ERGONOMICS ANALYSIS OF ONDO STATE GOVERNMENT'S FREE SHUTTLE BUS SEAT FOR SECONDARY SCHOOL PUPILS

BY

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CERTIFICATION

I acknowledge that I have read this work 'Ergonomics design and analysis of Ondo State Government's free shuttle bus seat for secondary school pupils' being carried out by Abolarinwa Bamgbola Oladapo and in my view, this work is adequate in terms of scope and quality for the award of Bachelor Degree in Mechanical Engineering

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DEDICATION

This research work is dedicated to God almighty who is my source of living and strength. in completing this work and to my parent, Hon. And Mrs. Abolarinwa J.A and lastly to my siblings and loved ones.

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ABSTRACT

Seat is one of the important components of a vehicle . The aim of this project is to evaluate the ergonomics design of the bus seat so that it will reduce. The anthropometric data of passengers relevant in assessing the ergonomic suitability of seats of buses use for secondary school pupils in Ondo State, Nigeria were measured and later compared with the relevant design variables of the seats. The relevant design variables measured included backrest frame height, backrest depth, backrest length, seat depth, seat height, and were measured with a metre rule and wooden vernier calipers. The passenger anthropometric variables measured included buttock-knee length, popliteal height (sitting), shoulder breadth, and were measured.

bus operator and users injuries. The goal of ergonomics design is to create a seat that optimally adjusts to each user's physical dimensions and optimizes the comfort of operator in a time. From the analysis that has done by using statistics analysis that shown ergonomics analysis is a key factor can include how a person sits, stands or moves about in an area. This would also include the length of time for these activities. Range of motion and how humans normally move are also taken into consideration. Ergonomists try to discover what makes certain situations more stressful on the body and how they can relieve this stress.

By improving the seat parameters according to those methods mentioned, the vehicle seats, such as buses' seats, could be developed in term of ride comfort for local purposes.The results of the project showed, among other things, that the design dimensions that need major adjustments are the components of the seats (as in the seat depth, seat/backrest length, and seating clearance) while the seat height needs little adjustment to accommodate at least 95% of the young users. The buses will be very ergonomically suitable for Nigerians pupils (Secondary and Primary alike) if necessary modifications may be effected by the automobile industry on the design variables of the seats.

CHAPTER 1

1.0 INTRODUCTION

Background

In the developing countries the ownership of cars is low compared to the developed countries. In fact, Hilling (1996) observed that access to personal means of transportation, frequency of trips and choice of mode are closely related to income levels. In Ethiopia, commercial transport operators depend largely on imported minibuses popularly called 'Mini-Bus' which in most cases do not come with passenger seats or when they do they are modified to accommodate more passengers to maximize their profits. Therefore, local manufacturers usually design or redesign the seats to suit the expectations of their customers without due consideration for the comfort and safety of the passengers. The question of the correct design of passenger seats with emphasis on comfort as regards the Ethiopian people arises due to the fact that required anthropometric measurements are not available and the local manufacturers assume that manufacture of seats is an art rather than engineering. Jeong & Park (1990) and Bridger (1995) noted that physical dimensions of furniture, equipment, clothing and workspaces are specified using anthropometric data to achieve proper ergonomic design.

Thus the use of anthropometric data in design may constitute improvement in the health and comfort of the users (Barroso et al., 2005). Similarly, Xiao et al. (2005) noted that anthropometric data is needed for ergonomically correct design of safe and efficient workplaces, equipment and tools. The main aim of this study is to gather anthropometric data necessary for the design and manufacture of passenger seats as well as to compare the data with that of the passenger seats presently in use. The main method of obtaining anthropometric dimensions has been reported is traditional anthropometry.

Ergonomics applied to transportation design requires that we take into consideration how the product is fit to the people that are using them. When products fit the users, the result can be more comfortable, higher productivity, and less stressful. Anthropometry is the science that measures the range of body sizes in a population, when designing products, it is important to remember that people come in many sizes and shapes. It is pertinent therefore to know the appropriate product that will maximize the comfort of user, more importantly when the population class is the children of ages between 10- 18years.

Ergonomics is the science of fitting the job to the worker, matching the physical requirements of the job with the physical capacity of the worker. Ergonomics is used to design an environment (layout, work methods, equipment, noise, etc.) which is compatible with each individual's physical and behavioral characteristics. Ergonomics looks at the behavior of the person performing the job. Good ergonomic design makes the most efficient use of worker capabilities while ensuring that job demands to not exceed those capabilities. Many years ago, equipment was built to do a job not to fit a person. Most factory jobs needed a tall person with long arms to work the equipment. Now factory equipment is adjustable to fit the different employees who work there. Another example is the old clerical chairs that were stationary. Now most chairs are adjustable.

1.1 Objectives

The main objective of this project are to carry out in determining the ergonomic suitability of the passenger seats in the bus use by the Ondo State Government under the free shuttle transport program made available for all public Secondary school pupils in Ondo State.

The general objective of the seat p\roject is to carry out the analysis of seat that would accommodate the extremes of the minibus seat population with minimal mechanical adjustment, and durable enough to withstand daily and prolonged use.

1.2 ScopeofWork

The basic scopes that want to achieve for the project to make successful and fulfill the objective are:

1. Perform the Ergonomics analysis with the new concept.
2. To carry Anthropometric analysis ,T test analysis and Chi-square at 95 per cent level of confidence.

1.3 **Problem Statement**

Sitting in a minibus through heavy traffic or long journey while dealing withstudents is more stressful and can make the driver develop musculoskeletal pain.To improve working conditions and retain students, many bus lines or bus express provide ergonomically designed seat for the users.Because of the limited amount of time allocated for the preparation and start of transit service, the actions to adjust the seat must be easy, intuitive, understandable, and quick. Finally, the seats must fit into the wide variation of urban transit bus workstations available. This lack of uniformity exists not only between bus manufacturers, but also among the bus models themselves.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 History of Busses

The history of bus dated back to the early 19th Century. In the early 1830's Sir Goldworthy Gruney from the UK had designed some kind of a Hugh stagecoach, which was powered by steam engine. This was probably the first kind of bus developed by mankind. However, the concept of buses has drastically changed in today's world (http://www.automobileindia.com/commercial-vehicles/bus-jeep-tractor-history.html).

Today, anything which is used to carry passengers and is self engineered is termed as a bus. It is normally used for fixed distances and routes. Any vehicle that carries more than 10 people is called a bus. However, after the first breakthrough in 1830, the development of buses took a new stage in 1895. It was during this time, that the first passenger bus with four to six horse power single cylinder engines was made in Germany. The modern term bus had come from the Latin word "Omnibus", meaning "for all". And by the 1915, bus service had started throughout the world. And slowly the Horse-Drawn Carriage and the Electric. Trolley cars were replaced by Buses (http://www.automobileindia.com/commercialvehicles/bus-jeep-tractor-history.html).

Initially, the structures of buses were not very different from trucks. They used to share the same kind of chassis with a different body. However, in 1922, an AmericanFirm for the first time had developed a chassis especially for bus service. It's a littledifferent from the truck chassis, which is a foot higher than that of the bus chassis. Italso had a front mounted engine, a wide tread and an extra long wheelbase. However,later an integral frame was developed for better performance. Soon after that, thegasoline electric buses were introduced and a few years later the diesel powered Busescame into being. Later in the 1950's air suspension was first implemented in thepassenger buses. Compared with the buses of the yesteryears today's buses consume\ more fuel, but at the same time are also more powerful than the buses of the past(http://www.automobileindia.com/commercial-vehicles/bus-jeep-tractor-history.html).

2.2 Buses

Bus is a derivation of Omnibus Vehicle meaning "vehicle for all", where Omnibus means "for all" in Latin (omnes meaning "all"), reflecting its early use for public transport. When motorized transport replaced horse-drawn transport starting 1905, a motorized omnibus was called an autobus, a term still used until now http://www.lingeriebrasandthongs.com). Nowadays technology had modified design a bus and technology has influenced design bus. The traditional configuration of a bus was an engine in the front and an entrance at the rear. After that with the transition to one-man operation, buses in the developed world have taken the form of mid or rear-engine designs, with a single door at the front, or multiple doors.

Front-engine buses still persist for niche markets such as school buses, some minibuses, and buses in less developed countries, which may be derived from truck chassis, rather than purpose-built bus designs. A motor vehicle for mass transit, built in various capacities and sizes, designed for carrying from 10 to 60 passengers or more on school, local, intercity, or interstate routes. A commercial bus usually operates on a regular schedule and travels a fixed route, and each passenger pays a fare. In general, a bus has a long body with the passengers sitting on benches or seats. A double-deck bus has two separate passenger compartments, one above the other. The articulated bus has two connected passenger compartments that bend at their connecting point as the bus turns.

2.3 History of minibus

In Hong Kong, minibus is commonly known as Public light bus. Public light buses were first introduced in 1969, with a view to regulate the illegal operations of minibuses at the time. In 1976, the total numbers of public light buses were 4,350 and at the end of 2009, this number has reduced to 4,349. The first public light bus had black and white checkered strips, and was commonly referred to as the zebra car. These zebra cars had the capacity of carrying not more than nine passengers. In 1988, the zebra design was changed to the red striped minibuses, which had the capacity of carrying 14 passengers, but later, this number was increased to 16. In 1972, government of Hong Kong introduced Green minibuses as against Red minibuses. These Red minibuses have no specific route and can adjust fares according to the demands; while on the other hand, the transport department controls the routes and fares of Green minibuses. These Green minibuses have 350 fixed routes with fixed timetabled services. At the end of 2009, the total number of Red minibuses in Hong Kong was 1,372. These red buses, as compared to green buses, are not particularly visitor-friendly; therefore, people of Hong Kong usually prefer green buses to travel.

Above is a brief history of minibus of Asia, particularly of Hong Kong. Minibuses are typically the most easiest and effecti ve way to travel from one destination to another. Minibuses, as compared to other ways of transportation, are affordable and easily accessible. Nowadays, the minibuses transportation has become adaptives to student. Minibuses is designed for the transport of the general public as a public service, rather than the private hire or use of buses for transport or other purposes. A bus is a road vehicle designed to carry passengers. Minibuses are the most widely used form of student shuttle provided that services and make the student easy and comfortable to move anyplace.

Nowadays, comfortable seating in a vehicle is no longer considered a luxury, but as a requirement. A seat that is comfortable in a showroom may have poor dynamiccharacteristics that make it uncomfortable whilst on road. Considered comfortable by a user also depends very much on the way a seat is used and how long it has been used. The optimum seat for one vehicle may not be the optimum seat for another vehicle. It is therefore important to consider both static and dynamic comfort when considering the quality of the in-vehicle experience.

2.4 Types of minibuses

There are many different types and configurations of minibuses, due to historical and local differences, and usage. Minibus designs can be classified in three main groups, with a general increase in seating capacity with each type:

- Van conversions. Simple, optional extras
- Body builds
- Purpose built

2.4.1 Van conversions

The most basic source of minibus is the van conversion, where the minibus is derived by modifying an existing van design. Conversions may be produced completely by the van manufacturer, sold as part of their standard model line-up, or be produced by specialist conversion companies, who source a suitably prepared base model from the van manufacturer for final completion as a minibus.

