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A study on procedure for classifying male muscular lower body somatotype from general anthropometric database

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Abstract

The most researches developing pattern of compression style sportswear were targeted at the live model that has muscular body build. The purpose of this study was developing a method for classifying men's lower body types in terms of muscular body build. The 3D human body scan data and body measurements of 30s of Size Korea were analyzed. The subjects (n=203) were men between the ages of 30 and 39 years. Men's muscular body build was classified with two key dimensions, thigh girth and calf girth. The subjects were divided into four groups. From each group, average subjects (n=42) whose height and weight were close to the mean value (mean±1/2 S.D.) were selected. 42 subjects were divided up as four groups. Group Ⅰ (n=7) was thigh and calf developed body type. Group Ⅱ (n=9) was thigh developed body type. Group Ⅲ (n=11) was calf developed body type. Group Ⅳ (n=15) was thigh and calf undeveloped body type. Four groups had distinct different at widths (n=4), depths (n=4), and girths (n=9) dimensions. The results showed that the muscular men in their 30s could be defined by thigh and calf girths. The thigh developed muscular men had thigh girth over 60cm and the calf developed muscular men had calf girth over 38cm. From each group one representative was selected by 3D body scan figure.

Keywords: lower body, muscular, somatotype, 3D body scan

I. Introduction

The three-dimensional (3D) anthropometric national survey projects were carried out on a large scale. The 3D human body shape data had been collected actively targeting a large amount of the general public in many countries such as the United States, the United Kingdom, France, Japan, South Korea and China (Oh & Chun, 2007). The various size-related institutes such as size UK, size USA and size Korea provide a system of size and 3D human body shape data (Apeagyei, 2010). Because massive materials of 3D human body data of the general public are recorded in these documents of institutes, many researches on how to utilize these materials took growing interest. Also the trend to the use of 3D anthropometric data is increased (Jeong et al., 2006). Especially information for 3D human body shape is widely used such as animation, computer games, art and sculpture, ergonomics, medicine and forensic, cosmetics and dermatology, anthropology, biometry

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and security, fitness and sport, fashion and beauty, communications and so on (D 'Apuzzo, 2007).

In the field of clothing, the 3D human body scan data was collected from the 1990s (Suh & Chun, 2004). The number of studies using a 3D body scan data was increasing (Suh & Oh, 2012). In Korea the national survey which scanned numerous South Korea people was completed. The 3D body scan data had been used in development of the dress form for clothing production for Korean male and female, such as the development of the cap, the process of product development (Jeong et al., 2006).

In the previous studies of clothing areas, there were researches for developed patterns by flattening the 3D body scan shape data (Oh, 2006). The automatically calculated the body dimensions were provided by the Korean standard institution (Kim & Choi, 2009). Its application field was spreading. In particular, the research method for flattening the 3D shape data, cases to be utilized in research of development of the tight fitted sportswear pattern have increased. For example this method was used in researches of sportswear development for the improvement of back muscle strength (Kim, 2012) and pattern development for cycle suit given tight-fit of the body (Jeong, 2006).

3D human body shape data, that reflects the curvature of the body surface of the human body, allows it facilitates to make tight-fit sportswear pattern that there is no ease between the body surface and the clothing. However, the compression style tight-fit clothing pattern has been developed by utilizing the 3D body scan data for a particular subject (Kim, 2012; Kim, 2008). The experimental subjects of previous researches which aimed for making tight-fit sportswear pattern were experienced persons of specific exercise or specific muscular body type persons.

In the most researches based on pattern development of compression style tight-fit sportswear, the experimental subjects were targeted at the muscular developed men (Choi, 2011; Kim, 2012). The criteria of selecting muscle developed subjects were the girth dimensions and the BMI index. However, these criteria were difficult to clarify the difference of physical size and body type characteristics between muscular subjects and general public. There is no an obvious way to verify who is the muscular person representing the general population. The methodology that defines selecting the muscular men with generality is needed.

This study discusses how to choose the muscular man within 30s from the lower body measurements data of Size Korea which measure the unspecified number of the general public. Based on the 3D human body shape data, we have proposed a method of classifying the muscular male lower body types.

