

U.S. Sizing Standards and the U.S. Female Consumer

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ABSTRACT

The Ready-To-Wear apparel customers of today, face a wide range of problems when attempting to buy apparel. They must try on garments of various sizes before they find one that fits them. In addition, they often have to make alterations to the garments since the fit is unsatisfactory. The American Society of Testing and Materials (ASTM) issued the present standard for body measurements for most figure types based on the PS42-70 database that was developed from anthropometric research conducted in 1941 by O'Brien and Shelton. That study consisted of a convenience sample of young, white, southern US women volunteers. The body shapes of people have undergone wide variations since that time due to generational variability, gender and race variability, changing lifestyles (nutrition, activities, environment, etc.), and other demographic changes. This makes it necessary to verify the accuracy of the existing sizing standards in fitting the current population.

A system was established to compare the body measurements of female subjects with existing sizing standards and identify the size that most closely fit each. In addition, the newly developed computer code determined the number of standard measurements that were out of tolerance from each of the subject's measurements. The standard measurements that were consistently out of tolerance from the sample measurements were also determined.

The current sizing standards were significantly insufficient at describing the body shapes/sizes of most of the subjects compared in this study. Inconsistencies existed in more than 50% of the measurements compared within the one size that was determined to provide the "best fit" for each subject. These findings suggest that researchers could significantly impact consumer satisfaction with the fit of apparel by working to redevelop the sizing systems to more accurately reflect the shapes of today's consumers.

Keywords: Sizing Standards, Best Fit Software System, fit, anthropometric research, sizing systems

1 Introduction

The Ready-To-Wear apparel customers of today face a wide range of problems when attempting to buy apparel. They must try on garments of various sizes before they find one that fits them. In addition, they often have to make alterations to the garments since the fit is unsatisfactory. Female consumers are left with great variation in size charts, figure types and proportions within the U.S. domestic apparel sizing system [1]. ASTM (formerly the American Society of Testing and Materials) issued the present standard for body

measurements for most figure types based on the PS42-70 database that was developed from anthropometric research conducted in 1941 by O'Brien and Shelton [2]. That study consisted of a convenience sample of young, white, southern US women volunteers. The sizing systems used by the apparel manufacturers are not standardized as they use their own sizing systems based on their end markets. According to McVey, incorrect sizing is the number one reason for returns [3]. Confusion and backlash from consumers have forced the issue of standardization finally to be addressed [4]. In order to improve the systems and ultimately customer satisfaction with the fit of ready-to-wear apparel, it is necessary to evaluate the apparel sizing systems that have been standardized for use today.

2 History of the American Sizing Systems:

The evolution of apparel sizing system occurred due to the introduction of ready-to-wear apparel in the apparel industry. During the later part of the nineteenth century, a sizing system for women was developed by professional dressmakers, tailors, and draftsmen [5]. Their techniques for measuring and fitting their clients were unique. When the demand for mass production of garments came into being in the 1920s, the need for a standard sizing system arose, since there was variation in the measurements of the same size among the different brands. In the 1930s when mail-order houses were becoming popular, fashion brought about tight-fitting garments, which led to lots of returns of ill-fitted garments [6]. Hence, the Mail Order Association of America (MOAA) along with the U.S. Department of Agriculture and Federal and State Work Project administrators and educational institutions conducted an anthropometric survey to develop the sizing system for women's apparel. The study's primary objective was to provide data from which the garment and pattern industry could develop a sizing system acceptable to consumers. Though the sample number was large (10,042 women), it was biased since the women belonged to age group of 18-30 and they were all volunteers [6].

Results of the data collection were to operate as the basic background for inventing a sizing standard. They were organized using the control dimensions of height and weight and the theory of proportionate sizing. It was published by the U.S. Department of Agriculture as a miscellaneous publication entitled "Women's Measurements for Garment and Pattern Construction" [6].

2.1 Organization of CS215-58

It wasn't until the 1950s, after further analysis of the 1939-40 data and another request from the MOAA for a sizing standard, that a standard was proposed. A public review in the fall 1954 mail order catalogs lead to industry and consumer endorsement in 1958. This voluntary standard was published by the National Bureau of Standards (NBS) as CS215-58 titled Body Measurements for the Sizing of Women's Patterns and Apparel [7]. As a voluntary product standard, the CS215-58 could be acknowledged, discarded, or revised in part or in total by each individual apparel manufacturer.

