Classification of male lower torso for underwear design

Z Cheng¹,² and V E Kuzmichev¹,²
¹ Ivanovo State Polytechnic University, Textile Institute, Ivanovo, Russia
² Wuhan Textile University, Clothing Institute, 1000 talent plan Laboratory, Wuhan, China

Email: zcheng@wtu.edu.cn, wkd37@list.ru

Abstract. By means of scanning technology we have got new information about the morphology of male bodies and have redistricted the classification of men’s underwear by adopting one to consumer demands. To build the new classification in accordance with male body characteristic factors of lower torso, we make the method of underwear designing which allow to get the accurate and convenience for consumers products.

1. Introduction
Contemporary design and labeling of men’s underwear based only on the main body sizes (such as waist and hip girth, height) and age (for children, adults, elderly). Consumer demands need more information about specific features and construction of underwear to be sure about wearing comfort and suit especially in waist and crotch areas [1]. On the other side, the contemporary fashion is considering and combining two styles of trousers and underwear to get fashionable and good-looking image of men [2]. Closely fitting trousers, especially skinny, should be equipped by underwear with shaping or compressive functions [3-5]. So, the anthropometric and methodological data bases should be renewed to design more comfortable and with many functions contemporary underwear.

2. Experiment steps

2.1. Schedule of body dimensions for classification
We have measured 60 Chinese males (19...25 year old) by Vitus Smart XXL 3D body scanner.

Table 1. Male body sizes, cm

| Parameter            | Height       | Waist girth | Hip girth | Body rise (waist to crotch level) | Navel to crotch level | Hip girth - waist girth |
|----------------------|--------------|-------------|-----------|-----------------------------------|-----------------------|-------------------------|
| Average              | 177.2 ± 10.0 | 75.2 ± 5.7  | 94.1 ± 4.8| 32.2 ± 2.0                        | 26.1 ± 0.9            | 18.9 ± 4.0              |
| Range                | 161.2...206.7| 64.2...92.5 | 93.6...114.1| 28.3...36.0                       | 20...31.7             | 8.4...29.4              |

Figure 1a shows the differences existing between 13 joining cross-sections taken from scanned bodies with the same waist and hip girth. So, to present the morphological features of real bodies’ new combination of body dimensions should be established.
To decrease the number of indexes, we developed new approach of lower torso classification for underwear design. Firstly, based on the method of body type classification by the difference between bust and waist girth according with the Chinese GB/T 1335.1-2008 Standard sizing systems for men garments [6-8], we used the same principle to classify. We calculated the difference between hip girth (HG 7520) and waist girth (WG 6510) and then divided all male lower torsos into 3 types — A, B, C. The average value of HG - WG is 18.9 cm, standard deviation is 4 cm. So, we established 3 intervals that based on types A, B, C as now, but we added the sub-types such as I, II, III, IV, V, VI.

Secondly, we proposed some new dimensions (figure 1b) to express the morphology of front (0620 is distance between more prominent point of belly and vertical, 0670 is distance between more prominent point of genitals and vertical) and buttock (0530 is distance between waist back point and vertical, 0540 is distance between buttock points and vertical).

2.2. Way of new classification
We used the next body dimensions as the base of new classification: For the volume of front and back, we selected the horizontal distance in figure 1b to calculate. DGR can describe the position between genitals and belly bulge. By this way we can determine the value of genitals bulge, adjust the waistband and bulge value into construction of front insert in pattern block. VF can describe the volume of genitals (length of front insert), we take the straight-line distance of body rise as reference to calculate index VF. DBGH can describe the position between the waist concave and the hip bulge, we can determine the value of hip. VB can describe the volume of hip (length of back).

Table 2. Explanations of new classification index

| Male lower torso profile | Index                                                                 |
|-------------------------|-----------------------------------------------------------------------|
|                         | DGR is difference 0670 - 0620 as the value of waist front to the peak point of genitals bulge. During -0.9 ... 2.4 cm, the average value is 0.58 cm, standard deviation is 0.67 cm. We divided the range of DGR into 3 intervals: (1) < -0.1 cm, (2) - 0.1 ... 1.3 cm, (3) > 1.3 cm. In investigated group 10 males have had negative values, 50 males have positive values. |
|                         | VF is difference CLF - BR, during 6.5 ... 12.4 cm, average is 9.4 cm, standard deviation is 1.1 cm, so we divided into 3 intervals, there are (1) < 8.3 cm, (2) 8.3 ... 10.5 cm, (3) > 10.5 cm. |
D_{BH} is difference 0530 - 0540 as the value of waist back arc to the peak point of hip back. During 1.1 ... 8.8 cm, the average value is 3.83 cm, standard deviation is 1.55 cm. We divided the value into 3 intervals based on the range, there are (1) < 2.1 cm, (2) 2.1 ... 5.5 cm, (3) > 5.5 cm.

V_{B} is difference CL\_B– BR, during 3.6 ... 11.3 cm, average is 7.1 cm, standard deviation is 1.5 cm. We divided the range into 3 intervals, there are (1) < 6.2 cm, (2) 6.2 ... 8.8 cm, (3) > 8.8 cm.

