International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 4, Jul-Aug 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Ergonomics and Safety: An Introduction

Paul A. Adekunte[1], Matthew N. O. Sadiku[2], Janet O. Sadiku[3]

[1]International Institute of Professional Security, Lagos, Nigeria
[2]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[3]Juliana King University, Houston, TX, USA

ABSTRACT

Ergonomics, also referred to as "human factors or human factors engineering" (HFE), is the application of psychological and physiological principles to the engineering and design of products, processes and systems. The main goals are to reduce human error, but to improve/increase productivity and system availability, enhance safety, health and comfort, with specific focus on the interaction between humans and equipment. The paper dives into the benefits, challenges, and the future prospects of ergonomics and safety.

KEYWORDS: *Ergonomics, human-factors engineering (HFE), safety, workplace, workstation, artificial intelligence (AI)*

How to cite this paper: Paul A. Adekunte | Matthew N. O. Sadiku | Janet O. Sadiku "Ergonomics and Safety: An Introduction" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-4, August 2024, pp.657-663, URL: www.ijtsrd.com/papers/ijtsrd67216.pdf

IJTSRD67216

INTRODUCTION

Ergonomics is the study of people in their working environment. An ergonomist designs or modifies the work to fit the worker, and not the other way round. The main goal is to eliminate or remove discomfort and risk of injury due to work. That is to say that the employee is the first and main priority in analyzing a workstation. The International Ergonomics Association (IAE) Executive Council in August 2000 said that: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance." Also Merriam-Webster defines ergonomics as "an applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely." The three types of ergonomics are: physical, cognitive, and organizational. The three main ergonomic stressors to look for when evaluating a job are: the force required to complete a task, any awkward or static working postures adopted in completing a task, and the repetitiveness of a task. Any of these factors, or any combination of these factors, may place someone at greater risk for discomfort [1-3]. According to Marras and Karwowski, human-factors engineering (HFE) is a subset of ergonomics, based solely on the relationship between the worker and his or her mechanical or technological equipment [4].

HISTORY OF ERGONOMICS

The history of the science of ergonomics is said to date back as far as humans do. Ergonomic principles were found in archeological discovery of rocks and animal bones used as extensions of the hand to help with tasks. Hippocrates in the 5th century B. C. used ergonomic principles in describing how a surgeon's workplace should be arranged during surgery to maximize safety and efficiency. Over the centuries, effectiveness of tools such as hammers, axes, and plows improved through changes in design and usage protocols, hence increasing productivity. In the mid-19th century, the Industrial Revolution resulted in large-scale manufacturing, based on ergonomic principles [5, 6]. It was Prof. Hugh Murrelli that first used the word in print after the study of ergonomics

became popular. After WWll Wojciech Jastrzebowski wrote about it in 1857 in Polish but was translated to English in 1897. In the early 1900s, the production of industry was still largely dependent on human power/motion and ergonomic concepts were developing to improve worker productivity [7].

World War ll also increased the interest in the interaction between humans and machines. The introduction of complex and sophisticated machines and weaponry placed new demands on an operator's cognition and response time. The success or failure of the machine was dependent on the operator's situational awareness, decision-making, attention, coordination and reaction. The best trained pilots were still involved in crashes, which has led to inspired interest on the design of controls and displays. When controls were made with more differential, and placed more logically, the frequency of "pilot error" was reduced – thereby creating efficiency and safety in relationship between human and machines, as shown in Figure 1.

The word or term "ergonomics" was derived from the Greek words "ergon" meaning work and "nomos" meaning natural laws. It was officially accepted in Britain in 1950. Later in 1952, Britain formed The Ergonomic Society. In 1957, the United States formed The Human Factors Society. The human factors and ergonomics continued to diversify in the decades that followed WWll, with The Space Age which created new human factors for consideration, including weightlessness and extreme gravitational forces. Coupled with this is the Information Age human-computer interface, as shown in Figure 2

BENEFITS OF ERGONOMICS AND HUMAN FACTORS

- Some industries that have benefited from ergonomics and human factors include: automotive, chemical, construction, military/defense, forestry, healthcare, manufacturing, mining, nuclear, petroleum, telecommunications, and firefighting. Ergonomic risk factors are present during activities both on and off work site. We therefore need a very good understanding of the following risk factors/challenges [8]:

1. Forceful exertions: under which are the followings:
- Lifting/carrying (patients and equipment)
- Forcible entry
- Maneuvering equipment
- Hoseline operations
- Hydrant operations
- Struck by objects
- Ventilation tactics

2. Awkward postures:
- Lifting/carrying (patients and equipment), as shown in Figure 3.
- Maneuvering equipment (ladders, stair chairs, gurneys, hoselines, tools)
- Getting on/off apparatus.
- Wearing Personal Protective Equipment (PPE) and self-contained breathing apparatus (SCBA).
- Crawling, crouching, twisting, bending.
- Ventilation tactics.

