ERGONOMICS: A PARADIGM SHIFT FROM FPJ TO FJP TOWARDS ADOPTING HUMAN-CENTRED ENGINEERING

INAUGURAL LECTURE

BY

PROFESSOR SALAMI OLASUNKANMI ISMAILA
Professor of Mechanical Engineering (Ergonomics)

(MNSE, MNIIE, MIAEng., R. Engr.)

DEPARTMENT OF MECHANICAL ENGINEERING
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Professor Olusola Babatunde Kehinde
B.Sc. (Agric Biology), M.Sc. (Crop Improvement)
Ph.D. (Ibadan), FGSN, FAIMP, FIHSC

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Professor Salami Olasunkanmi Ismaila
ND (Ilaro), B.Sc. (Hons) (Ife), M.Sc., Ph.D. (Ibadan)
MNSE, MNIIE, MIAEng., R. Engr. (COREN).
Professor of Mechanical Engineering (Ergonomics)

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Great FUNAABITES;
Distinguished Ladies and Gentlemen.

PREAMBLE

Mr. Vice-Chancellor, Sir, it is with a gladdened heart and gratitude to Allah (SWT) that I stand before this august gathering of eminent scholars and distinguished elites today to deliver the 92nd inaugural lecture of this noble institution titled **Ergonomics: A paradigm shift from FPJ to FJP towards adopting human-centered engineering**. This lecture is the 10th in the College of Engineering, the 4th in the Department of Mechanical Engineering: the first inaugural lecture was delivered by Late Professor S. B. Adejuyigbe, the second by Professor P. O. Aiyedun and the third by Professor M. A. Waheed.

Today is a landmark in a journey that was never in my dream, though a workmate of mine in 1985 was the first to call me “Professor” when I had yet to obtain my National Diploma but was on an industrial attachment at the moribund Nipol Plastics Ltd, Apata. I had worked with him at Diamond Foods Ltd, Alomaja as a factory hand. After my primary school education, I was already being advised to become a trailer driver/mechanic if not for my aunt who vehemently resisted that proposition and told my parents that I could become a better mechanic if I further my education.

My journey into academia started after I obtained my PhD in Industrial Engineering from the University of Ibadan. Before this time, after my National Diploma and University education, I worked in the industry for 16 years. While working in the industry, what was in vogue was an MBA (Master in Business Administration) degree for many who wanted a postgraduate degree, especially for those who wanted to progress in the managerial cadre. Due to the high number of people who sought admission for MBA and low quota, there was competition for MBA degree and the University of Ibadan introduced MMP (Master in Managerial Psychology) and MPP (Master in Personnel Psychology) programmes. I had a conversation with my immediate boss, Mr Ilarionos, a Greek who told me to seek admission to Industrial Engineering rather than MBA with my engineering background. He told me he did not see any reason for anyone with an engineering background to have MBA. I applied for admission in MSc (Industrial Engineering) and MMP with the intention that I will go for anyone that I was given admission. However, I was admitted for both and was in a dilemma. I then sought the spiritual intervention by praying to Allah to direct me. I had a dream that my Divisional Manager, Engr. Oboigbator (late), advised me to go for MSc in Industrial Engineering. I followed that dream of mine and enrolled for an MSc in the Department of Industrial and Production Engineering. After my MSc in 1999, Professor O. E. Charles-Owaba encouraged me to apply for a PhD as he was impressed with my score (83%) in Production-Inventory Systems Design, which was the best score ever obtained by a student he taught as of that time in that course. In the course of preparing my proposal for a PhD programme, I decided to look at ergonomics which was one of the topics in Advanced Work Systems Design and there was a dearth of experts. My choice of topic was spiritual, during the literature review, I found that the height of human beings decreases over the day which was linked to dehydration while narrowing down my research study to manual materials handling. A verse of the

Holy Quran came to my mind which reads *"la yukallifullahu nafsan illa wus'aha"* which translates to "Allah does not burden a person with something more than he can bear" (Surah Al-Baqarah 2:286).

It was then postulated that there was a link between the stature of human beings and load lifting. This postulation was behind my PhD thesis on "Post-Work Height Shrinkage Based Model for Predicting Safe Weight of Lift", which started my journey into the world of ergonomics.

Mr. Vice-Chancellor, Sir, with all modesty, I am the first to have a PhD in the area of ergonomics in the Department of Industrial and Production Engineering, University of Ibadan and arguably in Nigeria. *"fabiayyi alai rabbikuma tukadziban" (So which of the favours of your Lord would you deny?) [Surah Ar-Rahmaan 55:13]*.

After my PhD in the year 2006, I joined the services of the Federal University of Agriculture, Abeokuta in January 2007 as Lecturer I, rose through the ranks and my promotion as Professor was announced during the tenure of the Ag. Vice-Chancellor, Prof O. A. Enikuomehin with effect from 2016.

Ever since I found myself in the area of ergonomics, it has been an eventful and joyous journey. It is a very challenging area as it is an upcoming area, especially in our country, Nigeria.

1.0 Introduction

Ergonomics is used interchangeably for Human factors, Human factors Engineering, Human Engineering, Human factors Psychology, Engineering Psychology, Applied Ergonomics, Occupational Ergonomics, and Industrial Ergonomics. However, the most common terms are Ergonomics (as used in Europe) and Human factors Engineering (as used in the USA).

“Human factors Engineering" was emphasized by the US military with a concentration on human engineering and engineering psychology. Efforts focused on the "role" of an individual within a complex system. Their work aimed to understand and lessen the impact of the military working environment and new technology on human performance.

The emphasis of ergonomics is on work physiology and anthropometry while human factors is on experimental psychology and systems engineering (Helander, 1997). These minor differences in emphasis notwithstanding, the terms “human-factors engineering” and “ergonomics” may be considered synonymous.

1.1 Concept of Ergonomics

Ergonomics was derived from two Greek words “ergon”, which means “work” and “nomos”, which means “laws”, and ergonomics means “the laws of work” (Sluchak, 1992).

Fernandez (1995) defined ergonomics as the design of the workplace, equipment, machine, tool, product, environment, and system by taking into consideration the human’s physical, psychological, biomechanical, and physiological capabilities, and optimizing the effectiveness and productivity of work systems while assuring the safety, health, and well-being of the workers.

The International Ergonomics Association (2000) defined ergonomics or human factors as “the scientific discipline concerned with the understanding of interaction amongst human and other elements of a system, and the profession that applies theory, principles, data and methods to design, optimise human wellbeing and overall system performance. Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems to make them compatible with the needs, abilities and limitations of people.

The main aim of ergonomics is to reduce the risk of injury not only to make man available always but to also make his job easy for him with the ultimate goal of increasing in productivity to the benefit of the organization (Ismaila, 2010[a]).

Since humans will remain essential for the efficient and error-free functioning of any system, the main questions to answer are:

(i) what are the human issues a designer should consider when designing engineering facilities that involve humans? and
(ii) how should one address these issues when integrating humans in engineering facilities design, even at the design stage?

A report by the National Academy of Engineering (2004) in the USA states that soon, there will be ongoing developments in engineering, expanding toward tighter conditions between technology and the human experience including new products customized to the dimensions and capabilities of the user and the ergonomic design of engineered products.

Previously, ergonomics has been driven by technology (reactive design approach) but in the future, a proactive design approach would be adopted in which ergonomics would drive technology (Karwowski, 2005). The field of ergonomics is charged with tools and techniques for the development of optimal satisfying user, manufacturer, regulatory and other requirements of the product (Nadadur and Parkinson, 2013). It discovers and applies information about human behaviour, abilities, limitations and other characteristics to the design of tools, machines, systems, tasks, jobs and environments for productive, safe, comfortable and effective human use (Sanders and McCormick, 1987; Helander, 1997).

"The Human Factors and Ergonomics discipline advocates systematic use of the knowledge concerning relevant human characteristics to achieve compatibility in the design of interactive systems of people, machines, environments, and devices of all kinds to ensure specific goals. Typically, such goals include improved (system) effectiveness, productivity, safety, ease of performance and the contribution to overall human well-being and quality of life" (Karwowski, 2005: page 441). Therefore, ergonomists must integrate human beings into machine systems using rigorous scientific methods and appropriate techniques to identify human-machine mismatches and find workable solutions to these mismatches.

1.2 History of Ergonomics Globally

Christensen (1987) stated that a "good fit" between humans and tools was probably realized as important early in the development of the species. Pre-historic men discovered and engineered many different tools to fit their needs of bare necessities like hunting and eating. The science of ergonomics appears to have gained momentum in ancient Greece as some piece of evidence indicates that Hellenic civilization in the fifth century BC used ergonomic principles in the design of their tools, jobs, and workplaces. For example, Hippocrates described not only how a surgeon's workplace should be designed but also how the tools he uses should be arranged (Marmaras *et al.*, 1999). The archaeological records of the early Egyptian dynasties also showed that tools, and household equipment, among others, were made using ergonomic principles.

In the work environment, the selection and creation of tools, machines, and work processes continued. Over centuries, the effectiveness of hammers, axes and ploughs improved. With the Industrial Revolution, machines such as the spinning jenny (a machine that produced yarn to make cloth) and rolling mills (a method of flattening iron ore into flat sheets) were developed to improve work processes. This is the same motivation behind much of ergonomics today.

The relationship between types of work and musculoskeletal injuries was documented centuries ago. Bernardino Ramazinni (1633-1714) wrote about work-related complaints (that he saw in his medical practice) in the 1713 supplement to his 1700 publication, "De Morbis Artificum (Diseases of Workers)."

According to Bridger (2003), ergonomics was initially introduced into the literature by the Polish natural scientist Wojciech Jastrzebowski in his article titled "Rys ergonomji czyli nauki o pracy, opartej na prawdach poczerpnie˛tych z Nauki Przyrody" ("The outline of ergonomics, i.e. the science of work, based on the truths taken from the natural science") in 1857. After this introduction, the term was later reinvented and formally established by Murrell in 1949 (Edholm and Murrell, 1974). Banerjee (1962) reported that activity and research in ergonomics in industrially developing countries (IDCs) mainly began during the early 1960s.

Frederick Winslow Taylor started this approach of the "Scientific Management" method when he proposed a way to find the optimum method for carrying out a given task. Taylor found that he could, for example, triple the amount of coal that workers were shovelling by incrementally reducing the size and weight of coal shovels until the fastest shovelling rate was reached. Frank and Lillian Gilbreth expanded Taylor's methods to develop "Time and Motion Studies". They aimed to improve efficiency by eliminating unnecessary steps and actions. By applying this approach, the Gilbreths reduced the number of motions in bricklaying from 18 to 4.5, allowing bricklayers to increase their productivity from 120 to 350 bricks per hour.

In the early 1900s, the production of goods from the industry was still largely dependent on human power/motion and ergonomic concepts were developing to improve worker's productivity. Scientific management, a method that improved worker efficiency by improving the job process, became popular.

The Second World War prompted greater interest in human-machine interaction as the efficiency of sophisticated military equipment (i.e. aeroplanes) could be compromised by bad or confusing design. Design concepts of "fitting the machine" to the "size of the soldier" and logical/understandable control buttons evolved. After Second World War, the focus of concern expanded to include workers' safety as well as productivity. Research began in a variety of areas such as muscle force required to perform manual tasks; compressive low back disk force when lifting; cardiovascular response when performing heavy labour; and the perceived maximum load that can be carried, pushed or pulled.

Perhaps the most significant development in modern ergonomics was in the field of human-computer interaction, brought on by the explosion of computer usage in the workplace and, soon after, the home. Nearly every aspect of modern life now includes some level of ergonomic design. Automobile interiors, kitchen appliances, office chairs and desks, and other frequently used devices are designed ergonomically. Even the machines and tools used to build and assemble those devices are superbly ergonomic. By maximizing efficiency and, more importantly, user comfort and safety, ergonomics continues to make life easier.

Areas of knowledge that involved human behaviour and attributes (i.e., decision-making process, organization design, human perception relative to design) became known as cognitive ergonomics or human factors. Areas of knowledge that involved physical aspects of the workplace and human abilities such as force required to lift, vibration and reach became known as industrial ergonomics or ergonomics. The science of modern ergonomics includes the work of industrial engineers, industrial psychologists, occupational medicine physicians, industrial hygienists, and safety engineers. Professions that use ergonomics/ human factors information include architects, occupational therapists, physical therapists, occupational medicine nurses, and insurance loss control specialists.

1.3 Basic Ergonomics Model

The human-machine system is defined as a combination of human and equipment interaction and is the basic model in ergonomics.

Human-machine systems can be divided into three (Sanders and McCormick, 1993) as follows:

Manual Systems: When a person uses some hand tool or other powered implement to perform an activity or without the use of a tool or implement.

Mechanical Systems: This involves the use of one or more humans using powered equipment to perform a job. The function of man is to control the equipment.

Automated Systems: The performance of a job with minimal attention to the human component.

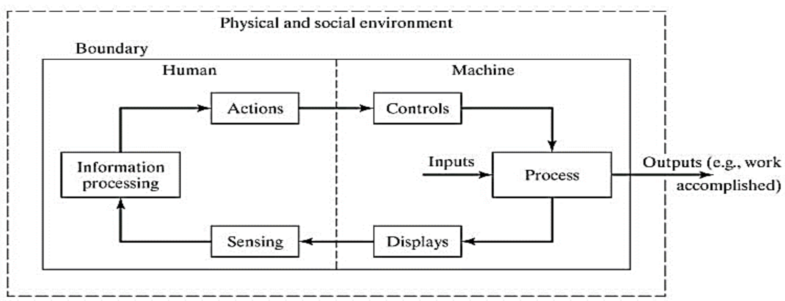


Figure 1: Basic Model in Ergonomics
Source: Sanders and McCormick (1993)

The basic model in ergonomics presented in Figure 1 consists of the human, machine and environmental components.

Human Components are those that perform three functions namely:

(i) Sensing the operation, which involves the use the 5 basic senses: seeing, hearing, smelling, tasting, and touching.
(ii) Information processing, which is use of the brain.
(iii) Actions, which is the use of effectors: fingers, hand, feet and voice.

Machine components also consist of three main components namely:

(i) The process, which is the function or operation that is performed by the human-machine system
(ii) Displays, which shows the action performed.
(iii) Controls is how humans interact with machines.

The environmental components consist of:

(i) Physical environment is the immediate and ambient-tools, workplace design, humidity, noise, temperature, lighting and vibration
(ii) Social environment is determined by co-workers, immediate supervisor, organizational structure and work organization.

In the basic ergonomics model, an individual operator works with a single machine. In any machine system, the human operator first uses a machine display which sends a signal that informs the individual something about the condition or the functioning of the machine. This display may be a pointer on a dial, a light flashing on a control panel, the readout of a digital computer, the sound of a warning buzzer, or a spoken command issuing from a loudspeaker.

