

DESIGN A BRA SIZING SYSTEM FOR VIETNAMESE WOMEN BASED ON 3D SCAN DATA

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ABSTRACT

This study focuses on the body shape of Vietnamese women, collected from large-scale measurement data, to establish a bra size system for mature Vietnamese women aged 18 to 55. Measurement data was collected from 1100 subjects using a 3D scanner. During the data collecting process, 18 measurements at the chest area were classified and used for the research and analysis. Data analysis is performed by the Principal Component Analysis (PCA) method and Numerical Analysis. Mean and median values are used to understand the central tendency of sizing charts. Standard deviation is leveraged to derive size categories, intervals and separate the outliers. Two size-matching solutions are implemented to find the optimal sizing system. The result found a 26 sizes bra system which is a combination of 5 band sizes and 6 cup sizes, with a response rate of 98.27% based on the primary dimensions of bust girth and underbust girth. The study's results were compared with the bra size systems of some countries in Asia and around the world, showing that differences in body shape have led to differences in the systems. the number of sizes. The ultimate goal of this research is to systematically establish a data database with local characteristics and significance that will contribute to sustainable development in academic research, industrial production, application, commercial activities, and service design in the future. The results of this study are meaningful for bra manufacturers in the Vietnamese market and for women in selecting suitable bras for their somatotype.

KEYWORDS

Bra; Sizing system; Size categories; Size intervals; Vietnamese women; 3D scan data.

INTRODUCTION

Vietnam has been and is a potential garment production and fashion market. Global brands through representative stores and online sales platforms are present in Vietnam, contributing to enriching and diversifying consumer choices. Therefore, domestic manufacturers are also increasingly investing in technology and design quality to compete for market share and strengthen their position with domestic consumers. Clothing is an integral part of everyday life. It protects not only the body but also the wearer, expresses their personality and aesthetic, helps individuals communicate confidently, and enhances their appearance, especially when it comes to bras.

Bras contribute a significant role in a woman's life. A correctly fitting bra is not only good for health [1, 2], as it can alleviate breast pain [2] and muscle fatigue or pain [3], but it also helps to shape and support the breasts [4]. It helps make the bust fuller and more attractive [5], and minimizes the effects of gravity,

slowing down the sagging process of the breasts [6]. However, if the size is wrong, it will not provide practical support [7]. It can affect health, make the wearer lose confidence in communication, and inhibit women from participating in daily physical activities [8] due to a less attractive appearance or difficulty in movement. Therefore, choosing a bra that fits your body size is something every woman desires.

Currently, in Vietnam, there has not been a system of bra sizes for Vietnamese women. Each manufacturer uses its sizing methods, such as Triumph [9], Victoria's Secret [10], and Calvin Klein [11]. Domestic bra manufacturers such as Vera [12], and Relax [13] also use their own developed sizing systems. This greatly affects consumers when they find it difficult to choose a bra suitable for their body size. Therefore, the goal of this research is to systematically establish a data database with local characteristics and significance that will support industrial production, application, commercial activities, and service design in the future. At the same time, this research helps

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Vietnamese women easily choose a bra suitable for their body size.

LITERATURE REVIEW

Bras not only have the function of protecting and shaping the women's bust but also make them more attractive, helping the wearer feel comfortable at work and confident in communication. Choosing a bra that matches the bust size is not easy for Vietnamese women, and this is because there is currently no specific bra size system for the Vietnamese body type. There has been no official research conducted on the bra sizing system for Vietnamese women.

Bra sizing systems are built around dividing users into groups with similar body measurements. Body size determines the key primary dimensions of grouping [14]. The bra size is composed of Band size and Cup size, denoted by two primary dimensions: Bust and Underbust [14, 15]. Therein, the underbust measurement determines the size of the bra band, which encircles the wearer's rib cage. Meanwhile, the difference between the bust girth and the underbust girth determines the bra cup size, representing the volume of the bust [14, 16]. Edward A.P. [17] developed a system of bra measurement for predicting post-augmentation breast size. In this research, the bras band size is still determined by underbust girth, while the cup size is determined by directly measuring the breast in proportion to the underbust circumference.