3. Sustained positions:
- Patient care
- Sitting, standing, bending, kneeling, crawling, as shown in Figures 4 and 5.

4. Repetitive/prolonged activity vibration:
- Power or hand tools

5. Extreme environmental conditions:
- Heat.
- Cold.
- Noise.
- Visual impairments – smoke, dust, weather.
- Particulate agents – smoke, dust.
- Liquid or gaseous agents.

6. Work station limitations:
- Sitting – posture and design of workspace.
- Visual display terminals.

7. Vehicular use:
- Sitting postures.
- Navigating in/out/on apparatus.

Emergency response personnel face inherent risk of injury every day they go to work due to their varied, complex, physically and mentally demanding, and often unpredictable working environment. Emergency service is a hazardous profession and injury prevention efforts must be a priority. Some interventions to reduce the risk of injury would include:

1. Awareness through education: share injury statistics with the workforce via the trends, prevalence, nature and cause.

Demonstration and education of correct techniques: lifting, bending, squatting, twisting, pushing/pulling.

Risk reduction practices should be introduced and maintained department wide.

2. Physical preparedness:

Physical fitness – cardiovascular/musculoskeletal strength and endurance.

Flexibility and mobility.

Power, agility, coordination.

Train for functional performance, job-simulated physical training.

Industrial athlete/tactical athlete mindset.

3. Mental preparedness:
Use available programs/peer support (FireStrong/Share the load).

Mental repetition of safe practices.

Recognize and address mental and emotional fatigue.

4. Skills training:
Repetition in predictable environments to produce automatic responses in an unpredictable environment.

Maintain correct and safe techniques at all times during training.

Train individually and as a crew (teamwork).

5. Equipment selection:
Research and vet.

Provide education regarding correct technique/use, review and repeat.

TYPES OF ERGONOMICS

There are four types of ergonomics: physical, cognitive, social or organizational, and neuroergonomics. Each of these affects how people interact with their environment, contributing to how effective they are in their work. There are several types of ergonomics which include: physical ergonomics, ergonomics for specific needs, cognitive ergonomics, organizational ergonomics, environmental ergonomics, corrective ergonomics, preventive ergonomics, micro-ergonomics, and macro-ergonomics [9].

Physical ergonomics is the most commonly known form of ergonomics. This deals with the physical load on the human body when performing activities. If disregarded, workers can develop musculoskeletal disorders (MSDs) – which affects the muscles, nerves, blood vessels, ligaments, and tendons increasing a worker's risk to injury.

Cognitive ergonomics is the method of designing and arranging information and data to create a light cognitive load. Perception, memory, reasoning, and motor response all affect how someone interacts with and performs his/her work. A higher cognitive workload causes more stress on the worker.

Social or organizational ergonomics combines the knowledge gained from other areas of the factory, like physical and cognitive ergonomics, to optimize safety and efficiency across the organization. This entails finding ways to optimize teamwork, improve communications, increase output, and bolster the overall quality of a product.

Neuroergonomics is a relatively new development involving the application of more in-depth neurophysiological methods such as brain imaging techniques. This advanced methodology can be used for evaluating the customers' preferences for one or another design of human-computer interfaces or for a particular version of industrial products (this latter task is sometimes related to the field of "neuromarketing") [10].

THE 10 BASIC PRINCIPLES OF ERGONOMICS

The field of ergonomics looks at how workers do their jobs and provides guidance on how they can accomplish tasks with more efficiency, safety and comfort. These are the basic principles of ergonomics [11]:

- Work in a neutral position.
- Decrease the need for excessive force.
- Keep materials within easy reach.
- Work at the proper height.
- Reduce unnecessary motions.
- Minimize fatigue caused by static load.
- Minimize contact stress.
- Leave adequate clearance.
- Move and stretch throughout the day.
- Keep your environment comfortable.