Having sensed the display, the operator interprets it, perhaps performs some computations, and reaches a decision using human abilities. Such include the ability to remember and compare current perceptions with past experiences, coordinate those perceptions with strategies formed in the past, and extrapolate from perceptions and past experiences to solve novel problems. Psychologists commonly refer to these activities as higher mental functions; ergonomists generally refer to them as information processing.

An example of a human-machine system is driving an automobile, a familiar example of a simple human-machine system. In driving, the operator receives inputs from outside the vehicle (sounds and visual cues from traffic, obstructions, and signals) and from displays inside the vehicle (such as the speedometer, fuel indicator, and temperature gauge). The driver continually evaluates this information, decides on courses of action, and translates those decisions into actions upon the vehicle's controls—principally the accelerator, steering wheel, and brake. Finally, the driver is influenced by such environmental factors as noise, fumes, and temperature.

1.4 Classification of Ergonomics

Ergonomics can be divided into the following (Figure 2):

(i) Physical ergonomics;

(ii) Environmental ergonomics;
(iii) Cognitive ergonomics; and
(iv) Organizational ergonomics.

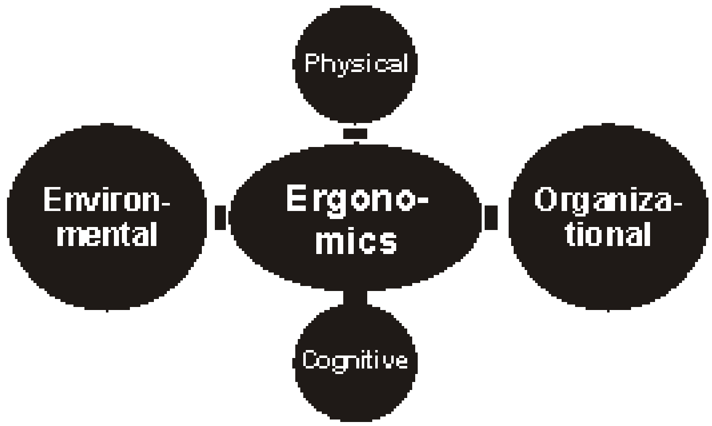


Figure 2: Classification of Ergonomics

Physical ergonomics is the study of the human anatomical, anthropometric, physiological and biomechanical as they relate to the physical activity of man. It can also be referred to as the physical interactions that people have with devices, making these interactions safe, error-free and efficient. The topics under this division of ergonomics include working postures, materials handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, safety and health (www.ergonomics.jp/original/inter/ ergodef-physical.html).

Environmental ergonomics concentrates on the interaction between man and his ambient environment. The topics under this include climate (temperature, humidity, heat and radiation), noise, vibration, lighting, pressure and so on as they affect man.

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. It refers to how people or teams interact with a system (or each other while using a system) from a psychological perspective. The topics here include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as they relate to human-system design.

Organizational ergonomics is the study of the optimization of socio-technical systems including their organizational structures, policies and processes. The topics under this division of ergonomics include communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, organizational culture, virtual organizations and quality management (www.ergonomics.jp/original/inter/ergodef-_organizational.html)

1.5 Multidisciplinary Nature of Ergonomics

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 human.

Up to the early 1960s, practising ergonomists were, generally, formally educated in physiology or psychology (Edwards, 2017). However, ergonomics is now a multidisciplinary field in which practitioners come from such diverse backgrounds with the popular fields being industrial engineering, psychology, anthropology, and medical sciences (Figure 3).

Industrial Engineering is the design of work systems and tools suitable for the workers, physiology is the study of the functioning and processes of living things, anatomy is the study of the physical structure of human beings, psychology is the study of the human mind and behaviour, occupational health and safety pertain to worker health promotion and protection as well as the avoidance of illnesses and injuries related to the workplace and anthropometry is the measurement of human dimensions.

Ergonomics is rooted in understanding how people use tools, products, and systems to accomplish desired tasks with less work-related musculoskeletal disorders, favourable environmental conditions and few human errors.

The relationships among these disciplines lead to designs that are safer, more acceptable, more comfortable, and more effective for accomplishing their given tasks.

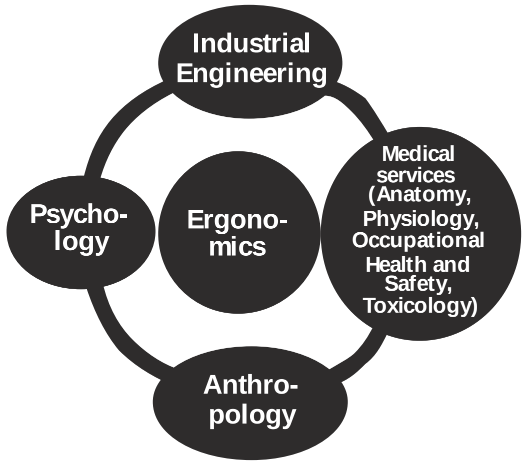


Figure 3: Multidisciplinary Nature of Ergonomics

1.6 Ergonomics and Human-Centred Engineering

Human nature is unique but varied, so varied that humans differ from one another in personality, structure, experience, habits, tastes, behaviour, mental, physical capabilities, and a host of other factors. Some are so sensitive that they react sharply to their environment. Even in the same tribes or family, no two individuals are the same (Ismaila and Samuel, 2014).

Since humans will remain essential for the efficient and error-free functioning of any system, the main questions to answer are: what are the human issues a designer should consider when designing engineering facilities that involve humans, and how should one address these issues when integrating humans in engineering facilities design, even at the design stage? The science of ergonomics provides guidelines and methods to address these questions.

User Centred Design (UCD) is a design theory that tries to place the end user at the centre of the design process. Donald Norman (1986) originated the phrase in the 1980s when he proposed criteria for designers to obtain acceptable usability results with their interfaces. Since then, many designers, academics, and policy-makers have advocated many strategies and techniques aimed at involving the end user in the design process, with the end user defined as the "person who will ultimately be using the product." The ISO modified the definition of UCD in its 2010 standard ISO 9241-210 to "address impacts on several stakeholders, not just those typically considered as users". Referring to the design approach as human-centered design (HCD), the active involvement of end-users is one of the key aspects of ergonomics to be considered.

Human-centred design (HCD) is defined by the ISO 9241-210:2019(E) standard on page 2 as "an approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques." "Usable systems can provide several benefits, including improved productivity, enhanced user well-being, stress avoidance, increased accessibility, and reduced risk of harm," according to the standard. Putting the user at the centre of the design process is also the driving premise of an HCD-related theory known as universal design. The involvement of users and the consideration of their characteristics in the design of facilities necessitate human-centered engineering. The HCD activity phases are as follows:

(1) identify the user and specify the context of usage;
(2) specify the user requirements;
(3) produce design solutions; and
(4) evaluate design solutions against requirements.

HCD is based on requirements engineering in that it tries to describe user needs and how they are addressed by the design at each step of development. This will create maximum user satisfaction and increase the safety performance of the device.

While ergonomics provides a foundation for addressing physical aspects of design, HCD expands the scope to create a more comprehensive and integrated approach that considers the entirety of the user experience and the broader engineering process. Together, these disciplines contribute to the creation of products and systems that are not only comfortable and efficient but also aligned with the diverse needs and expectations of users.

1.7 Applications of Ergonomics

Ergonomics has numerous applications across various industries and settings, aimed at optimizing the interaction between humans and their environments. Here are some broad categories of applications:

1. Designing workstations, and computer setups to promote comfort, reduce musculoskeletal strain, and enhance productivity in office environments.

2. Optimizing workstations, tools, and machinery in manufacturing settings to minimize physical strain, prevent injuries, and improve efficiency.
3. Designing medical equipment, hospital layouts, and patient care environments to enhance the well-being of healthcare professionals and improve patient outcomes.
4. Designing the interior of vehicles, aircrafts, and ships to ensure comfort, safety, and ease of operation for drivers, pilots, sailors, and passengers.
5. Incorporating ergonomic principles into the design of everyday products such as tools, appliances, and electronic devices to improve user experience and reduce the risk of injuries.
6. Designing computer peripherals, gaming consoles, and virtual reality systems with ergonomic considerations to enhance user comfort during extended use.
7. Designing farm equipment and tools to reduce physical strain on agricultural workers and enhance overall efficiency.
8. Implementing ergonomic principles in the design of construction tools, equipment, and workspaces to minimize the risk of injuries and improve worker well-being.
9. Designing classrooms, furniture, and educational materials to create an environment that supports student learning and reduces physical discomfort.

10. Designing military gear, equipment, and workspaces to accommodate the physical demands of soldiers, enhance performance, and reduce the risk of injuries.
11. Designing spacecraft, spacesuits, and space station environments to address the challenges of microgravity and ensure the well-being of astronauts during space missions.
12. Integrating ergonomic principles into the design of smart home devices to make them user-friendly, accessible, and comfortable for people of different ages and abilities.
13. Designing user interfaces for software, websites, and mobile applications to enhance usability and user experience, considering factors such as navigation, readability, and accessibility.
14. Adapting equipment and procedures for emergency responders to improve efficiency, reduce fatigue, and enhance safety during critical situations.
15. Applying ergonomic principles in the design of rehabilitation equipment and facilities to support individuals recovering from injuries or surgeries.

These applications demonstrate the versatility of ergonomics in addressing a wide range of contexts and industries, all with the common goal of optimizing human performance, safety, and well-being.

1.8 Transition from FPJ to FJP

The shift from "Fitting the Person to the Job" (FPJ) to "Fitting the Job to the Person" (FJP) indeed represents a significant paradigm shift in the field of ergonomics towards a more human-centred approach. This evolution reflects a recognition that designing systems and workplaces to accommodate the capabilities and needs of individuals is crucial for optimizing both human performance and well-being.

The paradigm shift towards Fitting the Job to the Person represents a more individualized and flexible approach. This recognizes that individuals have varying abilities, preferences, and physical characteristics. Designing jobs and work environments to accommodate this diversity improves overall job satisfaction, performance, and health.

1.7.1 Key aspects of fitting the job to the person

i. The design of workspaces, tools, and tasks can be customized to match the unique characteristics of individual workers. This may include adjustable furniture, adaptable tools, and personalized workstations.
ii. Jobs and tasks can be designed to allow for flexibility in how work is performed. This flexibility can take various forms, such as adjustable work hours, job rotation, and adaptable work processes.
iii. FJP emphasizes inclusivity by considering the needs of individuals with diverse abilities, ensuring that work environments are accessible to everyone. This aligns with the principles of universal design.

iv. FJP actively involves end-users in the design process, considering their feedback, preferences, and experiences. It also incorporates principles of usability and user experience to enhance overall job satisfaction.
v. FJP prioritizes the health and well-being of individuals by designing jobs that minimize physical strain, reduce stress, and promote a positive work environment.

1.7.2 The benefits of fitting the job to the person

The benefits of fitting the job to the person include the following:

i. Improved job satisfaction and morale,
ii. Increased productivity and efficiency,
iii. Reduced risk of musculoskeletal disorders and injuries,
iv. Enhanced adaptability to changing work requirements, and
v. Greater inclusivity and accommodation of diverse workforce needs.

Therefore, the shift from “Fitting the Person to the Job” to “Fitting the Job to the Person” signifies a move towards a more nuanced and personalized approach in ergonomics. This promotes the well-being and performance of individuals within the workplace. This human-centered engineering paradigm aligns with broader trends in design thinking and user-centric methodologies. Ismaila and Samuel (2014) noted that Nigerian engineers seek relevance in the production of functional items for Nigerians and consideration of ergonomics was actually not part of their focus. However, with the trends in other countries where products are designed for functionality, safety and comfort, the

Nigerian engineer is challenged either to concentrate on functionality or to combine functionality with safety and comfort. The combination of functionally with comfort and safety came as a result of human centered engineering.

Ergonomics highly encourages "Fitting the Job to the Person" and represents the paradigm shift towards a human-centered engineering.

1.9 Ergonomics in Nigeria

Ergonomics as a discipline in Nigeria probably started with Prof. Noah Kehinde Akinmayowa who obtained an MSc in ergonomics in 1979 through an open university course at the University of Birmingham (www.interaction_design.org/ references/author/ noah _k_akinmayowa. html). Though had a BSc. in Psychology from the University of Lagos, he later obtained PhD Engineering Production in 1982 from the Open University, Milton Keynes, U.K. He co-authored an article with Corlett and Sivayoganathan in 1981 titled "A new aesthesiometer for investigating vibration white finger (VWF)". He published another article titled "Computer Technology in the Educational Curriculum Development in Nigeria in the 21st Century" in 1993.

Other earliest researches (1980s) in ergonomics were in the area of agriculture. Nwuba (1981) carried out a study of the human energy requirement of selected hoes, machetes, axe and traditional shadoofs used for irrigation water-lifting by northern Nigerian farmers. Wagami (1983) performed ergonomic studies of commonly used farm tools in northern Nigeria. The tools covered included a ridging hoe (Garma), weeding hoe (Fartanya), chopping hoe (*Magiribi*), sickle (*Lauje*) and axe (*Gatari*). Igbeka and Oluleye (1986) conducted a study on some ergonomic considerations in operating a pedal thresher. Similarly, Igbeka (1993) reported that simple ergonomics interventions in gari frying task improved productivity and quality while they reduced fatigue and discomfort. Okunribido (2000) surveyed hand anthropometry of female rural farmworkers in Ibadan, western Nigeria while Ismaila and Charles-Owaba (2006) reported the effects of work and age on spinal shrinkage.

Ergonomics practitioners in Nigeria formed Ergonomics Steering Committee in the year 2002 for the promotion of ergonomics in the country. In September 2006, the Ergonomics Society of Nigeria was formed to promote the application of ergonomics knowledge, advance research and education in ergonomics and create public awareness of the advantages inherent in the application of ergonomics. At present, the Ergonomics Society of Nigeria is an affiliate member of the International Ergonomics Association.

The need for the application of ergonomics in Nigeria is essential due to the steady pace of industrialization, technology transfer and demand for a more humane way of life. Previous attempts to introduce ergonomics have faced several challenges (Adaramola, 2006). It is expected that by using local initiatives, and being sensitive to the social, cultural and political considerations of Nigeria, these problems can be addressed (Adaramola, 2006). However, a study conducted by Ismaila (2010) showed that there was a very low level of ergonomics awareness in Nigeria. The word ergonomics is oftentimes confused with economics. The application of ergonomics is, therefore, poorly appreciated in the country.

2.0 My Humble Contributions to Knowledge

Mr. Vice Chancellor, Sir, distinguished ladies and gentlemen, it is pertinent at this juncture to present some of my modest contributions to research activities in Industrial Engineering in the area of ergonomics. It is important to state that I was touched by the question of Professor Olaiya Balogun, who asked what my challenge was during the interview for the regularisation of my appointment. At the time of the interview, I had only one conference proceedings and was expecting the publication of my first journal article. To add to this, Professor P. O. Aiyedun, while advising members of the Department of Mechanical Engineering, stated that the best way to enjoy promotion when due was to publish at least three papers every year, and the issue of 'publish or perish', especially for somebody from the industry, crowned it all. I am also privileged to be working with people who are committed and hardworking. Most of the work that made me what I am today is collective research efforts with those who mentored me and those who allowed me to be their mentor.

