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RESEARCH ARTICLE

EVALUATION OF A MODELED OFFICE CHAIR IN AN OFFICE ENVIRONMENT AT KUMASI POLYTECHNIC IN GHANA

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ABSTRACT

The study was to evaluate the overall comfort and good and bad points in the design. The methodology for evaluating this single chair, rather than making a comparison among chairs, was developed from previous chair studies. The methodology was found to be quick and effective when applied to a modeled chair, giving information to institution head or users from institution on overall comfort and good and bad points in the design. Testing took place on twotasks: the use of measures which compare the chair against chair design principles and anthropometric data and evaluate chair experimentally at the real workplace. Thirty office workers individually used the chair for one day. The results showed that overall comfort of was quite comfortable, and cross tabulations between chair feature checklist or anthropometric data together with users' personal details (stature, weight, age),and general comfortprovided significant relationships. The chair features which related to overall comfort included chair height, chair depth, chair width, seat slope and the backrest curvature; while anthropometric data together with personal details that related to overall comfort included age, weight, width of bitrochanterand sitting shoulder height. Finally, chair comfort is influenced by ergonomic design principles and furniture design.

INTRODUCTION

Croney (1971) said sitting is a means of changing posture and bringing rest. Sitting on an office work chair plays an important role in the field of work. It is estimated that about 75% of work in industrialized countries is performed while sitting (Share, 2005).Volume of work to the individual worker has the tendency to contribute to pain. It follows that the more the volume of work, the longer the worker sits resulting in low back pain or worsens an existing back or neck problem (Triano, 2011; Alves, 2010). Adopting good sitting posture will enhance comfort and will not put a lot of stress and strain on the user's buttocks, back or arm muscles, and will allow the user's feet to be on the floor (Openshaw and Taylor, 2006). Good posture will protect the supporting structures of the body against injury or progressive deformity (Posture and chronic pain, 2010). Generally in normal office environments, many factors can influence workers' sitting posture; these include the anthropometric dimensions of office workers, the measurement and design features of the office furniture (Murphy *et al*, 2004).Branton (1969) makes the point that sitting is only a means to an end rather than an end in itself. The motivation for sitting is the task performed in the seat rather than the seat itself so the best that can be hoped for in sitting is to achieve a 'stateof non-awareness' of the seat. Despite this, performance changes in the task as a function of sitting are notoriously difficult to detect. For adjustable seats, McLeod *et al* (1980) only found a performance decrement when the seat was both maladjusted and perceived as uncomfortable. Similarly, recording of postures or movements on the seat (Rieck, 1969) have shown no correlation with direct comfort measures.

Field (1985) defines anthropometrics as a science that studies comparative dimensions of the human body, to arrive at the initial scale and dimensions of a piece of furniture. Specific measurements such as popliteal to floor height, buttock to popliteal length and width of bitrochanter are necessary in order to determine the dimensions of office furniture that will enable workers to maintain the correct sitting posture. Anthropometric data is one of the essential factors in designing machines and devices (Mebarki and Davies, 1990). Incorporating anthropometric data would yield more effective

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designs. The designs are more user friendly, safer, and enable higher performance and productivity. According to (Tunay and Melemez, 2008), static anthropometric data on the other hand, are widely used in determining the dimensions of furniture. They said anthropometric data are used in ergonomics to specify the physical dimensions of work spaces, equipment, furniture, and clothing.

Any evaluation procedure must be both valid and reliable. For chair evaluation, the use to which the chair is put is the overriding criterion in choosing a method for chair evaluation. Chair evaluations reported in the literature have assessed chairs used for auditoria (Wotzka *et al,* 1969), reading, typing and eating (Shackel *et al,* 1969), school work (Oxford, 1969), easy chairs (LeCarpentier, 1969) and 'just sitting' (Grandjean *et al,* 1973).

