

Designing and Manufacturing of a Tabloid Chair Using Ergonomic Design Concept and Comparison with the Existing Tabloid Chair

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Abstract: Ergonomics is the science of human fit. It decreases fatigue and discomfort through product design. Its aim is to achieve co-ordination between man and machine. Application of ergonomics in the design of office furniture, by taking into consideration, how the products can be designed to fit the people that are using them. This thesis includes the problems faced by the students of Shahjalal University of Science and Technology, Sylhet, Bangladesh, while using the tabloid chair, designed earlier. Our objective is to identify ergonomic problems and the effects of using the tabloid chair that was design earlier. A survey was conducted on 100 students who took part in the previous tabloid chair design and have used the tabloid chair that was designed earlier for at least one hour at a time. This survey mainly focuses on the discomfort of the users. The results show that 14, 16 & 23 of the users felt discomfort at their neck, lower back & shoulder respectively. A new design was proposed for tabloid chair, by analyzing the survey results and using anthropometric data taken from 150 students who took part in the previous study. So the users may not face further problems. Taking cost of materials and other factors into consideration a tabloid chair was fabricated using ergonomics design concepts. Then, a comparison was done between the fabricated tabloid chair and the existing tabloid chair, which is shown in the final chapter.

Keywords: Ergonomics, Design, Anthropometric data, Cost.

I. Introduction

Nowadays, tabloid chairs have become quite popular in educational institutions and business organizations. They are highly preferred for their high functionality, flexibility and low space requirement compared to a set of Table & Chair. In this modern knowledge based society, people spend an awful lot of time sitting on their chair on a daily basis. If the chair is not properly designed to fit, support and better equip the human body, user fatigue and discomfort is unavoidable. That's where ergonomics and human factor engineering come in. These disciplines can ensure that the chairs are perfectly designed for better performance and user comfort. So, nowadays ergonomically designed chairs have become a common necessity. The current design of the Ergonomic tabloid chair, which was formulated by our predecessors, contains some obvious flows. As such the current design requires further improvement.

II. Literature Review

Ergonomics is a science focused on the study of human fit, and decreasing fatigue and discomfort through product design. Ergonomics can be an integral part of design, manufacturing, and use. Knowing how the study of anthropometry, posture, repetitive motion, and workspace design affects the user is critical to a better understanding of ergonomics as they relate to end-user needs.

A research on "A Benefits Study of Ergonomically Designed Chairs with Direct Labor Employees" was done by John C. Peek which focuses on measuring changes in productivity related to ergonomic improvement [1].

Another research on "Improving Design of Chair with Flip Table (Analysis and Ergonomics) was conducted by Mohd. Fahmi Bin Ismail, Faculty of Mechanical Engineering, University of Malaysia, Pahang. The development during this project was to fulfill the learning objective that is to produce the frame of chair with adjustable flip table, by using low cost according to the human factor terms. The variety of applications from the project can be use to produce a product based on human factor [2].

Another research work was done by Nor Faizul Hayati bt Amir, faculty of manufacturing engineering, Technical University of Malaysia, Malacca, on "Design Improvement of Portable Writing Chair for Both Right and Left Handed Users". The purpose of this study was to design and manufacture a portable writing chair that can be used with equal facility by both right and left handed users [3].

III. Method

1. A primary Survey was conducted for the formation of questionnaire and gathered primary knowledge of the overall scenario of the chair condition and problems.
2. Primary questionnaire was checked for its eligibility and appropriateness. By modifying the primary questionnaire, the final questionnaires are being made.
3. Collect data and analyzed for identification and prioritize the problems and prepared improvement planned by follow ergonomics guideline.
4. Humans vary significantly in size and shape. So, in order to accommodate a range of people, anthropometric database was created by measuring various physical dimensions. The anthropometric data were collected and calculated by using Microsoft excel software.
5. Materials of chair and its cost related information were collected from different chair manufacturer.
6. Finally, after the main reasons of health problems being identified and tried to develop a chair, based on the anthropometric data base being created, that can able to resolve those health problems while working in such chair.