Therefore, my research efforts and publications in journals and conferences have been summarized below:

2.1 Lifting and Carrying of Load

Lifting and carrying loads is a common and potentially risky task that individuals encounter in various settings, from the workplace to daily domestic activities. Ensuring proper techniques and safety measures is essential to prevent injuries and promote overall well-being. By prioritizing proper lifting and carrying techniques, implementing safety measures, and creating a supportive environment, individuals can significantly reduce the risk of musculoskeletal injuries and promote a safer and healthier work or living space.

2.1.1 Development of model for safe weight of lift

Mr. Vice Chancellor, Ismaila (2006) carried out research on Manual materials handling (MMH) activities which include lifting, placing, carrying, holding, and lowering. The analysis of compensation claims by workers shows that Manual Materials Handling was responsible for 32% of workers' injuries and illnesses and 36 percent of costs (Health and Safety Commission, 1993; Murphy *et al.*, 1996). The widely celebrated models were the Practices Guide for Manual Lifting by National Institute of Occupational Safety and Health (NIOSH) termed the Action Limit which was reviewed and renamed the 1991 NIOSH equation and termed the Recommended Weight Limit (RWL); and the Maximum Acceptable Weight Limit (MAWL). The RWL was popular not only because it provided health practitioners with an empirical method of computing a weight limit for manual lifting but also because MAWL being subjective was suggested to be replaced with a more objective method whenever available (Snook, 1985).

Although there are many manual lifting models, they seem to have limited applications due to uncertainties in the existing scientific studies and theoretical models (Waters *et al.*, 1993).

Moreover, the models seem too general to be selectively used and perfectly match individuals to industrial tasks for safety and higher productivity. Based on the identified shortcomings of the earlier models, Ismaila and Charles-Owaba (2010) had proposed an approach that may lead to the development of a safe weight lift which may be subject – and task-specific and expected that such an approach may be more protective of workers than the approaches reported in the literature. Hence, Ismaila and Charles-Owaba (2012) developed a mathematical model for determining a safe weight of lift by considering the intratruncal pressure, post-work height shrinkage of the worker and strain energy of the intervertebral disc in terms of the Young Modulus of elasticity (E) of the articular cartilage (endplate of the disc); velocity of lift (u); acceleration due to gravity (g); vertical location of the load (V); horizontal length of the load from the ankles (H); vertical displacement of the load (D); the angle of lift (θ) and the lifter's anthropometric dimensions. Figure 4 shows the lifting body structure.

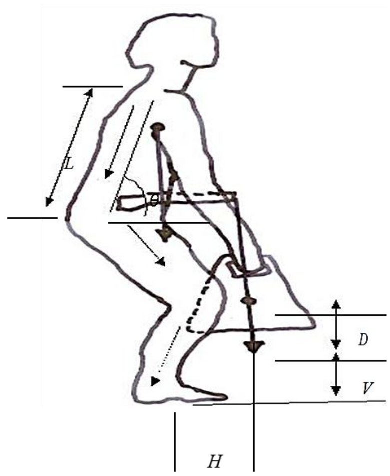


Figure 4: Lifting Body Structure:
Legend: H, horizontal location of load; V, vertical location; D, Vertical displacement of load
Source: Ismaila and Charles-Owaba (2012)

$$SWL = \frac{\pi \times l_f \times l_s \times x^2}{4}\left[\frac{E\left\{\frac{D+V}{H}\right\}cos\theta}{2gD + u^2\left\{\frac{D+V}{H}\right\}cos\theta}\right]$$

The model was applied using a range of values of the task parameters: D (vertical displacement), V (vertical location of the load), H (horizontal location of the load) adopted from NIOSH (1981); Young Modulus of elasticity (E) of the articular cartilage from Sokoloff (1966) and velocity of lift (u) from Lin *et al*. (1999). Measurements of L (from the first thoracic to the last lumbar), l_f (chest breadth) and l_s (chest depth) were taken from eighty-four (84) workers comprising those in the factory and market labourers engaged in lifting tasks that have a duration of eight hours. Also, the heights of each worker were measured just before the commencement of work (in the morning) and after work (in the evening) to determine the post-work spinal shrinkage, x. The age range of the workers considered was from 18 to 57 years with a mean spinal shrinkage of 0.014 m. The mean spinal shrinkage was used to obtain the safe weight of lift (SWL) while the highest permissible spinal shrinkage of 0.021 m obtained by Ismaila and Charles-Owaba (2008) was used to obtain the maximum safe weight of lift ($\mathrm{SWL}_{\mathrm{max}}$). A comparison of the recommended weight of lift, the maximum acceptable weight of the lift and the maximum safe weight of the lift are presented in Table 1.

Table 1: Comparison Between RWL, MAWL, SWL and SWL_{max} Values

D (m)	**V (m)**	**H (m)**	**RWL (kg)**	**MAWL (kg)**	**SWLMax (kg)**	**SWL (kg)**
0.25	0.260	0.37	9.9	11.0	6.6	**2.4**
0.25	0.260	0.45	8.2	9.0	6.1	**2.2**
0.25	0.260	0.58	6.3	9.0	5.6	**2.0**
0.51	0.125	0.37	8.6	11.0	5.6	**2.1**
0.51	0.125	0.45	7.1	9.0	5.3	**1.9**
0.51	0.125	0.58	5.5	8.0	4.8	**1.8**
0.76	0.000	0.42	7.0	9.0	4.8	**1.7**
0.76	0.000	0.5	5.9	8.0	4.5	**1.7**
0.76	0.000	0.63	4.7	7.0	4.2	**1.5**
0.25	0.920	0.37	11.1	12.0	3.4	**1.2**
0.25	0.920	0.45	9.1	10.0	3.3	**1.2**
0.25	0.920	0.58	7.1	10.0	3.2	**1.2**
0.51	0.785	0.37	10.5	10.0	3.1	**1.1**
0.51	0.785	0.45	8.6	9.0	3.0	**1.1**
0.51	0.785	0.58	6.7	9.0	2.9	**1.1**
0.76	0.660	0.37	10.0	9.0	2.8	**1.0**
0.76	0.660	0.45	8.2	9.0	2.8	**1.0**
0.76	0.660	0.58	6.4	9.0	2.7	**1.0**
0.25	1.540	0.37	8.9	10.0	2.3	**1.0**
0.25	1.540	0.45	7.3	8.0	2.2	**1.0**
0.25	1.540	0.58	5.7	8.0	2.2	**1.0**
0.51	1.410	0.37	8.5	9.0	2.1	**1.0**
0.51	1.410	0.45	7.0	7.0	2.1	**1.0**
0.51	1.410	0.58	5.4	7.0	2.1	**1.0**
0.76	1.280	0.37	8.6	8.0	2.0	**1.0**
0.76	1.280	0.45	7.1	7.0	2.0	**1.0**
0.76	1.280	0.58	5.5	6.0	2.0	**1.0**

Legend: V-Vertical location of the load; H- horizontal length of the load from the ankles; D-Vertical displacement of the load; RWL-Recommended Weight Limit; SWL_{max}-Maximum Safe Weight of Lift; MAWL-Maximum Acceptable Weight Limit

Source: Ismaila and Charles- Owaba (2012)

The study established a mathematical model to calculate the Safe Weight of Lift for manual load lifting. The model not only incorporates the lifting task parameters as used by NIOSH but also some relevant lifter's anthropometric dimensions (the chest area and spine length), spinal shrinkage and lift velocity. This model to determine the safe lifting capacity of an individual was valid.

2.1.2 Development of a model for safe backpack weight limit for secondary school students

Backpacks otherwise known as personal load carriage systems are commonly used among school children, adolescents and adults for daily transferring of personal belongings, books, stationeries and laptops to and from workplaces or school (Chow *et al*., 2011). The health effect of carrying a heavy backpack is evident and the concern for students' backpack safety cut across the globe. This is obvious from the peer-reviewed studies that have been conducted in Europe (Cardon and Balague, 2004; Negrini et al., 2004; Cottalorda *et al*. 2003), Asia (Chow *et al*., 2007), the Middle East (Al-Hazzaa, 2006), Australia (Vitiello and Pollard, 2002) and Africa (Ismaila and Oriolowo, 2015). The result of the review of literature from 1985 to 2002 conducted by Steele *et al*. (2013) included high-level evidence relating load carriage to postural changes in young people. Determining an acceptable limit for the load for a child is important to reduce injuries to the back, neck, and shoulders as well as posture problems. The combined effects of heavy loads, the position of the load on the body, size and shape of the load, load distribution, time spent carrying, physical characteristics and physical condition of the individual were hypothesized as factors which were associated with these problems (Knapik *et al*., 1996).

Efforts have been made to set a backpack mass limit for students, but a universal limit remains indefinable due to inconsistent results from scientific studies. Most studies found that an acceptable limit for school children should be between 10 and 15% of their body weight (BW) (Bauer and Freivalds, 2009; Brackley and Stevenson, 2004), though some studies have suggested it should not exceed 10% BW (Hong and Brueggemann, 2000). Moore and colleagues gave specific recommendations for limits for backpack weight-to-child weight ratios as 10% (Moore *et al*., 2007). Al-Hazzaa (2006) recommended between 5 and 10% BW. Backpack limit may not be a function of weight only but other anthropometric data may be necessary. A study conducted by Kroemer (1997) confirmed that to determine the safe limit for a load to be carried, individual differences such as body dimensions should be considered. Ismaila and Charles-Owaba (2012) used the spinal shrinkage principles to determine the weight of a load that a worker should lift to be safe, the study thus determined the backpack mass limit that students could carry to be safe with due consideration to their anthropometric characteristics.

Mr. Vice Chancellor, Ismaila (2018) proposed a model for the determination of the safe backpack weight limit for secondary school students using the following assumptions:

1. The spine is the most important aspect of the lifting structure and therefore it is given serious consideration.
2. Each of the end plates of the spine consists of hyaline and fibro cartilage and may be modelled as an isotonic elastic material.
3. An elliptical truncal cross-sectional area of the human subject is assumed

   Elliptical Truncal Area; $A = \frac{\pi \times l_f \times l_s}{4}$

   where l_f is the chest width measured across the chest at the nipple in m; and l_s is the chest depth measured at the chest from front (sternum) to back (spinal groove) in m.
4. The Modulus of elasticity of articular cartilage, E is assumed to be 7.0 MN/m^2 and a factor of safety of 1.25 was adopted. Therefore, E = 5.6 MN/m^2
5. The strain energy at the spine is the sum of the potential energy and kinetic energy of the load being lifted.
6. The normal walking of the backpack carrier occurs when Froude number $= 0.25 = \frac{u^2}{gl}$. where u = velocity of movement, g = 9.81 m/s^2 and l = leg length
7. The spinal shrinkage for a child, x = 0.0195 m

$$M_o = \frac{A \times E \times x^2}{2 \times L\left[g \times (SH) + \frac{u^2}{2}\right]}$$

where Mo = Weight of backpack
A = Elliptical Truncal Area
E = Modulus of elasticity of articular cartilage
x = Spinal shrinkage
L = Trunk Length g = gravity (9.81 m/s^2)
SH = Shoulder Height of the backpack carrier (m)
u = Velocity of movement of the backpack carrier

The obtained anthropometric data is presented in Table 2.

Table 2: Summary of Anthropometric Data of all Secondary School Students and Safe Backpack Limits

Statistics	**Age (years)**	**Weight (kg)**	**Height (m)**	**Leg length (m)**	**Chest depth (m)**	**Chest width (m)**	**Trunk length (m)**	**Shoulder height (m)**	**Safe backpack weight (kg)**	**Safe weight as % of body weight**
Number of students	324	324	324	324	324	324	324	324	324	324
Mean	12.87	47.06	1.55	0.90	0.14	0.18	0.42	1.21	3.96	8.96
Std. Deviation	1.90	12.22	0.12	0.08	0.02	0.02	0.07	0.13	0.91	3.05
Minimum	9.00	28.00	1.12	0.21	0.12	0.14	0.23	0.80	1.78	4.14
Maximum	18.00	95.00	1.89	1.12	0.20	0.24	0.98	1.57	8.55	26.72
Percentiles										
5	10.00	31.10	1.38	0.78	0.12	0.15	0.36	1.04	2.60	5.00
50	13.00	45.00	1.56	0.90	0.14	0.19	0.43	1.21	3.89	8.55
95	16.00	70.00	1.80	1.05	0.17	0.22	0.53	1.47	5.51	13.83

Source: Ismaila (2018)

The mean safe weight of the backpack for the male students was 3.97 kg (± 0.84 kg) representing 10.29 (±2.89) % of the body weight of the students while the 5th, 50th and 95th percentiles of the absolute safe weight of backpack were 2.87, 3.83 and 5.46 kg respectively. For the female students, the mean safe weight of the backpack was 3.97 kg (± 0.99 kg) representing 9.06 (±3.23) % of the body weight of the students while the 5th, 50th and 95th percentiles of the absolute safe weight of the backpack were 2.53, 3.96 and 5.56 kg respectively.

For all students, the mean safe weight of the backpack was 3.96 kg (± 0.91 kg) representing 8.96 (±3.05) % of the body weight of the students while the 5th, 50th and 95th percentiles of the absolute safe weight of the backpack were 2.60, 3.89 and 5.51 kg respectively.

2.2 Anthropometric Data Collection

Anthropometric data collection involves the measurement of various physical dimensions and characteristics of the human body. The purpose of this data collection is to gain insights into the size, shape, and composition of individuals or populations. This data is valuable in fields such as anthropology, ergonomics, nutrition, and healthcare, providing insights into growth patterns, nutritional status, and population characteristics. It is useful in the design of workplaces and tools.

2.2.1 Anthropometric data of hand, foot and ear of university students in Nigeria

Anthropometric data is needed in the design of products as it varies between individuals and nations (Roebuck *et al*., 1975). These data for Nigerians are presently scanty and this study is an attempt to provide data on hand, foot and ear for the improvements of hand gloves, handles, shoes, pedal dimensions, ear-phones and other related products. Mr. Vice Chancellor, Ismaila (2009) obtained the anthropometric data of hand, foot and ear of some university students using a random sample of 500 students and their ages were between 18 and 29 years (mean of 21.7 years). Two hundred and fifty of the samples were males and the same numbers were females. The dimensions measured were hand: length and breadth; foot: length, breadth and height; ear: height and breadth. The study presents the anthropometric data for the 5th, 50th and 95th percentiles for the above-presented variables (Table 3).

