ERGONOMICS

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Ergonomics

What is ergonomics?

- Ergonomics is designing a job to fit the worker so the work is safer and more efficient.
- Implementing ergonomic solutions can make employees more comfortable and increase productivity.

What is a musculoskeletal disorder?

- Musculoskeletal disorders (MSDs) are conditions that affect your body's muscles, joints, tendons, ligaments, and nerves. MSDs can develop over
- time or can occur immediately due to overload.

Importance of ergonomics

- Ergonomics is important because when you’re doing a job and your body is stressed by an awkward posture, extreme temperature, or repeated movement your musculoskeletal system is affected.

- Your body may begin to have symptoms such as fatigue, discomfort, and pain, which can be the first signs of a musculoskeletal disorder.

Advantages of Ergonomics

1. Increased savings

- **Fewer injuries**
- **More productive and sustainable employees**
- **Fewer workers' compensation claims**

2. Fewer employees experiencing pain

- **Implementing ergonomic improvements can reduce the risk factors that lead to discomfort.**

3. Increased productivity

- **Ergonomic improvements can reduce the primary risk factors for MSDs, so workers are more efficient, productive, and have greater job satisfaction.**

4. Increased morale

- **Attention to ergonomics can make employees feel valued because they know their employer is making their workplace safer.**

5. Reduced absenteeism

- **Ergonomics leads to healthy and pain-free workers who are more likely to be engaged and productive.**

The objectives of the study of Ergonomics

Objectives:

- The objectives of the study of ergonomics is to optimize the integration of man and machine so as to improve the work rate and accuracy.

It involves the design of:

(1) A work place be fitting the requirements of the work force.

(2) Machinery, Equipment and control devices in such a manner in order to minimize physical and mental strain on the individuals/workers there by improving the efficiency.

(3) A conducive “environment for the execution of the task most effectively.

- Though both Ergonomics and work study are complimentary and try to fit man to his machine or to fit the job to the workers, however, ergonomics in addition takes care of factors governing physical and mental strain.

Importance of Ergonomics:

Importance of Ergonomics:

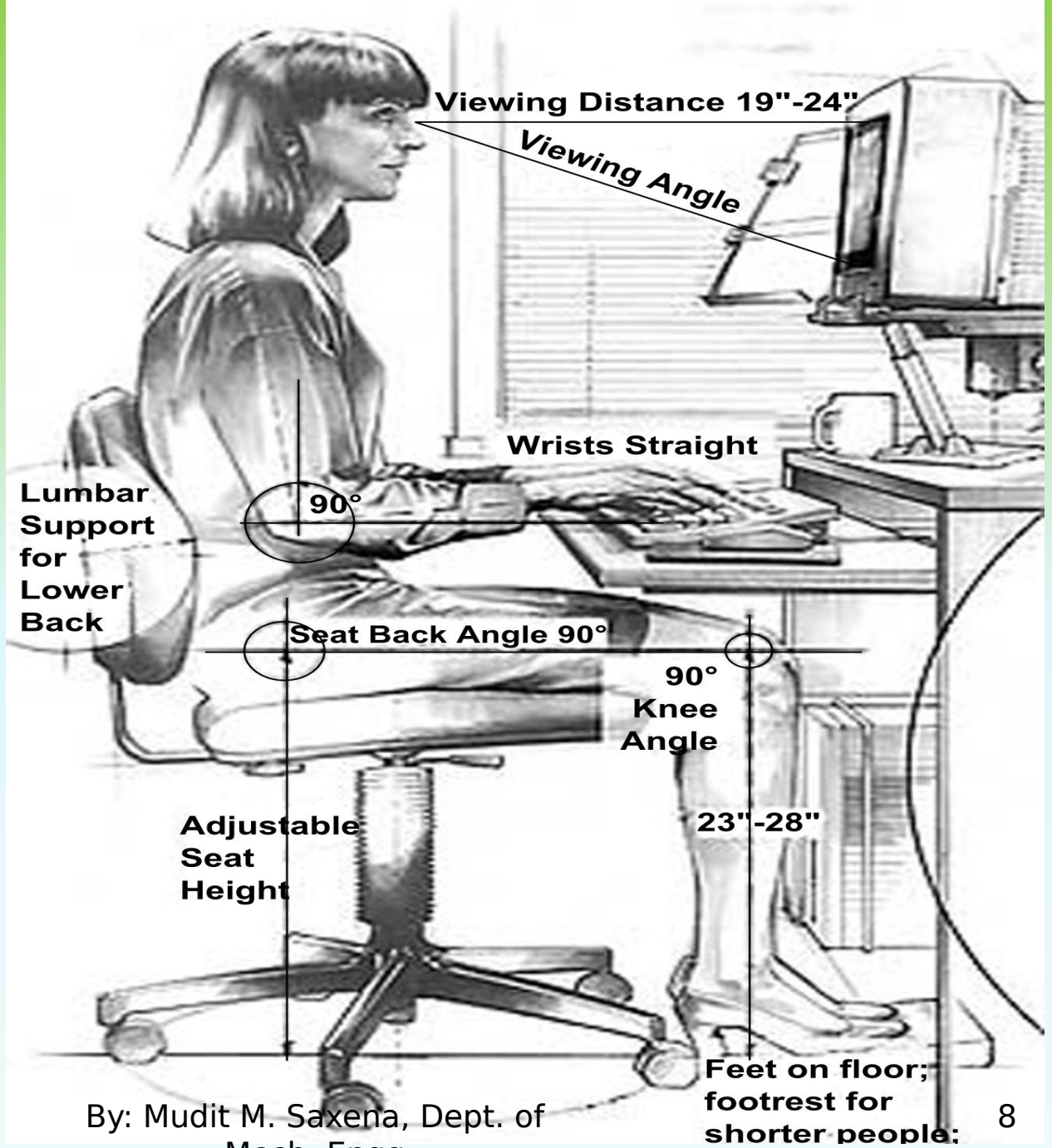
- Ergonomics plays a vital role in improving productivity. Though, it is fact that ergonomics itself does not produce anything. However, if properly exploited as on indispensable tool/ function in industry, it is capable of producing significant results. Importance of ergonomics as scientific discipline is improving with mechanization as indispensable strategy for survival. It is of great use for production/Industrial engineers and work study experts.

