesthetic appearance of the breasts. In addition to changing the shape of the breasts, the basic functions of a brassiere includes providing support and protection to the breasts. There have been several studies on the characteristics of the brassiere. Liao et al. [1] proposed a statistical technique to design and customise brassiere products. Cha [2] examined the uplifting effect of a prototype brassiere developed for Chinese women in Shanghai, China. Xue et al. [3] assessed the emotion conveyed by a brassiere, using the technique of Kansei engineering. They showed that the colour was the most important factor when designing a brassiere; in particular, the brassiere's base colour decides the basic emotion conveyed by the brassiere. There have also been studies on the factors affecting a brassiere's appearance and comfort. The shape of a brassiere varies depending on the

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breast volume and the pattern pieces. Inui et al. [4] investigated the internal three-dimensional (3D) structure of the breasts, which was not measurable previously for a woman in a sitting position, using a vertical Magnetic Resonance Imagining (MRI) system. Additionally, the effect of wearing a brassiere was assessed in terms of the relation between the external deformation and the internal structure of the breasts. McGhee and Steele [5] investigated a range of breast volumes and showed that the band sizes of women who have the same volume and cup size of brassiere differ depending on the individual. Wang et al. [6] proposed a method of predicting the amount of personalised brassiere cup dart in a 3D virtual environment. They simulated personalised female breast shapes and various aesthetic breast forms sculpted using different brassieres. Moulding of the brassiere cup has been investigated in several studies [7-10]. The factors of moving comfort have also been investigated. Zhou et al. [11] proposed a new method of evaluating 3D breast motion using a new breast coordinate system for a sports brassiere. Wang et al. [12] investigated the effect of the pressure distribution of different fabrics on the side straps and elastic hems of the brassiere. They showed that the clothing pressure increases with the increasing tensile resistance of the side-strap material. As described above, the sizes and shapes of brassieres differ depending on the individual body. In Japan, a woman purchases a brassiere taking into account the bust and under-bust sizes on the basis of Japanese Industrial Standards (JIS) L4006 [13]. In the JIS, a brassiere size is decided according to the difference between the girths of the under-bust and bust. The girth of the bust is measured passing the nipples of the bust whereas the under-bust passes underneath the breasts. The difference between the two girths (2.5 cm) is referred to as the cup size and classified in JIS as A, B, C, and so on. For example, if the under-bust size is 65 cm and the bust size is 80 cm, the brassiere size will be C65. According to a survey on the purchase of brassieres [14], 50% of Japanese women in their twenties to fifties purchase their brassieres according to the size without trying them on. In the survey, 33% of the respondents mentioned a poorly fitting verge line as a problem with the fitting of a brassiere. In addition to the bust size and under-bust size, it is said that the length and shape of the verge line of a bust vary depending on the individual. The verge line of the bust is the cross-sectional outline of the part connecting the bust and body as shown in Fig. 1. A brassiere usually has a wire running along the verge line. The wire length and shape should be decided according to the length and shape of the verge line of the bust. Thus, the wire length and shape need to be considered when designing a more comfortable and beautiful shape of the brassiere [14]. Lee et al. [15] scanned women's nude breasts using a 3D phase-shifting moiré and explored a measurement protocol with which to get a reliable boundary of the breast and thereby provided new shape parameters for breasts. The global average radius of the curvature of the bottom breast line was suggested as a useful shape parameter for the design of a comfortable and form-fitting brassiere. Lee et al. [16] also evaluated the performance of eight brassiere wires for different under shapes of women's breasts. They showed that the fitting of the global average of the radius of curvature of the wire to that of the bodyline of the under-breast curve was an important variable in the design of wires. However, the effect of the verge line on the appearance of brassieres is not clear, especially for the individual. Even in the case of women who have the same under-bust and bust sizes, the verge line can differ. It is thus necessary to take into account the verge line in designing a fitted brassiere for an individual. Therefore, we investigated the difference in verge lines for the individual bust for the same brassiere size. Furthermore, we proposed a new method of designing a brassiere taking into account the individual verge line using a computerised pattern-making system. We made three brassieres with different verge lines. By comparing their appearances, we investigated the effect of the verge line of busts of the same size on the brassiere appearance for the individual.

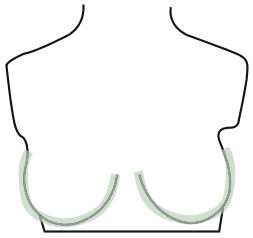


Fig. 1: Verge line of the bust

2 Difference in the Verge Line for the Same Brassiere Size

Differences in verge lines for individual busts of the same brassiere size (JIS) was investigated. Characteristics such as body shape and the area of the verge line were also investigated.