IV. Findings And Analysis

The study focuses on the students of Shahjalal University of Science and Technology, Sylhet, Bangladesh, who have used the tabloid chair previously made. The aim of this study is to find out the problems faced by the users and their recommendations. So, for accomplishing this goal a survey was conducted on 100 users using the tabloid chair that was previously made. Most of the users were taken from the Department of Industrial and Production Engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh. The majority of them were male students. Their weight and age ranged from 55 kg to 70 kg and 20 years to 23 years respectively. The data has been gathered through questionnaires. Every questionnaire was taken from the user after sitting on the previously made tabloid chair for at least one hour at a stretch.

4.1 Assessment of Average Time Spent on a Tabloid Chair

Various type of pain felt by the user while sitting on a tabloid chair depends largely on the time spent by the user on the tabloid chair. The data about the average time spent by a user on a tabloid chair is processed and tabulated in Table 4.1.

Table 4.1: Average Time Spent by the User on a Tabloid Chair.

Duration	1 hour	2 hour	3 hour	4 hour
No. of user	27	61	10	02

By using the data from Table 4.1, a pie chart was developed.

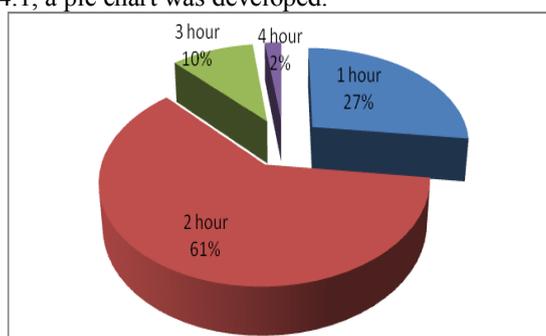


Fig 4.1: Average Time Spent on a Tabloid Chair by a user.

4.2 Assessment of Frequency of Pain Felt by the Users

This survey assesses the pain felt by the users while they are sitting on the tabloid chair that was made previously. After processing the data it is seen that 47 users felt no pain, 51 users felt pain sometimes and 02 users always felt pain.

Table 4.2: Frequency of Pain Felt by the Users.

Frequency	Never	Sometimes	Always
No. of user	67	31	02

4.3 Assessment of the Condition of Existing Seat Pan

To assess the present condition of the seat pan five categories were selected. They are: Very Bad, Bad, Fair, Good, and Excellent. The rating of the present seat condition given by the users is tabulated on Table 4.3.

Table 4.3: Condition of Existing Seat Pan.

Condition	Very Bad	Bad	Fair	Good	Excellent
No. of user	00	00	24	53	23

4.4 Assessment of Comfort Ability of the Previously Designed Chair

To find out the comfort ability of the previously designed chair a scale from 1 to 5 was selected, which signifies very bad, bad, good, very good, excellent respectively.

Table 4.4: Comfort Ability of the Chair Previously Designed.

Rating	1	2	3	4	5
No. of users	00	00	23	63	14

4.5 Assessment of Tab Height of the Previously Made Chair

Table 4.5 shows that (out of 100 users) tab height is appropriate for 71 users and 29 users feel that the tab height is not appropriate for them.

Table 4.5: Suitability of Tab Height.

Tab Height	Appropriate	Inappropriate
No. of users	71	29

4.6 Assessment of pain on hand while writing

This survey assesses the pain felt by the users while they are sitting on the tabloid chair that was made previously. After processing the data it is seen that 71 users felt no pain, 27 users felt pain sometimes and 02 users always felt pain.

Table 4.6: Pain Felt by the Users While Writing.

Frequency	Never	Sometimes	Always
No. of user	71	27	02

4.7 Assessment of health problems faced by users

Various types of pain and their causes are tabulated in Table 4.7 along with the number of effected users.

