Classification of Body Types of Vietnamese Middle-Aged Men in Ho Chi Minh City

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Abstract

The study aims to classify somatotype of Vietnamese middle-aged male living in Ho Chi Minh City. Thirty-two 3D anthropometric body measurements from 378 men aged from 30 to 60 are comprehensively studied. The results of the study are as follows: Three independent factors were extracted using factor analysis for cluster analysis, then classified into five body types. Group 1, accounting for 16.4%, is "short and proportional" body type with short height stature and normal body proportions but high waist, small thighs and chest, small neck and narrow shoulder. Group 2 can be called "short and fat" body type, accounting for 35.19%, is a low height stature and obesity level I with small thighs and knees, developed neck and shoulder. Group 3, accounting for 25.13%, is "medium height and fat" body type with average height stature and obesity level I, large girths and broad breadths, large neck and square shoulder. Group 4, accounting for 12.96%, is an overweight body group with tall height stature, long leg, narrow back and square shoulder, and it can be called "tall and proportional" body type. Finally, group 5 which accounting for 10.32%, is "tall and proportional" body type which characterized as obesity level I, tall stature, long leg, broad back and slope shoulder. This study contributes to the study of body type and anthropometric data in building avatar for digital fashion design software, at the same time contributing to the research and development of the size system for Vietnamese middle-aged male.

Keywords: body proportion, body shape characteristics, middle-aged, somatotype, Ho Chi Minh City, Vietnamese male.

1. Introduction

Along with the industrial revolution 4.0 during the heavy effects of the Covid pandemic on the fashion industry, people are familiar with shopping online with the support of 3D design, virtual try-on, etc. [1]. One of the important keys is the classification and identity of customer body shape for better fitting garments. To optimize the application of 3D design software to the design of garments for Vietnamese people, it is first necessary to build a library of virtual avatar models with anthropometric characteristics of each group subject.

Currently, Vietnamese fashion products are often designed according to a certain size system of each brand or company without paying attention to the classification of somatotype and body proportions. Previous research showed that anthropometric research is an important basis in determining the size of a garment, at the same time, body type characteristics affect the design for pattern blocks [2, 3]. However, the growth is not completely regular in body proportions over time. Even of the same race, of the same family line, even among individuals, differences in these characteristics and proportions of body parts are noticed [4].

In Vietnam, there are research studies about male and female anthropometric data of all ages [5], but research relates to male body type is mostly studying in the age range in their 20s. In 2019, there was the research with a huge participant of 5148 adult Vietnamese male [5]. This research was aiming for statistic analysing the anthropometric data for industrial design but not classifying body types. One representative official paper is Vietnamese garment size system TCVN 2009 established a system with 3 body type and 13 sizes for adult male from 18 to 65 [6]. In 2018, research about body size of southern Vietnamese men from 18 to 25 years, analyzed 4 groups simulated through the 3D V-Stitcher software. It can be seen that studies on male subjects are still limited in the wide range of age, especially lacking in middle-aged. The most currently research in 2022 about somatotype of 1106 Vietnamese male from 18 to 60 year-old who live in Ho Chi Minh City. These authors have classified objectives into 2 groups that showed clearly the difference, they are thin people and fat people. The results also indicate that the thin body type is mainly concentrated in the young age group from 18 to 30, while the fat body type is concentrated in the 30 to 60 age group. The paper demonstrates that more specific body shape classification is needed for

middle-age men, which provides data for 3D virtual avatar simulation, also diverse body shapes would support the better garment fit.

There are many research papers classifying the male body shape all over the world and countless in Asia. Recently, in 2020, the study of classifying the shape of Korean adult males with a height of less than 170 cm between the ages of 20 and 60, showed results with 4 body types [7]. In 2017, Japanese researchers classified three-dimensional data of 429 Japanese men aged 20 to 79 into 7 groups. The purpose of this research aimed to improve the made-to-measure garment fit through 3D design system [8]. In 2002, Chinese researcher studied the classification of body types of Chinese men in Beijing and Shanghai [9], giving results of 4 different male body types. Another paper in 2006 researched body shape analysis of 400 adult men in East China in the age 18 to 65 [10]. Results achieved 5 body types including 4 main body types and a minor group accounted for 1%. In 2020, there was a study about the shape and body type characteristics of oversized men in their 30s and 40s based on Korea's anthropometric data, resulting with 5 body types [11].

