MORPHOLOGICAL CLASSIFICATION OF MALE BODY MORPHOTYPES FOR THE APPAREL PRODUCT DESIGN IN SOUTH AFRICA

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ABSTRACT

Advances in the clothing sector gained new momentum in the 1980s when a three-dimensional (3-D) full-body scanner was developed to obtain anthropometric body measurement data accurately, quickly and non-intrusively. However, sizing systems currently in use in South Africa are outdated and still based on traditionally extracted anthropometric measurements of what was assumed to be the ideal body morphotype. This study introduces categorisations of male body morphotypes extracted from 3-D scans and anthropometric body measurements using Principal Component Analysis (PCA) and K-Means Cluster analysis. This exploratory study used a non-probability-purposive and convenience-sampled secondary anthropometric dataset for a cohort of 270 men from Gauteng province, South Africa, between the ages of 18 and 56 years. The objective was to provide the apparel industry with a comprehensive protocol for the statistical assessment of male body morphotypes, thereby mitigating the subjectivity associated with expert panels' visual assessments. The PCA based on the correlation matrix resulted in 42 e□tape anthropometric body measures of height, length, and girth to define and sort the different clusters of body morphotype categories. K-Means Cluster Analysis was conducted using principal component (PC) scores that produced five clusters, of which the height, length, girth, width, and buttocks angle factor loadings were determined as the independent variables. Four body morphotype clusters were identified: the Triangle (n = 45, 16.6%), Trapezoid (n = 47, 17.4%), Oval (n = 55, 20.4%) and Rectangle (n = 123, 45.5%). The measurements for the dominant body morphotype, namely the Rectangle, were a chest size of 37 inches to 41 inches (95 cm to 105 cm) and a waist size of 30 inches to 36 inches (77 cm to 92 cm). The use of PCA and K-Means cluster analysis resulted in the categorisation of the body morphotypes into distinct groups. The findings showed that men have differently shaped bodies, hence the need for menswear clothing manufacturers to revise body size charts to reflect the current body morphotypes and anthropometric measurements for men. This study contributes to the body of knowledge on sizing and fit by providing updated anthropometric data and highlights its application in enhancing clothing designs to better fit current male body morphotypes.

KEYWORDS

male body morphotypes, correlation coefficient, 3-D point cloud scans, 3D body scanner, body shape

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INTRODUCTION

Clothing manufacturers and retailers generally strive to design garments to fit the wearer's body well. To ensure a good fit, manufacturers and retailers of ready-to-wear (RTW) clothes often rely on notions of body morphotypes. Manufacturers, for example, currently employ the Trapezoid, with its larger chest girth and a smaller hip girth, as the 'ideal' male body morphotype (Mchiza *et al.* 2015). Relying on an existing body morphotype may, however, be problematic because the ideal may not match empirical reality, and because it does not use the most recent technologies and statistical methods.

A clear understanding of wearers' body morphotypes and body landmarks contributes to achieving the goal of good fit (Gupta & Zakaria 2014:35). According to Gupta and Zakaria (2014:42), a set of key body landmarks derived from accurate 3-D scanned anthropometric data serves as a point of reference to classify body morphotypes. Since the 1980s, body scanning technologies have been used to determine the body outlines of populations based on key body landmarks to classify body morphotype categories and assign correct sizes (Petrova & Ashdown 2012:238; Pandarum & Yu 2015;200).

The relationships between the body landmarks when using statistical methods such as Principal Component Analysis (PCA) are determined by the correlation coefficient associations among the anthropometric body measurements (Ahmed 2014:2; Alubel *et al.* 2017:2). The correlation coefficient determines those variables with a high degree of correlation to each principal component (PC). It can enhance fit satisfaction for a maximum number of the population while reducing the number of sizes (Brolin 2016:2; Schober *et al.* 2018:1763; Balach *et al.* 2020:57; Yadav & Chanana 2020:17:53). The values used to determine correlations between body landmarks and to identify key parameters are usually based on the BS 7231 standard. The standard states that, "if the correlation coefficient is less than 0.4 then there is no relationship; a correlation coefficient between 0.6 to 0.75 shows a mild relationship; and a correlation coefficient more than 0.76 a strong or high relationship" (Adu-Boakye *et al.* 2012:5; Alubel *et al.* 2017:2; Yadav & Chanana 2020:17).