There are three basic methods of evaluating chairs, apart from 'expert judgement' which Shackel *et al* (1969) found to be unreliable. These methods use measures which compare the chair against anthropometric data and chair design principles (e.g., Oxford, 1969; British Standard3044); use fitting trials to adjust the chair to the operator (Jones, 1969; LeCarpentier, 1969) and finally to have users evaluate the chairs experimentally, either in a laboratory setting (Shvartz *et al,* 1980, Grandjean *et al,* 1973, Shackel *et al,* 1969) or at the real workplace (e.g., McLeod *et al,* 1980; Wotzka *et al,* 1969; Jones, 1969; Shackel *et al,* 1969). Many evaluations combine two or more of these techniques (e.g., Wotzka *et al,* 1969; Oxford, 1969) and most recommendations on seating design (such as Diffrient *et al,* 1974; Panero and Zelnik, 1979) combine recommendations derived from all three methods.

RESEARCH METHODOLOGY

The study area for this study was Kumasi Polytechnic. A total of 30 questionnaires were randomly distributed to Kumasi Polytechnic administrative staffs with a hundred percent response rate. Data collected included anthropometric data, modeled office chair sizes, general comfort data of users, data on chair feature check lists recommended in the modeled office chair, data on relationship between overall comfort and anthropometric data together with personal details (such as age, height, and weight) of the subjects. For this study, a three-stage evaluation procedure was employed: (1) studying the design principles; (2) evaluate the modeled chair against published dimensional recommendations; and finally, (3) evaluate comfort directly at the workplace.

Studying chair design principles

To consider whether there was mismatch between anthropometric measurements and sizes of the office furniture, Table 1 is used. In the case of desk width and depth, no criteria were defined to compare with the anthropometric measure. Mismatch data is determined if the modeled office sizes are outside the mismatch decision: lower or shorter than minimum value and higher or taller than maximum value.

Comparison of dimensions of modeled office chair with recommended published dimensions

Published dimensional recommendations were gathered from a variety of sources and are compared with the modeled office chair sizes. It is noted that most of the recommendations are based on the same studies on evaluation and thus are closely comparable.

Users comfort evaluation

In this section, the modeled office chair is evaluated experimentallyat the real workplace using three different subjective evaluations of comfort such as:

- General/overall comfort rating
- A chair feature evaluation checklist
- Relationship between overall comfort and anthropometric data together with personal details

In this study, authors assessed seat comfort, not user comfort, and the user was only a channel of information from the seat to the evaluators. Scales were thus needed for overall comfort, anthropometric data with personal details and specific chair features. For chair features, authors resorted to ad hoc questions about specific chair features of interest. Using these questions authors were able to assess the comfort of the chair on the basis of seat height, seat depth, seat width, and seat slope and backrest curvature.

A two-stage evaluation procedure was employed in the third technique:

i. The scale for general comfort was administered every hour after the initial 5 min adjustment period, for a total of six hours. Subjects were required to mark a blank scale each time. Five minutes is considered long enough for a user to become familiar with a chair (Grandjean *et al,* 1973; Shackel *et al,* 1969).
ii. The anthropometric measurements together with personal details and chair feature checklist were administered at the end of the six hour working session for each subject.

For scales needed for generalcomfort, anthropometric measurementstogether with personal detailsand specific chair features (see Appendix).

Table 1 Description of measurements in furniture design

Measurement	Calculation		Mismatch decision
Popliteal height(i.e. seat height)	Office chair	Popliteal height: 88 – 95%	Chair too low if measurement < 88%; Fit (88.01 – 95%); Chair too high > 95%
Buttock-popliteal length (i.e. seat depth)	Office chair	Buttock-popliteal length: 80 – 95%	Seat too shallow < 80%; Fit (80.01 – 95%); Seat too deep > 95%

Source: Parcells *et al* (1999)

Data Analysis

To determine the fit or mismatch between the users anthropometric measurements and modeled office chair, descriptive statistics was employed. The evaluation of the general comfort on hourly basis; anthropometric measurements together with personal details and chair feature checklists at the end of the sixth hour, frequency tables and percentages were employed. To evaluate the users comfort at the workplace, Chi-square analysis was used to measure the level of relationship between general comfort and anthropometric measurements together with personal details. The use of Chi-square deals with the situation in which one has two variables (such as gender, age, height, weight, anthropometric measurements and general comfort) and to determine whether these variables are independent of one another (H_0: Independence between two variables).