Table 3: Anthropometric Data of Hand, Foot and Ear for Male and Female University Students

Parameter	**Male**				**Female**			
	Percentiles				**Percentiles**			
	5th	**50th**	**95th**	**SD**	**5th**	**50th**	**95th**	**SD**
Age (Years)	20	25	28.7	1.25	19	24	28	1.1
Foot Breadth (cm)	7.9	8.6	9.5	0.55	8.0	9.0	10.0	0.59
Foot Length (cm)	24.8	26.4	27.5	1.2	23.0	25.0	27.0	1.4
Foot Height (cm)	5.2	5.9	6.7	0.54	4.3	5.4	6.4	0.68
Hand Breadth (cm)	8.8	9.6	10.0	0.49	8.1	9.5	10.5	0.75
Hand Length (cm)	18.5	19.5	20.1	0.59	17.4	19.0	21.5	1.21
Hand Thickness (cm)	3.0	3.4	4.0	0.39	2.7	3.5	4.1	0.41
Ear Height (cm)	5.1	5.5	6.2	0.32	3.2	5.5	6.2	0.88
Ear Breadth (cm)	3.1	3.4	3.8	0.28	2.5	3.0	3.4	0.23

Source: Ismaila (2009)

The results of the t-Test showed that the foot breadth of the males differ significantly from those of the females ($t = -4.294$, $p = 0.000$), those of the females were larger. Similarly, there were significant differences between the foot lengths of the males and those of the females ($t = 5.607$, $p = 0.000$), those of the males were larger. For the foot heights also, there were significant differences ($t = 5.702$, $p = 0.000$), though the foot heights of the males were larger. There were no significant differences between the hand dimensions of the females and those of their male counterparts ($t = 0.261$, $p = 0.795$ for hand breadth; $t =1.668$, $p = 0.099$ for hand length; $t = 1.722$, $p = 0.088$ for hand thickness). Significant differences were noted in the ear anthropometric dimensions of the females and those of the males ($t = 4.112$, $p = 0.000$ for ear height; $t = 12.46$, $p = 0.000$ for ear breadth).

The study established that foot breadths of the females were larger than those of the males while the males had larger foot lengths. There were no significant differences between the hand dimensions of the males and those of the females. Similarly, there were no significant differences between the ear dimensions of males and the females.

2.2.2 Anthropometric survey and appraisal of furniture for Nigerian primary school pupils

Mr. Vice Chancellor, Ismaila *et al.* (2010[a]) obtained some anthropometric dimensions of pupils in primary schools and examined the likelihood of mismatch between the relevant body dimensions of the pupils with the furniture they presently use in class. Random samples of 200 pupils in 4 randomly selected public primary schools were used for the study. The age range of the children was from 5 to 14 years (mean = 9.8 years, SD = 2.9 years). Twenty-one anthropometric dimensions of the pupils and the dimensions of the furniture in the schools were measured. From the data obtained; means, standard deviations, minimum values, maximum values, 5th, 50th and 95th percentiles were computed using SPSS 16.0 statistical package. Also, Paired samples T-Test was conducted for the measurements of the male and female pupils at 0.05 level of significance using Microsoft Excel. The measured dimensions of the pupils (Table 4) were also compared with those of the desks and tables.

Table 4: Dimensions of Existing Furniture (cm)

Measured item	**Dimensions**
Desk Depth	28
Drawer Depth	20
Floor to Desk Height	42
Chair Height	72
Seat Height	35
Seat Breadth	90
Seat Depth	31
Upper Back Rest	38
Lower Back Rest	26

Source: Ismaila (2010[a])

Parcells *et al*. (1999) and Panagiotopoulou *et al* (2004) stated that a mismatch occurs when the seat height is greater than 95 percent and less than 88 percent of the popliteal height. Thus, the seat height of the pupils should be between 35.3 and 38.1 cm for a perfect match. The chair in use has a seat height of 35 cm which suggests that the seat is a bit low than the recommended dimension. Based on the current study, the seat breadth should lie between 23.2 and 27.8 cm but the seat breadth of the chair in use is 90 cm. Actually, the present design was to accommodate three pupils at a time. For the seat depth which should be between 29.5 and 31.8 cm, the actual seat depth is 31cm which may not totally accommodate the pupil. Too shallow a seat may cause the user to have sensation of falling off and may result in lack of support of the lower thighs (Panero and Zeinik, 1979). The desk clearance which should be between 50.0 and 51.1 cm was measured to be 62cm. This makes the desk too high for the pupils. The desk depth was measured to be 28cm instead of it to lie between 30.4 and 37.1 cm. This suggests that the desk is too shallow. Moreover, the drawer depth which should be between 15.2 and 18.6 cm was measured to be 20 cm. Though the chairs currently in use were not provided with armrest, the arm rest should be between 14.4 cm and 17.2 cm based on the study.

The results of the study showed that all the anthropometric dimensions of the males differ significantly from those of the females with the exception of the elbow hand grip and that there exists a mismatch between the anthropometric dimensions of pupils and the furniture they are currently using.

2.2.3 Design of ergonomically compliant desks and chairs for primary pupils

Pupils are required to sit for long period in schools (Knight and Noyes, 1999) and yet the effect of the design of school furniture on their behaviour and health has received comparatively little attention compared to their adult counterparts. At this stage of development, there may be changes to their spinal column due to wrong sitting posture because of use of incompatible school furniture. Molenbroek *et al*. (2003) reported that prolonged sitting by students for educational purposes might result in headache, neck pain and back pain particularly if there is a mismatch between the students and school furniture. Thus, chairs and desks must be designed for the user population taking into consideration their anthropometric parameters. For the Nigerian population, there seems to be very few reported anthropometric data on which the design of ergonomically compliant chairs and desks could be based. The few reported anthropometric data includes that of Igboanugo *et al*. (2002) on anthropometric data of Nigerian adult working class to serve as a data base for designers of domestic and industrial population; Ayodeji *et al*. (2008) on anthropometric data of Nigerian paraplegics and Ismaila (2008) on anthropometric data of the foot of Nigerian University students. Others are Ismaila (2009) on the anthropometric data of hand, foot and ear of University Students in Nigeria and Ismaila *et al*. (2010) on anthropometric survey and appraisal of furniture for Nigerian primary school pupils. Ismaila *et al*. (2010[a]) concluded that chairs and desks in use in the primary schools by pupils were probably designed using the anthropometric dimensions of the British or none at all because some of the dimensions were either low or high for the pupils. Thus, there seems to be no reported ergonomically compliant design of the chairs and desks for use by the primary school pupils in Nigeria.

Mr. Vice Chancellor, Ismaila *et al*. (2015[b]) proposed the design of ergonomically compliant desks and tables for pupils in primary schools in Ibadan, Oyo State, Nigeria. Eight anthropometric dimensions namely STH, BPL, SDH, POH, KH, ERH, HPB and

EHG as defined in Table 6 and shown in Figure 5 were measured with the use of Vernier Calliper, Stadiometer and measuring tape. The measurements were taken three times to ensure the correctness. The data obtained from the recorded measurements on prepared forms were combined into a file from which 5th, 10th, 50th, 75th, 90th and 95th percentiles were computed using Microsoft Excel Package. Also, 2-Tail Paired samples t-Test was conducted for the measurements of the male and female pupils for the three- age groups at 0.05 level of significance using SPSS 16.0 statistical package. The dimensions of the chairs and tables measured are shown in Tables 5-7.

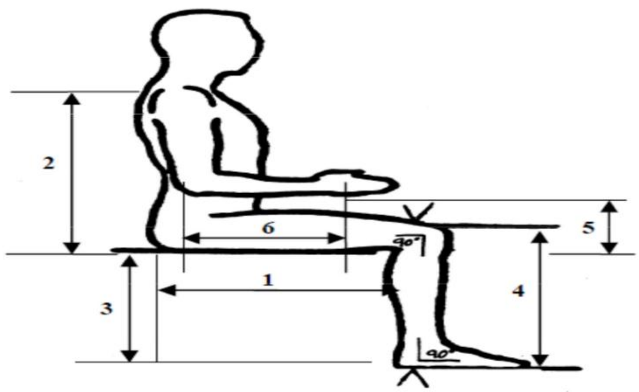


Figure 5: Measured Anthropometric Data

Legend**:** 1- Buttock-Popliteal Length (BPL); 2- Shoulder Height (SDH)**;** 3-Popliteal Height (POH); 4-Knee height (KH)**;** 5-Elbow Rest Height (ERH); 6-Elbow- Hand Grip

Source: Ismaila *et al*. (2015[b])

Table 5: Recommended Dimensions of Chairs and Desks for Pupils in Primary School with Ages Between 5 and 8 Years

Features	Anthropometric measurements	Deciding factors	Recommended dimensions
Seat surface Height	POH	75th percentile of POH	32.0 cm
Seat surface Depth	BPL	75th percentile of BPL (male)	33.0 cm
Seat surface Width	HPB	95th percentile of HPB+ 2 cm	30.0 cm
Armrest height	ERH	5th percentile of ERH	12.0 cm
Upper seat back rest height	SDH	75th percentile of SDH	39.0 cm
Desk surface Height	KH	75th percentile of KH + 2 cm	42.0 cm
Desk surface Width	HPB	95th percentile of HPB+ 2 cm	30.0 cm
Desk surface Depth	EHG	50th percentile of EHG	34.0 cm

Source: Ismaila *et al*. (2015[b])

Table 6: Recommended Dimensions for Chairs and Desks for Pupils in Primary School with Ages Between 9 and 12 Years

Features	Anthropometric measurements	Deciding factors	Recommended dimensions
Seat surface Height	POH	75th percentile of POH	37.3 cm
Seat surface Depth	BPL	75th percentile of BPL	38.0 cm
Seat surface Width	HPB	95th percentile of HBP + 2 cm	31.0 cm
Armrest Height	ERH	5th percentile of ERH	13.0 cm
Upper seat Back Rest Height	SDH	50th percentile of SDH	43.0 cm

Desk surface Height	KH	75th percentile of KH + 2 cm	49.0 cm
Desk surface Width	HPB	95th percentile of HPB	31.0 cm
Desk surface Depth	EHG	50th percentile of EHG	36.0 cm

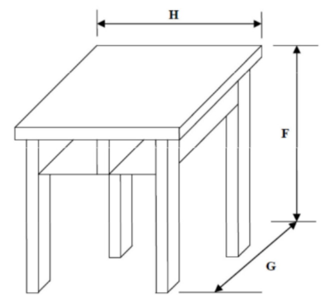
Source: Ismaila *et al*. (2015[b])

Table 7: Recommended Dimensions of Chairs and Desks for Pupils in Primary School with Ages Between 13 and 14 Years

Features	**Anthropometric measurements**	**Deciding factors**	**Recommended dimensions**
Seat surface height	POH	75th percentile of POH	40.3 cm
Seat surface depth	BPL	75th percentile of BPL	41.0 cm
Seat surface width	HPB	95th percentile of HPB+ 2 cm	31.0 cm
Armrest height	ERH	5th percentile of ERH	15.0 cm
Upper seat back rest height	SDH	75th percentile of SDH	44.0 cm
Desk surface Height	KH	75th percentile of KH + 2 cm	53.3 cm
Desk surface width	HB	95th percentile of HPB + 2 cm	31.0 cm
Desk surface depth	EHG	50th percentile of EHG	38.0 cm

Source: Ismaila *et al*. (2015 [b])

The proposed dimensions of desk (Figure 6) and chair (Figure 8) are presented in Table 9.



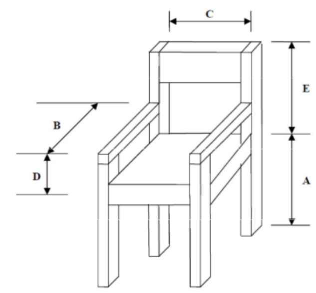


Figure 6: The proposed desk Figure 87 The proposed chair
Source: Ismaila *et al*. (2015 [b])
A, B, C, D, E, F, G and H are as defined in Table 8.

Table 8: Comparison Between the Dimensions of Existing Furniture and the Recommended Dimensions (cm)

Features	Pupil Furniture (5-8 years)	Pupil Furniture (9-12 years)	Pupil Furniture (13-14 years)	Existing Furniture
Seat surface height (A)	32.0 cm	37.3 cm	40.3 cm	35 cm
Seat surface depth (B)	33.0 cm	38.0 cm	41.0 cm	31 cm
Seat surface width (C)	30.0 cm	31.0 cm	31.0 cm	90 cm
Armrest height (D)	12.0 cm	13.0 cm	15.0 cm	-
Upper seat back rest height (E)	39.0 cm	43.0 cm	44.0 cm	38 cm
Desk surface height (F)	42.0 cm	49.0 cm	53.3 cm	62 cm
Desk surface width (G)	30.0 cm	31.0 cm	31.0 cm	90 cm
Desk surface depth (H)	34.0 cm	36.0 cm	38.0 cm	28 cm

Source: Ismaila *et al*. (2015[b])

2.2.4 Ergo-Analysis of school furniture in use by secondary school students in Southwestern Nigeria

Musculoskeletal discomfort and low back pain among school students have been traced to the mismatch between the school furniture and the anthropometric dimensions of the students (Parcells *et al*., 1999; Lin and Kang 2000). Ismaila *et al*. (2010[a]) noted that there exists a mismatch between the anthropometric dimensions of primary school pupils and the furniture they use. For proper ergonomic design of secondary school furniture, anthropometric data for Nigerian secondary school students are necessary and seem not reported.

Mr. Vice Chancellor, Ismaila *et al*. (2011) gathered the anthropometric data necessary for the design of secondary school furniture as well as compare the data with that of the school furniture presently in use by these students. A total of 480 students were randomly selected from eight public secondary schools and eight private secondary schools that were also randomly selected from the secondary schools in Ibadan, Southwestern Nigeria. Their ages range from 10 to 18 years (n = 480, SD = 2.3 years) for all the schools under study. The anthropometric data were collected on the basis of age rather than levels in schools and gender since the schools were co-educational. In the study, only Nigerians in the schools were considered irrespective of tribes. The data obtained from the public-school students were compared with those of the private school using the Paired Samples T-test (2-tailed) on SPSS 16.0.

The summary of the anthropometric dimensions in terms of means, standard deviations, 5th, 50th, and 95th percentiles are presented in Table 9 for the students in public and private schools.