BARRIERS TO IMPLEMENTING ERGONOMIC CONTROL MEASURES

Some other barriers are [12]:

- Lack of awareness: A major challenge is the lack of awareness and knowledge about ergonomics among managers, workers, and other stakeholders. Many people do not recognize the signs and symptoms of ergonomic hazards, such as eye strain, or stress, and musculoskeletal disorders. Tools and methods to use in identifying and assessing ergonomic hazards are surveys, checklists observations or measurements.
- Resistance to change: This can arise from different sources such as organizational culture, habits, preferences, or fear. Some people are reluctant to adopt new ways of working, or give up their existing equipment or practices. They could even see ergonomic changes as a threat to their autonomy, status, or performances. Hence, it is important to involve and consult with the workers and managers who will be affected by the ergonomic changes, and to address their concerns and expectations. Other strategies can be used to motivate and reward them, such as incentives, recognition, or participation.
- Resource constraints: This can limit the feasibility and effectiveness of ergonomic control measures.

These include financial, technical, human, or time resources which may be scarce or competing.

- Evaluation difficulties: This can hinder the monitoring and improvement of ergonomic control measures. These include the complexity and variability of ergonomic outcomes, the lack of reliable and valid indicators or methods, and the influence of other factors or interventions.
- Legal and ethical issues: This can arise from the implementation of ergonomic control measures. These include the compliance with relevant laws, regulations, standards, or guidelines, and the respect for the rights and responsibilities of workers, managers, and other stakeholders.

ARTIFICIAL INTELLIGENCE AND ERGONOMICS

Artificial intelligence (AI) is now changing the approach to workplace safety by using computer vision to analyze worker movements, postures, and environmental factors. AI-driven ergonomics technology enables real-time assessments, allowing for proactive adjustments that reduce ergonomic risks and create safer, more comfortable workplaces. Some of the benefits of AI are as shown in Figure 6 [13, 14]:

- 24/7 availability.
- Scalability.
- Improved accuracy and reduced rate of error.
- Enhanced safety.
- Performs mundane and repetitive tasks.
- Reduce the incidence of workplace injuries.
- Helps to improve employee well-being.
- Enhances overall productivity.
- Leveraging data-driven insights an organization can optimize resource allocation and streamline safety protocols.

CONCLUSION

The import of ergonomics cannot be overemphasized as it is about ensuring a good fit between people and the things they interact with. Ergonomics must be considered in the design of every product, system or environment. If ergonomics is not considered early in the design process, the designs are likely to fail commercially, as they would not fit the needs of the users – i. e. ensuring user-centered design process.

Work systems are made up of humans, the tools, processes, and technologies they use, and the work environment. HFE contributes to the creation of safe and sustainable work systems by the consideration of the interrelatedness of human, technical, and environmental components and the potential effects of work system design changes on all parts of the system. HFE also contributes to the economic health of organizations by enhancing worker well-being, capability and sustainability, maximizing performance, and direct costs as well as indirect costs from productivity losses, quality deficiencies, and employee turnover. Workplaces that are designed with HFE principles have better employee performance and produce better business results. HFE design in work systems is simply and unquestionably good business [15].

REFERENCES

[1] Ergonomics – Environment, Health and Safety – UNC EHS, https://ehs.unc.edu/ergonomics-environment-health

[2] What is ergonomics (HFE)? https://iea.cc/what-is-ergonomics

[3] "What is ergonomics? – LightGuide," (9 March 2021), https://www.lightguidesys.com/what-is-ergonomics

[4] "Ergonomics and human factors defined," In Emergency services ergonomics and wellness, (September 2020), https://www.ufsa.fema.gov/ch1-ergonomics...

[5] Ergonomics and Wellness (ergonomics/human factors history), https://www.usfa.fema.gosv/ch1-origin-er...

[6] J. James, (July 15, 2018), "The importance of ergonomics," https://www.linkedin.com/the-importance-of-ergonomics

[7] J. Jones, "Who is the father of ergonomics?" https://www.quora.com/who-is-the-father-of-ergonomics

[8] "Ergonomics: Risk factors," (February 28, 2024), https://blink.ucsd.edu/ergonomics-risk-factors

[9] M. Wahocho, (March 5, 2024), "What is ergonomics? Types of ergonomics and examples," https://www.hseblog.com/what-is-ergonomics-types-of....

