

Description and Classification of the Youth's Body Type in Shanghai

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Received: April 6, 2017

Accepted: April 17, 2017

Online Published: April 18, 2017

doi:10.5430/jbar.v6n1p52

URL: <https://doi.org/10.5430/jbar.v6n1p52>

Foundation item: innovation project of Shanghai University of Engineering Science, China (No. Cs1609001)

Abstract

The carried out standard of the garment size is not able to reflect the body shapes of the modern. In order to achieve a better standard, which is in accord with the requirement of the modern, the figures of 520 women and men, all in the age of 18 to 40, are measured. 18 variables of body shapes are chosen, and 7 variables are derived from them. All the data is processed by SPSS, and one-way analysis of variance (ANOVA) and cluster analysis are used. Both of women's upper and lower body shapes are classified into 6 categories, and the similar segregation is carried on men with 4 categories, which is an ideal classification. The results offer the support for understanding the current situation of the body shapes of young women and men in Shanghai, for customizing a new standard, and for providing theoretical basis and reference on optimization of designs of clothing structure.

Keywords: Body type, Adults, Shanghai, Cluster analysis

1. Introduction

The evolution of the human body is gradually formed, the standards of clothing size should also advance with the times in order to bring better services to the consumers and more accurate data to the workers in apparel industry. The large-scale measurement of the human body is important to collect more complete human data and follow the current evolution speed and level of human. The adult is a significant group in the garment market, so the research on body shapes of the adults is a dispensable link in designing clothing structure. The standard of the garment size GB/T1335-2008 shows the characteristics of the human bodies in the 21st century. With the change of life, the body shapes of citizens change as well. Therefore, the standard is not able to reflect the actual size. So far, more and more garment production tends to be of small scale, so the mode called 'Made To Measure' (MTM) appears. Besides dividing more precisely, this mode is more suitable for classifying the body shapes of contemporary human. In recent years, domestic and foreign scholars have launched this research, especially the research on body shapes that classified by regions and age. Some of the results have been applied for a patent.

This study aims at the body shape analysis among adults in Shanghai. The body shape data are obtained by two methods: Manual measurement and instrument measurement. The instruments are non-contact 3D body scanner, hand scanner and Martin measuring instrument (Originated from Germany. The body is scanned automatically in infrared. After processing, more than 100 figures for designing and tailoring garment can be obtained.) In all, 119 figures of human bodies are measured, including weight, height, neck girth, cervical height, waist, etc., after the analysis and comparison, the classification of men and women are carried on. This study can bring convenience to the apparel industry and their workers in some way, for the fitness of clothing is very important to the costume designers and other workers in the apparel industry or the private studios.

2. The body Measurement

2.1 Experimental Subjects

Men and women aging from 18-40 were chosen as subjects. Among those 520 adults, 265 are men and 255 are women.

2.2 Experimental Conditions and Instruments

The body shapes were measured in 3D human body measurement laboratory by non-contact 3D body scanner originated from Germany, Martin measuring instrument and tape measure. The temperature and humidity of the

laboratory were constant. In order to ensure the standardization of measurement and the accuracy of the data, a certain person was assigned to manipulate the whole course. All the subjects were all dressed in thin and light underwear, body remaining still and erected, eyes looking straight ahead, upper limbs sagging naturally.

Matters need attention:

- (1) Shoes and socks should be taken off
- (2) Clothing and weight should be reduced in order to ensure the accuracy of the weight.
- (3) Complete contact with the hand electrode and foot electrode should be ensured.
- (4) Arms drop naturally and keep fifteen degrees apart breadthwise
- (5) Moving and talking are not allowed during the experiment.
- (6) Physical contact is not allowed during the experiment.
- (7) Under certain circumstances, electrolytic paper should be utilized (if it is too dry or the horny skin of the tester is too thick)

2.3 Measurement and Methods

The software ScanWorX was used for measure variables. New variables were derived from the measurement according to the requirement, and finally 56 variables are utilized in the analysis of this research.

1) 26 variables of height and length: height, head length, cervical height, 7th cervical to hip, 7th cervical to knee, waist to knee, lower body length, waist height, hip height, maximum hip height, crotch height, belly height, maximum belly height, scapula height, breast height, neck front height, 7th cervical to waist, waist length, fork length, waist pelvis length, the length of 7th cervical to wrist, arm length, upper arm length, inside leg length, outside leg length, lateral height of waist.