2.1 Experimental

Five female university students who usually wear C70 size as the most fittable brassiere (under-bust size of 70 cm, bust size of 85 cm, JIS) were selected as subjects and their verge lines compared. The bust and under-bust girths were measured. The shapes of the verge lines were also obtained. The bust and under-bust girths were measured with a measuring tape while the subject wore a C70 brassiere to keep the breast shape at the time of wearing. To obtain the shape of the verge line, a solder wire was used. The starting point of the verge line was set at a point on the bust line (see Figs. 2 and 3). From the starting point, the solder wire was shaped to suit the verge line of the right bust by the subjects. The shaped solder wire was then scanned and traced using graphic software (Illustrator, Adobe Systems Software Ireland Ltd.) to obtain the verge line of each subject. The verge area (see Fig. 2) of the obtained verge line was also measured using graphic software (Photoshop, Adobe Systems Software Ireland Ltd. From the 3D scanning data, the under-bust line was defined at the horizontal cross section where the convexity of the bust vanished (see Table 2). The obtained under-bust lines were compared.

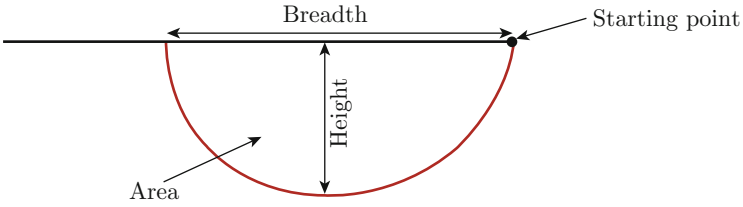


Fig. 2: Verge line and measurements

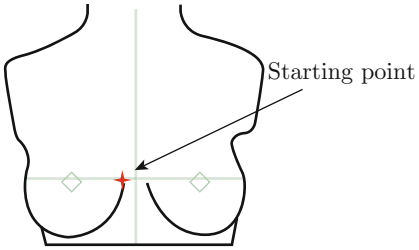


Fig. 3: Starting point of the verge line

2.2 Results and Discussion

The obtained verge lines are shown in Fig. 4. The verge line was assumed to be a 3D curve. Although the subjects' verge lines did not lie in a vertical plane, the obtained verge lines were almost in a plane. A verge line can thus be represented by an in-plane curve. Table 1 lists the obtained bust and under-bust sizes, the differences between the bust and under-bust sizes, the

brassiere sizes (JIS) and the areas, breadths and heights of the verge lines. Subjects 1 and 5 had wide breasts and subjects 2–4 had narrow breasts. The subjects' verge areas also differed. The verge area was around 90 cm^2 for subjects 1 and 5 and around 60 cm^2 for subjects 2–4. It was thus found that the verge line and cross-sectional shape differed depending on the individual, even for the same brassiere size.

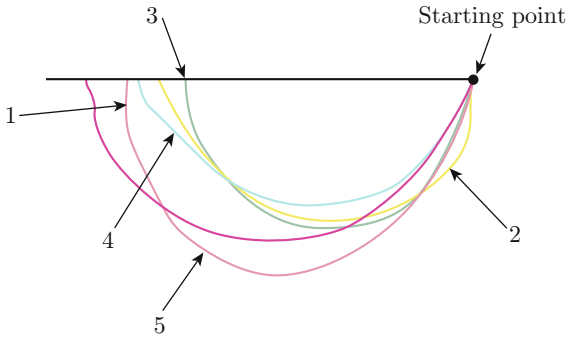


Fig. 4: Verge lines of the subjects whose brassiere sizes are 70C

Table 1: Measurements of subjects

Subject No.	Bust (cm)	Under-bust (cm)	Difference between bust and under-bust (cm)	Brassiere size (JIS)	Verge breadth (cm)	Verge height (cm)	Verge area (cm^2)
1	84.5	70.0	14.5		8.79	15.6	96.6
2	85.0	70.0	15		6.55	14.2	62.9
3	85.0	70.0	15	70C	5.83	15.0	56.3
4	84.5	69.5	15		6.88	13.0	61.7
5	84.5	70.0	14.5		7.37	17.3	87.6