Table 9: Anthropometric Data of Public and Private Secondary Students in cm

	Minimum		Maximum		5th Percentile		50th Percentile		95th Percen-tile		Standard Deviation		Mean	
	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr	Pu	Pr
Age (Years)	11	10	18	17	11	10	14.5	13.5	18	17	2.3	2.3	14.5	13.5
Stature	115.2	129.3	195.1	195.1	122.7	139.8	151	159.7	175.1	176.3	15.7	11.5	151.8	158.3
PH	27.8	30.6	48.4	44.8	28.6	38.0	39.5	40.2	41.7	42.1	3.8	1.8	38.0	40.0
SH	70	73.4	85	87.1	72.8	75.0	77.3	80.3	83.7	85.0	3.5	3.5	77.5	80.1
KH	37.3	41.6	61.0	59.5	40.0	49.3	53.0	53.3	56.5	55.9	5.1	2.4	51.3	53.0
EEB	24.1	28.7	90.1	90.1	26.1	29.3	39.1	36.8	50.1	43.2	8.1	6.1	38.1	36.1
SHS	25.8	35.0	55.1	56.5	30.1	43.3	44.1	47.9	54.3	55.0	7.1	4.0	43.5	48.4
ESH	12.8	13.5	25.3	18.7	13.5	15.0	16.0	16.5	18.0	17.9	1.4	0.9	15.9	16.6
BKL	33.9	43.2	62.8	61.9	35.9	46.8	48.0	54.6	59.8	58.0	6.8	3.4	48.7	53.4
BPL	33.2	36.0	60.3	50.1	35.1	36.9	43.8	44.0	56.1	47.3	6.5	3.0	43.8	43.2
FAR	39.8	42.1	63.4	61.0	43.3	49.6	52.8	54.8	59.0	58.8	4.6	3.2	52.2	54.3
TCH	8.9	10.0	18.0	18.0	9.9	11.3	13.0	13.7	16.3	16.1	2.0	1.4	13.0	13.7
EHL	26.4	21.2	42.0	40.1	28.2	30.7	32.1	34.0	40.0	38.6	3.2	3.0	32.7	34.4
HB	18.7	18.7	44.3	39.8	21.0	23.2	26.7	26.7	39.8	34.5	5.6	3.7	28.2	27.6
BB	26.2	29.7	46.7	49.2	27.3	30.7	38.1	38.1	44.7	44.8	5.9	5.2	36.6	37.2

Legend
Pu-Public School Students
Pr-Private School Students

Source: Ismaila *et al*. (2011)

The data for the public school students were statistically compared with those of the private schools and it showed that all the measured dimensions were not significantly different except Buttock-Popliteal Length and Hip Breadth. Table 10 presents the anthropometric data for all the students.

Table 10: Anthropometric Data for all Students (cm)

Parameter	Minimum	Maximum	5th percent-tile	50th percent-tile	95th percen-tile	Stan-dard devia-tion	Mean
Age (years)	10	18	10	14	18	2.3	14
Stature	1115.2	195.1	130.1	158.0	175.3	14.1	155.0
PH	27.8	48.4	30.2	39.8	41.9	3.2	39.1
SH	70.0	87.1	73.2	79.1	84.3	3.7	78.8
KH	37.3	61.0	41.7	53.2	56.5	4.1	52.2
EEB	24.1	90.1	28.0	38.1	48.6	7.3	37.1
SHS	25.8	56.5	31.0	47.0	54.8	6.2	46.0
ESH	12.8	25.3	13.8	16.3	18.0	1.3	16.2
BKL	33.9	62.8	42.2	53.7	58.1	5.9	51.0
BPL	33.2	60.3	36.1	44.0	54.3	5.1	43.5
FAR	39.8	63.4	44.5	53.8	59.0	4.1	53.3
TCH	8.9	18.0	10.1	13.5	16.3	1.8	13.4
EHL	21.2	42.0	29.0	32.7	39.6	3.2	33.6
HB	18.7	44.3	22.1	26.7	37.0	4.7	27.9
BB	26.2	49.2	28.8	38.1	44.8	5.6	36.9

Legend: PH-Popliteal height; SH-Sitting height; EEB-Elbow-elbow breadth; KH-Knee height; SHS-Shoulder height (sitting); ESH-Elbow sitting height; BKL-Buttock-knee length; BPL-Buttock-popliteal length; FAR-Functional arm reach; TCH-Thigh clearance height (Sitting); EHL-Elbow-hand length; HB-Hip breadth (Sitting); BB-Biacromial breadth
Source: Ismaila *et al*. (2011)

Table 11 presents the dimensions of existing furniture in the schools.

Table 11: Dimensions of Existing Furniture (cm)

Type of furniture	Seat height	Seat depth	Seat width	Back rest height	Desk height	Desk depth	Desk width
1	42	30	91	31	72	28	91
2	46	32	91	31	71	30	91
3	40	37	120	31	76	44	120
4	41	37	120	23	76	39	120

Source: Ismaila *et al*. (2011)

The data in the study indicate that the seats are too high for the students which makes the underside of the thigh to become compressed causing discomfort and restriction in blood circulation and in order to compensate for this, a sitting person moves forward his buttocks on the seat making the body stability to be weakened (Zacharkow, 1988) and may result in low-back pain if the posture is prolonged (Chaffin and Anderson, 1991). Also, the seats are too shallow which may cause the user not only to have the sensation of falling off the front of the chair but may also result in a lack of support of the lower thighs (Panero and Zeinik, 1979). Moreover, the desks are too high for the users and may cause abduction of the arms, elevation of the shoulder and kyphosis of the neck causing fatigue in the shoulder and neck muscles (Chaffin and Anderson, 1991). The anthropometric characteristics of the users are essential for the accomplishment of various tasks safely and economically. If mismatches exist between the human anthropometric data and equipment, tools and furniture, it may result in 'decreased productivity, discomfort, accidents, biomechanical stresses, fatigue, injuries, and cumulative traumas' (Mandahawi *et al*., 2008).

It may therefore not be a surprise if a higher percentage of the students complain of neck and lower back pain. It thus means that the anthropometric data of the Nigerian students were not used in the design and manufacture of school furniture used in those schools. To ensure a proper match between the school furniture and the anthropometric data of the students, it may be essential to use their data for the construction of the school furniture.

Designers to get approximate dimensions for designing items have often used standing height (Kothiyal and Tettey, 2001). Standing height is required for determining basic energy requirements, standardizing measures of physical capacity and adjusting the use of drugs (Mohanty *et al*., 2001). Standing height is one of the most available and easy-to-measure anthropometric dimensions. Models based on standing height to estimate other anthropometric dimensions would therefore be most appropriate. Two approaches to determine a specific dimension are to measure the standing height and then multiply with a given ratio (Chao and Wang, 2010) and the use of linear regressions (Robinette and McConville, 1981). The anthropometric regression models have been used in the development of ergonomic designs of various products and workstations. Ismaila *et al*. (2014) proposed 11 models using standing height to estimate necessary anthropometric dimensions for the design of school furniture. The results of the study showed that all anthropometric dimensions correlate more non-linearly with standing height than linearly. The proposed models will have wide applications for the estimation of anthropometric data necessary for the design and construction of school furniture for use in secondary schools in Southwestern Nigeria.

2.2.5 Ergo-Evaluation of urban bus driver's workstations in Southwest Nigeria

The focus of the ergonomics approach is the interaction between humans and other elements of a system and therefore the workstation so as to enhance efficiency, safety, and human well-being (Marras and Karwowski, 2006).

Driving postures employed by bus drivers should also take into consideration musculoskeletal and biomechanical factors, and make sure that all driving tasks are conducted within a comfortable reach range. The posture of the seated person depends on the planning of the seat itself, individual sitting habits and therefore the work to be performed.

Ajayeoba and Adekoya (2010) noted that little work has been done in the area of functional design relationships which are significantly useful in the bus operator workstation. Ismaila *et al*. (2021) evaluated the ergonomic performance of drivers' workstations in Southwest Nigeria. In this study, 30 anthropometric variables of 150 professional male drivers, randomly selected from seven urban centers (Abeokuta, Ilaro, Sagamu, Ijebu-ode, Oshodi, Yaba, Ibadan and Oyo) in three states (Lagos, Ogun and Oyo) in Southwest Nigeria were collected.

Similarly, 50 urban buses in two categories were considered. Category 'A' comprises of 6 common brands of urban minibuses with various capacities (MITSUBISHI – 10 seaters and 14 seaters, TOYOTA-COASTER – 30 seaters, MAZDA – 10seaters, HONDA – ODDYSEY 10-seater and NISSAN – URVAN 14 – seaters). Category 'B' consists of 4 common brands of midibuses (FOTON – 42 seaters, ASHOK – 42 seaters, TATA – 42 seaters and COMIL – 54 seaters). Measurement of the workstation parameters and the seat dimensions in all selected buses were done. Vertical and horizontal distances of the seat reference point to the pedal and steering wheel, with the seat dimensions were considered.

Table 12 presents the comparisons of drivers' seats structural dimensions for categories 'A' and 'B' and the suggested values.

Table 12: Comparisons of Drivers' Seats Structural Dimensions for Categories 'A' and 'B' and the current Study Values

S/N	SEAT PARAMETER	CATEGORY A (cm)	CATEGORY B (cm)	Current study Value(cm)	Determinant
1	Floor to Seat height	25.5 -40.25	39.15 – 43	46 - 50	Popliteal height
2	Seatpan depth / length	49 - 50	41.5 – 50	49.95 – 50.00	Popliteal length
3	Seatpan (back) width	38 - 44	38 - 46.4	334.7-40.15	Hip width
5	Backrest width (low back level)	47 - 51.5	45.73 - 53.25	34.7-40.15	Hip width
6	Backrest width (shoulder level)	42.25 - 47.5	34.6 - 43.59	40 – 50	Shoulder width
7	Backrest height	50 - 57.25	38.75 - 49.4	53 -58.15	Shoulder height
8	Armrest length(Right Hand only)	30 (Honda only)	None	47 – 54	Elbow to wrist length
9	Armrest height(Right Hand only)	11 – 19	None	15.9-27,5	Shoulder to elbow
10	Armrest width(Right Hand only)	7 (Honda only)	None	8 – 12	Hand Width
11	Headrest height	16 – 35 (adjustable)	20.2 – 38	18.75 – 37	Shoulder to head
12	Headrest width	22 – 32	26.6 -29.7	13.89 – 16	Shoulder width

Source: Ismaila *et al*. (2021)

The results of the analysis showed that there were mismatches between the drivers' anthropometric data and the design measurements of the present driver seats as well as the locations of both hand and foot controls in the drivers' workstations. With reference to the main objective of this study, it could therefore be concluded that the drivers' workstations in the urban buses used in Southwest Nigeria were not ergonomically fit for the urban bus drivers.

It was concluded that the drivers' workstations in the urban buses were not ergonomically fit for the bus drivers since the anthropometric dimension of the Nigerian male bus drivers were not considered in the design of the buses. Ismaila *et al*. (2021), therefore, suggested that there was a need to design the seat of bus drivers using their anthropometric data.

2.2.6 Development of mathematical models for effective placement of steering wheel and pedals in the bus drivers' workstations

The ergonomic design of a driver's workstation is a necessary component of drivers' safety and health protection. It was discovered that the majority of the drivers of public transport suffer a great deal of musculoskeletal disorders especially back and shoulder pains with attendant absenteeism. Mr. Vice Chancellor, Ismaila *et al*. (2022[a]) developed mathematical models for the design of bus drivers' workstations in Nigeria. Fifty urban buses selected from 10 brands were investigated by direct measurement. The buses were brands of urban small buses with various capacities and common brands of luxury buses categorized as A and B. Vertical and horizontal distances of the seat reference point to the pedal and steering wheel with the seat dimensions were considered. Anthropometric dimensions of 150 male urban bus drivers were taken from Southwest Nigeria. Data collected were analyzed using descriptive statistics. Four models were derived using a typical link-joint biomechanical line.

Figure 7 shows a typical link-joint biomechanical model of a seated bus driver using the seat reference point.

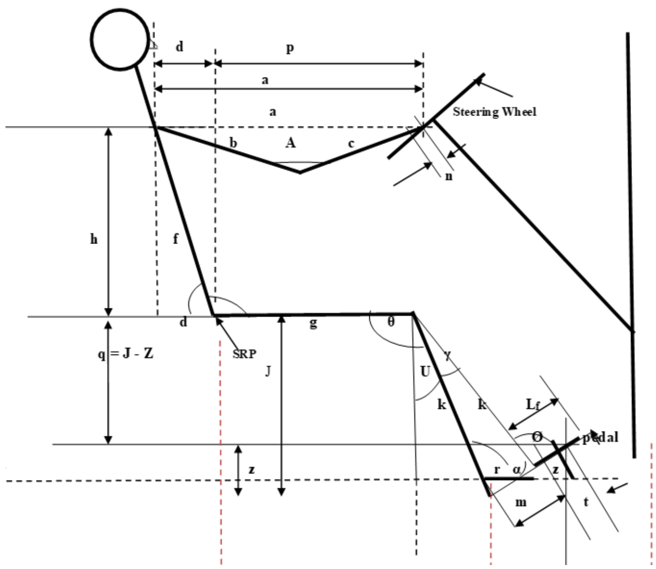


Figure 7: Typical link-joint biomechanical model of seated urban bus driver
Legend: p = Horizontal Distance of Steering Wheel (SW_H); h = Vertical Distance of Steering Wheel (SW_V)); w = Horizontal Distance of Foot Pedal (FP_H); q = Vertical Distance of Foot Pedal (FP_V)
Source: Ismaila *et al*. (2022[a])

The horizontal Distance of Steering Wheel from SRP,

$$SW_H = [(Lse)^2 + (Lew + 0.5Lh)^2 - 2(Lse)(lew + 0.5Lh)cosA]^{\frac{1}{2}} - [Lsb \times Cos(180 - Q)]$$

Vertical Distance of steering wheel from SRP,

$$SW_V = LsbSin(180 - Q)$$

Vertical Distance of Foot Pedal from SRP,

$$FP_V = LphCos(\theta - 90) - \left[\frac{LphSin(2\emptyset - 180)}{Sin(180 - \emptyset)} + 0.75Lf\right] Sin[\theta - (180 - \emptyset]$$

Horizontal Distance of Foot Pedal from SRP,

$$FP_H = Lbp + LphSin(\theta - 90) + \left[\frac{LphSin(2\emptyset - 180)}{Sin(180 - \emptyset)} + 0.75Lf\right] Cos[\theta - (180 - \emptyset]$$

Lse = $Shoulder\ to\ Elbow\ Length$; Lew = $Elbow\ to\ Wrist\ Length$; ; Lh = $Hand\ Length$; Lf = $Foot\ Length$; Lsb = $ShoulderHeight$; n = Half of hand Length; Q = $Back\ Angle$ ($with\ the\ thigh$); Lbp = $Length\ of\ Buttock\ to\ Popliteal$; k= Popliteal Height; θ = $Popliteal\ Angle$ ($with\ foot\ on\ the\ floor$); Ø = $Foot/Ankle\ angle$ ($with\ Foot\ on\ pedal$); Lse = $Shoulder\ to\ Elbow\ Length$; Lew = $Elbow\ to\ Wrist\ Length$; Lph = $Length\ of\ Popliteal\ to\ Hee$l

Figures 8 and 9 present the recommended placements of the steering wheel and seat for the mini buses and midi buses respectively.

