International Journal of Science and Engineering Applications
Volume 11-Issue 01, 09 - 21, 2022, ISSN:- 2319 - 7560
DOI: 10.7753/IJSEA1101.1002

A Statistical Model for Analyzing Anthropometric Data and Developing Clothing Sizing Systems for Libyan School Children

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Abstract: A garment sizing system is essential for effective clothing design and production. A sizing system classifies a specific population into homogeneous subgroups based on some key dimensions. Persons of the same subgroup have the same body shape characteristics, and share the same garment size. Anthropometric data plays important role in creating clothing sizing system. The current work represents the sixth step towards the overall goal of developing the Libyan children's clothing standards system based on physical measurements of the human body of Libyan schoolchildren. The objective of the current work is to study the physical measurements of students aged 6 to 17 years in the stages of primary, secondary. The body measurements of school children in Benghazi were collected and analyzed using simple statistics methods to understand the body ranges and current of student in all stages to develop the system sizing. The measurements were collected from previous projects. Some measurements were collected to complement a work of 90 (male and female) students between 6, 7 and 8 years old from a school in Benghazi. ANOVA test was used to determine differences between age groups.

Keywords: Anthropometric data; sizing system; children clothing; schoolchildren; Children anthropometry

1. INTRODUCTION

Anthropometry is the branch of the human sciences that deals with body measurement, such as size, shape, reach, strength and working capacity (Gupta, 2014; Qutubuddin et al, 2012). This science helps designers to create spaces and products that are more suitable for the users, by taking into consideration different body dimensions and different activity requirements (Viviani et al, 2018; Shiru and Abubakar, 2012; Dawal et al, 2012). There have been several attempts to describe and represent the characteristics of entire populations (Veitch et al, 2007; Viviani et al, 2018; Shiru and Abubakar, 2012; Dawal et al, 2012; Gupta, 2014; Qutubuddin et al, 2012). There are different factors, which affected sizing system, such as gender and age. Many researchers find that there are significant differences between gender and age among almost body measurements (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, Bilhassan et al, 2018 (a); Bilhassan, 2018 (b); Bilhassan et al, 2020).

This study is motivated by the need to examine anthropometric measurements among school children in Libya; it is customary in Libya to use Size charts developed from different countries. This article reports the sixth 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 all grades (aged 6 to 17 years) in the basic education stage.

2. METHODOLOGY

This section explains the material and method used in this research.

2.1 Participants

The data was collected by students from previous projects, were used (6-17 years) (Alarody et al, 2016; Albarki, 2017; Elmabrouk, 2017; Boushagour, 2018; Elurfi et al, 2018). These data are 19 measurements and 30 students per age group. There was a lack of data for age group (6-7-8). Sample size includes a total of the 90 Libyan primary students (45 males and 45 females). The fifteen students are from each a grade. The students aged between 6 to 8 years. The sample was randomly selected from one public school in the city of Benghazi during the school year (2018/2019). Measurements were taken after getting permission from the officials and principals in each school and all students voluntarily participated in the study. Table 1 includes summary of number of students included in the study.

Table 1. Summary of number of students included in the study

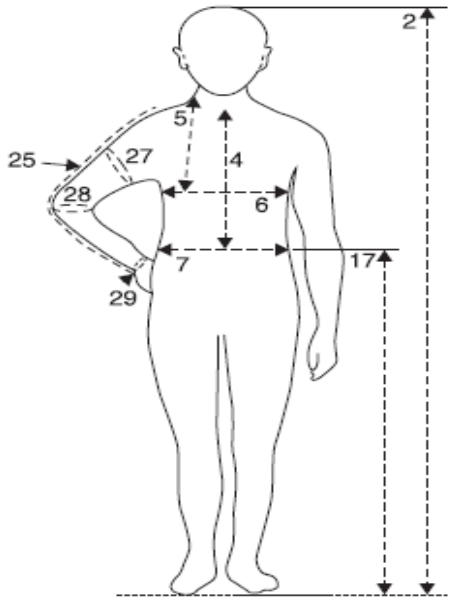
School Name	Neighborhood	Total number measured						Total
		Grade						
		6		7		8		
		M	F	M	F	M	F	
ALNAJAH SCHOOL	AL FWAYHAT	15	15	15	15	15	15	90

