Journal of
Design Studio
v:5 n: 1 July 2023

Design Studio Insights: Anthropometric Considerations for Ergonomic Design of Wet Services

Sudipti Biswas
Department of Architecture, Military Institute of Science and Technology (MIST), Dhaka, Bangladesh

Received: May 7th 2023, Revised: June 19th 2023, Accepted: June 23th 2023
Refer: Biswas, S., (2023), Design Studio Insights: Anthropometric Considerations for Ergonomic Design of Wet Services, Journal of Design Studio, V.5, N.1, pp 73-84.
S. Biswas ORCID: 0000-0002-0313-7198 (sudipti.biswas@arch.mist.ac.bd)
DOI: 10.46474/jds.1292295 https://doi.org/10.46474/jds.1292295

Abstract: Ergonomics is a vital consideration for space design. In architecture education, ergonomics is usually taught in the design studio with various learning methods such as lecture, demonstration, survey, design exercise etc. This article presents an anthropometric study through a design studio exercise dedicated to learning ergonomic considerations. It presents an anthropometric dataset prepared within the studio exercise for designing lavatory and kitchen spaces. In Bangladesh, there is a scarcity of anthropometric data useful for architecture, therefore some reference standards are consulted in the academic and practical field of architecture to integrate ergonomics in design. The presented dataset can serve as a source data for this purpose. Analysis of the derived dataset also raises questions about the suitability of the commonly practiced reference standards.

Keywords: Ergonomics, Design studio, Architecture, Anthropometry, Reference standards

Introduction

Ergonomics is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, it also considers the profession that applies theory, principles, data and methods to design for optimization of human wellbeing and system performance (International Ergonomics Association, 2000). In this vein, the importance and necessity of ergonomics in the built environment is widely acclaimed for building performance, users comfort and sustainable development (Attaianese, 2012, 2017; Attaianese & Duca, 2012; Biswas et al., 2021; Charytonowicz, n.d.; Costa et al., 2012; Eilouti, 2021; Garneau & Parkinson, 2016; Hendrick, 2008; Klamklay et al., 2008; Mokdad, 2002; Olguntürk & Demirkan, 2009; Pentikis et al., 2002; Pheasant & Haslegrave, 2018; Radjiyev et al., 2015; Sanders & McCormick, 1993).

Study of ergonomics in architecture education primarily focuses on the understanding of human activities and spatial requirement for comfortable accommodation and simultaneously generate elaborate analysis of the users and their living/working environment (Biswas, 2022; Biswas et al., 2021; Villeneuve, 2000). Scholars agree that integrating ergonomics in design schools have proven success in improving performance, functional efficiency, productivity, financial efficiency, workability safety, comfort and health in the built environment (Attaianese, 2017; Attaianese & Duca, 2012; Garneau & Parkinson, 2016, Charytonowicz, 2000; Olguntürk & Demirkan, 2009; Remijn, 2006). In architecture education, human factors and ergonomics are typically taught within the design studio courses, which is the core of architecture education. Sometimes separate lecture courses are offered. Biswas et al.

(2021) suggest that studio exercise of ergonomics improves the learning capabilities of students regarding preparation of architecture program and spatial efficiency in other design exercise. With several examples, in architecture and other discipline, Moody (2011) argues in favor of the studio approach for teaching ergonomics, pointing that the studio environment is the core strength that facilitates effective learning. The studio environment facilitates formal and informal interaction between the teachers and students, lateral learning, formal and informal critiques, feedback, open and group discussion etc. Such studio environment is very much intrinsic to architecture education, and often considered a culture. However, despite the recognized significance, scholars often consider that yet there is lack of ergonomic approaches in the academic field (Attaianese & Duca, 2012; Costa et al., 2012; Fross, 2014).

In Bangladesh, ergonomics is usually taught in the design studio format (Biswas, 2022; Biswas et al., 2021). Design studios usually employ different techniques for learning along with design project exercise. Students often receive hands on training with learning from the context through workshop, site visit, site survey, survey of specific functions, precedents study, standards study etc. In this way, studio exercise produce knowledge that is useful not only for the students, but also for practical field. This article presents knowledge generated in a studio project, dedicated for learning ergonomic considerations for designing wet service spaces, at the Department of Architecture, Military Institute of Science and Technology (MIST), Bangladesh. It presents an anthropometric dataset derived under the studio exercise. Following the dearth of anthropometric data for architectural design purpose in Bangladesh, the presented dataset in this article can be utilized as a basic source for designing wet service spaces and/or similar functions. Comparison between the dataset and reference standards, commonly consulted in practice and education of architecture, indicates that there is mismatch between the standards and local context.

Data for Ergonomic Design in Bangladesh

in Bangladesh, there is a vacuum in the field of anthropometric data for architecture. Building design is regulated by the national building code (GoB, 2020) and the regulations for building construction in the Dhaka Metropolitan area (Ministry of Housing and Public Works, 2008). These guidelines may have some ergonomic consideration, but they do not mention any reference or standards.