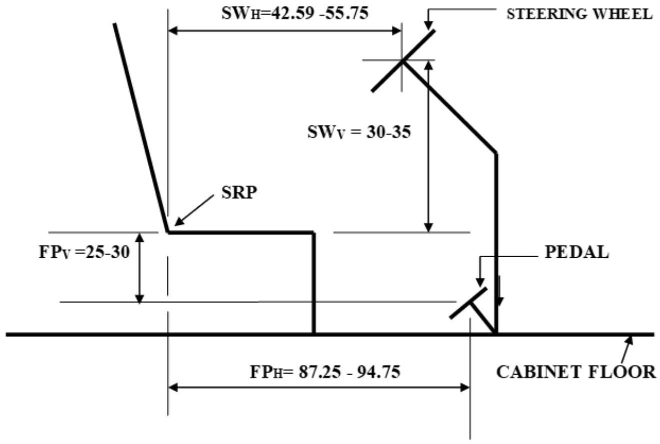


Figure 8: Placements of the Steering Wheel and Pedal in the Mini Buses
Source: Ismaila *et al*. (2022[a])

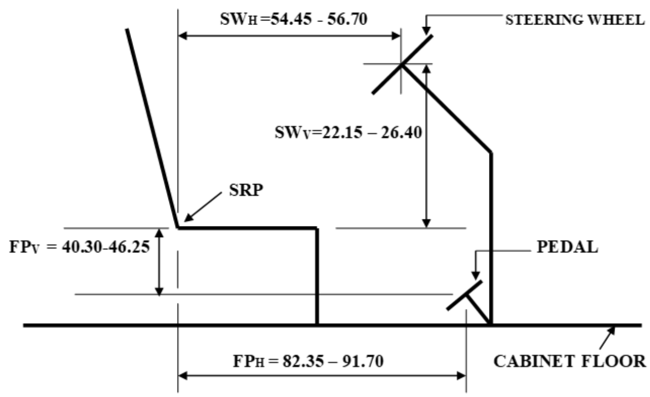


Figure 9: Placements of the Steering Wheel and Pedal in the Large Buses
Source: Ismaila *et al*. (2022[a])

The values obtained using the models for both horizontal and vertical distances of the steering wheel were 92.59-55.75 cm and 30-35 cm and foot pedal from the seat reference point (SRP) 87.25-94.75 cm and 25-30 cm for A buses; while horizontal and vertical distances of the steering wheel for B buses were 54.45-56.70 cm and 54.45-56.70 cm and foot pedal from the SRP were 82.35-91.70 cm and 40.30-46.25 cm, respective1y.

The determination of the appropriate placement of the steering wheels and foot pedals was achieved by the derivation of four different mathematical models. Conclusively, this study had adequately made provisions for ergonomic drivers' seats and appropriate placement of the steering wheels and pedals in the urban buses to be ergonomically suitable for the Nigerian drivers.

2.2.7 Anthropometric seat design for bus drivers in Southwestern Nigeria

Anthropometric measurements vary according to ethnicity, gender, age, race, occupation and patterns of nutrition (Ismaila, 2009; Spasojević-Brkić *et al*., 2014). Hence, anthropometry is needed in developing specific standards and requirements associated with manufactured goods and services to ensure the usability and suitability of products for the user population (Okunribido *et al*., 2007). Also, the safe and economical accomplishment of various tasks depends on the users' anthropometric characteristics (Ismaila *et al*., 2013).

Mr. Vice Chancellor, Ismaila *et al*. (2010[a]) reported one of the earliest ergonomic assessments of vehicle seats in Nigeria. The study obtained the anthropometric data of bus users to determine a possible mismatch between their relevant dimensions and bus seats.

Most buses used in Nigeria are imported; thus, the anthropometric dimensions of the citizens of the country of manufacture were used for the seat design. Poorly designed seats due to a mismatch in anthropometric measurements may lead to musculoskeletal disorders. Hence, there is a need to design an appropriate seat for particular bus drivers. Ismaila *et al*. (2022[b]) obtained the needed anthropometric dimensions of Nigerian bus drivers and designed an appropriate driver's seat based on the collected dimensions. Relevant anthropometric variables necessary for the driver's seat design were obtained from 150 randomly selected male bus drivers from seven towns in Ogun, Oyo and Lagos states. Seat dimensions of 50 urban buses in heavy and medium automobile categories were considered. The means, standard deviations and 5th, 50th and 95th percentiles were calculated. The existing seat dimensions (Figure 10) were compared with the required anthropometric measurements of the drivers for the seat design. Figure 11 shows the measured driver's anthropometric variables while Table 13 compares the existing seat dimensions with the recommended ones. Figure 12 shows the proposed seat design for Nigerian drivers.

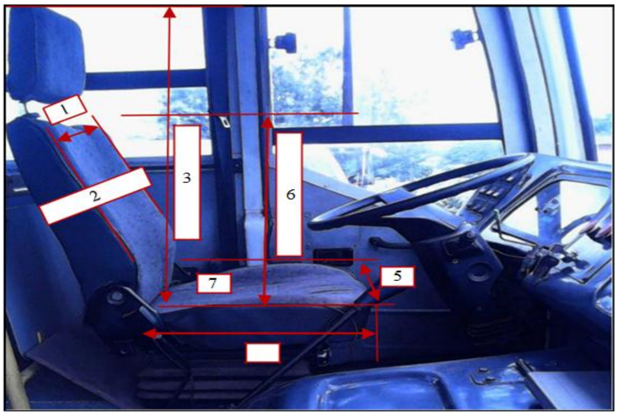


Figure 10: Measured seat variables

Legend: 1 – backrest width (shoulder); 2 – backrest width (lumbar); 3 – seat height; 4 – seat depth; 5 – seat front width; 6 – seat back height; 7 – seat back width

Source: Ismaila *et al*. (2022[b])

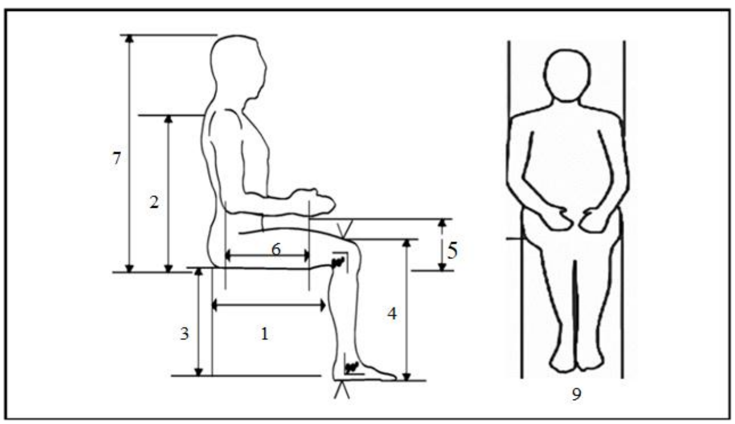


Figure 11: Measured driver's anthropometric variables (adapted from Ismaila *et al*., 2015[b])

Legend: 1 – buttock-popliteal length; 2 – sitting shoulder height; 3 – popliteal height; 4 – knee height; 5 – elbow rest height; 6 – elbow-hand grip; 7 – sitting height; 8 – shoulder width; 9 – hip breadth

Table 13: Comparison of the existing seat dimensions and the recommended ones

Anthropometric variable	Heavy automobile	Medium automobile	Proposed dimensions
Seat height (cm)	39.00-43.00	27.00-35.00	46. 45-50.45
Seat depth (cm)	40.00-50.00	49.00-50.00	39.00-48.26
Seat front width (cm)	47.00-50.00	50.00	46.83
Seat back width (cm)	38.00-47.00	38.00-44.00	46.83
Backrest width (lumbar)(cm)	34.00-43.89	47.00-52.00	46.83
Backrest width (shoulder) (cm)	46.00-54.00	42.00-48.00	48.95-57.85
Backrest height (cm)	43.00-50.00	54.00-55.00	53.00
Seat backrest angle			90°-130°

Source: Ismaila *et al*. (2022[b])

Mr. Vice Chancellor, Ismaila *et al*. (2022 [b]) found that the existing bus seats in Nigeria were not compatible with the necessary anthropometric dimensions of the Nigerian drivers, which may force the drivers to adopt an uncomfortable posture that will consequently put them at risk of musculoskeletal disorders. It was also revealed that there were significant differences between the recommended and current dimensions of seat height and depth. Finally, the study proposed a design of an appropriate seat for the target population using the obtained anthropometric data. The design can be used for fabricating their seats to reduce the associated disorders.

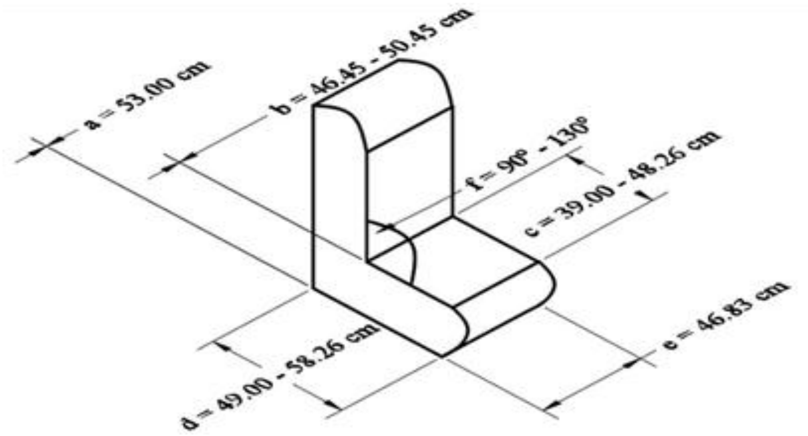


Figure 12: Proposed seat design for Nigerian drivers backrest height (a); seat height (b); seat depth (c); backrest depth (d); seat front width (e); and seat backrest angle (f)
Source: Ismaila *et al*. (2022[b])

2.3 Ergonomic Evaluation and Assessment

Ergonomic evaluation and assessment refer to the process of analyzing and improving the design of workspaces, tools, and tasks to ensure they fit the needs and capabilities of individuals, promoting health, safety, and productivity. The process encompasses various methods and considerations to create workspaces that align with the physical and cognitive capabilities of individuals.

2.3.1 Ergonomic evaluation of packaging workers' posture in a food manufacturing company

One of the main factors influencing workload is working posture while work-related musculoskeletal disorders lead to substantial economic losses to individuals and the community. There are currently many methods of assessing the working postures and workload; these include the Ovako Working Posture Analyzing System (OWAS), the Rapid Upper Limb Assessment (RULA), the Rapid Entire Body Assessment (REBA) and the Postural Loading on the Upper Body Assessment (LUBA). RULA is an effective method for assessing the risk level of a job which consists of moving the upper limbs, like the hands, arms, shoulders, neck, and back (McAtamney *et al*., 1993). It evaluates the ergonomic risk factors by observing the posture of employees while they are working at their workstation directly and does not require special or pre-existing equipment.

Mr. Vice Chancellor, Ismaila *et al*. (2020[a]) conducted an ergonomic evaluation of the working posture of workers engaged in various processes in the packaging section of a food manufacturing company using RULA. Codes were developed using Microsoft Visual Basic 6.0 to aid and fast-track the whole data assessment process and compare the individual final score of each subject with the RULA Standard.

Figure 13 presents the RULA score with assessed body parts and final score while Table 14 presents description of ergonomic risk level, the number of subjects in percentage, and risk level of workers at the packaging section in a food manufacturing company. The workers were exposed to various degrees of ergonomic risk levels depending on the section. Workers at the Palletizing section, which constitute 10.0% of the workforce, experienced very high ergonomic risk levels (grand score of 7) and thus were required to be investigated with the request for immediate change in their work condition. Twenty five percent of the workforce were engaged with folding activities and experienced medium ergonomic risk levels (grand score of 4) that required them to be placed only under investigation.

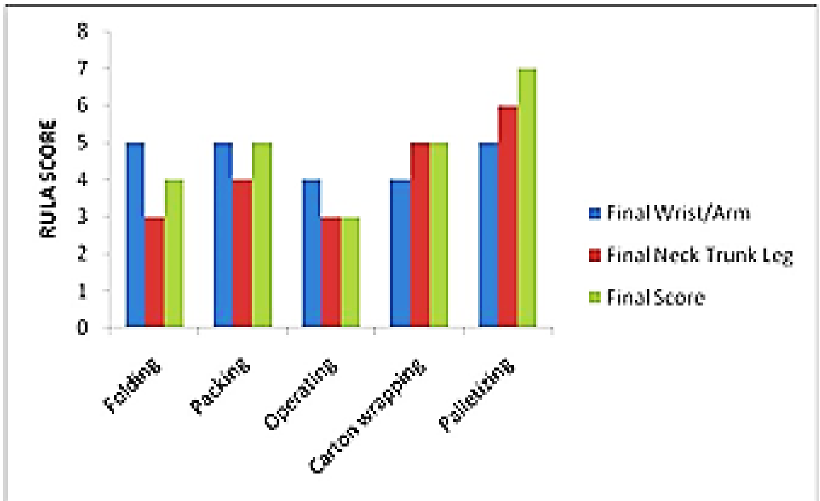


Figure 13: RULA Score with Assessed Body Parts and Final Score
Source: Ismaila *et al*. (2020[a])

Table 14: Percentage Description of Ergonomic Risk Level

Activity	Final score	Number of subjects	Percentage of subjects	Remark	Ergonomic risk level
Operating	3	10	25	Investigate further	Medium
Folding	4	10	25	Investigate further	Medium
Packing	5	12	30	Investigate further and change soon	High
Carton wrapping	5	4	10	Investigate further and change soon	High
Palletizing	7	4	10	Investigate and change immediately	Very High
Total		40	100		

Source: Ismaila *et al*. (2020[a])

Four subjects that were involved in carton wrapping activities which constitute 10% of the workforce under review experienced high ergonomic risk levels (grand score of 5) and thus were required to be investigated with change request soon in the work condition because this process subjected the workers to the ulnar deviation of approximately twelve degrees on the wrist and a forward flexion of fifteen degrees on the neck and spine.

According to RULA method, the awkward postures adopted by the workers in the food manufacturing company has been categorized as having medium to very high-risk level. Operating and Folding workers were at medium risk of musculoskeletal disorder, while Packing and Carton wrapping workers were at high risk of musculoskeletal disorder and Palletizing workers were at very high risk of musculoskeletal disorders. Hence, ergonomic interventions are required in this section. Proper training of workers and awareness may reduce the risk of musculoskeletal disorders.

2.3.2 Ergonomic risk assessment of maintenance Job

Ergonomics risk factors are factors that bring about the risk of musculoskeletal injuries which are found in jobs requiring repetitive, forceful, or prolonged exertions of the hands: frequent or heavy lifting, pushing, pulling, or carrying of heavy objects; and prolonged awkward postures. Risk assessment is the careful examination and evaluation of what could cause harm to life and properties so as to come up with precautions that will arrest the menace. Methods have been developed to assess the risk involved in jobs. These methods either address the task (Revised NIOSH) or the worker (RULA, REBA, OWAS, etc.). There is, therefore, the need to develop a risk assessment model that will combine task factors, workers' characteristics and environmental factors.

Mr. Vice Chancellor, Ismaila *et al.* (2020[b]) developed a work severity risk index for the maintenance activities in a power generation plant. From this study, the analysis and evaluation of ergonomics risk assessment in jobs are divided into four stages:

Stage 1: Dividing Jobs into units

The maintenance jobs in the power plant were examined and classified into six units, with mechanical, electrical and general work given attention in each of the units.