DOI: 10.7753/IJSEA1101.1002

Total	15	15	15	15	15	15	90

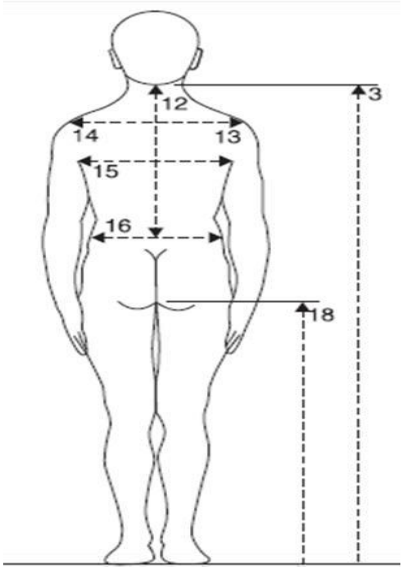
2.2 Body Measurements

Based on the objective of this project, only nineteen anthropometric dimensions are selected and used to establish the clothing sizing systems for students. These dimensions are selected based on previous studies (Ariadurai et al, 2009; Adu-Boakye et al, 2012; Alarody et al, 2016; Albarki et al, 2017; Elmabrouk et al, 2017; Boushagour et al, 2018; Elurfi et al, 2018; Bilhassan et al, 2018 (a); Bilhassan et al, 2018 (b); Bilhassan et al, 2019). Table 2 and Fig.1 to Fig.3 show the body dimensions. These measurements are used to make different types of clothing such as school uniforms. Readings were also taken two times and the average of the readings was recorded as the actual anthropometric measurements of the respondents.



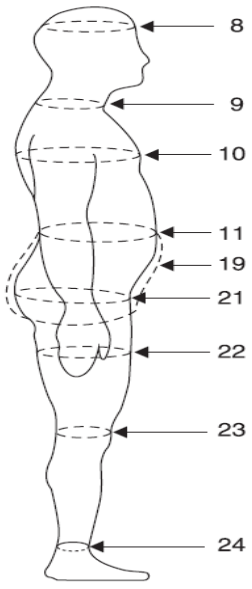
Code	*Attribute*
2	Height (Ht)
4	Centre front waist length (CFWL)
5	Highest shoulder to chest (HSC)
6	Front chest width (FCW)
7	Front waist (FW)
17	Waist height (WHt)
25	Arm length (ArL)
27	Upper arm girth (UArG)
28	Elbow girth (EG)
29	Wrist girth (WG)

Figure 1. Measures recorded from the front of the body (Gupta and Zakaria, 2014).



Code	*Attribute*
3	Cervical height (CerHt)
12	Centre back waist length (CBWL)
13	Arm hole depth (Ar.H.D)
14	Across back shoulder width (ABSW)
15	Across back width (ABW)
16	Back waist (BW)
18	Crotch height (CrHt)

Figure 2. Measures recorded from the back of the body (Gupta and Zakaria, 2014).



Code	*Attribute*
8	Head circumference (HC)
9	Mid-neck girth (MNG)
10	Chest girth (CG)
11	Waist girth (WG)
19	Crotch length (CrL)
21	Hip girth (HG)
22	Thigh girth (TG)
23	Knee girth (KG)
24	Ankle girth (AG)

Figure 3. Body girths or circumferences (Gupta and Zakaria, 2014).

DOI: 10.7753/IJSEA1101.1002

Table 2. The Anthropometric Dimension

No.	Body Dimension
1	Weight
2	Height
3	Head circumference
4	Neck circumference
5	Waist circumference
6	Chest circumference
7	Hip circumference
8	Arm circumference
9	Shoulder to shoulder length
10	Shoulder to wrist length
11	Shoulder to waist length
12	Front body length
13	Back body length
14	Waist to hips length
15	Shoulder length
16	Front body width
17	Back body width
18	Calf circumference
19	Knee circumference

2.3 Anthropometric Data Analysis

The collected data was analyzed using Minitab 17.1 statistical software. Descriptive statistics (using Microsoft Excel) such as mean, median, mode, min., max. and standard deviation were calculated for each dimension. As expected, data for all measurements followed a normal distribution. The ANOVA test was conducted to identify differences between the age groups. The results from this test were used to develop the clothing sizing system (Adu-Boakye et al., 2012).

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis

As expected that all measurements follow a normal distribution. This study found that the mean height for male is (116.54,123.99, 125.49, 137.40, 143.33, 147.15, 150.16, 154.32, 166.72, 169.08, 176.43, 176.43) cm for grade 6 to 17 respectively, while mean height for female respondents is (117.19, 126.17, 124.54, 139.70, 143.00, 152.63, 147.54, 158.59, 157.32, 158.70, 159.66, 159.33) cm for grade 6 to 17 respectively. The standard deviation (SD) for almost all dimensions is quite large, showing great variation in the measurements.

3.2 Differences of Anthropometric Measurements by Gender (T-test)

T-tests were carried out to identify differences between males and females of 6 to 17 years of age. T-tests were carried out to identify how many sizes are to be developed based on the results of the analysis (Gupta and Gangadhar, 2004). The following sections are presented the results of t-test.