The CS215-58 identified four classifications of women and covered nine different body types. The four classifications of women included "Misses", "Women's", "Half-Sizes", and "Juniors". Three height groups were recognized as "Tall", "Regular", and "Short". Three hip types were recognized as "Slender", "Average", and "Full". The bust was the same for all of the groups. This yielded a three-way system of the size number (based on the bust measurement), the height group, and the body type (based on the bust-hip relationship) [7]. An example of the system would be 14S+. This designation would mean a size 14 bust, short

in height, and a full hip type. A complete listing of the size ranges for each of the four classifications is covered in Table 1.

Table 1. Size Ranges For The CS215-58 Standard

Misses Regular Height (R)		Misses Tall Height (T)		Misses Short Height (S)	
<i>Hip Type</i>	<i>Sizes</i>	<i>Hip Type</i>	<i>Sizes</i>	<i>Hip Type</i>	<i>Sizes</i>
Average	8 to 22	Average	10 to 20	Average	8 to 18
Slender (-)	10 to 22	Slender (-)	12 to 18	Slender (-)	12 to 18
Full (+)	8 to 16	Full (+)	10 to 14	Full (+)	8 to 12

Women's Regular Height (R)		Women's Tall Height (T)		Half-Sizes Short Height (S)	
<i>Hip Type</i>	<i>Sizes</i>	<i>Hip Type</i>	<i>Sizes</i>	<i>Hip Type</i>	<i>Sizes</i>
Average	30 to 42	Average	32 to 40	Average	10 ½ to 24 ½
Slender (-)	32 to 42	Slender (-)	N/A	Slender (-)	12 ½ to 22 ½
Full (+)	28 to 38	Full (+)	30 to 36	Full (+)	8 ½ to 20 ½

Junior Regular Height (R)		Junior Tall Height (T)		Junior Short Height (S)	
<i>Hip Type</i>	<i>Sizes</i>	<i>Hip Type</i>	<i>Sizes</i>	<i>Hip Type</i>	<i>Sizes</i>
Average	7 to 19	Average	9 to 17	Average	9 to 15

Note: Taken from [7].

Problems did exist with the CS215-58 and were credited to the 25-year-old data, which represented obsolete and outdated body proportions [8]. At the persistence of the MOAA, the NSB brought about procedures for revising CS215-58.

2.2 The Organization of PS42-70

The only available data at the time was health surveys made in 1960-62 by the United States Public Health Service [9]. The studies followed a census plan and were thus representative of the population. Measurement included height, weight, several girths and diameters that were adequate to suggest general size, but not to the shape differences [9-10]. Because the 1939-40 study was the only resource of all-embracing measurements for the female adult population, it was again used as a base for the revision process [8]. The revision of CS215-58 was published in 1970 as PS42-70, Body Measurements for the Sizing of Women's Patterns and Apparel [11].

The health surveys of 1960-62 explained that adults were somewhat taller and heavier than those of 1940 [9]. This prompted a change in the size designations for females particularly in the PS42-70. Because the bust girth was a crucial measurement in the old and the new data, the bust girth was increased by one grade interval per size code for all figure types. The Misses and Junior figure types were also changed so that the hip girth was a constant 2" interval where the old hip girth of the CS215-58 was increased proportionate to bust girth as the size designation increased [12]. The "Slim" and "Full" hip options within all figure types were eliminated as well as the "Tall" option in the Juniors' and Women's figure types. Size ranges for each of the classifications also changed. See Table 2 for a complete listing of size ranges.

Table 2. Size Ranges In PS42-70

Juniors'		Juniors' Petite	
Sizes: 3 to 17		Sizes: 3P to 15P	
Misses'	Misses' Petite	Misses' Tall	
Sizes: 6 to 22	Sizes 8P to 18P	Sizes: 10T to 22T	
Women's		Half-Sizes	
Sizes: 34 to 52		Sizes: 12 ½ to 26 ½	

Note: Taken from [11].