Research results from the paper 'breast volume and bra size [18] demonstrate the range of breast volumes within each size and the variations amongst different bra sizes. The authors measured the breast volume of 104 women via water displacement and compared it to their professionally fitted bra sizes. The results showed that the large variation in breast volumes is associated with different band sizes. Therefore, the authors suggest that women should not consider themselves solely based on cup size but rather as a combination of band and cup size. Some research has proposed a method of classifying bra cup size based on breast arc length, as accurate measurements of breast arc length could be useful for bra cup sizing and design. Pechter [19] defined bra cup size A as a breast arc length of 7 inches and size B as a breast arc length of 8 inches. Each additional inch in breast arc length corresponded to the next larger bra cup size. In Bengtson's research [20], the author used the direct measurement method to collect and analyze breast arc length from more than five thousand volunteers. The author proposes that there is a 2 cm difference in the breast arc length among different bra sizes. This is also the basis for the author to propose a method for choosing the bra size in women undergoing breast augmentation surgery based on breast size.

Many bras are unsuitable because wearers often choose the wrong cup size, incorrect bra band size,

or incorrectly determine their bust size. Previous international research has primarily focused on improving bust cup suitability. In a study on the bra sizing system for Chinese women, Zheng [21] presented a new approach to determine bra sizes based on the established sizing system. In this method, the underbust measurement determines the band size, while the bra cup size is determined by the ratio of bust depth and width. In the research of Seoyoung Oh [14], the author proposed a novel method to determine bra sizes. According to this research, the bra band size is determined by the underbust measurement, and the cup size is determined by three measurements: the bust's width, depth, and arc length. Yu Liu [22] suggested the inclusion of bust width when constructing a bra sizing system. While these studies hold theoretical significance, they lack practicality as wearers face challenges in accurately measuring their bust depth, width, and breast volume comfortably.

Therefore, this research utilizes basic 3D measurements of the human body and applies the principal component analysis method to identify the dominant dimensions. The main objectives of this study involve determining the optimal bra sizing system for Vietnamese women through discriminant analysis and crosstabulation, which are the two primary components of the sizing trials.

METHODOLOGY

Determine the research size sample

Formula (1) is used to determine the minimum sample size:

$$n = \frac{s^2 * Z^2}{e^2} \quad (1)$$

Where n is size sample; S is the standard deviation; Z is features of the probability and e is standard error

The standard deviation of 5.75 cm was determined by experimentally measuring the bust size of 30 random samples. The probability features a value of 2.58, which is determined by a probability $P = 0.99$, and a standard error of 0.5. Base on these values, the minimum sample size required is calculated to be 880.3. A Scanning study was conducted on 1145 adult female models working in Hanoi, aged 18-55 during the period from 2017 to 2022. Throughout the data collection process, the models wore thin bras without cup pads to minimize measurement errors.

Determine body measurements

Based on previous research conducted by Oh Seolyoung [14], Zheng [21], Kristina Shin [23], and Avşar [24], a total of 18 body measurements in the bust region were determined. These measurements including four circumferences, five height measurements, six horizontal measurements, and three vertical measurements, all extracted from 3D data. The specific measuring positions are illustrated

Table 1. Abbreviations and reports of the research measurements.

Ord	Measurements	ABBr	Descriptions
1.	Side neck to waist	Cc-e	Distance from the side neck point to waist plane
2.	Shoulder to waist	Cv-e	Distance from the shoulder point to the waist plane
3.	Upper bust to waist	Cnt-e	Distance from upper bust plane to waist plane
4.	Bust point to waist	Cdn-e	Distance from bust point to waist plane
5.	Underbust to waist	Ccn-e	Distance from under-bust plane to waist plane
6.	Side neck to bust point length	Dc-n	Length clings to the body from the side neck to the bust point.
7.	Side neck to under bust-length	Dc-in	Length clings to the body from the side neck point over the bust to the underbust point.
8.	Neck hollow point to bust pt	Dh-n	Length from Neck hollow point to bust point
9.	Upper bust arc width	Rnt	Length clings to the body from the front right armpit crease point to the left.
10.	Bust arc width	Rn	Length clings to the body over the bust line from the front right side to the left.
11.	Underbust arc width	Rcn	Length clings to the body over the underbust line from the front right side to the left.
12.	Waist arc width	Reo	Length clings to the body over the waistline from the front right side to the left.
13.	Bust point to bust point	Rdn	Distance from the left bust point to the right
14.	Bust cup length	Dcv	Length clings on the body over the bust line from the end side of the cup over the bust point to the center front.
15.	Upper bust girth	Vnt	Measure clings on the body the upper bust girth
16.	Full bust girth	Vn	Measure clings on the body the full girth through the two bust points
17.	Underbust girth	Vcn	Measure clings on the body the underbust girth
18.	Waist girth	Veo	Measure clings on the body, the waist girth through the smallest of the torso