II. Theoretical Background

1. Application of 3D body scan data

3D human body shape data was used for somatotype analysis. To classify the body type, the researchers analyzed 3D scanning data. The data was also utilized in a pattern making and a dress form production. Concretely, there was a study that presents a 3D dress form model to analyze the trend of fat distribution of the body type through dimensional differences according to the 3D human body shape data of 30s female which was measured in Size Korea (Suh & Oh, 2012). Also the research that performed body type analysis with 3D measurement targeting elderly women was conducted (Lee et al., 2004). But somatotype researches or dress form development researches for making tight-fit sportswear are not sufficient. It is required that the research and process are needed about selecting body type for developing sportswear utilizing 3D body shape data.

The advantages of 3D body scanning technology are saving time and cost. It also can measure dimensions that are not able to measure in the traditional measuring method (Lee et al., 2004). In the 3D body measurement studies, there are researches on shape data utilization using a 3D scanner. The other researchers developed pattern by flattening the 3D body scan shape data. The researches made garment pattern by flattening the human body surface shape data had been carried out since the 1970s. It has been extremely popular since 2000s (Suh & Chun, 2004). The methods on development of tight-fit sportswear pattern utilizing a 3D scan data were various. Some researchers flattened the body curvature (Jeong, 2006) and the others used triangular mesh flattened method with a focus on dermatomes etc (Kim, 2008). However these studies may have limitations in body type screened. Their experimental subjects were a specific subject. In order to develop the patterns for general consumers the experimental subjects should be a representative figure of the general population. In consideration of the functionality and subjects wearing on tight-fit sportswear, the research must precede selection process of representative body type.

2. The selection process of muscular body shape subjects

The researches on change in body surface dimension as dynamic motion posture are considered to the body type of experimental subject (Choi, 2011; Kim 2012).

Body shape has an important meaning in clothing production process of the mass production such as evaluation to fit, manufacture of clothes and clothing correction and so on (Jeong et al., 2006). For this reason, it is more important to know exactly what body type characteristics of consumer than anything (Jeong & Kim, 2008).

Body type of the experimental subject for developing sportswear pattern is muscular male body type in general. The compression sportswear is aimed for holding the blurring of the muscles (Kraemer et al., 2010). The researchers are tended to test the function of sample garments with muscular person whose muscles are developed. Ready-to-wear clothing that mass-produced to target the general public of unspecified number are hard to give a better fit for muscular men (Kim, 1991; Kim, 2000; Kwon, 1998; Kwon & Jeon, 2000). The most of compression style sportswear does not have ease amount, it is a tight fit garment.

The subject for the researches about developing of sportswear by utilizing a 3D human body shape data differs of depending on the research purpose. In order to make compression style sportswear, which is designed to reflect the 3D body surface change of athletic body during the movement, it is important that using the 3D human body scanning data of sports experienced subjects (Oh, 2006; Jeong, 2005).

For developing compression style sportswear, previous researchers measured a live model that had muscular body type (Choi, 2011; Kim 2012). They had presented criteria to define muscular body type such as girth dimensions (chest, waist, abdomen, hip, thigh, calf, knee, ankle) and BMI index which distinguished the obesity. Kim (2012) had designed a compression style whole body suit by considering the anatomy structure of the human body. She selected the muscular body type with BMI index value from the data of 2004 Size Korea. She defined the muscular men whose BMI index value belonged to the normal range but the girth measurements were relatively larger than the mean value. Choi (2011) has designed compression style sports pants. She claimed that the muscular body type had relatively large muscle quantity and larger girth dimension than the standard. These studies show that the criteria for selecting the muscular body type were girth dimensions and BMI. However, the range of the girth dimensions for the muscular men was not clearly defined.

III. Methods

1. Subjects population

The materials used for this study were extracted from the 3D automatically measured human body data for a total of 203 males in their 30s (between

〈Table 1〉 Descriptive statistics of subject population: 30s in the Size Korea (n=203)

Dimensions	Mean	S.D.	Min.	Max.
Stature (cm)	172.43	5.93	154.18	185.18
Weight (kg)	71.34	10.67	48.30	108.90
BMI	24.29	3.11	17.20	33.00
Thigh girth (cm)	59.76	5.88	46.18	73.43
Calf girth (cm)	37.33	2.66	31.37	44.91

30 to 39) in the 6th Size Korea anthropometric data base. Population's average height was 172.43cm, weight was 71.34kg, and BMI value was 24.29 〈Table 1〉.

