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Ergonomics Consideration for Hospital Bed Design: A Case Study in Bangladesh

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Hospital beds and other similar types of beds are used not only in hospitals, but in other health care facilities and settings, such as nursing homes, assisted living facilities, outpatient clinics, and in home health care. There has more variations in the design of hospital bed and no one is designed with considering anthropometric data of Bangladesh. *Anthropometry involves the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape which can be used to identify the physical dimensions of hospital bed. In this study, 35 patients and 35 doctors have given their opinion through a set of questionnaires. A total of 103 male students of Rajshahi University of Engineering and Technology (RUET) participated for anthropometric measurement. Four anthropometric dimensions related to normal hospital bed have measured using meter scale. The result shows that back pain, fatigue, blood circulation problem, comfort and sleep are related to the anthropometric factors of hospital bed. , Analytic Hierarchy Process (AHP) analysis shows that patient bed length is most responsible for patient physical demand which is related to anthropometric factor stature. Linear regression analysis shows the relationship of stature with others anthropometric measurement related to normal hospital. This study will help the furniture industries in Bangladesh to design the products and will provide a clear conception about physical dimensions of Bangladeshi male people.*

Keywords: Hospital Bed, Ergonomics, Anthropometry, Analytic Hierarchy Process.

1. Introduction

Hospital bed is used in hospital and designed for patients and others in need of some form of health care. Improper design of medical bed is responsible for many types of psychological and physical problems like back pain and it hampers to sleep. In the developed countries middle-edged people who suffer from backache often report that their backache started when they were in their twenties, the period when many of them are still attending university (Watson et al. 2002). Our health is directly influenced by the way we sleep. It is a common truth that quality of life depends on quality of sleep. An adequate comfortable sleep can significantly extend your life. Improper sleep may cause a lot of problems and even diseases like osteochndrosis, radiculities, arthritis, blood supply disturbance, insomnia, allergy, asthma, etc. Hospital bed and others furniture should be

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designed considering ergonomics. The word "Ergonomics" comes from two Greek words "ergon," meaning work, and "nomos" meaning laws (Bridger 1995). It is the interaction among man, machine and environment which focuses on the interactions between the works demand and worker capabilities. Anthropometry is one of the basic parts of ergonomics that refers to the measurement of human body. It is derived from the Greek words “anthropos” means man and “metron” means measure (Bridger 1995). Anthropometric data are used in ergonomics to specify the physical dimensions of workspaces, equipment, furniture and clothing to “fit the task to the man” (Grandjean 1980) and to ensure that the physical mistakes between the dimensions of equipment and products and the corresponding user dimensions are avoided.

2. Literature Review

Chou & Haiao (2005) have used two-dimensional anthropometric data for developing an electric scooter in Taiwan. The developed electric scooter resulted in a significant improvement in its appearance and ergonomic performance. The hierarchical estimation method was applied to 60 anthropometric variables by using the 1988 US Army anthropometric survey data and used to design an occupant package layout in a passenger car (You & Ryu 2005). In 2006 Sebo et al. have collected anthropometric data that were performed by 12 primary care physicians on 24 adult volunteers in Geneva, Switzerland and that was published in 2008.

Anthropometric data must contain at least some valuable information about certain aspect of person’s diet and health. Cvrcek (2006) have explained that the height and weight variation of adolescent boy’s exhibit a pattern that is inconsistent with that for a normal healthy population.

For ergonomic product design with better safety, comfort and health consideration three-dimensional anthropometry is very important as it gather rich information. Chang et al. (2007) have used three-dimensional anthropometric measurements that offer much more surface information than traditional dimension measurement and proposed methods for low cost portable hand-hell laser scanner along with a piece of glass used as a hand support to reduce scanning shadow areas. Engineering design is a strong determinant of workplace ergonomics. A survey among 680 engineers in 20 Danish enterprises indicated that engineers are not aware that they influence the work environment of other people (Broberg 2007). Ergonomics had a low rating among engineers, perhaps because neither management nor safety organizations expressed any expectations in that area. The study further indicated that the effects of ergonomics training in engineering schools were very limited.