- The approach in this methodology is that the problem form the point that the equipment and work places should be designed around capabilities of workmen; so that less human fatigue, error and conflict shall occur, which ultimately helps in providing job satisfaction.

Human characteristics relevant to industrial performance

- **Human characteristics relevant to industrial performance may be considered under following three main handlings:**
  - **(i) Performance factors:**
  - Biodynamic, biostatics, environmental factors, information handling.
  - **(ii) Personal characteristics:**
  - Work capacity, attitude skill, intelligence and anthropometry.
  - **(iii) Attitude factors:**
- Job organization. It is clear from the factors mentioned above that the consideration of people in industry, in the structure set out does not conform to the structure of medical knowledge meaning there by that it is neither field of psychologist or sociologist only but some of the knowledge from all relevant fields will be required.

- The discipline which embraces this area and provides acknowledging support form other areas such as human sciences is ergonomics. This is relatively a new science and is concerned with a scientific study of relationship between man and his working environment.


Viewing Distance 19"-24"
Viewing Angle
Wrists Straight
Lumbar Support for Lower Back
90°
Seat Back Angle 90°
90° Knee Angle
Adjustable Seat Height
23"-28"
Feet on floor; footrest for shorter people;

Fatigue

- Fatigue refers to the issues that arise from excessive working time or poorly designed shift patterns. It is generally considered to be a decline in mental and/or physical performance that results from prolonged exertion, sleep loss and/or disruption of the internal clock.

- It is also related to workload, in that workers are more easily fatigued if their work is machine-paced, complex or monotonous.

- Fatigue results in slower reactions, reduced ability to process information, memory lapses, absent-mindedness, decreased awareness, lack of attention, underestimation of risk, reduced coordination etc.

- Fatigue can lead to errors and accidents, ill-health and injury, and reduced productivity. It is often a root cause of major accidents

Key principles in fatigue

- Fatigue needs to be managed, like any other hazard.
- It is important not to underestimate the risks of fatigue. For example, the incidence of accidents and injuries has been found to be higher on night shifts, after a succession of shifts, when shifts are long and when there are inadequate breaks.
- Employees should be consulted on working hours and shift patterns. However, note that employees may prefer certain shift patterns that are unhealthy and likely to cause fatigue.
- Develop a policy that specifically addresses and sets limits on working hours, overtime and shift-swapping, and which guards against fatigue.

Key principles in fatigue

- There are many different shift work-schedules and each schedule has different features. This sheer diversity of work and workplaces means that there is no single optimal shift system that suits everyone. However, a planned and systematic approach to assessing and managing the risks of shift work can improve the health and safety of workers.

- There are a number of key risk factors in shift schedule design, which must be considered when assessing and managing the risks of shift work. These are the workload, the work activity, shift timing and duration, direction of rotation and the number and length of breaks during and between shifts. Other features of the workplace environment such as the physical environment, management issues and employee welfare can also contribute to the risks associated with shift work.