[10] Osama Mohammed Elmardi Suleiman Khayal, (July 2019), "Human factors and ergonomics," https://www.researchgate.net/human-factors-and-ergonomics

[11] A. Sheprak, "The 10 basic principles of ergonomics," https://www.forconstructionpros.com/the-10-basic-principles-of-ergonomics

[12] What are some common challenges or barriers to implementing ergonomic control measures? (March 22, 2023),

https://www.linkedin.com/what-are-some-common-challenges-or-barriers

[13] The future of ergonomics: How AI is transforming workplace safety, (23/12/2023), https://www.knowella.com/the-future-of-ergonomics

[14] The power of AI and computer vision in ergonomic risk monitoring, https://benchmarkgensuite.com/the-power-of-ai-and-computer-vision-in-ergonomic

[15] H. W. Hendrick, (September 2003), "Determining the cost-benefits of ergonomics projects and factors that lead to their success," *Applied Ergonomics*, vol. 34, no. 5, pp 419-427, https://www.sciencedirect.com/determining-the-cost-benefits-of-ergonomics

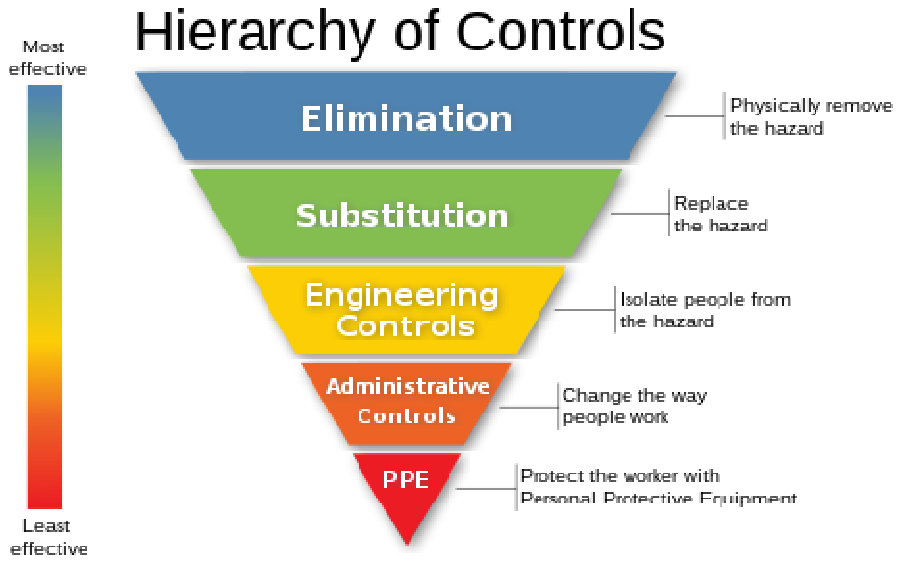

Figure 1. Ergonomic hazard.

Source:https://www.google.com/search?sca_esv=6781866871af96e0&sxsrf=ADLYWILeNetwtr8N0jjgyuvSmv42gSoUgw:1718008144674&q=images+on+ergonomics+by+wikipedia&tbm=isch&source=lnms&prmd=ivsnbmz&sa=X&ved=2ahUKEwiytbyJz9CGAxU8UUEAHa9uAlcQ0pQJegQICxAB&biw=1366&bih=580&dpr=1#imgrc=hV0IG8J0pZ_rrM

