

Ergonomic study of commuters’ bus cabin.

Sunday Ojolo & Adebayo OGUNDARE

Mechanical Engineering Department, University of Lagos, Yaba,
Nigeria

Abstract:

Various types of bus cabin are being used as commercial means of transportation in Nigeria. The bus cabin features are clearly seen in the Mazda and Hiace buses, which are imported into Nigeria as fairly used buses and accommodate 14 commuters. This work aim is to ergonomically design the bus cabin that accommodates commuters with a view to ensuring comfortability throughout the period of travel. Four parks were surveyed and forty (40) Hiace buses each were used as sample areas for data collection. The ergonomic design in a bus cabin was approached using the anthropometry of the commuters. The anthropometric data of commuters important to examine the ergonomic comfortability of the seats in the bus cabin were obtained and thereafter compared with important design attributes including: the backrest frame height, backrest depth, backrest length, seat depth, seat height etc. This was done with a view to examining the existing design. In a bid to achieve this task, anthropometric data of 200 persons were taken. This comprises 80 females and 120 males. Questionnaires were also administered to the commuters to obtain information on the cabin used and postural discomfort experienced in the course of their journeys. In addition, the design attributes of Hiace buses cabins were measured. The outcome of the measurements revealed various grey areas that require redesign and most importantly, since the primary concern is with commuters in the bus cabin, the seat becomes the priority. In the redesign of the seat the back-rest length is sectionalized with appropriate cushion. This will permit every segment of the backbone to rest fully on the seat without causing musculoskeletal related disorder. The seats are redesigned to accommodate three passengers in a row. When this ergonomic design is fully incorporated into the buses’ cabins used in Nigeria; issues relating to discomfort and musculoskeletal disorder resulting from wrong posture while travelling would be a thing of the past. In addition, this could serve as enhancement to emerging automobile industry in Nigeria on the design of bus cabin.

1. Introduction

Mobility is important in human life and key to economic vitality and social life and consumes 11% of spendable income (Dana, 2001). Most people do not own personal car and even those who do still prefer to go through public transport. Public transportation is not only employed by most Lagosians as in other parts of the world, as a means of transportation to move freely from one place to another to engage in several activities producing goods and services for either

economic or social activities (Hunt, 1991) but it is also a major occupation of several Lagosians providing millions of people with job ranging from the bus drivers, conductors, motor mechanics and several other stake holders in the commercial transport operations. Commonly employed for public transport among others is the commuter buses popularly known as *danfo*, which form the highest percentage of buses, employed in the transport industry for transporting goods and people for long or short distances between towns, villages in Lagos and interstates. The use of these commuter buses has increased over the years which necessitate the evolution in the design of the commuter to achieve faster, more streamlined, cleaner, economical, reliable, comfortable and safe vehicles (Miller and Suther, 1983).

Furthermore, in the design of a bus cabin the interiors is usually a point of call in which the commuters are the major interest. The bus cabin layout includes selection of locations for the seat, luggage, entry and exit door etc. with regard to the dimensional constraint (including floor height, roof height, cab length etc). This layout problem is referred to as the commuter packaging.

However, seats in a bus cabin are being regarded as a major prerequisite in the design of automobile. The bus cabin seats are usually designed to possess good dynamic features as well as providing good comfortability while the bus cabin is being used, thus it is imperative to incorporate both static and dynamic comfort into the design of a bus cabin seat.

The vast majority of these commuter buses are used imported buses, which required improvised design and fabrication of seats for passengers' cabin. These improvised seats are constructed by artisans and welders without proper design consideration and consultation of the anthropometric data of the proposed users and as such suffers from aesthetics and ergonomic features. The poor construction of the cabin seat are evident in the height of the seat, back rest, space in-between two seats, length of seats, width of seats and material of construction (ILO, 1992). Considering the duration of travel, the bus cabin seat, which accommodates the commuter, is regarded as an important entity.

The improper design and construction of these seats poses are a great challenge to these lucrative ventures as it could results in occasional minor accidents causing injuries, tearing of commuters' clothes, difficulties in evacuation in case of accidents or fire and difficulties in entering or exiting the buses. Although sitting requires less physical efforts than standing or walking but put a lot of stresses on the lumbar area, thus combined effect of sedentary lifestyle and a job or activity that requires sitting may lead to many health problems (Bailer, 1982; Sanders and McCormic, 1987).

The design and selection of suitable seats is critical in reducing the risk of accidents and in battling health problems arising from prolonged sitting position associated with commuters who use commuter buses for both long and short distance travel. With

ergonomic approach sitting is viewed as specific specialized activity, which influenced the interaction of a sitting person with the immediate environment. Since the productivity of workers can be increased by proper design of work places and procedures (Fredrick,1975) the health and safety of commuters can be improved following the same principles because ergonomic product is believe to reduce fatigue and repetitive strain, and boosting productivity by providing comfort and enhanced usage (Mandal, 1992; Hunt, 1991) . It is obvious that a number of bus cabin used as commercial means of transportation in Lagos, Nigeria is characterized with low static strain, which do not result in acute damage, but overtime might result to musculoskeletal injuries due to the duration of constraint.