In the above overview about research papers in males' body types aged from 20 to 60 among Asian countries such as Japanese, Korean, Chinese, results showed that the number of male body types of each research varied from 5 to 7. In Vietnamese there are not a research focusing on the variation of body type for middle-aged male. Therefore, the research in this article focuses on classifying the body shape of middle-aged Vietnamese men between the ages of 30 and 60 who live in Ho Chi Minh City, thereby also an analyzing the shape and proportions of the body. The study of body shape classification which supply basis data for setting avatar of 3D design software is extremely necessary, contributing to the simulation and visualization of the specific characteristics of each people group with different characteristics of age group, gender, region. This research contributes to the Vietnamese virtual model library in 3D design software, it is also aiming to improve the made-to-measure garment fit through 3D design system.

2. Research Content and Methodology

2.1. Research Contents

- Research on body classification, body proportions of Vietnamese men between the ages of 30 and 60 living Ho Chi Minh City.

- Compare body proportions and distributions of each body type in each age group.

2.2. Research Subjects

The sample size *(n)* in this paper was determined according to the formula $n = (t * SD)^2 / m^2$. Therein, the standard deviation of 5.0 was determined by experimentally measuring the shoulder height of 30 random samples, features of the probability of 1.96 determined by probability $P = 0.95$, with a standard error of 0.5, scanning studied of 384. Data were taken directly from the Size Stream 3D body scanner system in 2020. During the scan of body surface data, the models wore briefs to minimize measurement errors when measuring. However, there are still 6 faulty measurements. Therefore, the data processed in this paper is 378.

The subjects of this study were 378 middle-aged men between the ages of 30 and 60 with the data taken directly from the Size Stream 3D body scanner system. Among them, there are 96 men in their 30s (from 30 to 39 years old) accounting for 25.40%, 150 men in their 40s (from 40 to 49 years old) accounting for 39.68%, 132 men from 50 to 60 years old, accounting for 34.92%. In this study, anthropometric data of 38 body measurements were used to determine the characteristics related to body shape of adult Vietnamese men. The 38 measurements used are important in simulation the avatar in the CLO3D software, and typical body measurements including: 14 heights, 14 girths, 7 lengths, 2 widths and weight are shown in Table 1.

Table 1: Body measurements used in the study

Category	Measurement items		Number
Height	Body height Head height Shoulder slope Chin 8-height Collar front height Neck front height Shoulder height Chest height	Abdomen height Waist height eat fold height Crotch height Thigh height Knee height	14
Girth	Neck girth Chest girth Bust girth with drop Axilla chest girth Waist girth Abdomen girth Hip girth	Thigh girth Knee girth Calf girth Bicep girth Wrist girth Elbow girth Ankle girth	14
Length	Arm length Back neck to wrist Half back center to waist Foot length	Total rise Center front neck to waist Inseam	7
Width	Back shoulder width Across back		2
Other	Weight		1
Total			**38**

2.3. Research Methodology

Data collection method is using Size Stream full body 3D scanner.

SPSS 26.0 for Windows was used for analysis body classification, using direct measurement data of Vietnamese men aged 30 to 60 living in Ho Chi Minh City. The process is following:

- First, determined the statistical characteristics of the dimensions through mean, median, mode, standard deviation, maximum value, minimum value, kurtosis, percentile. At the same time, determined the normal distribution of measurements through histograms with normal curve and standard probability histograms (Normal QQ Plots), and determinede the reliability of the scale. Considered eliminating variables with asymmetric bell-shaped distributions with large differences in median and median values.

- Next, the factors in a total of 38 measurements were determined through factor analysis with rotation method - Varimax applied to rotate the components. KMO and Bartlett's test to see the fit of variables in principal component analysis. To determine the reliability of the scale, we determine the Cronbach's Alpha coefficient in the range from 0 to 1. As the Cronbach's Alpha coefficient gets closer to 1, the higher the confidence level is; the more Cronbach's Alpha coefficient gets closer and closer to 0, the lower the reliability is [12]. At the same time, factors with eigenvalues greater than or equal to 1 are selected for factor extraction [12].

- Subgroups were analysized by K-means cluster analysis and discriminant analysis. The number of clusters is tested through the number of clusters by K-means cluster analysis from 2 to 5 cluster [2, 12]. Discriminant analysis is shown through a scatter plot. The scatter plot shows the degree of overlap between the discriminant score distributions. The fewer elements that overlap, the better the distinction [12].

- In case the final number of clusters is determined from 3 or more clusters, one-way analysis of variance (ANOVA) will be performed, if the final number of clusters is 2 clusters, the independent-samples t-test will be performed to observe the difference in human body size for each body type after the results of the cluster analysis [12].

- Display classification of body shape of objectives through CLO3D software.