There are studies in the health sector that have anthropometric data, but they mostly contain stature, weight, and body mass index (BMI) (Flora et al., 2009). Some studies have covered detail anthropometry of body parts, like hand, ear, face, head etc. and/or focused on specific tribal people in Bangladesh. (Akhter et al., 2010; Asadujjaman et al., 2019, 2019; Hossain, 2015; Tania et al., 2020).

Some studies covered anthropometry for furniture such as classroom and library furniture (Hoque et al., 2014; M. Parvez et al., 2022; M. S. Parvez et al., 2021; S. Parvez et al., 2022; Shah et al., 2013), hospital bed (Chakraborty et al., 2014; Islam et al., 2013)etc. These provide better dataset; however, they are not designed for architecture. Following the severe deficiency of anthropometric data for architects, architecture schools tend to rely on reference standards (Biswas, 2022; Biswas et al., 2021).

Methods and Materials

This study is primarily derived from a design studio course, namely ARCH 2101: Design Studio III in the Spring 2022 semester dedicated for learning anthropometry to integrate ergonomics in design. The author was in lead of the studio along with two other colleagues. This article focuses on the knowledge generated from an anthropometric survey within the studio exercise and further analysis of the survey results.

Project Design

The project was exercised with a series of lectures, study, demonstration, and a survey aimed to develop an understanding of anthropometric determinants of design for

specific functions, which was wet service in this case. Following lectures and literature study, demonstrations were made in the studio with live activity of the studio instructors and students with dummy fixtures and scale models to develop an understanding of the relation of human body dimensions and different postures for comfortably performing a particular task. Afterwards, an anthropometric survey was conducted.

Anthropometric Survey

The survey was conducted by the students. Participants were selected according to convenience. Body measurements were taken from 144 adult individuals 72 male and 72 female. The participants included all the students of the class, their family members, and students of other departments in MIST. All the participants participated in the survey voluntarily and with informed consent that the data would be used for academic purposes. The participants received no compensation or incentive for their participation. The age range of the participants was 18 to 67 years for female and 18 to 74 years for male.

Selection of Body Dimensions

All the dimensions considered in this study were static dimension. Dynamic dimensions are usually more applicable for designing equipment, tools workstations etc. In this study, dynamic dimensions were not essential for kitchen and lavatory function. Considering the reach related dimensions as dynamic might have brought better design consideration for reaching upper cabinets, but due to the resource constraints of dynamic dimension measurement system, reach dimensions were considered as static and measured at specific positions.

The postures were selected based on the relevance for kitchen (primarily sink) and lavatory (primarily wash basin) and based on review of three reference books that are commonly consulted in the practice and education of architecture. The books consulted are:

1. Time-Saver Standards for Building Types (De Chiara & Callender, 1990)
2. Human Dimension and Interior Space: A source Book of Design Reference Standards (Panero & Zelnik, 1979)
3. Neufert Architects Data (Neufert & Neufert, 2012)

Along with age and weight, 13 body dimensions were selected for the survey based on relevance. The dimensions are selected following the reference standards for convenient comparison. These dimensions are as follows.

Stature: It is the vertical distance from the floor to the top of the head measured while the subject stands upright and looking straight ahead (Panero & Zelnik, 1979). This data is required to determine the minimum distance of overhead obstructions from the floor.

Eye Height: It is the vertical distance from the floor to the corner of the eye measured while the subject looking straight ahead (Panero & Zelnik, 1979). This data is useful for considering the height of upper cabinet in kitchen and mirror/medicine cabinet in the lavatory.

Shoulder Height: It is the vertical distance from the floor to the top of the shoulder (acromion) measured while the subject stands upright and looking straight ahead. This data is data is useful for considering the height of elements like upper cabinet/shelf/towel rack etc. in the kitchen and lavatory (Neufert & Neufert, 2012).

Elbow Height: It is the vertical distance from the floor to the depression formed at the elbow, where the forearm meets the upper arm (Panero & Zelnik, 1979). This is required to determine the height of work counter/sink and wash basin.

Navel Height: It is the vertical distance from the floor to the navel of the subject standing upright. This measurement is considered as a substitution of waist height following the difficulty of measuring waist height. This data is associated with the comfort in bending forward which is considered to determine the height of the work counter/lower cabinet and wash basin (De Chiara & Callender, 1990; Neufert & Neufert, 2012).

Maximum Body Depth: It is the horizontal distance between the most anterior point on the

body (usually chest or abdomen) to the most posterior point (usually buttock or shoulder) (Panero & Zelnik, 1979). This body dimension must be considered to determine adequate interior space and the clearance between counters/appliances/fixtures.

Maximum Body Breadth: It is the maximum distance across the body including arms (Panero & Zelnik, 1979). The implication is similar to the maximum body depth.