The anthropometric measurement can be used as a basis for the design of workstations and personal protective equipments that can make work environments safer and more users friendly. Currently, there is increasing demand for this kind of information among those who develop measures to prevent occupational injuries and increase the level of satisfaction. Anthropometric measurements among 1805 Filipino workers in 31 manufacturing industries showed data for standing, sitting, hand and foot dimensions, breadth and circumference of various body part and grip strength that was the first ever comprehensive anthropometric measurement of Filipino manufacturing workers in the country which is seen as a significant contribution to the Filipino labor force who are increasingly employed by both domestic and foreign multinationals and was published in 2007 (Pardo-Lu 2007). This study helps Filipino working population for the economic design of workstations, personal protective equipments, tools, furniture and interface systems that aid in providing a safer, effective, more productive and user friendly workplace.

Das, Shikdar & Winters (2007) demonstrated the beneficial effect of a combined work design and ergonomics approach, specially for the redesign of a workstation for a repetitive drill press operation that increase both the production output and operator satisfaction. The result showed significant improvement in production quantity (22%) and quality (50%) output as a consequence of applying work design and ergonomics principles.

In Turkey, the static anthropometric measurements of 13 dimensions from 1049 students were obtained while they were standing and sitting that was published in 2008 (Tunay & Melemez 2008). To be used in classroom and laboratory design the necessary anthropometric data was analyzed to determine the limit value. Existing dimensions of desks and chairs were compared with the student's anthropometric measurements. It was observed that there was a mismatch between popliteal height and seat height, knee height and desk clearance, buttock to popliteal length and seat depth. Comparing Turkish students and other nation's student the result showed that there was significant difference in anthropometric measurements.

Like increased workload, flexibility efforts and productivity requirements, musculoskeletal disorders show noticeable impacts on the workers health in their own professional environment. Lanfranchi & Duveau (2008) have presented a predictive model on musculoskeletal pain in relation to maneuver margin, workload and work recognition.

Metha et al. (2008) have designed seat dimensions for tractor operator's based on anthropometric data of 5434 Indian male agricultural workers considering comfort ability of operators because if the operator's seat is not comfortable, their work performance may be poor and there is also a possibility of accidents. Another anthropometric survey was carried out by Dewangan, Owary & Datta (2008) for female agriculture workers (age ranged 18-60 years) of two north eastern (NE) hill states of India, namely Arunachal Pradesh and Mizoram. Collected data were statistically analyzed and also compared with those of American, British, Chinese, Egyptian, Japanese, Korean, Maxican and Taiwanese female workers that showed in stature, Indian women are shorter by 9.27 cm as compared to American women.

Daneshmandi, Isanezhad & Hematinezhad (2008) have shown the effect of classroom furniture on back pain, neck, and lumber and lag fatigue when the students used them. A total of 203 male students from 32 classes of 8 different schools of the urban community were randomly selected in this study. The investigation showed a significant relationship between the tired fillings of the subjects with every dispositional condition of the classroom. Necessary standards during manufacturing the equipments of schools according to anthropometric specifications and ergonomics consideration reduce tired feelings and pain of the students that increases learning and concentration.

Some students of Industrial Engineering in Maxico complained that the activities of tutors create fatigue, neck and back pain after classes (Hernandez, Quiroga & Bustillos 2009). After that, a research of 52 students, 46 males and 6 females between 19 to 23 years old, have estimated the anthropometric parameters of popliteal height, buttock-popliteal length, sitting elbow and wide of the hip of students as well as the dimensions of the desk and calculated relations between them and compared it with international recommendations. The research demonstrated that the desk type used by the study population have mismatches with anthropometric measures of the users and probably are the cause of fatigue and muscle aches cited. They recommended that it is required to meet student's health problem, to acquire adjustable desks or at least desks of different dimensions according to the anthropometric measurements of male and female users.

Niu, Li, & Salvendy (2009) have analyzed 510 head samples of Chinese young men that help to analyze human body surfaces, sizing of shape-fitting wearing items, clinical practice. Braking and steering-assistance features of hospital bed have direct effects on task efficiency and physical demand. Thus appropriate selection of specific designs able to improve productivity and contribute to a reduction in work related musculoskeletal disorders risk among healthcare workers. Kim et al (2009) have done a repeated measure experimental study considering work related musculoskeletal disorders aimed to increase effectiveness of hospital bed design features (brake pedal location and steering-assistance) in terms of physical demands and usability during brake engagement and patient transportation tasks.