Van conversions involve adding windows to the bodywork, and seating to the cargo area. Van conversion minibuses outwardly look the same shape as the parent van, and the driver and front passenger cabin remains unchanged, retaining the driver and passenger doors. Access to the former cargo area for passengers is through the standard van side sliding door, or the rear doors. These may be fitted with step equipment to make boarding easier. Optional extras to van converted minibuses can include the addition of a rollsign for transit work, and/or a full-height walk-in door, for passenger access to the former cargo area. For public transport use, this door may be an automatic concertina type. For other uses, this may be a simple plug style coach door. Depending on the relevant legislation, conversions may also involve wheelchair lifts and tachograph equipment. A van conversion with a passenger area in the front and a storage area in the back, behind a fixed bulkhead, is called a splitter bus. Examples of vans used for these conversion minibuses are; Ford Transit, Hyundai H350, Mercedes-Benz Sprinter, Toyota Hiaceand Volkswagen Crafter.

2.4.2 Bus body building

Another method of building a minibus is for a second stage manufacturer to build a specific body for fitting to a semi-completed van or light truck chassis. These allow a higher seating capacity than a simple van conversion. Often, the second stage manufacturer is a bus manufacturer.

In a body-on-chassis minibus, a cabin body is installed on a van or light truck chassis encompassing the drivers area. These designs may retain some outward signs of the original van, such as the hood and grill. Other designs are visually a complete bus design, and it is merely the chassis underneath that is from the van design. The body-on-chassis approach gives the advantage of higher seating capacity, or more room for passenger comfort, through a larger cabin area. There is also the advantage of being able to have the drivers seat positioned in a small cubicle, next to the main passenger entrance, allowing the driver to collect fares in a transit bus role.Examples of body built minibuses are: Busette (cut away chassis), Optare CityPacer (visually complete bus based on a van chassis), Plaxton Beaver (built on the Mercedes-Benz T2 and later the Vario chassis). Examples of vehicles used for this type of minibussses are: Ford Transit, Freight Rover and Isuzu Elf locally built as the NQR bus.

2.4.3 Purpose- built bus

A next generation approach to the van-derived or cutaway chassis approach is for manufacturers to produce an integral design, where the whole vehicle is purposely designed and built for use as a minibus. This is usually done by an integral bus manufacturer, although large automotive groups also produce their own models. These designs are often available in long high capacity versions. and may attract different designations, such as midibus, or light bus. Examples of purpose- built minibuses are: Hino Liesse, Isuzu Journey, MCW Metrorider (also termed a midibus). Nissan Diesel RN. Nissan Civilian, Mitsubishi Fuso Rosa, Toyota Coaster, Karsan J9 Premier(Similar-looking ancestor Peugeot J9 is a van conversion), Karsan J10, and so on.

2.5 Mini bus seat

Minibus Seats have sculptured cold cured foams for comfort and longevity and comply to regulations FMVSS.302 flame retardant. Seat construction benefits from using two full width channels on the under frame for ease of fixing pedestal legs and to assist in utilizing the best way of avoiding obstacles on the vehicle floor. The anthropometric data of passengers of the free shuttle bus is shown in Fig.1.

Fig. 1: **Types of mini bus seats**

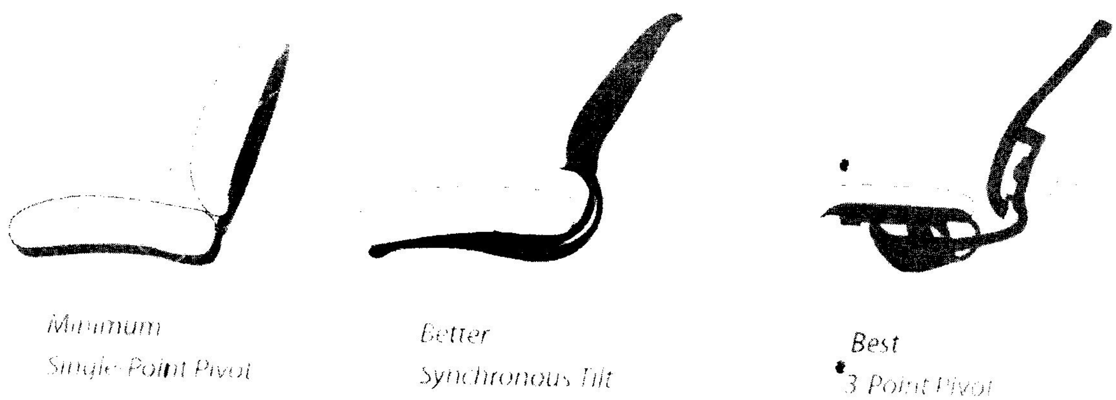

Fig. 2: **seat**

2.6.1 Rigid seat

Rigid Seat trimmed in air permeable black textile.Seat features:- 150mm fore / aft slide adjustment 60mm 2 lever height and inclination adjustment All controls at front of seat Backrest recline Option for lap seat belt Optional fold up armrests with angular adjustment Optional height adjustable headrest.

2.6.2 **Compressor air seat**

Air Suspension Seat with Integrated Compressor. Black Air Permeable Textile Upholstery. The seat offers the optimum ride comfort, isolating the occupant from harmful shocks and vibrations. No air supply required. Requires 12V electrical supply.

2.7 Ergonomics

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people. Ergonomics helps to harmonize things that interact with people in terms of people's needs, abilities and limitations. Ergonomics is the science of fitting the job to the worker and adapting the work environment to the needs of humans. An overall goal of ergonomics is to promote health and safety and to optimize productivity. The term ergonomics comes from the Greek words *ergon*, meaning work, and *nomos*, meaning laws—thus, laws of work. The study of ergonomics as a way to reduce human error began in the military during the Korean War. Ergonomics is derived from the greek works "ergon" meaning work, and "nomos" meaning "rule" or "legitimacy". Therefore, ergonomics is defined as the study of the relationship between men and his occupation, equipment and environment and in particular, the application of anatomical and psychological knowledge to the problem arising thereform(Anderson et-al,1984). Ergonomics is the science of adapting our bodies to our tools, working places, offices, relaxation and worship centers, schools and hospitals, cars buses and lorries as well as the general environment. Charls-Owaba(2003), defined Ergonomics as the "scientific study of the relationship of man and his working environment". He stressed further that ergonomics is best explained in the context work system – the combination of man facilities and pther resources to accomplish any form of task. Member of the human race spend a major part of their lives sitting down either working, travelling, relaxing, reading, playing certain games or instruments, discussing, meeting, learning or even eating. As we all know, the chairs or seat we use cover the gamut of comfort.

Ergonomics is therefore aimed at increasing the effectiveness and efficiency thereby consequently increasing productivity and promoting health,safety and satisfaction of men and women in any working environment with special respect to sitting positions.

Burgar and Dejung (1962), emphasized on the impact of ergonomics on workers' productivity as a compromise is found between the workers capabilities and the task requirement. Jones (1969) studied postures and feelings in a highly adjustable car driving seat in optimal condition and developed a seat and driving controls adequate for 28% of English drivers. Over the last five years, a study on the relationship between ergonomic office environments and productivity has been underway. The sample group include managerial,technical, and clerical workers from a broad cross-section of North American Industry.

The health and safety implications of the inherent discomfort in the ergonomically unfit sitting postures in our automobiles have given rise to researchers' interests with a view to designing ergonomically acceptable seats and sitting positions. In recent years, vehicle seat designs have placed an emphasis on mitigating seat discomfort as a response to consumer demands. Traditionally, the seating development process has been dependent upon an iterative design process that involves trial and error (Verver et al. 2005). This approach is very time consuming, costly and often ineffective for informing design decisions (Kolich and Taboun 2004).

Hence, there is a need for a better approach towards understanding the causal pathway of discomfort in seat design. Many approaches have been utilised in an attempt to understand discomfort but have tended to be subjective in nature. Subjective evaluations are highly variable and can fluctuate depending on several parameters such as aesthetic bias, distraction through entertainment systems, psychological status and environment (De Looze, Kuijt-Evers, and Van Dieen 2003; Helander 2003; Alamdari 1999).

People can subjectively report whether they feel discomfort in a seat but have difficulty explaining why they feel that way. Subjective impressions tend to be weak measures because they require a large subject pool to reduce the variability (Lee and Ferraiuolo 1993).

The measurement of subjective responses tends to be a crude evaluation of a person's physical state of discomfort because the mind's filter can potentially distort or bias interpretations. Hence, many efforts to quantify discomfort have been unable to provide an objective understanding of discomfort. Quantification of physiological responses due to tissue loading might facilitate a more objective understanding of the magnitude of physical exposure that would elicit discomfort. The location, magnitude and timing of tissue loading relative to seat features and reported comfort are poorly understood.

Previous studies suggest that there may indeed be a link between discomfort and biomechanical measures and physiological measures, and these relationships may provide a rationale to make seating design more objective (Helander and Zhang 1997; Zhang, Helander, and Drury 1996). In order to obtain objective quantification of discomfort, it would be desirable to understand the potential causal pathways leading to reports of discomfort.

Previous work quantifying discomfort has considered various features such as anthropometry (Kolich and Taboun 2004; Kolich 2003, 2004; Stubbs, Pellettiere, and Pint 2005), physiological change (Jianghong and Long 1994; Bush et al. 1995; Callaghan, Gregory, and Durkin 2010; Durkin et al. 2006), vibration (Ebe and Griffin 2000; Inagaki et al. 2000), pressure distribution (Kyung and Nussbaum 2008; Gyi and Porter 1999; Fenety, Putnam, and Walker 2000) and kinematics (Kingma and van Dieen 2009; Lengsfeld et al. 2000; Solaz et al. 2005).

These approaches provide potential concepts to objectively understand what may systematically lead to discomfort. However, it still remains unclear on how much physiological change may elicit reports of discomfort and how individual differences, such as anthropometry, may affect those changes. For example, postural kinematics may be influenced by seat design features and an individual's anthropometry. In smaller vehicle cockpits, taller people may have more of a forward-flexed posture during seating which may induce a flexion-relaxation response, offsetting the load to the ligaments (O'Sullivan et al. 2006). When the ligaments are loaded in tension, pain receptors may be stimulated (Solomonow 2009), thus triggering discomfort.

Understanding these connections may shed light on why some designs may lead to ischaemia, fatigue and discomfort in some people but not others. Quantifiable measurements were chosen depending on the context that comfort and discomfort are separate entities relative to the findings of Zhang et al. (1996). They contend that comfort was typically driven through aesthetic bias (subjective), whereas discomfort was dependent on biomechanical and physiological responses (objective).