Elbow Span: It is the distance between the tips of two elbows of the horizontally outstretched upper arms flexed so that the fingertips of the hands meet in front of the body while the subject stands upright. This data is required to determine adequate interior space in front of and from the side walls to use kitchen and lavatory fixtures (De Chiara & Callender, 1990; Neufert & Neufert, 2012; Panero & Zelnik, 1979).

Forward Arm Reach: The horizontal distance from the back of the shoulder to the fingertip while the subject standing upright and extending the arm forward. This distance is useful to determine adequate interior space in front of and from the front wall/furniture/fixture (De Chiara & Callender, 1990; Neufert & Neufert, 2012; Panero & Zelnik, 1979).

Forward Grip Reach: The horizontal distance from the back of the shoulder to the thumb tip measured while the subject standing upright, extending the arm forward and the index finger toughing the thumb tip (Panero & Zelnik, 1979). The implication is similar to the forward arm reach.

Overhead Reach: It is the vertical distance from the floor to the fingertip measured while the subject stands upright and extends the arm at an angle of approximate 60°. This data is useful to determine the hight of upper cabinet/shelf for comfortable use (De Chiara & Callender, 1990; Neufert & Neufert, 2012; Panero & Zelnik, 1979).

Squatting Position Width: this is the width of squatting position measured from the back to the fingertip while the subject is sitting in a squatting position with one arm extended and one knee bended. This dimension is required to decide adequate interior space in front of a furniture/fixture required for maneuvering and cleaning (De Chiara & Callender, 1990; Neufert & Neufert, 2012; Panero & Zelnik, 1979).

Squatting Position Height: This is the height of squatting position measured from the floor to the top of the head while the subject is seated in a squatting position with one arm

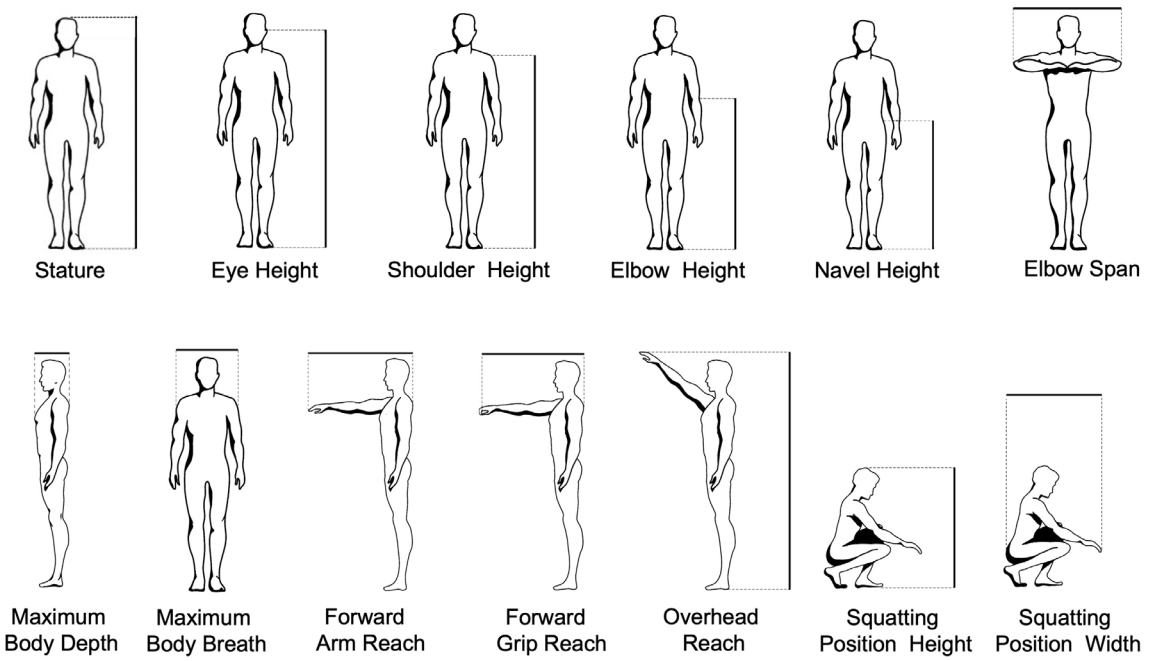

Figure 1: *Body dimensions measured in the study.*

extended and one knee bended. The implication is like the squatting position width.

These dimensions are shown graphically in the Figure 1.

Taking Measurements

For this survey state-of-the-art anthropometric tools were not available. Therefore, measurements were taken with conventional measurement tools. The students took measurements at the studio, at the hostel, and at their home. The students prepared a measuring corner in their studio, students from the other departments came to the studio and measurements were taken. All measurements were taken with the subject wearing regular summer clothing and without shoes or with socks only.

As precision measurement tools was not available, therefore each of the measurement was taken three times and the average was considered. Due to the lack of calipers, cardboards/rulers/any stiff material were used as substitution to improve the accuracy of measurements. The students worked in groups, and they assisted each other in taking measurements. This procedure is shown in the Figure 2.

