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An anthropometric study to develop clothing charts for seventh, eighth and ninth grades of Benghazi schoolchildren

S. A. Bilhassan*, F. Albarki, A. Bu-Hager, M. Basheer, M. Ali

Department of Industrial Engineering and Manufacturing Systems, Faculty of Engineering, University of Benghazi, Benghazi, Libya.

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* Corresponding author:
E-mail address: salima.bilhassan@uob.edu.ly
S. A. Bilhassan

ABSTRACT

A sizing system classifies a specific population into homogeneous subgroups based on some key body dimensions. Individuals in the same subgroup have the same body shape characteristics, and share the same garment size. Anthropometric data plays an important role in creating clothing sizing system. The current project is the third step towards the overall objective to develop a clothing sizing system for Libyan children based on anthropometric body measurements of Libyan schoolchildren. The aim of the current project is to collect, examine and analyze anthropometric measurements for students in grades seven, eight and nine in the basic education stage, using simple statistical methods, in order to understand the body ranges and variations to develop sizing system for these grades. ANOVA tests were used to identify differences between age groups. The results showed that there are differences between most of the body measurements except the waist circumference, chest circumference, arm circumference, elbow circumference, shoulder length, front body width and back body width. Pearson correlation coefficients analysis was carried out to determine the interrelationships between the various body measurements. These findings showed that the weight and waist circumference were very strongly correlated with some other dimensions. The mean values and the standard deviation were used for creating size steps for the size chart. Three kinds of sizes were identified: L (large), M (medium) and S (small).

1. Introduction

Development of clothing sizing systems is important to reduce clothing fit problems. This is important for children because of the period of potential growth and body development. The sizes of schoolchildren's clothing affect the growth and influence body movements (Gupta and Zakaria, 2014; Kang and *et al*., 2001). So, the sizing system used to manufacturing their clothing should be based on a scientific understanding of body shapes.

The clothing sizing system gives the right clothing fit for allowing for growth. Sizing system is affected by different factors such as age and gender. Many researchers examine if body measurements had significant differences between gender and age (Ariadurai *et al*., 2009; Bari *et al*., 2015; Beazley, 1999; Chung *et al*., 2007; Gupta and Gangadhar, 2004; Gupta and Zakaria, 2014; Kang *et al*., 2001; Lee, 2013; Muslim *et al*., 2014; Zakaria, 2011) According to the results of those studies, children in the same age groups seem to have varying body dimensions. Therefore, a range of body sizes is developed based on several lengths related to height (Park and Suh, 1999) and several girths indicating body shape. Moreover, a statistically significant difference in height and almost of body measurements between age groups is reported (Bari *et al*., 2015).

Currently, in Libya, there are no size charts for all age groups. For practical purposes, it is customary in Libya to use Size charts developed from different countries. This applies to the children's wear as well. This work has made it possible to develop the size charts for boys and girls in Libyan schools. This article reports the third step towards the overall objective. The overall objective is to develop a size chart based on anthropometric body measurements of Libyan schoolchildren. This article covers the results of the seventh, eighth and ninth grades in the basic education stage.

2. Materials and Methods

2.1. Participants

Sample size includes a total of 90 Libyan primary boy's students for the study with thirty students from each grade. The age range of the sample size was kept between 12 and 14. The sample was randomly selected from one public school and one private school in the city of Benghazi during the school year (2016/2017). Measurements were taken after getting permission from the officials and principals in each school and all students voluntarily participated in the study.

2.2. The Body Measurements

Approximately twenty-eight body measurements were taken twice on each subject, including height and weight, based on the objective of the research and previous studies (Alarody *et al*., 2015; Ariadurai *et al*., 2009, Elmabrok *et al*., 2016) as shown in Table 1. During anthropometric data measurements, two kinds of equipment were used, i.e. flexible and rigid tapes. The subjects were asked not to wear shoes when their height and weight measurements were taken and the subjects were asked to wear light clothes during measurement. The measurements were taken on the right side of the body, which is actually bigger than the left side if the participants are right-handed.

2.3. Anthropometric Data Analysis

After conducting the anthropometric survey, the anthropometric data obtained from this study served as the basis of information for the analysis. Statistical Package (Minitab) Version 17.1 was employed for data inputting and analysis. Descriptive statistics including mean, min., max., and standard deviation, were used to describe and summarize the data collected. Subsequently, ANOVA test and

Pearson correlation coefficients analysis were conducted to develop the sizing system. The objective of using each test is as follows.

Table 1

Body Dimensions

No.	Body Dimensions	No.	Body Dimensions
1	Weight	15	Shoulder to waist length
2	Height	16	Front body length
3	Head circumference	17	Back body length
4	Neck circumference	18	Waist to hips length
5	Waist circumference	19	Shoulder length
6	Chest circumference	20	Front body width
7	Hip circumference	21	Back body width
8	Arm circumference	22	Knee circumference
9	Elbow circumference	23	Calf circumference
10	Wrist circumference	24	Waist to Ankle length
11	Thigh circumference	25	Knee height
12	Shoulder to shoulder length	26	Inside leg length
13	Shoulder to wrist length	27	Outside leg length
14	Shoulder to wrist length	28	Trousers length

The aim of ANOVA analysis is to identify differences between age groups. Moreover, Pearson correlation coefficients analysis was carried out to determine the interrelationships between the various body measurements. Size chart is to be developed based on the results of the analysis. Standard deviation and operations of addition or subtraction are used to determine the S (small) size and L (large) size (Adu-Boakye *et al.*, 2012).