Ajayeoba and Adekoya (2012) describes the ergonomic suitability of the passenger seats in the molue buses used in Lagos by collecting the passengers' anthropometric variables which include buttock knee length, popliteal height (sitting), shoulder breadth, etc. In the end the result revealed, among other things, that the design dimensions needing major adjustments are the components of the seats (i.e. the seat depth, seat/backrest length, and seating clearance) while the seat height needs little adjustment to accommodate at least 95% of the users.

Ismaila et al. (2010) obtained the anthropometric data of users of passenger buses and examine the possible mismatch between their relevant dimensions and the seats they sit on when in these buses. The results showed a degree of mismatch between the passengers' bodily dimensions and the seat dimensions, which is an indication that the anthropometric data of the Nigerian passengers was not employed in the manufacture of the seats in the buses.

TRB (2006) works on ergonomics design and analysis of bus driver seat aims to improving the ergonomics design of the bus driver seat thus reducing bus operator injuries, improved health and performance; by creating a seat that optimally adjusts to each user's physical dimensions and optimizes the operator in a time. From the RULA analysis conducted, it was deduced that ergonomics analysis is a key factor, which dictates how a person sits, stands or moves about in an area alongside the length of time. The range of motion and how human being move were also taken into consideration.

Eliane et al. (2004) examined human factors in designing of a more comfortable aircraft cabin for passengers, by grouping the elements of comfort into four models, which are passenger bubble, health model, community model and the aesthetic ergonomical model. All these models put different requirements on the passengers' environment, sometimes overlapping, but sometimes also conflicting. In order to support designing for comfort, a model in which these requirements can be combined based on cognitive function analysis were presented. Six principles were identified as guide to the design: affordance, situational awareness, individualisation, customisation, variability and flexibility.

Due to the short time frame available for preparing and commencement of the journey, the demand to adjust the commuters' seat must be easy, quick and understandable. In order to actualize the objectives of this work, anthropometric and design measurement were taken to redesign the bus cabin ergonomically.

2. Materials and methods

In carrying out this work, three main instruments were used to acquire anthropometric data of commuters. The instruments used are measuring tape, chalk and meter rule. The chalk was used to mark off distances before the measuring tape or meter rule was used to take measurement. The meter rule was used to take measurement of popliteal height, which is the distance from the lower thigh to the foot while sitting.

2.1. Interview and questionnaire

Case studies of Ojota park, Yaba Park, Oshodi Park and Jibowu park in Lagos metropolis were considered because of their busy schedule since they are the major terminals where commuters joined buses in Lagos to and fro the western, eastern, southern and northern parts of the country. However, Hiace buses, Urvan buses, Mazda buses and Benz buses are the buses found in these parks but Hiace and Mazda buses are the most common. Forty (40) Hiace commuter bus cabins are considered. The dimensions of the cabins were measured.

A total of two hundred (200) respondent were tested individually, five (5) respondents per bus i.e. two (2) female and three (3) male. Questionnaires were administered to obtain data on commuter cabin used and postural discomfort experienced in the course of the journey. Both structural and functional anthropometric data were obtained from each respondent after which questionnaires were administered. Personal interviews were also conducted to accommodate the shortcomings of the questionnaires. The respondents were matured men and women who were either ready to embark on a journey or were just returning. Body measurements of respondents were taken both in sitting and standing positions. The study was carried out for five days in a week for four weeks. Internal dimensions of two Hiace buses were carried out and a total of ten respondents were tested in each park per day.

2.2. Commuters' bus cabin dimension

The length, width, and height of the interior of the bus cabins and the seats were measured and recorded. Though the buses considered are Hiace buses but the interior dimensions differ from each other.

2.3. Subjects' anthropometry

Anthropometry data obtained from respondents were height, shoulder-to-shoulder length, shoulder height from waist, femur length, tibia length and popliteal height. All these data were obtained while subjects were standing except popliteal height, which was obtained while subjects were sitting. Other information gathered through the

Journal Prevention & Ergonomics; Vol:9, N°:3. Year:2015, ISSN:1112-7546. EISSN:2676-2196

questionnaire, personal interview were: age, sex, names, destination, duration of the journey, purpose of travelling, and stress encountered among others.

The mean, standard deviation and t-test was computed for each group of data. The mean of data was computed to determine the average of the height, shoulder to shoulder length, femur length, tibia length and popliteal height for each group of data. The mean is given as

$$\bar{X} = \frac{\sum x_i}{N}$$

Where x_i is the set of values of height or shoulder to shoulder length or femur length or tibia length or popliteal height, and N is the Total number data. The standard deviation of the data is given as

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{X})^2}$$

The t-test was used to compare the means between two groups sampled in the same park using equation (3)

$$\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2 + \sigma_2^2}{N(N-1)}}}$$

3. Results and discussions

The summary of the anthropometric data of male and female respondents obtained from parks used in this study are documented in Tables 1-8. The internal dimensions of the Haice buses used by respondents are also documented in Tables 9 -12.