Data Analysis

Statistical analysis involved simple examination of the data set through descriptive statistics. This included the mean, mode, range, standard deviation, and selected percentiles. Comparison between male and female dimensions was done with t test.

Both male and female dimensions were compared with the references. For comparison, Human Dimension and Interior Space: A source Book of Design Reference Standards (Panero & Zelnik, 1979), mentioned as HD, was preferred, because of its elaborate data for both male and female. The other references, Time-Saver Standards for Building Types (De Chiara & Callender, 1990), mentioned as TSS, and Neufert Architects Data (Neufert & Neufert, 2012), mentioned as NAD, mostly provide dimensions with gender-neutral drawings. Often, in these two references, it is possible to determine gender in the illustration with features like such as clothing, body shape, hair style etc.

Limitations

The study limitations include small sample size, lack of high-quality measuring instruments, specific reference to service function etc. As the study was carried in the design studio, therefore it was not possible to conduct a random survey of a large sample size representing the national population, and in this case, convenience sampling was the rational choice. It was a student exercise, therefore, there could be human error in precision and accuracy in taking each

Figure 2: *Students taking body measurements.*

measurement. This study particularly focused on the use of kitchen sink and wash basin, therefore, the results may be generally applicable for similar functions that require moderate forward bending, hand movement, and reach in standing position.

Result and Discussion

The survey results are shown in the Tables 1-6. The results contain statistical description of the survey data, selected percentile values, comparison between male and female dimensions and comparison of the survey data with the reference standards. All the measurements are expressed in cm.

Table 1 and Table 2 shows survey results male and female along with the reference dimensions.

Table 1: *Male anthropometric dimensions and reference standards (unit cm)*

Sl.	Anthropometric features	Male (n=72)				Reference		
		Maximum	Minimum	Mean	Std. Dev.	Male HD	Unisex NAD	Unisex TSS
1	Age	74.00	18.00	29.42	13.70	-	-	-
2	Weight	89.00	54.00	70.81	8.66	96.20	-	-
3	BMI	32.63	16.95	24.25	3.49	-	-	-
4	Stature	193.75	154.60	171.29	7.60	188.60	175.00	175.26
5	Eye Height	183.00	144.00	160.47	7.63	174.20	-	-
6	Shoulder Height	165.00	125.60	143.08	7.63	155.70	150.00	-
7	Elbow Height	120.00	95.00	108.55	5.11	120.10	-	-
8	Navel Height	114.00	87.00	100.38	6.35	-	-	-
9	Maximum Body Depth	38.00	15.24	25.48	4.14	33.00	30.00	24.13
10	Maximum Body Breadth	57.50	38.00	47.31	4.10	57.90	50.00	50.80
11	Elbow Span	101.00	80.30	90.34	4.90	-	100.00	-
12	Forward Arm Reach	107.00	76.80	85.77	5.44	-	87.50	86.36
13	Forward Grip Reach	98.00	68.00	80.18	5.96	88.90	-	-
14	Overhead Reach	230.70	183.80	201.99	10.16	-	200.00	190.50
15	Squatting Position Height	112.80	72.00	92.69	9.89	-	112.50	109.22
16	Squatting Position Width	107.00	67.90	87.67	7.87	-	70.00	55.80

Table 2: *Female anthropometric dimensions and reference standards (unit cm)*

Sl.	Anthropometric features	Female (n=72)				Reference		
		Maximum	Minimum	Mean	Std. Dev.	Female HD	Unisex NAD	Unisex TSS
1	Age	67.00	18.00	27.51	11.83	-	-	-
2	Weight	86.80	38.70	59.80	9.82	90.30	-	-
3	BMI	34.24	15.70	24.22	3.94	-	-	-
4	Stature	176.50	144.00	157.22	6.38	172.70	175.00	175.26
5	Eye Height	168.00	133.00	146.66	6.34	162.80	-	-
6	Shoulder Height	148.00	117.00	130.65	5.86	141.40	150.00	
7	Elbow Height	116.00	89.00	99.18	4.41	110.70	-	-
8	Navel Height	108.00	77.50	93.75	5.58	-	-	-
9	Maximum Body Depth	36.00	18.00	24.96	4.08	-	30.00	24.13
10	Maximum Body Breadth	54.00	30.00	43.29	4.79	46.80	50.00	50.80
11	Elbow Span	91.50	68.40	82.19	4.78	-	100.00	-
12	Forward Arm Reach	88.00	71.12	78.80	3.82	-	87.50	86.36
13	Forward Grip Reach	81.00	63.00	73.28	3.71	80.50	-	-
14	Overhead Reach	214.00	166.80	185.60	9.25	-	200.00	190.50
15	Squatting Position Height	105.00	68.00	86.74	9.26	-	112.50	109.22
16	Squatting Position Width	103.00	60.00	80.60	9.03	-	70.00	55.80

The Table 3 and Table 4 presents mean, mode, maximum, minimum, standard deviation and selected percentile values that can be helpful for practical purpose.