3. Results and Discussion

3.1. Descriptive Analysis

As expected that all measurements follow a normal distribution. The mean and standard deviation for all measurements are shown in Table 2.

Table 2

The mean and standard deviation by age in cm

Body dimensions	Age 12	Age 13	Age 14
1	41.598	50.603	55.702
2	150.160	158.587	166.717
3	54.517	54.337	56.378
4	31.608	30.872	33.243
5	75.360	75.313	77.207
6	77.773	80.407	79.778
7	76.692	87.195	91.652
8	26.568	27.607	27.440
9	27.153	28.553	27.727
10	15.031	16.192	16.182
11	43.535	46.525	50.190
12	24.935	27.175	27.135
13	40.062	39.083	42.500
14	54.530	56.085	61.623
15	40.295	29.690	38.183
16	34.610	34.702	37.887
17	42.572	44.407	49.385
18	27.515	23.880	25.747
19	14.460	14.585	14.458
20	37.010	35.938	36.793
21	38.007	37.350	37.327
22	35.157	38.280	36.257
23	31.352	33.952	34.928
24	83.695	82.390	83.762
25	38.850	40.377	43.077
26	64.938	70.068	72.628
27	67.725	71.143	76.330
28	83.772	82.728	83.308

3.2. Differences of Anthropometric Measurements by gender

Table 3 shows that almost all of the anthropometric measurements differ significantly (P-value < 0.05) between the ages of respondents. These differences would be considered to produce clothing that is appropriate for children of different ages. There are no differences in the anthropometric measurements: waist circumference, chest circumference, arm circumference, elbow circumference, shoulder length, Front body width, Back body width, Waist to Ankle length and Trousers length. These differences would not be considered in design the clothing sizing systems that are appropriate for children of different age groups.

Table 3

Differences of anthropometric measurements by age using ANOVA test

Anthropometric measurements	P-value	Significant difference
5	0.657	not Sig.
6	0.402	not Sig.
8	0.498	not Sig.
9	0.291	not Sig.
19	0.939	not Sig.
20	0.450	not Sig.
21	0.670	not Sig.
24	0.537	not Sig.
28	0.724	not Sig.

3.3. Correlation Analysis

Key measurements should be those, which have the strongest correlations with most other body dimensions. The stronger the correlation, the better suited that dimension is for use as a key dimension in classifying the sample population to develop sizing system. They can be good predictors of the size of other parts of the body. The criteria for key measurements vary and there are various methods to be established in this regard. By using correlation coefficients it could be possible to identify key measurements. Correlation coefficient values indicate the strength of linear relationships between variables and were, as such, implemented in this study. The following statements explain whether there are relationships between measurements (Gupta and Gangadhar, 2004):

- If the correlation coefficient is ,0.5 then no relationship;
- If the correlation coefficient is between 0.5 and 0.75 then there is a mild relationship;
- If the correlation coefficient is 0.76 it indicates a strong relationship.

Table 4 illustrates strong relationships between measurements and shows the correlations between each measurement and the other. It is noted that the weight measurement appears to have a strong correlation with chest circumference, wrist circumference and thigh circumference. Waist circumference has a strong correlation with chest circumference and arm circumference. Moreover, height has a strong correlation with Shoulder to wrist length. In addition, chest circumferences, thigh circumference, waist to hips length and inside leg length have a strong correlation with arm circumference, calf circumference, shoulder length and outside leg length respectively. From these findings, it may be concluded that weight measurement is the most critical measurement. Weight and Waist circumference are key measurements of body garments. In general, it can be inferred that these dimensions are the important landmarks on the body and hence should be related closely to the garment measurements.

3.4. Development of Size Chart

The sizing system was developed according to the design limit, which accommodated 95% of the sample population. The development of the size chart was carried out by using values obtained from the statistical information of body dimensions. The mean values and the standard deviation were used for creating size steps for the size chart. The mean value is equivalent to the average size and the size M of every size chart.