3 Making of a Brassiere Pattern Taking into Account the Verge Line

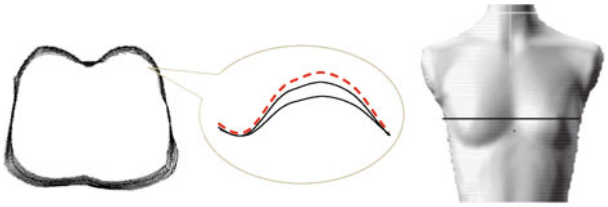
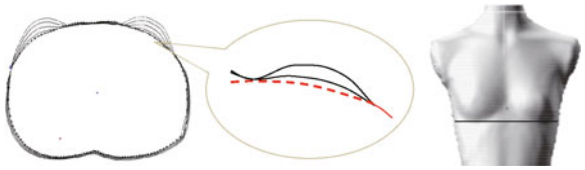
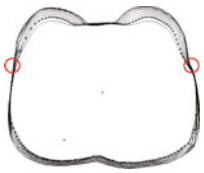
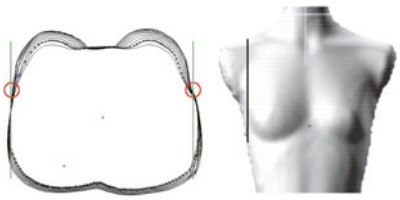
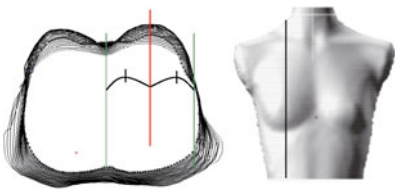
In our previous study, a system of individualized pattern-making was developed by modifying a traditional draping technique. Skirts, trousers and upper-body garments were successfully made with the system [17-23]. Taking into account the verge line of the individual, we developed a pattern-making method for an individual's brassiere using a computerised pattern-making system. Employing the design method to make brassieres with various positions of the verge line, we verified the effect of the position of the verge line on the appearance and fittability of the brassieres when worn on dummies.

3.1 Pattern-making System of the Brassiere Taking into Account the Verge Line

In the pattern-making system, individual patterns were obtained through computerised pattern

development with individually reconstructed 3D body shapes. A body model was constructed from 3D body scanning data in virtual space. The body model was converted into a polyline model. The polyline model comprised contour lines having the same vertical coordinate of the body. The clothing model was constructed by modifying the polyline model. The fabric model, expressed with a lattice of regular intervals, covered the surface formed by the grainlines by generating shear deformation [23].

Table 2: Definitions of lines and points in designing brassiere patterns

Line or point	Definition	Figure of line or point
Bust line	The horizontal cross-sectional line along which the convexity of the bust is greatest	
Under-bust line	The horizontal cross-sectional line along which the convexity of the bust vanishes on the body	
Median line	Vertical cross-sectional line of the intersection between the sagittal plane and front body surface; the line passing through the points of greatest indent of the bust and back lines of horizontal cross sections of the body	
Verge point	The intersection of the verge line and the bust line on the underarm side	
Verge-point line	A line parallel to the median line at the verge point	
Bust centre line	A line parallel to and intermediate of the median line and verge-point line	

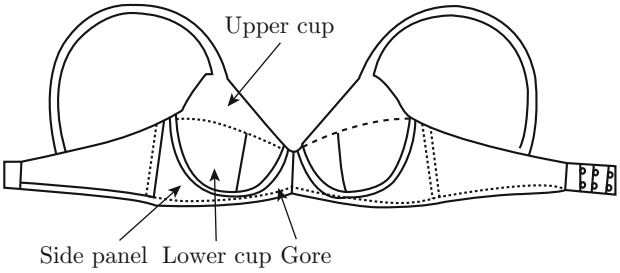


Fig. 5: Parts of the brassiere [25]

In this study, half-cup brassiere patterns were made including one pattern piece of the upper cup, two pieces of the lower cup, a gore and side panels as shown in Fig. 5 [24, 25]. The term half-cup means that the upper cup covers half of the upper bust. In making the brassiere patterns, the bust line, under-bust line, median line, verge point, verge-point line and bust centre line was considered as defined in Table 2. First, the grainline and warp and weft directions on the body model was set. Lines equivalent to the median line and bust line were set as the warp and weft, respectively. The grainline of the outer side part of the lower cup and side panel was set along a line connecting the verge point and the line where median lines divide into two parts from the cross-sectional shape as shown in Fig. 6. The covering was applied taking into account the limit of the shear angle. The covering stops at the edge of the fabric model or the shear limit. The shear limit angle was set as 26 degrees [23]. On the covered model, the cutting lines were set as shown in Fig. 6. A basic verge line at the border of the body and bust was set as shown in Fig. 6. The basic verge line at the border of an appropriate plane was set to meet the bust outline. To investigate the effect of the verge line on the brassiere appearance and fittability, the basic verge line was contracted and enlarged by rotating the border plane 5 degrees about a horizontal axis in the width direction as shown in Fig. 7. The covered model was developed in plane to obtain the pattern. The obtained pattern is shown in Fig. 6. We made the pattern for the right half of the brassiere and obtained the left half by converting the right half.