There is a dearth of reported scientific studies using correlation research methods such as PCA to identify the key body landmarks essential for clothing production for men in South Africa. To enhance the anthropometric size charts currently available, this study, therefore, integrates body morphotypes in the development of anthropometric size charts for men. Aligning these charts with actual body morphotypes not only improves sizing accuracy but also caters to consumer preferences for well-fitting, comfortable clothing. This alignment is crucial as it influences purchasing behaviour, with consumers increasingly seeking garments that are fashionable with a personalised fit.

The study proposed the following research hypotheses.

Hypothesis 1

The dominant male body morphotypes can be classified using the 3-D scanned dataset of 270 men residing in Gauteng Province, South Africa.

Hypothesis 2

The upper and lower body anthropometric characteristics of men within the dominant morphotypes are expected to differ significantly from those of the other body morphotypes identified in the 3-D dataset.

LITERATURE REVIEW

Anthropometric research for body morphotype categorisation has evolved significantly over the past decade, particularly in the context of apparel design. Earlier studies predominantly relied on traditional measurement tools such as dressmaker's tape measures or callipers (De Klerk *et al.* 2014:88; Gupta & Zakaria 2014:42). While these methods provided foundational insights into human body measurements, they were limited by observer error, inaccurate landmark positioning, incorrect subject alignment, and improper tool application (Apeagyei 2010:64; Gill 2015:2; Dianat *et al.* 2018:1705). Furthermore, critical body landmarks essential for well-fitting garments, such as the width and depth of the armscye, were difficult to measure precisely (Gupta & Zakaria 2014:42, Pandarum *et al.* 2017:3). These limitations highlighted the need for more advanced and accurate measurement techniques.

The introduction of three-dimensional (3-D) body scanning technologies in the 1980s marked a significant advancement, addressing many of the shortcomings of traditional methods. These technologies allow precise, non-intrusive, and rapid collection of body measurements, revolutionising the field (Pandarum & Yu 2015:200). The adoption of 3 -D body scanners has enabled the development of more accurate sizing systems compared to traditional models, which often relied on assumed ideal body morphotypes that do not reflect the diversity of actual body shapes in a population (Muthambi *et al.* 2016:2; Ola-Afolayan *et al*. 2021:52). This misalignment often results in garments with poor fit, leading to high return rates by consumers in stores (Mchiza *et al.* 2015:10; Varte *et al.* 2017:32). Therefore, developing accurate sizing systems through advanced 3-D anthropometric techniques is crucial for designing well-fitting apparel for a larger proportion of the population (Schober *et al.* 2018:1763).

While 3-D body scanning technologies offer significant benefits, the data generated should be effectively analysed to inform sizing system development. Newer approaches utilise statistical methods such as Principal Component Analysis (PCA) and K-Means Clustering to group and classify body morphotypes, advancing the theory and methodology in the field (Wilson 2016; Naveed *et al.* 2018; Saeidi 2018; Sun *et al.* 2019; Lee *et al.* 2020). PCA reduces dimensionality and identifies significant body measurements for classification (Gupta & Zakaria 2014:42), while K-Means Clustering categorises these measurements into distinct body morphotypes (Cottle 2012:9).

Wilson (2016) used the SizeUSA 3-D dataset to categorise men aged 26 to 35 into four geometric body morphotypes; Oval, Rectangle, Trapezoid, and Inverted Trapezoid. Although this study offers a framework for understanding body morphotypes in the U.S., its applicability in South Africa may be limited. Saeidi (2018) classified men aged 18 to 35 into three body morphotypes groups; Flat Straight/Ectomorph, Moderate Curvy-Straight/Mesomorph, and Curvy/Endomorph using the same dataset, but these categories may not fully capture the diversity of non-Western populations. Lee *et al.* (2020) identified three body morphotype clusters in obese Korean men aged 36-64; those with a Flat Abdomen but Prominent Buttocks, those with a Developed Abdomen and Buttocks, and those with Vertical Thighs and Drooped Buttocks with Tilted Thighs. While these studies apply PCA and K-Means Clustering effectively, their results are often geographically specific and may not generalise to regions such as South Africa.