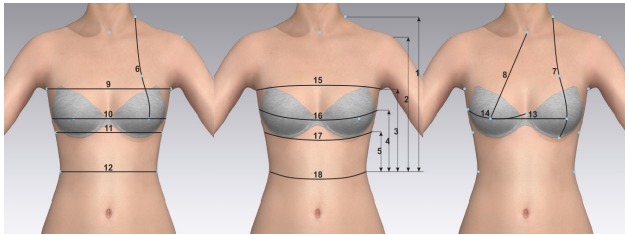


Figure 1. Research measurements positions.

in Figure 1. Abbreviations and descriptions for each measurement used in this study can be found in Table 1.

Determine the bust's primary dimensions

The Principal Component Analysis (PCA) method is employed to identify the primary dimensions. In this process, the factors with the highest value in each column of the rotated factor matrix is selected as the primary dimension. The dimensions chosen as master sizes undergo testing for standard distribution, considering the conditions: the mean value approximates the median, the standard distribution chart is examined, the asymmetric coefficient (Sk) approaches zero, the Inspection Kolmogorov - Smirnov test is conducted for sample sizes exceeding 500 with Sig. value larger than 0.05, and the normal Q-Q Plot indicates a linear pattern in the average probability chart.

Determine the bra size system's average size, size interval, and size number for the bra size system

The average size is determined by considering the frequency of occurrence for each size. The size interval for the primary dimension is established using standard deviation (SD) of the measurements and is then compared with previous research findings. The number of sizes is determined based on the response rate for each of individual sizes.

RESULTS AND DISCUSSIONS

Results 3D data statistics

To ensure the reliability of this research and the results, the study uses the Z coefficient to determine the unknown number [27]. If the z-value of some X_i values < 3 , those values are considered to fall within the acceptable range of distribution.

Z-value is determined by (2)

$$z = \frac{|X_i - \bar{X}|}{\sigma} \quad (2)$$

Where X_i is any value of X ; \bar{X} is Mean; σ is the standard deviation

With $Z < 3$, which mean

$$\frac{|X_i - \bar{X}|}{\sigma} < 3 \quad (3)$$

Equation (3) can be rewritten as

$$\bar{X} - 3\sigma < X_i < \bar{X} + 3\sigma \quad (4)$$

Table 2. Descriptive analysis results of chest measurements.

Ord.	ABBr.	N	Mode	Min	Max	Median	SD	Mean	$\bar{X} - 3\sigma$	$\bar{X} + 3\sigma$
1.	Cc-e	1100	41.25	33.50	48.55	40.75	2.67	40.61	32.59	48.63
2.	Cv-e	1100	35.50	27.00	42.59	35.00	2.69	34.72	26.65	42.79
3.	Cnt-e	1100	22.50	15.00	32.75	24.50	3.22	24.36	14.69	34.03
4.	Cdn-e	1100	21.00	12.00	28.00	20.00	2.79	19.96	11.58	28.33
5.	Ccn-e	1100	14.00	6.50	19.50	13.00	2.50	12.82	5.32	20.31
6.	Dc-n	1100	24.94	18.25	31.38	24.51	2.30	24.63	17.73	31.53
7.	Dc-cn	1100	33.48	25.93	41.31	33.34	2.66	33.53	25.56	41.50
8.	Dh-n	1100	20.09	14.86	25.27	19.59	1.89	19.71	14.03	25.38
9.	Rnt	1100	42.45	31.38	53.09	40.85	3.55	40.92	30.28	51.56
10.	Rn	1100	43.09	34.25	54.73	43.55	3.31	43.69	33.77	53.62
11.	Rcn	1100	32.18	24.06	42.80	33.12	3.27	33.14	23.33	42.95
12.	Reo	1100	39.19	29.18	46.04	36.94	3.07	37.01	27.81	46.21
13.	Rdn	1100	17.20	12.89	21.21	16.70	1.51	16.73	12.19	21.26
14.	Dcv	1100	19.20	13.10	26.90	19.80	2.39	19.69	12.53	26.84
15.	Vnt	1100	84.82	70.12	100.24	84.61	5.31	84.64	68.71	100.57
16.	Vn	1100	92.43	73.64	101.10	86.47	4.97	86.47	71.55	101.40
17.	Vcn	1100	68.02	61.84	88.51	72.87	5.21	73.11	57.48	88.75
18.	Veo	1100	76.63	58.95	92.66	74.47	5.14	74.57	56.15	93.00