3.2.1 Differences of anthropometric measurements by gender (for all ages)

The results of t-test show that almost all of the anthropometric measurements have no significant differences between the genders of respondents for all age groups 6 to 17 years. These differences would not be considered in design the clothing

sizing systems that are appropriate for children of different gender. These results diverse comare with results found in other researchers (Bilhassan et al, 2018 (b); Bilhassan et al, 2019)

There are differences in the anthropometric measurements: waist circumference, Arm circumference, and Knee circumference. These differences would be considered to design clothing sizing systems for different gender (as shown in Table 3).

Table 3. Differences of anthropometric measurements by gender

MEASUREMET	P-Value	Sig.
1	0.86	Not sig
2	0.14	Not sig
3	0.35	Not sig
4	0.29	Not sig
5	0.012	Sig
6	0.004	Not sig
7	0.35	Not sig
8	0.007	Sig
9	0.63	Not sig
10	0.80	Not sig
11	0.40	Not sig
12	0.90	Not sig
13	0.139	Not sig
14	0.95	Not sig
15	0.09	Not sig
16	0.26	Not sig
17	0.58	Not sig
18	0.44	Not sig
19	0.028	Sig

3.2.2 Differences of anthropometric measurements by gender (for ages group 6-11)

The results show that almost of the anthropometric measurements there are no differences significantly between the genders. These differences would not be considered to produce clothing that is appropriate for children of different genders. These results contrast with other researches (Bilhassan, 2018(b); Bilhassan (2019))

There are differences in the anthropometric measurements: neck circumference, waist circumference, and back body length as shown in Table 4.

3.2.3 Differences of anthropometric measurements by gender (for ages groups 12-17)

The results of t-test show that almost all of the anthropometric measurements have significant differences between the genders of respondents for age groups 12 to 17 years. These differences would be considered in design.

There are no differences in the anthropometric measurements: chest circumference, hip circumference, arm circumference, shoulder to wrist length, and shoulder to waist length, front body length, waist to hips length, back body width, calf circumference and knee circumference. These differences would not be considered to design clothing sizing systems for different gender (as shown in Table 5).

International Journal of Science and Engineering Applications
Volume 11-Issue 01, 09 - 21, 2022, ISSN:- 2319 - 7560
DOI: 10.7753/IJSEA1101.1002

3.3 Differences of Anthropometric Measurements by Age (ANOVA)

3.3.1 Difference between anthropometric measurements for female for all ages groups

Table 6 shows that all of the anthropometric measurements have difference significantly 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 for all measurements.

Table 4. Differences of anthropometric measurements by gender for age groups 6-11

MEASUREMET	P-Value	Sig.
1	0.50	not sig
2	0.27	not sig
3	0.50	not sig
4	0	Sig
5	0	Sig
6	0.77	not sig
7	0.27	not sig
8	0.21	not sig
9	0.44	not sig
10	0.10	not sig
11	0.93	not sig
12	0.08	not sig
13	0	Sig
14	0.09	not sig
15	0.11	not sig
16	0.10	not sig
17	0.17	not sig
18	0.15	not sig
19	0.14	not sig

Table 5. Differences of anthropometric measurements by gender for age groups 12-17

MEASUREMET	P-Value	Sig.
1	0.64	not sig
2	0.05	not sig
3	0.24	not sig
4	0.83	not sig
5	0.52	not sig
6	0	Sig
7	0	Sig
8	0	Sig
9	0.60	not sig
10	0	Sig
11	0.03	Sig
12	0	Sig
13	0	Sig
14	0	Sig
15	0.41	not sig
16	0.12	not sig
17	0	Sig
18	0	Sig
19	0	Sig

3.3.2 Difference between anthropometric measurements for female for ages groups 6-11 (ANOVA)

Table 7 shows that all of the anthropometric measurements have significant difference significant between the ages of respondents. These differences would be considered to produce clothing that is appropriate for children of different ages.

There are differences in the anthropometric measurements: weight, height, head circumference, neck circumference, waist circumference, chest circumference, shoulder to shoulder length, shoulder to wrist length, shoulder to waist length, front body length, back body length, waist to hip length, shoulder length, and front body width, These differences would be considered to design clothing sizing systems for different gender.

Table 6. Differences of anthropometric measurements by age groups for female (ANOVA)

MEASUREMET	P-Value	Sig.
1	0	Sig
2	0	Sig
3	0	Sig
4	0	Sig
5	0	Sig
6	0	Sig
7	0	Sig
8	0	Sig
9	0	Sig
10	0	Sig
11	0	Sig
12	0	Sig
13	0	Sig
14	0	Sig
15	0	Sig
16	0	Sig
17	0.03	Sig
18	0.02	Sig
19	0.01	Sig

Table 7. Differences of anthropometric measurements by age groups 6-11 for female (ANOVA)

MEASUREMET	P-Value	Sig.
1	<0.01	Sig
2	<0.01	Sig

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3	<0.01	Sig
4	<0.01	Sig
5	<0.01	Sig
6	<0.01	Sig
7	0.51	not Sig
8	0.08	not sig
9	0.04	Sig
10	<0.01	Sig
11	<0.01	Sig
12	<0.01	Sig
13	0.03	Sig
14	0.03	Sig
15	0.04	Sig
16	0.13	Sig
17	0.06	not sig
18	0.05	not sig
19	0.05	not sig

3.3.3 Difference between anthropometric measurements for female for ages groups 12-17

The results of ANOVA show that almost all of the anthropometric measurements have significant differences between the genders of respondents for age groups 12 to 17 years. These differences would be considered in design. There are differences in the anthropometric for all measurements except back body width as shown in Table 8.