3. Results and Discussion

3.1. Statistical Analysis Results of Dimensions

The results of the analysis of statistical features, histograms with normal curve and the standard probability histogram (Normal Q - Q Plots) show that 36 anthropometric measurements used are all average values $(\bar{X})$ located in close to the median (Me) and mode values *(Mo)*. Moreover, these measurements have their reliability within the allowable limits. However, the remaining 2 dimensions are 'total rise' and 'half back center to waist' have the difference between the mean values and the median values was greater than 1 cm. The mean value of total rise is 83.02 cm and the median value is 85.09 cm, the difference is 2.07 cm. Half back center to waist's mean is 48.01 cm and the median value is 49.09 cm, the difference is 1.08 cm. At the same time, these two dimensions have a Skewness close to -1. Thus, from the above data, it is possible to exclude 2 measurements of total rise and half back center to waist, which do not have the shape of the normal distribution curve for future analysis to be accurate. In addition, the two excluding measurements may contribute insignificantly to the body type classification.

To determine the reliability of the scale, we determine the Cronbach's Alpha coefficient in the range from 0 to 1. As the Cronbach's Alpha coefficient gets closer to 1, the higher the confidence level is, and the more Cronbach's Alpha coefficient gets closer and closer to 0, the lower the reliability. With 36 measurements defined above, Cronbach's Alpha coefficient of 0.947 shows a very good scale.

3.2. Results of the Factor Analysis to Classify the Body Type

To identify the factor groups affecting the physique of Vietnamese men between the ages of 30 and 60, 36 anthropometric data were used to analyze the main component by factor. The number of factors is determined before reviewing the results of the screening test and interpreting the factors. In particular, to clarify the characteristics of the elements, the Varimax rotation method was applied.

In this method, the variables or anthropometric data used are 36 body measurements of 378 middle-aged men between the ages of 30 and 60 which were determined by the standard 3D scanning method, these measurements all follow a highly reliable normal distribution. To check whether the selected variables are suitable for factor analysis, KMO and Bartlett's tests were performed through 4 analysis turns to remove bad variables. Excluded variables are variables with low factor loading or high factor loading of 0.5 or more for two or more factors and high load for factors with different concepts [9]. In addition, important variables are needed in setting up virtual avatars in CLO3D software, several unimportant variables were removed. After removing 4 unimportant variables, the results of KMO and Bartlett's test are determined in Table 2 with a KMO value of 0.890 and a confidence

value of significant is of 0.000, indicating statistically consistent values. Therefore, factor analysis was performed with 32 anthropometric measurements.

Table 2: Results of KMO and Bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.890
Bartlett's Test of Sphericity	Approx. Chi-Square	23557,982
	DF	496
	Sig.	0.000

Finally, 3 factors determining the body shape of middle-aged Ho Chi Minh City -Vietnamese men were extracted in Table 3 with 32 measurements, cumulative variance is 73.313%. At the same time, the Cronbach' alpha coefficient of each factor is greater than 0.6, showing that the analysis results can be used.

The characteristics of each element can be described as follows. Factor 1: Factor 1 consists of 15 measurements that can be called "body length and height dimension factors". The highest value is shown shoulder height at 0.939, followed by chin height at 0.930, body height at 0.928, thigh height and crotch height at 0.909, collar front height at 0.886, neck front height at 0.885, seat fold height at 0.872, bust height at 0.853, knee height at 0.808, waist height at 0.783, abdomen height at 0.756 and arm length, back neck to wrist, and foot length at 0.729, 0.724 and 0.566 respectively. This coefficient shows an eigenvalue of 10,967, which explains 34.271% of the total variance and is the most explanatory of the three factors. This is a highly reliable size group with a defined Cronbach' alpha coefficient of 0.966. At the same time, this is a characteristic factor for the height of the body, the ratio between the dimensions of this factor allows determining the ratio of the upper and lower body parts of the body.

Table 3: Factor analysis results

Factor	Measuremennt item	Factor loading	Eigen values	Cumulative %	Cronbach' α
Height and length of the body	Shoulder circumference height	0.939	10.967	34.271	0.966
	Chin height	0.930			
	Body height	0.928			
	Thigh height	0.909			
	Crotch height	0.909			
	Collar front height	0.886			
	Neck front height	0.885			
	Seat fold height	0.872			
	Chest height	0.853			
	Knee height	0.808			
	Waist height	0.783			
	Abdomen height	0.756			
	Arm length	0.729			
	Back neck to wrist	0.724			
	Foot length	0.566			
Body circumference and weight of the body	Hip circumference	0.899	9.568	64.170	0.950
	Abdomen circumference	0.884			
	Weight	0.868			
	Waist circumference	0.853			
	Thigh circumference	0.828			
	Side neck trunk length	0.825			
	Bicep circumference	0.822			
	Elbow circumference	0.798			
	Axilla chest circumference	0.784			
	Calf circumference	0.784			
	Bust girth with drop	0.767			
	Chest circumference	0.764			
	Knee circumference	0.747			
Shoulder and neck area	Across back	0.735	2.926	73.313	0.606
	Back shoulder width	0.577			
	Shoulder drop	0.548			
	Neck circumference	0.427			
Note. Rotation method: Varimax, Extraction method: PCA (principal component analysis).					

