Int. J. Res. Ind. Eng. Vol. 7, No. 2 (2018) 224–234

International Journal of Research in Industrial Engineering
www.riejournal.com

Office Chair Design: A Systematic Approach of Ergonomic Design Based on the Anthropometric Measurement of Bangladeshi People

L. Noshin, H. Sen Gupta*, Md. G. Kibria

Department of Industrial Engineering and Management, Faculty of Mechanical Engineering, Khulna University of Engineering and Technology, Khulna, Bangladesh.

A B S T R A C T

The world of ergonomic evaluation considerate the human biomechanics and anthropometric measurement an integral part of product design and development work. In this paper, we have given an attempt to design an ergonomically fitted office chair suitable for Bangladeshi people. In this paper, the anthropometric data analysis has been done in order to determine the necessary dimensions suitable for the office chair. Lastly, an ergonomically fitted office chair is designed based on this anthropometric data analysis. The concept of the paper is to focus on the dimensional changes that the Bangladeshi people need for their comfort in the ergonomic office chair. The structural difference in different regions makes us inspired to think about the office chair ergonomics for Bangladeshi people. In short, this paper reflects the entire process of designing an ergonomic office chair suitable for them.

Keywords: Office chair, Ergonomics, Human factor, Anthropometry.

Article history: *Received: 24 February 2018* *Revised: 03 May 2018* *Accepted: 09 June 2018*

1. Introduction

In the era of industrialization, technology has unlocked an enormous way of advancement in product design and development. Product developers are challanged everyday to satisfy the need of customers for the coordination of functions, aesthetic look, ergonomics, cost, manufacturing and marketing. Ergonomics refer to the process of designing or modifying workplace, product or service suitable for human comfort level. Consideration of ergonomics has added a new

* Corresponding author
E-mail address: himadrisengupta.himu@gmail.com
DOI: 10.22105/riej.2018.128451.1040

dimension in the field of product design and development. There is the combination of phychology, engineering, anthropometry, biomechanics and many other fields. The prime concern of ergonomics is to provide the human safety and increase productivity. In order to get an ergonomic design, the anthropomrtric investigation is necessary to identify the currect measurement of human body parts. Anthropometric investigation is a process of measuring the physical dimensions and mass properties of human body. The characteristics of the human body parts varies from region to region. According to a study of National Health and Nutrition Examination Surveys (NHANES) in USA, the average height over 20 years of female is 161.8 cm and is 175.7 cm for male [1], whereas the average height of Bangladeshi midrange female is 150.6 cm and is 167.64 cm for male [2]. For this reason, the anthropometric data varies from each region. A study on anthropometric data shows that the European American has larger lower limbs than the Asian American but smaller than the African American [3]. So, considering this user diversity, arises a question in structural design and comfort level for different types of people. A lot of researches have been done in western world as well as Asian countries for ergonomically fitted office chair. The research work of O Ismaila et al. [4] showed an anthropometric analysis for furniture design in respect to Abeokuta**,** South-Western Nigeria. The same study is done by Taifa and Desai but regarding to India [5]. The difference between the O Ismaila et al. and Taifa and Desai research works is the variation in anthropometric data analysis. The anthropometric data analysis is so important that the lots of countries work on it only for data evaluation purpose. The study of athropometric measurement among Malaysian adults is an example of it [6]. A comparison of anthropometric characteristics among the countries of China, Japan, Korea**,** and Tiwan is also seen from the survey of Lin et al. [7].

The idea of "Ergonomic Office Chair for Bangladeshi people" comes from the viewpoint of these research works. In this paper, we want develop an ergonomic office chair suitable for Bangladeshi people. For this purpose, the need of office chair for Bangladeshi people is being identified first. After getting a clear concept of people's need, the anthropometric data analysis has been done. Finally, the correct measurement for ergonomic office chair has been determined. The paper narrates the reflection of the required design and the dimension of the Bangladeshi people.