Table 8. Differences of anthropometric measurements by age groups 12-17 for female (ANOVA)

MEASUREMET	P-Value	Sig.
1	<0.01	sig
2	<0.01	sig
3	<0.01	sig
4	<0.01	sig
5	<0.01	sig
6	<0.01	Sig
7	<0.01	sig
8	<0.01	sig
9	<0.01	sig
10	<0.01	sig
11	<0.01	sig
12	<0.01	sig
13	<0.01	sig
14	<0.01	sig
15	<0.01	sig
16	<0.01	sig
17	0.37	not sig
18	<0.01	sig
19	<0.01	sig

3.3.4 Differences between anthropometric measurements for male for all year

There are differences in the anthropometric for all measurements (table 9).

Table 9. Differences of anthropometric measurements by all year for male (ANOVA)

MEASUREMET	P-Value	Sig.
1	<0.01	Sig
2	<0.01	Sig
3	<0.01	Sig
4	<0.01	Sig
5	<0.01	Sig
6	<0.01	Sig
7	<0.01	Sig
8	<0.01	Sig
9	<0.01	Sig
10	<0.01	Sig
11	<0.01	Sig
12	<0.01	Sig
13	<0.01	Sig
14	<0.01	Sig
15	<0.01	Sig
16	<0.01	Sig
17	0.37	Sig
18	<0.01	Sig
19	<0.01	Sig

3.3.5 Difference between anthropometric measurements for male for ages groups 6-11

Table 10 shows that all of the anthropometric measurements are difference significantly 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: 8, 16 and 17. These differences would not be considered in design the clothing sizing systems that are appropriate for children of different age groups. There are differences in the anthropometric for all measurements except arm circumference.

Table 10. Differences of anthropometric measurements by age groups 6-12 for female (ANOVA)

MEASUREMET	P-Value	Sig.
1	<0.01	Sig
2	<0.01	Sig
3	<0.01	Sig
4	<0.01	Sig
5	<0.01	Sig
6	<0.01	Sig
7	<0.01	Sig
8	0.26	not sig
9	<0.01	Sig
10	<0.01	Sig
11	<0.01	Sig
12	<0.01	Sig
13	<0.01	sig
14	<0.01	sig
15	<0.01	sig
16	<0.01	sig
17	<0.01	sig

DOI: 10.7753/IJSEA1101.1002

18	<0.01	sig
19	<0.01	sig

3.3.6 Differences for male for ages groups 12-17

Table 11 shows that all of the anthropometric measurements are difference significantly 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 measurement 7.

These differences would not be considered in design the clothing sizing systems that are appropriate for children of different age groups.

There are differences in the anthropometric for all measurements.

3.4 Correlation Analysis

A key measurement should also be a body measurement with strong relationships with most other body dimensions. Consequently based on this selection, it was possible 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. Pearson correlation coefficients analysis was carried out to determine the interrelationships between the various body measurements. The following statements explain the strength of the relationship between measurements:

- If correlation coefficient is , 0.5 then no relationship;
- If correlation coefficient is between 0.5 and 0.75 then there is a mild relationship;
- If correlation coefficient is 0.76 it indicates a strong relationship (Gupta and Gangadhar, 2004).

Table 11. Differences of anthropometric measurements by age groups 12-17 for male (ANOVA)

MEASUREMET	P-Value	Sig.
1	<0.01	Sig
2	<0.01	Sig
3	<0.01	Sig
4	<0.01	Sig
5	<0.01	Sig
6	<0.01	Sig
7	<0.01	Sig
8	<0.01	Sig
9	<0.01	Sig
10	<0.01	Sig
11	<0.01	Sig
12	<0.01	Sig
13	<0.01	Sig
14	<0.01	Sig
15	<0.01	Sig
16	<0.01	Sig
17	<0.01	Sig
18	<0.01	Sig
19	0.01	Sig

3.4.1 Correlation analysis for female

It is noted that the weight measurement strong correlation with height and waist circumference. All results for strong relationship between measurements were presented in Table 12.

Additionally front body width has strong with back body width, calf circumference, knee circumference. Additionally back body width has strong with calf circumference and knee circumference. Additionally calf circumference has strong with knee circumference. From these results, it may be concluded that weight measurement is the most critical measurement is shoulder to shoulder length and shoulder to wrist length and shoulder to waist length common to 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.