Factor 2: Factor 2 can be called "the factor indicating body circumference and weight" is a group of circumference and weight values with 13 circumference and weight measurements. The highest value shown in the hip circumference is 0.899, followed by the abdomen circumference with 0.884, the weight body is 0.868, the waist circumference is 0.853, the thigh circumference is 0.828, side neck trunk length is 0.825, bicep circumference is 0.822, the remaining measurements are high results, all greater than 0.7. This factor can represent the degree of obesity of the body. This factor shows eigenvalue of 9.568, which explains 29.899% with high confidence with Cronbach's alpha coefficient of 0.950.

Factor 3: The factor includes 4 measurements: across back, back shoulder width, shoulder drop and neck circumference. This factor can be called "the size factor of the neck and shoulder area of the body". In this factor, the across back is 0.735, the back shoulder width is 0.577, the shoulder drop is 0.548 and the neck circumference is 0.427. The higher this factor, the more developed the shoulders, back, and neck. The eigenvalue of this factor is 2,926, which explains 9.143% of the total variance and the cumulative variance ratio is 73.313%.

3.3 Results of Body Type Analysis

To classify the body types, K-means cluster analysis and discriminant analysis were performed by using factor scores extracted through factor analysis as an independent variable [2,3,7,8,9,10,11]. To visually interpret the cluster analysis results, a scatter plot has been presented in Fig. 1.

The scatter plot shows the degree of overlap between the discriminant score distributions. The fewer factors that overlap, the better the discrimination [12]. The results of the discriminant analysis showed that 97.9% of the clustered cases were correctly classified in the five-cluster solution, while it was 97.7% in the 2-cluster solution, 95.5% in the 3-cluster solution, 97.6% in the 4-cluster solution, 96.8% in the 6-cluster solution, 96% in the 7-cluster solution, 96.6% in the 8-cluster solution, 96.3% in the 9-cluster solution, 95.2% in the 10-cluster solution. From those results, the five-cluster solution is the most appropriate to classify the body of Ho Chi Minh City -Vietnamese men aged 30 to 60.

3.4. Results of Body Type Characteristics

In case the final number of clusters is determined from 3 or more clusters, one-way analysis of variance (ANOVA) will be performed, if the final number of clusters is 2 clusters, the independent-samples t-test will be performed to observe the difference in human body size for each body type after the results of the cluster analysis [12].
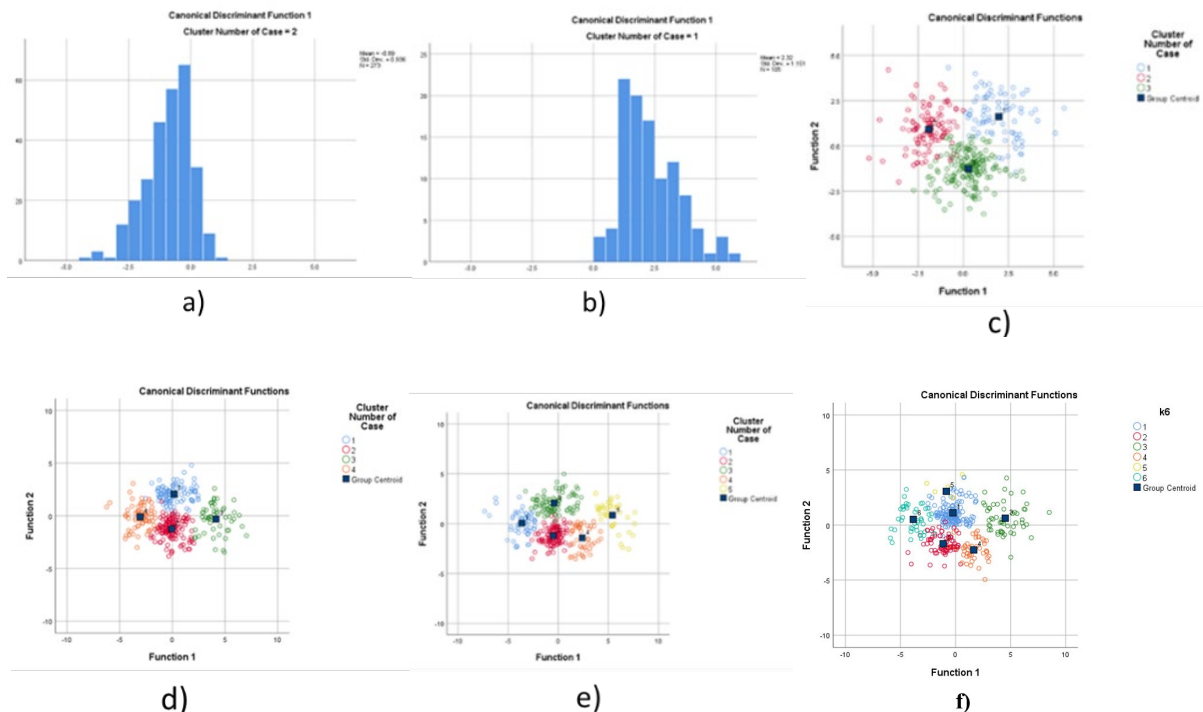

