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A Study on Breast Type Classification & Discrimination Using Manual Measurement- Focusing on Korean Women in Their 20s -

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[Abstract]

The manual measurements of 182 unmarried women subjects in their 20s was classified 4-breast types. For the breast type classification, 4 factors were identified, such as overall breast factor, upper breast internal shape factor, breast volume factor, and lower breast external shape factor. The breast shapes were 'breast with well-grown upper part', 'flat breast', 'breast with well-grown lower part', and 'protruded breast'. The breast types can be differentiated in 10 items of actual anthropometric dimension the length between frontal neck point and nipple point, length between lateral neck point and nipple point, length between the breast inner points, nipple to nipple breadth, diameter below the breast, inner depth of breast, outer length of breast, length below the breast, length between breast outer point and upper breast point, and contour line length below the breast.

▸ **Key words**: Breast type, Breast shape, Manual Measurement, Classification

[요 약]

20대 미혼 여성 182명의 직접 계측치를 이용한 유방유형 분류에 유방전체 형상 요인, 유방상부 내측형상 요인, 유방볼륨 요인, 유방하부외측형상 요인 등 4가지 요인이 추출되었다. 군집분석을 통해 '상부발달 유방', '밋밋한 유방', '하부 발달 유방', '돌출한 유방' 등 4유형의 유방유형으로 분류하였다. 유방유형은 목앞점~젖꼭지점길이, 목옆점~젖꼭지점길이, 유방안쪽점 사이간격, 젖꼭지 간격, 유방아래직경, 유방내측깊이, 유방바깥쪽길이, 유방아래길이, 젖가슴가쪽점~젖가슴위쪽점길이, 젖가슴 밑 윤곽선길이 등 10개 항목으로 판별 가능하다.

▸ **주제어**: 유방유형, 유방형태, 직접측정, 판별

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I. Introduction

There is not much data analyzing female breasts. People are reluctant to expose their breasts and refuse to touch them compared to other bodies.

Consumers have a significant dissatisfaction arising from the nonconformity of the size and shape of brassieres corresponding to the breast type, apart from the standardization, because most brassiere manufacturers map out their product planning based on the standard breast type of young consumers[1][2][3][4][5][6][7][8].

Although there has been the need to produce the brassieres designed with three-dimensional scan data, the automatic dimension measurement algorithm has yet to be developed for specific parts of human body, such as breast, as well as the algorithm that classifies the breast type.

Recently, studies are being conducted to classify breast types using 3D scan data. Han et. al.[9] analyzed and classified breast shape of women aged 11~15 using 3D body scan data of Size Korea. And 30 items from each of the scan were measured using RapidForm XOR 3 program. As the results of cluster analysis, woman's breast types were classified into four types, those are protrusion type, drooped breast covering a large area type, the least prominent breast with a highest nipple point type and, the obesity of the chest and breast circumferences with the slightly prominent and the least drooped breast type. Meanwhile, in research to analyze the characteristics of and changes in breast shapes of women in their 30s[10], With 3D data from the 6th Korean Human Dimension Survey, the breasts have been categorized into three different shapes. Shape I is sagging type, shape II is flat type, and shape III is a conical shape breast.

In this study, we measured breasts of 182 unmarried women subjects in their 20s, We intend to compare the difference between the two methods of measurement and the difference in dimension by breast type by performing direct and three-dimensional measurements.

II. Methods

1. Subjects and anthropometry

The 182 subjects who participated in the wearing experiment in this study were female college students in their early 20s, with an average age of 21. They were measured from April 23 to May 21, 2015, after explaining the meaning of this study to the subject, obtaining consent to participate in the experiment, giving a small case to those who voluntarily participated, and pledging not to use the results of this study elsewhere.

For the measurement reference point and reference line, we referred to the KS A ISO 8559: 2008a(anthropometry for the design of clothes)[11], KS A ISO 7250: 2008b(anthropometry for ergonomic design)[12], and preceding studies related to the breast[13][14][15].

Regarding the reference point in the direct measurement, breast upper point, breast lower point, breast inner point, and breast outer point were determined. The breast upper point is the point intersecting the horizontal line drawn from front armpit point and the line that extends from the mid-shoulder point to the nipple point. The breast lower point is the point located vertically down from the nipple point. The breast inner point is located toward the inner breast area when the length between the "horizontal line extended to the front armpit point" and the "horizontal line of breast lower point" is divided in equal half. The breast outer point is the point intersecting the line drawn from front armpit point to the bisection point of lateral waist and the line which halved the length between the "horizontal line extended to the front armpit point" and the "horizontal line of breast lower point". The point is located toward the outer breast area.