3.4.2 Correlation analysis for male

The results illustrate relationships between measurements and shows the correlation coefficients between each measurement and the other. It is noted that the measurement appears to have strong relationships with other measurements as shown in Table 13. From these findings it may be concluded that measurement is the most critical measurement: height, head circumference, neck circumference are key measurements to 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.

Table 12. Strong relationship between measurements for female

Dimensions	Strong relationship
1	5-2
2	8-5
3	8-5-4
4	11-8
5	-
6	7
7	-
8	-
9	19-18-17-16-15-14-13-12-11-10
10	19-18-17-16-15-14-13-12-11
11	19-18-17-16-15-14-13-12
12	19-18-17-16-15-14-13
13	19-18-17-16-15-14
14	19-18-17-16-15
15	19-18-17-16
16	19-18-17
17	19-18
18	19
19	-

Table 13. Strong relationship between measurements for male

Dimensions	Strong relationship
1	9-5-2
2	16-14-9-5-4
3	18-16-14-11-9-8-5-4
4	18-14-11-8-5
5	16-14-9-8

DOI: 10.7753/IJSEA1101.1002

6	19-18-7
7	19
8	18-16-14-11
9	16
10	-
11	14
12	-
13	-
14	18-16
15	-
16	-
17	18
18	19
19	-

3.5 Regression analysis

Types of regression analysis: There are two types of regression analysis; the first is linear regression, which is the most widespread. Linear regression means that we study the linear relationship. The second type is the nonlinear regression that we need when studying relationships in the form of a curve rather than a straight line.

3.5.1 Results of regression (male)

3.5.1.1 Key dimension 1

y=- 74 - 2.4 x1 - 3.54 x2 + 10.6 x3 + 0.71 x4 + 3.37 x5
where;
Y=height,
x1=neck circumference,
x2=waist circumference,
x3=shoulder to shoulder length,
x4=waist to hips lngth,
x5=front body width.

3.5.1.2 Key dimension 2

y = 38.5 + 0.100 x1 - 0.152 x2 + 0.500 x3 + 0.394 x4 - 0.0256 x5 - 0.0730 x6
0.129 x7 + 0.0973 x8
Where,
Y= head circumference,
x1= neck circumference,
x2= waist circumference,
x3=arm circumference,
x4= shoulder to shoulder length,
x5=shoulder to waist length,
x6= waist to hips length,
x7= front body width,
x8=calf circumference.

3.5.1.3 Key dimension 3

y = 7.27 + 0.032 x1 + 0.199 x2 + 0.101 x3 - 0.016 x4 + 0.417 x5
where,
Y= neck circumference,
x1= waist circumference,
x2= arm circumference,
x3= shoulder to waist length,
x4= waist to hips lngth,
x5= calf circumference

3.5.2 Results of regression (female)

3.5.2.1 Key dimension 1

y = 111 - 1.09 x1 - 0.638 x2 - 0.428 x3 + 2.32 x4 + 0.48 x5 - 1.18 x6 - 0.320 x7 + 0.028 x8
Where;
y== shoulder to waist length,
x1=front body length,
x2=back body length,
x3= waist to hips length,
x4=shoulder length,
x5=front body width,
x6=back body width,
x7= calf circumference,
x8=knee circumference.

3.5.2.2 Key dimension 2

y = - 39.6 + 0.127 x1 + 0.573 x2 + 0.165 x3 + 0.560 x4 + 0.57 x5 - 0.02 x6 + 0.199 x7 + 0.710 x8 + 0.296 x9
Where;
y=shoulder to wrist length,
x1== shoulder to waist length,
x2=front body length,
x3=back body length,
x4= waist to hips length,
x5=shoulder length,
x6=front body width,
x7=back body width,
x8= calf circumference,
x9=knee circumference.

3.5.2.3 Key dimension 3

y = 41.1 + 0.859 x1 - 0.037 x2 - 0.362 x3 - 0.135 x4 - 0.726 x5 - 0.554 x6 - 0.016 x7 + 0.001 x8 + 0.167 x9 - 0.260 x10
Where;
Y= shoulder to shoulder length,
x1=shoulder to wrist length,
x2== shoulder to waist length,
x3=front body length,
x4=back body length,
x5= waist to hips length,
x6=shoulder length,
x7=front body width,
x8=back body width,
x9= calf circumference,
x10=knee circumference.

3.6 Principle component analysis

Principal component analysis (PCA) is a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. The results of principle component analysis show in tables (Table 14 and Table 15 below for male and female).