Iseri & Arslan (2009) have done a large survey of 4205 civilians (2263 males and 1942 female) in the year of 2007 to estimate the anthropometric characteristic of the Turkish population by geographic region, age and gender which showed 37 measurements that are commonly used in industry. Husein et al (2010) have studied on facial anthropometry and aesthetic measurements to compare Indian American women with North American white women. In this study the researchers obtains 30 anthropometric measurements of 102 Indian American women and the result showed significant difference in 25 of 30 facial measurements. Laios & Giannatsis (2010) have employed virtual modeling technique and the method of principle component analysis for ergonomic evaluation and redesign of children bicycles based on anthropometric data. In Greece the redesigned bicycles are now in full Production and distribution is underway in many commercial outlets as proper fitting increases cycling performance, efficiency, and comfort and injury prevention.

Unsafe medical care leads to the suffering of millions of patients every year. Human Factors and Ergonomics (HFE) is that scientific discipline which provides unique approach for examining complex socio-technical systems. System approach, roles and methods of human factors and ergonomics have been studied by Carayon & Buckle (2010). The system approach carefully developed by human factors and ergonomics specialists over the past 50 years has a vital role to play in addressing healthcare challenges (Carayon & Buckle 2010).

Hossain & Ahmed (2010) present 36 linear and static anthropometric dimensions and weight of 88 male students living in three residential halls of Bangladesh University of Engineering and Technology (BUET) for the design of five mostly used residential hall furniture (Bed, Chair, Desk table, Book shelf and Locker). They showed the different percentages of mismatches between furniture dimensions and corresponding body dimensions of individual users.

Anthropometric data varies from region to region. Chuan, Hartono and Kumar (2010) were collected anthropometric data of the Singaporean and Indonesian populations. The data were mainly from university students. In total, 245 male and 132 female subjects from Indonesia and 206 male and 109 female subjects from Singapore were measured. This study used 36 measurement dimensions. The authors made a comparison with previous anthropometric data collected in 1990 of over a thousand Singaporeans. Statistical analysis showed that Singaporeans both male and female tend to have larger dimensions than Indonesians in general. In addition, the data reveal the current sample to be significantly larger on more than 50 percent of the dimension measured for both males and females. Hafizi et al. (2010) have run a large anthropometric study on primary school children in Iran that explained negative impact on human health if the use of furniture fails to fulfill anthropometric data of its users. Gathering data about anthropometric dimensions are important as anthropometric data can change by time. In many communities anthropometric data have been measured especially among school, college and university students. Study was designed to obtain anthropometric dimensions of Iranian children aged 7-11 years and data were obtained on 2030 primary school students (1015 males and 1015 females) in Yazd of Iran. Study showed a descriptive statistics as well as key percentiles for 17 static anthropometric data. The result showed some difference in anthropometric data with other studies and significant gender differences in some dimensions as well. In order to create a data bank for furniture design a study was run in Iran which measured anthropometric dimensions of Iranian university students

(Mirmohammadi et al. 2011). They measured 20 anthropometric dimensions of 911 university students (475 males and 436 females), aged 18-25 years, that showed a significant difference between anthropometric dimensions of their populations with others population. Except for buttock-knee all dimensions measured were significantly different between two genders.

Hedge, James & Pavlovic-Veselinovic (2011) have optimized the implementation of healthcare information technology considering risk of work related musculoskeletal disorders in ways that will benefit user performance while minimizing their injury risks. In the patient transportation study, the use of a steering lock reduced the number of adjustments and decreased perceived physical demands during bed maneuvering. Additionally, the adjustable push height reduced shoulder moments during an in-room bed start-up task. The contour feature reduced patient sliding distance with repeated bed raising/lowering, which can potentially reduce the demands placed on healthcare workers to reposition them. Metha et al. (2011) have suggested that proactive ergonomic considerations in hospital bed design can reduce physical demands placed on healthcare workers. Widanarko et al. (2011) have described the prevalence of musculoskeletal symptoms in New Zealand where a sample of 3003 men and women aged 20-64 were randomly selected. Musculoskeletal symptoms experienced during 12 months in 10 body regions were assessed in telephone interviews using a modified version of the Nordic Musculoskeletal Questionnaires. The highest prevalence was for low back (54%), neck (43%), and shoulder (42%). Females reported a statically significantly higher prevalence of musculoskeletal symptoms in the neck, shoulder, wrist/hands, upper back and hips/thighs/buttocks regions compared to males while males reported more symptoms of elbows, low back and knees. There were no statistically significant differences in prevalence among age groups.