RESULTS AND ANALYSIS

Anthropometric dimensions of the workers

The data regarding anthropometric dimensions popliteal to floor height, buttock to popliteal length, sitting shoulder height, width of bitrochanter, stature and weight were analysed according to the institution. Table 2 shows descriptive statistics (Mean, Standard deviation, minimum and maximum) of all the six analyzed variables.The weight was estimated to be 68.27kg with stature of 1686.47 and popliteal to floor height of 431.63mm.

Table 2 Anthropometric dimensions of the workers

Measurements	Mean	Std. Deviation	Minimum	Maximum
Weight	68.27	13.170	1570	1830
Stature	1686.47	75.342	1570	1830
Popliteal-floor height	431.63	26.711	380	480
Buttock-popliteal length	471.17	31.940	425	520
Sitting shoulder height	515.23	33.547	435	590
Width of bitrochanter	410.27	38.295	360	530

Studying chair design principles

In this section, the authors would match anthropometric measurements and the size of the modeled office chair to evaluate the appropriateness of the modeled office chair according to the recommended criteria in **Table 1**. The mismatch values are made possible with the help of **Tables 1 and 2**. Calculations of the minimum and maximum limits of popliteal to floor height (seat height) and buttock to popliteal length are as follows:

Popliteal height (seat height):

Maximum height 43.2 x 9.5 mm = 410.4mm

Minimum height 43.2 x 8.8 mm = 380.2mm

Buttock popliteal length (seat depth):

Maximum depth 47.1 x 9.5 mm = 447.5mm

Minimum depth 47.1 x 8.0 mm = 376.8mm

Taking the calculated values of mismatch criteria for judging appropriateness and the height and depth of the modeled office chair, comparison can be made as shown in Table 3. The findings indicate that, the modeled office chair was appropriate for the workers since the sizes of the modeled office chair were within the fit range according to Parcells *et al* (1999).

Table 3 Comparison between modeled office chair sizes and the recommended criteria

Measure	Appropriate measurements	Modeled office chair sizes
Popliteal to floor height (seat height)	380 – 410	410
Buttock to popliteal length (seat depth)	377 – 448	447

Comparison of modeled office chair sizes with recommended published dimensions

Detailed dimensional recommendations were gathered from a variety of sources and are compared with the modeled office chair sizes. It is noted that most of the recommendations are based on the same studies on evaluation and thus are closely comparable. The seat height and seat slope of the modeled office chair are in line with all the recommended published dimensions in Table 4. The angle of backrest of the modeled office chair is in line with those proposed by (Croney, 1971; Dreyfuss, 1966; Panero and Zelnik, 1979). Seat depth did not conform to any of the dimensions from all the authors. This may be due to longer thighs of respondents in the present study as compared to those involved in the chairs used by the authors. The backrest height did not conform to any of the dimensions. It is because; the modeled office chair was constructed to give user good opportunities to relax the back and neck muscles occasionally (Grandjean, 1980). Investigators Anderson and Ortengren (1974), Nachemson (1974) and Yamaguchi *et al* (1972), have studied the effects of seat angle and the shape of the backrest, on disc pressure. The experiments have revealed that the best conditions for relaxation of the spine have been provided by a seat angle to the horizontal of 3° and an angle between the seat and the backrest of 102°.

User comfort evaluation

Table 5 provides the general idea of the distribution of scores in the 'Descriptive Statistics' output. Out of the 30 respondents, 17 (56.7%) were males and 13 (43.3%) were females. About 26.7% of the respondents were aged below 25 years, 25 – 35 years (46.7%) and 26.7% were 36 years and above. Most of these respondents (60%) weighed between 50 – 70 kg, whereas the remaining 40% were from 71 – 110 kg. It was realized that a great number of the respondents had the following measurements: 53% having sitting shoulder height (501 – 550mm); 47% having width of bitrochanter as 350 – 400mm; 40% having knee height (511 – 540mm); 33% having popliteal to floor height (411 – 440mm); and lastly 33% having buttocks to popliteal length (431 – 460mm).