2) 29 variables of girth and thickness: mid neck girth, neck girth, shoulder across, side neck to shoulder, across front, milk interval, bust, thoracic cavity band, under bust girth, across back, waist pelvis distance, waist, hip girth, buttock girth, maximum hip girth, belly, maximum belly circumference, upper arm girth, wrist girth, thigh girth, knee girth, ankle girth, cervix thickness, hip thickness, chest thickness, abdominal thickness, bust-waist difference, bust-hip difference, hip-waist difference.

3) 1 variable of angle: shoulder slope.

The procedure of measurement:

- (1) The receptionist served the subjects
- (2) The subjects were dressed
- (3) The weight, reach height and height of the subjects were measured
- (4) The gauge points were pasted
- (5) The posture was detected.
- (6) The subjects were scanned.

3. Pretreatment of Data

In order to ensure that the following analysis and statistic can be carried on normally, the data should be pretreated. The contents of the pretreatment mainly include the following parts [2]

(1) Normal distribution test: in the analysis of data of human body, certain analytical methods require samples from the normal distribution of the population. After the normal distribution test, the data showed normal distribution.

(2) Check the abnormal values. Too large or too small data are likely to be abnormal values, influential data points, or wrong data. In this paper, the methods of processing the data are showed as follows: if the abnormal values appear in the data of height, directly remove the entire data; if the abnormal values appear in some parts of the body, only remove the value of this part.

(3) Process the missing values. The values that are not collected or values that are abnormal values or influential data points are all missing values, which should all be deleted. The presence of missing values may be inconvenient for subsequent analysis. In this paper, missing values were replaced by the mean value of all the non-missing values, so that the overall data distribution was closer to the center and the feature was more obvious.

4. Analysis of Data

Descriptive analysis refers to describing the data samples fundamentally, and obtaining the essential characteristics of describing variables. Due to various aspects of the errors in the measurement, before the formal analysis of the data of human bodies, the data should be initially verified, the abnormal and missing values should be ensured, and the bad samples and unavailable data should be excluded. After processing, 1080 samples were ensured to be valid.

4.1 The Analysis of Fundamental Statistics

In this paper, the descriptive analysis by SPSS was used to calculate the four basic statistics (the minimum, the maximum, the mean and the standard deviation) of the male and female adults in Shanghai. The minimum and maximum values can reflect the minimum and maximum values of the measured data of a certain item among all the subjects; the mean can reflect the average level of a certain item among all the subjects; the standard deviation can reflect how much the data deviate from the mean value. The larger the deviation from the mean is, the more obvious the fluctuation is, and vice versa. Table 1 shows:

- (1) In terms of height, the height of young men and women in Shanghai is of a wide range. The average height of women is about 158.41cm, and that of men is estimated 169.3cm, both of which are close to the average values in the national standard.
- (2) In terms of girth, the average girth of women is smaller than men.

Table 1. Fundamental statistics of men and women bodies

Values	Man				Woman			
	Minimum	Maximum	Mean	standard deviation	Minimum	Maximum	Mean	standard deviation
Weight	45.0	110.9	67.267	11.1472	35	524	55.98	30.962
Neck girth	35	50	43.18	2.673	31	46	37.77	2.217
Shoulder across	35	48	40.44	2.197	33	72	38.19	5.614
Shoulder slope	16	34	26.20	3.292	14	52	25.74	5.003
Across front	33	49	39.12	2.934	29	49	38.18	3.341
Bust	78	119	94.43	7.965	76	114	89.20	6.165
Across back	29	45	36.76	3.035	27	41	33.55	2.485
Waist	62	116	82.31	10.086	59	105	73.45	7.605
Buttock girth	82	111	94.77	5.766	78	118	93.15	5.746
Height	152	196	169.30	6.329	142	177	158.41	5.898
Cervical height	129	167	144.29	5.802	113	150	133.87	5.918
7 th cervical to knee	89	115	99.80	3.856	82	104	92.82	3.611
Back length	35	47	41.05	1.995	32	44	37.78	2.012
Breast height	107	142	121.35	5.307	99	128	112.42	5.028
Neck front height	112	162	136.84	6.766	114	313	129.20	12.824
Waist height	92	123	104.11	4.698	86	112	97.25	4.453
Crotch height	61	88	72.12	4.126	58	81	68.46	3.924
Crotch to waistband	19	27	22.66	1.646	19	32	24.13	1.300

Note: Weight/kg, Shoulder slope/degree, all the other values/cm

4.2 Analysis of the Coefficient of Variation

The coefficient of variation is another statistic of the degree of variation of the values in the data. During comparison of the degree of variation of two or more values, if the unit of value is the same as the unit of the mean, the standard deviation can be used directly in the comparison. If the unit or mean is different, the standard deviation cannot be used to compare the degree of variation, and the ratio of the standard deviation to the mean (relative value) is used. This ratio is called the coefficient of variation, denoted as $C \cdot V$. The coefficient of variation can eliminate the effect of differences between units and/or between means on comparison of the degree of variation of two or more data.