International Ergonomics Association Technical Committee has been formed due to the concern of increasing prevalence and role of information and technology in the lives of children as well as the incident of back pain and heavy loads children carry in back packs (Bennett& Tien 2012). A survey was sent to Ergonomics for Children and Educational Environments to describe a cross-section of international efforts to address the health and the future of children. It is possible to analyze and predict with an applied ergonomics that is sensitive to the social complexities of workplace, including power, gender, hierarchy and fuzzy system boundaries (Dekker 2012).

Dianat et al. (2012) have evaluated the potential mismatch between classroom furniture dimensions and anthropometric characteristics of 978 Iranian high school students (498 girls, 480 boys), aged 15 to 18 years. The mismatch was varied between the high-school grade levels and between genders, indicated their special requirements and possible problems.

In Bangladesh the use of ergonomics is very fewer in hospital and others workplace. The objectives of this study is to determine the relationship with physical demand (back pain, fatigue, blood circulation problem, comfort and sleep) with anthropometric factors for hospital bed and to build an anthropometric database for Bangladeshi patient to find correlation among some pairs of these anthropometric factors.

3. Research Methodology

The study has been conducted at Rajshahi, Bangladesh. Data of 35 patients and 35 doctors has been collected from Rajshahi Medical College and Hospital, Rajshahi to determine the relationships between patient's physical demand and anthropometric factors related to normal hospital bed through Independent Test. After that, Analytic Hierarchy Process has done to determine what anthropometric factor is most responsible for these physical demands. The range of the patient ages were 20-54 years old.

Four anthropometric measurements of 103 students have been measured from Shahid Lt. Selim Hall of Rajshahi University of Engineering and Technology (RUET), Rajshahi. AHP shows that anthropometric measurements strature, elbow span, popliteal height and vertical grip reach are related to bed length, bed wide, bed height and bed stand height respectively for normal hospital bed. After that, mean and standard deviation have calculated. Then, using simple linear regression analysis correlation equations have calculated for some pairs of data set.

4. Result Analysis

4.1 Independent Test

Table 1: Expected and observed value

Factors / Problems	Bed length/ Stature	Bed width/ Elbow span	Bed height/ Political Height	Bed Stand Height/Vertical grip reach	Total
Back pain	58(31.310)	23(22.310)	0(17.873)	0(9.507)	81
Fatigue	37(46.385)	21(33.051)	51(26.478)	11(14.085)	120
Blood circulation problem	32(48.318)	29(34.429)	43(27.582)	21(14.671)	125
Comfort	61(76.148)	55(54.260)	45(43.469)	36(23.122)	197
Sleep	59(44.838)	48(31.950)	2(25.596)	7(13.615)	116

Here, the number 58 in the second column, second row means among 35 doctors and 35 patients that means among 70 peoples, 58 people think that bed height is responsible for back pain. In the table the no 0 means no one has said that bed height and bed stand height are responsible for back pain.

Expected frequency is indicated by first bracket and calculated by the following equation:
Expected frequency = (column total) ×(row total)/ (grand total)
Thus, the expected numbers of frequency of bed length that are not related to back pain are:

$$\left(\frac{247}{639}\right) \times \left(\frac{81}{639}\right) \times (639) = 31.310$$

Degree of freedom, ν = (row−1)×(column−1) = (5-1)×(4-1)=12

$\chi^2 = \sum (o_i - e_i)^2 / e_i$

χ^2_{cal} = 22.75+0.021+17.873+9.507+1.899+3.253+22.710+0.675+5.511+0.856+8.618+2.730+3.013+0.010+0.054+7.173+4.473+8.062+21.752+3.214 = 144.154

Now,

1. H_0 = Problems are not related to anthropometric factors.
2. H_1 = Problems are related to anthropometric factors.
3. Level of significance, α = 0.05, 0.01
4. Degree of freedom, ν = 12
5. χ^2_{cal} = 144.154
6. $\chi^2_{0.05,\,12}$ = 21.026 < χ^2_{cal}
7. $\chi^2_{0.01,\,12}$ = 26.217 < χ^2_{cal}
8. Decision: H_0 is rejected.

That means, problems of patients are related to anthropometric factors.