2.8 Characteristics Of Ergonomics

Physical Characteristics (primarily interaction between the worker and the work setting)

- Posture
- Force
- Velocity/acceleration
- Repetition
- Duration
- Recovery time
- Heavy dynamic exertion
- Segmental vibration

Environmental Characteristics (primarily interaction between the worker and the work environment)

- Heat stress
- Cold stress
- Whole body vibration
- Lighting
- Noise

2.8.1 Human Posture

Posture is the position of the body while performing work activities. Awkward posture is associated with an increased risk for injury. It is generally considered that the more a joint deviates from the neutral (natural) position, the greater the risk of injury. Posture issues can be created by work methods (bending and twisting to pick up a box; bending the wrist to assemble a part) or workplace dimensions (extended reach to obtain a part from a bin at a high location; kneeling in the storage bay of an airplane because of confined space while handling luggage). Specific postures have been associated with injury. For example:

Wrist

- Flexion/extension (bending up and down)
- Ulnar/radial deviation (side bending)

Shoulder

- Abduction/flexion (upper arm positioned out to the side or above shoulder level)
- Hands at or above shoulder height

Neck (cervical spine)

- Flexion/extension or bending the neck forward and to the back
- Side bending as when holding a telephone receiver on the shoulder

Low back

- Bending at the waist, twisting

2.8.2 Force

Task forces can be viewed as the effect of an exertion on internal body tissues (e.g., compression on a spinal disc from lifting, tension within a muscle/tendon unit from a pinch grasp), or the physical characteristics associated with an object(s) external to the body (e.g., weight of a box, pressure required to activate a tool, pressure necessary to snap two pieces together). Generally, the greater the force, the greater the degree of risk. High force has been associated with risk of injury at the shoulder/neck (Berg et al., 1988), the low back (Herrin et al., 1986), and the forearm/wrist/hand (Silverstein et al., 1987). It is important to note that the relationship between force and degree of injury risk is modified by other work risk factors such as posture, acceleration/velocity, repetition, and duration. Two examples of the interrelationship of force, posture, acceleration/velocity, repetition and duration are:

1. A 20-pound weight lifted in a smooth, slow manner one time directly in front of the body from a 28 inch shelf to a 32 inch shelf will be much less of a risk than a 20-pound weight lifted quickly 60 times in 10 minutes from the floor to a 60 inch shelf.

2. A 45-degree neck flexion position held for one minute will be much less of a risk that a 45-degree neck flexion position held for 30 minutes.

Better analysis tools (e.g., 1991 Revised NIOSH Lifting Equation) recognize the interrelationship of force with other risk factors relative to overall task risk. Five additional force-related injury risk conditions have been extensively studied by researchers and ergonomists. They are not "rudimentary" risk factors. Rather, they are a workplace condition that presents a combination of risk factors with force being a significant component. Their common appearance in the workplace and strong association with injury prompts their introduction here.

2.9 Physical characteristics

Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. (Relevant topics include working postures, materials handling, repetitive movements, work related musculoskeletal disorders, workplace layout, safety and health.). The anthropometric variables that needed to be considered included: buttock-knee length (BKL), buttock-popliteal length (BPL), popliteal height, sitting (PHS), shoulder breadth (SB), shoulder height, sitting (SHS) and stature (S) as shown in (Fig. 3) below.

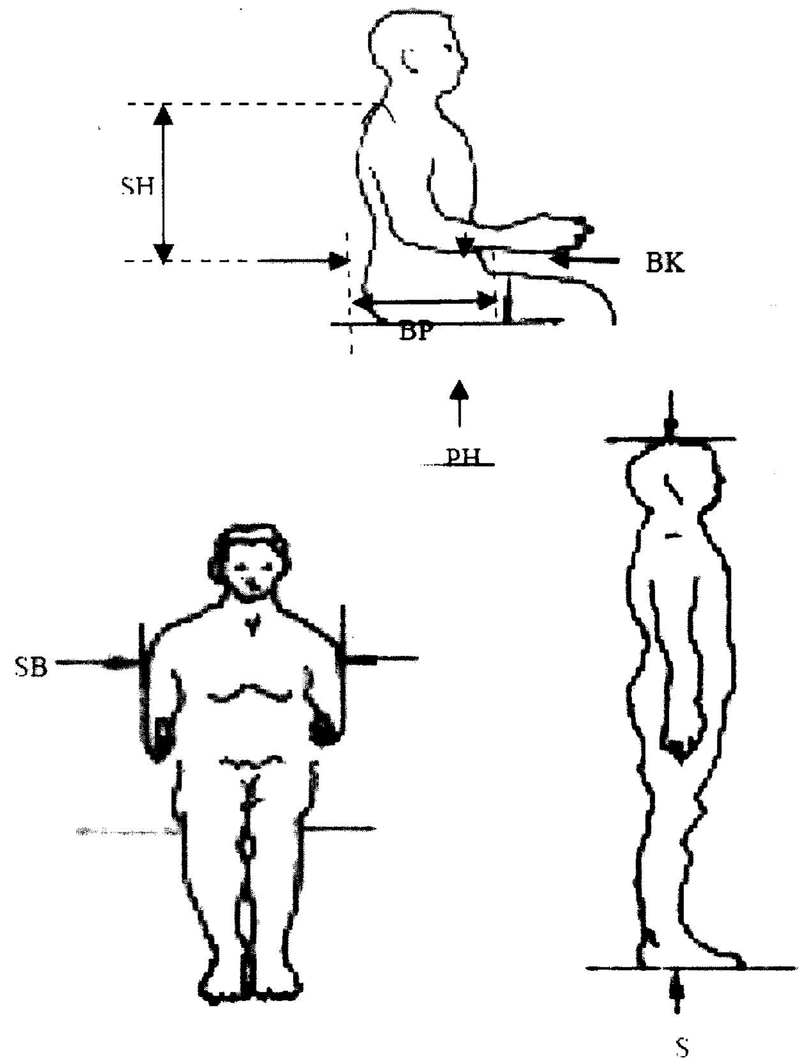

Fig 3: Anthropometric variables relating to seat design (Hertzberg, 1972 and SAE 1980).

2.10 Cognitive Ergonomics

Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. (Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system design.

2.11 Application of ergonomics

There is no gainsaying the fact that the field of ergonomics is of paramount importance nowadays and has a variety of applications. As mentions ealier, member of the human race spend a major part od their lives sitting down either working, travelling relaxing reading. Discussing or even eating . and as we know the chairs or seat we use cover the gamut of comfort. Invariably, ergonomics is applicable in our homes especially the domestic furniture we use such as dinning chair and tables, main sitting room chairs and central table, reading chairs and tables. Ergonomics is also applicable in our offices and even in our private cars and commercial vehicles. Other notable areas of applications include product design and production ergonomics. The main goal of product design ergonomics is to offer a product adapted to the customer to the best extent possible while the customer base is more-or-less unknow. The goal of production ergonomics however, is to provide working environment in manufacturing and service companies that are adapted to human beings. The objectives here is to reduce stress of the worker and optimize his performance ratio at the same time.

Other areas of application wheere today systematical errgonomics development are used include aviation (main concept design in airplanes anthopometical design of interior, ships and boats, land transportation means such as cars, buses, vehicles, lorries, motorcycles and even bicycles. Some other importance areas include maintenance (chemical plants, nuclear power stations, field where the aspects of human reliability play a major role), and in offices (office chair and table, software ergonomics). In public transportation, the role of ergonomics is also very important and the effects are seen in the new models of vehicles seen on our roads, in terms of improved safety and user comfort, convenience and satisfaction. In Nigeria, popular huge yellow buses called *molue* are found mostly in Lagos and are built by roadside metal fabrication workshops without recourse to any formal design specifications (Ajayeoba et al, 2009).

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Methods, Sources of Data and Data Collection Techniques

A descriptive survey research method was employed in order to assess the current status of students seats comfort in minibus popularly called free shuttle in Ondo State, Nigeria. They are always available by 7.30am and 1.30pm every school day in the major cities in Ondo State; Akure, Owo, Ikare and Ondo city, all in Ondo State. It is a free transport program introduced by the erstwhile administration of Dr. Olusegun Mimiko as Governor, which took off in 2012.

The age of the subjects ranged between 11 and 18 years (mean of 15.77 years). The survey was carried out over a period of one week. The data collected was analyzed using descriptive statistics such as means, standard deviations, and fifth, fiftieth and ninety-fifth percentiles using. The data obtained from the passengers was compared with the relevant dimensions of the seats using Independent samples t test (2-tailed) Anthropometric measurements of sitting posture and Chi-square at 95 percent level of confidence.

3.2 Sample Selection And Percentile Analysis

Statistics can generally be define as the scientific method of inquiry that is involve in obtaining, classifying, organising summarizing, compiling, presenting, analysing, and interpreting numerical data with a view to drawing valid conclusion and making reasonable decisions based on the data.

When representative samples are taken from a population, the findings from the study are generalized to the population. The sizes of the sample should be large enough for the following reasons.

(a) To allow for appropriate analysis.

(b) To provide for the desired level of accuracy in estimates of proportions.

(c) To allow validity of significance tests.

From survey, it was observed that the widely used passage buses in this region are mini bus containing 14 to 18 passengers usually the Toyota hiace, And Nissan Urvan.

The Anthropometric measurements of sitting posture that are to be considered in seat design are: Seat Height (SH), Cervical Height (CH), Elbow Height (EH), Buttock Patella (BP), Buttock Popliteal (BPL), Buttock-Knee (BKL), Biacromial Breadth (BB), Elbow-Elbow Breadth

(EEB). Relevant bus seat dimensions include. Seat Height (SH), Seat Depth (SD), Seat Breadth (SB) and Back Rest Height (BRH). In any statistical distribution, the percentile is the measurement of partition of an object into 100 equal parts. Percentile is often expressed in term of percentage.

Mathematically, according to Murray R.S (1992),

$$p_x = Lp_x + \frac{\frac{Nx}{100}}{Fpx} - \sum Fpx$$

Where Px = The percentile number being referred to i.e x= 1,2,---99

Lpx = The lower class boundary of the xth percentile class.

$\sum FPx$ = The sum of the frequency before the xth percentile class.

FPx = The frequency of the xth percentile class

N= Sample size (Total frequency)

C = The class interval

X = Desired percentile

A percentile analysis was carried out to determine the5^{th}, 50^{th}, 95^{th}, and percentile signifying 2 degrees of freedom. The minimum, maximum and average value were obtained. Further analysis was carried out by the use of the T-test whereby the bus seat dimension are relatively compared with human (anthropometric) dimension. The minimum, maximum and average valve were obtained.