The breast contour line was defined to be the continuous and natural curve with reference to the wrinkle formed when the breast was pushed inward, the wrinkle formed when the breast was pushed upward, and the arch-shaped deltoid

muscle that is hardened when the hands is put on the waist and the strain was applied to the front armpit area. The breast-related reference point and measurement items were based on the preceding studies[16].

The breast-related reference point and average dimensions of subjects are presented in Fig. 1 and Table 1.

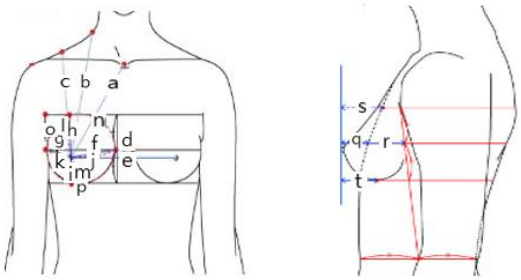


Fig. 1. Method of measurement items breast-related

The breast volume was estimated by measuring the volume of water filled up to the reference point after marking the outline extending to the breast inner point, breast upper point, breast outer point, and breast lower point with the water-based pen and mixing the water and alginate at a ratio of 1:1 which was then applied to the breast and removing the frame that was hardened a few minutes later(see Fig. 2). Breast volume measurement was repeated three times to calculate the average.

Fig. 2. Measurement method of breast volume

2. Method for analyzing the anthropometric measurement data

The factor analysis was conducted to identify the component factors of breast by using the SPSS win 12.0 program, and the cluster analysis was performed to classify the breast types. In addition, the ANOVA analysis was conducted to compare and analyze the difference based on the breast types, along with the discriminant analysis.

III. Results and Discussion

1. Identification of the breast component factors

Major component analysis of breast-related items was conducted, along with the rotation

Table 1. Measurement items

Classification		Measurement items	Mean(S.D.)		Measurement items	Mean(S.D.)
Upper body-related items	1	Chest circumference	81.07(4.74)	6	Underbust breadth	25.13(1.70)
	2	Bust circumference	82.88(7.01)	7	Chest depth	15.69(1.47)
	3	Underbust circumference	71.79(4.83)	8	Bust depth	16.44(1.75)
	4	Chest breadth	26.90(1.69)	9	Underbust depth	15.93(1.73)
	5	Bust breadth	26.20(1.92)			
Breast-related items	1	Anterior neck to bust point(a)	19.58(2.10)	12	Length of upper breast(l)	10.06(2.10)
	2	Neck point to bust point(b)	24.59(2.46)	13	Length of below breast(m)	6.15(1.94)
	3	Mid-shoulder to bust point(c)	23.41(2.34)	14	Length of breast upper point to breast inner point(n)	13.25(1.51)
	4	Breast inner point- Breast inner point (d)	1.35(0.63)	15	Length of breast outer point to breast upper point(o)	10.88(1.31)
	5	Bust point-bust point(e)	17.70(1.48)	16	Fold length of under breast(p)	22.06(2.09)
	6	Diameter of inner breast(f)	7.90(1.14)	17	Depth of inner breast(q)	4.67(1.50)
	7	Diameter of outer breast(g)	6.01(1.27)	18	Depth of outer breast(r)	7.90(1.70)
	8	Diameter of upper breast(h)	8.22(1.91)	19	Depth of upper breast(s)	4.84(1.54)
	9	Diameter of below breast(i)	4.97(1.12)	20	Height of the nipple point(t)	4.19(1.36)
	10	Length of inner breast(j)	9.19(1.62)	21	Circumferential length of breast	19.43(2.95)
	11	Length of outer breast(k)	10.24(1.68)	22	Breast volume	271.72(126.12)

( ) : These alphabet symbolize in fig.1

based on varimax, to classify the breast types, and the results of the factor analysis are presented in Table 2. 4 factors were found to have the eigenvalue equal to or exceeding 1, and the total variance of the 4 factors was 68.93%.