Table 1: Anthropometric Characteristic of Male Respondents in Ojota Park

	Age (years)	Height (cm)	Shoulder- to- shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Popliteal height (cm)
1	29	170.21	36.89	44.12	43.37	47.21	48.01
2	29	171.04	45.72	57.15	50.80	43.18	49.53
3	29	147.32	48.26	43.69	42.93	40.64	40.89
4	29	173.48	46.74	49.28	45.72	44.95	44.45
5	30	72.72	38.88	43.18	43.43	45.21	48.01
6	30	144.78	53,34	43.18	38.10	39.37	43.18
7	31	172.00	53.34	42.42	50.8	38.10	46.99
8	31	160.02	48.26	43.18	45.72	38.10	45.72
9	31	177.80	50.04	50.80	45.72	40.64	47.50

10	31	170.18	53.34	49.53	42.64	38.10	48.26
11	31	186.69	50.80	60.96	55.88	48.26	55.88
12	32	178.05	49.02	60.96	55.88	50.29	51.05
13	34	168.42	43.43	47.24	46.48	44.48	44.96
14	34	168.28	55.12	44.45	45.72	41.91	46.99
15	35	189.78	53.34	38.10	37.57	37.85	37.85
16	35	160.02	53.34	49.53	43.18	38.10	45.73
17	37	172.72	46.99	53.34	44.45	45.72	50.80
18	37	158.75	49.53	55.88	53.34	48.26	50.80
19	37	165.10	52.83	58.42	50.80	41.91	50.80
20	37	158.25	43.69	52.07	38.86	37.34	48.26
21	39	160.02	42.42	40.64	43.43	45.72	48.26
22	42	180.34	46.99	57.15	43.18	39.88	49.53
23	47	166.39	44.45	54.61	41.91	38.10	45.73
24	47	175.26	48.06	49.53	45.72	45.72	46.48
25	48	180.34	46.99	49.53	43.18	44.45	49.53
26	48	157.40	45.72	46.99	44.45	43.18	44.13
27	48	152.40	48.77	40.64	39.88	41.01	45.01
28	51	147.32	50.80	38.61	40.89	40.39	38.61
29	53	181.10	50.80	51.56	50.04	46.48	46.99
30	53	158.24	48.77	42.44	47.50	40.64	51.05
Sum	1125	5024.92	1447.65	1459.18	1361.56	1275.19	1408.9
Mean	37.5	167.50	48.26	48.64	45.39	42.51	46.96
S/D	7.91	11.36	4.44	6.65	7.50	3.67	4.94

Table 2: Anthropometric Characteristic of Female Respondents in Ojota Park

	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Popliteal height (cm)
1	27	172.21	46.87	43.18	43.43	47.73	42.33
2	28	181.10	45.72	48.79	48.01	45.72	45.72
3	29	154.94	48.26	43.18	43.18	38.10	46.23
4	29	165.10	49.71	49.78	46.97	45.11	46.06
5	31	173.51	46.81	49.28	46.99	44.45	45.21
6	37	154.94	48.28	43.87	40.19	39.11	49.26
7	37	165.72	49.28	46.97	44.45	44.23	45.21
8	31	154.94	48.27	43.89	41.17	39.77	41.21
9	39	160.02	49.02	41.40	39.88	40.64	40.39
10	39	172.73	48.18	48.03	45.01	42.36	47.34
11	39	173.51	46.87	49.72	47.10	44.45	45.71
12	39	173.51	46.87	49.72	47.10	44.45	45.71
13	51	160.02	49.07	42.33	39.87	46.64	46.77
14	52	172.21	46.99	43.18	41.40	42.69	42.12

15	52	144.77	45.93	40.64	39.88	41.40	41.93
16	53	158.24	48.76	41.42	46.53	40.13	51.05
17	60	175.26	51.05	46.23	43.43	42.67	41.91
18	60	173.57	51.87	46.23	41.89	49.03	50.17
19	61	177.04	46.39	57.13	50.30	44.11	49.53
20	63	157.38	43.97	43.37	44.17	43.97	45.00
Sum	863	3316.38	958.423	916.41	879.62	8658.48	909.95
Mean	43.15	165.82	47.91	45.82	43.98	453.42	45.49
S/D	11.87	0.39	2.30	4.00	3.02	2.69	3.23

Table 3: Anthropometric Characteristic of Male Respondents in Yaba Park

	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Popliteal height (cm)
1	28	181.10	45.72	48.79	48.01	45.00	45.72
2	28	176.26	47.98	43.18	43.44	43.60	42.91
3	29	170.21	36.87	44.12	43.36	47.21	51.01
4	29	147.32	48.26	43.69	42.93	40.64	40.89
5	29	173.48	46.74	49.28	45.72	44.95	44.45
6	30	172.72	39.88	43.18	43.73	45.21	48.01
7	30	144.78	53.34	43.18	38.1	39.37	43.18
8	31	160.02	48.26	43.18	45.72	38.10	45.72
9	31	186.69	50.80	60.13	46.01	43.83	43.19
10	31	170.18	53.34	49.53	42.67	38.10	46.23
11	32	178.05	29.02	60.96	55.88	50.2 9	51.05
12	34	168.42	43.43	47.24	46.48	44.48	44.96
13	35	198.78	53.34	38.10	40.89	40.39	38.61
14	36	186.69	50.80	60.96	55.88	48.26	49.01
15	37	174.50	51.05	46.23	43.33	42.67	42.15
16	37	175.28	50.80	48.01	45.72	40.01	40.89
17	39	172.73	48.18	48.03	45.01	42.36	47.34
18	39	160.02	8.260	43.18	45.72	38.10	45.72
19	39	172.73	49.01	48.03	45.11	42.36	43.01
20	47	175.26	46.06	49.53	45.72	45.72	46.01
21	48	180.34	46.90	53.34	44.45	45.72	50.80
22	48	152.40	48.77	40.64	39.88	41.40	45.01
23	51	147.32	50.80	36.61	37.85	37.85	38.11
24	52	144.80	45.93	40.63	39.85	41.40	41.93
25	52	144.80	45.96	40.67	39.91	41.43	42.06
26	60	175.26	51.07	47.13	43.43	42.19	43.01
27	61	177.01	46.93	41.62	40.88	42.40	42.44
28	61	177.04	46.37	57.13	590.30	44.11	45.13