Stage 2: Identifying Ergonomics Risk Factors in each of the units

This stage makes use of questionnaires, checklists, physical inspections, workers' interviews and records checking for near misses, accidents and musculoskeletal injuries in identifying inherent hazards and risks in the power station.

The musculoskeletal injury factors that could contribute to the risk for each of those jobs were divided into job or task factors (Factor A), personnel or personal factors (Factor B) and environmental factors (Factor C).

Each of the factors has components or parameters that are responsible for the power plant maintenance ergonomics problems. Specifically, it was difficult to fit or match the worker with the job.

Stage 3: Assigning Values to Ergonomics Risk Factors

These are the assessment of all the possible risk factors that have been identified in stage 2 based on the extent of exposure to magnitude (how much), duration (how long), and frequency (how often, how fast) and concerning each of the maintenance units. The assessment was done based on the potential severity of impact (generally a negative impact, such as damage or loss of loss life) and the probability of occurrence.

Stage 4: Computation of Risk Index

Risk Index is the Rate (or probability) of occurrence multiplied by the impact of the event and is expressed as:

Risk Index = Impact of Risk event × Probability of Occurrence, or
Risk Index = Severity/Consequence × Rate of Occurrence/ Likelihood of event.

The impact of the risk event could be called the severity or consequences of the event and is assessed on a scale of 1 to 5, where 1 and 5 represent the minimum and maximum possible impact of an occurrence of a risk, respectively.

The probability of occurrence is likewise assessed on a scale from 1 to 5, where 1 represents a very low probability of the risk event occurring while 5 represents a very high probability of occurrence. These axes are expressed in mathematical terms and the Risk Index ranging from 1 through 25 was divided into three sub-ranges of 1- 8, 9-15 and 16-25 representing Low, Medium and high values respectively.

$$Work\ Severity\ Index\ (WSI) = 0.24 \times TRI_{personal\ facor} + 0.22 \times TRI_{environmental\ factor} + 0.54 \times TRI_{task\ factor}$$

Table 15 shows the obtained parameters from the assessed workers while Table 16 presents the categorization of work severity index. Table 17 presents the work severity indices for the assessed workers

Table 15: The Parameters Obtained from the Assessed Workers

Subject	Duration (hours)	Age (year)	Weight (kg)	Height (m)	Body mass (Kgm^{-2})	Experience (year)	Designation
1	9	49	70	1.77	22.35	20	Technologist
2	9	32	76	1.62	28.96	6	Field Engineer
3	9	30	80	1.77	25.54	4	Field Engineer
4	9	44	65	1.58	26.04	16	Engineer (Mech.)
5	9	48	64	1.57	25.96	22	Engineer (Elect.)
6	9	60	65	1.60	25.39	30	Engineer (Project)
7	9	33	77	1.75	25.14	5	Field Engineer

8	9	29	74	1.78	23.35	3	Field Engineer
9	9	31	66	1.57	26.77	4	Field Engineer
10	9	28	76	1.66	27.57	1	Trainee Engineer

Source: Ismaila *et al*. (2020[b])

Table 16: Categorization of Work Severity Index

Risk score	**Categorization of Work Severity Index**
1-8	Low risk
9-15	Medium risk
16-25	High risk

Source: Ismaila *et al*. (2020[b])

Table 17: Work Severity Indices for the Assessed Workers

Subject	**Total Risk Index for personal factor ($\mathbf{TRI_{personal\ factor}}$)**	**Total Risk Index For environmental factor ($\mathbf{TRI_{environmental\ factor}}$)**	**Total Risk Index for task factor ($\mathbf{TRI_{task\ factor}}$)**	**Work Severity Index (WSI)**
1	2.24	3	1.47	1.99
2	3.07	3	7.76	5.59
3	3.42	3	5.91	4.67
4	2.62	3	5.54	4.28
5	2.55	3	2.21	2.47
6	2.86	3	8.4	5.88
7	3.45	3	8.4	6.02
8	3.14	3	8.4	5.95
9	3.45	3	8.4	6.02
10	3.45	3	11.05	7.46
Mean	3.03	3	6.75	5.03
Standard deviation	0.42	0	2.85	1.62

Source: Ismaila *et al*. (2020[b])

Task and personal factors generated high musculoskeletal injury for workers during maintenance job due to their increased total risk score and their relative weight. Therefore, this risk assessment technique may reduce the possibility of lost time injury, medical injury, first aid injury and fatality. It may maximize resources and uphold best practices of safety management in industries. However, the assessed risk parameters for environmental and organizational factors were minor and they will rarely cause musculoskeletal injuries because their estimated risk score and relative weight were below 0.5. This means that the company has little to spend on injuries caused by these two factors during manual job handling. The implication of these results is that control measures are required for those factors of relative weight above 0.50. The modified and developed risk assessment worksheet covers virtually the entire maintenance job of a typical Otto engine; therefore, the worksheet becomes relevant. Prioritizing the identified environmental, personal and task factors will necessitate proper proactive control measures that will mitigate the risk of musculoskeletal injuries during maintenance activities in a power station. The consequences of organizational factor in this research are extremely not felt, therefore further research is recommended in this direction so as to reveal possible impeding factors and parameters that could affect ergonomics of maintenance jobs in power stations.

2.4 Safety and Health

Safety and health refer to the measures and conditions that aim to protect individuals from harm and promote well-being in various environments, such as workplaces or public spaces. Environmental factors play a significant role in the decrements in pulmonary function and the development of respiratory diseases. The effect of respiratory protection on respiratory flow rates of vehicle spray painters and a model for the establishment of peak expiratory flow rate were developed.

2.4.1 Relationship between some anthropometric measurements and the peak expiratory flow rate of tobacco factory workers

Mr. Vice Chancellor, I was part of a team of researchers, Aiyedun *et al*. (2018), that established the relationship between some anthropometric measurements and the peak expiratory flow rate of tobacco factory workers. Peak expiratory flow rate (PEFR) according to Crapo (1994) is one of the pulmonary lung-function tests that provide a quantifiable measure of lungs. It is used to test and monitor diseases that affect the lung function, monitor the effects of the environment, occupational exposures, assess risks of surgery and in pre-employment evaluation or for insurance.

Eighty out of 302 male permanent workers that had been employed for at least three years with no history of cardiovascular diseases were involved in the study. Participants were informed a few days before the study commenced, and they were given adequate information. The consents of the participants were obtained before the start of the study. A modified British medical research council respiratory disease questionnaire (Lebowitz and Burrows, 1976) was administered to all subjects who were grouped into two classes of directly exposed and indirectly exposed. The directly exposed workers were those in all production departments: Primary Manufacturing Department (PMD), Secondary Manufacturing Department (SMD), Filter Rod and Maintenance Department.

The indirectly exposed workers were those in the Human Resources Department, Information Technology Department, Engineering, and Logistic and Supply Chain Department. The selection criteria were ages between 20 and 40 years, length of work in the tobacco factory of not less than three years (3 years), no smoking and no history of a pulmonary or cardiac disease. The measured anthropometric data (chest width and depth, height and weight) were analyzed using SPSS (V 16.0) to develop predictive models for PEFR of tobacco factory workers.

Table 18 presents the mean values of the anthropometric dimensions and PEFR of the workers according to their departments. It shows that workers in PMD are susceptible to the negative effects of tobacco dust inhalation with the highest percentage decrease in PEFR of 20.18%. This is followed by SMD (7.47%), information technology (4.46%), logistics and supply chain (4.01%), human resources (3.29%), engineering (3.27%), filter rod (2.96%) and maintenance (2.95%) departments.

Table18: Mean Values of Anthropometric Measures and Pre- and Post-PEFR of the Workers Based on Departments

Department	Age (years)	Height (cm)	Weight (kg)	Chest area (m^2)	Pre-shift PEFR (L/min)	Post-work PEFR (L/min)	% shift change
SMD	30.20	168.89	65.80	0.11	501.00	467	-7.47
PMD	32.30	168.10	64.60	0.13	480.00	406.00	-20.18
Filter Rod	32.10	168.99	65.50	0.14	495.00	481.00	-2.96
Maintenance	34.10	165.16	70.60	0.11	492.00	478.00	-2.95
Human Resources	32.90	170.66	70.50	0.11	514.00	498.00	-3.29
Information Technology	34.20	173.66	68.70	0.13	510.00	489.00	-4.46

Engineering	32.30	173.42	70.70	0.13	518.00	501.00	-3.27
Logistics and Supply Chain	32.70	168.58	70.30	0.12	509.00	490.40	-4.01

Source: Aiyedun *et al*. (2018)

When the data for the directly exposed were divided by the year of exposure (Ismaila *et al*., 2015), the model for predicting the PEFR improved with R^2 = 0.986. The improved model is stated in Equation 3.4.1b:

PEFRimproved directly exposed = 5.26 – 2.46 (age) + 3.28 (height) + 0.41 (weight) – 256.09 (chest area)

……..…3.4.1a

Equation 3.4.1a is the model to estimate PEFR of the indirectly exposed group with R^2 = 0.884.

PEFRindirectly exposed = 221.89 – 4.51 (age) + 2.49 (height) + 0.15 (weight) + 0.39 (year of exposure) – 71.32 (chest area)

……….3.4.1b

The confounding factors of age, gender, height, weight, chest area and length of exposure to determine PEFR for the tobacco workers were observed to be correlated with PEFR either positively or negatively. Years of exposure was not one of the best predictors of PEFR, though expected, probably because of the occasional use of personal protective equipment (PPE) during the operation and within the factory premises to reduce the effect of tobacco dust. Besides, some workers may be involved in other activities outside the factory, which might affect the PEFR. It is necessary to enforce the use of PPE to reduce workers' exposure to tobacco dust in the workplace.

The study showed that workers in a tobacco factory are exposed to tobacco dust irrespective of their department. The developed models could be used to determine the PEFR of workers in a tobacco manufacturing company.

2.4.2 Noise exposure as a factor in the increase of blood pressure of workers in a sack manufacturing industry

Workers in manufacturing industries are exposed to noise generated by the manufacturing processes that results in auditory and non-auditory effects on them. Mr. Vice Chancellor, Ismaila and Odusote (2014) conducted a study on the effect of exposure to noise on the blood pressure of workers in a sack manufacturing company as there is presently sparse literature on the subject in Nigeria.

Table 19 shows the descriptive statistics of the data obtained from the study. The values of the systolic blood pressure when the workers were off work (SBPO) were consistently lower than systolic blood pressure during the morning duty (SBPM) and systolic blood pressure during the night duty (SBPN) with p = 0.001. Table 21 shows a descriptive of the SBPO, SBPM and SBPN while Table 22 shows the ANOVA table for comparison between the means of SBPO, SBPM and SBPN. From Table 22, since the p-value (0.000) is less than 0.05; it means that there is sufficient evidence to conclude that at least one of the means of SBPO, SBPM and SBPN is different from the others. However, no significant differences were observed between the diastolic blood pressure of the workers during morning duty (DBPM) and night duty (DBPN). Similarly, there were no significant differences between the values of DBPM and the diastolic blood pressure of the workers when they were off work (DBPO).

Table 19: Descriptive Statistics for the Obtained Data

Parameters	N	Minimum	Maximum	Mean	Std. deviation
SBPM (mmHg)	62	100.00	152.00	121.6452	12.00286
SBPN (mmHg)	62	110.00	176.00	126.1774	12.14060
SBPO (mmHg)	62	100.00	142.00	117.4355	9.98790
DBPM (mmHg)	62	70.00	100.00	76.9194	6.03079
DBPN (mmHg)	62	63.00	100.00	77.9677	7.03846
DBPO (mmHg)	62	70.00	92.00	75.7097	5.54974
Duration at work (Years)	62	1.00	20.00	9.2419	5.37964
Noise (dB)	62	86	103	92.85	5.919
Age (Years)	62	18.00	48.00	31.6129	7.71703

SBPM = Systolic Blood Pressure during morning duty; SBPN = Systolic Blood Pressure during night duty; SBPO = Systolic Blood Pressure during off-duty; DBPM = Diastolic Blood Pressure during morning duty; DBPN = Diastolic Blood Pressure during night duty; DBPO = Diastolic Blood Pressure during off duty.
Source: Ismaila and Odusote (2014)

Table 20: Descriptive of SBPM, SBPN and SBPO

Para-meter	N	Mean	Std. deviation	Std. error	95% Confidence interval for Mean		Mini-mum	Maximum
					Lower bound	Upper bound		
SBPM	62	121.6452	12.0028	1.5243	118.5970	124.6933	100.00	152.00
SBPN	62	126.1774	12.1406	1.5418	123.0943	129.2606	110.00	176.00
SBPO	62	117.4355	9.9879	1.2684	114.8990	119.9719	100.00	142.00
Total	186	121.7527	11.9083	0.87316	120.0301	123.4753	100.00	176.00

SBPM = Systolic Blood Pressure during morning duty; SBPN = Systolic Blood Pressure during night duty; SBPO = Systolic Blood Pressure during off-duty
Source: Ismaila and Odusote (2014)

Table 21: ANOVA of SBPM, SBPN and SBPO

Criteria	**Sum of squares**	**Df**	**Mean square**	**F**	**Sig.**
Between groups	2370.140	2	1185.070	9.087	0.000
Within groups	23864.484	183	130.407		
Total	26234.624	185			

Source: Ismaila and Odusote (2014)

Figure 14 shows that the SBPN, SBPM and SBPO values decreased steadily from when the noise level was about 86 dBA until the noise level was about 89 dBA and increased steadily until the noise level was 91 dBA. Their values also decreased from 91 dBA until the noise level reached about 95 dBA before it increased until the maximum noise level in the factory was reached.

Figure 15 shows the relationship between the values of DBPM, DBPN and DBPO. The DBPM and DBPO values followed the same from when the noise level was about 85 dBA until it was about 90 dBA. However, while these values increased, those of DBPN decreased until the noise level was about 88 dBA before they increased.