Table 3. Bartlett's test results and KMO index.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.755
Bartlett's Test of Sphericity	Approx. Chi-Square	31906.403
	df	153
	Sig.	.000

After removing the unknown numbers, 1100 sets of body size parameters with Z-coefficients of dimensions all smaller than 3 are used for the analysis, as shown in Table 2.

Table 2 shows measurements for adult women, indicating an average bust girth of 86.47 cm with standard deviation of 4.97 cm. The smallest bust girth (Vn) recorded is 73.64 cm, while the largest is 101.10 cm, resulting in a difference range is 27.46 cm. The average under-bust girth (Vnt) is 73.11 cm, with the standard deviation of 5.21 cm. The smallest measurement is 61.84 cm, and the largest is 88.51 cm, showing the difference range of 26.67 cm. Furthermore, the overbust girth (Vnt) measures at an average of 84.64 cm, with an standard deviation of 5.31, the smallest is 70.12 cm, the largest is 100.24 cm, and the difference range is 30.12 cm.

Results of determining principal dimensions

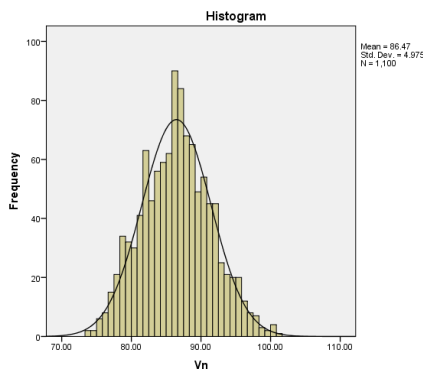
PCA results in Table 3 show that the KMO index is 0.755, which is greater than 0.5. This proves that the data used for factor analysis is entirely appropriate [28].

Barlett's test result is 31906.403 with a significance level of <0.05, which means that the variable numbers are correlated and satisfy the conditions for factor analysis. Factor analysis performed 74.718% according to Total Variance Explained with Varimax rotation Sums of squared loadings. Table 4 showed the initially grouping of the 18 observed variables into three factors. Group 1 gathers ten similar characteristic variables related to girths and widths of the upper torso, accounting for 37.742%. The variables of bust girth (Vn) and underbust girth (Vcn) have the highest values in the first factor. Group 2 consists of five similar characteristic variables related to distance from the waist to extreme points of the upper torso, accounting for 21.861%. Group 3 comprises three similar characteristic variables and denotes the relationship between the bust and neck points, accounting for 15.115%. The variable with the highest value at factor 3 is the length from the side neck point to the bust point (Dcn). This result is similar to the current bra sizing systems. The ISO system of international standards (ISO 4416) [29] also the bra size system of other countries [16] use bust girth and underbust girth to determine the bra size system. Commercial lingerie brands such as Triumph [9], Calvin Klein [10], Amoena [30], and Eva's Intimates [31]... all use bust and underbust circumference to determine the size of bras.

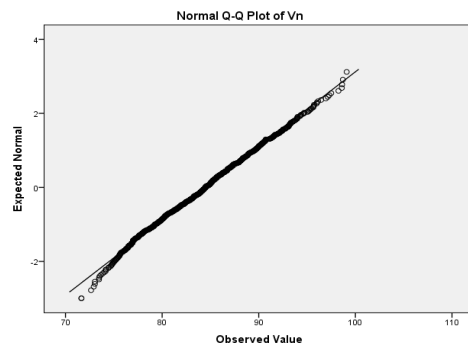
Therefore, this research uses bust girth and underbust girth to determine the sizes for Vietnamese female bras. These two variables hold the highest value in the first factor, indicating their strong influence on the sizing system. Moreover, these measurements can be easily obtained by the wearers themselves, ensuring convenience and accuracy.