General comfort rating

The Table 6 shows that 43% or more respondents feel quite comfortable in the modeled office chair, while 10% of the respondents feel stiff on the chair given the various time periods.

Table 4 Comparison of dimensions of modeled office chair with published recommendations

Source	Seat width	Seat depth	Seat height	Backrest height	Seat slope	Angle of backrest
Croney	432 – 482	336 – 381	356 – 482	102 – 203	0 – 5°/3 - 5°	95 – 115°
Diffrient *et al*	406	381 – 406	345 – 523	152 – 229	0 – 5°	95°
Dreyfuss	381	305 – 381	381 – 457	129 – 203	0 – 5°	95 – 105°
Grandjean	400	400	378 – 528	200 – 300	3 – 5°	Adjustable
Panero&Zelnik	432 – 482	394 – 406	356 – 508	152 – 229	0 – 5°	95 – 105°
Woodson&Conover	381	305 – 381	381 – 457	152 - 203	3 – 5°	200°
Modeled office chair	324 – 410	377 – 448	380 – 410	444 – 580	3°	102°

Table 5 Descriptive Statistics

	Variable	Frequency	Per cent (%)
Gender	Male	17	56.7
	Female	13	43.3
Age (years)	Less than 25	8	26.7
	25 – 35	14	46.7
	36 – 45	5	16.7
	46 and above	3	10.0
Height (mm)	1500 – 1600	4	13.3
	1601 – 1700	14	46.7
	1701 – 1800	11	36.7
	1801 – 1900	1	3.3
Weight (kg)	50 – 70	18	60.0
	71 – 90	11	36.7
	91 – 110	1	3.3
Popliteal to floor height	350 – 380	1	3.3
	381 – 410	8	26.7
	411 – 440	10	33.3
	441 – 470	8	26.7
	471 – 500	3	10.0
Buttock to popliteal length	400 – 430	4	13.3
	431 – 460	10	33.3
	461 – 490	7	23.3
	491 – 520	9	30.0
Sitting shoulder height	400 – 450	1	3.3
	451 – 500	9	30.0
	501 – 550	16	53.3
	551 – 600	4	13.3
Knee height	450 – 480	3	10.0
	481- 510	8	26.7
	511 – 540	12	40.0
	541 – 570	7	23.3
Width of bitrochanter	350 – 400	14	46.7
	401 – 450	13	43.3
	451 – 500	2	6.7
	501 – 550	1	3.3

A chair feature evaluation checklist

With respect to respondents view about the modeled chair features, respondents who agree to the fact that the chair is of a standard features ranges from 57% to 80% (*Add strongly agree and agree together*) as shown in Table 7.

Relationship between overall comfort and anthropometric data together with personal details

As can be seen in Table 8, the shortfall of three respondents represents those who felt stiff in the modeled office chair.

Respondents in the age groups

The survey shows that 67% of the respondents who were youth (35 years and below) reported that they felt comfortable when they sit in the modeled office chair to do office work.

Respondents in the weight groups

The survey shows that 53% of participants who ranges from 50
– 70kg felt comfortable.

Anthropometric measurements

Respondents having width of bitrochanter of 350 – 400mm registered 47%, followed by 401 – 450mm (40%) with 501 – 550mm registering the least (3%). Similarly, respondents with the highest sitting shoulder height (501 – 550mm) were highly comfortable (43%), followed by 451 – 500mm (30%), 551 – 600mm (13%) and 400 – 450mm (3%). The comfort of a chair means that the chair is able to support a user in such a way that he/she can perform at desk comfortably. Secondly, it should be strong enough to bear the weight of the user (Hammond *et al*., 1980). In this study, 67% and 23% of respondents who were youth (35 years and below) and adults (above 35 years) felt comfortable in the modeled office chair respectively. This is in line with what was reported by Atlas Ergonomics (2008) that older employee is more likely to experience work-related discomfort. Also when it comes to the influence of weight on fit and comfort within the office environment, there are two key factors that affect the expected relationship:

1. The weight of employees affects show they interact with furniture, equipment, and the workstation. As employees move into higher obese classifications, their physical characteristics will challenge their ability to use standard furniture, resulting in a poor fit and lack of comfort.
2. Known health hazards associated with obesity may contribute to baseline levels of discomfort outside of the workplace, which can transfer to higher levels of discomfort at work.