29	64	60.20	48.06	43.18	45.72	44.01	45.07
30	72	143.10	44.97	41.63	40.11	40.49	40.57
Sum	1241	5247.44	1432.27	1355.57	1329.52	289.35	1336.76
Mean	41.37	174.10	47.74	45.19	44.32	42.98	44.56
S/D	12.85	15.20	3.68	6.50	4.18	2.86	3.44

Table 4: Anthropometric Characteristic of Female Respondents in Yaba Park

	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Popliteal height (cm)
1	29	148.31	50.18	39.61	38.85	37.85	38.72
2	31	170.18	53.34	49.53	42.67	38.10	40.30
3	31	170.18	53.34	49.53	42.67	38.10	40.30
4	35	198.78	53.34	38.10	40.89	40.39	38.61
5	36	186.84	50.80	60.96	55.88	48.26	55.88
6	37	174.50	50.80	48.01	45.72	40.01	45.01
7	37	172.72	46.99	49.53	43.18	44.45	49.53
8	43	180.34	46.99	57.15	43.18	39.88	43.12
9	47	166.39	44.45	54.61	41.91	38.10	45.72
10	47	175.26	48.06	49.53	45.72	45.72	46.48
11	48	168.34	55.12	44.45	45.72	41.91	46.99
12	49	160.02	48.26	43.18	45.72	38.10	41.37
13	50	177.80	50.04	50.80	45.72	40.64	47.50
14	51	157.48	45.72	46.99	44.45	43.18	44.13
15	52	160.02	49.02	41.40	39.88	40.64	40.93
16	53	158.24	48.77	42.42	47.50	40.64	51.05
17	53	158.24	48.77	42.42	47.50	40.64	51.05
18	53	181.10	50.80	51.56	50.04	46.48	46.99
19	60	168.34	55.12	44.45	45.72	41.91	46.99
20	63	158.75	49.53	55.88	53.34	48.26	50.01
Sum	904	3380.78	981.78	977.89	900.93	833.85	909.02
Mean	45.20	169.04	49.09	48.89	30.03	27.96	30.30
S/D	7.8	10.56	2.40	3.75	4.21	6.89	4.20

Table 5: Anthropometric Characteristic of Male Respondents in Oshodi Park

	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Popliteal height (cm)
1	27	147.32	48.26	43.69	42.93	40.64	40.89
2	30	144.78	53.34	43.18	38.10	39.37	40.79

3	34	168.28	55.12	44.45	45.72	41.19	43.93
4	37	170.18	53.24	49.53	42.67	38.10	46.23
5	37	167.89	49.77	47.98	49.88	51.30	52.11
6	38	160.06	53.34	59.53	43.18	38.70	40.97
7	38	170.21	36.87	44.12	43.37	47.21	50.18
8	39	160.02	42.42	40.64	43.43	45.72	48.26
9	39	152.40	48.76	50.10	39.88	41.01	45.01
10	42	152.40	48.76	50.10	39.88	41.01	45.01
11	47	166.39	44.43	54.61	41.97	38.10	43.17
12	47	172.72	39.88	43.18	43.43	45.21	48.01
13	47	175.26	48.06	49.53	45.72	45.72	46.99
14	47	181.10	50.58	51.56	50.04	46.48	46.97
15	48	160.02	42.42	40.64	43.43	45.72	48.26
16	48	157.48	45.72	46.69	42.93	40.64	40.98
17	49	152.40	48.77	40.64	39.88	41.01	43.18
18	53	158.24	48.77	42.42	47.50	40.64	51.05
19	53	154.94	48.26	43.18	43.18	38.10	42.26
20	53	175.26	48.06	49.53	45.72	45.72	46.77
21	56	181.10	45.72	48.79	48.01	45.72	46.19
22	57	180.77	48.99	55.18	44.18	39.88	39.99
23	60	154.94	48.27	43.87	40.19	39.11	41.33
24	61	177.04	46.37	57.13	50.30	44.19	49.53
25	63	165.10	52.83	58.42	50.80	41.91	43.77
26	72	158.75	52.80	55.88	53.34	48.26	50.80
27	73	175.26	49.53	46.23	43.43	42.67	43.88
28	75	160.02	51.05	41.40	39.88	40.64	41.19
29	75	164.94	49.02	48.08	46.00	42.29	45.07
Sum	1436	14783.15	1393.94	48.08	46.00	42.49	45.07
Mean	49.52	9.32	48.07	6.29	5.77	3.20	4.73