Table 4. Result of factor analysis with Varimax rotation.

Factor name	Variables	ABBr	Component		
			1	2	3
1: Girths and widths of the upper torso	Full bust girth	Vn	.925	-.012	.221
	Underbust girth	Vcn	.925	.005	.083
	Upper bust girth	Vnt	.908	.057	.157
	Underbust arc width	Rcn	.862	-.176	-.002
	Upper bust arc width	Rnt	.841	-.066	.073
	Bust arc width	Rn	.835	-.177	.232
	Waist girth	Veo	.816	.284	.283
	Waist arc width	Reo	.816	.285	.284
	Bust cup length	Dcv	.560	-.114	.147
	Bust point to bust point	Rdn	.454	-.109	.276
2: Distance from waist to extreme points of the upper torso	Side neck to waist	Cc-e	.046	.900	.343
	Shoulder to waist	Cv-e	.057	.888	.237
	Bust point to waist	Cdn-e	-.044	.886	-.327
	Underbust to waist	Ccn-e	.043	.861	-.255
	Upper bust to waist	Cnt-e	-.235	.720	-.065
3: Relationship between the bust point and neck points	Side neck to bust point length	Dc-n	.281	-.054	.869
	Side neck to under bust-length	Dc-cn	.135	.110	.789
	Neck hollow point to bust point	Dh-n	.313	-.139	.770
Factor loading (%)			37.742%	21.861%	15.115%

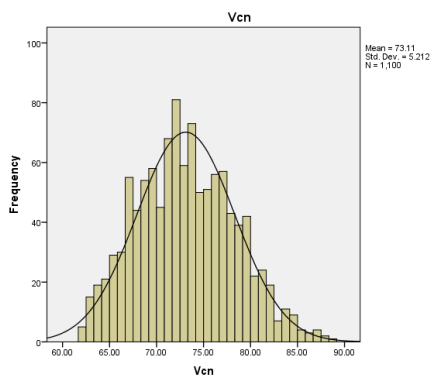


(a)

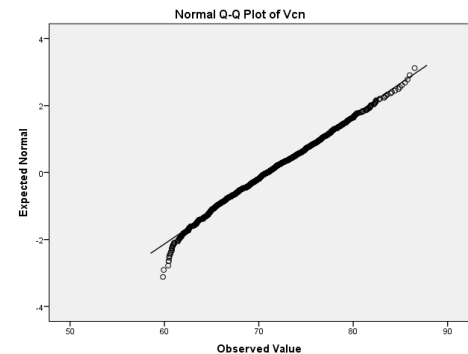


(b)

Figure 2. The standard distribution test of bust girth; (a) bell-shaped; (b) Q_Q plot.



(a)



(b)

Figure 3. The standard distribution test of underbust girth; (a) bell-shaped; (b) Q_Q plot.

The standard distribution test shows that the Mean of bust girth, at 86.47, is approximately equal to its Median of 86.47. The Mean of underbust girth, at 73.11, is roughly equivalent to the Median of 72.87. The *Sk* value is close to zero for bust and underbust girth, with values of 0.001 and 0.14, respectively. The distribution charts of these two measurements, shown in Figures 2a and 3a, exhibit a bell-shaped curve. The Kolmogorov-Smirnov test yields significant results for bust and underbust girth, with values of 0.2 and 0.68, respectively, exceeding the threshold of 0.05. The standard probability Q-Q plots, in Figures 2b and 3b, demonstrate a linear relationship, indicating that the measured values of the bust and underbust girth adhere to the standard distribution rule.

Determine the average size, size interval, and size number of the bra size system

Bra size including two parts band size and cup size [15]. The first crucial step is determining the average band size, following by selecting the size intervals for the band and the cup for the adjacent sizes. In Vietnam, the Metric system in centimeters (cm) is widely used and familiar, making it the unit of choice for the band size measurements. Cup size, on the other hand, is determined by the difference between bust girth and underbust girth [15]. According to the statistical results, the average underbust girth is 73.11 cm. The frequency chart of underbust girth in Figure 3a illustrates that an underbust girth of 70 cm to 75 cm (*V_{cn}*) has the highest frequency. Moreover, round numbers are more advantageous for communication purposes, also 73.11 leaning toward 75. Therefore, the primary dimensions for underbust girth with a value of 75 cm, will serve as the foundation for developing a bra size system in this research.