Male body size is generally larger than the female. The derived dataset for male and female are compared which confirms this difference. Statistical test (2 tailed paired t test for each category of male and female samples, $\alpha = .01$) shows that all the male body dimensions are significantly larger than the female with only one exception, the maximum body depth. The Table 5 shows the result.

Table 3: *Male anthropometric dimensions (unit cm)*

		Male (n=72)					Percentile		
Sl.	Anthropometric features	Max	Min	Mode	Mean	Std Dev	90th	50th	10th
1	Age	74.00	18.00	21.00	29.42	13.70	-	-	-
2	Weight	89.00	54.00	80.00	70.81	8.66	-	-	-
3	BMI	32.63	16.95	-	24.25	3.49	-	-	-
4	Stature	193.75	154.60	172.00	171.29	7.60	181.90	171.25	162.36
5	Eye Height	183.00	144.00	160.00	160.47	7.63	170.77	160.00	150.18
6	Shoulder Height	165.00	125.60	145.00	143.08	7.63	153.75	143.20	134.03
7	Elbow Height	120.00	95.00	109.00	108.55	5.11	114.95	108.95	101.60
8	Navel Height	114.00	87.00	102.00	100.38	6.35	107.00	101.00	91.61
9	Maximum Body Depth	38.00	15.24	22.00	25.48	4.14	31.08	25.10	21.36
10	Maximum Body Breadth	57.50	38.00	47.00	47.31	4.10	52.27	47.15	42.01
11	Elbow Span	101.00	80.30	93.00	90.34	4.90	96.52	90.00	84.73
12	Forward Arm Reach	107.00	76.80	83.00	85.77	5.44	92.92	84.50	80.10
13	Forward Grip Reach	98.00	68.00	79.00	80.18	5.96	88.50	79.05	74.63
14	Overhead Reach	230.70	183.80	210.00	201.99	10.16	215.80	201.25	189.03
15	Squatting Position Height	112.80	72.00	95.00	92.69	9.89	104.00	93.50	78.07
16	Squatting Position Width	107.00	67.90	89.00	87.67	7.87	97.54	88.30	79.10

Table 4: *Female anthropometric dimensions (unit cm)*

		Female (n=72)					Percentile		
Sl.	Anthropometric features	Max	Min	Mode	Mean	Std Dev	90th	50th	10th
1	Age	67.00	18.00	21.00	27.51	11.83	-	-	-
2	Weight	86.80	38.70	59.00	59.80	9.82	-	-	-
3	BMI	34.24	15.70	20.16	24.22	3.94	-	-	-
4	Stature	176.50	144.00	154.00	157.22	6.38	165.00	157.00	149.00
5	Eye Height	168.00	133.00	150.00	146.66	6.34	153.68	145.70	139.39
6	Shoulder Height	148.00	117.00	127.00	130.65	5.86	137.92	130.50	122.97
7	Elbow Height	116.00	89.00	101.00	99.18	4.41	104.00	99.00	94.00
8	Navel Height	108.00	77.50	94.00	93.75	5.58	99.27	94.00	87.27
9	Maximum Body Depth	36.00	18.00	21.00	24.96	4.08	30.00	24.00	20.45
10	Maximum Body Breadth	54.00	30.00	43.00	43.29	4.79	49.95	43.00	37.95
11	Elbow Span	91.50	68.40	80.00	82.19	4.78	88.00	82.00	76.91
12	Forward Arm Reach	88.00	71.12	80.00	78.80	3.82	83.93	79.00	73.59
13	Forward Grip Reach	81.00	63.00	73.00	73.28	3.71	78.00	73.00	68.87
14	Overhead Reach	214.00	166.80	180.00	185.60	9.25	197.00	186.00	172.90
15	Squatting Position Height	105.00	68.00	94.00	86.74	9.26	98.00	86.36	75.70
16	Squatting Position Width	103.00	60.00	80.00	80.60	9.03	92.80	80.00	69.96

Table 5: *Male anthropometric dimensions compared with female dimensions (unit cm)*