2. Classification of lower body shapes

The lower body shapes of the males in their 30s (between 30 to 39) were classified by thigh girth and calf girth. Those dimensions were used as key dimensions to define muscular male body shape in the previous studies (Jeong & Kim, 2008). The average thigh or calf measurements of the subjects in their 30s (n=203) in the 6th Size Korea data (2010) were 59.76cm and 37.33cm respectively. Those subjects were classified into 4 groups: Group Ⅰ consisting of those with both thigh and calf girths were over the mean value; Group Ⅱ consisting of those with thigh girth was over the mean value but calf girth was below the mean; Group Ⅲ consisting of those with thigh girth less than the mean but calf girth was over the mean; and Group Ⅳ consisting of those with both thigh and calf girths were below the mean value.

The difference of body build for four groups was verified by one-way ANOVA test. If there existed any significant different between groups, the tukey verification test was performed. Total of 30 dimensions of 3D lower body automatic measurements were analyzed.

3. Process of extracting representative subject from each group

In order to extract the representative lower body muscular type person within each group, the subjects with average body build were selected. Their height and weight were close to the average range (mean ±1/2 S.D.). From the each average subjects group one representative subject was selected. The representative subject had extreme value on the thigh girth and calf girth within the group. He was the right posture person. Their 3D body scan shape data were screened to select the person in the right posture.

Ⅳ. Results and Discussion

1. Classification of the subjects by thigh girth and calf girth

Referencing the mean value of thigh girth (mean= 59.76cm) and calf girth (mean=37.33cm), the researchers classified the subjects into 4 groups. The subjects with their thigh and calf girths more than the mean value were falling under Group Ⅰ (n=63). The subjects with their thigh girth more than the mean but calf girth less than the mean were belonged to Group Ⅱ (n=33). The subjects with thigh girth less than the mean but calf girth more than the mean were falling under Group Ⅲ (n=28). The subjects

〈Table 2〉 Range of thigh girth and calf girth measurement among four groups (n=203)

Groups	Thigh girth (cm)	Calf girth (cm)	N (%)
Group Ⅰ	≥59.76	≥37.33	63 (31.0)
Group Ⅱ	≥59.76	<37.33	33 (16.3)
Group Ⅲ	<59.76	≥37.33	28 (13.8)
Group Ⅳ	<59.76	<37.33	79 (38.9)

with both thigh and calf girths less than the mean value belonged to Group Ⅳ (n=79) (Table 2).

2. Comparison of body dimensions by groups

By utilizing the one-way ANOVA test 30 body dimensions of the four groups were compared. The items that showed significant differences were weight (p<0.001), BMI index (p<0.001), stature (p<0.05) and many other dimensions. The girth dimensions indicated difference between the groups were waist girth, abdomen girth, waist (omphalion) girth, hip girth, thigh girth, knee girth, calf girth, minimum leg girth

〈Table 3〉 Comparison of body measurements by group (n=203)