Existing research on men's body morphotypes predominantly focuses on populations from the United States and the Republic of Korea (Wilson 2016; Saeidi 2018; Lee *et al.* 2020). This focus limits the applicability of these findings to other geo-demographic groups. South Africa, with its diverse population, presents unique challenges and opportunities for anthropometric research. Despite the variability in body morphotypes among South African men, there is a notable lack of studies applying advanced methods to develop sizing systems for this population. This gap underscores the need for localised sizing systems that reflect the unique anthropometric characteristics of South African men, ultimately contributing to better-fitting garments and improved consumer satisfaction.

METHODOLOGY

Research Design

Due to the stringent rules and regulations regarding human movement and resulting from the COVID-19 pandemic, secondary data was used, namely a 3-D anthropometric dataset from the years 2019 to 2020 that had been collected by Tabo (2020). The raw anthropometric dataset, comprised 286, 3-D point cloud scans and 64 anthropometric measurements of men. It was collected at the University of South Africa (UNISA), Florida Campus in Gauteng using a structured white light-based [TC]^2 NX-16 3-D full-body scanner. The anthropometric data was collected under the Ethical Clearance Numbers 2021/ CAES_HREC/058 and 2018/SSR-ERC/023.

Sampling

Prior to body scan generation, a non-probability-purposive convenience sampling method was used to select 286 men aged 18 to 56 years. The men from various ‘walks of life’ were purposively selected to voluntarily participate in the study. All the men prepared for the scan by changing to form-fitting light grey leggings provided in the body scanning laboratory.

Data Collection

While they were being scanned, the men maintained a standard body posture, stance and scanning position by standing on the footprints that are marked on the floor of the body scanning cubicle (Pandarum *et al.* 2011:3; Varte *et al.* 2017:30). The stance and position minimise the number of e-tape measurements that would have to be discarded as a result of “holes” in the scans of hidden areas such as underarms when using white light-based scanners. For all body landmarks, the men were scanned three times. Therefore, 286 3-D point cloud scans comprising 64 body landmark measurements were derived in accordance with the ISO 8559 -1 (2017) and SANS 8559-1 (2019).

Data analysis

A total of 16 body scans containing missing values were excluded. The remaining 270 complete scans of men aged 18 to 56 years were used for statistical analysis. These men represented four ethnic groups: Indian (3%), White (11%), Coloured (12%) and Black (74%). Thereafter, since the 3-D dataset consisted of 64 body landmarks, inferential data analysis was applied using a multivariate statistical approach, namely PCA and K-means Cluster Analysis. The dimensionality of 64 variables was reduced to five principal components based on the correlation matrix.

RESULTS AND DISCUSSION

The five principal components based on the correlation matrix resulted in 42 e-tape anthropometric measurements of the key vertical (height and length) and horizontal (girth and width) body landmarks required to define the different clusters of body morphotype categories (Table 2).

Thereafter, the Kaiser-Meyer-Olkin (KMO) and Bartlett's test were conducted to predict if all the 42, e-tape measurements were suitable for PCA analysis. According to Chang and Schulz (2018:4), a KMO measure between 0.7 and 0.8 indicates "that the body landmarks determined by the PCA are suitable for analysis." Bartlett's test measure must be less than 0.05 to predict a dataset that is suitable for a PCA analysis. In this study, the KMO measure and Bartlett's test measure were 0.8 and 0.00, respectively.

All 42 body landmarks were deemed suitable for PCA analysis. The PCA based on the Correlation matrix grouped the key body landmarks into the fewest principal components (PCs). To determine the number of PCs to be retained, three criteria were calculated namely: the scree plot (Figure 1), percentage of variance criterion (Table 1), and component matrix (Table 2).

