Anthropometry Data for 4th Year UniMAP Student

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***Abstract*- Anthropometry is a science of measurements and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human bodies. This paper was taken out from laboratory session of EPT 433 (Ergonomics). It shows the anthropometric data of males and females student. The student have to measure their anthropometry dimensions (static dimensions) using anthropometry equipments which available in the Ergonomics Lab, Kg. Wai. There are 48 anthropometry dimensions that were measured for 36 students. From the collected data, the value of Mean, Standard deviation, , 1st, 5th, 25th, 50th, 75th, 90th, 95th, and 99th percentile were calculated.**

Keywords- Anthropometry, Ergonomics, Statistical Analysis, Anthropometric Data.

I. INTRODUCTION

A. Anthropometric Definition

Anthropometry is the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body. The name derives from 'anthropos', meaning human and 'metrikos', meaning of the pertaining of measuring (Roebuck, 1995).

Pheasant (2001) define anthropometry as the branch of the human sciences that deals with the body measurements: particularly with measurements of body size, shape, strength and working capacity meanwhile Hughes (1996) define anthropometry as the scientific measurement and collection of data about human physical characteristics and the application (engineering anthropometry) of these data in the design and evaluation of systems, equipment, manufactured products, human made environments, and facilities

The other researcher such as Openshaw and Taylor (2006) define that anthropometry is the science that measures the range of body sizes in a population. When designing a product it is important to remember that people come in many sizes and shapes. Anthropometric data varies considerably between regional populations. For example, Scandinavian populations tend to be taller, while Asian and Italian populations tend to be shorter.

B. Dimension of human body

Dimensions of the human body which influence the design of personal and operational equipment are of two types (Hughes, 1996):

a) Static dimensions, which are measurements of the head, torso, and limbs in normal positions
b) Dynamic dimensions, which measurements are taken in working positions or during movement.

However, this paper only considers the static dimension. All the data measured is in static condition.

If applicable, designers and human factors specialists shall use the relevant anthropometric design criteria and guidelines from this guide associated with (Hughes, 1996):

a) Hand and finger access
b) Handle features for lifting and carrying
c) Spacing between controls
d) Common working positions

C. Ergonomics and design

There are 5 fundamental fallacies in ergonomics which are (Pheasant, 2001):

1. Design satisfactory for me is good for all
2. Design satisfactory for average person is good for all
3. Variability in human being is so great – people adaptable
4. Ergonomics is expensive – products are purchased on appearance & styling, ignore ergonomics requirement
5. Ergonomics is an excellent idea. I always design things with ergonomics in mind – but 1 do intuitively & rely on my common sense so I don't need tables of data or empirical studies.

Pheasant (2001) highlight 3 types of information that required in optimizing the decision about dimensions selection in designing the products. They are:

1. Anthropometric of characteristics of the user population

2. The ways in which these characteristics might impose constraints upon the design
3. The criteria that define an effective match between the product & the user

Anthropometric methods are among the basic working tools for the analysis and development of engineering design requirements by human factors and ergonomics professional. Considerations include the wide range in sizes, proportions, mobility, strengths, and other factors that define human being physically. Human sensing and performance capabilities are in part related to these physical characteristics, so anthropometric concerns also influence many aspects of human factors related to physiology and psychology of comfort and perception (Roebuck, 1995).

D. Anthropometric measurement devices

Tapes can be used to measure circumferences, contours, and curvature as well as straight lines.

An anthropometer , which is a straight, graduated rod with one sliding and one fixed arm, can be used to measure the distance between two clearly identifiable body landmarks.

The spreading caliper has two curved branches joint in a hinge. The distance between the tips of the two branches is read on a scale attached on the caliper.

A small sliding compass can be used for measuring short distances, such as hand length and hand breadth. Boards with holes of varying diameters drilled on it can be used to measure finger and limb diameters.

Basic anthropometric measuring instruments are: (a) anthropometer with straight branches, (b) curved branches for anthropometer, (c) spreading calipers, (d) sliding compass.

