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ANTHROPOMETRIC EVALUATION OF A UNIVERSITY LECTURE HALL'S SEAT

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ABSTRACT

Ergonomics deals with the methods and processes of designing workplaces so that they fit the individuals that make use of them. This paper focuses on the anthropometric evaluation of the lecture hall's seat of a University. Two anthropometric dimensions, the popliteal height (PH) and the buttock-popliteal length (BP) of 188 undergraduate students using the University lecture hall were taken. The lecture hall's seat has height of 465mm and depth of 405mm. It was found that 61% of the student population used for the study was in the fit range of the seat height. Examining the seat depth and buttock to popliteal length, it was observed that 53.7% of the students may be comfortable using the present seat depth design of 405mm dimension, while over 46% of the students' population used for the study might not be able to utilize the backrest of the seat. From this study, it was found that the seat depth of the University lecture hall's seats were not adequate and a model should be developed to determine the most appropriate seat depth required for the University's lecture hall's seats.

Keywords: *Anthromometric dimensions, Ergonomics, Seat, Popliteal height, Buttock-popliteal height*

INTRODUCTION

Anthropometric evaluation involves the collection and analysis of the dimensions of the human body for the purpose of ergonomic design of the workplace (Ismaila, 2009). It was stated by Thariq, *et al.,* (2010) that chairs are one of the most important furniture in a learning environment. Different authors have testified to the fact that many students spend a great part of their time in school sitting (Linton, et al., 1994). When the sititng posture becomes uncomfortable, problems such as; low back pain, neck and shoulder pain becomes apparent, this was reported by Mandal (1985).

In addition, Evans, *et al.,* (1992) noted that whenever there is a mismatch between the thigh's length and the seat depth, there would be a significant seating discomfort and also a mismatch between the seated elbow height and table height would cause pains in the shoulders and neck of the student. Because of the fact that about 75% of the human's body weight is being supported by only 26cm^2 of the sitting surface of the seat, there is bound to be a high compressive stress from this phenomena (Tichauer, 1978). Therefore, there is the need to design seats that will enable the loads in the buttocks and thighs to be well distributed by the leg support. To buttress this fact, Chaffin, *et al.* (2006) confirmed that the feet should be at ninety degrees to the ankle on the floor,

this will prevent the thighs from supporting the weight of the lower leg.

Several adjustable model tables and chairs were developed and evaluated by Jung (2005) in order to solve the problem of discomfort and musculoskeletal disorders in students. These prototypes are not however visible in developing countries such as Nigeria because of the paltry budget apportioned to the educational sector (Oyewole, et al., 2010).

It is in view of the above that prompted the authors of this work to evaluate the anthropometric data of all year two engineering students of Federal University, Oye-Ekiti, located in the south west of Nigeria. This evaluation will help in future designs of sitting furniture in the university community.

LITERATURE REVIEW

Several works have been done in the area of ergonomic design of seats in a learning environment Adejuyigbe and Ali (2004) identified the ergonomic problems of various furniture items used by staff and students of a Federal University and provided optimal design for them. However, the downside of this was that the proposed specifications were based on foreign anthropometric data. In contrast, Kolawole and Amedu (2007) evaluated the anthropometric data of a university furniture. The data used were students of a higher institution of learning domiciled in Nigeria. A highlight of possible mismatch between students' body dimensions and dimensions of classroom furniture was done for a sample of 170 students for a university in Malaysia (Negin and Fairuz, 2012). Results showed that mismatch existed to a proportion of about 9.5 cm and 28cm for the chair height and back rest respectively. The study is however limited to the fact that several nationalities are represented in small ratio in the institution thereby making the data not robust enough. Osquei-Zadeh, *et al* (2012) considered anthropometric data for library furniture in an Iranian university. Their work showed that the elbow and sitting popliteal height used for the furniture dimensions were inadequate. It was noted that design dimensions should be altered by about 1.6% for the chair seat height. It was also reported by Tunay and Melemez (2008) that furniture plays a significant effect on human health. It thus becomes essential to use anthropometric dimensions of the nationalities for which the study was carried out. In their study, they found out that the comfort and health can be improved by designing furniture that would minimize injuries caused by wrong designs.

A more detailed work on the relationship between ergonomic chair and musculoskeletal disorders was done by Sepehri, *et al.* (2013). A sample of about 810 students were analysed. Their results went further to prove that exercise and correct patterns of sitting using appropraite chairs can help prevent several kinds of musculoskeletal anomalties. In many universities, students have been known to spend long hours in lecture halls, classrooms and libraries staying in static sitting position. Prolong sitting is a known risk factor for the development of musculoskeletal disorders. This is made worse if the seat design is not convinient for the students (Reddy, 2015). The prolong use of poorly designed furniture that fails to accommodate the antropometric characteristics of its user have a negative effect on human health (Agha, 2010). It is geramane therefore to analyze the antropometric dimensions of students using a university's hall seat.