Table 1: Seat Dimensions of Data Collected from sample bus

NUMBER	*SH*	*SD*	*SB*	*BRH*
1	*38.7*	*36.4*	*34..7*	*41.1*
2	*39.1*	*40.8*	*39.1*	*39.5*
3	*39.2*	*43.9*	*37.2*	*42.1*
4	*38.6*	*37.7*	*38.5*	*41.1*
5	*38.3*	*42.8*	*38.3*	*40.6*
6	*40.1*	*41.6*	*35.1*	*39.5*
7	*38.4*	*38.5*	*36.5*	*41.5*
8	*39.5*	*42.9*	*35.9*	*38.1*
9	*39.4*	*42.8*	*38.1*	*38.5*
10	*38.6*	*40.6*	*35.2*	*40.1*
11	*39.2*	*37.8*	*37.7*	*38.5*
12	*39.0*	*40.6*	*38.1*	*39.5*
13	*38.1*	*41.3*	*36.7*	*42.0*
14	*39.1*	*41.2*	*36.5*	*38.5*
15	*39.2*	*43.6*	*38.1*	*39.7*

Table 2: Anthropometric Data Collected

NO	HHT	PH	SH	KH	EEB	ESH	BKL	BPL	TCH	HB	BB
1	167.4	38.5	87.4	54.4	43.1	70.3	62.3	50.5	16.3	39.3	43.1
2	168.2	40.1	78.5	55.4	43.5	75.6	59.6	53.7	18.1	37.3	45.7
3	165.5	39.7	80.7	56.8	39.2	74.9	57.2	48.4	12.9	28.1	36.0
4	160.7	38.3	73.0	54.8	43.7	68.9	62.5	50.5	16.1	41.5	43.9
5	163.2	41.3	76.5	56.7	49.5	70.4	63.7	53.6	13.8	33.2	41.6
6	170.0	38.7	84.9	54.6	43.6	74.0	61.1	50.0	14.0	31.5	30.7
7	173.0	39.5	83.9	53.9	42.5	73.0	57.0	50.2	15.1	37.7	41.8
8	172.3	40.1	82.5	56.7	47.8	72.8	60.0	49.4	13.5	36.4	43.3
9	173.0	39.0	83.8	54.3	43.6	74.2	61.0	51.9	13.9	31.3	30.6
10	172.8	41.3	87.6	57.6	46.9	78.0	62.5	51.6	11.3	39.1	44.1
11	182.0	44.9	87.9	58.8	39.9	67.5	56.8	58.6	16.7	39.6	48.1
12	186.4	42.9	89.9	58.3	37.0	78.9	62.6	50.0	14.0	31.7	38.6
13	179.9	41.3	80.3	57.8	42.5	75.6	68.0	58.6	16.8	39.5	43.9
14	181.9	44.7	87.3	58.1	39.6	67.0	56.1	58.3	16.4	39.0	40.0
15	182.6	46.1	88.6	57.6	42.0	67.6	65.8	43.7	16.9	38.3	41.8

CHAPTER 4

4.0 RESULT AND DISCUSSION

Calculation involving the Seat Height of eighteen passengers' bus

SH=38.7+39.1+39.2+38.6+38.3+40.1+38.4+38.5+39.4+38.6+39.2+39.0+38.1+39.1+39.2. = 584.5

$\frac{584.5}{15} = 38.97$

$$\dot{X} = 38.97$$

$$|X - \dot{X}|^2 = |38.7 - 38.97|^2 = 0.07$$

$$|39.1 - 38.97|^2 = 0.02$$

$$|39.2 - 38.97|^2 = 0.05$$

$$|38.6 - 38.97|^2 = 0.74$$

$$|38.3 - 38.97|^2 = 0.45$$

$$|40.1 - 38.97|^2 = 1.23$$

$$|38.4 - 38.97|^2 = 0.28$$

$$|39.5 - 38.97|^2 = 0.21$$

$$|39.4 - 38.97|^2 = 0.14$$

$$|39.2 - 38.97|^2 = 0.05$$

$$|39.0 - 38.97|^2 = 0.009$$

$$|38.1 - 38.97|^2 = 0.76$$

$$|39.1 - 38.97|^2 = 0.02$$

$$|39.2 - 38.97|^2 = 0.053$$

S.D=0.07+0.02+0.05+0.74+0.45+1.23+0.28+0.21+0.14+0.05+0.0009+0.76+0.02+0.053=4.0739

$S.D = \sqrt{\frac{4.0739}{15}} = 0.367$

Calculation involving the Seat depth of eighteen passengers

Mean = 36.4 + 40.8+43.9+37.7+42.8+41.6+38.5+42.9+42.8+40.6+37.8+40.6+41.3+41.2+43.6 =612.5

$=\frac{612.5}{15} = 40.83$

Let mean be represented by$\bar{x}$ and the data recorded be represented by x.

$[x - \bar{x}]^2$ =$[36.4 - 40.833]^2 = 19.65$

$[x - \bar{x}]^2 = [40.8 - 40.833]^2$= 0.0001

$[x - \bar{x}]^2 = [43.9 - 40.833]^2$= 9.406

$$[x - \bar{x}]^2 = [37.7 - 40.833]^2 = 9.816$$

$[x - \bar{x}]^2 = [42.8 - 40.833]^2$= 3.869

$[x - \bar{x}]^2 = [41.6 - 40.833]^2$= 0.588

$[x - \bar{x}]^2 = [38.5 - 40.833]^2$=5.443

$[x - \bar{x}]^2$= $[42.9 - 40.833]^2$= 4.272

$[x - \bar{x}]^2$= $[42.8 - 40.833]^2$= 3.87

$[x - \bar{x}]^2$= $[40.6 - 40.833]^2$= 0.054

$[x - \bar{x}]^2$= $[37.8 - 40.833]^2$= 9.20

$[x - \bar{x}]^2$= $[40.6 - 40.833]^2$= 0.054

$[x - \bar{x}]^2$= $[41.3 - 40.833]^2$= 0.22

$[x - \bar{x}]^2$= $[41.2 - 40.833]^2$= 0.135

$[x - \bar{x}]^2$= $[43.6 - 40.833]^2$= 7.655

$$\sum[x-\bar{x}]^2 = 19.65 + 0.001 + 9.406 + 9.816 + 3.869 + 0.588 + 5.443 + 4.272 + 3.87$$
$$+ 0.054 + 4.272 + 3.87 + 0.054 + 9.20 + 0.054 + 0.22 + 0.135 + 7.655$$
$$= 82.45$$

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}} = \sqrt{\frac{82.45}{15}} = 2.344$

Calculation involving the seat breadth of eighteen passengers

Mean of the data collected

=34.7+39.1+37.2+38.5+38.3+35.1+36.5+35.9+38.1+35.2+37.7+38.1+36.7+36.5+38.1= 555.7

$=\frac{555.7}{\mathbf{15}} = 37.05$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2$ =$[34.7 - 37.0]^2 = 5.29$

$[x-\bar{x}]^2$ =$[39.1 - 37.0]^2 = 4.41$

$[x-\bar{x}]^2$ =$[37.2 - 37.0]^2 = 0.04$

$[x-\bar{x}]^2$ =$[38.5 - 37.0]^2 = 2.25$

$[x-\bar{x}]^2$ =$[38.3 - 37.0]^2 = 1.69$

$[x-\bar{x}]^2$ =$[35.1 - 37.0]^2 = 3.6$

$[x-\bar{x}]^2$ =$[36.5 - 37.0]^2 = 0.25$

$[x-\bar{x}]^2$ =$[35.9 - 37.0]^2 = 1.21$

$[x-\bar{x}]^2$ =$[38.1 - 37.0]^2 = 1.21$

$[x-\bar{x}]^2$ =$[35.2 - 37.0]^2 = 3.24$

$[x-\bar{x}]^2$ =$[37.7 - 37.0]^2 = 0.49$

$[x - \bar{x}]^2$ =[38.1 − 37.0]^2 = 1.21

$[x - \bar{x}]^2$ =[36.7 − 37.0]^2 = 0.09

$[x - \bar{x}]^2$ =[36.5 − 37.0]^2 = 0.25

$[x - \bar{x}]^2$ =[38.1 − 37.0]^2 = 1.21

$\sum[x - \bar{x}]^2$ = 5.29 + 4.41 + 0.04 + 2.25 + 1.69 + 3.6 + 0.25 + 1.21 + 1.21+ 3.24 +0.49 + 1.21+ 0.09 +0.25 + 0.21 =26 .44

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}} = \sqrt{\frac{26.44}{15}}$ =1.33

Calculation involving the Back Rest Height of eighteen passengers

Mean of the data collected

= 41.1 + 39.5 + 42.1 + 41.1 + 40.6 + 39.5 + 41.5 + 38.1 + 38.5 + 40.1 + 38.5 + 39.5 + 42.0 + 38.5 + 39.7= 600.3

$$\frac{600.3}{15} = 40\ .02$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x - \bar{x}]^2$ =[41.1 − 40.02]^2 = 1.17

$[x - \bar{x}]^2$ =[39.5 − 40.02]^2 = 0.27

$[x - \bar{x}]^2$ =[42.1 − 40.02]^2 = 4.33

$[x - \bar{x}]^2$ =[41.1 − 40.02]^2 = 1.17

$[x - \bar{x}]^2$ =[40.6 − 40.02]^2 = 0.34

$[x - \bar{x}]^2$ =[39.5 − 40.02]^2 = 0.27

$[x - \bar{x}]^2$ =[41.5 − 40.02]^2 = 2.19

$[x - \bar{x}]^2$ =[38.1 − 40.02]^2 = 3.69

$[x-\bar{x}]^2 = [38.5-40.02]^2 = 2.31$

$[x-\bar{x}]^2 = [40.1-40.02]^2 = 0.0064$

$[x-\bar{x}]^2 = [38.5-40.02]^2 = 2.31$

$[x-\bar{x}]^2 = [39.5-40.02]^2 = 0.27$

$[x-\bar{x}]^2 = [42.0-40.02]^2 = 3.92$

$[x-\bar{x}]^2 = [38.5-40.02]^2 = 2.31$

$[x-\bar{x}]^2 = [39.7-40.02]^2 = 0.10$

$$\sum[x-\bar{x}]^2 = 1.17 + 0.27 + 4.33 + 1.17 + 0.34 + 0.27 + 2.19 + 3.69 + 2.31 + 0.0064 + 2.31 + 0.27 + 3.92 + 2.31 + 0.10 = 24.6564$$

Standard deviation $= \sqrt{\frac{\sum[x-\bar{x}]^2}{n}} = \sqrt{\frac{24.6564}{15}}$ **=1.28**

Calculation involving the Height H T of eighteen passengers

Mean of the data collected

167.4 + 168.2 + 165.5 + 160.7 + 163.2 + 170.0 + 173.0 + 172.3 + 173.0 + 172.8 + 182.0 + 186.4 + 179.9 + 181.9 + 182.6= 2598.9

$$\frac{2598.9}{15} = 173.26$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2 = [167.4-173.26]^2 = 34.34$

$[x-\bar{x}]^2 = [168.2-173.26]^2 = 25.60$

$[x-\bar{x}]^2 = [165.5-173.26]^2 = 60.22$

$[x - \bar{x}]^2 = [160.7 - 173.26]^2 = 157.75$

$[x - \bar{x}]^2 = [163.2 - 173.26]^2 = 101.20$

$[x - \bar{x}]^2 = [170.0 - 173.26]^2 = 10.63$

$[x - \bar{x}]^2 = [173.0 - 173.26]^2 = 0.067$

$[x - \bar{x}]^2 = [172.3 - 173.26]^2 = 0.92$

$[x - \bar{x}]^2 = [173.0 - 173.26]^2 = 0.067$

$[x - \bar{x}]^2 = [172.8 - 173.26]^2 = 0.23$

$[x - \bar{x}]^2 = [182.0 - 173.26]^2 = 76.038$

$[x - \bar{x}]^2 = [186.4 - 173.26]^2 = 172.134$

$[x - \bar{x}]^2 = [179.9 - 173.26]^2 = 43.82$

$[x - \bar{x}]^2 = [181.9 - 173.26]^2 = 74.30$

$[x - \bar{x}]^2 = [182.6 - 173.26]^2 = 86.86$

$$\sum [x - \bar{x}]^2 = 34.34 + 25.60 + 60.22 + 157.75 + 101.20 + 10.65 + 0.067 + 0.92 + 0.067 + 0.23 + 76.038 + 172.134 + 43.82 + 74.30 + 86.862 = 844.1888$$

Standard deviation $= \sqrt{\frac{\sum[x-\bar{x}]^2}{n}} = \sqrt{\frac{844.1888}{15}} = 7.52$