Within the CS215-58 standard, the Juniors' proportions were smaller than Misses' by ½ inch at the Bust, 1 inch at the Waist, and Hip Girths, and 1/8 inch in the back length. Within the PS42-70 standard, for the same bust size code, the Misses' and Juniors' categories continue alike except Juniors' were assigned an even shorter Back Length. Sizes incorporated would span a bust range of 31 ½ to 44 inches. Changes in the dimensions of Women's sizing from the CS215-58 to the PS42-70 were restricted to increasing Bust, Waist, and Hip Girths by 1 inch and Back Length by 1/8 inch. Half-size girths were changed as in Women's but back length remained the same [8].

2.3 Current Standards for Female Clothing

2.3.1 Junior Category

For the Junior size category, there is no current standard. The most recent body measurement tables are found in the PS 42-70.

2.3.2 Misses' Category

Since 1970, no new research has been completed for the Misses' size category that would update this body measurement information. The current standard in the United States which lists body measurements of the adult female figure type, sizes 2 through 20, is the American Society of Testing and Materials (ASTM) standard #D 5585-95. The Standard Table of Body Measurements for Adult Female Misses Figure Type, Sizes 2-20 [13] publication was derived originally from the PS42-70 database, which was developed from the anthropometric research conducted in 1941 by O'Brien and Shelton.

2.3.2 Women's Category

Within the last 10 years, research was conducted at the University of Arizona by Reich and Goldsberry that represented body measurements of adult women age 55 and older [14]. The ASTM publication D 5586-95 is entitled Standard Tables of Body Measurements for Women Aged 55 and Older (All Figure Types) [15]. This research resulted from the inappropriate representation of the fit concerns for women over 55. Morris and Bader [16] documented that aging was accompanied by physical changes that took place gradually, at differing times and in varying degrees.

3 Suggested New Sizing Systems

Several studies have attempted to create new sizing systems or to suggest improvements to the current system but none have yet to be adopted by the United States government as a standard. Gazzuolo [17] developed a theoretical framework for describing body form variation, which could be useful in creating a sizing system. Her research determined that a system based on averages was inadequate. She proposed to limit the variance by sorting the sample by special user groups or by sorting the sample by a major pattern-shape variable. Visual analysis would be a crucial element in developing a standard along with dimensional data.

Salusso-Deonier [8] proposed a "Principal Component Sizing System" (PCSS) with principal components of laterality and linearity. From an analysis of body measurements of 1330 women, she concluded that a majority of the sample could not achieve appropriate fit with the PS42-70. She found that her PCSS provided "good fit" for 90% of each sub-sample tested.

McCulloch, Ashdown, and Paal [18] proposed an optimization approach to apparel sizing. Efficient sizing systems were defined based on a mathematical model of garment fit. Nonlinear optimization techniques were then used to derive a set of possible sizing systems using multidimensional information from anthropometric data. The proposed methodology enabled the development of sizing systems that could either increase accommodation of the population, reduce the number of sizes in the system, or improve the overall fit in accommodated individuals.

Robinette [19] derived an anthropometric sizing system that was based on regression estimates from the largest stature and weight values of a sample. The values selected for a given size represented only the people in that size category and were not scaled up or down from other sizes. The key dimension (height and weight) values were the largest for each category. The value of the third dimension was the top of the range. To illustrate this system, a three-dimension block example was used as in Figure 1. Size X would fit Block A and Block C, Size Y would Fit Block E and Block F, and Size Z would fit Block B and Block D. There would be a 10 unit gap occurring in some blocks. This system would have the same

number of sizes, all of the blocks would be covered, and would be covered with less error than the scaled Medium or the scaled size model.