The coefficient of variation is calculated as:

$$C.V = (SD \div MN) \times 100\%$$

Note: Standard deviation – SD;

Mean – MN

In the statistical analysis of the data, if the coefficient of variation is greater than 15%, it is necessary to consider that the data may be abnormal, and should be removed, as Table 2 shows.

Table 2. The coefficient of variation of the data of men and women

Values	Men			Women		
	Mean	Standard deviation	Coefficient of variation /%	Mean	Standard deviation	Coefficient of variation /%
Weight	67.27	11.15	0.17	55.98	30.96	0.55
Neck girth	43.18	2.67	0.06	37.77	2.22	0.06
Shoulder across	40.44	2.20	0.05	38.19	5.61	0.15
Shoulder slope	26.20	3.29	0.13	25.74	5.00	0.19
Across front	39.12	2.93	0.07	38.18	3.34	0.09
Bust	94.43	7.96	0.08	89.20	6.16	0.07
Across back	36.76	3.03	0.08	33.55	2.48	0.07
Waist	82.31	10.09	0.12	73.45	7.61	0.10
Buttock girth	94.77	5.77	0.06	93.15	5.75	0.06
Height	169.30	6.33	0.04	158.41	5.90	0.04
Cervical height	144.29	5.80	0.04	133.87	5.92	0.04
7 th cervical to knee	99.80	3.86	0.04	92.82	3.61	0.04
Back length	41.05	1.99	0.05	37.78	2.01	0.05
Breast height	121.35	5.31	0.04	112.42	5.03	0.04
Neck front height	136.84	6.77	0.05	129.20	12.82	0.10
Waist height	104.11	4.70	0.05	97.25	4.45	0.05
Crotch height	72.12	4.13	0.06	68.46	3.92	0.06
Crotch to waistband	22.66	1.65	0.07	24.13	1.30	0.05

Note: Weight/kg, Shoulder slope/degree, all the other values/cm

5. Classification of Body Shape

China's current standard of the garment size GB / T1335-2008 classifies human's body shape into four types based on the difference of body's net chest and net waist, which does not subdivide the human body, also not enough to reflect the human's body differences. On the other hand, the development trend of the garment industry, tailored production methods, needs to establish a subdivided database of human body, taking the more detailed body shapes and targeted tops and bottoms into account, so this study attempts to classify upper and lower body separately. In this paper, we add the derived variables, which can reflect the vertical and horizontal changes of the human body and other related variables as the reference index of body classification. These derived variables are all calculated by the important parts of the human body, the derived variables are shown in Table 3.

Table 3. Derived variables and their definition

Derived variable	Definition	Derived variable	Definition
Bust-waist difference	Bust-waist	Bust-waist ratio	Bust/waist
Waist-hip difference	Hip-waist	Hip-waist ratio	Hip/waist
2B*/h		2W*/h	
2H*/h			

5.1 Cluster Analysis of Men's Body Shape

5.1.1 Cluster Analysis of Men's upper Body Shape

Data is possessed with one-way analysis by SPSS in order to inspect and analyze the derived variables of the measuring points of men's upper body and the decisive factors of human's upper body shape, including height, bust and waist. The value of F of the one-way analysis of variance (ANOVA) and significance levels are shown in Table 4. The results showed that the significant effect of bust-waist ratio is more obvious than the other three indexes. The standard value of the significance probability given in statistical software SPSS is 0.05. So the only variable is used as the indicator and the role of cluster analysis. With K-MEANS cluster analysis, indexes of the samples divided into class 3,4,5,6 terminate the cluster center and sample ratio. Both are shown in table 5. After dividing the objects into different classes, with comparison, we find that dividing them into four types of clustering results is the best choice for in this way the difference of two neighboring classes is the closest, and also the result is clear and uniform. Therefore, this paper divides the young men's upper body shape into four types, which are respectively represented by letter A, B, C, D, E, F. The classification results are shown in table 6.