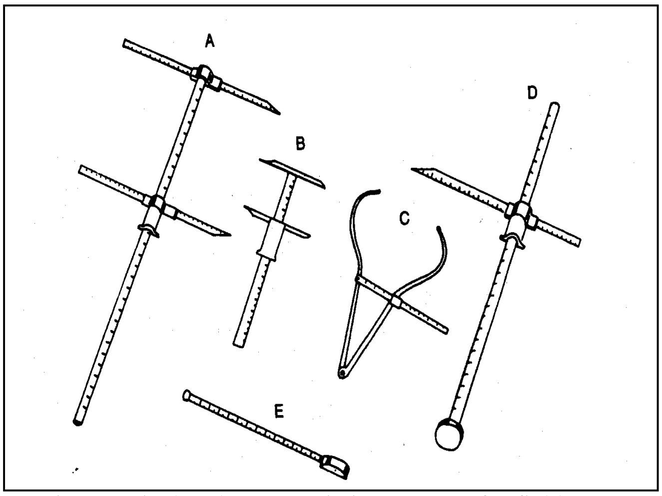

Fig.1: typical anthropometric instruments for field use

E. Standard anthropometric postures

1) Standard standing posture

The subject stand erect, pulling himself up to his full height and looking straight ahead, with his shoulders relaxed and his arms hanging loosely by his sides. He stands free of wall and measuring instruments

2) Standard sitting posture

The subject sit erects on a horizontal, flat surface, pull up to his full height and looking straight ahead. The shoulders are relaxed, with the upper arms hanging freely by the sides and forearms horizontal (i.e. the elbows are flexed to a right angle). The height of the seat is adjusted (or blocks are placed under the feet) until the thighs are horizontal and the lower legs are vertical (i.e. the knees are flexed to a right angle). Measurements are made perpendicular to two references plane is a real or imaginary plane which touches the back of the uncompressed buttocks and shoulder blades of the subject. The *seat reference point* (SRP) lies at the point of intersection of these two planes and the *median plane* of the body (i.e. the planes that divides it equally into its right and left halves)

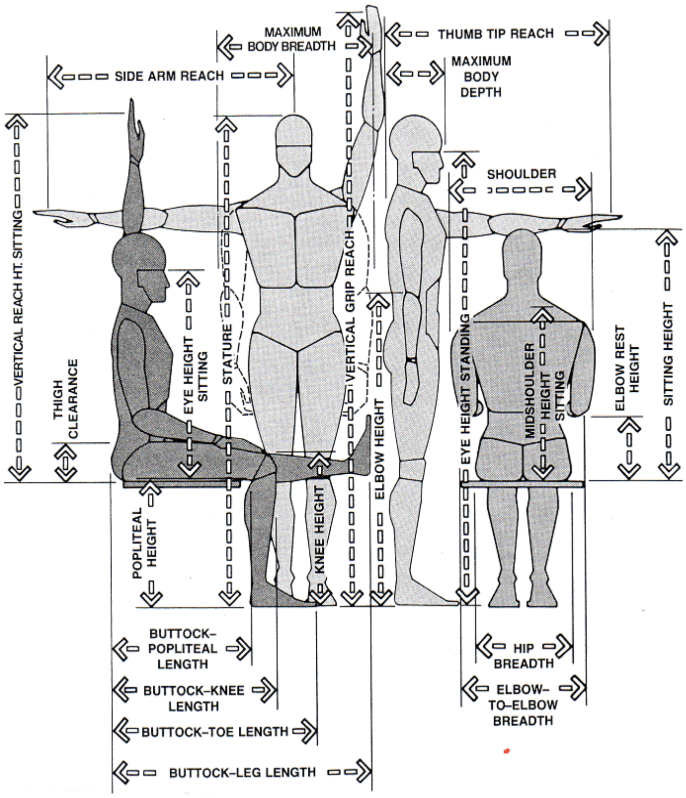

Fig.2: Anthropometric (body) measurements of most use to designers of interior spaces (Panero, J. and Zelnik, M., 1979, p. 30).