Table 6: Anthropometric Characteristic of Female Respondents in Oshodi Park

	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Popliteal height (cm)
1	28	181.03	47.97	48.79	49.10	46.17	47.03
2	29	150.72	49.07	46.88	42.33	44.31	45.73
3	31	140.70	41.97	43.70	40.13	38.71	40.13
4	35	198.05	53.87	53.17	43.89	44.37	44.37
5	37	166.77	52.93	58.70	50.80	43.98	44.33
6	37	154.94	48.27	43.87	40.19	39.80	40.17
7	38	160.02	53.18	40.97	43.88	38.30	46.72
8	39	160.05	53.13	42.05	46.78	47.10	48.07

9	46	166.39	43.47	51.63	40.19	38.10	46.72
10	48	157.48	45.77	46.99	44.45	43.38	44.13
11	48	168.11	51.11	46.38	43.93	45.72	45.71
12	48	157.87	49.33	46.89	44.47	43.18	44.07
13	49	160.72	42.42	40.64	43.42	45.724	6.71
14	51	148.18	48.77	40.86	41.73	42.81	43.17
15	52	144.77	45.93	40.46	39.88	43.40	44.39
16	53	168.22	55.71	40.93	43.87	49.11	50.13
17	53	181.10	50.80	51.56	50.04	46.48	46.99
18	61	157.87	49.33	46.89	44.47	43.18	44.07
Sum	783	2928.60	825.31	831.64	793.53	786.01	809.56
Mean	43.50	162.70	45.85	46.20	44.09	43.67	44.97
S/D	8.77	8.70	3.25	4.63	3.74	6.23	3.11

Table 7: Anthropometric Characteristic of Female Respondents in Jibowu Park

	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Popliteal height (cm)
1	29	173.48	46.74	49.28	45.72	44.95	44.78
2	29	173.48	46.74	45.78	45.20	47.13	48.07
3	29	170.29	36.87	44.37	43.19	48.08	51.01
4	30	173.48	50.80	60.96	55.88	48.26	55.88
5	30	136.84	53.83	47.15	39.33	40.87	41.78
6	31	160.02	48.26	43.18	45.72	38.10	43.77
7	34	178.05	49.02	60.92	55.88	50.29	51.09
8	35	198.78	53.34	38.10	40.89	43.78	44.93
9	37	186.69	46.74	49.26	45.72	44.95	44.97
10	37	158.75	49.53	55.88	53.34	48.26	56.87
11	37	170.98	43.17	43.87	42.18	42.17	40.38
12	38	178.69	50.80	60.97	55.88	48.26	53.87
13	39	160.02	42.48	40.67	43.43	45.72	48.07
14	45	172.37	39.87	43.18	43.47	45.31	48.01
15	47	175.26	48.06	49.53	45.72	48.31	49.18
16	47	175.26	48.06	49.53	45.78	45.89	46.73
17	48	180.34	4.99	53.34	44.45	45.72	48.97
18	48	152.40	48.17	40.07	39.98	43.49	44.73
19	48	144.78	48.77	40.64	39.88	41.40	40.87
20	49	158.17	46.17	43.18	44.19	45.71	45.81
21	49	175.88	29.07	50.80	45.79	47.13	48.11
22	51	147.32	48.87	38.61	37.85	37.85	40.10
23	53	181.17	50.69	51.87	50.40	46.77	45.83
24	53	181.10	50.80	51.56	50.04	46.48	46.97

25	57	186.17	51.30	49.78	51.17	50.18	51.10
26	58	169.87	49.11	48.09	44.97	45.87	47.12
27	61	147.32	50.08	38.61	40.89	40.39	38.61
28	71	152.40	53.34	43.18	38.10	39.37	43.18
Sum	1220	4754.36	1348.39	1332.26	1275.04	1260.09	1340.79
Mean	43.75	169.80	48.16	47.58	45.54	45.02	47.89
S/D	6.89	0.83	4.53	5.28	7.40	3.39	6.12

Table 8: Anthropometric Characteristic of Female Respondents in Jibowu Park

	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur length (cm)	Tibia length (cm)	Polpiteal height (cm)
1	28	181.10	45.72	48.79	48.01	45.72	45.72
2	29	170.11	36.87	44.12	43.43	45.21	48.01
3	31	160.37	48.26	43.15	45.72	38.10	40.73
4	32	173.43	46.74	49.28	45.72	44.95	44.57
5	34	167.57	48.31	52.37	45.13	37.98	41.12
6	35	198.74	53.34	38.10	40.89	40.39	38.61
7	37	173.51	46.81	50.13	47.34	44.45	45.13
8	37	158.75	43.69	52.07	38.86	37.34	43.18
9	39	168.72	43.49	48.24	46.48	44.48	44.45
10	42	180.34	46.77	57.15	43.18	39.88	43.81
11	47	166.39	44.48	54.61	41.91	38.10	45.72
12	48	180.34	46.99	53.34	44.18	45.15	45.33
13	52	144.77	45.93	40.64	39.88	41.40	42.30
14	52	172.21	46.79	49.87	46.77	44.93	45.71
15	53	160.02	53.34	49.53	43.18	38.10	45.72
16	57	172.73	48.18	48.03	51.01	42.36	47.18
17	60	1745.21	46.99	43.18	41.40	42.67	42.97
18	61	177.04	46.37	57.13	50.09	44.11	43.77
19	61	183.31	51.77	57.15	52.38	51.87	52.13
Sum	835	3264.41	890.84	936.91	855.56	807.19	846.16
Mean	43.95	171.81	46.89	49.31	45.63	42.48	44.53
S/D	10.63	12.15	6.89	6.65	2.30	7.31	4.87