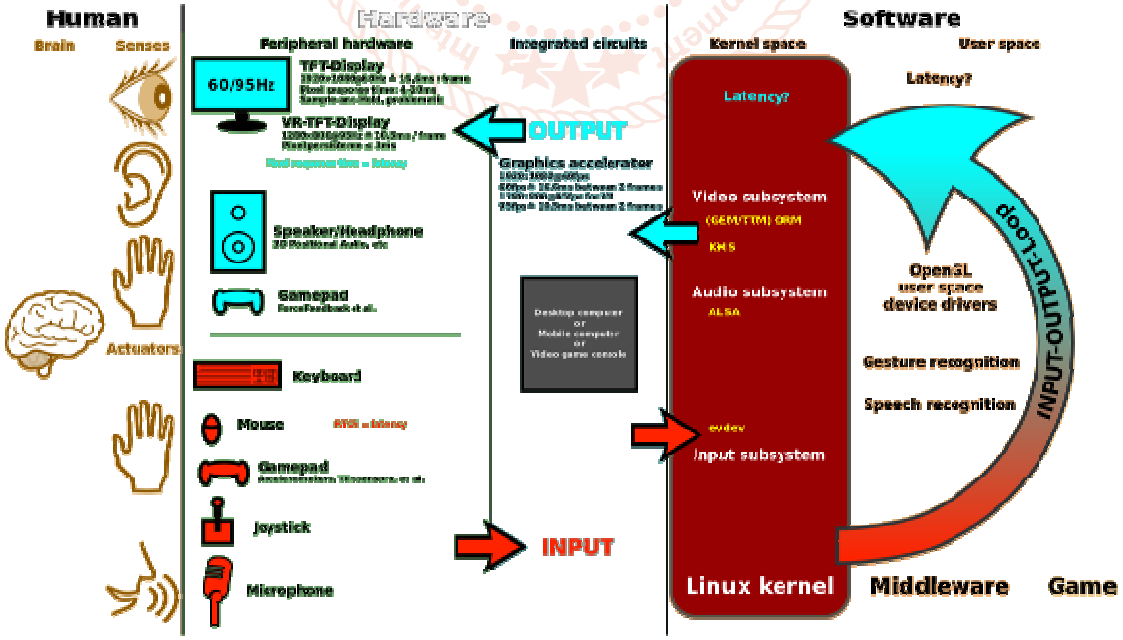

Figure 2. User interface design.

Source:https://www.google.com/search?sca_esv=64160ab7fa5a873f&sxsrf=ADLYWILZZvhdkpVqL80KdJUyn5b4Z5UIug:1718008991112&q=images+on+ergonomics+by+wikipedia&tbm=isch&source=lnms&prmd=ivsnbmz&sa=X&ved=2ahUKEwjz8oqd0tCGAxVxQEEAHT7sDYEQ0pQJegQICxAB&biw=1366&bih=580&dpr=1#imgrc=7xa7hRm6uNf0_M

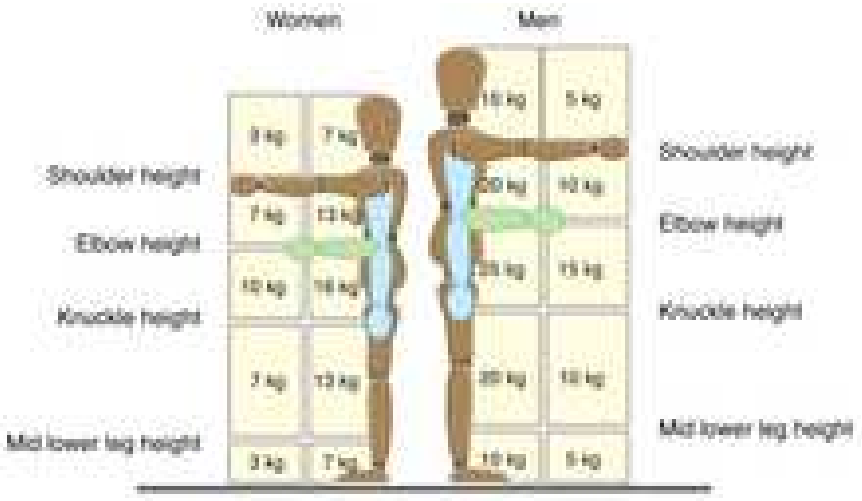

Figure 3. Ergonomics.