Dimensions		Groups	Group Ⅰ (n=63)	Group Ⅱ (n=33)	Group Ⅲ (n=28)	Group Ⅳ (n=79)	F-value
Lower body		Weight (kg)	82.11^{a} (9.48)	68.88^{b} (6.16)	71.02^{b} (5.05)	63.89^{c} (6.84)	70.88***
		BMI	27.41^{a} (2.5)	23.86^{b} (1.88)	23.82^{b} (1.7)	22.14^{c} (2.24)	67.67***
		Stature	174.07^{a} (5.85)	171.24^{b} (5.83)	173.69^{ab} (4.93)	171.17^{b} (6.04)	3.80*
	Height (cm)	Waist	104.56 (4.47)	102.84 (4.58)	104.98 (3.63)	103.09 (4.46)	2.54
		Abdomen	99.75^{a} (4.59)	97.81^{ab} (4.04)	99.54^{ab} (3.38)	97.33^{b} (4.13)	4.83**
		Waist (omphalion)	100.53 (4.30)	99.32 (4.09)	101.55 (3.56)	99.93 (4.58)	1.61
		Hip	85.38^{ab} (3.77)	83.64^{a} (3.57)	86.19^{b} (3.34)	84.11^{ab} (4.06)	3.61*
		Crotch	76.05 (3.79)	74.79 (4.13)	77.54 (3.25)	75.73 (4.09)	2.63
		Knee	46.20^{a} (2.18)	45.31^{a} (2.13)	46.43^{a} (1.81)	45.20^{a} (2.34)	3.87*
		Lateral malleous	12.72 (18.57)	19.12 (25.57)	19.79 (26.99)	16.72 (23.66)	0.90
	Length (cm)	Body rise	19.18 (1.77)	19.20 (2.06)	18.79 (1.59)	18.98 (1.81)	0.42
		Waist to hip	19.55 (1.78)	19.68 (2.06)	19.22 (1.63)	19.44 (1.84)	0.37
		Waist to lateral malleous	98.12 (4.33)	96.72 (4.37)	98.39 (3.57)	96.75 (4.18)	2.08
	Width (cm)	Waist	32.58^{a} (2.32)	29.71^{b} (1.69)	29.69^{b} (1.69)	28.34^{c} (1.81)	56.45***
		Abdomen	32.99^{a} (2.24)	30.35^{b} (1.44)	30.41^{b} (1.72)	29.52^{b} (1.56)	45.12***
		Waist (omphalion)	33.07^{a} (2.17)	30.35^{b} (1.56)	30.28^{b} (1.70)	29.09^{c} (1.82)	53.55***
		Hip	35.70^{a} (1.48)	34.08^{b} (1.13)	34.40^{bc} (1.24)	33.48^{c} (1.33)	32.89***
	Depth (cm)	Waist	25.29^{a} (2.43)	22.32^{b} (1.93)	21.96^{bc} (2.05)	20.72^{c} (2.26)	49.92***
		Abdomen	25.47^{a} (2.42)	22.71^{b} (1.85)	22.37^{bc} (1.80)	21.26^{c} (1.92)	49.74***
		Waist (omphalion)	25.25^{a} (2.35)	22.50^{b} (1.98)	22.09^{b} (1.97)	20.84^{c} (1.97)	49.58***
		Hip	26.91^{a} (1.66)	24.54^{bc} (1.49)	25.09^{b} (1.18)	23.80^{c} (1.41)	53.22***
	Girth (cm)	Waist	92.80^{a} (7.41)	83.48^{b} (5.63)	83.16^{b} (6.27)	78.36^{c} (6.17)	58.07***
		Abdomen	94.02^{a} (7.18)	85.19^{b} (5.11)	84.67^{bc} (5.49)	81.47^{c} (5.32)	53.76***
		Waist (omphalion)	93.96^{a} (7.10)	84.86^{b} (5.43)	83.91^{b} (5.81)	80.10^{c} (6.34)	56.38***
		Hip	100.47^{a} (4.47)	94.23^{b} (3.50)	94.78^{b} (2.83)	91.50^{c} (3.79)	64.19***
		Thigh	65.85^{a} (3.29)	63.20^{b} (2.55)	56.27^{c} (2.07)	54.70^{c} (3.40)	178.06***
		Knee	38.46^{a} (1.91)	35.55^{c} (1.24)	36.81^{b} (1.42)	35.08^{c} (1.54)	55.79***
		Calf	40.22^{a} (1.92)	35.98^{c} (1.04)	38.44^{b} (0.89)	35.20^{c} (1.45)	144.97***
		Minimum leg	22.47^{a} (0.99)	20.50^{c} (0.87)	21.64^{b} (1.00)	20.18^{c} (0.89)	78.26***
		Maximum ankle	27.36^{a} (1.28)	25.34^{c} (0.93)	26.52^{b} (0.93)	25.20^{c} (1.11)	49.93***

*p<0.05, **p<0.01, ***p<0.001

and maximum ankle girth (p<0.001). The width dimensions showed the difference between groups were waist width, abdomen width, waist (omphalion) width and hip width (p<0.001). The depths dimensions showed the difference between groups were waist depth, abdomen depth, waist (omphalion) depth and hip depth (p<0.001). The height dimensions indicating difference between the groups were abdomen height (p<0.01), hip height, and knee height (p<0.05) (Table 3).