Factor 1 was found to be overall breast shape factor(24.41% of total variance), and turned out to be the variance with the highest explainability among the factors indicating the volume of breast. Factor 2 was named the upper breast inner shape factor(18.19% of total variance), and Factor 3 was named the breast volume factor(16.18% of total variance). Meanwhile, Factor 4 was named the lower breast outer shape factor(10.14% of total variance).

Table 2. Factor analysis of breast measurement items

Factor	Type	Factor Load	Eigenvalue	Distribution (%) (Cumulative distribution)
Overall breast shape	Diameter of upper breast	0.81	5.12	24.41 (24.41)
	Length of upper breast	0.74		
	Lateral shoulder to bust point	0.73		
	Lateral neck to bust point	0.71		
	Length of breast outer point to breast upper point	0.68		
	Fold length of under breast	0.65		
	Length of outer breast	0.59		
	Mid-shoulder to bust point	0.59		
	Anterior neck to bust point	0.58		
Inner shape of upper breast	Bust point-bust point	0.90	3.82	18.19 (42.61)
	Diameter of inner breast	0.71		
	Length of inner breast	0.60		
	Depth of upper breast	0.57		
	Length of breast upper point to breast inner point	0.41		
Breast volume	Breast inner point - breast inner point	-0.72	3.39	16.18 (58.79)
	Height of nipple point	0.65		
	Length of lower breast	0.65		
	Depth of outer breast	0.55		
	Depth of inner breast	0.55		
Outer shape of lower breast	Diameter of lower breast	-0.82	2.12	10.14 (68.93)
	Diameter of outer breast	0.56		

2. Classification of breast types

K-means cluster analysis of the data related to 182 subjects was conducted with the independent variables of the 4 factors identified from the factor analysis of breast-related dimension measurements. Based on the results, the breast types were classified into 4 cluster types as shown in Table 3. To determine the characteristics of each cluster, the post-hoc analysis(Duncan Test) was performed after conducting the analysis of variance.

The cluster Type 1 had higher factor scores for inner shape of upper breast and overall breast shape, and was characterized by the large inner shape of 'upper breast' and the smallest outer shape factor of 'lower breast' among the 4 types and therefore was named 'breast with well-grown upper part'.

Type 2 had the smallest factors of overall breast shape, inner shape of 'upper breast', and breast volume, and slightly small outer shape factor of

'lower breast', and was named 'flat breast'.

Type 3 usually had the round shape, and had slightly high factor of breast volume and outer shape of 'lower breast', and therefore was named 'breast with well-grown lower part'.

Type 4 had the largest volume among the 4 types, and had the highest scores for the factors of overall breast shape, inner shape of 'upper breast', breast volume, and outer shape of 'lower breast', and was named as 'protruded breast'.

The appearance rate of Type 2 was 41.2%, the highest, which suggests that the flat breast type comprised the highest proportion among the Korean women in their 20s. The appearance rate of 'breast with well-grown lower part' stood at 33.5% in Type 3, and the appearance rate of 'breast with well-grown upper part' was 14.3% in Type1. The appearance rate of protruded breast was 11.0%, the lowest.

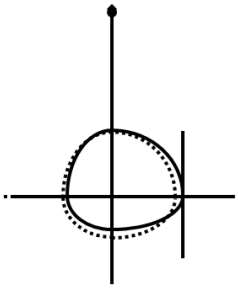
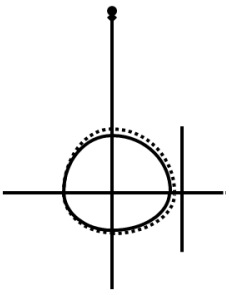
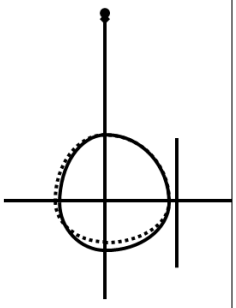
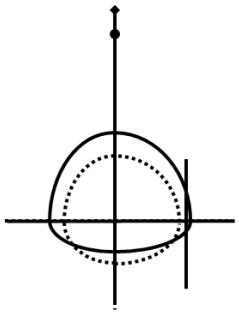
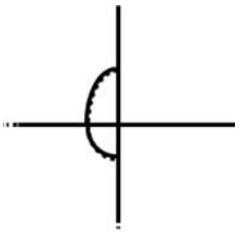
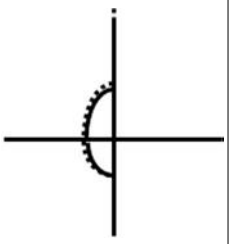
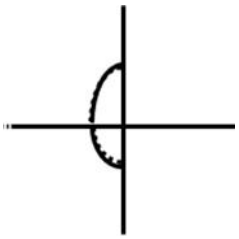
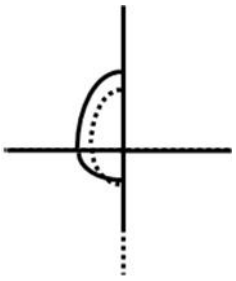
According to the Institute for Human Sciences in Japan, re-approved by Sohn[16], women's breast types are divided into the Flat Breast, Cone, Hemisphere, Protusion and Dropping types.