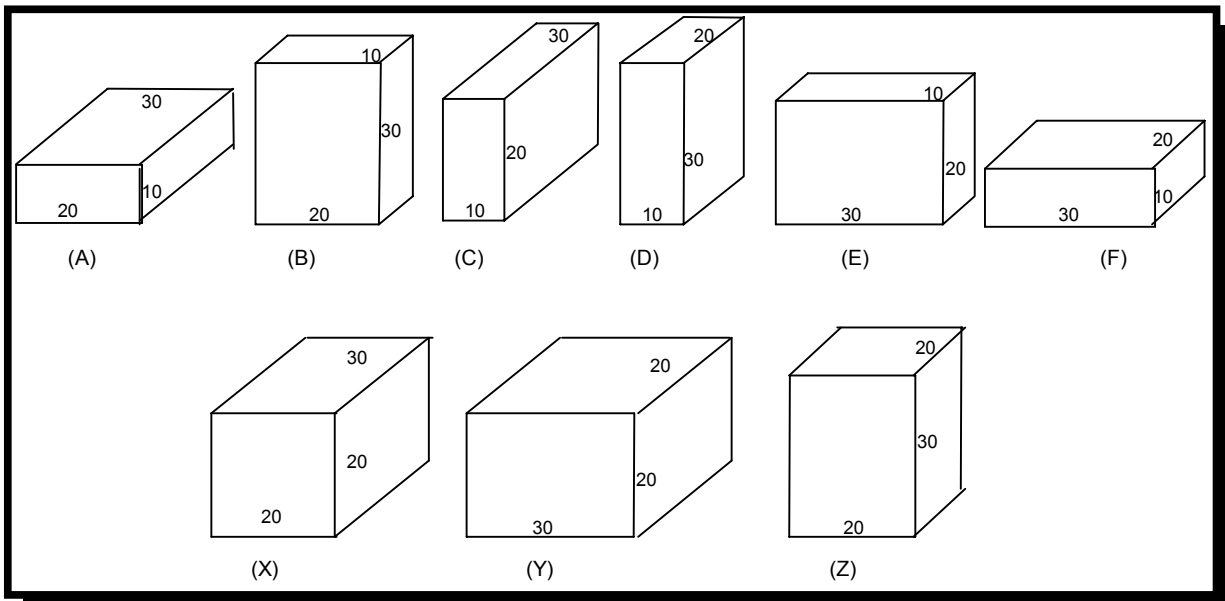


Figure 1. Illustration of Robinette's anthropometric sizing system [19].

4 Issues Concerned With Dissatisfaction Of The Sizing Standards

4.1 Defects in the 1941 Survey

Manufacturers rely on various sources, including U.S. government statistics, to guide them in formulating clothing specifications and grade rules [4]. The anthropometric research done in 1941 consisted of young white females who volunteered, from the southern states of the U.S. The study was biased since it could be seen that people who are comfortable with their body shapes would have volunteered for the study, while those who are not confident would not have volunteered. This causes dissatisfaction among today's apparel buyers since the measurement tables obtained from the 1941 survey results do not illustrate the whole population.

4.2 Fit and Sizing

Good fit is an important criterion for women as they make clothing choices [20]. Perceptions of fit may vary from one person to another. Age, body shape, fashion, and culture play an important role in people's preferences of fit. Younger women like their garments to closely fit their bodies, whereas older women give importance to comfort more than close fit when choosing their garments. Also, women who are comfortable with their body may like their clothing to fit them more closely, whereas women who are not happy with their body shapes may not like close fitting garments. Therefore, in addition to body measurements as a basis for apparel sizing, manufacturers and retailers must understand consumer's perceptions of physical comfort, psychological comfort, and appearance which all impact the consumer decision process [3].

4.3 Diversification of the Population

The population of America has become very diverse. There have been vast changes in the population patterns during the past five decades. Racial mixes are different from what they

had been during 1941. Because of these rapid changes, body measurements should be revised at least every 10 years, if not more often.

4.4 Changes in Lifestyle

People's lifestyles undergo various changes over time. Due to changes in diet habits, exercise, immigration influences, nutrition, etc. the shapes of people undergo vast transformations. With the popularity of sports and improvements in nutrition, hygiene and living standards, the population is becoming healthier, stronger and more slender [21]. (LePechoux, 1998).

5 Purpose Of The Study

The study was designed to add to our knowledge of the current Apparel Sizing Standards and allow us to evaluate the appropriateness of their design. ASTM 5585 [13] which is the most current sizing standard established for use, was taken for the study. The purpose was to determine whether the measurements of the current population of the United States are essentially represented by this apparel-sizing system. Influences of age, height, and weight on the fit accuracy of the subject with her standard size were analyzed. Twenty-one measurements were taken from the body-scan data of each female and compared with each of the standard sizes. The standard size that best fits them or the size that is closest to their body size was found. The number of times the measurements falls out of tolerance from the standard measurement was determined.