Table 6 General Comfort ability in Hours

Comfortability	Hours											
	1		2		3		4		5		6	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I feel completely relaxed	6	20.0	6	20.0	5	16.7	4	13.3	4	13.3	3	10.0
I feel perfectly comfortable	4	13.3	5	16.7	7	23.3	6	20.0	6	20.0	7	23.3
I feel quite comfortable	16	53.3	14	46.7	13	43.3	15	50.0	15	50.0	15	50.0
I feel barely comfortable	1	3.3	2	6.7	2	6.7	2	6.7	2	6.7	2	6.7
I feel stiff	3	10.0	3	10.0	3	10.0	3	10.0	3	10.0	3	10.0

Table 7 Features recommended for the modeled office chair

	Strongly agree		Agree		Neutral		Disagree		Strongly agree	
Variable	No. of users	%	No. of users	%	No. of users	%	No. of users	%	No. of users	%
Height(correct)	4	13.3	19	63.3	2	6.7	4	13.3	1	3.3
Depth(correct)	6	20.0	15	50.0	5	16.7	4	13.3	0	0.0
Width(correct)	8	26.7	16	53.3	2	6.7	4	13.3	0	0.0
Seat slope (correct)	6	20.0	11	36.7	11	36.7	2	6.7	0	0.0
Backrest curvature (fits well)	8	26.7	14	46.7	6	20.0	2	6.7	0	0.0

Table 8 Participants comfortability in personal details and anthropometric measurements

Measurements	Comfortable Number of Participants	Number of Percentage
Age (years)		
Less than 25	8	26.7
25 – 35	12	40.0
36 – 45	5	16.7
46 and above	2	6.7
Weight (kg)		
50 – 70	16	53.3
71 – 90	11	36.7
91 – 110	-	-
Width of bitrochanter (mm)		
350 – 400	14	46.7
401 – 450	12	40.0
451 – 500	-	-
501 – 550	1	3.3
Sitting shoulder height (mm)		
400 – 450	1	3.3
451 – 500	9	30.0
501 – 550	13	43.3
551 – 600	4	13.3

CONCLUSION

On the basis of comparison of modeled office chair with anthropometric data, recommended published dimensions, user comfort evaluation, obtained results and their analysis, the following conclusions can be drawn:

1. The modeled office chair mostly conformed to recommended published dimensions.
2. The general comfort rating of the modeled office chair is quite comfortable.
3. At least 57% of the respondents agreed to the fact that, the chair features used in the construction of the modeled office chair were of standard measurements.
4. The modeled office chair met some appreciable standard levels and illustrate that perhaps efforts by manufacturers and designers to adopt its sizes and features in construction will enhance the performance of workers in the office environment.
5. The modeled office chair was ergonomically designed because of no mismatch between workers anthropometric data and its sizes.
6. Sitting at work on a comfortable seat helps to relax the body and reduce energy consumption.
7. The present study combined three of the techniques of methodologies for chair evaluation such as studying ergonomics principles, comparison of sizes of the modeled office chair with recommended published dimensions and users comfort evaluation experimentally at the workplace.
8. The study identified several distinct features related to chair comfort including the seat height, seat depth, seat width, seat slope, and backrest curvature.
9. Chair comfort is influenced by ergonomics in design as well as chair construction. Workers who felt stiff in the modeled office chair would wish that the backrest is constructed with a chain mechanism to help in back and forth movement of the backrest when sit in. Seat surface should be tilted backwards so that the buttocks will not slide forwards. A tilt of 3° to the horizontal is recommended. The backrest should be inclined at 103° to the seat.

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