Table 4.7: Various Types of Problems and Their Causes.

Problem	Population	Cause
Shoulder pain	23	Improper tab height.
Neck pain	18	Improper tab height & backrest angle.
Elbow pain	16	Improper tab height & size.
Wrist pain	16	Improper tab height & size.
Back pain	05	Improper backrest angle.
Lower back pain	14	Improper backrest angle & seat depth.
Posture pain	05	Poor condition of seat pan.
Thigh pain	04	Improper seat height & depth
Knee pain	03	Improper seat height.

4.8 Preferable Material for Seat

The Purpose of this study to find out, which material the user prefers most for the seat pan.

Table 4.8: Preferable Material for Seat.

Material	Wood	Metal	Plastic	Foam	Metal + Wood
Population	06	00	12	82	00

4.9 Preferable chair for classroom Purposes

To find out the preference of tabloid chair in the classroom a scale from 1 to 5 was selected, which signifies very bad, bad, good, very good & excellent respectively. 33 users rated 3 and 61 users rated 4 out of 5.

Table 4.9: Preference of Tabloid Chair.

Rating	1	2	3	4	5
No. of users	00	00	33	61	06

4.10 Assessment of User Requirement

Table 4.10: User Requirements.

Features	Total Population	Yes %	No %
Seat height adjustability	100	14	86
Tab height Adjustability	100	58	42
Back support adjustability	100	43	67
Additional arm-rest	100	49	51
Head/Neck support	100	64	36
Lower back support	100	52	48
Basket for Bag/File	100	91	09
Tab movement mechanism	100	68	12

4.11 Results

Based on the finding and analysis done above we came to the following conclusions regarding the design improvement of the tabloid chair.

Table 4.11: Selected design improvements.

specifications	comments
Seat height	No improvement required
Seat depth	No improvement required
Seat width	No improvement required
Back rest height	Increase to medium level
Back rest width	No improvement required
Back rest angle	No improvement required
Tab height	Make adjustable
Tab size	increase
Arm-rest height	Add arm-rest
Basket under seat	Add basket

4.12 Conclusion

This study tried to find out the present scenario of the tabloid chair that was designed earlier. The analysis shoes that about 33 percent users feel pain on different parts of their body while sitting on the previously designed chair, and 29 percent users feel that the tab height and size is not appropriate for them. Only 67 percent of the users feel complete comfort sitting on the previously designed tabloid chair. The users are used to sitting on the tabloid chair for 1-3 hours straight. Even though majority of the users are comfortable with the previously designed tabloid chair, quite a few users feel discomfort. As such a new design for an ergonomic tabloid chair is required

V. Design And Fabrication

After the Survey of various health problems faced by the users of the previously designed tabloid chair, it was seen that the majority of the population felt complete comfort. But still a large number of users were not fully satisfied. It means that there are still opportunities to improve the comfort ability of the previously designed tabloid chair. The anthropometric data of 150 students, who took part in the previous study, were taken into account for designing a new tabloid chair. The method of design that had been used is given below in figure 6.1.



Fig 5.1: Method of Tabloid Chair Design.

5.1 Anthropometric Data

Anthropometric data were collected from 2007 batch to 2010 batch student and the data was tabulated in Microsoft excel. Using a statistical formula named *percentile*, which returns the kth percentile of values in a range. For calculating 95th, 50th, 5th percentile of various anthropometric measurement, the values of k = 95, 50, 5 were used. The processed data are shown in Table 5.1.

Table 5.1: Anthropometric Data of 95th, 50th and 5th Percentile.

	Min (cm)	Max (cm)	95 th percentile (cm)	50 th percentile (cm)	5 th percentile (cm)
Popliteal height	37	51	47	44	40
Buttock knee depth	41	63	61	55	48.45
Buttock Popliteal depth	38	54	50.55	46	41
Elbow to elbow breadth	38	56	51	45	40
Sitting elbow height	17	27	26	21	18
Sitting height	68	87	83	77	71
Hip breadth	28	40	37	33	30
Thigh clearance	10	18	16	13	11

5.2 Design Specification

Table 5.2: Anthropometry in Terms of Chair Measurement [8].