Table 1: Annotation Table

No	Dimension	Description
1	Stature	The vertical distance from the floor to the vertex (crown of the head)
2	Eye height	Vertical distance from the floor to the inner canthus (corner) of the eye
3	Shoulder height	Vertical distance from the floor to the acromion (bony tip of the shoulder)
4	Elbow height	Vertical distance from the floor to the radiale (bony landmark from the upper end of the radius which is palpable on the outer surface of the elbow)
5	Hip tip	Vertical distance from the floor to the greater trochanter (a bony prominence at the upper end of the thight bone, palpable on the lateral surface of the hip
6	Knuckle height	Vertical distance from the floor to the metacarpal III (i.e. the knuckle of the middle finger)
7	Fingertip height	Vertical distance from the floor to the dactylion (i.e. the tip of the middle finger)
8	Sitting height	Vertical distance from the sitting surface of the vertex (crown of the head)
9	Sitting eye height	Vertical distance from the sitting surface to the inner canthus of the eye
10	Sitting shoulder height	Vertical distance from the seat surface to the acromion
11	Sitting elbow height (elbow rest height)	Vertical distance from the seat surface to the underside of the elbow
12	Thigh thickness (thigh clearance)	Vertical distance from the seat surface to the top of the uncompressed soft tissue of the thigh at its thickness point, generally where it meets the obdomen
13	Buttock knee length	Horizontal distance from the back of the uncompressed buttock to the front of the kneecap
14	Buttock popliteal length	Horizontal distance from the back of the uncompressed buttock to the popliteal angle
15	Knee height	Vertical distance from the floor to the upper surface of the knee (usually measured to the quadriceps muscle rather than kneecap)
16	Popliteal height	Vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps femoris muscle inserts into the lower leg
17	Shoulder breadth (bideltoid)	Maximum horizontal breadth across the shoulders, measures to the protrusions of the deltoid muscles
18	Shoulder breadth(biacromial)	Horizontal distance across the shoulders measured between the acromia(bony points)
19	Hip breadth	Maximum horizontal distance across the hips in the sitting position
20	Chest(bust) depth	Maximum horizontal distance from the vertical reference plane to the front of the chest in men or breast in women
21	Abdominal depth	Maximum horizontal distance from the vertical refence plane to the front of the abdomen in the standard sitting position
22	Shoulder elbow length	Distance from the acromion to the underside of the elbow in the standard sitting position
23	Elbow fingertip length	Distance form the back of the elbow to the tip of the middle finger in a standard sitting position
24	Upper limb length	Distance from the acromion to the fingertip with the elbow and wrist straight(extended)
25	Shoulder grip length	Distance from the acromion to the centre of an object gripped in the hand, with the elbow and wrist straight
26	Head length	Distance between the glabella (the most anteriror point on the forehead between the brow ridges) and the occiput (back of the head) in the middle
27	Head breadth	Maximum breadth of the head above the level of the ears
28	Hand length	Distance from the crease of the wrist to the tip of the middle finger with the hand held straight and stiff
29	Hand breadth	Maximum breadth across the palm of the hand (at the distal ends of the metacarpal bones)
30	Foot length	Distance parallel to the long axis of the foot, from the back

		of the heel to the tip of the longest toe
31	Foot breadth	Maximum horizontal breadth, wherever found, across the foot perpendicular to the long axis
32	Span	Maximum horizontal distance between the fingertips when the both arm are stretched out sideways
33	Elbow span	Distance between the tips of the elbows when both upper limb are stretched out sideways and the elbows are fully flexed so that the fingertips touch the chest
34	Waist circumference	Should be measured at level of midway between the lower rib margin and iliac crest with the tape all around the body in horizontal position

F. Statistical Analysis of anthropometrics

In order to deal with variabilities in engineering design, an anthropometric dimension is analyzed as a statistical distribution rather than a single value. Normal distribution is the most commonly used statistical distribution because it approximates most anthropometric data quite closely.

1) Normal distribution

The normal distribution can be visualized as the normal curve, shown in Figure 3 as a symmetric, bell shape curve.

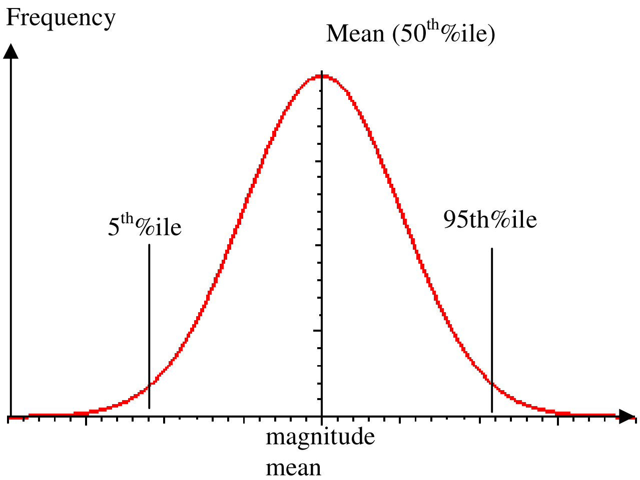

Fig.3: Normal Distribution

The mean and the standard deviation are two key parameters of the normal distribution. The mean is a measure of central tendency that tells us about the concentration of a group of scores on a scale of measurement. The mean is calculated as the sum of all the individual measurements divided by the sample size (the number of people measured).