2. Literature Review

In the world of industrial evaluation, the choice and taste of people for product are changing rapidly. As a result, hundreds of newer product are being introduced or being modified daily in order to achieve customer satisfaction. Now a days, along with the structural revolution, the human factor and ergonomics are the important consideration in product design. Human factor refers to the nature of physical and physiological behavior of human under a particular working condition, product or service. Today customers are more conscious than any time for choosing the right product for them. So, in order to survive in this competitive world, the firms have to focus on human comfort along with the structural improvement in design. Human factor and

ergonomics are complementary to structural design. The focus of human factor and ergonomics is to design a product suitably. The ergonomic design of a chair has become an important concern for the last 30 years [7]. With the industrial revolution, the employee's productivity concern in chair design increased more and more. Now a days, a lot of research works are going on ergonomic office chair design in order to give employee the best facility in working condition. More and more, the analysis for improving the present chair condition is performing everyday. A study of Floyd and Roberts showed the basic anatomical and phychological priciples in chair design [8]. Another work of Horton et al. [9] described that the angulation and back rest support is equally important in chair design as it infuences the head and neck posture. Groenesteijn et al. [10] showed the impact of chair characteristics like chair control, seat, back rest angle on human behaviour, and posture depending on the task they perform. According to Coleman et al. [11] the adjustable lumber support is more preferable for the users because of the difference in physical characteristics. Some patents on ergonomic office chair design have achieved a worldwide recognition. United States patent numbered 5015038, 5035466, and 4981326 are the symbol of progress in sitting and backrest design, support, and adjusting mechanism [12, 13, and 14]. Besides, the US patent numbered 5711575, 5281001, 4765684, and US 6824219 B2 showed the design of adjustable lumber support, arm support, retractable knee rest, and extending foot with ergonomic office chair [15, 16, 17, and 18]. All these researches added a new dimension in ergonomic office chair design.

The following paper is based on the ergonomic office chair design using anthropometric measurement of Bangladeshi people. The structural characteristics of diferent people varies due to the geographical variation. In western world, many of the research tasks have already done based on the anthropometric measurements of their people. Being a developing country, Bangladesh is still far behind from the research work like ergonomic office chair design. As a result, the office chairs we often have used are not as comfortable as it should be. In order to solve this problem, a simple attempt is taken to utilize the anthropometric measurements of Bangladeshi people in order to design a ergonomic office chair.

3. Research Methodology

The entire research methodology can be divided into some portions which are described below.

3.1 Sample Selection

In order to continue our research work, the first task that is done is the sample selection. Based on different office personnel and their working hours, we have surveyed almost 500 people. Among them, 250 are male and remaining are female at the range of 22 to 45 nearly.

3.2 Anthropometric Measurement Instrument

Anthropometry is a process of measuring physical dimensions and mass properties of human body. An anthropometric data helps us to find out the exact size and shape suitable for the office chair design. Anthropometric data varies from person to person. So, it is a complicated process to determine the exact size and shape of an ideal office chair. To take that measurement, mainly, three instruments are used like measuring tape, stature measuring scale and scale ruler. All these instruments are utilized to continue the survey of the 500 people.

3.3 Anthropometric Measured Position

To design an ergonomic office chair, it is important to take some specific anthropometric measurement and seventeen measurements (see Figure 1) were taken in this case. The detail description of those anthropometric measured position is represented in Table 1.

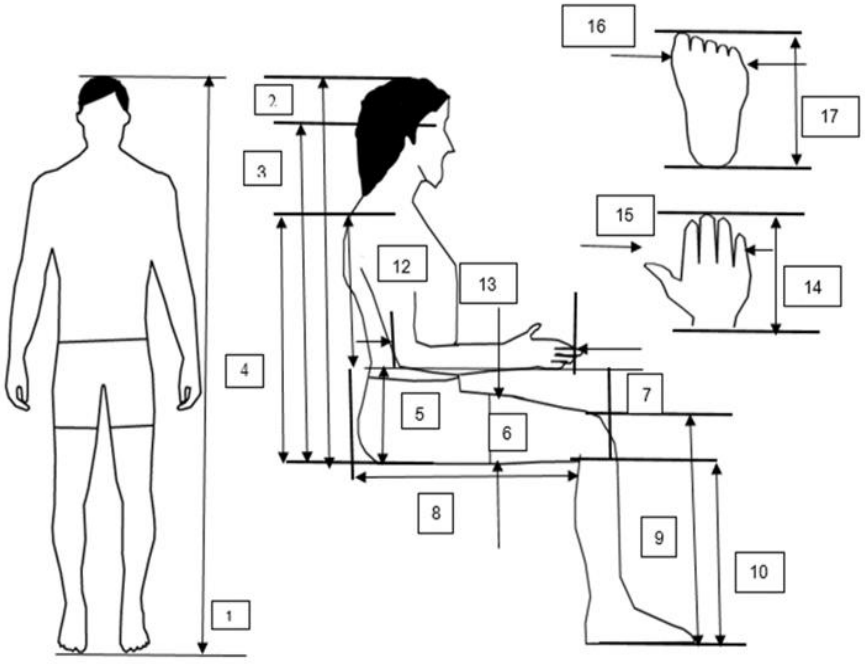

Figure 1. **Anthropometric measured position.**

Table 1. Anthropometric measured position.