Calculation involving the popliteal Height of eighteen passengers

Mean of the data collected =38.5 + 40.1 + 39.7 + 38.3 + 41.3 + 38.7 + 39.5 + 40.1 + 39.0 + 41.3 + 44.9 + 42.9 + 41.3 + 44.7 + 46.11 =966.4

$$\frac{966.4}{15} = 64.43$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$$\frac{1252.8}{15} = 83.52$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x - \bar{x}]^2$ =$[87.4 - 83.52]^2 = 15.05$

$[x - \bar{x}]^2$ =$[78.5 - 83.52]^2 = 25.20$

$[x - \bar{x}]^2$ =$[80.7 - 83.52]^2 = 7.95$

$[x - \bar{x}]^2$ =$[73.0 - 83.52]^2 = 110.67$

$[x - \bar{x}]^2$ =$[76.5 - 83.52]^2 = 49.28$

$[x - \bar{x}]^2$ =$[84.9 - 83.52]^2 = 1.90$

$[x - \bar{x}]^2$ =$[83.9 - 83.52]^2 = 0.14$

$[x - \bar{x}]^2$ =$[82.5 - 83.52]^2 = 1.04$

$[x - \bar{x}]^2$ =$[83.8 - 83.52]^2 = 0.078$

$[x - \bar{x}]^2$ =$[87.6 - 83.52]^2 = 16.65$

$[x - \bar{x}]^2$ =$[87.9 - 83.52]^2 = 19.18$

$[x - \bar{x}]^2$ =$[89.9 - 83.52]^2 = 40.70$

$[x - \bar{x}]^2$ =$[80.3 - 83.52]^2 = 10.368$

$[x - \bar{x}]^2$ =$[87.3 - 83.52]^2 = 14.29$

$[x - \bar{x}]^2$ =$[88.6 - 83.52]^2 = 25.81$

$$\sum[x - \bar{x}]^2 = 15.05 + 25.20 + 7.95 + 110.67 + 49.20 + 1.90 + 0.14 + 1.04 + 0.078$$
$$+ 16.65 + 19.18 + 40.70 + 10.368 + 14.29 + 25.81 = 338.316$$

Standard deviation = $\sqrt{\frac{\Sigma[x-\bar{x}]^2}{n}} = \sqrt{\frac{338.316}{15}}$ =4. 75

Calculation involving the k Height of eighteen passengers

Mean of the data collected =54.4+ 55.4 + 56.8 + 54.8 + 56.7 + 54.6 + 53.9 + 56.7 + 54.3 + 57.6 + 58.8 + 58.3 + 57.8 + 58.1 + 57.6= 845.8

$$\frac{845.8}{15} = 56.39$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x - \bar{x}]^2$ =$[54.4 - 56.39]^2 = 3.96$

$[x - \bar{x}]^2$ =$[55.4 - 56.39]^2 = 0.98$

$[x - \bar{x}]^2$ =$[56.8 - 56.39]^2 = 0.17$

$[x - \bar{x}]^2$ =$[54.8 - 56.39]^2 = 2.53$

$[x - \bar{x}]^2$ =$[56.7 - 56.39]^2 = 0.1$

$[x - \bar{x}]^2$ =$[54.6 - 56.39]^2 = 3.20$

$[x - \bar{x}]^2$ =$[56.7 - 56.39]^2 = 0.1$

$[x - \bar{x}]^2$ =$[54.3 - 56.39]^2 = 4.37$

$[x - \bar{x}]^2$ =$[57.6 - 56.39]^2 = 1.46$

$[x - \bar{x}]^2$ =$[58.8 - 56.39]^2 = 5.81$

$[x - \bar{x}]^2$ =$[58.3 - 56.39]^2 = 3.65$

$[x - \bar{x}]^2$ =$[57.8 - 56.39]^2 = 1.99$

$[x - \bar{x}]^2$ =$[58.1 - 56.39]^2 = 2.92$

$[x - \bar{x}]^2$ =$[57.6 - 56.39]^2 = 1.46$

$[x - \bar{x}]^2$ =$[53.9 - 56.39]^2 = 6.2$

$$\sum[x-\bar{x}]^2 = 3.96 + 0.98 + 0.17 + 2.53 + 0.1 + 3.20 + 0.1 + 4.37 + 1.46 + 5.81 + 3.65 + 1.99 + 6.2 + 2.92 + 1.46 = 38.9$$

Standard deviation $=\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{38.9}{15}}$ **=1. 61**

Calculation involving the EEB of eighteen passengers

Mean of the data collected = 43.1 + 43.5 + 39.2 + 43.7 + 49.5 + 43.6 + 42.5 + 47.8 + 43.6 + 46.9 + 39.9 + 37.0 + 42.5 + 39.6 + 42.0= 644.4

$$\frac{644.4}{\mathbf{15}} = 42.96$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2$ $=[43.1-42.96]^2 = 0.02$

$[x-\bar{x}]^2$ $=[43.5-42.96]^2 = 0.29$

$[x-\bar{x}]^2$ $=[39.2-42.96]^2 = 14.14$

$[x-\bar{x}]^2$ $=[43.7-42.96]^2 = 0.55$

$[x-\bar{x}]^2$ $=[49.5-42.96]^2 = 42.77$

$[x-\bar{x}]^2$ $=[43.6-42.96]^2 = 0.41$

$[x-\bar{x}]^2$ $=[42.5-42.96]^2 = 0.21$

$[x-\bar{x}]^2$ $=[47.8-42.96]^2 = 23.43$

$[x-\bar{x}]^2$ $=[43.6-42.96]^2 = 0.41$

$[x-\bar{x}]^2$ $=[46.9-42.96]^2 = 15.52$

$[x-\bar{x}]^2$ $=[39.9-42.96]^2 = 9.36$

$[x-\bar{x}]^2$ =$[37-42.96]^2=35.52$

$[x-\bar{x}]^2$ =$[39.6-42.96]^2=11.3$

$[x-\bar{x}]^2$ =$[42-42.96]^2=0.92$

$[x-\bar{x}]^2$ =$[42.5-42.96]^2=0.21$

$$\sum[x-\bar{x}]^2 = 0.02+0.29+14.14+0.55+42.77+0.41+0.21+23.426+0.41+15.52+9.36+38.52+11.3+0.92+0.21=155.056$$

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{155.056}{15}}$ =**3.215**

Calculation involving the ESH of eighteen passengers

Mean of the data collected = 70.3 + 75.6 + 74.9 + 68.9 + 70.4 + 74.0 + 73.0 + 72.8 + 74.2 + 78.0 + 67.5 + 78.9 + 75.6 + 67.0+ 67.6=1088.7

$$\frac{1088.7}{\mathbf{15}}=72.58$$

Let mean be represented by$\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2$ =$[70.3-72.58]^2=5.2$

$[x-\bar{x}]^2$ =$[75.6-72.58]^2=9.12$

$[x-\bar{x}]^2$ =$[74.9-72.58]^2=5.38$

$[x-\bar{x}]^2$ =$[68.9-72.58]^2=13.54$

$[x-\bar{x}]^2$ =$[70.4-72.58]^2=4.75$

$[x-\bar{x}]^2$ =$[74.0-72.58]^2=2.01$

$[x-\bar{x}]^2$ =$[73.0 - 72.58]^2 = 0.17$

$[x-\bar{x}]^2$ =$[72.8 - 72.58]^2 = 0.04$

$[x-\bar{x}]^2$ =$[74.2 - 72.58]^2 = 2.62$

$[x-\bar{x}]^2$ =$[78.0 - 72.58]^2 = 29.37$

$[x-\bar{x}]^2$ =$[67.5 - 72.58]^2 = 25.80$

$[x-\bar{x}]^2$ =$[78.9 - 72.58]^2 = 39.94$

$[x-\bar{x}]^2$ =$[75.6 - 72.58]^2 = 9.12$

$[x-\bar{x}]^2$ =$[67.0 - 72.58]^2 = 31.13$

$[x-\bar{x}]^2$ =$[67.6 - 72.58]^2 = 24.80$

$$\sum[x-\bar{x}]^2 = 5.19 + 9.12 + 5.38 + 13.54 + 4.75 + 2.01 + 0.17 + 0.04 + 2.62 + 29.37 + 25.80 + 39.94 + 9.12 + 31.13 + 24.80 = 202.98$$

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{202.98}{15}}$ **=3.68**

Calculation involving the BKL of eighteen passengers

Mean of the data collected= 62.3 + 59.6 + 57.2 + 62.5 + 63.7 + 61.1 + 57.0 + 60.0 + 61.0 + 62.5 +56.8 + 62.8 +68.0 + 56.1 + 65.8= 916.4

$$\frac{916.4}{\mathbf{15}} = 61.1$$

Let mean be represented by$\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2$ =$[62.3 - 61.1]^2 = 1.44$

$[x-\bar{x}]^2$ =$[59.6 - 61.1]^2 = 2.25$

$[x - \bar{x}]^2$ =$[57.2 - 61.1]^2 = 15.21$

$[x - \bar{x}]^2$ =$[62.5 - 61.1]^2 = 1.96$

$[x - \bar{x}]^2$ =$[63.7 - 61.1]^2 = 6.76$

$[x - \bar{x}]^2$ =$[61.1 - 61.1]^2 = 0$

$[x - \bar{x}]^2$ =$[57.0 - 61.1]^2 = 16.81$

$[x - \bar{x}]^2$ =$[60.0 - 61.1]^2 = 1.21$

$[x - \bar{x}]^2$ =$[61.0 - 61.1]^2 = 0.01$

$[x - \bar{x}]^2$ =$[62.5 - 61.1]^2 = 1.96$

$[x - \bar{x}]^2$ =$[56.8 - 61.1]^2 = 18.49$

$[x - \bar{x}]^2$ =$[62.8 - 61.1]^2 = 2.89$

$[x - \bar{x}]^2$ =$[68.0 - 61.1]^2 = 47.61$

$[x - \bar{x}]^2$ =$[56.1 - 61.1]^2 = 25$

$[x - \bar{x}]^2$ =$[65.8 - 61.1]^2 = 22.09$

$\sum[x - \bar{x}]^2 = 1.44 + 2.25 + 15.21 + 1.96 + 6.76 + 0 + 16.81 + 1.21 + 0.01 + 1.96 + 18.49 + 2.89 + 47.61 + 25 + 22.09 = 163.69$ s

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{163.69}{15}}$ **=3.30**

Calculation involving the BPL of eighteen passengers

Mean of the data collected=

50.5+53.7+48.4+50.5+53.6+50.0+50.2+49.4+51.9+51.6+58.6+50.0+58.6+58.3+43.7 =779

$$\frac{779}{\mathbf{15}} = 51.93$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x - \bar{x}]^2$ =$[50.5 - 51.93]^2 = 2.04$