Table 9: Internal Dimension of Haice Buses Used by Respondents in Ojota Park

	Length (cm)	Width (cm)	Height (cm)
1	280.16	150.11	128.76
2	292.10	152.40	132.08
3	284.48	148.59	129.54
4	281.18	148.59	129.03
5	280.16	149.61	127.25

6	284.48	150.26	129.54
7	284.73	148.59	129.54
8	284.48	148.84	129.54
9	281.69	151.89	132.08
10	284.48	149.10	127.76
Sum	2837.94	1498.34	1295.37
Mean	283.79	149.83	129.54
S/D	10.20	1.20	2.20

Table 10: Internal Dimension of Haice Buses Used by Respondents in Yaba Park

	Length (cm)	Width (cm)	Height (cm)
1	279.40	149.55	127.81
2	280.67	151.11	132.01
3	279.51	149.10	127.00
4	80.67	148.59	129.54
5	284.458	148.84	132.08
6	285.24	148.59	129.54
7	292.13	149.10	129.29
8	278.47	148.59	129.54
9	281.69	149.08	129.54
10	284.48	148.59	129.54
Sum	2826.74	1491.14	296.65
Mean	282.67	149.11	129.67
S/D	14.79	0.50	2.25

Table 11: Internal Dimension of Haice Buses Used by Respondents in Osbodi Park

	Length (cm)	Width (cm)	Height (cm)
1	281.07	150.11	128.77
2	292.30	153.07	129.07
3	283.50	149.13	127.25
4	281.18	148.97	135.70
5	280.16	146.79	129.79
6	284.49	150.17	129.55
7	283.77	148.84	132.18
8	284.93	151.73	128.97
9	281.69	149.78	132.09
10	284.40	149.78	129.97
Sum	2837.40	1498.37	1303.34
Mean	283.75	149.84	130.33
S/D	10.06	2.50	5.14

Table 12: Internal Dimension of Haice Buses Used By Respondents in Jibowu Park

	Length (cm)	Width (cm)	Height (cm)
1	280.17	150.13	128.76
2	281.07	148.59	132.08
3	280.17	149.59	132.08
4	284.32	151.89	131.09
5	284.73	150.77	129.77
6	281.69	149.87	129.54
7	284.48	148.59	129.03
8	285.75	151.17	132.08
9	284.97	149.13	129.79
10	280.17	148.78	128.66
Sum	2827.52	1498.29	1298.78
Mean	282.75	14.83	129.88
S/D	11.81	1.19	1.84

From the summary of the results obtained, it is observed that the mean age of the respondents is 43 years. The mean height is 168.56cm and the standard deviation is 9.43. The mean shoulder height from waist is 47.46cm and the standard deviation is 5.47. The mean shoulder-to-shoulder length is 47.74cm and the standard deviation is 4.0. The mean fibia length is 43.12cm and the standard deviation is 4.5. The mean popliteal height of respondents is 44.71cm and the standard deviation is 4.3. From the standard deviation values obtained, it shows that the heights of respondents used in the study spread over a wide range while the other anthropometric data obtained clustered round their mean values.

The mean length of space in the cabin is 283.24cm and the standard deviation is 11.84. The mean width of space is 149.65cm and the standard deviation is 1.35. The mean height of space in the haice bus is 129.86cm and the standard deviation is 2.86. From the standard deviations obtained, it shows that the lengths of space in the haice buses used in this study vary from each other i.e. up to 10cm while the heights and widths of space cluster around their mean values.

Information obtained from personal interview showed that the two (2) main causes of discomfort in the haice buses used for long journey purposes are; inability of commuters to stretch or move their bodies when required during these journeys which could lead to severe pains in a particular part of the body. Comparing the average shoulder-to-shoulder length which is 47.75cm and the average width of space available for seat which is 149.65cm, commuters will be more comfortable and be able to move their body when required if they sit three (3) in each row.

Another major stress encountered by commuters is excessive pressure on the underside of the thigh which occurred when the seat height is too high which is a deviation from the general accepted

principle of seat designs which states that the seat heights should be lower than the popliteal height which is the distance between the floor and the lower thigh when seated.

3.2. The redesigned commuters' cabin

3.2.1. Average anthropometric data of the subject

Tables 13-14 show the data used in redesigning the commuters' cabin.