Serial No.	Measurement	Description
1.	Stature	The vertical distance from the floor to the vertex
2.	Sitting Height	Vertical distance from the sitting surface to the vertex
3.	Sitting Eye Height	Vertical distance from the sitting surface to the inner corner of the eye
4.	Sitting Shoulder Height	Vertical distance from the sitting surface to the acromion.
5.	Sitting Elbow height	Vertical distance from the sitting surface to the underside of the elbow.
6.	Thigh clearance	Vertical distance from the sitting surface to the highest point of the thigh.
7.	Buttock-Knee Length	Horizontal distance from the back of the uncompressed buttocks to the front of the kneecap.
8.	Buttock-Popliteal Length	Horizontal distance from the back of the uncompressed buttocks to the back of the knee.
9.	Knee Height	Vertical distance from the floor to the upper surface of the knee.
10.	Popliteal height	Vertical distance from the floor to the popliteal angle at the inner surface of the knee.
11.	Hip Breadth	Maximum horizontal distance at the sitting position.
12.	Shoulder-Elbow Length	Distance from the acromion to underside of the elbow in a sitting position.
13.	Elbow Fingertip Length	Distance from the back of the elbow to the tip of the middle finger in a standard sitting position
14.	Hand Length	Distance from crease of the wrist to the tip of the middle finger
15.	Hand Breadth	Maximum breath across the palm of the hand
16.	Foot Length	Distance from the back of the heel to the longest toe.
17.	Foot Breadth	Maximum horizontal breadth across the foot perpendicular to the long axis

3.4 Anthropometric Data Analysis

The collected anthropometric data were analyzed with the help of Microsoft Excel and SPSS, separately for male (see Table 2) and female (see Table 3). Mainly, the 5th percentile, 50th percentile and 95th percentile were used to design the office chair.

Table 2. Statistical approach for the anthropometric measurement of male official personnel.

Measurement Name	Min Value	Max Value	5th Percentile	50th Percentile	95th Percentile	Mean	SD
Stature	151	180.5	156.85	166.25	180.02	167.175	7.59
Sitting Height	56	90	76	80	87.52	81.217	4.94
Sitting Eye Height	64	80	66.47	70.75	77.55	71.175	3.53
Sitting Shoulder Height	48.5	63	49.97	53	59	53.722	3.09
Sitting Elbow height	16	27	16.95	21.25	26	21.233	2.7
Thigh clearance	10	18.5	10.97	13	16	13.292	1.84
Buttock-Knee Length	44.5	56	45.95	49	55	49.867	3
Buttock-Popliteal Length	38	49	40.9	45	48.5	45.092	2.44
Knee Height	45	57.5	46	50.5	55.52	50.908	3.32
Popliteal height	36	49	36.97	41	46.5	41.217	3.26
Hip Breadth	29	41	30.95	36	39	35.992	2.54
Shoulder-Elbow Length	29.5	38	30	33	36	32.917	2.32
Elbow Fingertip Length	37.5	49	41.97	45	48	44.933	2.06
Hand Length	15	20	15	16.5	18	16.525	0.95
Hand Breadth	10	14	11	12.5	14	12.492	0.94
Foot Length	16	27	22.97	25.5	27	25.15	1.62
Foot Breadth	9	12	10	11	11.52	10.724	0.64

4. Result and Discussion

By analyzing all the anthropometric measurements of male and female official personnel, the final specification for the design of the ergonomic chair is proposed which can cover the maximum number of male and female. Recommended specifications for the multi-featured ergonomic office chair are given in Table 4. To make the chair fit ergonomically, anthropometric measurements were taken to the official personnel to set the final dimensional specification for the office chair. During taking the anthropometric measurement, a lot of problem were faced as people were too much uncomfortable to help us. A lot of time was taken to analyze those data. Microsoft Excel and SPSS are utilized to check the results. The anthropometric measurement of male and female are analyzed separately to understand the variance. A lot of variation was found from different perspective.