Fig. 1. Scatter plot in case of 2, 3, 4, 5 and 6 groups

a) and   b) Case 2 groups   c) Case 3 groups   d) Case 4 groups   e) Case 5 groups   f) Case 6 group

.

Table 4. The results of ANOVA of factor scores   *Unit: cm, kg.*

Factor	Measurement item	Mean <SD>						F
		Group 1 (n = 62)	Group 2 (n = 133)	Group 3 (n = 49)	Group 4 (n = 95)	Group 5 (n = 39)	Total (n = 378)	
Height and length of the body	Shoulder height	126.62 D <2.84>	127.78 D <2.57>	130.33 C <3.04>	133.92 B <2.58>	137.86 A <2.90>	130.50 <4.58>	174.122***
	Chin height	140.32 D <3.13>	140.95 D <2.68>	143.54 C <3.52>	147.97 B <3.11>	152.21 A <3.48>	144.11 <5.07>	164.920***
	Body height	163.09 D <3.57>	164.75 D <2.74>	168.05 C <3.31>	172.08 B <3.37>	176.43 A <3.00>	167.95 <5.39>	182.692***
	Thigh height	65.56 B <2.75>	65.42 B <2.22>	66.39 B <3.21>	70.38 A <2.37>	71.20 A <2.09>	67.41 <3.45>	88.377***
	Crotch height	70.64 B <2.75>	70.50 B <2.22>	71.48 B <3.21>	75.46 A <2.37>	76.28 A <2.09>	72.49 <3.45>	88.360***
	Collar front height	135.37 D <2.90>	136.82 D <2.61>	138.98 C <3.41>	142.94 B <2.89>	146.71 A <4.25>	139.42 <4.78>	140.289***
	Neck front height	132.13 D <2.89>	133.54 D <2.66>	135.80 C <3.37>	139.67 B <2.90>	143.56 A <4.19>	136.18 <4.80>	141.555***
	Seat fold height	72.34 D <2.80>	72.75 CD <2.34>	74.12 C <3.38>	77.28 B <2.42>	78.93 A <2.36>	74.64 <3.53>	81.595***
	Chest height	115.31 D <2.91>	116.28 CD <2.63>	117.88 C <3.26>	122.33 B <3.24>	124.83 A <4.60>	118.73 <4.61>	104.922***
	Knee height	38.89 D <1.18>	39.62 C <1.20>	40.26 C <1.21>	41.34 B <1.39>	43.10 A <1.09>	40.37 <1.76>	68.540***
	Waist height	90.79 B <4.19>	90.52 B <2.90>	92.03 B <3.40>	96.60 A <3.86>	97.91 A <4.19>	93.05 <4.65>	64.842***
	Abdomen height	86.11 B <3.66>	85.53 B <3.25>	86.94 B <3.08>	91.38 A <3.53>	90.88 A <4.11>	87.83 <4.30>	51.734***
	Arm length	55.03 D <2.02>	55.34 D <1.74>	56.34 C <2.13>	58.34 B <1.64>	59.40 A <1.93>	56.61 <2.42>	70.791***
	Back neck to wrist	72.92 C <2.33>	73.98 C <1.86>	75.66 B <2.46>	76.79 B <2.04>	80.08 A <1.93>	75.36 <2.96>	98.098***
	Foot length	24.75 C <1.23>	24.67 C <1.09>	25.01 BC <0.89>	25.41 B <1.05>	26.55 A <1.02>	25.11 <1.24>	26.635***
Body circumference and weight of the body	Hip circumference	91.83 E <2.40>	97.54 C <2.78>	102.69 B <2.98>	95.30 D <2.94>	105.12 A <4.43>	97.49 <4.99>	167.836***
	Abdomen circumference	86.56 D <3.43>	93.67 B <2.29>	99.45 A <3.13>	89.43 C <3.23>	101.01 A <5.54>	92.94 <5.74>	194.175***
	Weight	59.10 E <3.66>	68.08 C <3.36>	76.47 B <3.66>	65.59 D <4.62>	84.45 A <5.74>	68.76 <8.23>	289.753***
	Waist circumference	82.92 D <3.11>	89.26 B <2.98>	95.53 A <3.50>	85.58 C <2.97>	95.40 A <4.72>	88.74 <5.43>	163.787***
	Thigh circumference	50.79 E <2.68>	54.74 C <2.85>	57.92 B <3.41>	52.95 D <2.84>	60.31 A <3.40>	54.63 <4.07>	84.883***
	Side neck trunk length	160.04 D <3.52>	166.28 C <3.76>	172.55 B <4.18>	165.85 C <4.53>	178.25 A <5.50>	167.20 <6.55>	137.438***
	Bicep circumference	27.82 D <1.68>	30.56 C <1.39>	31.69 B <1.39>	28.16 D <1.74>	32.69 A <1.65>	29.88 <2.29>	110.145***
	Elbow circumference	25.24 D <0.8>	26.89 C <1.04>	27.58 B <1.09>	25.79 D <1.06>	28.66 A <1.29>	26.61 <1.46>	92.093***
	Axilla chest circumference	93.66 E <3.61>	99.47 C <2.43>	104.22 B <2.89>	95.62 D <2.89>	105.93 A <3.52>	98.83 <4.97>	175.260***
	Calf circumference	34.91 E <1.96>	37.57 C <1.62>	39.02 B <2.08>	36.13 D <2.03>	40.51 A <2.01>	37.26 <2.51>	72.890***
	Bust girth with drop	89.23 D <3.50>	96.48 B <2.66>	101.47 A <3.16>	91.65 C <3.29>	102.70 A <4.78>	95.36 <5.59>	178.909***
	Chest circumference	91.19 D <3.65>	98.21 B <2.61>	103.28 A <3.42>	93.31 C <3.41>	104.18 A <4.65>	97.10 <5.57>	167.534***
	Knee circumference	34.88 D <1.80>	36.96 C <1.80>	38.50 B <2.25>	36.13 C <1.56>	40.61 A <2.39>	36.99 <2.46>	68.54***
Size of the shoulder and neck area of the body	Across back	35.38 B <2.89>	37.87 A <3.21>	38.75 A <2.72>	35.75 B <3.79>	39.08 A <3.71>	37.17 <3.58>	16.422***
	Back shoulder width	42.32 D <2.32>	44.89 BC <2.49>	45.90 B <2.76>	44.01 C <2.35>	48.80 A <2.32>	44.78 <2.98>	46.925***
	Shoulder drop	4.62 B <0.65>	4.75 AB <0.66>	4.63 B <0.53>	4.70 AB <0.66>	5.04 A <0.63>	4.73 <0.67>	3.077**
	Neck circumference	40.60 D <2.51>	42.09 BC <1.72>	43.18 AB <1.94>	41.34 CD <1.95>	43.48 A <1.96>	41.94 <2.71>	20.268***
BMI		22.23	25.08	27.08	23.23	28.52	24.38	