Flat type and extrusion type were found to be the same type in this study, and Hemisphere type corresponds to the upper development type with convex top. Meanwhile, the type of development below in this study can be said to be the middle of the Cone type or Dropping type. Since the subject of this study is young women, the complete drop type is rare, so it can be said that it is a compromise between the cone type and the drop type, which is the breast lower development type.

Table 3. Breast component factors by type

Factors \ Cluster Type	Type 1	Type 2	Type 3	Type 4	Overall M(SD)	F value
	Breast with well-grown upper part	Flat breast	Breast with well-grown lower part	Protruded breast		
	n=26 (14.3%)	n=75 (41.2%)	n=61 (33.5%)	n=20 (11.0%)	n=182	
Overall breast shape	17.23^{b}	15.84^{c}	16.99^{b}	19.57^{a}	16.83 (1.55)	66.16 ***
Inner shape of upper breast	11.42^{b}	10.04^{d}	10.48^{c}	11.95^{a}	10.60 (1.11)	32.01 ***
Breast volume	4.85^{bc}	4.49^{c}	4.92^{b}	6.49^{a}	4.91 (0.98)	33.56 ***
Outer shape of lower breast	5.04^{c}	5.48^{b}	5.83^{ab}	5.95^{a}	5.58 (0.79)	8.94 ***
	Ordinary breast base area Ordinary volume Breast with well-grown upper part	Small breast base area Small volume Small inner upper part of breast	Ordinary breast base area Ordinary volume Breast with well-grown lower part	Large breast base area Large volume Breast with well-grown upper and lower parts		

a>b>c Different characters mean different groups.
***p<.001.

Type	Type 1 Breast with well-grown upper part	Type 2 Flat breast	Type 3 Breast with well-grown lower part	Type 4 Protruded breast
Front				
Side				
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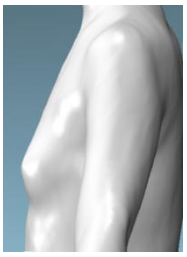
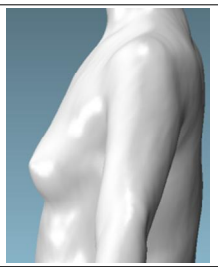
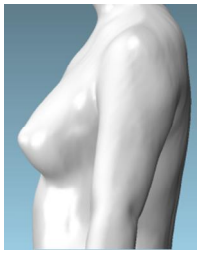
Instance				
Dotted line means average, solid line means type.				

Fig. 3. Cross section and silhouette in breast type

3. Dimension of breast-related items by breast type

The distribution test(Duncan Test) was performed to determine the difference in the mean value for the anthropometric measurement items of the breast based on the breast type. The results are presented in Table 4.

Type 1 had relatively short in length between the breast inner points, and has relatively longer length compared to the diameter or depth of breast, and furthermore had larger diameter or length in the upper breast part compared to the lower breast part, thus showing a tendency that the upper breast was developed more than the lower breast.

Type 2 had the shortest nipple-to-nipple breadth and the smallest length and depth of breast. In addition, Type 2 had the shortest length of breast contour line and therefore had the smallest breast and protrusion.

Type 3 had the smallest inner diameter and inner depth of breast and had the largest diameter

below the breast, showing a tendency that the lower part of the breast was developed.

Type 4 had the shortest length between the breast inner points and the smallest diameter below the breast, but was found to have the largest diameter, depth, length of breast and the largest contour line of breast among all the 4 types. Generally, Type 4 had the large and protruded breasts.