Table 3. Statistical approach for the anthropometric measurement of female official personnel.

Measurement Name	Min Value	Max Value	5th Percentile	50th Percentile	95th Percentile	Mean	SD
Stature	139.7	170.18	149.479	156.21	163.8935	156.24	5.932392
Sitting Height	70	86	72	79	84.1	78.72	3.644367
Sitting Eye Height	61	76	62.95	69.5	73	68.82	3.35
Sitting Shoulder Height	47	67	48	53	57.05	52.62	3.34
Sitting Elbow height	17	32	19	21.5	27.15	22.4	3.02
Thigh clearance	9	16	9.95	13	15.05	12.5	1.61
Buttock-Knee Length	41	64	48	54	63	54.35	4.79
Buttock-Popliteal Length	41	56	42	47	54	47.97	3.69
Knee Height	41	55	43.9	48	53.05	47.77	3.3
Popliteal height	37	53	37.95	41	45.05	41.4	2.8
Hip Breadth	34	52	42	46.5	47.05	47.2	4.41
Shoulder-Elbow Length	28	37	29	32.5	36	32.4	2.18
Elbow Fingertip Length	31	49	38.9	42	47	42.3	2.82
Hand Length	12	17	13	15	16.525	14.73	1.12
Hand Breadth	10	14	10	11	14	11.57	1.35
Foot Length	20	27	21	23	25.05	23.12	1.34
Foot Breadth	9	12	9	10	11	10.02	0.69

Using SPSS, the normal distribution test was also done to check the normality of anthropometric measurement, and found four measurement parameters for female and five measurement parameters for male, which only follow the normal distribution and that is because of the similar nature of the data. The geographic region that we surveyed carry almost the same anthropometric measurements for male and female. Due to these, the normal distribution test on SPSS shows the negative result about the normal distribution of different data.

After all of those, the final chair was designed using Solidworks 2017. The front view of the chair is illustrated in Figure 2 and the side view is represented in Figure 3 and Figure 4. As the office chair is a multi-featured product with a lot of multidirectional movement, the huge amount of time was required to complete the design. However, the research with ergonomics was very much interesting as there were a lot of things to learn.

Table 4. Recommended specification for the multi-featured ergonomic office chair.

Serial No.	Feature	Related Anthropometric Measure	Allowance		Percentile		Dimensions (cm)	Observed Criteria
			Type	Dimensions (cm)	5th Percentile	95th Percentile		
1	Adjustable Seat height	Popliteal height	Shoe Allowance	3	37.95	46.5	40.95-49.5	Female 5th Percentile + Shoe Allowance to Male 95th Percentile + Shoe Allowance
2	Depth of Seat Surface	Buttock-Popliteal Length	None	None	47	48.5	48.5	50th percentile of Male
3	Seat Surface Width	Hip breadth	Movement Allowance + Cloth Allowance	7.62	30.95	47.05	54.67	95th Percentile of Female + Movement Allowance + Cloth Allowance
4	Backrest Width	Hip breadth	Movement Allowance	5	30.95	47.05	52.05	95th Percentile of Female + Movement Allowance
5	Adjustable Backrest Height	Sitting shoulder height	Cloth Allowance	2	48	59	50-61	4th Percentile of Female + Cloth Allowance to 95th Percentile of Male + Cloth Allowance
6	Backrest Angle	None	None	None	None	None	100 -115 Degree	From Literature Review
7	Adjustable Armrest Height	Sitting elbow height	None	None	16.95	26	16.95-26	5th Percentile of Male to 95th Percentile Male
8	Armrest Length	Elbow Fingertip Length - Hand Length	None	None	27	30	30	95th Percentile of Male
9	Knee rest Length	Buttock-Knee Length	None	None	48	55	55	95th Percentile of Male

Figure 2. Designed chair in 3D front view [Designed by Solidworks 2017 x64 Edition].

Figure 3. Design chair in 3D side view [designed by solidworks 2017 x64 edition].

Figure 4. Design chair with different features in 3D side view [designed by solidworks 2017 x64 edition and rendered by luxion keyshot pro v5.0.86 [32-64bit].