4.1.2 Analytic Hierarchy Process (AHP)

Table 2: The fundamental scale (Saaty 1990)

Level of preference weights	Definition	Explanation
1	Equally Preferred	Two activities contribute equally to the objective
3	Moderately	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly or essentially favor one activity over another
7	Noticeable dominance	An activity is strongly favored over another and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest degree possible of affirmation
2,4,6,8	Intermediate values	Used to represent compromise between the preferences listed above
Reciprocals	Reciprocals for inverse comparison	

Table 3: Evaluation at level 1

Attribute	C1	C2	C3	C4	C5	Geometric mean	Normalized weight
C1	1	2	5	3	5	2.72	0.43
C2	1/2	1	5	3	5	2.06	0.33
C3	1/5	1/5	1	2	3	0.75	0.12
C4	1/3	1/3	1/2	1	9	0.50	0.08
C5	1/5	1/5	1/3	1/9	1	0.27	0.04
Total	2.23	3.73	11.83	9.11	23.00	6.30	

Geometric mean for back pain = (1*2*5*3*5) ^ (1/5) =2.72
Normalized weight for back pain = 2.72/6.30 = 0.43
λ max = ∑(Normalized weight of each row*sum of respective column)
= 2.23*0.43+3.73*0.33+11.83*0.12+9.11*0.08+23.00*0.04
= 5.2582
Consistency Index (C.I) = (λ max-n)/ (n-1) = 0.0646 for n=4; R.I= 1.11
Consistency Ratio (C.R) = C.I/R.I = 0.0646/1.12=0.0577= 5.77 % < 10%, so acceptable.

Table 4: Average Random Index (RI) based on matrix size (adapted by Saaty, 1980)

N	1	2	3	4	5	6	7	8	9	10
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 5: Evaluation for attribute for back pain

Parameter	Vertical grip reach	Elbow Height	Popliteal height	Stature (Bed length)	Geometric mean	Normalized weight
Vertical grip reach	1	1/2	1/2	1/4	0.5	0.11
Elbow height	2	1	1	1/3	0.9	0.19
Popliteal height	2	1	1	1/3	0.9	0.19
Stature (Bed length)	4	3	3	1	2.45	0.51
Total	9	5.5	5.5	1.91	4.75	

Geometric mean for vertical grip reaches (Stand height) =.50
For Elbow Height = 0.90
For Popliteal height = 0.90
Similarly calculation for Stature (Bed length)
Eigenvector, λ max = 4.0541
From Table 2 Random index = 0.89 (for n=4), Consistency Index CI= (λmax−n)/ (n−1) =0.018
Consistency ratio CR = CI/RI = 0.02 = 2.00 % < 10%, so, acceptable.

Table 6: Evaluation for attribute For Fatigue

Parameter	Vertical grip reach	Elbow Height	Popliteal height	Stature (bed length)	Geometric mean	Normalized weight
Vertical grip reach	1	1	1/3	1/5	0.51	0.096
Elbow height	1	1	1/3	1/5	0.51	0.096
Popliteal height	3	3	1	1/3	1.32	0.250
Stature (bed length)	5	5	3	1	2.94	0.56
Total	10.00	10.00	4.67	1.73	5.28	

Geometric mean for Vertical grip reach =0.51
For Elbow Height = 0.51
For Popliteal height = 1.32
Similarly calculations for Stature (Bed length)
Eigenvector, λ max = 4.056
From Table 2 Random index = 0.89 (for n=4), Consistency Index CI= (λmax−n)/ (n−1) =0.019 consistency ratio CR = CI/RI = 2.11 % <10 %, so, acceptable.

Table 7: Evaluation for attribute for blood circulation problem

Parameter	Vertical grip reach	Elbow Height	Popliteal height	Stature (bed length)	Geometric mean	Normalized weight
Vertical grip reach	1	4	4	1/5	1.34	0.20
Elbow height	1/4	1	1	1/9	0.41	0.062
Popliteal height	1/4	1	1	1/9	0.41	0.062
Stature (bed length)	5	9	9	1	4.49	0.67
Total	6.5	15	15	1.42	6.65	

Geometric mean for vertical grip reach (Stand height) = 1.34
Eigenvector λ max = 4.11
Consistency Index (C.I) = (λ max-n)/(n-1) = 0.0367 (for n=4); R.I= 0.89.
Consistency Ratio (C.R) = 0.0407 = 4.07 %< 10%, so, acceptable.