Specification	Measurement	Value (cm.)
Seat height	Popliteal height + shoe allowance 2.54 cm	43
Seat depth	Buttock popliteal depth – clearance 12.7cm	37
Seat width	Hip breadth × cloth allowance 1.3	43
Backrest height	Sitting height×0.8	61
Backrest width	ANSI	30 (min.)
Backrest angle	ANSI	105°
Tab height	sitting elbow height + allowance	25
Tab size	Survey	34×40

5.3 Design

Based on the findings, design guidelines, recommendations and using the anthropometric data and percentile range, the designed tabloid chair, seat pan, tab and backrest are show in the following figure. The design was done by AutoCAD 2007 & Google Sketch up.



Fig 5.2: Isometric view of the Designed Tabloid Chair.



Fig 5.3: Orthogonal view of Proposed Tabloid chair.

5.4 Material Selection

The materials selected for the construction of the new Tabloid chair and the reason behind the selection of those materials is given below.

Hollow Cylindrical Steel Bar: Cylindrical bar is selected for the frame of the chair. It can be bended to a certain angle which reduces time and machining cost. In this project 2.94cm (1.16 inch) steel tubes were used.

Wood: To support the foam of seat pan and backrest wood sheet is selected. Wood is fastened with the steel by means of screw to provide a support for foam.

Metal Basket: Steel Basket has been used under the seat pan to keep students bag. It was built using 0.3inch steel rods and 0.5 inch steel tubes.

Particle Board: Tab is an important component of a tabloid chair. Tab should be strong and rigid enough to provide support to hand while writing and also light in weight. For this practical board is selected for making tab. In this project Otobi Melamine particle board was used.

Foam: About 52 percent users prefer foam as seat pan material. So, in fulfilling user preference foam is selected as seat pan material. It is also used in backrest. In this project Carmo rubber foam was used.

Rexene: It is one kind of plastic to cover foam used on seat and back rest.

5.5 Costing

To determine the total cost of the fabrication of proposed tabloid chair Bill of Material and Labor cost is need. Bill of material for producing a single tabloid chair is given in Table 5.3.

Table 5.3: Bill of Materials

No.	Items	Quantity	Rate in Taka	Price in Taka
1.	Cylindrical hollow tube (1.16")	20ft	25	500.00
2.	Cylindrical hollow tube (0.5")	2.5 ft	12	30.00
3.	Steel rod (0.3")	20 ft	7.5	150.00
4.	Wood	3.5 ft ²	54	190.00
5.	Rexene	7ft ²	36	250.00
6.	Foam	5ft ²	50	250.00
7.	Particle Board	2 ft ²	75	150.00
8.	Caps	10pcs	2	20.00
9.	Screws	10pcs	1	10.00
10.	Key screws	2pcs	17.5	35.00
Total cost of material				1585.00

The labor cost to produce a single piece is approximately = 150 Taka

Total cost of material = 1585 Taka

So, total cost incurred to produce proposed tabloid chair = 1735 Taka

If we go for mass production (150pcs), then the labor cost will be reduced to 60 taka /piece and each Tabloid Chair would cost approximately 1200 taka.