6 Data Collection And Procedures

6.1 Body Scanner and Subjects

Body scan data was available from the [TC]² Image Twin body scanner database at the College of Textiles, North Carolina State University. For the study, data was collected between January 2001 and May 2002 with a total of 254 people. The age distribution of the sample is shown in Figure 2.

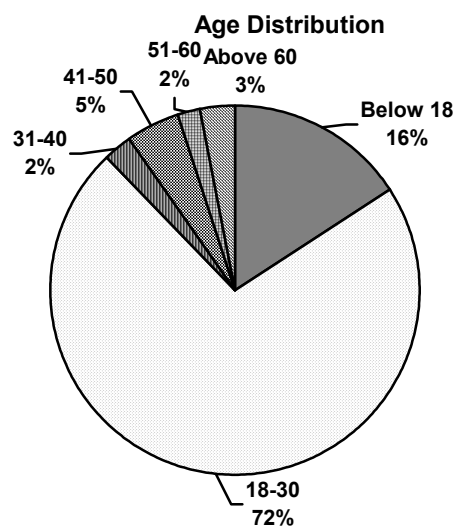


Figure2. Age Distribution of the Sample

6.2 Measurements for Comparison

The girth, vertical, width, and length measurements considered for this comparative study were chosen based on their applicability to the specific standard under study and the importance of the measurements in determining a person's specific size. There were 21 body measurement used, including: bust, waist, high hip, hip, neck base, upper arm, thigh, crotch length, cervical height, waist height, hip height, crotch height, front waist length, back waist length, rise, across shoulder, back blade width, chest width, shoulder length, arm length, and between bust points.

6.3 Database

A database was created in Microsoft Access. Two tables were created, one for storing the sizing standards (called Projections) and the other for storing the subject measurements. A 'Form' designed in the Access software compared the subject's 21 measurements with the 21 measures for each of the size standards. It then calculated and displayed the best fitting standard that is closest to the subject's body size. The result was projected in three different ways. The form was designed such that the user is able to view both the subject's measurements and the standard measurements along with the details of the subject as shown in the Figure 3. The comparison was done in three different ways – Percentage Difference, Tolerance Difference and Weighted Tolerance Difference.

	05020201	55+ JP 5586 15	Difference	Distance
Bust	36.77	37.29	1	14
Waist	29.72	33.21	1	
HighHip	37.14	39.79	1	
Hip	40.94	40.53	0	
NeckBase	15.34	15.86	1	
UpperArm	10.50	12.46	1	
ThighMax	23.66	23.52	0	
TotalCrotch	28.89	29.38	0	
CervicalHeight	55.74	60.52	1	
WaistHeight	41.69	38.34	1	
HipHeight	30.54	31.69	1	
CrotchHeight	30.54	27.57	1	
FtWaistLength	13.23	13.14	0	
BkWaistLength	14.89	15.38	1	
Rise	10.83	10.77	0	
AcrossShoulder	15.43	15.35	0	
Cross_backWidth	14.58	15.38	1	
Cross_chestWidth	16.12	14.55	1	
ShoulderLength	4.86	4.92	0	
ArmLength	21.19	22.52	1	
BustpointtoBustpoint	6.60	7.74	1	
Gender	Female	Height	64.05	
Race	White	Weight	140.00	
Age	21.00			

Figure 3. Form 'Fit'

6.3.1 Percentage Difference

The Percent Difference formula calculates the closest size based on the percentage difference between the subject's measurement and the standard measure that was determined to provide the "best fit". For every 5% difference between the standard and the subject's measurement, the 'Difference' was calculated as one and the sum of the Difference values for the 21 measurements was calculated and displayed as 'Distance'. The standard, which has the least value of 'Distance', was taken as the standard that would provide the "best fit" for the subject.

6.3.2 Tolerance Difference

For the Tolerance Difference formula, each measurement was given a tolerance limit. If the difference between the subject's measurement and the standard measurement fell within this value, the difference was counted as zero. If the measurement fell outside the tolerance value, the difference was counted as one. The tolerances were taken from the Apparel Design and Production Handbook [22], which gave a list of tolerances used customarily by the industry. Here too, the standard corresponding to the least value of 'Distance' was taken as the closest standard size to provide the "Best Fit" for the individual.