In previous research on sizing system for Vietnamese women, various intervals have been proposed for the bust size. Some studies suggested a 5 cm interval (Tran, MK [32, 33],) or 4 cm (TCVN 5782 – 2009 [34]; 2010 [35]; 2015 [36]; 2019 [37]). Several famous bras sizing systems worldwide, including those from Japan [16], China [21], Korea [23], Britain [16], US [16], Calvin Klein [10], and Victoria's Secret [11] also use 5 cm interval for bust and underbust size. Besides, other bras sizing systems such as ISO 4416, Imperial, and metrics for bras use a 4 cm interval for bust and underbust size. In addition, Italian [16], France [16], Spain [16], Australian [16], Triumph [9], and Amoena [30] bra size charts use a 5 cm bust size interval and a 4 cm underbust size interval. Considering that the standard deviation of the underbust girth in this research is 5.21 cm, a 5 cm interval for the bra band size would align with be recognized as previous studies mentioned above and be appropriate.

The statistical results describing measurement Drop: Birth girth (*V_n*) – Underbust girth (*V_{cn}*) in Table 5 show that the smallest difference is 7.21 cm, and the largest is 21.88 cm. The average difference between these two circumferences is 13.36 cm, with the standard deviation of 2.37. In addition, previous researchers applied standard deviation as the size interval [32, 38, 39]. Since the difference between bust and underbust girth is a criterion related to breast size, further analysis is necessary to determine the value round standard deviation, 2 cm or 2.5 cm, which would be the size interval between adjacent bra cup sizes. As mentioned above, the underbust girth determines the bra band size; therefore, 5 cm sets the size interval for the bra band. Therefore, two sizing models will be conducted with different size intervals for the dominant measurement. The two trial sizing models are: 85(± 2.5 cm) and 75(± 5 cm); 85(± 2 cm) and 75(± 5 cm).

Table 5. Descriptive Statistics of measurement Drop: Birth girth – Underbust girth.

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Vn - Vcn	1100	14.67	7.21	21.88	13.3607	2.37103
Valid N (listwise)	1100					

Table 6. The response ratio of the sizes for the two options.

The minimum response rate for size [%]	System 1 85(2.5)&75(5)		System 2 85(2)&75(5)	
	Total response [%]	Size quantity	Total response [%]	Size quantity
From 0.5%	98.27	26	96.64	29
From 1.0%	94.00	20	92.65	23
From 1.5%	90.27	17	89.09	20
From 2.0%	86.91	15	82.73	16

Table 7a. Response ratio of size system 85 (±2.5) & 75 (±5).

Underbust girth [cm]	Bust girth [cm]											
	72.5-75	75-77.5	77.5-80	80-82.5	82.5-85	85-87.5	87.5-90	90-92.5	92.5-95	95-97.5	97.5-100	
65(61-65)	0.36	1.82	3.64	1.55	0.73	0.09	0.00	0.00	0.00	0.00	0.00	0.00
70(66-70)	0.00	0.82	4.09	9.27	7.91	4.27	0.55	0.00	0.00	0.00	0.00	0.00
75(71-75)	0.00	0.00	0.18	1.36	5.45	14.73	9.91	2.73	0.82	0.09	0.00	0.00
80(76-80)	0.00	0.00	0.00	0.00	0.55	2.36	6.09	9.36	2.73	1.36	0.18	0.00
85(81-85)	0.00	0.00	0.00	0.00	0.00	0.00	0.09	1.00	2.27	2.09	0.82	0.00
90(86-90)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.09	0.45	0.00
Total (%)	0.36	2.64	7.91	12.18	14.64	21.45	16.65	13.09	6.00	3.64	1.45	

Table 7b. Response ratio of size system 85 (±2) & 75 (±5).