3. The average body build subjects of each group

Among the subjects in each group, the average build subjects whose height and weight close to the mean value (mean±1/2 S.D., height; 154.18~185.18cm, weight; 48.30~108.90kg) were extracted again. They were named as the average body build subjects. From Group Ⅰ consisting of 63 subjects with both of thigh and calf developed, 7 subjects were selected. Their thigh and calf were well developed. Their

〈Table 4〉 Descriptive statistics of average subjects of four body type group (n=42)

Groups	N	Stature (cm)		Weight (kg)		BMI	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Ⅰ	7	171.47	1.63	72.64	1.80	24.94	0.59
Ⅱ	9	173.00	1.42	73.87	1.99	25.12	0.66
Ⅲ	11	172.48	1.54	69.89	2.67	23.87	0.90
Ⅳ	15	172.09	1.50	69.36	2.28	23.55	0.82

〈Table 5〉 Comparison of body dimensions of average subjects (n=42)

Dimensions		Body type groups				F-value
		Ⅰ(n=7)	Ⅱ(n=9)	Ⅲ(n=11)	Ⅳ(n=15)	
Width (cm)	Waist	29.64	30.57	29.82	29.75	1.10
	Abdomen	29.98	31.30	30.18	30.60	2.50
	Waist (omphalion)	30.27	31.37	30.27	30.67	1.92
	Hip	34.15	34.73	34.15	34.38	0.53
Depth (cm)	Waist	22.55	23.51	21.84	22.40	2.57
	Abdomen	22.58^{ab}	23.76^{a}	22.01^{b}	22.63^{ab}	3.52*
	Waist (omphalion)	22.44^{ab}	23.61^{ab}	21.83^{b}	22.34^{ab}	3.79*
	Hip	25.12^{ab}	25.79^{a}	24.93^{ab}	24.51^{b}	3.74*
Girth (cm)	Waist	83.15	86.60	83.61	83.15	1.79
	Abdomen	84.12^{b}	88.48^{a}	84.02^{b}	85.42^{ab}	3.54*
	Waist (omphalion)	84.51^{ab}	88.30^{a}	83.81^{b}	85.24^{ab}	2.98*
	Hip	94.59^{b}	97.23^{a}	94.25^{b}	94.02^{b}	4.69**
	Thigh	64.50^{a}	64.23^{a}	56.91^{b}	56.69^{b}	40.76***
	Knee	36.81	36.28	36.86	35.80	1.93
	Calf	38.96^{a}	36.25^{b}	38.04^{a}	36.21^{b}	24.04***
	Min. leg	21.73^{a}	20.71^{bc}	21.47^{ab}	20.45^{c}	5.51**
	Max. ankle	26.60^{a}	25.45^{bc}	26.35^{ab}	25.18^{c}	8.14***

*p<0.05, **p<0.01, ***p<0.001

average height was 171.47cm and average weight was 72.64kg. From Group Ⅱ consisting of 33 subjects with only thigh developed, 9 subjects were selected. Their average height was 173.00cm and average weight maintained 73.87kg. Among the subjects consisting of 28 with only calf developed in Group III, 11 were selected. Their average height was 172.48cm and average weight maintained 69.89kg. Among 79 subjects in Group Ⅳ without thigh nor calf developed, 15 subjects were selected. Their average height was 172.09cm and average weight was 69.36kg. As a result, the stature and weight between Group Ⅲ and Group Ⅳ were similar. Group Ⅰ and Group Ⅱ were heavier than those in Group Ⅲ and Group Ⅳ 〈Table 4〉.

The 17 body dimensions of the average subjects belonged to four groups were compared. The results showed that abdomen depth, waist (omphalion) depth, hip depth, abdomen girth, waist (omphalion) girth ($p<0.05$), hip girth, minimum leg girth ($p<0.01$), thigh girth, calf girth, maximum ankle girth ($p<0.001$) were significantly different among groups. The girth dimensions were also significant difference among groups. The abdomen girth ($p<0.05$), waist girth ($p<0.05$), hip girth ($p<0.01$) of Group Ⅱ were greater than others 〈Table 5〉.

4. Selection of representative subjects

The body measurements of the 42 average subjects showed that the thigh developed body type groups (Ⅰ, Ⅱ) have thigh girth over 60cm and calf developed body types (Ⅰ, Ⅲ) have calf girth over 38cm. Four representative subjects were selected from a total of 42 average subjects 〈Table 6〉.

The representative subjects were satisfied with the two conditions below.

First, the balanced body proportion and posture are required. Their 3D body shapes were eye ball tested at the front/side/back view. From the front view, the vertical reference line passing the omphalion and crotch landmarks was evaluated. If the line was deviated either to its left or right, the subject was excluded. From the side view, the vertical reference line passing the ear lobe landmark was evaluated. If the subject showed scoliosis, turtle-necked, round-shouldered or abdominal obese, the subject was excluded. From the back view, the vertical reference line passing the center back waist landmark was evaluated. The subjects showed asymmetric were excluded.