Sl.	Anthropometric features	Male (n=72)		Female (n=72)		Difference	*P* Value
		Survey Mean	Std. Dev	Survey Mean	Std. Dev	Male - Female	
1	Stature	176.50	7.60	157.22	6.38	14.07	3.13066E-20
2	Eye Height	168.00	7.63	146.66	6.34	13.81	1.5564E-18
3	Shoulder Height	148.00	7.63	130.65	5.86	12.43	7.29613E-19
4	Elbow Height	116.00	5.11	99.18	4.41	9.37	1.19674E-19
5	Navel Height	108.00	6.35	93.75	5.58	6.63	2.66491E-10
6	Maximum Body Depth	36.00	4.14	24.96	4.08	0.52	0.402667536
7	Maximum Body Breadth	54.00	4.10	43.29	4.79	4.02	2.7902E-08
8	Elbow Span	91.50	4.90	82.19	4.78	8.14	5.23241E-16
9	Forward Arm Reach	88.00	5.44	78.80	3.82	6.97	3.83982E-13
10	Forward Grip Reach	81.00	5.96	73.28	3.71	6.90	2.19338E-12
11	Overhead Reach	214.00	10.16	185.60	9.25	16.39	1.13334E-16
12	Squatting Position Height	105.00	9.89	86.74	9.26	5.95	2.56327E-05
13	Squatting Position Width	103.00	7.87	80.60	9.03	7.07	1.94227E-07

Table 6: *Male and female anthropometric dimensions compared with reference standards (unit cm)*

Sl.	Anthropometric features	Male			Female		
		Survey Mean	Survey Mean- Ref. Male	Survey Mean- Ref. Unisex	Survey Mean	Survey Mean- Ref. Female	Survey Mean- Ref. Unisex
1	Age	67.00	-	-	27.51	-	-
2	Weight	86.80	-25.39	-	59.80	-30.50	-
3	BMI	34.24	-	-	24.22	-	-
4	Stature	176.50	-17.31	-3.97	157.22	-15.48	-18.04
5	Eye Height	168.00	-13.73	-	146.66	-16.14	-
6	Shoulder Height	148.00	-12.62	-6.92	130.65	-10.75	-19.35
7	Elbow Height	116.00	-11.55	-	99.18	-11.52	-
8	Navel Height	108.00	-	-	93.75	-	-
9	Maximum Body Depth	36.00	-7.52	-4.52	24.96	-	-5.04
10	Maximum Body Breadth	54.00	-10.59	-3.49	43.29	-3.51	-7.51
11	Elbow Span	91.50	-	-9.66	82.19	-	-17.81
12	Forward Arm Reach	88.00	-	-1.73	78.80	-	-8.70
13	Forward Grip Reach	81.00	-8.72	-	73.28	-7.22	-
14	Overhead Reach	214.00	-	1.99	185.60	-	-14.40
15	Squatting Position Height	105.00	-	-19.81	86.74	-	-25.76
16	Squatting Position Width	103.00	-	17.67	80.60	-	10.60

As mentioned earlier, in Bangladesh some reference standards are followed for ergonomic considerations in architecture, it is quite logical to question the suitability of such standards for the local context.

Table 6 presents the difference between the survey mean and reference standards for both male and female. In case of unisex difference, the larger dimension is considered. The differences clearly indicate that the Bangladeshi people are smaller in size than the references.

This study suggests two important considerations. First, dimensions of male body are considerably different from the female which must be considered for the users' comfort. Although perfect design for the users is impossible, however careful consideration of the anthropometric determinants is expected to ensure comfort and safety. The male-female considerations are vital for designing both

private and public spaces. Secondly, the body dimensions of Bangladeshi male and female are smaller than the common reference standards. Therefore, blind application of such standards may result in inefficiency and discomfort. This also indicate that there is need for further research in this area and the necessity of national database.

Conclusion

Anthropometric data is very important for the architects to design space that optimize building performance and users concern for comfort, safety, and health. Unfortunately, there is a sever paucity of anthropometric data that can be directly utilized in the field of architecture in Bangladesh, which lead to following reference standards that may not be applicable for the local people. In this dearth, this study presents an anthropometric dataset which is explicitly designed for architecture.

This dataset was derived from a design studio exercise, and thus the purpose and fit is appropriate. A total of 13 body dimensions were measured from 144 male and female. The dataset was compared between male and female, as well with the widely consulted reference standards. The results led in two directions. First, the difference between male and female body dimensions were significant, which must be considered in relation to the user profile of the space to be designed. Such difference is aligned with the finding of other anthropometric studies in different field (for example M. S. Parvez et al., 2021; S. Parvez et al., 2022). Second, the dataset, for both male and female, showed a considerable difference from the reference standards. Some other studies in different fields, have indicated that the Bangladeshi population are generally somewhat smaller, in comparison of a few dimensions like stature, hand length etc. (for example Imrhan et al., 2009; Khadem & Islam, 2014; M. S. Parvez et al., 2022; Shahriar et al., 2020), but none of them are applicable for architecture. This study clearly showed the comparison enumerating each dimension with gender specific and unisex references. This finding certainty questions blunt application of references and urges for the obligation of a national reference standard, as well as widescale research in this field.

The presented dataset offers all necessary values and can be directly applied in Bangladesh. It is also expected that, it might be helpful for some other South Asian countries if the anthropometric features are close to Bangladeshi population.