Table 13: Average Anthropometric Characteristics of Male and Female Respondents in all the Parks

Parks	Age (years)	Height (cm)	Shoulder-to-shoulder length (cm)	Shoulder height from waist (cm)	Femur Length (cm)	Tibia Length (cm)	Popliteal Height (cm)
Ojota	39.76	166.83	48.12	47.51	44.82	42.87	46.38
Yaba	39.76	166.83	48.12	47.51	44.82	42.87	46.38
Oshodi	42.90	172.56	48.28	46.67	44.61	42.56	44.92
Jibowu	44.38	154.23	44.38	44.52	42.55	40.36	42.33
Mean	41.10	160.36	44.79	45.39	42.61	41.35	43.74

Table 14: Internal Dimension of Haice Buses Used by Respondents in all the Parks

Parks	Length (cm)	Width (cm)	Height (cm)
Ojota	2837.49	1498.34	1295.37
Yaba	2826.74	1491.14	1296.65
Oshodi	2837.49	1498.37	1303.34
Jibowu	2827.52	1498.29	1298.78
Sum	11329.24	5986.14	5194.14
Mean	283.24	149.65	129.85

3.2.2. The redesigned commuters' bus cabin

The redesigned seating in the commuters' cabin is presented in Figure 1. The seats were designed based on the anthropometric of the commuters and the cabin dimensions obtained in this study. From the anthropometric data obtained, the average popliteal height is 44.71cm, which is within the seat height range of 43.18cm-45.72cm as recommended by Mandal (1992). At a seat height lower than 43.18cm, there will be high pressure on the lower leg, which will result in excessive pains, and swollen legs. At seat heights higher than 45.72cm, there will be excessive pains on the underside of the thigh, which will reduce the blood circulation to the lower legs. Comparing the average femur length and space, which are 43.12cm and 283.24cm respectively, it shows that the vehicle owners can maintain four (4) rows of seats in the commuter cabin (Haice bus) as it is presently practice.