Table 4. One-way analysis of variance (ANOVA) of derived variables from measurement parts and keys parts of upper body

Object	Body part	Bust-waist difference	Bust-waist ratio	2B*/h	2W*/h
Value of F	Height	0.138	0.008	1.323	1.238
	Bust	0.784	0.824	1.622	1.336
	Waist	1.233	1.504	0.984	0.893
Significance levels	Height	0.043	0.004	0.123	0.016
	Bust	0.005	0.000	0.066	0.003
	Waist	0.154	0.034	0.185	0.171

Table 5. The proportion of data possessed by K-MEANS cluster analysis and human samples (upper body)

Category	Bust -waist ratio	Proportion /%	Bust -waist ratio	Proportion /%	Bust -waist ratio	Proportion /%	Bust -waist ratio	Proportion /%
1	1.23	25	1.19	41	1.04	9	1.07	14
2	1.15	53	1.11	36	0.10	22	0.12	30
3	1.07	22	1.05	12	1.22	20	1.03	4
4			1.26	11	1.16	44	1.23	12
5					1.29	5	1.18	35
6							1.29	5

Table 6. Clustering results of men's upper body shape

Code of body shape classification	Bust-waist ratio	Number of samples
A	1.19	117
B	1.11	103
C	1.05	34
D	1.26	31

5.1.2 Cluster Analysis of Men's Lower Body Shape

By using the same research methods of upper body, data is possessed with one-way analysis by SPSS in order to inspect and analyze the derived variables of the measuring points of lower body and the decisive factors of human's lower body shape, including height, waist and hip. The value of F of the one-way analysis of variance (ANOVA) and significance levels are shown in table 7. The results indicate that the significant effect of $2W^*/h$ and hip-waist ratio are more obvious than the other two indexes, so the two variables are used as indicators and the roles of cluster analysis. With K-MEANS cluster analysis, indexes of the samples divided into class 3,4,5,6 terminate the cluster center and sample ratio. Both of them are shown in table 8. After dividing the objects into different classes, with comparison, we find that dividing them into four types of clustering results is the best choice, for in this way the difference of two neighboring classes is the closest, and also the result is clear and uniform. Therefore, this paper divides the young men's lower body shape into four types, which are respectively represented by letter A, B, C, D, E, F. The classification results are shown in table 9.

Table 7. One-way analysis of variance (ANOVA) of derived variables from measurement parts and keys parts of lower body

Object	Body part	Hip-waist difference	Hip-waist ratio	$2H^*/h$	$2W^*/h$
Value of F	Height	1.353	1.418	1.23	1.238
	Bust	1.488	1.619	1.124	1.336
	Waist	1.06	1.527	1.026	0.893
Significance levels	Height	0.002	0.009	0.014	0.002
	Bust	0.003	0.006	0.289	0.003
	Waist	0.321	0.029	0.434	0.073

Table 8. The proportion of data possessed by K-MEANS cluster analysis and human samples (lower body)

Class	$2W^*/h$ / hip-waist ratio	Proportion/%	$2W^*/h$ / hip-waist ratio	Proportion /%	$2W^*/h$ / hip-waist ratio	Proportion /%	$2W^*/h$ / hip-waist ratio	Proportion /%
1	0.85/1.26	35	0.83/1.27	23	1.00/1.13	23	1.23/1.00	5
2	0.98/1.15	36	1.18/1.03	13	0.90/1.21	30	0.92/1.2	25
3	1.12/1.06	29	1.05/1.1	32	1.09/1.08	24	1.1/1.07	22
4			0.93/1.19	32	0.81/1.29	16	0.78/1.33	7
5					1.22/1.01	7	0.85/1.25	17
6							1.01/1.13	24

Table 9. Clustering results of men's lower body shape

Code of body shape classification	Hip-waist ratio	2W*/h	Number of samples
A	1.27	0.83	66
B	1.03	1.18	37
C	1.1	1.05	91
D	1.19	0.93	91

5.2 Cluster Analysis of Women's Body Shape

5.2.1 Cluster Analysis of Women's upper Body Shape

Data is possessed with one-way analysis by SPSS in order to inspect and analyze the derived variables of the measuring points of women's upper body and the decisive factors of human's upper body shape, including height, bust and waist. The value of F of the one-way analysis of variance (ANOVA) and significance levels are shown in Table 10. The results showed that the significant effect of bust-waist ratio is more obvious than the other three indexes. The standard value of the significance probability given in statistical software SPSS is 0.05. So the only variable is used as the indicator and the role of cluster analysis. With K-MEANS cluster analysis, indexes of the samples divided into class 3,4,5,6 terminate the cluster center and sample ratio. Both of them are shown in table 11. After dividing the objects into different classes, with comparison, we find that dividing them into six types of clustering results is the best choice for in this way the difference of two neighboring classes is the closest, and also the result is clear and uniform. Therefore, this paper divides the young women's upper body shape into six types, which are respectively represented by letter A, B, C, D, E, F. The classification results are shown in table 12.