Table 14. Principal component analysis for male

Variable	PC1	PC2	PC3
M1	-0.144	-0.357	-0.104
M2	-0.242	-0.262	-0.018
M3	0.313	0.083	0.003
M4	0.317	0.014	-0.013
M5	-0.236	-0.255	-0.088
M6	0.226	-0.262	-0.182
M7	0.151	-0.296	-0.322
M8	0.306	0.023	-0.048
M9	-0.191	-0.299	-0.051

DOI: 10.7753/IJSEA1101.1002

M10	0.013	-0.366	0.146
M11	0.250	0.024	-0.205
M12	0.197	-0.102	0.589
M13	0.032	-0.297	0.628
M14	0.310	0.006	-0.005
M15	0.228	-0.183	0.004
M16	-0.256	-0.184	-0.083
M17	0.226	-0.188	-0.030
M18	0.272	-0.194	-0.081
M19	0.146	-0.335	-0.143

Table 15. Principal component analysis for female

Variable	PC1	PC2	PC3
F1	0.027	0.312	0.447
F2	0.006	0.421	0.092
F3	0.011	-0.428	0.095
F4	0.015	-0.392	0.178
F5	0.024	0.381	0.274
F6	0.130	-0.068	0.599
F7	0.158	-0.146	0.49
F8	0.129	-0.384	0.104
F9	0.288	0.115	-0.032
F10	0.286	0.096	0.049
F11	0.283	-0.114	-0.03
F12	0.295	0.026	-0.079
F13	0.280	0.081	-0.155
F14	0.289	-0.115	-0.048
F15	0.301	-0.005	-0.086
F16	0.290	0.114	-0.107
F17	0.295	0.023	-0.076
F18	0.304	-0.001	-0.051
F19	0.303	0.028	-0.04

3.7 Development of Size Charts

The development of the size chart was carried out using values obtained from the statistical information based on the ANOVA test of body dimensions. The mean values and the standard deviations were used for creating size steps for the size chart. Therefore, different sizes of clothing for female and male aged 6 to17 years must be developed due to the differences in some measurements between age groups three sizes were developed: S (small), M (medium) and L (large).

These sizes were developed because of there were multiple body shape in each group of 6 to 17 years old (as shown in Table 16 and 17). There is a difference between ages in height measurement and most of the measurements based on ANOVA analysis. One of the values can be calculated if there is no difference between each parameter. However, three values can be calculated if there is difference between each parameter according to ANOVA.

Table 16. Size chart for age groups 6 to 11.

Measurements	Grade	Male and female		
		S	M	L
1	6	10.01	22.62	35.23
	7	16.58	26.41	36.25
	8	14.71	27.41	40.11
	9	20.87	34.07	47.27
	10	19.35	39.47	59.59
	11	22.24	46.52	70.80
2	6	105.44	116.87	128.30
	7	113.67	125.08	136.49
	8	113.85	125.01	136.18
	9	122.30	138.55	154.80
	10	131.24	143.17	155.09
	11	132.95	149.89	167.18
3	6	46.85	51.76	56.67
	7	48.93	52.82	56.72
	8	48.63	52.68	56.73
	9	48.77	53.30	57.83
	10	50.54	54.10	57.66
	11	50.75	54.17	57.58
4	6	23.13	27.18	31.23
	7	23.14	28.29	33.44
	8	24.21	28.13	32.04
	9	23.37	29.00	34.63
	10	13.87	32.45	51.03
	11	25.77	33.05	40.33
		male			Female		
		s	m	l	S	m	l
5	6	44.92	69.49	94.06	49.78	60.90	72.02
	7				51.01	61.18	71.35
	8				49.63	6.01	73.66
	9				51.42	6.71	78.25
	10				48.26	10.77	91.34
	11				48.82	9.47	86.71

Table 16. cont.

Measurements	Grade	Male and female		
		S	M	L
6	6	53.56	63.67	73.79
	7	53.27	62.76	72.25
	8	52.19	65.13	78.06
	9	45.95	67.93	89.92
	10	53.31	69.90	86.49
	11	54.55	75.45	96.35
		male			Female		
		S	m	l	S	m	l
7	6	61.34	68.00	75.53	50.07	66.30	82.53
	7	55.59	65.21	74.83			
	8	54.93	70.82	86.71			
	9	46.32	64.00	81.68			
	10	48.05	69.68	91.32			
	11	47.72	74.03	100.35			
		male and female					
		s	M	l			
8	6	16.02	22.46	28.90			
	7						
	8						
	9						
	10						

	11			
		male and female		
		s	M	l
9	6 7 8 9 10 11	26.19	35.64	45.09
		male and female		
		male and female		
		s	M	l
10	6 7 8 9 10 11	28.14	43.22	58.30
		male and famel		
		s	M	l
11	6 7 8 9 10 11	18.81	36.05	53.28
14	6 7 8 9 10 11	9.02	15.79	22.55
		male and female		
		s	M	l
15	6 7 8 9 10 11	4.35	12.28	20.20
		male and female		
16	6 7 8 9 10 11	23.62	32.47	41.32

Table 16. cont.