METHODS

The major users of the university lecture theatre are the students. A survey of the relevant anthropometric dimensions which includes popliteal height and buttock to popliteal length were taken. A population size of 188 students which are the 200 level students using the furniture was analyzed. Students mean age was 20.45 $\pm$ 3.88 years. Students are instructed to sit comfortably on the chair as depicted in Figure 1.

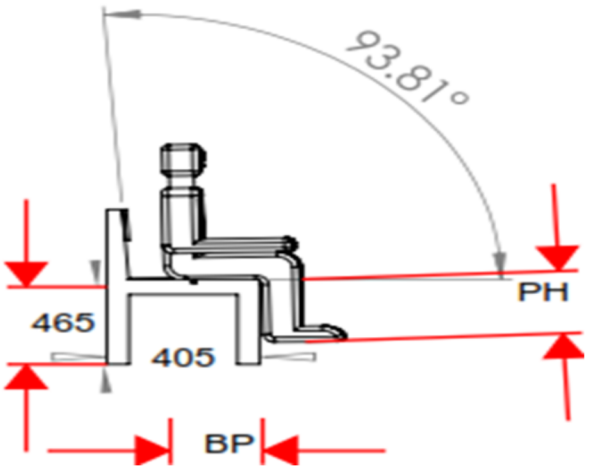

Figure 1: Sitting Position

Where BP= Buttock to popliteal length
PH= popliteal height

Anthropometric data were collected by using the methods of Gouvali and Boudolos (2006) who advised that anthropometric data should be taken by using an anthropometry giant venier caliper and metal tape rule. The engineering lecture hall consists of chairs in form of pews that have a standard height and seat depth.

This is uniform for a total of 102 of such pews. A drawing of a pew is shown in Figures 2 and Figure 3. A photograph of the existing seat being used by students is shown in Figure 4:

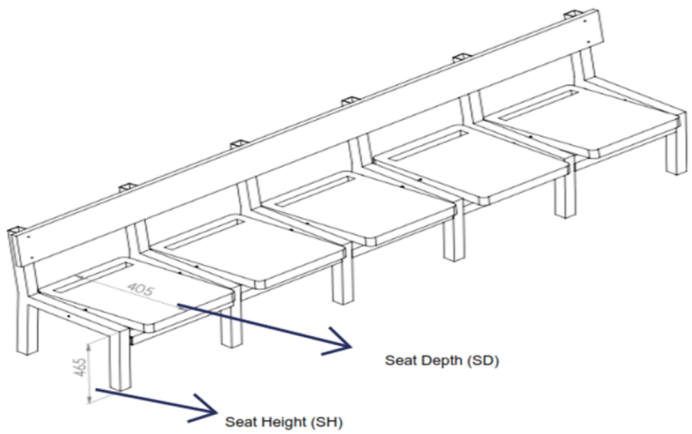

Figure 2: The University lecture Theatre seats

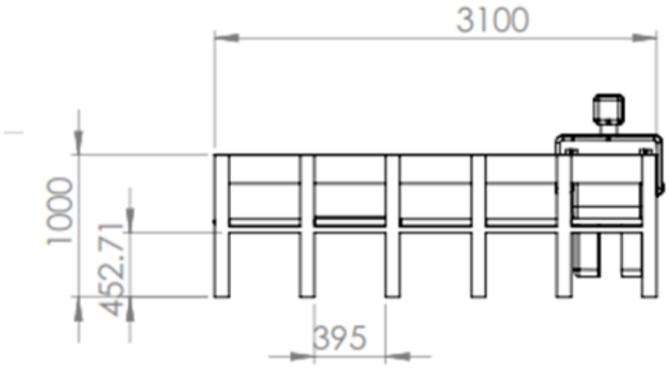

Figure 3: Dimensions of the University Lecture Theatre seats

Figure 4: Lecture hall seat photograph

Description of Measurements:

Seat Height

This is defined as the vertical distance taken from the horizontal floor to the underside of the seat rest. This is depicted in Figure 2

Seat Depth

This is defined as the horizontal distance along the seating surface taken from the back of the seat to the front of the seat as depicted in Figure 2

Popliteal Height

This is defined as the vertical distance that is measured at 90^{o} knees flexion from the foot resting on the floor taken to the posterior surface of the knee. The student is told to seat comfortably with the lower leg hanging

freely. The measurement is carefully taken in this position. This measurement is necessary in order to determine the fit criteria of the seat height. Refer to figure 1

Buttock-Popliteal Length

This is defined as the horizontal distance that is measured at 90o knees flexion from the posterior surface of the buttock to the posterior surface of the knee. The student is told to seat comfortably with thighs fully supported by the seat and the lower leg hanging freely. The measurement is taken from the measurement block to the forward edge of the sitting surface. This measurement is necessary in order to determine the fit criteria of the seat depth (Figure 1).