6.3.3 Weighted Tolerance

A Weighted Tolerance formula was developed to calculate the degree to which a measurement was out of tolerance with the standard. The value of 'Difference' was increased from zero to three based on the tolerance level. For example, if the difference between the subject's measurement and the standard measurement was within tolerance, the value of Difference was zero; if it was within twice the tolerance value, it was one, if it was within three times the tolerance level, it became two or else, the value of Difference was three. The 'Difference' values of all the 21 measurements were added up to get the final distance. As before, the standard size having the lowest 'Distance' value was taken as the standard size that would provide the "Best Fit" for the individual.

The results of the Percentage Difference, Tolerance Difference and Weighted Tolerance evaluations were stored in three different tables. Data analysis was done on the tables using an Excel Spreadsheet.

7 Results

Results were drawn from the number of subjects who fell out of tolerance from their ASTM Missy standard size in each of the 21 measurements.

7.1 Tolerance Level

The average number of measurements that were out of tolerance with the "Best Fit" standard was 10 out of the 21 measurements. That is, for every subject, at least 48% of the measurements were not within the tolerance limits for their "Best Fit" standard size. Among the 254 subjects, the number of people who fell out of tolerance for each measurement category was determined. The results are shown in the Figure 4.

It can be seen that among 254 subjects, 253 people fell out of tolerance from their standard in the bust measurement. Likewise, more than 100 subjects fell out of tolerance in all of the twenty-one measurements. Overall, at least 74% of the subjects fell out of tolerance from their standard size in their body measurements.

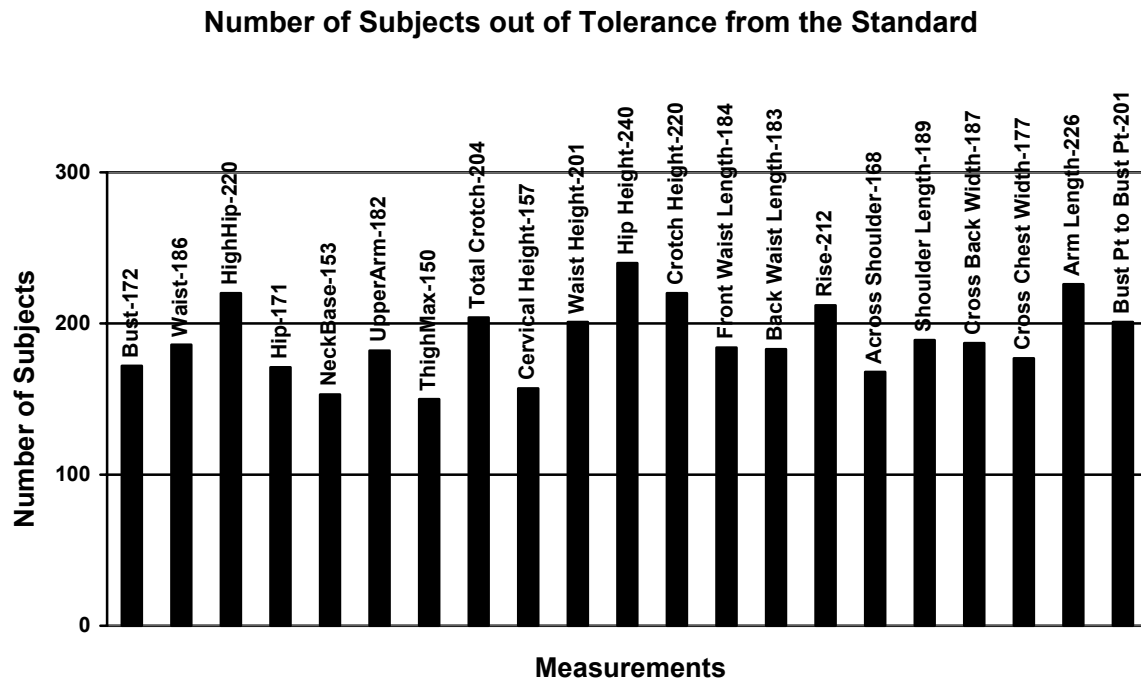


Figure 4. Tolerance Difference for each measurement.