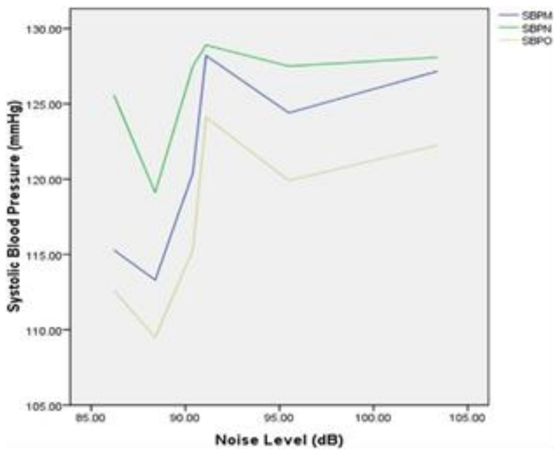


Figure 14: Relationship Between Noise Levels and Systolic Blood Pressure of the Participants

Source: Ismaila and Odusote (2014)

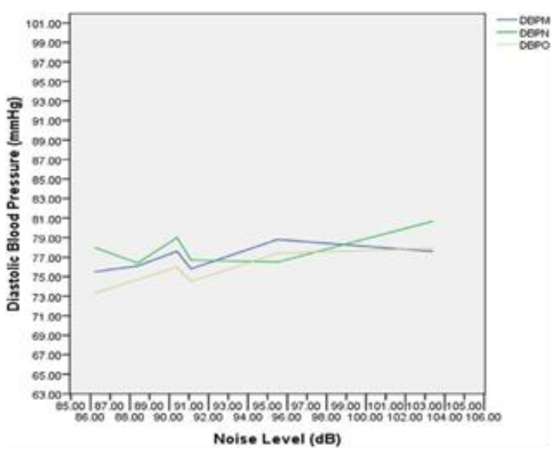


Figure 15: Relationship between noise levels and Diastolic Blood Pressure of the participants.

DBPM = Diastolic Blood Pressure in the Morning; DBPN = Diastolic Blood Pressure at Night; DBPO = Diastolic Blood Pressure during off-duty

Source: Ismaila and Odusote (2014)

Mr. Vice Chancellor, Ismaila and Odusote (2014) suggested that workers should not be exposed to more than 89 dBA as this had the least effect on the systolic blood pressures, though the diastolic blood pressures had least values at about 91 dBA. However, an experimental study conducted in the laboratory had found that workers' blood pressure increased after exposure to industrial noise levels greater than 95 dBA (Holand *et al*., 1999).

2.4.3 Cardiovascular strain of sawmill workers

Due to the high level of manual handling involved in sawmilling operations, the workers are exposed to higher levels of risk and high physical workload. Heart rate is commonly used to estimate energy expenditure or physical strain during sports, work or daily activities (Bot and Hollander, 2000). Mr. Vice Chancellor, Ismaila *et al*. (2013[b]) assessed cardiovascular strain during sawmilling operations in terms of physical workload, based on heart rate changes. The resting and working heart rates were measured and cardiovascular load (%CVL), cardiovascular strain (%CVS) and relative heart rate (%RHR) calculated for 35 sawmill workers.

%CVS was calculated with Equation 3.4.3:

$$\%CVS = \frac{(HRwork - HRrest)}{HRrest} \times 100\% \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.4.3$$

where $HRwork$ = mean working heart rate; $HRrest$ = resting heart rate. Astrand and Rodahl’s categories of work intensity were used to classify %CVS: light ($HRwork < 90$); moderate ($90 \leq HRwork < 110$); heavy ($110 \leq HRwork < 130$), very heavy ($130 \leq HRwork < 150$) and extremely heavy ($150 \leq HRwork < 170$).

Consequently, %CVS was classified as follows: 0% – 50% = acceptable, no action required; 51% – 80% = moderate, action required within a few months; 81% – 120% = high, action required within a few weeks; 121% – 150% = very high, action required within a few days and 151% – 180% = intolerable, action required immediately (Astrand and Rodahl, 1986).

Based on heart rate only, the works in sawmills were classified as very heavy and extremely heavy. Similarly, a high-level category was recorded for %CVL and a very high range for %CVS. Thus, the workload in sawmill operations is usually very high and can lead to physiological strain of the workers. There is a need to redesign the work content of this occupation to prevent excessive strain in the workers, as this will increase their productivity and reduce their health risks.

2.5 Special Assignments/Community Service

I have had the honour of holding various administrative, academic, and ad-hoc positions both locally and internationally, providing me with invaluable opportunities to make a positive impact on the community.

2.5.1 Administrative

Mr. Vice Chancellor, Sir, I have held various administrative and academic positions that have imparted academic excellence to both students and staff at this university. This includes, among others, the following: (a) Head of Unit (Mechanical), Works and Services Department, Federal University Agriculture, Abeokuta (June 2008–March 2010); (b) PG Coordinator, Department of Mechanical Engineering (May 2010–January 2011) (c) Deputy Dean, College of

Engineering, Federal University of Agriculture, Abeokuta (January 2011–February 2014) (d) Director, Federal University of Agriculture Bureau of Transportation, Federal University of Agriculture, Abeokuta (December 2015–June 2018).

Mr. Vice Chancellor, Sir, I was the Dean of the College of Engineering at this University between August 1, 2018 and July 31, 2021. This unique opportunity opened to me various gateways to educate the youth, improve their academic perception, and improve their preparedness for tomorrow.

2.5.2 Activity profile

Mr. Vice Chancellor, Sir, I have been a member of various committees at this university, among which are: (a) Member of Senate, January 2011–2014; October 2016–date (b) Member, Appointments and Promotions Committee for Academic Staff (July 2018 – date) (c) Member, Board of Survey (December 2018-date) (d) Chairman, 2nd College of Engineering International Conference, 2018. (e) Chairman, Technical Subcommittee, 1st College of Engineering International Conference, 2017 (f) Representative of the Senate on Physical Planning and Capital Works Committee, October 2012–2015 (g) Member of the Committee on the Review of the University Calendar, 2012 (h) Member of the Implementation Committee for COREN Accreditation of engineering programmes, 2012 (i) Member of the Special Committee on COREN accreditation of engineering programmes, 2012 (j) Member, Users Committee for the Construction of 2,500 Auditorium, 2011 (k) Representative of the College of Engineering on the Promotion Assessment Panel in Works and Services, 2010- 2014 (m) Member, College Board of the College of Food Science and Human Ecology, 2010-2012 (n) College of Engineering Representative on the Promotion Assessment Committee for Library, 2008 (o) Member, College of Engineering Committee on Study, Research, and Publication, 2009.

2.5.3 Community service and international engagement

Vice Chancellor, Sir, I was the Technical Secretary, Committee of Deans of Engineering and Technology in Nigerian Universities (CODET) (August 2018-2021) (b) Member, National Engineering Games Committee, Nigerian Society of Engineers, 2013 (c) President, Tai Estate House Owners' Association, Off Olorunsogo-Akanran Road, Idi-Osan Bus Stop, Ibadan (October 2011–2015) (e) Member, Membership Board of the Nigerian Society of Engineers, 2010 (f) Financial Secretary, Association of Professional Bodies of Nigeria, Oyo State Chapter, 2010–2012 (g) Member, Audit Committee of Nigerian Society of Engineers, 2009 (h) Council Member, Nigerian Society of Engineers, 2008–2009 (i) Chairman, Nigerian Society of Engineers (Ibadan Branch), 2008–2009 (j) Inspector, Engineering Regulation Monitoring, Ibadan Zone (2006-date) (k) Vice Chairman, Nigerian Society of Engineers (Ibadan Branch) 2006 to 2007 (l) Treasurer, Nigerian Society of Engineers (Ibadan Branch), 2004 to 2005 (m) Technical Secretary, Nigerian Society of Engineers (Ibadan Branch) for years the 2001, 2002, and 2003.

Mr. Vice Chancellor, Sir, I have also reviewed for many international and local journals, including but not limited to: (a) Theoretical Issues in Ergonomics Science, published by Taylor & Francis, UK. (b) Journal of Engineering, Design, and Technology, published by Emerald Group Publishing Limited, United Kingdom

(c) NSE (Nigerian Society of Engineers) Technical Transactions, Nigeria (d) Ergonomics, published by Taylor & Francis, United Kingdom (e) Journal of Engineering Science and Technology, published by the School of Engineering, Taylor's University, Malaysia (f) African Journal of Science, Technology, Innovation, and Development, published by Taylor and Francis, United Kingdom (g) ErgonomicsSA, published by the Ergonomics Society of South Africa (h) International Journal of Reliability and Safety, published by Inderscience Publishers, United Kingdom (i) Member of the Editorial Board of the International Journal of Engineering Research in Africa, published by TransTech Publications Inc., Switzerland.

I have also been an external examiner and assessor at the following universities: (a) University of Ibadan, Ibadan; (b) Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria; (c) Federal University, Oye Ekiti; (d) Federal University of Technology, Akure; (e) Federal University of Technology, Owerri; (f) Afe Babaolola University, Ado Ekiti.

Mr. Vice Chancellor, Sir, I have been a research proposal evaluator for the Research Grants Council, Hong Kong, China, since 2017 and was recently appointed as a Research Fellow, INTI International University, Malaysia. I have the opportunity to attend the European Safety and Reliability Conference at the Norwegian University of Science and Technology, Trondheim, Norway, between June 17 and 21, 2018. I was also at the International Conference on Industrial Engineering and Operations Management, Dubai, United Arab Emirates (UAE), from March 3–5, 2015.

2.5.4 Academic mentorship and guidance

I have been a major and minor supervisor in many undergraduate and postgraduate research pursuits. Most especially, Mr. Vice Chancellor, I have been privileged, in conjunction with Adesuyi O.E., Oyelami A. T., and Shittu T. A., to patent the development of a vertical yam-pounding machine with patent number NG/PT/NC/2022/6296 in Nigeria on August 8, 2022.

I have also been a major or co-supervisor of MSc and PhD dissertations and theses, respectively. I wish to inform you that one of the them is today a Professor of Mechatronics (Professor A. A. Adekunle, FUOYE) and another is a Chief Lecturer (DR. S.A. Odunlami, Federal Polytechnic, Ilaro). I serve as a mentor, offering valuable guidance to numerous students, alumni, and staff of this university and other institutions both within and outside Nigeria. My mentorship extends beyond the realm of mechanical engineering careers to encompass general academics, life experiences, and spiritual matters.

3.0 Conclusion

Mr. Vice-Chancellor Sir, distinguished ladies and gentlemen, I have attempted through this lecture to discuss the importance of adopting ergonomics principles in all areas of life. I have, thereby, showed that the applications of ergonomics make life pleasant, comfortable, exciting and cost effective. I also showed that it is important for heads of industries to adopt ergonomics principles to reduce the attendant costs associated with business-as-usual principles, in fact good ergonomics is good economics. There is a need for proactiveness in design of workplaces and tools by adopting ergonomics as this is the future of technology such that products will satisfy the customers and meet other regulatory requirements. It is essential that the principle of "Fitting the Job to the Person" rather than "Fitting the Person to the Job" must be adopted as God created man with capabilities and limitations and this fact must be recognised. You will agree with me that the transition from "Fitting the Person to the Job" to "Fitting the Job to the Person" is actually towards adopting human factors in the design of engineering facilities.

4.0 Recommendations

In the adoption of the principle of "Fitting the Job to the Person", and thus improve ergonomics practice in Nigeria, or any location, there is the need to implementing measures that optimize the design of workspaces, equipment, and processes to enhance the well-being and productivity of individuals. This involves a collaborative effort between the government, regulatory bodies, businesses, and other stakeholders.

In view of this, I hereby recommend as follows:

(i) There is a need to ensure that workstations are designed to support neutral postures. This includes proper desk and chair height, as well as appropriate placement of computer monitors and other equipment. Employers should provide adjustable furniture to accommodate the varying ergonomic needs of employees.

(ii) The teachers and head of schools should strictly follow the school timetable and advise the students or pupils appropriately such that only the required books are brought to school on daily basis. This will reduce the load that students bring to schools which is expected not to exceed 10.29% of body mass for males and 9.06% of body mass for females. By taking these steps, we can create a healthier and more ergonomic working environment across the country, leading to improved productivity, reduced healthcare costs, and enhanced overall well-being for the workforce.

(iii) Workers should be exposed to more than to more than 89 dBA to reduce their susceptibility to incidence of high blood pressure.

(iv) There is the need for training programs to educate workers and employers about the importance of ergonomics and proper workplace practices. The training should include the correct use of furniture, tools, and equipment to prevent musculo-skeletal disorders.

(v) Integrate ergonomic considerations into existing occupational health and safety policies. Ensure that businesses are required to conduct regular ergonomic assessments and address identified issues. Involve employees in the assessment process to gather feedback and insights on their ergonomic needs.

(vi) An anthropometric data bank serves various purposes across different industries and fields. It is essential for tailoring designs, products, and services to the unique characteristics of the human body. It contributes to improved functionality, comfort, and safety across various industries, promoting inclusivity and addressing the diverse needs of the population.

(vii) Encourage regular breaks and stretching exercises to prevent prolonged periods of sitting and reduce the risk of musculoskeletal issues. The habit of sitting in a meeting for four hours without a break is not healthy and should be discouraged.

(viii) Introduce basic ergonomic principles in educational curricula to instill awareness and good habits from an early age. Educate students on the importance of posture, healthy work habits, and the risks associated with poor ergonomics.

(ix) The government should create a department in the National Productivity Center to promote and oversee ergonomic practices. The department will also establish and enforce ergonomic standards for various industries. There should be support for research and initiatives focused on improving ergonomic practices and providing ergonomic solutions.

5. Acknowledgements

Mr. Vice Chancellor Sir, I give thanks to Allah for His infinite mercies on me; my being alive today is due to this. I could have died on August 4, 1989, when I was involved in a traffic accident that affected my left eye and right leg. I thank Him for his favour, mercy, grace, love, protection and provisions that have sustained me till date. He is to be praised for making me ‘somebody’ from ‘nobody’. Alhadulillah!!!

I appreciate all the former Vice Chancellors of this university that I interacted or worked with. Prof. I. Adamson, who employed me in January 2007 on a temporary appointment that was regularised during the tenure of Prof. O. O. Balogun. I later worked under Prof. O. O. Balogun as Head (Mechanical Unit), Works and Services. Prof. O.B. Oyewole appointed me as a Director of FUNAABOT., Professor O. A. Enikuomehin, who announced my professorship and gave me and my team at FUNAABOT letters of commendation, Professor F. K. Salako, and the current Vice Chancellor, Professor O. B. Kehinde. I thank you so much, sirs.

I wish to thank the Deputy Vice-Chancellor (Academic), Prof. Olukayode D. Akinyemi, Deputy Vice-Chancellor (Development), Prof. Kolawole Adebayo, the Ag. University Registrar, Mrs. Oluwatoyin Dawodu, the Ag. Bursar, Mr. Olukayode Osinuga and, the University Librarian, Dr Abayomi Owolabi for their support. I also thank all past Deputy Vice Chancellors, Registrars, Bursars and University Librarians that I have worked with.

I appreciate the College of Engineering family, especially the past Deans, the current Dean, Prof. O. U. Dairo, all past and current Head of Departments, and Professors in the College, including Profs E. S. A. Ajisegiri, B. A. Adewumi, J. K. Adewumi, M. A. Waheed, I. A. Adejumobi, S. I. Kuye, O. R. Adetunji, O. S. Awokola, T. M. A. Olayanju (immediate past Vice-Chancellor, Landmark University, Omu Aran), J. O. Akinyele, A. A. Aderinlewo, I. A. Ola, A. E. Adeleke, the Head of my Department, Dr. N. O. Adekunle, colleagues in my Department, Dr. Anyanwu, Olamide, and Olaitan, I have a good working relationship with you all, and I am very grateful.

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