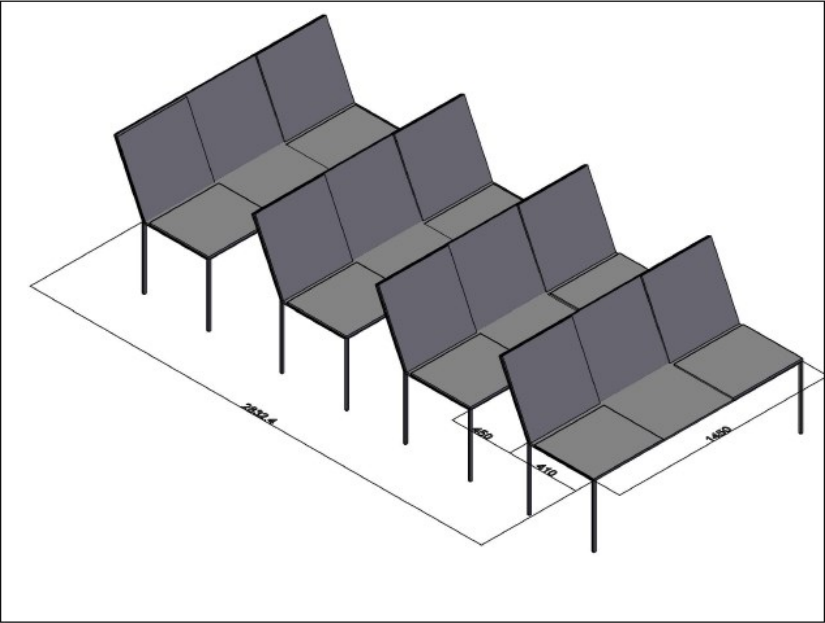


Figure 1 (a): A 3D view of the redesigned commuters’ bus seat

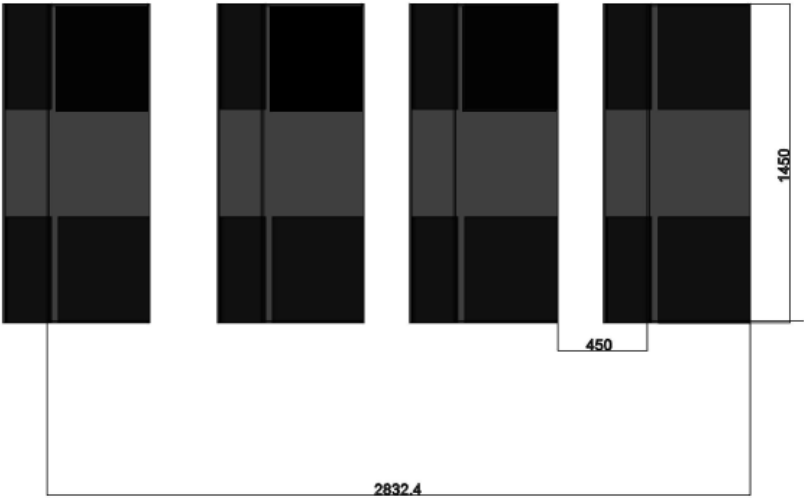


Figure 1 (b): The plan of the redesigned commuters’ bus seat

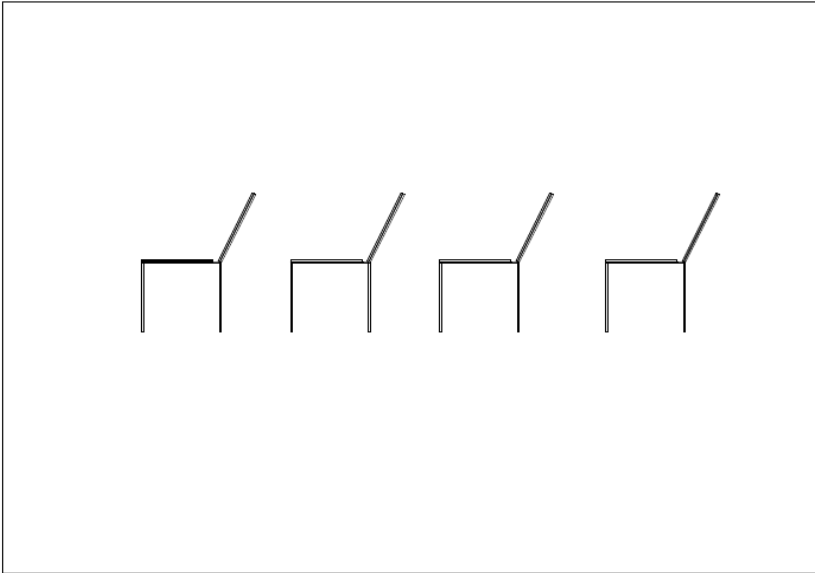


Figure 1 (c): Side view of the redesigned commuters' bus seat

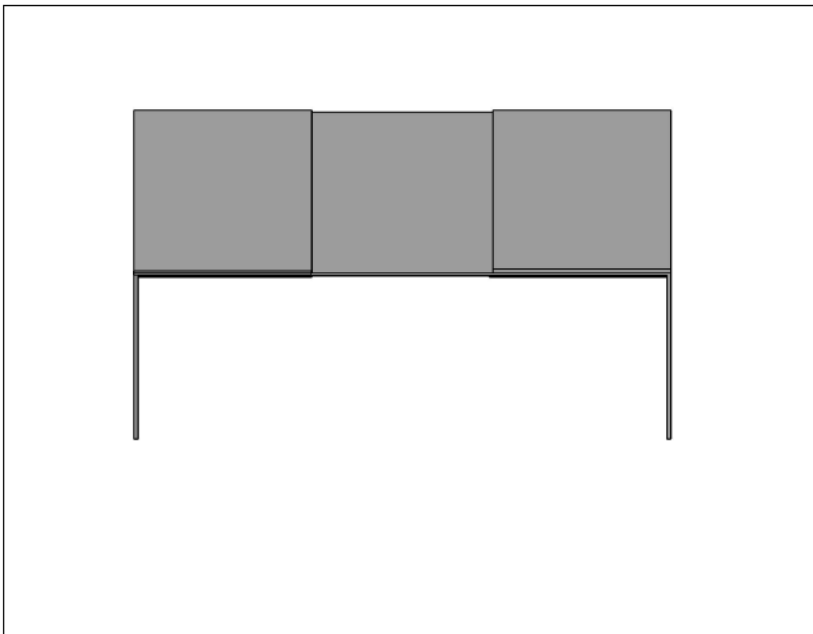


Figure 1 (d): Front view of the redesigned commuters' bus seat

4. Conclusions

The ergonomic design of commuters cabin commonly used in Nigeria has been presented in this work. The anthropometric data of the commuters obtained indicated that commuters can sit

comfortably in the redesigned cabin seats for considerable long hours while embarking on journey without any issues arising from postural discomfort. The new seat can accommodate three (3) commuters in a row making a total of 12 passengers as against the prevailing 16.

5. References

1. Ajayeoba, O.A. and Adekoya, L.O. (2012) Evaluation of the ergonomic suitability of passenger seats in *molue* buses in Nigeria, Journal of Mechanical Engineering, Vol. 1, No. 2, pp 4-11.
2. Bailey, R.W. (1982). Human Performance in Engineering, C. R. C Press Inc. Florida U.S.A, pp 703 – 717
3. Dana, S.D. (2001). Statistical and Data Analysis for The Behavioral Science, McGraw-Hill Publishing Company, New York, pp 365 – 387
4. Fredrick W. T. (1975). Human-Factors Engineering, Human Factors and International Reviews of Ergonomics, London.
5. Hunt, W. (1991). Postural and Visual loads at Video Display Terminal workplace: constrain posture. Department of Hygienic and Ergonomics, pp 917 – 937.
6. International Labour Office (1992) Preventing stress at work, Conditions of Work Digest, Vol. 11, No. 2, pp 35-38.
7. Mandal, G. (1995). Investigation of the lumbar flexion of office workers. Contemporary Ergonomics Proceedings of the Ergonomics Society's Conference, UK, pp 233 – 237.
8. Miller, W. and Suther T. (1983). Display station Anthropometrics: Preferred height and angle settings for video display terminal workstation and keyboards, pp 401 – 408
9. Netterstrom, B. and Laursen, P. (1981) Incidence and prevalence of ischaemic heart disease among urban bus drivers in Copenhagen, Scandinavian Journal of Social Medicine, Vol.9, pp. 75-79.
10. Sanders, S.M. and McCormic, E.J. (1987). Human Factor in Engineering and Design, McGraw-Hill Publishing Company, New York, pp 331 – 360
11. Transport Research Board (2006). America City & Country available at www.transitmetrokc.gov/tops/bus/ridefree.htm