Table 4

Correlation coefficients

	6	8	10	11	14	19	23	27
1	0.84*	0.69	0.78*	0.84*	0.54	0.41	0.75	0.35
2	0.43	0.38	0.66	0.65	0.76*	0.33	0.59	0.56
5	0.81*	0.76*	0.56	0.59	0.34	0.15	0.60	0.18
6		0.78*	0.69	0.69	0.29	0.41	0.66	0.18
11					0.56	0.36	0.77*	0.32
18						0.96*	0.16	0.19
26								0.80*

*Strong relationship

Three-size steps approach was used to develop the size chart for all body dimensions. To obtain three steps for three categories of body sizes, two standard deviations (2SD) value is added to the mean to obtain one value that is higher than the mean. Two standard deviations (−2SD) values are subtracted from the mean sequentially to obtain one value that is less than the mean for all body dimensions except key body dimensions. Based on the ANOVA test of body dimensions, there is a difference between ages in height measurement and most of the measurements. One of the values can be calculated if there is no difference between each dimension. However, three values can be calculated if there is a difference between each parameter according to ANOVA as shown in Table 5.

Determining the lower and upper limit for key dimensions (weight and waist circumference) is an important step, which helps in establishing the limit of each size and demonstrates the extent of coverage for inter size ranges for key dimensions. The lower and the upper limits are determined by adding or subtracting a value of the standard deviation of each body dimension to the midpoint value for weight and waist circumference as presented in Table 5. A value of 0.01 is subtracted from the figure obtained below the midpoint to demarcate limits between the lower value of the next size and the upper value of the previous size. In order to avoid overlapping of figures with the next size, a value of 0.01 is subtracted from the upper limit making it less than the next value according to researches that were done by Adu-Boakye *et al.*, 2012. The lower and the upper limits are important in establishing what percentages of the population are covered by each size.

4. Conclusion

The following conclusions were derived

1. As expected that all measurements follow a normal distribution.
2. From the results of ANOVA test, there were differences of anthropometric measurements between age groups except the arm waist circumference, chest circumference, arm circumference, elbow circumference, shoulder length, front body width, back body width, waist to ankle length and trousers length.
3. The key dimensions should be those, which have the strongest correlations with most other body dimensions using Pearson correlation coefficients analysis. From these findings it may be concluded that weight measurement is the most critical measurement. Weight and waist circumference are key measurements of body garments. In general, it can be inferred that theses dimensions are the important landmarks on the body and hence should be related closely to the garment measurements.
4. In conclusion, the main aspect that needs to be seen by an apparel manufacturer is clothing size. They need to know the exact size before producing their clothes. Thus, the development of sizes should be according to their procedure in order to produce an accurate size that fits the consumer's body, especially children.

Table 5

Clothing Size Chart of Respondents (CM)

Measurements		S	M	L
1				
	12	27.48- 36.88	36.89- 46.29	46.30- 55.71
	13	14.54- 38.57	38.58- 62.62	62.63- 89.61
	14	10.81- 40.73	40.74- 70.65	70.66- 100.59
2				
	12	142.22	150.16	158.10
	13	142.48	158.59	174.69
	14	153.18	166.72	180.25
3				
	12	50.50	54.52	58.53
	13	49.36	54.34	59.32
	14	50.62	56.38	62.14
4				
	12	28.14	31.61	35.08
	13	25.98	30.87	35.76
	14	28.06	33.24	38.43
5		40.05-67.18	67.19-85.32	85.33-103.47
6		64.09	79.32	94.55
7				
	12	47.52	76.69	105.86
	13	66.10	87.20	108.29
	14	69.90	91.65	113.40
8		20.00	27.21	34.41
9		21.08	27.81	34.54
10				
	12	13.52	15.03	16.54
	13	13.74	16.19	18.64
	14	13.58	16.18	18.79
11				
	12	37.77	43.54	49.30
	13	34.23	46.53	58.82
	14	38.18	50.19	62.20
12				
	12	22.02	24.94	27.85
	13	22.84	27.18	31.51
	14	24.06	27.14	30.21
13				
	12	37.00	40.06	43.12
	13	30.62	39.08	47.54
	14	34.71	42.50	50.29
14				
	12	49.21	54.53	59.85
	13	46.60	56.09	65.57
	14	55.11	61.62	68.13
15				
	12	30.17	40.30	50.42
	13	25.24	29.69	34.14
	14	20.10	38.18	56.27
16				
	12	31.26	34.61	37.96
	13	30.06	34.70	39.34
	14	27.61	37.89	48.16
17				
	12	35.37	42.57	49.78
	13	28.41	44.41	60.41
	14	38.91	49.39	59.86
18				
	12	21.18	27.52	33.85
	13	18.00	23.88	29.76
	14	19.61	25.75	31.88
19		11.46	14.50	17.55
20		29.75	36.58	43.41
21		31.15	37.56	43.97
22				
	12	30.27	35.16	40.05
	13	31.03	38.28	45.53
	14	26.95	36.26	45.56
23				
	12	26.65	31.35	36.05
	13	24.80	33.95	43.11
	14	28.23	34.93	41.62
24		73.00	83.28	93.56
25				
	12	34.29	38.85	43.41
	13	34.75	40.38	46.00
	14	34.49	43.08	51.66
26				
	12	55.44	64.94	74.44
	13	56.20	70.07	83.94
	14	63.93	72.63	81.33
27				
	12	57.16	67.73	78.29
	13	53.28	71.14	89.01
	14	64.47	76.33	88.19
28		73.97	83.27	92.57

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