Table 10. One-way analysis of variance (ANOVA) of derived variables from measurement parts and keys parts of upper body

Object	Body part	Bust-waist difference	Bust-waist ratio	2B*/h	2W*/h
Value of F	Height	1.016	0.894	0.96	0.826
	Bust	2.034	1.76	0.985	1.284
	Waist	0.691	0.927	1.227	1.227
Significance levels	Height	0.026	0.046	0.37	0.113
	Bust	0.002	0.012	0.494	0.158
	Waist	0.104	0.037	0.065	0.311

Table 11. The proportion of data possessed by K-MEANS cluster analysis and human samples (upper body)

Category	Bust-waist ratio	Proportion/%	Bust-waist ratio	Proportion/%	Bust-waist ratio	Proportion /%	Bust-waist ratio	Proportion /%
1	1.3	19	1.2	45	1.38	1	1.38	9
2	1.23	48	1.34	7	1.17	31	1.26	27
3	1.15	33	1.13	16	1.11	10	1.1	13
4			1.27	32	1.3	18	1.32	11
5					1.24	40	1.19	24
6							1.15	16

Table 12. Clustering results of women's upper body shape

Code of body shape classification	Bust-waist ratio	Number of samples
A	1.38	22
B	1.26	67
C	1.1	32
D	1.32	27
E	1.19	59
F	1.15	40

5.2.2 Cluster Analysis of Women's Lower Body Shape

By using the same research methods of upper body, data is possessed with one-way analysis by SPSS in order to inspect and analyze the derived variables of the measuring points of lower body and the decisive factors of human's lower body shape, including height, waist and hip. The value of F of the one-way analysis of variance (ANOVA) and significance levels are shown in Table 13. The results show that the significant effect of $2W^*/h$ and hip-waist ratio are more obvious than the other two indexes, so the two variables are used as indicators and the roles of cluster analysis. With K-MEANS cluster analysis, indexes of the samples divided into class 3,4,5,6 terminate the cluster center and sample ratio. Both are shown in table 14. After dividing the objects into different classes, with comparison, we find that dividing them into six types of clustering results is the best choice for in this way the difference of two neighboring classes is the closest, and also the result is clear and uniform. Therefore, this paper divides the young women's lower body shape into 6 types, which are respectively represented by letter A, B, C, D, E, F. The classification results are shown in table 15.

Table 13. One-way analysis of variance (ANOVA) of derived variables from measurement parts and keys parts of lower body

Object	Body part	Hip-waist difference	Hip-waist ratio	$2H^*/h$	$2W^*/h$
Value of F	Height	0.819	0.736	0.912	0.826
	Bust	1.156	1.164	1.212	1.284
	Waist	1.849	2.091	1.076	1.227
Significance levels	Height	0.179	0.032	0.285	0.113
	Bust	0.044	0.065	0.218	0.158
	Waist	0.005	0.001	0.364	0.192

Table 14. The proportion of data possessed by K-MEANS cluster analysis and human samples (lower body)

Category	Hip-waist ratio / $2W^*/h$	Proportion /%	Hip-waist ratio / $2W^*/h$	Proportion /%	Hip-waist ratio / $2W^*/h$	Proportion /%	Hip-waist ratio / $2W^*/h$	Proportion /%
1	1.35/0.84	39	1.36/0.84	38	1.37/0.82	29	1.39/0.81	19
2	1.15/1.11	17	1.25/0.95	44	1.29/0.9	28	1.25/0.94	24
3	1.25/0.95	44	1.11/1.37	1	1.15/1.11	14	1.11/1.37	5
4			1.16/1.1	17	1.23/0.98	28	1.23/1.03	16
5					1.11/1.37	1	1.13/1.12	10
6							1.32/0.87	26

Table 15. Clustering results of women's lower body shape

Code of body shape classification	Hip-waist ratio	2W*/h	Number of samples
A	1.39	0.81	47
B	1.25	1.94	59
C	1.11	1.37	12
D	1.23	1.03	40
E	1.13	1.12	25
F	1.32	0.87	64

6. Conclusion

On the basis of human body measurement, all the data is processed by SPSS, and one-way analysis of variance (ANOVA) and cluster analysis are used. Respectively, we have the index of upper and lower body-type classification of male and female is obtained. What's more, by using fast sample clustering, both of women's upper and lower body shapes are classified into 6 categories, and the similar segregation is carried on men with 4 categories, which is an ideal classification. In all, 36 categories of young women's body shape, and 16 categories of young men are obtained. The classification method is not only conducive to the independent design of the upper and lower, but also to avoid the classification of rough body defects. The research results can provide strong data support for those clothing manufacturers whose target customers are young women and men in Shanghai.

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