7.2 Weighted Tolerance

From the Figure 5, we can see that most of the subjects' measurements fell out of the tolerance limit by one level. This means that the subject's measurement values differed from the standard measurement values by less than twice the tolerance value. On an average, 23% of the measurement values fell within tolerance, 57% of the measurement values fell under the tolerance level of one, 5% of the subjects' measurement values fell under a tolerance level of two and 15% of the measurements fell above the tolerance level of two.

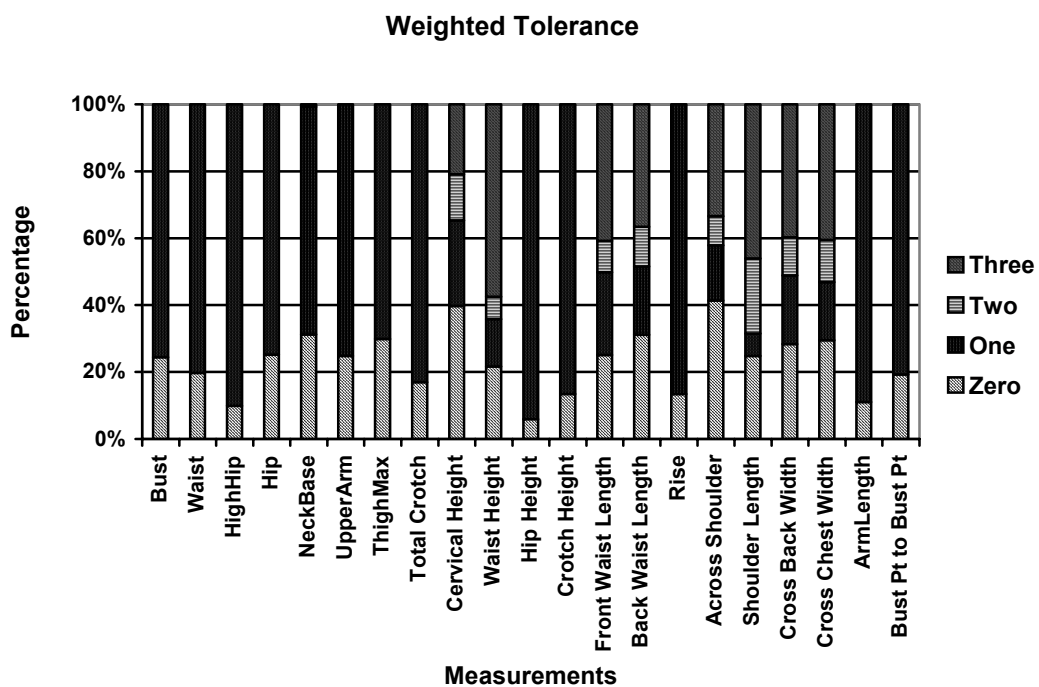


Figure 5. Weighted Tolerance Difference for each measurement.

7.3 Influence of Age on Distance Value

The distributions of 'Distance' for different age groups are as shown in Figure 6. Two types of statistical analysis were done to see the influence of a subject's age on her accuracy of fit with her "Best Fit" sizing standard. First, ANOVA was performed on the subjects' age and their 'Distance' value. It was found that as a whole, age has an influence of about 7% in determining the Distance value as illustrated in Figure 7. As age increases, the 'Distance' value decreases at a level of significance of 95%.

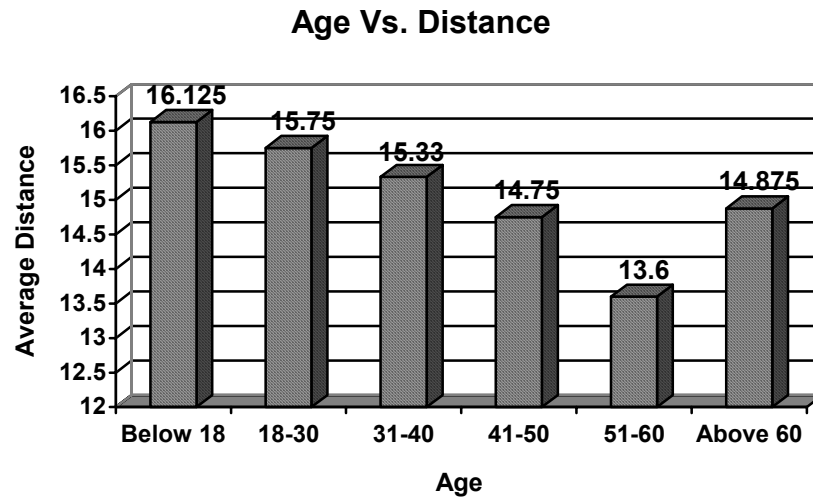


Figure 6. Influence of age on level of difference from "Best Fit standard.