Measurements	Grade	Male and female		
		S	M	L
12	6 7 8 9 10 11	21.54	37.14	52.74
		male			Female		
		s	m	l	S	M	l
13	6	17.99	23.00	24.61	26.38	45.57	64.76
	7	14.12	37.37	60.61			
	8	26.18	41.10	56.02			
	9	34.16	39.90	45.64			
	10	35.64	41.25	46.86			
	11	33.63	41.03	48.43			
		male and female		
		s	M	l

Table 16. cont.

Measurements	Grade	Male			Femle		
		S	M	L	S	M	L
17	6	26.37	30.00	32.06	16.80	30.58	44.36
	7	24.60	32.30	40.01			
	8	24.43	33.32	42.22			
	9	22.74	27.83	32.93			
	10	22.80	31.57	40.33			
	11	23.07	30.63	38.20			
18	6	22.31	23.00	25.44	19.51	27.23	34.95
	7	22.91	25.13	27.36			
	8	23.01	24.77	26.54			
	9	19.84	26.37	32.89			
	10	21.30	30.20	39.10			
	11	22.37	32.23	42.10			

19	6	23.91	23.00	28.08	22.44	30.01	37.58
	7	24.47	28.19	31.91			
	8	24.52	27.56	30.59			
	9	22.27	29.93	37.60			
	10	24.52	32.53	40.55			
	11	26.01	34.30	42.59			

Table 17. size chart for age groups 12 to 17.

Measurement	Grade	Male and Female		
		S	M	L
1	12	15.58	43.62	71.67
	13	28.53	50.90	73.28
	14	27.23	54.57	81.90
	15	32.69	58.79	84.89
	16	23.07	64.72	106.36
	17	37.36	63.23	89.10
2	12	134.43	148.85	163.27
	13	141.88	156.46	171.03
	14	145.77	162.02	178.26
	15	143.89	163.89	183.89
	16	145.36	166.57	187.78
	17	146.48	167.88	189.29

Table 17. cont.

Measurement	Grade	Male and Female		
		S	M	L
3	12	50.66	54.55	58.43
	13	49.70	54.62	59.54
	14	50.00	55.95	61.90
	15	50.54	55.42	60.29
	16	51.13	55.88	60.64
	17	51.14	56.34	61.53
4	12	23.83	29.83	35.83
	13	26.16	31.32	36.47
	14	27.41	32.65	37.90
	15	25.80	35.63	45.46
	16	26.48	36.16	45.84
	17	28.39	36.95	45.51
5	12	42.64	70.59	98.53
	13	56.14	74.23	92.32
	14	56.46	75.06	93.67
	15	62.27	80.25	98.23
	16	61.97	82.33	102.69
	17	61.47	83.48	105.48

		male			female		
		s	m	l	S	m	l
6	12	67.73	77.77	87.82	39.85	69.54	99.22
	13	63.76	80.41	97.05	64.86	82.50	100.14
	14	60.79	79.78	98.77	61.55	82.60	103.64
	15	63.37	81.23	99.10	63.70	86.09	108.47
	16	64.39	84.15	103.91	73.26	87.78	102.30
	17	67.28	83.67	100.05	70.74	91.42	112.09
7	12	47.52	76.69	105.86	48.14	77.63	107.13
	13	66.10	87.20	108.29	72.76	90.58	108.40
	14	69.90	91.65	113.40	64.84	90.80	116.76
	15	54.26	75.30	96.34	74.91	97.30	119.68
	16	48.95	75.27	101.58	62.65	94.12	125.59
	17	54.40	75.27	96.14	68.73	99.41	130.08

Table 17. cont.

Measurement	Grade	male			female		
		s	m	l	S	m	l
8	12	20.81	26.57	32.33	14.16	23.67	33.17
	13	19.21	27.61	36.01	20.96	25.98	31.01
	14	19.99	27.44	34.89	20.86	26.76	32.67
	15	18.88	25.37	31.85	21.76	27.56	33.37
	16	18.22	26.40	34.58	21.80	27.43	33.06
	17	18.33	25.90	33.47	11.86	30.24	48.61

		male and female		
		s	M	l
9	12	32.55	38.72	44.89
	13	30.98	38.32	45.66
	14	30.7	39.61	48.52
	15	30.7	42.46	50.22

DOI: 10.7753/IJSEA1101.1002

	16	34.69		42.46	50.22		
	17	34.42		43.2	51.98		
		male			Female		
		s	m	L	S	M	L
10	12	49.21	54.53	59.85	43.02	53.29	63.56
	13	46.60	56.09	65.57	45.57	52.46	59.34
	14	55.11	61.62	68.13	45.72	55.63	65.54
	15	52.70	57.03	61.36	46.39	52.42	58.45
	16	51.66	56.02	60.38	45.71	53.16	60.60
	17	49.76	55.97	62.17	36.20	51.98	67.75
		male			Female		
		s	m	l	s	m	L
11	12	30.17	40.30	50.42	26.93	34.18	41.44
	13	25.24	29.69	34.14	26.28	34.54	42.80
	14	20.10	38.18	56.27	20.21	35.76	51.30
	15	37.82	43.97	50.11	31.26	35.78	40.30
	16	36.50	44.42	52.33	31.53	36.24	40.94
	17	40.92	47.40	53.88	27.14	37.88	48.62

Table 17. cont.