$[x - \bar{x}]^2$ =$[53.7 - 51.93]^2 = 3.13$

$[x - \bar{x}]^2$ =$[48.4 - 51.93]^2 = 12.46$

$[x - \bar{x}]^2$ =$[50.5 - 51.93]^2 = 2.04$

$[x - \bar{x}]^2$ =$[53.6 - 51.93]^2 = 2.79$

$[x - \bar{x}]^2$ =$[50.0 - 51.93]^2 = 3.72$

$[x - \bar{x}]^2$ =$[50.2 - 51.93]^2 = 2.99$

$[x - \bar{x}]^2$ =$[49.4 - 51.93]^2 = 6.4$

$[x - \bar{x}]^2$ =$[51.9 - 51.93]^2 = 0.0009$

$[x - \bar{x}]^2$ =$[51.6 - 51.93]^2 = 0.11$

$[x - \bar{x}]^2$ =$[58.6 - 51.93]^2 = 44.49$

$[x - \bar{x}]^2$ =$[50.0 - 51.93]^2 = 3.72$

$[x - \bar{x}]^2$ =$[58.6 - 51.93]^2 = 44.49$

$[x - \bar{x}]^2$ =$[58.3 - 51.93]^2 = 40.58$

$[x - \bar{x}]^2$ =$[43.7 - 51.93]^2 = 67.73$

$\sum[x - \bar{x}]^2 = 2.04 + 3.13 + 12.49 + 2.04 + 2.74 + 3.72 + 2.99 + 6.4 + 0.0009 + 0.11 + 44.49 + 3.72 + 44.49 + 40.58 + 67.73$=236.6909

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{236.6909}{15}}$ =3.97

Calculation involving the TCH of eighteen passengers

Mean of the data collected=

16.3+18.1+12.9+16.1+13.8+14.0+15.1+13.5+13.9+11.3+16.7+14.0+16.8+16.4+16.9=225.8

$$\frac{225.8}{\mathbf{15}} = 15.05$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x - \bar{x}]^2$ =$[16.3 - 15.05]^2 = 1.56$

$[x - \bar{x}]^2$ =$[18.1 - 15.05]^2 = 9.30$

$[x - \bar{x}]^2$ =$[12.9 - 15.05]^2 = 4.62$

$[x - \bar{x}]^2$ =$[16.1 - 15.05]^2 = 1.10$

$[x - \bar{x}]^2$ =$[13.8 - 15.05]^2 = 1.56$

$[x - \bar{x}]^2$ =$[14.0 - 15.05]^2 = 1.10$

$[x - \bar{x}]^2$ =$[15.1 - 15.05]^2 = 0.0025$

$[x - \bar{x}]^2$ =$[13.5 - 15.05]^2 = 2.40$

$[x - \bar{x}]^2$ =$[13.9 - 15.05]^2 = 1.32$

$[x - \bar{x}]^2$ =$[11.3 - 15.05]^2 = 14.06$

$[x - \bar{x}]^2$ =$[16.7 - 15.05]^2 = 2.72$

$[x - \bar{x}]^2$ =$[16.8 - 15.05]^2 = 3.06$

$[x - \bar{x}]^2$ =$[16.4 - 15.05]^2 = 1.82$

$[x - \bar{x}]^2$ =$[16.9 - 15.05]^2 = 3.42$

$$\sum[x-\bar{x}]^2 = 1.56 + 9.30 + 4.62 + 1.10 + 1.56 + 1.10 + 0.0025 + 2.40 + 1.32 + 14.06 + 2.72 + 1.10 + 3.06 + 1.82 + 3.42 = 49.1425$$

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{49.1425}{15}}$ **=1.81**

Calculation involving the HB of eighteen passengers

Mean of the data collected=

39.3+37.3+28.1+41.5+33.2+31.5+37.7+36.4+31.3+39.1+39.6+31.7+39.5+39.0+58.3= 563.5

$$\frac{563.5}{\mathbf{15}} = 37.57$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2$ =$[39.3 - 37.57]^2 = 2.99$

$[x-\bar{x}]^2$ =$[37.3 - 37.57]^2 = 0.07$

$[x-\bar{x}]^2$ =$[28.1 - 37.57]^2 = 89.68$

$[x-\bar{x}]^2$ =$[41.5 - 37.57]^2 = 15.44$

$[x-\bar{x}]^2$ =$[33.2 - 37.57]^2 = 19.09$

$[x-\bar{x}]^2$ =$[31.5 - 37.57]^2 = 36.84$

$[x-\bar{x}]^2$ =$[37.7 - 37.57]^2 = 0.01$

$[x-\bar{x}]^2$ =$[36.4 - 37.57]^2 = 1.36$

$[x-\bar{x}]^2$ =$[31.3 - 37.57]^2 = 39.31$

$[x-\bar{x}]^2$ =$[39.1 - 37.57]^2 = 2.34$

$[x - \bar{x}]^2$ =$[39.6 - 37.57]^2 = 4.12$

$[x - \bar{x}]^2$ =$[31.7 - 37.57]^2 = 34.45$

$[x - \bar{x}]^2$ =$[39.5 - 37.57]^2 = 3.72$

$[x - \bar{x}]^2$ =$[39.0 - 37.57]^2 = 2.04$

$[x - \bar{x}]^2$ =$[58.3 - 37.57]^2 = 429.73$.

$$\sum[x - \bar{x}]^2 = 2.99 + 0.07 + 89.68 + 15.44 + 19.09 + 36.84 + 0.01 + 1.36 + 39.31 + 2.34 + 4.12 + 34.45 + 3.72 + 2.04 + 429.73 = 681.19$$

Standard deviation $= \sqrt{\frac{\sum[x-\bar{x}]^2}{n}} = \sqrt{\frac{681.19}{15}} = \mathbf{6.74}$

Calculation involving the BB of eighteen passengers

Mean of the data collected=

43.1+45.7+36.0+43.9+30.7+41.6+41.8+43.3+30.6+44.1+48.1+38.6+43.9+49.0+41.8= 622.2

$$\frac{622.2}{\mathbf{15}} = 41.48$$

Let mean be represented by$\bar{x}$ and the data recorded be represented by x.

$[x - \bar{x}]^2$ =$[43.1 - 41.48]^2 = 2.62$

$[x - \bar{x}]^2$ =$[45.7 - 41.48]^2 = 17.80$

$[x - \bar{x}]^2$ =$[36.0 - 41.48]^2 = 30.03$

$[x - \bar{x}]^2$ =$[43.9 - 41.48]^2 = 5.86$

$[x - \bar{x}]^2$ =$[41.6 - 41.48]^2 = 0.01$

$[x - \bar{x}]^2$ =$[30.7 - 41.48]^2 = 116.20$

$[x - \bar{x}]^2$ =$[41.8 - 41.48]^2 = 0.10$

$[x - \bar{x}]^2 = [43.3 - 41.48]^2 = 3.31$

$[x - \bar{x}]^2 = [30.6 - 41.48]^2 = 118.37$

$[x - \bar{x}]^2 = [44.1 - 41.48]^2 = 6.86$

$[x - \bar{x}]^2 = [48.1 - 41.48]^2 = 43.82$

$[x - \bar{x}]^2 = [38.6 - 41.48]^2 = 8.29$

$[x - \bar{x}]^2 = [43.9 - 41.48]^2 = 5.85$

$[x - \bar{x}]^2 = [49.0 - 41.48]^2 = 56.55$

$[x - \bar{x}]^2 = [41.8 - 41.48]^2 = 0.10$

$$\sum [x - \bar{x}]^2 = 2.62 + 17.80 + 30.03 + 5.86 + 0.01 + 116.20 + 0.10 + 3.31 + 118.37 + 6.86 + 43.82 + 8.29 + 5.58 + 56.55 + 0.10 = 415.68$$

Standard deviation $= \sqrt{\frac{\sum [x - \bar{x}]^2}{n}}$

$\sqrt{\frac{415.68}{15}} = 5.26$

Table 3: The students' body dimensions measured at Oyemekun Grammar school, Ondo State

Number	PH	KH	EEB	ESH	BKL	BPL
1	18.5	33.6	20.0	17.1	14.0	13.4
2	18.3	33.6	20.1	17.4	14.1	13.4
3	18.3	33.7	20.3	17.4	14.1	13.1
4	18.1	33.6	20.3	17.5	14.2	12.5
5	18.3	33.6	20.0	17.4	14.3	11.6
6	18.3	33.6	20.2	17.3	14.1	13.1
7	18.3	33.6	20.2	17.3	14.1	12.7
8	18.4	33.8	20.6	17.9	14.3	12.7
9	18.5	33.8	20.5	17.7	14.1	12.6
10	18.4	33.6	20.1	17.2	14.1	12.7
11	18.4	33.6	20.3	17.3	14.3	12.7
12	18.4	33.6	20.1	17.4	14.1	12.6
13	18.4	33.6	20.1	17.4	14.1	13.1
14	18.4	33.7	20.1	17.4	14.0	13.2
15	18.4	33.6	20.3	17.6	14.0	12.8
16	18.5	33.6	20.0	17.0	14.0	12.9
17	18.3	33.7	20.4	17.0	14.0	12.1
18	18.5	33.8	20.4	17.2	14.1	12.5
19	18.1	33.6	20.6	17.1	14.1	12.7
20	18.2	33.7	20.0	17.5	14.1	13.3

Calculation involving the PH of the student

Mean of the data collected=

18.5+18.3+18.3+18.1+18.3+18.3+18.3+18.4+18.5+18.4+18.4+18.4+18.4+18.4+18.4+18.5+18.3 +18.5+18.1+18.2=367

$$\frac{367}{\mathbf{20}} = 18.35$$

Let mean be represented by$\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2$ =$[18.5-18.35]^2=0.0225$

$[x-\bar{x}]^2$ =$[18.3-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.3-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.1-18.35]^2=0.0625$

$[x-\bar{x}]^2$ =$[18.3-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.3-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.3-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.4-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.5-18.35]^2=0.0225$

$[x-\bar{x}]^2$ =$[18.4-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.4-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.4-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.4-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.4-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.4-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.5-18.35]^2=0.0225$

$[x-\bar{x}]^2$ =$[18.3-18.35]^2=0.0025$

$[x-\bar{x}]^2$ =$[18.5-18.35]^2=0.0225$

$[x-\bar{x}]^2$ =$[18.1-18.35]^2=0.0625$

$[x-\bar{x}]^2$ =$[18.2-18.35]^2=0.0225$

$\Sigma[x-\bar{x}]^2 = 0.0225 + 0.0025 + 0.0025 + 0.0625 + 0.0025 + 0.0025 + 0.0025 + 0.0225 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0225 + 0.0625 + 0.0225 = 0.2675$

Standard deviation $= \sqrt{\frac{\Sigma[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{0.2675}{20}} = \mathbf{0.11565}$

Calculation involving the KH of the student

Mean of the data collected=

33.6+33.6+33.7+33.6+33.6+33.6+33.8+33.8+33.6+33.6+33.6+33.7+33.6+33.6+33.7+33.8+33.6 +33.7=673

$$\frac{673}{\mathbf{20}} = 33.65$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2 = [33.6 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.7 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.8 - 33.65]^2 = 0.0225$

$[x-\bar{x}]^2 = [33.8 - 33.65]^2 = 0.0225$

$[x-\bar{x}]^2 = [33.6 - 33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.7-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.7-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.8-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.6-33.65]^2 = 0.0025$

$[x-\bar{x}]^2 = [33.7-33.65]^2 = 0.0025$

$\sum[x-\bar{x}]^2 = 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0225 + 0.0225 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0025 + 0.0225 + 0.0225 + 0.0025 + 0.0025 = 0.1325$

Standard deviation $= \sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{0.1325}{20}} = \mathbf{0.0814}$

Calculation involving the EEB of the student

Mean of the data collected=

20.0+20.1+20.3+20.3+20.0+20.0+20.2+20.2+20.6+20.5+20.1+20.3+20.1+20.1+20.1+20.3-20.0 +20.4+20.420.4+20.6+20.0 = 404.6

$$\frac{404.6}{\mathbf{20}} = 20.23$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x.