Table 4. Difference in the dimension of breast component items by breast type Unit: cm

Item \ Type	Type 1 Breast with well-grown upper part breast	Type 2 Flat breast	Type 3 Breast with well-grown lower part	Type 4 Protruded breast	Total M(SD)	F Value
	n=26	n=75	n=61	n=20	n=182	
Length between the breast inner points	1.16^{b}	1.74^{a}	1.40^{b}	0.85^{c}	1.31(0.61)	11.43 ***
Bust point-bust point	19.46^{a}	17.11^{c}	17.83^{b}	18.27^{b}	17.81(1.46)	24.32 ***
Inner diameter of breast	8.86^{b}	7.39^{d}	7.86^{c}	9.40^{a}	7.98(1.19)	31.18 ***
external diameter of breast	5.82^{b}	6.11^{b}	5.75^{b}	7.95^{a}	6.15(1.34)	18.74 ***
Diamete above the breast	8.20^{b}	7.13^{c}	8.41^{b}	10.98^{a}	8.13(1.79)	42.83 ***
Diameter below the breast	4.27^{c}	4.86^{b}	5.91^{a}	3.97^{c}	5.03(1.16)	33.32 ***
Inner depth of breast	4.82^{b}	4.41^{bc}	4.08^{c}	7.28^{a}	4.67(1.49)	40.56 ***
external depth of breast	7.89^{b}	7.11^{c}	8.30^{b}	9.71^{a}	7.91(1.68)	18.47 ***
Depth of upper breast	5.43^{b}	4.59^{c}	4.91^{bc}	6.75^{a}	5.05(1.48)	14.71 ***
Height of nipple point	4.30^{b}	3.85^{b}	4.34^{b}	6.19^{a}	4.34(1.32)	22.22 ***
Inner length of breast	9.85^{b}	8.35^{c}	8.82^{c}	11.30^{a}	9.05(1.48)	39.51 ***
Outer length of breast	9.69^{c}	9.57^{c}	10.74^{b}	12.70^{a}	10.32(1.63)	34.39 ***
Length above the breast	10.50^{b}	9.10^{c}	10.21^{b}	13.07^{a}	10.11(1.95)	35.39 ***
Length below the breast	5.50^{c}	5.72^{c}	6.75^{b}	8.44^{a}	6.33(2.07)	13.74 ***
Length between upper breast point and breast inner point	13.53^{ab}	12.79^{c}	13.02^{bc}	14.08^{a}	13.12(1.48)	5.08 **
Length between breast peripheral point and upper breast point	9.97^{c}	10.52^{b}	11.66^{a}	12.15^{a}	11.00(1.27)	29.79 ***
Length of contour line below the breast	22.78^{b}	20.77^{c}	23.40^{b}	24.33^{a}	22.33(2.17)	38.95 ***
Breast volume	280.85^{b}	221.33^{c}	283.18^{b}	487.00^{a}	279.75(122.04)	41.90 ***

a>b>c Different characters mean different groups. ** p<.01, *** p<.001

4. Discriminant analysis of breast types

The discriminant analysis was conducted to determine the relative importance of the discernment of the representative items identified through the stepwise processing method based on the 21 items used for the factor analysis.

A total of 10 variables were found to have significant contribution to such discernment as

shown in Table 5. The influential factors were examined in the discriminant function in which the absolute value of canonical discriminant coefficient was 0.4 or higher. In relation to the discriminant function 1, the extent of contribution was greater in the order of the length between the breast peripheral point and upper breast point, length between frontal neck point and nipple point, outer length of breast, inner depth of breast, and diameter below the breast.

Regarding the discriminant function 2, length below the breast had significant contribution. As for the discriminant function 3, the extent of contribution was greater in the order of inner depth of breast, nipple-to-nipple breadth, length between lateral neck point and nipple point, and contour line below the breast.

Table 5. Discriminant coefficient of breast types

Discriminant variables	Canonical discriminant function 1	Canonical discriminant function 2	Canonical discriminant function 3
Anterior neck to bust point	-0.55	0.23	0.00
Lateral neck to bust point	-0.05	0.33	0.43
Length between the breast inner point	-0.34	-0.18	0.03
Nipple-to-nipple breadth	-0.24	-0.11	0.71
Diameter below the breast	0.45	-0.18	0.14
Inner depth of breast	-0.50	-0.13	-0.78
Outer length of breast	0.52	0.15	-0.29
Length below the breast	0.09	0.40	-0.10
Length between breast peripheral point and upper breast point	0.5	0.32	-0.11
Contour line below the breast	0.07	0.34	0.43