- Sleep disturbances can lead to a ‘sleep debt’ and fatigue. Night workers are particularly at risk of fatigue because their day sleep is often lighter, shorter and more easily disturbed because of daytime noise and a natural reluctance to sleep during daylight.

Noise

- The main health effect of noise exposure is hearing impairment caused by damage to the cochlear hair cells.

- Tinnitus (constant ringing in the ears) is another consequence of noise exposure, most often linked to impact noise such as that from percussive tools. Lastly, some non auditory health effects have been attributed to noise exposures, particularly persistent environmental noise doses.

- These effects include high blood pressure, heart disease, sleep disturbance and mood changes. Various other conditions have been cited as noise linked although the evidence of causal association is much weaker.

Noise

- If you walk into a sufficiently noisy environment, you will leave with at least some hearing loss. If the damage has not been severe this will recover during the next few hours but can take up to 48 hours to recover. This phenomenon is known as temporary threshold shift.

- If the noise exposure was severe, or you repeat it often enough, the hearing loss may become permanent.

- Excess noise characteristically damages hearing at the higher frequencies first, hence there is a characteristic ‘warning’ pattern of hearing change that can be recognised in an individual when health screening by audiometry is conducted.

VIBRATIONS

Hand transmitted vibration.

- Hand transmitted vibration is a common hazard in Industrial workplaces. Anyone using hand-held power tools, holding materials being machine processed or using some hand guided machinery is at risk.

- Frequent exposure can cause a range of permanent injuries to the hands and arms known collectively as Hand-Arm Vibration Syndrome (HAVS).

VIBRATIONS

Whole body vibration

- Regular long term exposure to Whole Body Vibration (WBV) is associated with back pain alongside other factors such as poor posture and heavy lifting. **WBV** risks exist where any commercial, industrial or construction vehicles are driven regularly for most of the day.

- The vibration is transmitted through the seat or the feet of the machine operator/driver Aims of this Document The aims of this document are:

- To identify the relevant existing legislation and guidance to identify the key issues and principles of health surveillance to summarize the measures required to approach exposure control within the workplace

VIBRATIONS

Whole Body Vibration

- Drivers of some mobile machines, including certain tractors, fork lift trucks and quarrying or earth-moving machinery, may be exposed to WBV and shocks, which are associated with back pain. Other work factors, such as posture and heavy lifting, are also known to contribute to back problems for drivers and the relative importance of WBV is not clear at present.
- Inadequate seat damping and/or poor springs can significantly increase the energy transmitted to the driver when a vehicle rides over uneven surfaces. It is good practice to have regular preventative maintainence undertaken on the seats and their mountings in industrial vehicles.
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VIBRATIONS

- **Recommendations**
- Risk assessments should be conducted for all areas where workers may be subject to noise exposure or vibration.
- Assessments of driving position and the adequacy of seat damping should be regularly assessed in all commercial or industrial machines.
- Health surveillance programmes should be established for all personnel who are known to be or thought to be at risk of noise or hand-arm vibration exposure above the statutory limits.

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Heat

- **How does the body react to heat?**
- The body reacts to heat by increasing the blood flow to the skin's surface, and by sweating. This results in cooling as sweat evaporates from the body's surface and heat is carried to the surface of the body from within by the increased blood flow. Heat can also be lost by radiation and convection from the body's surface.

- **Typical example of a heat stress situation**
- Someone wearing protective clothing and performing heavy work in hot and humid conditions could be at risk of heat stress because:
- Sweat evaporation is restricted by the type of clothing and the humidity of the environment.
- Heat will be produced within the body due to the work rate and, if insufficient heat is lost, deep body temperature will rise.
- As deep body temperature rises the body reacts by increasing the amount of sweat produced,which may lead to dehydration.
- Heart rate also increases which puts additional strain on the body.
- If the body is gaining more heat than it can lose the deep body temperature will continue to rise.
- Eventually it reaches a point when the body's control mechanism itself starts to fail.
- The symptoms will worsen the longer they remain working in the same conditions.
- .

Heat

- **What are the effects of heat stress?**
- Heat stress can affect individuals in different ways, and some people are more susceptible to it than others.
- Typical symptoms are:
- an inability to concentrate;
- muscle cramps;
- heat rash;
- severe thirst - a late symptom of heat stress;
- fainting;
- heat exhaustion - fatigue, giddiness, nausea, headache, moist skin;
- Heat stroke - hot dry skin, confusion, convulsions and eventual loss of consciousness. This is the most severe disorder and can result in death if not detected at an early stage.