Fit and Non-Fit Criteria

Popliteal Height and Seat Height

When the seating surface becomes too high, the underside of the thigh becomes overly compressed which cause discomfort and result in restriction in the flow of blood. Also, when the seating surface is too low, this will result in knee flexion angle becoming too small which will cause the student's weight to be transferred to a small area at the ischia tuberosity (Nguyen, 2003). In order to mitigate against this problem, Gouvali and Boudolos (2006) found out that the seat height should be lower than popliteal height. The range of the fit criteria is shown in the expression below:

$$(P+2)\cos 30^{\circ} \leq SH \leq (P+2)\cos 5^{\circ} \quad (1)$$

Where SH is the seat height and PH is the popliteal height.

This expression was used for all students whose anthropometric data were obtained.

As an illustration, consider a student with popliteal height of 530mm from part of the collected data shown in Table 1. Substituting this in Equation 1, we have that

$$460.73 \leq SH \leq 529.98$$

Where SH is 465mm

From the above it can be seen that the lecture hall seat fits student 1. Similar calculations were done for other students and the result is part of the summary in Table 1

Buttock to Popliteal Length and Seat Depth

It was proposed by Milanese and Grimmer (2004) that the seat depth should always be less than the buttock to popliteal length of the user. A discomfort will therefore exist if the reverse were to be the case. This discomfort will be as a result of not utilizing enough area of the back rest for support of the lumbar spine. On the other hand, if the seat depth were significantly less than the buttock to popliteal length of the students, the thighs would not be supported in the sitting position.

The range of the fit criteria given by Gouvali and Boudolos (2006) was adopted, this is shown in Equation 2:

$$0.8\,PB \leq SD \leq 0.99\,PB \quad (2)$$

Where PB is the buttock to popliteal length and SD is the seat depth

The students buttock to popliteal length dimensions were substituted in Equation 2 and the seat depth of the chair was compared for each student. Part of this result is shown in Table 2

RESULTS AND DISCUSSION

The anthropometric data of 10 students out of the 180 students analyzed is summarized in Table 1. There is a limitation of space for the whole data in this paper, so a statistical summary is shown.

As displayed in Table 3, it can be shown that 115 students which represents 61.2 % of the students are found to be within the 'fit' range of the seat's height of 465mm. the implication of this is that about 38.8% of the students may be experiencing discomfort in using the seats by having a restriction in their blood circulation to their legs. Also, much of their body weights are being transferred to a small area of ischial tuberosities.
Examining the seat depth and buttock to popliteal length, it is seen that a little above average which is 101 (53.7%) of the students may be comfortable using the present seat depth design of 405mm dimension. A lot over 46% of the students might not be able to utilize the backrest of the seat or are not having their thighs supported while siting.

As a result of the foregoing discussions, it can be deduced that the seat height is not a major problem, but the seat depth is an issue of concern. This could lead to age-long back pains as depicted in a study done by Reddy (2015).

As a likely remedy to the challenge of the seat depth dimension, adjustable seats could be constructed and put into use.

Table 1: Anthropometric data for students (Part) all dimensions in mm

S/No	Subject	Seat Height	Popliteal Height (P)	Buttock Popliteal Length	Seat Depth	Decision
1	Student 1	465	530	590	405	True
2	Student 2	465	470	590	405	True
3	Student 3	465	470	580	405	True
4	Student 4	465	470	580	405	True
5	Student 5	465	470	580	405	True
6	Student 6	465	470	580	405	True
7	Student 7	465	460	560	405	False
8	Student 8	465	554	540	405	False
9	Student 9	465	530	540	405	True
10	Student 10	465	490	540	405	True

Table 2 : Statistical summary of Anthropometric dimensions for 188 students

Anthropometric dimension	maximum (mm)	Minimum (mm)	Mean	Standard deviation
Popliteal Height	554	380	475.06	32.7
Buttock to Popliteal length	590	230	465	50.93

Table:3 Summary of Students in Fit and Not fit classes with percentages in bracket

Chair dimensions	Fit	Not Fit	Total
seat height (465mm)	115(61.2%)	73(38.8%)	188
seat depth(405mm)	101(53.7%)	87(46.3%)	188

CONCLUSION AND RECOMMENDATION

The compatibility of a University lecture hall's chairs have been studied and evaluated from anthropometric perspective. Relevant anthropometric dimensions such as popliteal height and buttock to popliteal length were measured. Also, the chair's dimensions which are the seat's depth and seat's height were measured. Comparision of these data was done in order to determine the 'fit' and 'non-fit' class. From this study, it was found that the seat depth of the chair does not fit most of the students. Therefore, it is recommended that for further study, a new research area known as machine learning technique could be harnessed. In this technique, model would be developed from data of a larger sample of users. This model would be iterated in order to predict best fit data points for the dimensions of the proposed seat.

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It was with deep sadness that we learnt of the death of Felix Olugbenga Ajayi in December 2016, he was the one who initiated this research idea. His commitment to engineering education and his unique manner of relating with his students and colleagues will be forever remembered. While acknowleging his contributions we dedicate this work to his loving memory.

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