Note. *** p <.001; **<.02 The alphabet is the result of a Post-hoc test (Scheffe test) (A > B > C > D > E).

▮ : Size with the highest mean   ▯ : Size with the lowest mean

The group analysis results of this paper show that 5 types of people are the most optimal, so to determine the characteristics and differences of each body group, one-way analysis of variance ANOVA and Post-hoc test for each type was performed. The mean, standard deviation, F-test results for the 32 measurements and BMI values for each group are presented in Table 4. The evidence for reasonable grouping results is explained as follows.

The Sig reliability of the F-test value is less than 0.001, demonstrating a clear separation between the 5 groups. The standard deviation SD of each body measurement of a total of 378 study subjects is larger than the SD of each subgroup, which means that there is a concentration of subjects with the same body type in each subgroup. The men from group 1 has the smallest body measurements in the 5 groups, while the

men from group 5 has the largest body measurements. Group 3 focuses on the group of subjects whose length and height are approximately the average measurement of 378 studied subjects, but the circumference and shoulder sizes are smaller than the average size. Group 2 has length, height, and shoulder and neck dimensions that were smaller than the mean of the 5 groups, while girth measurements and weight were similar to the mean of 5 groups.

Besides the characteristics of body size statistics, the results of analysis of the ratio of height, length and width of each body type are of interest to further explain the body characteristics presented in Table 5. The meta-analysis of the analytical results in Tables 3,4,5 leads to the following conclusions about the physique characteristics of each body type of Vietnamese men live in Ho Chi Minh City.