Underbust girth [cm]	Bust girth [cm]													
	73-75	75-77	77-79	79-81	81-83	83-85	85-87	87-89	89-91	91-93	93-95	95-97	97-99	99-101
65(61-65)	0.36	1.09	2.91	2.00	1.18	0.55	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70(66-70)	0.00	0.64	2.36	4.27	8.27	6.55	3.91	0.73	0.09	0.00	0.00	0.00	0.00	0.00
75(71-75)	0.00	0.00	0.18	0.36	1.55	4.91	11.18	10.45	4.82	1.55	0.18	0.00	0.09	0.00
80(76-80)	0.00	0.00	0.00	0.00	0.00	0.55	1.55	4.55	6.45	6.00	2.00	1.27	0.27	0.00
85(81-85)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.82	2.09	1.73	0.73	0.45
90(86-90)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.09	0.27	0.27
Total (%)	0.36	1.73	5.45	6.64	11.00	12.55	16.73	15.73	11.82	8.36	4.45	3.09	1.36	0.73

Previous studies have suggested that the optimal sizing system is the one that can satisfy the majority of wearers while having the smallest number of sizes, achieved by selecting the response ratio of the measurements in the system [40]. The minimum response ratio for each size was 1.53% in Gupta’s study [41], 1.6% in Park’s study [42], and 1% in Tran, MK’s study [33]. The results of the trials, presented in Table 6, provide details on the response rates of sizes when considering minimum response levels from 0.5%, 1.0%, 1.5%, and 2.0%, respectively. The response rate indicates the percentage of people who fit into each bra size.

Table 7a illustrates the number of sizes for the Vn&Vcn size of 85(± 2.5) & 75(± 5) when taking the response level of 0.5% or higher. Although the other rates have significant total response rates (94.00 with 1.0%, 90.27 with 1.5%, 86.91 with 2.0%), they serve more than 80% of the subjects. However, choosing these rates will remove many sizes that have a high frequency of occurrence. For example, selecting the 1% response rate would eliminate five sizes, the 1.5% response rate would remove eight sizes, and the 2.0% response rate would discard ten sizes. Therefore, the study selected the 0.5% response rate to establish the numerical size system, which resulted in a total response rate of 98.27% and included 26 numerical measures. Table 7b illustrates the number of sizes for the Vn&Vcn size of 85 (± 2) & 75 (± 5) when taking the response level of 0.5% or higher. When comparing the data dispersion between Tables 7a and 7b, a difference in concentration of the highest response rate is evident. Table 7a shows that the

average number for a 75 cm underbust girth and an 85-87.5cm bust girth reaches 14.73%, while table 7b only reaches 11.18%. A higher concentration of individual sizes is preferred for the size system.

From the results in Table 6, it can be seen that the combination 85 (2.5) & 75 (5) achieved better results for bra sizing systems. Among the two options tested with response rates of 0.5%, 1.0%, 1.5%, and 2.0%, the size factor 85 (2.5) & 75 (5) archived the highest total response rates and the smallest number of sizes. Therefore, the study selected the number 85 (5) & 75 (5) systems as the basis for developing a bra size numbering system for Vietnamese women. Table 7a describes the response rates for each size, taking response levels from 0.5% or higher to 1.0%, 1.5%, and 2.0%.

Labelling the size for the Vietnamese bra size system

The cup sizes in the international bra numbering system are assigned alphabetically starting with AA, A, B, C, and D. These are numerical sizing systems; other bras are widely applied in the manner of names and shown as above [14]. The difference between bustline and underbust circumference for Cup A is 10cm [14, 16]. Cup sizes AA, B, C, D... there are differences with cup A with corresponding size intervals. This study has determined that the optimal size interval for the Vn-Vcn difference of adult Vietnamese women is 2.5 cm.

Table 8. Bra cup sizes classified by the range difference between bust girth and underbust girth.

Difference [cm] (Vn-Vcn)	< 10.0	10.0-12.5	12.5-15.0	15.0 – 17.5	17.5-20.0	> 20.0
Bra cup sizes	AA	A	B	C	D	E

Table 9. The range of difference between bust girth – underbust girth corresponding to the range of size.

Underbust girth	Difference bust girth – underbust girth [cm]		Range of size
	Min	Max	
65(61-65)	9.92	20.48	A – D
70(66-70)	7.59	21.36	AA–E
75(71-75)	7.21	21.88	AA–E
80(76-80)	7.29	20.73	AA-E
85(81-85)	7.36	16.73	AA-C

Table 10. Vietnamese bra size system.