VI. Comparison: Old Design Vs New Design

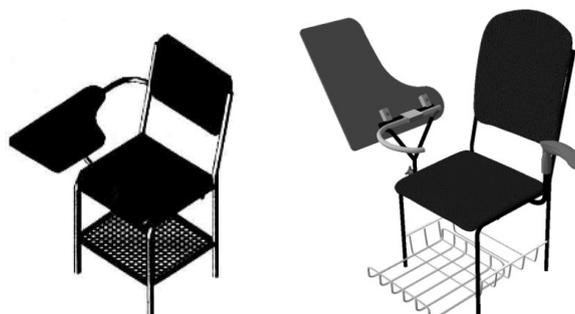


Fig 6.1: Old Vs New Design

Table 6.1: Comparison between the previous and new design

Sl.	Previous Design	New Design
1	In the previous design, there was simply an empty space, under the seat pan, to place bag or files for the user. To do that, the user had bend over and put considerable stress on the body.	In the new design a metal basket is fitted with forward & backward motion. The basket can be pulled out from under the seat pan, which makes it easier for the user to deposit the bag or files.
2	The tab mechanism of the previous design was based on the reciprocating and rotating motion of a metal tube, through another metal tube with slightly larger diameter. The mechanism was crude, noisy and shaky.	In the new design the same mechanism has been perfected by fitting a plastic tube through Teflon seals. It decreased noise and friction and makes the mechanism more rigid.
3	In the previous design no additional hand-rest was introduced. The logic was to prevent the restriction of the user's movement in the tabloid chair.	In the new design a rotating additional arm-rest has been introduced. It provides support for the other arm, without restricting user movement.
4	In the previous design the tab height was made fixed. Tab height was selected is such a way that would fit maximum number of users. But still quite a few were dissatisfied with the fixed tab height. Some even suggested an adjustable tab height.	In the new design an adjustable tab height mechanism was introduced, to fit all the users perfectly.
5	In the previous design the tab size was selected to give room for a paper while writing (12"×12"). But in this modern era, a pen & paper is not sufficient for academic activities. Room for facilitating additional class accessories such as ruler, instrument box, calculator or even books is necessary.	In the age of IT many advanced accessories are being used in classrooms. In this modern educational system it is quite common for students to use laptop computers in class activities. Age of pen & paper are behind us. Therefore in the new design the tab size was selected in such a way, that it would facilitate even a laptop.
6	In the previous design the backrest height was selected just below shoulder level. This design does not provide enough support for the shoulder and the neck. This may give rise to neck & shoulder pain.	In the new design the backrest height was increased to provide support up to the neck level.

VII. Conclusion

The use of the tabloid chair in the classrooms is increasing day by day. Typically manufactured tabloid chairs are not designed to accommodate the dimensions of the individual user. Also they do not consider adjustability features. As a result the chair is a fit for only a small portion of the population. Without proper design sitting will require greater muscular force and control to maintain stability and equilibrium. This in turn results in greater fatigue and discomfort and is likely to lead to poor postural habits as well as neck or back complaints. Hence we took on a study to further improve the previously designed Tabloid chair in such a way, which would fit and satisfy almost all of the users.

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References

- [1] "A Benefits Study of Ergonomically Designed Chairs with Direct Labor Employees" was done by John C. Peek, 1992.
- [2] "Improving Design of Chair with Flip Table" (Analysis and Ergonomics), conducted by Mohd. Fahmi Bin Ismail, Faculty of Mechanical Engineering, University of Malaysia, Pahang.
- [3] Nor Faizul Hayati bt Amir, faculty of manufacturing engineering, Technical University of Malaysia, Malacca, on "Design Improvement of Portable Writing Chair for Both Right and Left Handed Users".
- [4] "Designing an Ergonomic Chair for a VDT Workstation" in the Department of industrial and production engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh by Md. AbulKalam Azad and Muhammad Selim Reza.
- [5] "Application of ergonomics in designing computer chair and comparative analysis between two leading chair manufacturers" by Gazi Muhammad Sharif Hossain and Shajal Chandra Biswash Student of Industrial and Production Engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh.
- [6] Helander, "A guide to ergonomics of manufacturing" by Taylor & Francis, 1995, USA.
- [7] "Human Factors in Engineering & Design" McGraw-Hill (7th edition), 1992, USA.
- [8] "Ergonomics & Design a Reference Guide" by Scott openshaw & Erin Taylor.