Table 5: Ratio between height, length and width of each body group

Comparison rate	Human body proportions					
	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Medium**
Height: Chin Height	1:0.86	1:0.86	1:0.85	1:0.86	1:0.86	1:0.86
Height: Throat height	1:0.83	1:0.83	1:0.83	1:0.83	1:0.83	1:0.83
Height: Height of the neck	1:0.81	1:0.81	1:0.81	1:0.81	1:0.81	1:0.81
Height: Shoulder Height	1:0.78	1:0.78	1:0.78	1:0.78	1:0.78	1:0.78
Height: Chest height	1:0.71	1:0.71	1:0.70	1:0.71	1:0.71	1:0.71
Height: Waist height	1:0.56	1:0.55	1:0.55	1:0.56	1:0.56	1:0.55
Height: Belly height	1:0.53	1:0.52	1:0.52	1:0.53	1:0.52	1:0.52
Height: Butt Height	1:0.44	1:0.44	1:0.44	1:0.45	1:0.45	1:0.44
Height: Hip Height	1:0.43	1:0.43	1:0.43	1:0.44	1:0.43	1:0.43
Height: Thigh height	1:0.40	1:0.40	1:0.40	1:0.41	1:0.40	1:0.40
Height: Knee height	1:0.24	1:0.24	1:0.24	1:0.24	1:0.24	1:0.24
Height: Sleeve length	1:0.34	1:0.34	1:0.34	1:0.34	1:0.34	1:0.34
Height: Length from the 7th neck to the top of the shoulder to the wrist	1:0.45	1:0.45	1:0.45	1:0.45	1:0.45	1:0.45
Height: Feet Length	1:0.15	1:0.15	1:0.15	1:0.15	1:0.15	1:0.15
Height: Width at armpit	1:0.22	1:0.23	1:0.24	1:0.22	1:0.24	1:0.23
Height: Shoulder width	1:0.26	1:0.28	1:0.28	1:0.27	1:0.30	1:0.28
Height: Shoulder	1:0.03	1:0.03	1:0.03	1:0.03	1:0.03	1:0.03
Waist: Necklace	1:0.49	1:0.47	1:0.45	1:0.48	1:0.46	1:0.47
Waist: Bust over the top of the chest	1:1.10	1:1.10	1:1.08	1:1.09	1:1.09	1:1.09
Waist: bust measured 3 cm below the bust	1:1.08	1:1.08	1:1.06	1:1.07	1:1.08	1:1.08
Waist: Bust at armpit crease	1:1.13	1:1.11	1:1.09	1:1.12	1:1.11	1:1.11
Waist: Waist circumference	1:1.04	1:1.05	1:1.04	1:1.05	1:1.06	1:1.05
Waist: Buttocks	1:1.11	1:1.09	1:1.08	1:1.11	1:1.10	1:1.10
Waist: Thigh	1:0.61	1:0.61	1:0.61	1:0.62	1:0.63	1:0.62
Waist: Knee circumference	1:0.42	1:0.41	1:0.40	1:0.42	1:0.43	1:0.42

■ : The type with the highest density   □ : The type with the lowest density.

Group 1 is accounted for 16.4% of the total of 378 men in the survey, the short male group, with all sizes smaller than average. Through factor 1 indicating the length and height of the body and analyzing the body proportions, this is a group of people with high waist and average lower body length. The factor indicating body circumference and mass shows that this is the body group with the smallest circumference in the 5 groups, but the ratio of bust, buttock to waist circumference is larger than the average group, while waist circumference and thigh circumference compared to waist circumference were lower than the average group. Factor 3 shows that group 1 has the smallest neckline, small and horizontal shoulders. At the same time, this body group's BMI of 22.23 that determines as an average body type. Thus, group 1 is the body group with low height and high waist, normal body proportions and well balance, small thighs, chest, neck and shoulder area.

Group 2 is accounted for the highest percentage with 35.19%. Through the test on the difference of factor 1, it shows that this is the group of subjects whose length and height are smaller than the average group's size. At the same time, the ratio of length and height to body height dimensions, also all the circumference dimensions of this group are equivalent to average group. However, ratio thigh-to-waist of the group 2 slightly smaller than the average group. Factor 2 represents the circumference dimensions, together with body mass and BMI indicating that this group is a class I obese body type with a BMI of 25.08. Meanwhile, factor 3 for neck and shoulder size also showed sizes comparable to those of the average group. Thus, through the analysis, it is clear that group 2 is a class I obesity group with a short body group, a average proportioned body, small thighs and knees.