$$\mathbf{M = \sum (X_i) / N} \qquad \mathbf{(1)}$$

M is the mean of the sample,
X_i represents the ith measurement
N is the sample size

The standard deviation is a measure of the degree of dispersion or scatter in a group of measured scores. The standard deviation, s, is calculated with the following formula:

$$s = \sqrt{(\sum (X_i - M)^2 / (N-1))} \qquad \mathbf{(2)}$$

2) Percentile

A percentile value of an anthropometric represents the percentage of the population with a body dimension of a certain size or smaller. This information is particularly important in design because it helps to estimate the percentage of the user population that will be accommodated by a specific design.

For normal distributions, percentile can be easily calculated by using table below and the following formula together

$$\mathbf{X = M + F \times s} \qquad \mathbf{(3)}$$

X = percentile value being calculated
M = mean of the distribution
F = multiplication factor corresponding to the required percentile
s = standard deviation

Below are the multiplication factors for percentile calculation:

Percentile	F
1st	-2.326
5th	-1.645
10th	-1.282
25th	-0.674
50th	0
75th	0.674
90th	1.282
95th	1.645
99th	2.326

II. RESULT AND DISCUSSION

The responders of this measurement are all students of Ergonomics class (EPT433) session 0809. Each of them has to measure all 48 anthropometry dimension of their body and record the data. Only static dimension involve in this measurements. Annotation table as in table 1 has been developed and act as a guide to the responders which dimension should be measured.

The measurement has been done using basic anthropometry measurement instrument which is available in the laboratory. The equipments are anthropometer with straight branches, curved branches for anthropometer, spreading calipers, and sliding compass. However, the measurement also can use measuring tape for example to measure the circumferences. The students have to choose the suitable instrument for the measurement since wrong instrument for wrong measurement may affect the accuracy of the measurement. Once all the measurement was completed, the value of mean, standard deviation, 1^{st}, 5^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th}, and 99^{th} percentile were calculated using equation 1, 2, and 3.

For Mean, the calculation was using equation 1.

$$\mathbf{M = \sum (X_i) / N} \qquad \mathbf{(1)}$$

M is the mean of the sample,
X_i represents the *i*th measurement
N is the sample size

For standard deviation, the calculation was using equation 2

$$s = \sqrt{\left(\sum (\mathbf{X}_i - \mathbf{M})^2 / (\mathbf{N}-1)\right)} \qquad \mathbf{(2)}$$

For percentile, the calculation was using equation 3

$$\mathbf{X = M + F \times} s \qquad \mathbf{(3)}$$

X = percentile value being calculated
M = mean of the distribution
F = multiplication factor corresponding to the required percentile
s = standard deviation

Appendix A shows the calculated data for 48 body dimensions that been measured by 4^{th} year UniMAP students (course EPT 433).

III. CONCLUSION

This paper is referring to measurement of human body dimension in static condition. In future, the dynamic condition should be considered. 48 dimensions of males and females student has been measured and value of mean, standard deviation, 1^{st}, 5^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th}, and 99^{th} percentile were calculated. This value can be used in designing the products for this population. Knowledge of the population distribution characteristics are necessary to project and extract design limits and to apply them to design problems.

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REFERENCES

[1] D. Wagner, J.A. Birt, M. Snyder, and J.P. Duncanson, “Human Factors Design Guide” *FAA Technical Center, Atlantic City International Airports NJ*, January 1996.

[2] J. J. A. Roebuck. “Anthropometric Methods: Designing to Fit the Human Body” 1995.

[3] J. Zerzan, “Anthropometry Procedures,” March, 2007.

[4] K. Kroemer, H. Kroemer, and E.K. Kroemer. “Ergonomics How to Design for Ease and Efficiency” 2nd ed., 2000.

[5] S. Openshaw, E. Taylor, “Ergonomics and Design A reference guide,” 2006.

[6] S. Pheasant, “Bodyspace; Anthropometry, Ergonomics and the Design of Work,” 2nd ed. 2001.