5. Conclusion

In most of the country, anthropometric measurement is a great concern for ergonomic design. Numerous research is regularly done to improve the ergonomic design in order to satisfy the customer want. The paper showed a clear effort to develop an ergonomic office chair on the perspective of Bangladeshi people. The anthropometric measurement of Bangladeshi people was taken and the actual dimensions for ergonomic office chair were determined. The prime motto of the chair is "one size fits for all". In the country like Bangladesh it is a huge step to measure the anthropometric data for population as it needs a huge expenditure. Finally, the paper also recommends to carry out this type of task in our country so that people of our country be more conscious of ergonomically designed furniture.

References

[1] Fryar, C. D., Gu, Q., & Ogden, C. L. (2012). Anthropometric reference data for children and adults: United States, 2007-2010. *Vital and health statistics. Series 11, data from the national health survey*, (252), 1-48.

[2] Subramanian, S. V., Özaltin, E., & Finlay, J. E. (2011). Height of nations: A socioeconomic analysis of cohort differences and patterns among women in 54 low-to middle-income countries. *PLoS one*, *6*(4), e18962.

[3] Hedge, A., & Breeuwsma, K. (2008). Chair design beyond gender and age. *spine*, *6*, 7.

[4] O Ismaila, S., I Musa, A., B Adejuyigbe, S., & D Akinyemi, O. (2013). Anthropometric design of furniture for use in tertiary institutions in Abeokuta, South-western Nigeria. *Engineering review : International journal for publishing of original researches from the aspect of structural analysis, materials and new technologies in the field of mechanical engineering, shipbuilding, fundamental engineering sciences, computer sciences, electrical engin,*, *33*(3), 179-192.

[5] Taifa, I. W., & Desai, D. A. (2017). Anthropometric measurements for ergonomic design of students' furniture in India. *Engineering science and technology, an international journal*, *20*(1), 232-239.

[6] Karmegam, K., Sapuan, S. M., Ismail, M. Y., Ismail, N., Bahri, M. S., Shuib, S., ... & Hanapi, M. J. (2011). Anthropometric study among adults of different ethnicity in Malaysia. *International journal of physical sciences*, *6*(4), 777-788.

[7] Lin, Y. C., Wang, M. J. J., & Wang, E. M. (2004). The comparisons of anthropometric characteristics among four peoples in East Asia. *Applied ergonomics*, *35*(2), 173-178.

[8] Floyd, W. F., & Roberts, D. F. (1958). Anatomical and physiological principles in chair and table design. *Ergonomics*, *2*(1), 1-16.

[9] Horton, S. J., Johnson, G. M., & Skinner, M. A. (2010). Changes in head and neck posture using an office chair with and without lumbar roll support. *Spine*, *35*(12), E542-E548.

[10] Groenesteijn, L., Vink, P., de Looze, M., & Krause, F. (2009). Effects of differences in office chair controls, seat and backrest angle design in relation to tasks. *Applied ergonomics*, *40*(3), 362-370.

[11] Coleman, N., Hull, B. P., & Ellitt, G. (1998). An empirical study of preferred settings for lumbar support on adjustable office chairs. *Ergonomics*, *41*(4), 401-419.

[12] Mrotz III, W. C. (1991). *U.S. Patent No. 5,015,038*. Washington, DC: U.S. Patent and Trademark Office.

[13] Mathews, M. K., & Weber, J. A. (1991). *U.S. Patent No. 5,035,466*. Washington, DC: U.S. Patent and Trademark Office.

[14] Heidmann, C. (1991). *U.S. Patent No. 4,981,326*. Washington, DC: U.S. Patent and Trademark Office.
[15] Hand, R. S., Pekar, R. W., & Weber, J. A. (1999). *U.S. Patent No. 5,902,011*. Washington, DC: U.S. Patent and Trademark Office.
[16] Bergsten, J. D., & Bergsten, D. A. (1994). *U.S. Patent No. 5,281,001*. Washington, DC: U.S. Patent and Trademark Office.
[17] Kvalheim, A. M., & Pedersen, F. M. (1988). *U.S. Patent No. 4,765,684*. Washington, DC: U.S. Patent and Trademark Office.
[18] Rückstädter, H. (2004). *U.S. Patent No. 6,824,219*. Washington, DC: U.S. Patent and Trademark Office.