$[x-\bar{x}]^2 = [20.0-20.23]^2 = 0.053$

$[x-\bar{x}]^2 = [20.1-20.23]^2 = 0.017$

$[x-\bar{x}]^2 = [20.3-20.23]^2 = 0.0049$

$[x-\bar{x}]^2 = [20.3-20.23]^2 = 0.0049$

$[x-\bar{x}]^2 = [20.0-20.23]^2 = 0.053$

$[x-\bar{x}]^2 = [20.2-20.23]^2 = 0.0009$

$[x-\bar{x}]^2 = [20.2-20.23]^2 = 0.0009$

$[x-\bar{x}]^2 = [20.6-20.23]^2 = 0.137$

$[x-\bar{x}]^2 = [20.5-20.23]^2 = 0.073$

$[x-\bar{x}]^2 = [20.1-20.23]^2 = 0.017$

$[x-\bar{x}]^2 = [20.3-20.23]^2 = 0.0049$

$[x-\bar{x}]^2 = [20.1-20.23]^2 = 0.017$

$[x-\bar{x}]^2 = [20.1-20.23]^2 = 0.017$

$[x-\bar{x}]^2 = [20.1-20.23]^2 = 0.017$

$[x-\bar{x}]^2 = [20.3-20.23]^2 = 0.0049$

$[x-\bar{x}]^2 = [20.0-20.23]^2 = 0.053$

$[x-\bar{x}]^2 = [20.4-20.23]^2 = 0.0189$

$[x-\bar{x}]^2 = [20.4-20.23]^2 = 0.0189$

$[x-\bar{x}]^2 = [20.6-20.23]^2 = 0.137$

$[x-\bar{x}]^2 = [20.0-20.23]^2 = 0.053$

$\sum[x-\bar{x}]^2 = 0.053+0.017 + 0.0049 + 0.0049 + 0.053 + 0.0009 + 0.0009 + 0.135 + 0.073 + 0.017 + 0.0049 + 0.017 + 0.017 + 0.0049 + 0.053 + 0.0189 + 0.0189 + 0.137 + 0.053 = 0.5889$

Standard deviation $= \sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{0.5889}{20}} = \mathbf{0.1716}$

Calculation involving the ESH of the student

Mean of the data collected=

17.1+17.4+17.4+17.5+17.4+17.3+17.3+17.9+17.9+17.2+17.3+17.4+17.4+17.4+17.6+17.0+17.0 +17.0+17.2+17.1+17.5=347.3

$$\frac{347}{\mathbf{20}} = 17.365$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x

$[x-\bar{x}]^2 = [17.1 - 17.365]^2 = 0.07$

$[x-\bar{x}]^2 = [17.4 - 17.365]^2 = 0.001225$

$[x-\bar{x}]^2 = [17.4 - 17.365]^2 = 0.001225$

$[x-\bar{x}]^2 = [17.5 - 17.365]^2 = 0.018225$

$[x-\bar{x}]^2 = [17.4 - 17.365]^2 = 0.001225$

$[x-\bar{x}]^2 = [17.3 - 17.365]^2 = 0.004225$

$[x-\bar{x}]^2 = [17.3 - 17.365]^2 = 0.004225$

$[x-\bar{x}]^2 = [17.9 - 17.365]^2 = 0.2862$

$[x-\bar{x}]^2 = [17.9 - 17.365]^2 = 0.2862$

$[x-\bar{x}]^2 = [17.2 - 17.365]^2 = 0.0272$

$[x-\bar{x}]^2$ =$[17.4-17.365]^2=0.001225$

$[x-\bar{x}]^2$ =$[17.4-17.365]^2=0.001225$

$[x-\bar{x}]^2$ =$[17.4-17.365]^2=0.001225$

$[x-\bar{x}]^2$ =$[17.6-17.365]^2=0.0552$

$[x-\bar{x}]^2$ =$[17.0-17.365]^2=0.1332$

$[x-\bar{x}]^2$ =$[17.0-17.365]^2=0.1332$

$[x-\bar{x}]^2$ =$[17.2-17.365]^2=0.0272$

$[x-\bar{x}]^2$ =$[17.1-17.365]^2=0.07$

$[x-\bar{x}]^2$ =$[17.5-17.365]^2=0.018225$

$$\sum[x-\bar{x}]^2 = 0.07+0.001225+0.001225+0{,}018225+0.001225+0.004225$$
$$+0.004225+0.2862+0.2867+0.0272+0.004225+0.001225$$
$$+0.001225+0.001225+0.0552+0.1332+0.1332+0.0272+0.07$$
$$+0.018225 = 1.144875$$

Standard deviation $=\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{1.144875}{20}} = \mathbf{0.239}$

Calculation involving the BKL of the student

Mean of the data collected=

14.0+14.1+14.1+14.2+14.3+14.1+14.1+14.3+14.1+14.1+14.3+14.1+14.1+14.3+14.1+14.1+14.0
+14.0+14.014.0+14.0+14.0+14.1+14.1+14.1=282.1

$$\frac{282.1}{\mathbf{20}} = 14.105$$

Let mean be represented by$\bar{x}$ and the data recorded be represented by x

$[x - \bar{x}]^2$ =$[14.0 - 14.105]^2 = 0.01$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.2 - 14.105]^2 = 0.01$

$[x - \bar{x}]^2$ =$[14.3 - 14.105]^2 = 0.04$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.3 - 14.105]^2 = 0.04$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.3 - 14.105]^2 = 0.04$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.1 - 14.105]^2 = 0.$

$[x - \bar{x}]^2$ =$[14.0 - 14.105]^2 = 0.01$

$[x - \bar{x}]^2$ =$[14.0 - 14.105]^2 = 0.01$

$[x - \bar{x}]^2$ =$[14.0 - 14.105]^2 = 0.01$

$[x - \bar{x}]^2$ =$[14.0 - 14.105]^2 = 0.01$

$$\sum[x-\bar{x}]^2 = 0.01+0+0+0.01+0.04+0+0+0.04+0+0+0.04+0+0+0,01$$
$$+0.01+0.01+0.01+0.01+0+0+0+0.01+0.01+0.01 = 0.19$$

Standard deviation = $\sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{0.19}{20}}$ **= 0.097**

Calculation involving the BPL of the student

Mean of the data collected=

13.4+13.4+13.1+12.5+11.6+13.1+12.7+12.7+12.6+12.7+12.7+12.6+13.1+13.2+12.8+11.9+12.1 +12.5+12.7+13.3=254.7

$$\frac{254.7}{\mathbf{20}} = 12.7$$

Let mean be represented by $\bar{x}$ and the data recorded be represented by x

$[x-\bar{x}]^2$ =$[13.4-12.7]^2 = 0.49$

$[x-\bar{x}]^2$ =$[13.4-12.7]^2 = 0.49$

$[x-\bar{x}]^2$ =$[13.1-12.7]^2 = 0.16$

$[x-\bar{x}]^2$ =$[12.5-12.7]^2 = 0.04$

$[x-\bar{x}]^2$ =$[11.6-12.7]^2 = 1.21$

$[x-\bar{x}]^2$ =$[13.1-12.7]^2 = 0.16$

$[x-\bar{x}]^2$ =$[12.7-12.7]^2 = 0.$

$[x-\bar{x}]^2$ =$[12.7-12.7]^2 = 0.$

$[x-\bar{x}]^2$ =$[12.6-12.7]^2 = 0.01$

$[x-\bar{x}]^2$ =$[12.7-12.7]^2 = 0.$

$[x - \bar{x}]^2 = [12.7 - 12.7]^2 = 0.$

$[x - \bar{x}]^2 = [12.6 - 12.7]^2 = 0.01$

$[x - \bar{x}]^2 = [13.1 - 12.7]^2 = 0.16$

$[x - \bar{x}]^2 = [13.2 - 12.7]^2 = 0.25$

$[x - \bar{x}]^2 = [12.8 - 12.7]^2 = 0.01$

$[x - \bar{x}]^2 = [11.9 - 12.7]^2 = 0.64$

$[x - \bar{x}]^2 = [12.1 - 12.7]^2 = 0.36$

$[x - \bar{x}]^2 = [12.5 - 12.7]^2 = 0.04$

$[x - \bar{x}]^2 = [12.7 - 12.7]^2 = 0.$

$[x - \bar{x}]^2 = [13.3 - 12.7]^2 = 0.36$

$$\sum [x - \bar{x}]^2 = 0.49 + 0.49 + 0.16 + 0.04 + 1.21 + 0.16 + 0 + 0 + 0.01 + 0 + 0 + 0.01 + 0.16 + 0.25 + 0.01 + 0.64 + 0.36 + 0.04 + 0 + 0.36 = 4.39$$

Standard deviation $= \sqrt{\frac{\sum[x-\bar{x}]^2}{n}}$

$\sqrt{\frac{4.39}{20}} = \mathbf{0.469}$

FORMULAR USED FOR THE PERCENTILES

$5^{TH} = L + \left(\frac{\frac{5}{100}N - CP}{FM}\right) \times i$

$50^{TH} = L + \left(\frac{\frac{50}{100}N - CP}{FM}\right) \times i$

$95^{TH} = L + \left(\frac{\frac{95}{100}N - CP}{FM}\right) \times i$

Table 4 Percentiles of seats dimension

DIMENSION	5TH PERCENTILE	50TH PERCENTILE	95TH PERCENTILE
SH	30.98	35.32	41.47
SD	32.2	47.37	47.8
SB	31.75	43	40.18
BRH	36.83	39.83	44
PH	31.44	39.87	49.47
KH	51.125	56.75	60.08
HB	27	40.5	54
BB	32	45.5	49.75