BRA BAND SIZE	Underbust girth [cm]	BRA CUP SIZE					
		AA	A	B	C	D	E
		Bust girth [cm]					
65	61 - 65	-	75-77.5	77.5-80	80-82.5	82.5-85	-
70	66 - 70	75-77.5	77.5-80	80-82.5	82.5-85	85-87.5	87.5-90
75	71 - 75	80-82.5	82.5-85	85-87.5	87.5-90	90-92.5	92.5-95
80	76 - 80	82.5-85	85-87.5	87.5-90	90-92.5	92.5-95	95-97.5
85	81 - 85	90-92.5	92.5-95	95-97.5	97.5-100	-	-

Table 11. Conversion between Band size and Underbust girth[16].

UNDERBUST GIRTH [cm]		60-65	65-70	70-75	75-80	80-85
BAND SIZE	This research	65	70	75	80	85
	International	60	65	70	75	80
	Japan, Korea	60	65	70	75	80
	UK, USA	28	30	32	34	36
	France, Spain	75	80	85	90	95

Table 12. Bra cup size comparison between several size systems.

DIFFERENCE BUST-UNDERBUST VN-VCN [cm]		<10	10-12	12-14	14-16	16-18	18-20	20-22
CUP SIZE	This research	AA	A	A/B	B/C	C/D	D	E
	International		AA	A	B	C	D	E
	Japan, Korea	AA	A	B	B/C	C	D	E
	UK, USA	AA	A	B	B/C	C	D	E/DD
	France, Spain		AA	A	B	C	D	E

Moreover, the results in Table 5 show that the minor cup size corresponding to the Vn-Vcn difference is 7.21 cm, the giant cup size corresponding to the Vn-Vcn difference is 21.88 cm, and the average cup size corresponding to the mean Vn-Vcn difference is 13.36 cm. Considering, the 14.67 cm range difference between bust and underbust girth, it is possible to identify six cup sizes, namely AA, A, B, C, D, and E. These results are shown in Table 8.

Table 9 shows the difference between bust girth and underbust for each bra band size group. This table allows for the identification of smallest and largest cup size as well as the cup size range for each belt size

group. Combining the results from Tables 7, 8, and 9, the bra sizing system proposed in this study is determined and presented in Table 10.

The results in Table 10 show the Vietnamese bra sizing system, which consists of a total of 26 numerical sizes, divided into five groups based on five bra band sizes: 65, 70, 75, 80, and 85. The smallest band size is 65 with 4 cup sizes, the most prominent band size is 85 with 4 cup sizes, while the other average band sizes have more cup sizes. These 26 sizes can meet 98.27% of Vietnamese women aged 18 to 55 years. From the bra sizing Table 10, the wearers can determine their bra size. Customers

collate the underbust circumference in the first and second columns to select the band size; then collate the bust girth to fit their bust cup size.

Table 11 shows the similarities in bra band sizes between this study and other sizing systems, particularly in Asian countries such as Japan and Korea. This table also provides a comparison of band sizes between this study and sizing systems used in UK, USA, France, and Spain. Table 12 compares the cup bra sizes in this research to those used in several countries' bra sizing systems. The results indicate that the relationship between the cup size name and the difference between bust and underbust measurements in Japanese, Korean, British, and American sizing systems has no difference with the findings of this study. For instance, a difference range of 10-12 cm corresponds to a cup size of A, which aligns with the AA cup size in France and Spain. In the survey, bra size is closely resemble the dimensions used in Japan and Korea, both in terms of band size and cup size. The number size in the study is similar to that of Japan and Korea. This result also demonstrates the practical significance of the study.

CONCLUSION

The breast area is a sensitive part of a women's body. Choosing a bra suitable for the bust size is one of the critical factors that help support and protect the bust area, creating confidence and comfort for women when using it. In this study, the bra size system for Vietnamese women builds on 3D measurements taken from 2017 to 2022, of 1100 adult Vietnamese women living in Hanoi, Vietnam, aged 18-55. Using principal component analysis and crosstabulation, the author has established a system of bra sizes for Vietnamese women, meeting 98.27% of the population in the study age group. The parameter set includes 26 different sizes, including the system of 5 band sizes and 6 cup sizes.

This research will be a valuable database in industrial garment manufacturing practices when designing patterns for mass-customization, applied in teaching-related subjects on women's bra design, and contributing to the section that proposes options for adjusting the fit of the bras to the Vietnamese body. The limitation of the topic is that the size of bras for bigsize women with bust size greater than 100 cm has not been determined yet.

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