We divided all bodies into 3 levels (table 3). The range of CL\_F is 35.8 ... 46.9 cm, the average value is 41.6 cm, and the standard deviation is 2.5 cm. The range of CL\_B is 34.1 ... 44.2 cm, the average value is 39.3 cm, and the standard deviation is 2.2 cm.

**Table 3. New classification based on the new body sizes**

| Levels of classification | Torso features | Dimensions | Calculations | Index |
|--------------------------|----------------|------------|--------------|-------|
| 1st                      | Total sizes   | HG, WG     | = HG - WG    | Type A, B, C |
| 2nd                      | Genitals bulge| D_{GR}, CL\_F, BR | D_{GR} = 0670 - 0620; V_{F} = CL\_F - BR | Group I,II, III |
| 3rd                      | Buttock bulge | D_{BH}, CL\_B, BR | D_{BH} = 0530 - 0540; V_{B} = CL\_B - BR | Group IV,V,VI |

Using the dimensions from Tables 1-3, we divided all 60 bodies in accordance with new approach. Table 5 shows the examples of body’s identification by means of new classification.

**Table 4. Range of new classification of male torsos, cm**

| First level | Types and ranges | Std. Dev. |
|-------------|------------------|-----------|
| HG, cm      | A (Small) HG < 89 |           |
|             | B (Medium) 89 ≤ HG ≤ 97 |           |
|             | C (Large) HG > 97 | ± 4       |
| D_{GR}, cm  | I 0 ≤ D_{GR} ≤ 1.3 | > 1.3     |
| V_{F}, cm   | II 8.3 ≤ V_{F} ≤ 10.5 | > 10.5    |
| D_{BH}, cm  | III < 2.1 | ± 1.5     |
| V_{B}, cm   | IV 2.1 ≤ D_{BH} ≤ 5.5 | > 5.5     |
| Total Proportions | V 69 ... 77 | 10 ... 15 |
Table 5. Examples of male torso identification

| Type | A-I-IV | B-II-V | B-III-V |
|------|--------|--------|---------|
| HG   | 88.7   | 92.1   | 95.1    |
| Δ    | 10.7   | 19.4   | 22.2    |
| DGR  | -0.1   | 1.1    | 1.7     |
| V_F  | 6.5    | 10.0   | 10.6    |
| V_B  | 2.0    | 2.3    | 5.6     |
| V_B  | 5.9    | 7.4    | 6.4     |

2.3. Pattern block designing
We have developed the new method of the pattern block designing of underwear and have selected the reasonable ease allowance of knitted materials according to the new classification [9]. Figure 2 shows the example of underwear pattern block that was build by the dimensions /4-6/, /6'-15/ (according with First level from Table 4), length /24-25/ (genitals bulge), /17-15/ and curve /15-23/ (according with Second level) and the length (back crotch width) /10-1/, curve /4-10/ (according with Third level).

![Figure 2](image)

Figure 2 Basic pattern block of underwear: a - back, b - front [9]

3. Conclusion
Based on these main indexes, we have classified the male lower torsos into special groups with its morphology characteristics. Also we have prepared the recommendations how to design the underwear pattern block for different types of bodies, to choose the structure of underwear with more reasonable and satisfy characteristics in accordance with the male body morphology. Furthermore, the new classification could help consumer to choose the underwear that can be labeled by new way. Next step we will include 3D simulation try-on.
This work is supported by I’d company (Wuhan Lovegod High-level Dress & Adornments Co., Ltd. Wuhan, Hubei, China).

References
[1] Cheng Zhe and Kuzmichev V. 2016 Consumer Preferences About Men's Underwear 23th Int. Conf. on scientific-technical (Ivanovo), vol 1, p. 192–195.
[2] Li Feng 2014 A Brief Analysis of the Development Trend of Chinese Men's Underwear (Value Engineering vol 22), p. 322-323.
[3] Chen Peng-peng and Chen Dao-ling 2014 Analysis of men's underwear (Progress in Textile Science & Technology), vol 1, p. 58–61.
[4] Kuzmichev V and Cheng Zhe 2014 Analysis of pressure distribution in system body-men’s underwear Conf. of AUTEX 2014 World Textile (Bursa, Turkey) (Recep EREN), p. 45.
[5] Kuzmichev V, Cheng Zhe and Adolph. D 2015 Development of male underwear compression designing Conf. of AUTEX 2015 World Textile (Bucharest, Romania) (Gheorghe Asachi Technical University of Iasi), p. 100.
[6] [GB/T 1335.1 - 2008 Standard sizing systems for men garments (Beijing: Standardization Administration of China), p. 1.
[7] Wang Qi-ming 2016 Female body classification in Jiangsu and Zhejiang based on cross-sectional area of body (Journal of Textile Research ), vol 5, p. 131-136.
[8] LIANG Suzhen 2016 Research on Body Type's Characteristics of Male College Students in Fujian Area Based on 3D Body Scanning (Journal of Clothing Research) , vol 1, p. 152-156
[9] Cheng Zhe and Kuzmichev V. 2013. Methods of designing men's compression underwear (Sewing Industry ) , vol 2, p. 45–49.