Group 3 is accounted for 12.96% of the total 378 men participating in the survey. Key factor analysis for body length and height revealed that this group was of average height, with body proportions comparable to that of the average group. Meanwhile, the main factor group 2 represents the circumference and weight sizes, showing that this is the group with dimensions larger than the average group. The BMI is 27.08 which is in class I obese body type. The other factor shows results on shoulder and neck dimensions indicating that this is a person with a developed shoulder, neck and back

area. Thus, group 3 is a group of people with grade I obesity who has a average height, a balanced body proportion, horizontal shoulders, and developed neck and back size.

Group 4 is accounted for 25.13%. Analysis of the difference of factor 1 shows that this is a group of tall people with a long lower body. In contrast to body group 3, group 4 was indicating that this group slightly overweight body group with BMI of 23.23. Bust to waist girth ratio showed that the waist was larger than the average group. Factor 3 for neck and shoulder size shows similar sizes to the average group but with a smaller back area. Thus, through the analysis, it can be seen that group 4 is the group of overweight and tall body, long lower body, small circumferences, horizontal shoulders and underdeveloped back area.

Finally, group 5 is accounted for at least 10.32% of the total 378 men who participated in the survey. The ANOVA results showed the differences of factor height and length dimensions which are the tallest and longest among the five groups. Factor 2 and BMI show that this is the 1st obese body group with a BMI of 28.52, and all circumference and weight sizes of this group are the largest and much larger than the average. Specifically, the bust size (104.18 cm) is 7.08 cm larger than the average size; waist (95.40 cm) larger than average size 6.66 cm; butt circumference (105.12 cm) is 7.63 cm larger than average size. Meanwhile, factor 3 for neck and shoulder size indicates a larger than average neck (43.48 cm) 1.52 cm larger than average; shoulders are steeper and wider; wide back. So, through analysis, it is clear that group 5 is a group of tall and obese people of grade I, high waist and buttocks, developed shoulders and back, sloping shoulders.

The characteristics of each body type is summarized and input anthropometric data to the 3D software. Fig. 2 displays the physique classification of 5 groups of middle-aged Ho Chi Minh City-Vietnamese men between the ages of 30 and 60 through CLO3D software. Comparison of avatar display results on CLO3D software between 5 body groups of 378 subjects in this study is shown in Fig. 3, showing the difference in body proportions according to height and circumference of 5 body groups.

Fig. 2. The results show the physique classification of 5 body groups of middle-aged Vietnamese men living in Ho Chi Minh City.
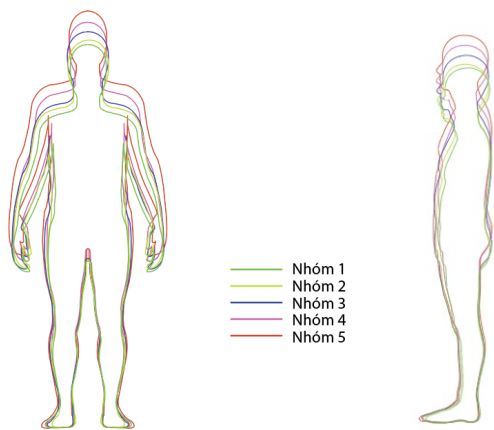
Fig. 3. Comparison of avatar body contours of 5 body types

4. Conclusion

This study conducted to obtain body anthropometric data through 3D scanners of 378 Vietnamese men between the ages of 30 and 60 who live in Ho Chi Minh City.

The results of the main component analysis show that there are 3 factors affecting the classification of male body shape in Vietnam: the factor indicating the body's height and length, the factor indicating the circumference of the body and weight, an indicator of the size of the shoulder and neck area of the body. The results of K-mean cluster analysis and discriminant analysis showed that there exist 5 body shape groups of Vietnamese men between the ages of 30 and 60 live in Ho Chi Minh City. The characteristics of each body type are displayed through avatars on CLO3D software. Group 1 is the body group with low height, high waist, normal body proportions, proportionate, small thighs and chest, narrow neck and shoulder area. Group 2 is the short body group but balanced, it belongs to the group of level I obesity, small thighs and knees, broad neck and shoulders. Group 3 is a body group of average height, a balanced body proportion, grade I obesity, horizontal shoulders, developed neck and back size. Meanwhile, group 4 is the tall body group, high lower body, overweight, small circumferences, horizontal shoulder and narrow back. Finally, group 5 is the group of tall and obese grade I, high waist and hip, broad shoulders and back, sloping shoulders.

This paper analyzes the shape and proportions of the body in order to contribute to the virtual model library in 3D design software, it also aims to improve the made-to-measure garment fit through 3D design system.

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