The discriminant probability of each Type was obtained as shown in Table 6 based on the discriminant analysis that applied the 21 items which had been used in the factor analysis as independent variable and also applied the 4 types as dependent variable. The accuracy of discriminant function was 90.1%. Considering the prior probability by type, 25 persons out of 26 were discriminated accurately in Type 1, and the discriminant probability was 96.15%. Type 2 had the discrimination accuracy of 93.33% with 70 persons, and Type 3 had the discrimination accuracy of 86.89% with 53 persons. Meanwhile, Type 4 had the discrimination accuracy of 80.00% with 16 persons. In other words, 3.85% was discriminated inaccurately in the breast Type 1, and 6.66% was discriminated inaccurately in the breast Type 2. And 13.11% was discriminated inaccurately in the breast Type 3 while 20.00% was discriminated inaccurately in the breast Type 4. Thus, the Type 1 was found to have the lowest rate of mis-classification, and involved only 18 cases wherein the type was classified wrongly in comparison with the group categorization.

Table 6. Discriminant probability by breast type Unit: Person(%)

		Group categorization				Total
		Type 1	Type 2	Type 3	Type 4	
		Breast with well-grown upper part	Flat breast	Breast with well-grown lower part	Protruded breast	
	Type 1	25(96.15)	1(3.85)	-	-	26(100)
	Type 2	1(1.33)	70(93.33)	4(5.33)	-	75(100)
	Type 3	-	8(13.11)	53(86.89)	-	61(100)
	Type 4	-	1(5.00)	3(15.00)	16(80.00)	20(100)
Total		26(14.28)	80(43.96)	60(32.97)	16(8.79)	182(100)

The 10 items were classified to ensure the discrimination of breast type by using the anthropometric data of individuals. The discriminant function of each type is presented in Table 7. The each breast type was classified into different categories in terms of the body shape by substituting the 'classification function coefficient of each breast type' for the 10 items such as the length between frontal neck point and nipple point, length between lateral neck point and nipple point, length between the breast inner points, nipple to nipple breadth, diameter below the breast, inner depth of breast, outer length of breast, length below the breast, length between breast peripheral point and upper breast point, contour line below the breast, which are the actual anthropometric data of individuals, based on the type that had the highest score of classification.

By measuring the dimension associated with breast, Substitute the dimension into the Type 4 classification function.

For example, Type1= -292.84+6.04(Anterior neck to bust point)+ 6.23(Lateral neck to bust point)+ 4.62(Length between the breast inner points)+ 10.93(Bust point-bust point)+ 2.65(Diameter below the breast)-10.25(Inner depth of breast)-3.73(Outer length of breast)+ 1.48(Length below the breast)+ 5.04(Length between breast outer point and upper breast point)+ 3.91(Contour line below the breast). If the calculated value is higher than other types(Type2, Type3, and Type4), the breast type corresponds to Type 1.

Table 7. Classification function by breast type

Category	Type 1	Type 2	Type 3	Type 4
(Constant)	-292.84	-241.35	-280.94	-294.79
Anterior neck to bust point	6.04	5.02	4.57	5.99
Lateral neck to bust point	6.23	5.51	6.03	6.12
Length between the breast inner points	4.62	3.41	2.03	2.80
Bust point-bust point	10.93	9.33	9.62	8.96
Diameter below the breast	2.65	3.56	4.32	2.32
Inner depth of breast	-10.25	-9.67	-11.46	-9.41
Outer length of breast	-3.73	-2.43	-1.88	-2.31
Length below the breast	1.48	1.53	1.84	2.29
Length between breast peripheral point and upper breast point	5.04	6.25	7.46	6.91
Contour line below the breast	3.91	3.29	3.97	3.89

IV. Conclusion and suggestion

For the breast type classification, 4 factors were identified, such as overall breast factor, upper breast internal shape factor, breast volume factor, and lower breast external shape factor. Through the cluster analysis, the breast shape was classified into 4 types, i.e., 'breast with well-grown upper part', 'flat breast', 'breast with well-grown lower part', and 'protruded breast'.

The breast types can be differentiated based on 10 items of actual anthropometric dimension such as the length between frontal neck point and nipple point, length between lateral neck point and nipple point, length between the breast inner points, nipple to nipple breadth, diameter below the breast, inner depth of breast, outer length of breast, length below the breast, length between breast peripheral point and upper breast point, and contour line length below the breast.

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