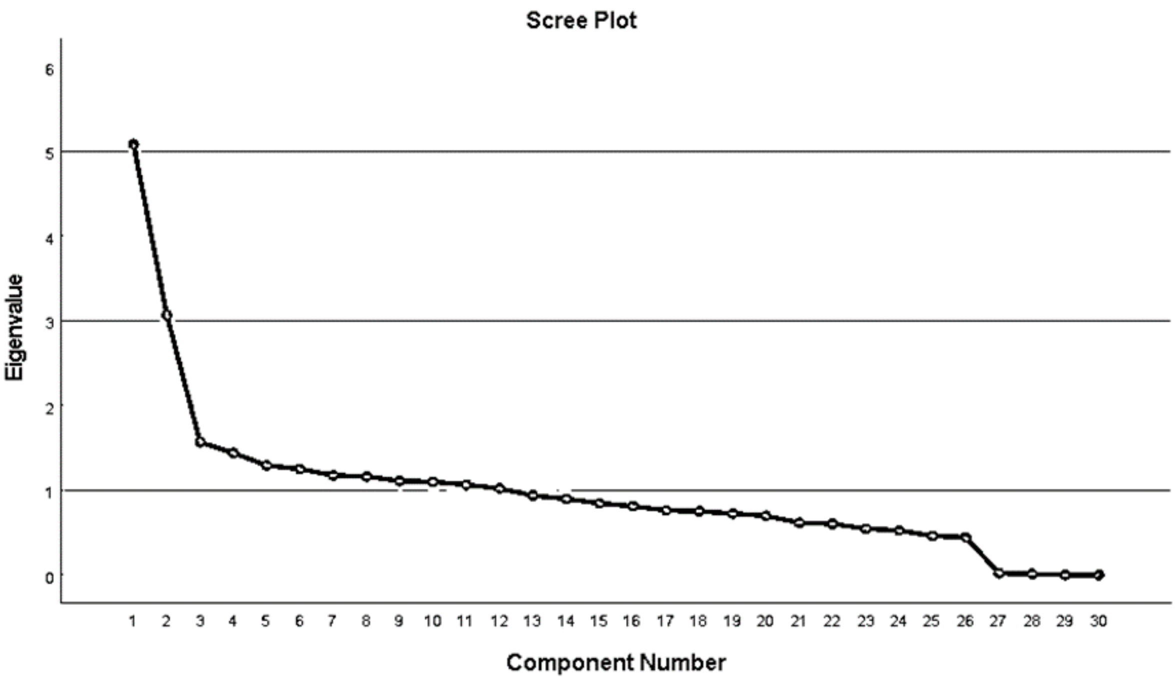

FIGURE 1: A SCREE PLOT OF PCA FOR THE E-TAPE BODY DIMENSIONS REQUIRED TO CLASSIFY MALE BODY MORPHOTYPES

TABLE 1: THE TOTAL VARIANCE EXPLAINED BY EACH PC FOR THE E-TAPE BODY DIMENSIONS REQUIRED FOR THE CLASSIFICATION OF MALE BODY MORPHOTYPES

Total variance explained			
	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	5.8	26.3	26.3
2	1.8	8.1	34.4
3	1.4	6.2	40.6
4	1.3	5.8	46.4
5	1.2	5.6	52.0

The Scree plot criterion graph visualised the number of PCs that should be retained based on the eigenvalue. According to Amao (2018:1) and Chuerubim and Da Silva (2018:1028), the PCs with Eigen values greater than one in the scree plot criterion graph are retained when determining the key body landmarks. Furthermore, the number of PCs to retain in the scree plot criterion graph was also determined by the breakpoint (curve) resembling an 'elbow' morphotype that is commonly considered as a cut-off area (Gupta & Zakaria 2014:106; Kleinlugtenbelt *et al*. 2018:28; Schulze & Boscardin 2018:11; Sheperis *et al*. 2019:28).

Table 1 shows the percentages of the total variance criterion explained by each PC that was retained for the selection of the key body landmarks for the classification of body morphotypes for the 270 men.

A large proportion (26.3%) of the variance in the e-tape anthropometric dataset was explained (Table 1) by the first component (PC1) followed by 8.1% in the second component (PC2), 6.2% in the third component (PC3), 5.8% in the fourth component (PC4) and 5.6% in the fifth component (PC5). The five PCs explained that at least 50% of the total variances were chosen as significant (Gupta & Zakaria 2014:107) and retained for further analysis, explaining a cumulative percentage of 52.0% of the e-tape body landmarks.

Based on the results from the scree plot and the table of total variance, the next step in the analysis, namely the component matrix, was determined (Table 2). This made it possible to identify all the high-factor loadings for each vertical and horizontal body landmark in each of the five principal components.

The vertical body landmarks are correlated to the lengths and heights and the horizontal body landmarks to the girth and width of the body morphotypes. The factor loading scores indicate how strongly the e-tape anthropometric measurements correlate with each principal component (Gupta & Zakaria 2014:4). Therefore, the 42 vertical and horizontal body landmarks that demonstrated factor loadings greater than 0.40 highlighted (Table 2) are explained as follows.