Measurement	Grade	male			female		
		s	m	l	s	m	l
12	12	31.26	34.61	37.96	25.17	32.25	39.33
	13	30.06	34.70	39.34	26.15	34.08	42.00
	14	27.61	37.89	48.16	28.30	35.98	43.66
	15	34.11	38.37	42.62	25.81	30.97	36.12
	16	31.06	38.50	45.94	24.21	33.08	41.94
	17	33.42	39.42	45.41	23.42	31.79	40.16
		male			female		
		s	m	l	s	m	l
13	12	35.37	42.57	49.78	28.75	35.49	42.23
	13	28.41	44.41	60.41	28.32	35.85	43.38
	14	38.00	49.09	60.18	29.86	37.20	44.55
	15	44.10	53.33	62.57	40.02	45.40	50.77
	16	43.87	53.67	63.47	37.68	44.41	51.13
	17	47.06	53.55	60.04	33.39	44.15	54.91
		male			female		
		s	m	l	s	m	l
14	12	21.18	27.52	33.85	18.20	24.52	30.84
	13	18.00	23.88	29.76	13.01	17.47	21.93
	14	18.39	26.26	34.12	19.10	22.40	25.69
	15	14.97	17.13	19.30	12.51	17.05	21.58
	16	14.82	16.63	18.45	6.70	17.78	28.87
	17	14.61	16.82	19.02	7.07	18.97	30.86
		male and female					
		s		M		l	
15	12	9.73		13.4		17.07	
	13	10.66		14.73		18.8	
	14	7.65		14.7		21.74	
	15	10.81		15.12		19.44	
	16	8.77		14.57		20.38	
	17	7.94		15.6		23.26	
		s		M		l	
16	12	28.24		36.36		44.48	
	13	28.78		35.21		41.63	
	14	26.8		35.2		43.61	
	15	28.06		37.53		47.01	
	16	26.21		35.97		45.73	
	17	26.56		37.67		48.78	

Table 17. cont.

Measurement	Grade	male and female		
		s	M	l
17	12	18.63	38.17	57.72
	13			
	14			
	15			
	16			
	17			
		male		female

DOI: 10.7753/IJSEA1101.1002

		s	m	l	s	m	l
18	12	26.65	31.35	36.05	19.58	30.72	41.87
	13	24.80	33.95	43.11	28.01	33.64	39.28
	14	27.50	36.20	44.90	27.28	33.59	39.90
	15	27.14	35.78	44.43	28.22	34.92	41.63
	16	26.02	35.03	44.05	30.05	34.91	39.77
	17	25.15	34.72	44.28	28.93	36.09	43.25
		male			female		
		s	m	l	s	m	l
19	12	30.27	35.16	40.05	36.90	44.97	53.03
	13	31.03	38.26	45.48	33.94	42.09	50.24
	14	26.95	36.26	45.56	36.71	45.00	53.29
	15	30.08	36.62	43.16	31.36	38.57	45.77
	16	15.98	37.60	59.22	30.26	39.81	49.35
	17	28.50	35.88	43.26	29.24	36.27	43.29

4. CONCLUSION

The following conclusions were derived

1. As expected that all measurements follow a normal distribution.

2. The ANOVA test was used to find the differences between age groups. From the results of these tests, there were differences of anthropometric measurements between age groups for females (ages group from 6 to 11), except hip circumference, arm circumference, back body width, calf circumference and knee circumference are no significant differences. However, most of measurements are significant difference except back body width for age group 12 to 17. For male students, all measurements are significant differences except arm circumference (age group 6-11). However, there are no significant differences between age groups (12-17) for all measurements (male students).

3. The key dimensions should be those which have the strongest correlations with most other body dimensions. Form the results, it can be concluded that Height, Head circumference and Neck circumference is very strongly correlated with some of dimensions for male students. Moreover, Shoulder to Shoulder length, shoulder to wrist length, and shoulder to waist length are key dimensions for female students. 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.

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.

5. ACKNOWLEDGMENTS

This study is a part of a BSc. project conducted at School of Industrial and Manufacturing Systems Engineering at University of Benghazi in Fall 2018-2019. The authors would like to thank all participants for their contributions.

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