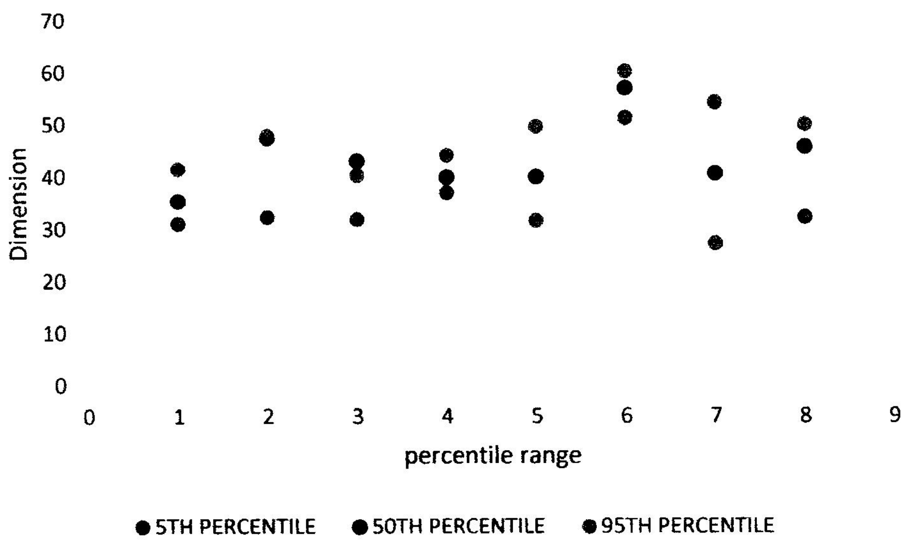

Fig 4 Percentiles of seats dimension

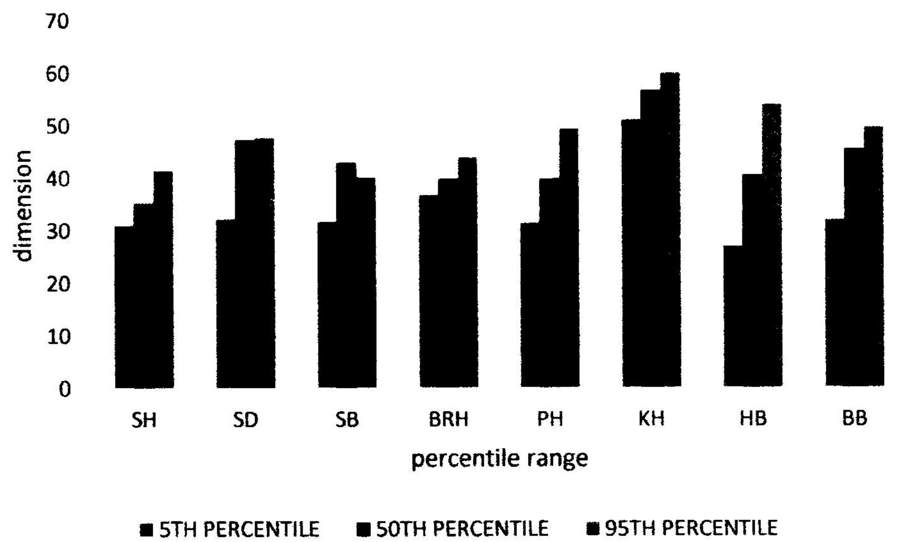

Fig 4 and 5 show graphical representations of each of the five relevant anthropometric variables and the statures of seat and pupils respectively. Fig 3 and 2, on the other hand show that there are strong relationships (as seen in their regression coefficients) within the five relevant variables and between the five variables and the stature.

Table 5 Percentiles of pupil's dimension

DIMENSION	5TH PERCENTILE	50TH PERCENTILE	95TH PERCENTILE
PH	17.85	18.36	18.75
KH	33.42	33.55	33.77
EEB	20.22	20.2	20.54
ESH	17.03	17.3	17.83
BKL	14.02	14.117	14.33
BPL	11.15	12.54	14.71

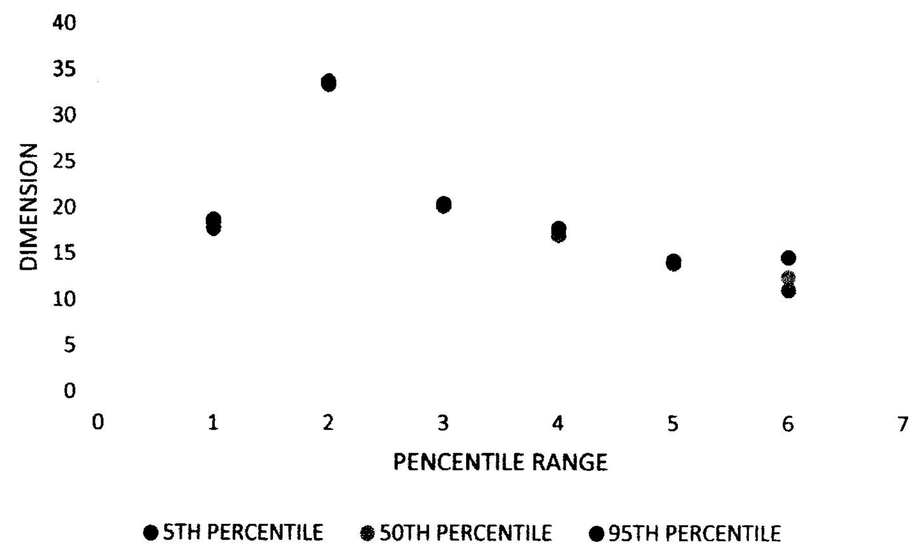

Fig 5 Percentiles of pupil's dimension

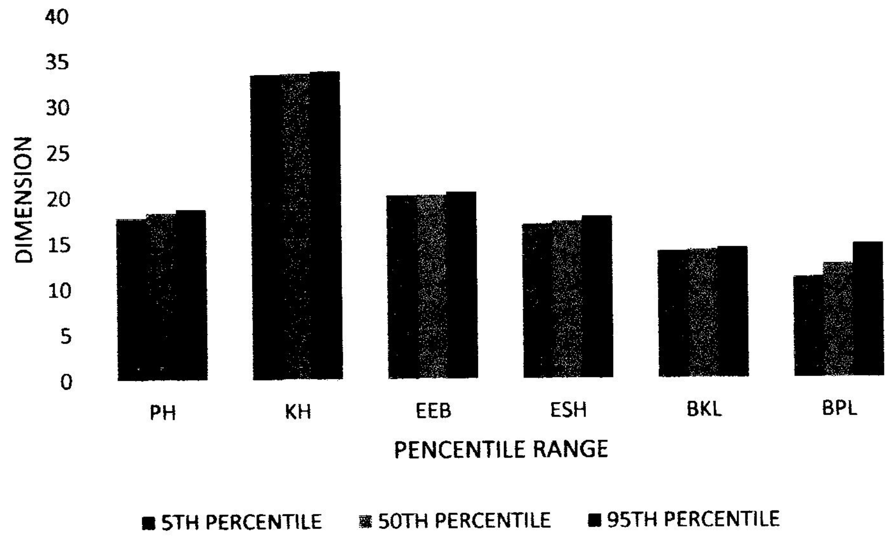

Fig 6 Percentiles of pupil's dimension

T-test Analysis

$$t = (\bar{X}_1 - \bar{X}_2) \div \sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}$$

Where :t=t- statistic, $X1$ = sample-1 mean, $X2$ = sample-2 mean, $s1$= sample-1 standard deviation, $s2$ = sample-2 standard deviation, $n1$= sample-1 size and $n2$ = sample-2 size

PH SEAT AND PH OF PUPILS

$$t=(64.43-18.35)\div\sqrt{\frac{23.46^2}{966.4}+\frac{0.11565^2}{367}}$$

=61.06

KH SEAT AND KH OF PUPILS

$$t=(56.39-33.65)\div\sqrt{\frac{1.61^2}{845.8}+\frac{0.0814^2}{673}}$$

=357.54

SD SEAT AND EEB OF PUPILS

$$t= (40.833-20.23)\div \sqrt{\frac{2.344^2}{612.5} + \frac{0.1716^2}{404.6}}$$

=216.6568

SH SEAT AND ESH OF PUPILS

$$t= (83.52-17.365)\div \sqrt{\frac{4.75^2}{1252.8} + \frac{0.23936^2}{347.3}}$$

=496.34

SB SEAT AND BKL OF PUPILS

$$t=(37.05-14.105)\div \sqrt{\frac{1.33^2}{555.7} + \frac{0.097^2}{282.1}}$$

=404.569

BB SEAT AND BPL OF PUPILS

$$t= (41.48-12.7)\div \sqrt{\frac{5.26^2}{415.68} + \frac{0.469^2}{254.7}}$$

=426.85

Table 5 Chi-square statistic (X^2) for related anthropometric dimensions and seat dimensions

Anthropometric dimensions and seat dimensions	Values	Percentile			Total x^2
		5TH	50TH	95TH	
PH- PH	Observed values (O)	31.44	39.87	49.47	85.88
	Expected values (E)	17.85	18.36	18.75	
	$(O-E)^2 \div E$	10.346	25.2	50.33	
KH-KH	Observed values (O)	51.12	56.75	60.08	

	Expected values (E)	33.42	33.55	33.77	45.88
	$(O-E)^2 \div E$	9.34	16.04	20.5	
SB-EEB	Observed values (O)	32.2	47.37	47.88	
	Expected values (E)	20.22	20.2	20.54	79.82
	$(O-E)^2 \div E$	7.1	36.54	36.18	
SH-ESH	Observed values (O)	30.98	35.32	41.47	
	Expected values (E)	17.03	17.3	17.83	61.54
	$(O-E)^2 \div E$	11.43	18.77	31.34	
SB-BKL					
	Observed values (O)	31.75	43	40.18	
	Expected values (E)	14.02	14.12	14.33	128.14
	$(O-E)^2 \div E$	22.42	59.09	46.63	
BB-BPL	Observed values (O)	32	45.5	49.75	
	Expected values (E)	11.15	12.54	14.71	209.08
	$(O-E)^2 \div E$	38.99	86.63	83.46	

The existing seat depth was between 47.8 cm and 33.2 cm which means that the seats are shallow and may cause the user not only to have the sensation of falling off the front of the chair but may also result in the lack of support of the lower thighs (Panero & Zeinik, 1979).

When dealing with a seat height and seat depth, the dimension employed needs to be smaller than the average dimension of the popliteal height (PH) and buttocks to popliteal length (BPL) (it needs to be the 5thpercentile of the popliteal height (PH) and buttocks to popliteal length) (David & Oborne, 1987). As per this, the seat height and seat depth should be 30.98 cm and 32.2 cm respectively.

Parcells et al. (1999) suggest that a chair whose seat height is >95% or <88% of popliteal height (PH) is a mismatch for the user. This suggests that the seat height should be between 39.9 cm and 37 cm (using the mean value of 42 cm) as compared to between 37.5 cm and 40.4 cm which makes the seats too high. Too high seats do not allow the feet to reach the floor which makes the passengers uncomfortable (Kroemer, 1971) and may result in low-back pain if the posture is prolonged (Chaffin & Anderson, 1991).

Similarly, the seat depth should be between 45.6 cm and 38.4 cm as Parcells et al. (1999) stated that a mismatch exists between buttocks to popliteal length (BPL) and seat depth when the seat depth is >95% or <80% of the buttocks to popliteal length (BPL). The existing seat depth was between 41.6 cm and 34 cm which means that the seats are shallow and may cause the user not only to have the sensation of falling off the front of the chair but may also result in the lack of support of the lower thighs (Panero & Zeinik, 1979)

CHAPTER 5

5.0 CONCLUSION

Through subjective assessment, seat dimensions had been evaluated although the respondents were satisfied with some of the dimensions of existing passenger seats of minibus, they still complained about certain .dimensions of the seats, such as seat depth and back rest width. the current study shows a mismatch between the dimensions of existing locally manufactured passenger seats of minibus and the anthropometric dimensions of passengers. This suggests that anthropometric data of the passengers was not employed in the design and manufacturing of the seats. This study is an indication that passenger seats of minibus and passengers' anthropometric dimensions are at variance. As it has been discussed in the literature review, seat design heavily relies on the anthropometric data to meet an ergonomic seat design. Therefore, the study provides anthropometric data that can be used by the local manufacturers of minibus seats for the design and fabrication of these seats. Therefore, the objectives of this study have been achieved and would definitely assist in an ergonomic passenger seat design of minibus. However, there are still spaces for development of the passenger seat design of minibus.

RECOMMENDATIONS

Local seat manufacturers usually design or redesign the seats to suit the expectations of their customers without due consideration for the comfort and safety of the passengers.

It is recommended that while designing seats, designers should use guidelines for seat dimensions proposed by the Society of Automotive Engineers (SAE).

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