The dominant factor in **PC1** was the body height measures of the neck (front and back height), chest height, stomach height, thigh height, right-calf height, left-calf height, and left-knee height. Body lengths included the inseam left length, the left-waist to hip length, and the right-back waist to crotch level length. The body girth measures identified were of the left forearm girth and left bicep girth. Therefore, this component has been labelled as the *height, length, and girth mixed factor*.

PC2 was primarily dominated by body girth measures such as the left-leg surface girth, left-thigh girth, waist girth, hip girth, left-calf girth, and chest girth. Body lengths included left-shoulder to elbow length, left-front side

TABLE 2: THE TOTAL VARIANCE EXPLAINED BY EACH PC FOR THE E-TAPE BODY DIMENSIONS REQUIRED FOR THE CLASSIFICATION OF MALE BODY MORPHOTYPES

Body Dimensions	PC1	PC2	PC3	PC4	PC5
Neck height (front)	**0.982**	-0.127	-0.061	0.028	-0.025
Neck height (back)	**0.982**	-0.125	-0.062	0.027	-0.026
Chest height	**0.980**	-0.145	-0.065	0.027	-0.020
Stomach height	**0.973**	-0.152	-0.044	0.023	-0.028
Thigh height	**0.960**	-0.043	-0.069	0.110	-0.031
Left in-seam	**0.959**	-0.046	-0.071	0.108	-0.032
Right calf height	**0.950**	-0.104	-0.076	0.102	-0.058
Left calf height	**0.942**	-0.086	-0.075	0.097	-0.059
Left knee height	**0.733**	-0.033	0.103	-0.244	0.195
Left waist to hip	**0.596**	-0.315	0.031	0.054	0.122
Left forearm	**0.547**	0.112	-0.134	-0.036	0.139
Left bicep	**0.523**	-0.054	-0.314	0.100	-0.051
Right back waist to crotch level	**0.469**	0.295	0.005	0.209	-0.024
Waist front	-0.238	**0.546**	0.094	-0.196	0.176
Left leg surface	0.157	**0.507**	0.170	-0.137	0.135
Left thigh	0.119	**0.497**	-0.178	0.078	-0.246
Left shoulder to elbow	-0.015	**0.483**	0.037	-0.119	0.118
Waist girth	-0.175	**0.469**	0.045	-0.291	0.112
Overarm height	0.092	**0.465**	-0.180	-0.268	0.215
Left front side neck to armscye level	0.160	**0.451**	-0.060	-0.150	-0.012
Hip girth	0.012	**0.444**	-0.017	-0.139	0.098
Right coat in-sleeve	-0.157	**0.434**	0.074	**0.491**	-0.060
Left calf	0.059	**0.428**	-0.070	-0.076	0.035
Chest front	0.064	**0.427**	0.009	0.289	-0.148
Chest girth	0.029	**0.414**	-0.039	0.080	-0.092
Hip height	0.063	0.099	**0.934**	0.121	0.138
Left knee	0.094	-0.038	**0.624**	-0.223	-0.026
Right shoulder length	0.019	-0.109	**0.510**	**0.534**	-0.113
Shoulder to shoulder width	0.112	0.075	**0.485**	**0.438**	0.075
Right thigh length	0.055	-0.050	**0.425**	0.018	0.378
Right ankle height outside	-0.024	0.100	0.038	**0.503**	0.099
Left out-seam	0.061	0.165	0.324	**0.498**	-0.208
Buttocks angle	-0.061	0.076	-0.261	**0.423**	0.314
Left coat out-sleeve	0.226	-0.003	-0.083	**0.439**	0.333
Left shirt sleeve	0.285	0.240	0.312	**0.471**	-0.208
Left ankle girth	0.053	0.097	0.377	**0.482**	-0.357
Left shoulder to waist back	0.031	0.137	-0.045	0.211	**0.453**
Right shoulder to waist back	-0.079	0.065	0.222	0.069	**0.450**
Right knee	0.112	0.251	-0.051	-0.146	**0.420**
Across chest horizontal	-0.069	0.349	0.090	0.160	**0.434**
Abdomen front	-0.188	0.190	0.018	0.129	**0.458**
Abdomen girth	-0.112	0.132	-0.004	-0.034	**0.496**

neck to armscye level length and, right-coat in -sleeve length. The body heights were overarm height and waist-front height. The width was the chest front width. PC2 was thus termed the *girth, length, height, and width mixed factor*.