Source:https://www.google.com/search?sca_esv=6781866871af96e0&sxsrf=ADLYWILeNetwtr8N0jjgyuvSmv42gSoUgw:1718008144674&q=images+on+ergonomics+by+wikipedia&tbm=isch&source=lnms&prmd=ivsnbmz&sa=X&ved=2ahUKEwiytbyJz9CGAxU8UUEAHa9uAlcQ0pQJegQICxAB&biw=1366&bih=580&dpr=1#imgrc=k69QoZPO9zCm8M

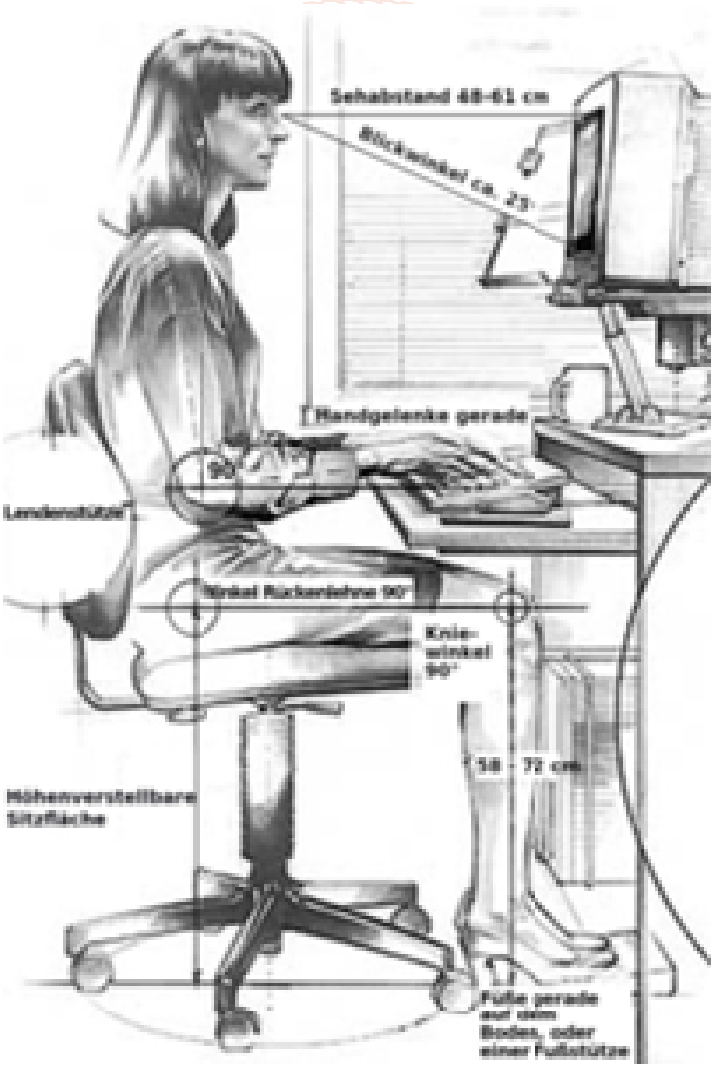

Figure 4. Ergonomic hazard.

Source:https://www.google.com/search?sca_esv=6781866871af96e0&sxsrf=ADLYWILeNetwtr8N0jjgyuvSmv42gSoUgw:1718008144674&q=images+on+ergonomics+by+wikipedia&tbm=isch&source=lnms&prmd=ivsnbmz&sa=X&ved=2ahUKEwiytbyJz9CGAxU8UUEAHa9uAlcQ0pQJegQICxAB&biw=1366&bih=580&dpr=1#imgrc=XV9AgNZgkUZb-M

Figure 5. Standing Dealing Collecting Cards Ergonomics.jpg

Source:https://www.google.com/search?sca_esv=64160ab7fa5a873f&sxsrf=ADLYWILZZvhdkpVqL80KdJUyn5b4Z5UIug:1718008991112&q=images+on+ergonomics+by+wikipedia&tbm=isch&source=lnms&prmd=ivsnbmz&sa=X&ved=2ahUKEwjz8oqd0tCGAxVxQEEAHT7sDYEQ0pQJegQICxAB&biw=1366&bih=580&dpr=1#imgrc=zSJWSJwxWnJcKM

Figure 6. Artificial intelligence.

Source:https://www.google.com/search?sca_esv=84a78df3fe3b98f2&sxsrf=ADLYWIJnQmRjHBiJscvKG6uovB19DjmAw:1718113530154&q=images+of+aidriven+ergonomics+by+wikipedia&tbm=isch&source=lnms&prmd=ivsnbmz&sa=X&ved=2ahUKEwjt85fV19OGAxUgUaQEHfnVBDMQ0pQJegQIDBAB&biw=1366&bih=580&dpr=1#imgrc=1IIPzY4M35CL0M