Figure 7. Distribution of distance based on age.

ANOVA was done by grouping the subjects based on their age and it was found that there was a significant difference in the 'Distance' value between each age group. For example, Figure 8 illustrates the plot for the age group of 18-30 and it can be seen that as age increases there was a decrease in the 'Distance' value.

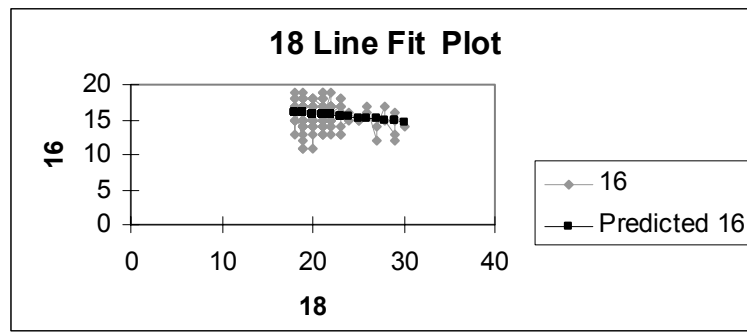


Figure 8. Distance distribution for the age group of 18-30.

7.4 Height and Distance

Height has an overall influence of 3% on determining the values of 'Distance' at a 95% significance level. Figure 9 illustrates that as height increased, the value of 'Distance' decreased.

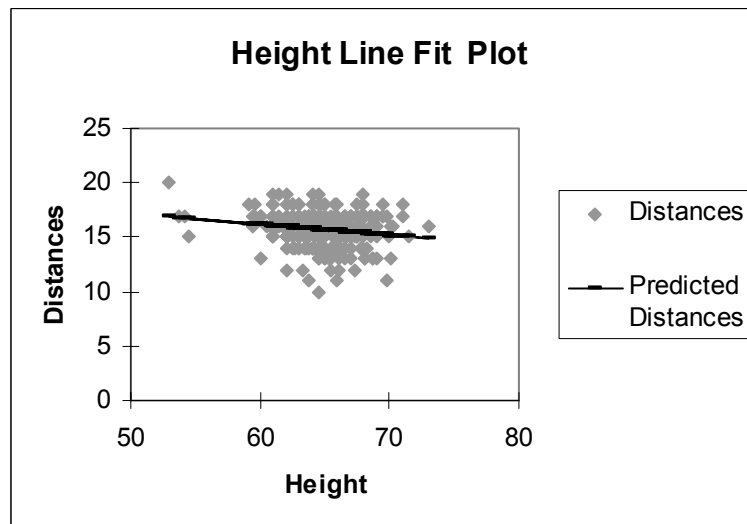


Figure 9. Distance distribution with respect to height.

7.5 Correlation Analysis

A correlation analysis was performed on the results. It was found that as age increased, the value of 'Distance' decreased. Similarly, as height increased, 'Distance' decreased; whereas an increase in Weight decreased the 'Distance' value. See Table 3 for a list of values.

Table 3. Correlation Analysis of Age, Height, Weight on Distance

	<i>Age</i>	<i>Height</i>	<i>Weight</i>	<i>Distances</i>
Age	1			
Height	0.002503	1		
Weight	0.13468	0.51935	1	
Distance	-0.26013	-0.17591	0.057958	1

8 Conclusions

The current sizing standard was significantly insufficient at describing the body shapes/sizes of most of the subjects compared in this study. Inconsistencies existed in almost 50% of the measurements compared within the one size that was determined to provide the “Best Fit” for each subject. Among the 254 subjects, 183 were between the age of 18 and 30, the age group best represented by the ASTM standards. These findings suggest that researchers could significantly impact consumer satisfaction with the fit of apparel by working to redevelop the sizing systems to more accurately reflect the shapes of today’s consumers.

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