Acknowledgment: The author is grateful to Chowdhury Ali Imam and Dristi Chakma who were involved in the studio, to the students participating in the design studio course, and to the survey participants.
Conflict of Interest: The author stated that there are no conflicts of interest regarding the publication of this article.
Ethics Committee Approval: N/A
Author Contributions: The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.
Financial Disclosure: The author declared that this study has received no financial support.

References

Akhter, Z., Begum, J. A., Banu, M. L. A., Alam, M. M., Hossain, S., Amin, N. F., Uddin, M. M., & Yasmin, Q. S. (2010). Stature Estimation Using Head Measurements in Bangladeshi Garo Adult Females. *Bangladesh Journal of Anatomy*, 7(2), 101–104. https://doi.org/10.3329/bja.v7i2.6096

Asadujjaman, M., Rashid, M. H. O., & Rana, S. (2019). Anthropometric Measurement of External Ear and Correlation with Age in North Regional People of Bangladesh. *Bangladesh Journal of Medical Science*, 18(2), 206–210. https://doi.org/10.3329/bjms.v18i2.40686

Attaianese, E. (2012). A broader consideration of human factor to enhance sustainable building design. *Work*, 41, 2155–2159. https://doi.org/10.3233/WOR-2012-1020-2155

Attaianese, E. (2017). Ergonomics of Built Environment i.e. How Environmental Design Can Improve Human Performance and Well—Being in a Framework of Sustainability.

Ergonomics International Journal, s1. https://doi.org/10.23880/EOIJ-16000S

Attaianese, E., & Duca, G. (2012). Human factors and ergonomic principles in building design for life and work activities: An applied methodology. *Theoretical Issues in Ergonomics Science*, 13(2), 187–202. https://doi.org/10.1080/1463922X.2010.504286

Biswas, S. (2022). Teaching Ergonomics in the Online Studio. *Journal of Design Studio*, 4(2), 237–247. https://doi.org/10.46474/jds.1183490 https://doi.org/10.46474/jds.1183490

Biswas, S., Kundu, G., & Imam, C. A. (2021). Learning Human Factors/Ergonomics (HFE) in Architectural Education: A Study of Studio Approach in Bangladesh. *Creative Space*, 9(1), 29–41. https://doi.org/10.15415/cs.2021.91003

Chakraborty, R. K., Asadujjaman, M., & Nuruzzaman, M. (2014). Fuzzy and AHP approaches for designing a hospital bed: A case study in Bangladesh. *International Journal of Industrial and Systems Engineering*, 17(3), 315–328.

Charytonowicz, J. (n.d.). *Architecture and Ergonomics*. 4.

Costa, A. P. L., Campos, F., & Villarouco, V. (2012). Overview of ergonomics built environment. *Work*, 41, 4142–4148. https://doi.org/10.3233/WOR-2012-0710-4142

De Chiara, J., & Callender, J. H. (1990). *Time Saver Standards for Building Types* (3rd ed.). McGraw-Hill.

Eilouti, B. (2021). A Framework for Integrating Ergonomics Into Architectural Design. *Ergonomics in Design: The Quarterly of Human Factors Applications*, 106480462098367. https://doi.org/10.1177/1064804620983672

Flora, M. S., Mascie-Taylor, C., & Rahman, M. (2009). Conicity Index of Adult Bangladeshi Population and their Socio-Demographic Characteristics. *Ibrahim Medical College Journal*, 3(1), 1–8. https://doi.org/10.3329/imcj.v3i1.2910

Fross, K. (2014). Ergonomics in the Practice of Project Architect on Selected Examples. In M. Kurosu (Ed.), *Human-Computer Interaction. Theories, Methods, and Tools* (Vol. 8510, pp. 77–85). Springer International Publishing. https://doi.org/10.1007/978-3-319-07233-3_8

Garneau, C. J., & Parkinson, M. B. (2016). A survey of anthropometry and physical accommodation in ergonomics curricula. *Ergonomics*, 59(1), 143–154. https://doi.org/10.1080/00140139.2015.1052853

GoB. (2020). *Bangladesh National Building Code*, BNBC. Government of the People's Republic of Bangladesh. http://www.dpp.gov.bd/upload_file/gazettes/39201_96302.pdf

Hendrick, H. W. (2008). Applying ergonomics to systems: Some documented "lessons learned." *Applied Ergonomics*, 39(4), 418–426. https://doi.org/10.1016/j.apergo.2008.02.006

Hoque, A. S. M., Parvez, M. S., Halder, P. K., & Szecsi, T. (2014). Ergonomic design of classroom furniture for university students of Bangladesh. *Journal of Industrial and Production Engineering*, 31(5), 239–252.

Hossain, Z. (2015). Estimation of hand anthropometry among Bangladesh adults living in four different areas [PhD Thesis]. Bangladesh Health Professions Institute (The academic institute of CRP ….