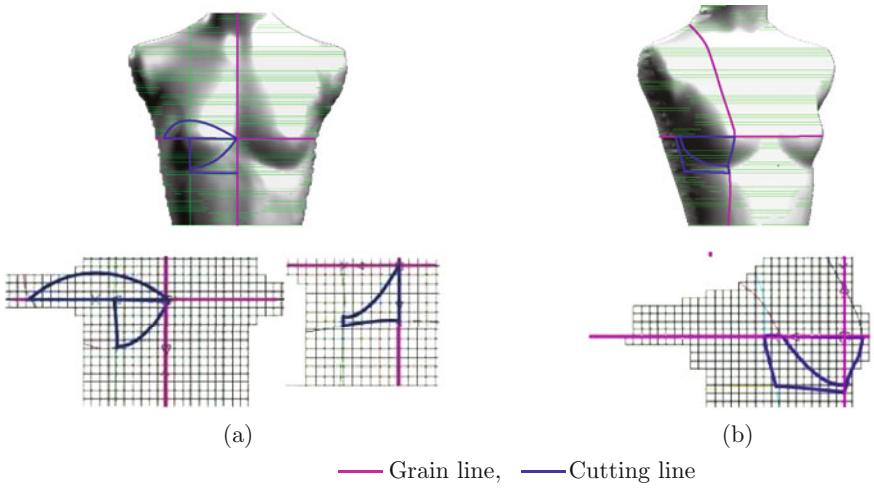
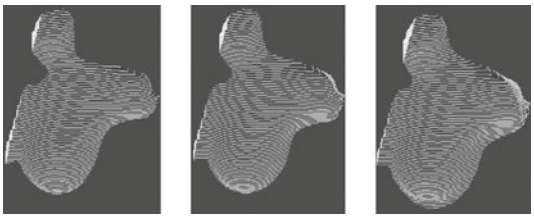


Fig. 6: Grainline and cutting line on the model and the developed pattern



(a) Contracted (b) Basic (c) Enlarged

Fig. 7: Three verge lines obtained by changing the border plane on the model

3.2 Experimental

Three dummy models (Real dummy L74, L34, FP-94, Nanasai Co., Ltd.) were used to make brassiere patterns employing the computerised pattern-making system. Three different brassieres were made by changing the verge line of each dummy model (to obtain nine different brassieres in total). The dummies had different bust sizes; their specifications are given in Table 3. The verge lines of the dummies are shown in Fig. 8. Brassieres were made with sheeting cloth (100% cotton, see Table 4) using the obtained patterns. The wearing appearances of the brassieres was compared.

Table 3: Specifications of subject dummies

Dummy	Photo	Size	
Dummy A		Bust	78.5 cm
		Under-bust	68 cm
		Brassiere size (JIS)	A65
Dummy B		Bust	77 cm
		Under-bust	65 cm
		Brassiere size (JIS)	B65
Dummy C		Bust	85 cm
		Under-bust	71 cm
		Brassiere size (JIS)	C70

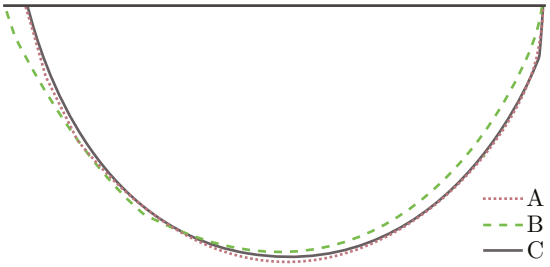


Fig. 8: Verge lines of dummies

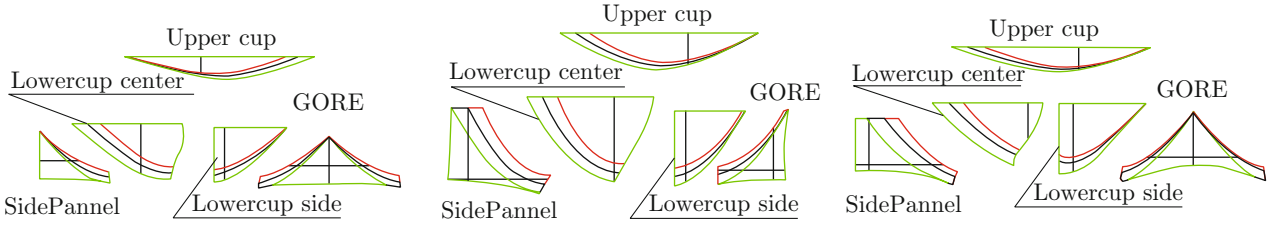
Table 4: Specifications of cloth

Structure	Yarn density (N/cm)		Yarn count (tex)	
	warp	weft	warp	weft
Plain	30	24	28	36