PC3 was dictated by body height measures such as hip height. The body length measures were of the right-shoulder length and right-thigh length The body width was of shoulder-to-shoulder width. The body girth measure was of the left-knee girth. This component was accordingly named the *height, length, width, and girth mixed factor.*

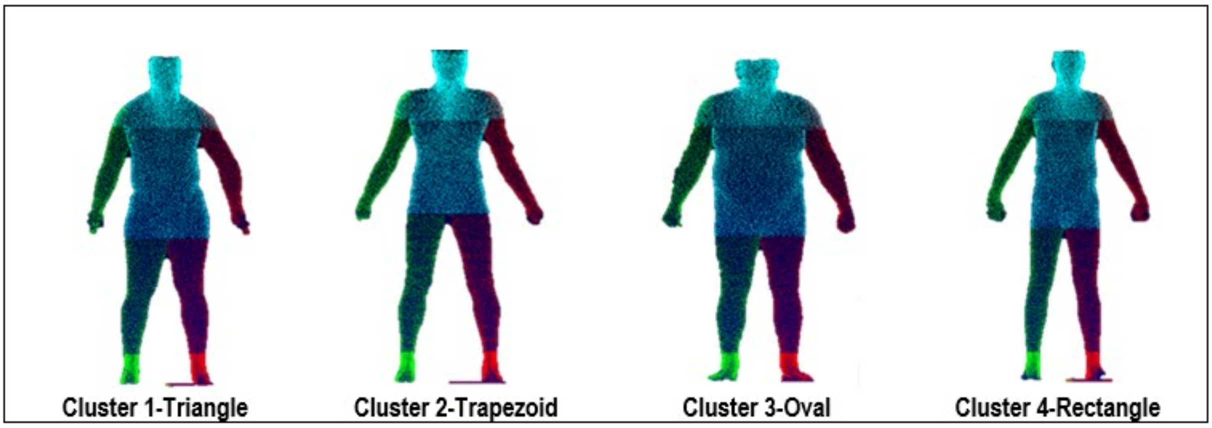

FIGURE 2: TRIANGLE, TRAPEZOID, OVAL AND RECTANGLE MEN'S BODY MORPHOTYPES

In **PC4**, the body length measures were dominant, such as the right-coat in-sleeve length, right- shoulder length, left-outseam length, left-coat out-sleeve length and left-shirt sleeve length. The height was right-ankle height outside. The body width was shoulder-to-shoulder width. The body girth was the left-ankle girth. The angle was the buttocks angle. The component was therefore named the *length, height, width, and angle mixed factor*.

PC5 was dominated by body girth measures of the right-knee girth and abdomen girth. The body lengths were the left-shoulder to waist back length and right-shoulder to waist back length. The body widths were across chest horizontal width and abdomen front width. This component was termed the *girth, length, and width mixed factor*.

Based on these (PC1 to PC5) key body landmarks, Cluster Analysis was performed to determine the distinct clusters that defined the 270 men's body morphotypes.

Cluster analysis to categorise the body morphotypes of the men

To classify the dominant body morphotypes of the men, K-means Cluster Analysis was conducted in SPSS version 27 software using PC scores of the factors for PC1 to PC5. The scores of the height, length, girth, width, and buttocks angle factor loadings were loaded as independent variables to classify the dominant body morphotype categories of men. The K-Means Cluster Analysis divided the key anthropometric measurements into clusters and sorted one body morphotype from the other (Cottle 2012:9). Therefore, the first step in the analysis was to identify the number of clusters that explain the men's body morphotype categories.

The analysis showed that the four-cluster model was the most appropriate to classify the dominant body morphotypes for the men in this study. The four-cluster model that classified each body morphotype cluster statistically by observing and comparing the scores of the body landmarks within each distinct cluster was based on the results of the K-Means method. Four body morphotype clusters namely the Triangle (n = 45,16.6%), Trapezoid (n = 47, 17.4%), Oval (n = 55, 20.4%) and Rectangle (n = 123, 45.5%) were identified. The dominant body morphotype of men within each cluster is illustrated in Figure 2.