Imrhan, S. N., Sarder, M. D., & Mandahawi, N. (2009). Hand anthropometry in Bangladeshis living in America and comparisons with other populations. *Ergonomics*, 52(8), 987–998. https://doi.org/10.1080/00140130902792478

International Ergonomics Association. (2000). *What Is Ergonomics* (HFE)?

https://iea.cc/what-is-ergonomics/

Islam, M. A., Asadujjaman, M., Nuruzzaman, M., & Mosharraf, M. (2013). Ergonomics consideration for hospital bed design: A case study in Bangladesh. *Ergonomics*, 1(1).

Khadem, M. M., & Islam, Md. A. (2014). Development of anthropometric data for Bangladeshi male population. *International Journal of Industrial Ergonomics*, 44(3), 407–412. https://doi.org/10.1016/j.ergon.2014.01.007

Klamklay, J., Sungkhapong, A., Yodpijit, N., & E. Patterson, P. (2008). Anthropometry of the southern Thai population. *International Journal of Industrial Ergonomics*, 38(1), 111–118. https://doi.org/10.1016/j.ergon.2007.09.001

Ministry of Housing and Public Works. (2008). ইমারত নির্মাণ বিধিমালা ২০০৮ (Dhaka Metropolitan Building Construction Rules, 2008). Ministry of Housing and Public Works.

Mokdad, M. (2002). Anthropometric study of Algerian farmers. *International Journal of Industrial Ergonomics*, 29(6), 331–341.

Moody, L. (2011). A studio-based approach to teaching ergonomics and human factors. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 55(1), 545–549.

Neufert, E., & Neufert, P. (2012). *Neufert Architects' data*. John Wiley & Sons.

Olguntürk, N., & Demirkan, H. (2009). Ergonomics And Universal Design In Interior Architecture Education. *METU Journal of the Faculty of Architecture*, 26(2), 123–138. https://doi.org/10.4305/METU.JFA.2009.2.7

Panero, J., & Zelnik, M. (1979). *Human Dimension & interior Space: A Source Book of Design Reference Standards*. Watson-Guptill.

Parvez, M. S., Shahriar, M. M., Tasnim, N., & Hoque, A. S. M. (2022). An anthropometry survey of Bangladeshi university students. *Journal of Industrial and Production Engineering*, 39(2), 89–108.

Parvez, M. S., Tasnim, N., Talapatra, S., Kamal, T., & Murshed, M. (2021). Are library furniture dimensions appropriate for anthropometric measurements of university students? *Journal of Industrial and Production Engineering*, 1–16.

Parvez, M., Talapatra, S., Tasnim, N., Kamal, T., & Murshed, M. (2022). Anthropomorphic Investigation into Improved Furniture Fabrication and Fitting for Students in a Bangladeshi University. *Journal of The Institution of Engineers* (India): Series C, 103(4), 613–622.

Parvez, S., Tasnim, N., Talapatra, S., Ruhani, A., & Hoque, A. S. M. (2022). Assessment of Musculoskeletal Problems among Bangladeshi University Students in Relation to Classroom and Library Furniture. *Journal of The Institution of Engineers* (India): Series C, 103(3), 279–292.

Pentikis, J., Lopez, M. S., & Thomas, R. E. (2002). Ergonomics evaluation of a government office building. *Work*, 18(2), 123–131.

Pheasant, S., & Haslegrave, C. M. (2018). *Bodyspace: Anthropometry, ergonomics and the design of work*. CRC press.

Radjiyev, A., Qiu, H., Xiong, S., & Nam, K. (2015). Ergonomics and sustainable development in the past two decades (1992–2011): Research trends and how ergonomics can contribute to sustainable development. *Applied Ergonomics*, 46, 67–75. https://doi.org/10.1016/j.apergo.2014.07.006

Sanders, M. S., & McCormick, E. J. (1993). *Human Factors in Engineering and Design* (7th ed.). McGraw Hill, Inc.

Shah, R. M., Bhuiyan, M. A. U., Debnath, R., Iqbal, M., & Shamsuzzoha, A. (2013). Ergonomics Issues in Furniture Design: A

Case of a Tabloid Chair Design. In A. Azevedo (Ed.), *Advances in Sustainable and Competitive Manufacturing Systems* (pp. 91–103). Springer International Publishing. https://doi.org/10.1007/978-3-319-00557-7_8

Shahriar, M. M., Parvez, M. S., & Lutfi, M. (2020). A survey of hand anthropometry of Bangladeshi agricultural farm workers. *International Journal of Industrial Ergonomics*, 78, 102978. https://doi.org/10.1016/j.ergon.2020.102978

Tania, I. J., Zaman, F., Morium, U., Akter, M., & Rashid, S. (2020). Anthropometric Study of Facial Height among Tribal (Garo) and Non-Tribal Bangladeshi Female of Greater Mymensingh District in Bangladesh. *Journal of Current and Advance Medical Research*, 7(1), 36–39.

Villeneuve, J. (2000). The Contribution of Ergonomics to the Design of Hospital Architecture. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 44(26), 189–196. https://doi.org/10.1177/154193120004402615