3.3 Results and Discussion

3.3.1 Making Patterns

By employing the proposed method, three brassiere patterns were made for each dummy. The obtained patterns are shown in Fig. 9. In comparing the three patterns for one dummy, the enlarged patterns spread out equally from the patterns for the basic verge line and the contracted patterns were narrow compared with the patterns for the basic verge line.



(a) Dummy A (b) Dummy B (c) Dummy C

Fig. 9: Contracted (red lines), basic (black lines) and enlarged (green lines) brassiere patterns of dummies

3.3.2 Making Brassieres and Those Comparisons

Brassieres were made from the obtained patterns. The cup parts and side panels without the parts of the wing, back, hook tape, eye tape, shoulder strap, loop and ring was made. The wearing appearance and fittability of the brassieres worn on the dummies were compared. The front, side and top views of the brassieres worn by each dummy are shown in Tables 5–7. Each constructed brassiere was put on the dummy using double-sided tape on the outline of the brassiere except for the upper parts of the cups. The side panels of the three different brassieres were fixed to the same position of the one dummy.

In the case of dummy A, the brassiere made with the pattern of the basic verge line fitted the dummy well. The brassiere with the enlarged verge line had too much allowance at the side

Table 5: Brassieres made for dummy A

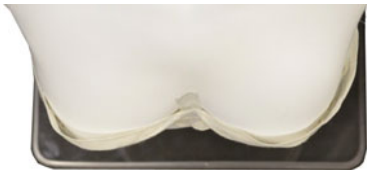
Dummy A	Front view	Side view	Top view
Contracted verge line			
Basic verge line			
Enlarged verge line			

part and thus did not fit the body of the dummy. The brassiere with the contracted verge line had cups that were too small and cloth that was drawn out to form wrinkles. This brassiere was unable to cover the whole bust. The results for dummy A reveal that a change in the verge line affects the brassiere cup. In the case of dummy B, the right half of the brassiere made with the pattern of the basic verge line naturally fitted the dummy. However, there was unnecessary allowance for the left half of the brassiere. This was because the right and left breasts of the dummy were different. In the case of the brassiere having the contracted verge line, the cups were too small and the cloth was drawn out to form wrinkles. The brassiere of the enlarged verge line had too much allowance. In the case of dummy C, the brassiere made with the pattern of the basic verge line was able to cover the entire bust shape. As for the results of dummies A and B, the brassiere with the contracted verge line was too small and too tight. Thus, the material was drawn out and unable to cover the bust naturally. The brassiere of the enlarged verge line had too much allowance in the cup parts and the cups thus looked too large. Contracting the verge lines reduced the size of the cup shapes in all cases. Thus, to cover the bust, the cloth was drawn out to the right and left, and the cup shifted from its original location. There was therefore a risk of exposing the bust. The brassieres with an enlarged verge line commonly had too much cup allowance as the cup shape spread sideways. In other words, there was too much space between the dummy and brassiere, and the brassiere did not fit the dummy. The results therefore show that a change in the verge line greatly affects the cup shape and appearance of a brassiere. To make a more fitted brassiere, it is necessary to consider an appropriate verge line in an inclined

Table 6: Brassieres made for dummy B

Dummy B	Front view	Side view	Top view
Contracted verge line			
Basic verge line			
Enlarged verge line			

Table 7: Brassieres made for dummy C

Dummy C	Front view	Side view	Top view
Contracted verge line			
Basic verge line			
Enlarged verge line			

plane.

4 Conclusion

The effect of the verge line on the appearance of brassieres was investigated and it was clarified that verge lines differed for the same brassiere size according to the individual's body shape. A method of designing a brassiere was proposed taking into account an individual's verge line. Brassiere patterns and brassieres employing the proposed design method was made. The verge line was found to affect both the bust cup shape and the appearance of the brassiere. Thus, the verge line should be taken into account in designing a more-fitted brassiere.

Acknowledgement

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