Second, the distribution of the thigh and calf girths was evaluated.

In Group I, subject #5 was selected as a representative subject, subject #2 and subject #7 were excluded because they showed an asymmetric posture. In Group Ⅱ, subject #14 was selected. In Group III, subject #17 was selected. In Group IV, subject #37 was selected 〈Fig. 1〉. Four representative subjects (#5, #14, #17, #37) were in a right posture and symmetric body shape 〈Fig. 2〉.

V. Conclusion

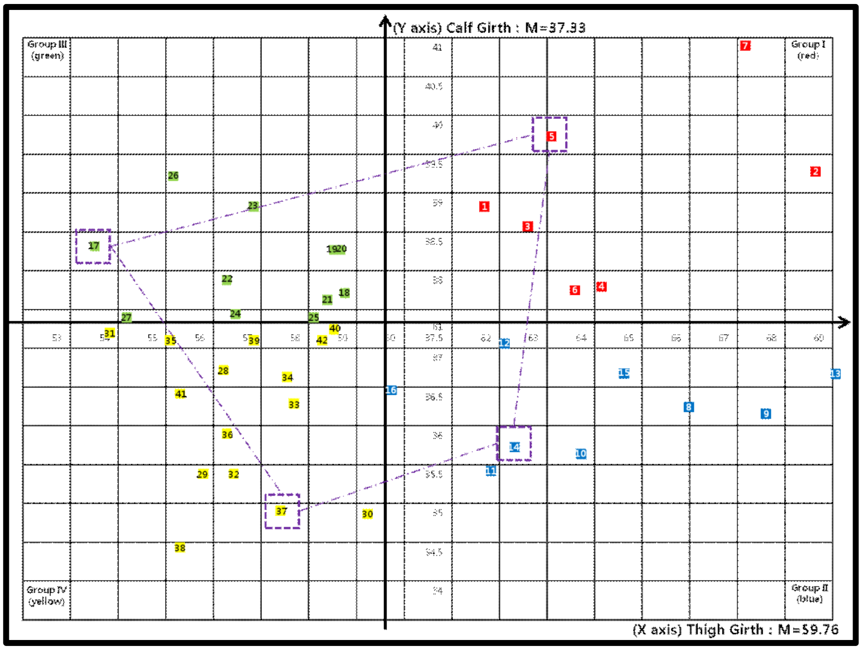
This study examined the process of extracting male muscular lower body types from the 3D body scan data base of the general population. The two key dimensions adopted for the classification of the male muscle lower body types were thigh girth and calf girth. The data base utilized was 3D body shape database in the 6th Size Korea (2010).

The men in their 30s were classified into four groups by their thigh and calf girths. The type Ⅰ had the thigh and calf developed body build (n=63). The type Ⅱ had the thigh developed body build (n=33), the type Ⅲ had the calf developed body build (n=28) and the type Ⅳ had thigh and calf undeveloped (n=79).

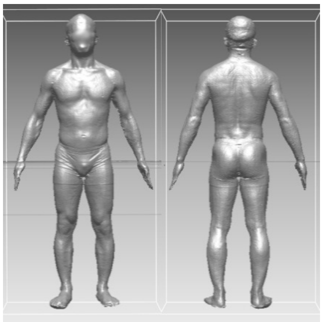
Four groups show distinct different at the width, depth, and girth dimensions. The 42 average subjects having average range of height and weight were selected from general population (n=203). Among them, thigh developed groups had a thigh girth over 60cm, calf developed groups had a calf girth over 38cm. In each group, one representative subject was selected.