Triangle morphotypes

Apropos the height, length, girth, width, and buttocks angle factor loading, men in Cluster 1 were classified as a Triangle. Men who fell in this body morphotype category had the shortest neck average (-2.114; -2.116), stomach (-0.174) and chest (-2.079) in terms of height. The results show that men in this category had the shortest side of the neck point to the armscye level at the front and were longer at the left-waist at the back. These men were shortest from the waist at the back to crotch level, and shortest at the hip height. The thigh height, the knee height and the ankle height were the longest, with the calf and the inseam being shortest. Therefore, these men were longest in the lower body. Furthermore, the men in this morphotype category exhibited narrow shoulders in terms of the shoulder-to-shoulder width measurements, with the most prominent buttocks. These men had a chest that was smaller than the hip. Overall, these men were large in the thigh and ankles, and their calves were prominent. The legs were longer in the right-thigh length and left-knee height, except for the calf height, which was the shortest.

Trapezoid morphotypes

Based on the anthropometric characteristics of the length, height, girth, width and buttocks angle factor loadings, the men in Cluster 2 were classified as a Trapezoid body morphotype. This body morphotype category had neither a too-long nor too-short neck (0.176; 0.178), stomach (0.134) nor a longer chest (0.176) in terms of height.

The men in this category tended to be short from the side of the neck point to the armscye level at the front and long in length from the shoulder to the waist at the back. These men were short from the waist at the back to crotch level, and long at the hip height; however, they had the shortest lower body in terms of the thigh height, knee height, calf height, and the inseam and outseam. These men exhibited a broad chest with a narrow abdomen front with prominent buttocks. The chest measurements were broader than their waist and hip girths. The hip was smaller than the chest but larger than the waist. Overall, these men tended to be leaner around the thighs, knees, and ankles, with prominent biceps and a large forearm.

Oval morphotypes

The anthropometric characteristics of the length, height, girth, width, and buttocks angle factor loading for men in Cluster 3 were classified as an Oval body morphotype. This body morphotype category had the longest neck (0.491; 0.492), chest (0.475) and stomach (0.489) in terms of height. Men in this category exhibited the longest side of the neck point to the armscye level at the front, and shorter shoulder to the left-waist at the back. In these men the waist at the back to crotch level was longer, and shorter at the hip height area. The thigh height, the ankle height, the left-inseam, and the left-outseam were longer, except for the left-knee height. Therefore, these men's lower body area was longer in length. The men in this morphotype category exhibited the broadest shoulders, chest, waist and abdomen based on the shoulder-to-shoulder width, chest front, waist front and abdomen front measurements (in Figure 2). The buttocks were the least prominent with the men who had a larger waist girth than the chest and hip. Overall, these men were larger in their abdomen, the thighs, the knee, and the ankle, with prominent calves. Their arm length and leg length fell into the longer length category, with a large forearm but with a less-prominent bicep.

Rectangle morphotypes

In terms of height, length, girth, width, and buttocks angle factor loading, men in Cluster 4 were classified as a Rectangle. Men in this body morphotype category were taller than men in other morphotype categories in terms of the average neck height (front and back) of (0.467; 0.466), chest height of (0.467), the left -front side neck to armscye level of (-0.088). Men in this category exhibited the longest lower body of all the body morphotype categories based on the average hip height of (0.114), thigh height of (0.492), left-knee height of (0.300), calf height (right and left) of (0.460; 0.448), left-waist to hip of (0.285) and the left-inseam of (0.492). These men were the leanest of all body morphotype categories based on their average chest girth (-0.272), waist girth (-0.259), hip girth (-0.274)., calf girth (-0.058), across chest horizontal width (-0.069) and waist front (-0.102), with the least prominent buttocks. The men in the rectangle morphotype category had a chest girth equal to the size of their hips.

Because the Rectangle morphotype was dominant, and to assess to what extent our statistical analyses coincided with current practice in the garment industry, we thereafter sought to verify whether an independent visual assessment would corroborate our categorisation. Accordingly, a set of 10 full-body front views of the 3-D scans was extracted on the anthropometric measurements of the small, average, and large male rectangle subjects. Fifteen clothing designers in Gauteng each independently viewed this full set. All 15 clothing experts agreed that the men grouped within Cluster 4 were of a Rectangle body morphotype.