Table 8: Evaluation for attribute for sleep

Parameter	Vertical grip reach	Elbow Height	Popliteal height	Stature (bed length)	Geometric mean	Normalized weight
Vertical grip reach	1	2	1/5	1/8	0.47	0.07
Elbow height	1/2	1	1/4	1/9	0.34	0.05
Popliteal height	5	4	1	1/5	1.41	0.21
Stature (bed length)	8	9	5	1	4.35	0.66
Total	14.5	16	6.45	1.44	6.57	

Geometric mean for Vertical grip reach (Stand height) =0.47
Eigenvector λ max = 4.12
Consistency Index (CI) = (λ max-n)/(n-1) = 0.04 (for n=4); R.I= 0.89
Consistency Ratio (C.R) = C.I/R.I = 0.0444 = 4.44 % < 10%, so, acceptable.

Table 9: Evaluation for attribute for comfort

Parameter	Vertical grip reach	Elbow Height	Popliteal height	Stature (bed length)	Geometric mean	Normalized weight
Vertical grip reach	1	3	1/2	4	1.57	0.3298
Elbow height	1/3	1	1/3	2	0.686	0.144
Popliteal height	2	3	1	3	2.06	0.432
Stature (bed length)	1/4	1/2	1/3	1	0.452	0.0949
Total	3.583	7.5	2.167	10	4.76	

Geometric Mean = 1.57
Eigenvector λ max = 4.1469
Consistency index, CI = (λ max −n) / (n−1) = 0.0489 (for n=4); R.I= 0.89
Consistency ratio, C.R = C.I/R.I = 0.0543 = 5.43% <10%, so, acceptable.

Table 10: AHP for final evaluation

Anthropometric parameter	Attributes & their Weights					Composite weight	Rank
	Back pain (0.43)	Fatigue (0.33)	Blood circulation problem (0.12)	Sleep (0.08)	Comfort (0.04)		
Vertical grip reach (stand height)	0.110	0.096	0.200	0.070	0.3298	0.122	4
Elbow span (Bed width)	0.190	0.096	0.062	0.050	0.144	0.130	3
Popliteal Height (Bed Height)	0.190	0.250	0.062	0.210	0.432	0.206	2
Stature (Bed length)	0.510	0.560	0.670	0.660	0.0949	0.540	1

Sample calculation
Composite weight for Vertical grip reach (Stand height) =0.43*0.110+0.096*0.330+.20*0.12+0.070*0.096+0.04*0.3298=0.122

1. Result shows that for back pain, fatigue, blood circulation problem and sleep of patient bed length is most responsible which is related to anthropometric factor stature.
2. After that, bed width is responsible which is related to anthropometric factor elbow span.
3. Then, bed height is responsible which is related to anthropometric factor popliteal height.
4. At last, Bed stand height is responsible which is related to anthropometric factor Vertical grip reach.
Linear Regression Analysis

If $\bar{X}$ is the mean of a random sample of size n from a population with variance σ^2, the one-sided 100(1-α) % for μ is given by:
Upper one-sided bond: $(\bar{x} + z_\alpha \sigma)/\sqrt{n}$
Lower one-sided bond: $(\bar{x} - z_\alpha \sigma)/\sqrt{n}$
For normal bed for sleeping if we use 95percentile then, mismatch will occur for 5 percent people and they can use it with tilting. But, it is a problem for the patient to tilt if mismatch occur. So this is why we have considered one sided confidence bonds. For stand height most of the case nurses help the patients to use net and nurse uses stand height. For this reason, we do not consider one sided confidence bonds for stand height.

Table 11: Mean and Standard deviation of anthropometric data

	Stature (cm)	Elbow span(cm)	Popliteal height (cm)	Vertical grip reach (cm)
Mean	167.3141	88.33078	43.74369	201.8814
Standard deviation	10.6542	3.8495	1.6215	14.2085

Table 12: Summary of the correlation analysis while taking independent variable x = stature

Dependent variables (Y)	Prediction equation
Elbow span	Y=0.850467x-52.4467
Popliteal height	Y= 33.39599+0.05979x
Vertical grip reach	Y=157.94156+0.2476x

From these equations, if anyone gives his stature height only, he will have proper dimension for hospital bed.

5. Summary and Conclusions

Every patient deserves a safe and comfortable sleeping and bed environment. Hospital bed needed to design in such a way that both the patient and health care workers feel comfort, safe and convenience. Ergonomics or human factors are very important for the design of hospital bed and other furniture. Our case study shows the relationship of hospital bed with patient various problems like back pain, blood circulation problem, fatigue, sleep and comfort and what factors are responsible at most. This study gives a better solution for Bangladeshi people to design hospital bed according to anthropometric data of this regional people. This will increase patient safety and comfort for Bangladeshi people.

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