〈Table 6〉 Body measurements of the average subjects (n=42)

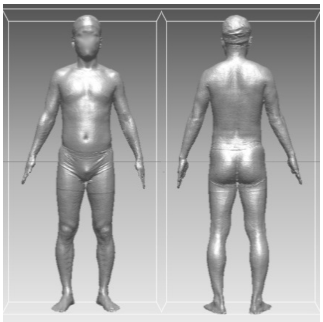
Items / Groups	Subjects	BMI	Weight (kg)	Stature (cm)	Thigh girth (cm)	Calf girth (cm)	Thigh G./ calf G.(cm)
Group Ⅰ	1	24.7	71.4	169.93	61.88	38.98	1.59
	2	24.5	70.4	170.68	68.75	39.25	1.75
	3	25.5	73.4	170.93	62.78	38.53	1.63
	4	24.0	72.1	174.18	64.25	37.73	1.70
	5	25.1	71.7	169.93	63.02	39.69	1.59
	6	25.7	75.8	173.18	63.62	37.58	1.69
	7	25.1	73.7	171.43	67.22	40.99	1.64
Group Ⅱ	8	25.9	75.7	172.93	64.72	36.72	1.76
	9	25.7	76.5	174.18	67.74	36.22	1.87
	10	25.1	75.7	174.68	63.89	35.66	1.79
	11	25.6	74.2	172.43	61.93	35.49	1.74
	12	25.7	73.9	171.32	62.07	37.10	1.67
	13	25.1	72.5	171.18	69.37	36.65	1.89
	14	24.6	72.9	173.93	62.44	35.74	1.75
	15	24.2	70.0	171.68	66.09	36.23	1.82
	16	24.2	73.4	174.68	59.83	36.48	1.64
Group Ⅲ	17	23.2	68.4	173.43	53.67	38.32	1.40
	18	22.6	66.4	173.43	58.91	37.68	1.56
	19	23.5	67.7	170.93	58.64	38.27	1.53
	20	24.8	69.7	170.93	58.64	38.27	1.53
	21	25.5	73.6	170.43	58.47	37.60	1.56
	22	24.5	70.4	170.43	56.29	37.92	1.48
	23	24.4	73.6	173.18	56.99	38.81	1.47
	24	22.8	67.4	172.18	56.57	37.44	1.51
	25	24.3	73.7	174.18	58.12	37.43	1.55
	26	23.4	69.9	173.68	55.40	39.23	1.41
	27	23.6	68.0	174.43	54.36	37.43	1.45
Group Ⅳ	28	23.7	68.0	171.18	56.29	36.71	1.53
	29	24.7	73.6	173.43	55.98	35.39	1.58
	30	24.3	69.3	171.43	57.82	36.25	1.60
	31	23.8	71.2	173.68	53.91	37.28	1.45
	32	24.4	70.2	170.93	56.46	35.46	1.59
	33	22.7	67.1	171.68	59.12	34.87	1.70
	34	24.4	71.3	171.62	57.60	36.66	1.57
	35	22.7	66.2	170.43	55.08	37.17	1.48
	36	22.1	67.6	175.18	56.18	35.95	1.56
	37	22.8	67.9	171.93	57.42	34.99	1.64
	38	23.1	70.3	174.43	55.49	34.40	1.61
	39	23.7	69.5	170.68	56.90	37.12	1.53
	40	24.6	73.3	173.18	58.59	37.27	1.57
	41	23.3	68.1	170.93	55.25	36.49	1.51
	42	22.9	66.8	170.68	58.22	37.10	1.57



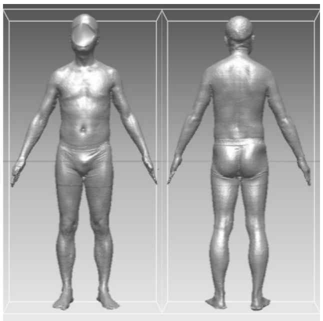
〈Fig. 1〉 Average subjects distribution in each group



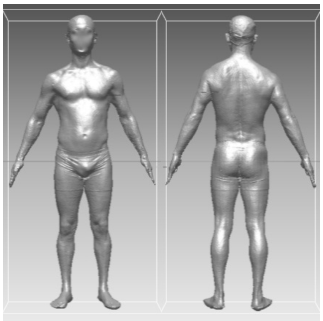
(a) Subject #5 (Group Ⅰ)



(b) Subject #14 (Group Ⅱ)



(c) Subject #17 (Group Ⅲ)



(d) Subject #37 (Group Ⅳ)

〈Fig. 2〉 Representative subjects of four groups

The results of this study imply that the thigh and calf girth are reliable key dimensions classifying muscle developed lower body build of men. The process of analyzing the postures from front, back and side view of the 3D scan shape data was useful.

The suggested method might be successful to select the lower body muscular male subjects from general population. The results of this study were limited in the male subjects in their 30s. The following studies will need to work on applying for this method for other age groups.

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