CONCLUSION

The ‘ideal’ male body morphotype currently used by manufacturers of ready-to-wear (RTW) clothes is the Trapezoid morphotype, with its larger chest girth and a smaller hip girth. However, our study of 270 men distinguished four cluster categories of body morphotypes, namely the Triangle, Trapezoid, Oval and Rectangle, with the Rectangle being most common. This use of the Trapezoid morphotype ideal poses challenges for men from other categories. Our findings, for example, showed that individuals classified as having a Triangle morphotype are smaller in the chest girth with larger hip girth measurements when compared to the Trapezoid morphotype. This suggests that a basic RTW shirt will have to be altered to accommodate the larger chest girth of the Trapezoid morphotype, which could result in a loose fit around the chest area for men identified as having a Triangle morphotype. Furthermore, for a basic trouser, the hip measurements tailored to the Trapezoid body morphotype might fit snugly around the hip for men characterized as having a Triangle morphotype. However, men identified as having an Oval morphotype have very large chest and hip girth measurements. This implies that the RTW basic shirt manufactured based on the chest girth measurements of the Trapezoid is likely to fit tightly across the chest in men of an Oval morphotype. Furthermore, these men are likely to experience gaping of the basic trouser at the centre front, and the side seams are likely to pull forward between the hip and waist, resulting in vertical measurement wrinkles around the crotch.

The dominant morphotype, Rectangle (123; 45.5%), had a similar girth measurement in the chest and hip. In contrast, the Trapezoid ‘ideal’ body morphotype shows a larger chest girth relative to a smaller hip girth. Such variations in the chest and hip measurement of RTW clothes that are manufactured and graded for a Trapezoid morphotype as the base size means that the majority of the men (i.e. those classified as Rectangular) experience fit problems in their chest and hip girths. For men belonging to the Rectangle morphotype, RTW garments, such as a basic trouser, are likely to fit tightly around the hip due to a larger hip girth than that of men belonging to the Trapezoid morphotype. This implies that, to achieve the proper fit in their standard trousers, men of a Rectangular morphotype are likely to alter the side seams due to unflattering wrinkles at the crotch and a waistband that does not fasten properly. Accordingly, this study suggests that the clothing manufacture and retail sectors should review their ideal body shapes for men to provide better-fitting upper and lower body garments when segmenting their target markets.

In summary, this exploratory study provides the apparel industry with a comprehensive, easy-to-adapt guideline for statistically clustering and sorting male body morphotypes when using PCA and K-Mean Cluster analysis. It is hoped that this methodology will eliminate the subjectivity inherent in assessing morphotypes. Furthermore, the study also suggests that the different morphotype categories are used in conjunction with the body anthropometric measurements in target market segmenting and in developing base size pattern blocks in the apparel manufacturing and retail sector.

CONTRIBUTION OF THE STUDY TO GARMENT SIZING AND FIT RESEARCH

This study advances the theoretical framework of existing body morphotype classification models through the use of K-means clustering using updated 3-D body scan data. Therefore, providing a more detailed understanding of male body morphotypes beyond traditional anthropometric classifications. Practically, the updated anthropometric data supports the development of more accurate size charts and body morphotype classifications, enabling garment manufacturers to develop sizing systems that better accommodate diverse male body morphotypes, thus improving garment fit and consumer satisfaction. The identification of distinct body morphotype clusters and their statistical characteristics further supports the development of standardised sizing guidelines, enhancing consistency in garment sizing across the industry. The researchers suggest that the Rectangle morphotype, due to its statistical prevalence, be considered the 'ideal' morphotype to improve sizing and fit for male consumers in the country.

LIMITATIONS OF THE STUDY

Further studies might focus on a larger sample size representative of the different populations to establish similarities and differences both within and between ethnic groupings when using the proposed study methodology. The researchers further suggest that a basic pattern-block be developed for both shirt and trouser garments for the different morphotypes identified with their corresponding anthropometric measurements. These garments ought to be test-fitted on a sample of men for wearer trials. Additionally, the inclusion of factors such as body volume index (BVI) and body mass index (BMI) among men with a Rectangle body morphotype could further extend the scope of our understanding of this body morphotype and advance endeavours to ensure that garments are made to fit the wearer's body as well as possible.

RECOMMENDATIONS FOR FURTHER STUDIES

Further studies might focus on a larger sample size representative of the different populations to establish similarities and differences both within and between ethnic groupings when using the proposed study methodology. The researchers further suggest that a basic pattern-block be developed for both shirt and trouser garments for the different morphotypes identified with their corresponding anthropometric measurements. These garments ought to be test-fitted on a sample of men for wearer trials. Additionally, the inclusion of factors such as body volume index (BVI) and body mass index (BMI) among men with a Rectangle body morphotype could further extend the scope of our understanding of this body morphotype and advance endeavours to ensure that garments are made to fit the wearer's body as well as possible.

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