Heat

- **Where does heat stress occur?**
- Examples of workplaces where people might suffer from heat stress because of the hot environment created by the process, or restricted spaces are:
- glass and rubber manufacturing plants;
- mines;
- compressed air tunnels;
- conventional and nuclear power plants;
- foundries and smelting operations;
- brick-firing and ceramics plants;
- boiler rooms;
- bakeries and catering kitchens;
- laundries.
- In these industries working in the heat may be the norm. For others it will be encountered more irregularly depending on the type of work being done and changes in the working environment, eg seasonal changes in outside air temperature can be a significant contributor to heat stress.

Heat - How to reduce the risks?

- Remove or reduce the sources of heat where possible:
- **Control the temperature** using engineering solutions, eg
  - change the processes
  - use fans or air conditioning
  - use physical barriers that reduce exposure to radiant heat.
- **Provide mechanical aids** where possible to reduce the work rate.
- Regulate the length of exposure to hot environments by:
  - allowing workers to enter only when the temperature is below a set level or at cooler times of the day,
  - issuing permits to work that specify how long your workers should work in situations where there is a risk,
  - providing periodic rest breaks and rest facilities in cooler conditions.

Heat - How to reduce the risks?

- **Prevent dehydration.** Working in a hot environment causes sweating which helps keep people cool but means losing vital water that must be replaced. Provide cool water in the workplace and encourage workers to drink it frequently in small amounts before, during (this is not possible in some situations eg respiratory protective quipment use or asbestos removal) and after working.

- **Provide personal protective equipment.** Specialised personal protective clothing is available which incorporates, for example, personal cooling systems or breathable fabrics. This may help protect workers in certain hot environments. Protective clothing or respiratory protective equipment is often required when there will be exposure to some other hazard at work eg asbestos. This type of equipment, while protecting from the other hazard, may increase the risk of heat stress.

- **Provide training for your workers,** especially new and young employees, telling them about the risks of heat stress associated with their work, what symptoms to look out for, safe working practices and emergency procedures.

- **Allow workers to acclimatise** to their environment and identify which workers are acclimatised/assessed as fit to work in hot conditions.

- **Identify employees who are more susceptible** to heat stress either because of an illness/condition or medication that may encourage the early onset of heat stress, eg pregnant women or those with heart conditions.
  Advice may be needed from an occupational health professional or medical practitioner.

- **Monitor the health of workers at risk**. Where it is considered that a residual risk remains after implementing as many control measures as practicable, you may need to monitor the health of workers exposed to the risk. You should then seek advice from occupational health professionals with a good working knowledge of the risks associated with working in heat stress situations

Lighting

- In this context “good lighting” is lighting that enhances employee productivity and reduces stress by making tasks easier to perform. Good lighting also creates a pleasant working environment. This improves employee job satisfaction, reduces absenteeism, and increases employee retention.
- **What are the effects of bad lighting?**
  “Bad lighting” is lighting that is inappropriate for the tasks being performed. The level of illumination may be too low or too high, excessive direct or reflected glare may be present, thecolor rendering of artificial light sources may be inadequate, or the distribution of light may be inappropriate.
- Poor lighting has been associated with a variety of problems including low productivity, high human error rates, eye strain, headache, a reduction in mental alertness, general malaise, and low employee morale. Each of these problems can have a significant negative economic impact onany business organization. Poor lighting may also cause employees to assume awkward body postures, which may contribute to the development of cumulative trauma disorders (CTDs) such as carpal tunnel syndrome.
  The answer to this question depends on the type of work being performed at the workplace and the specific improvements that will be made.
- Some of the direct and indirect economic benefits that businesses might realize are:
- A direct reduction in lighting costs
- An increase in employee productivity
- An improvement in employee well-being that usually reduces absenteeism and improves employee retention
- Each of these outcomes is discussed below.

What economic benefits can businesses expect if they improve workplace lighting?

Direct reductions in energy costs for lighting

- An economic benefit sometimes associated with workplace lighting improvements is a reductionin energy costs. Several approaches have been used to achieve this benefit.One way to improve workplace lighting and to decrease lighting costs at the same time is toreduce overall illumination from artificial light sources when it is too high.

- This reduction maybe accomplished by replacing existing lamps with lamps having a lower lumen output and by removing lamps that are not needed. Lighting costs will be significantly reduced, and employee productivity may increase as well.

- Another strategy for improving workplace lighting that also reduces operating costs is to increaseuse of natural light by installing skylights and making other modifications to facilities. This greatly reduces the amount of light required from artificial sources.

- Another advantage of using daylight is that it illuminates walls and ceilings to create a more natural-appearing workspace. The Lockheed plant in Seattle,

What economic benefits can businesses expect if they improve workplace lighting?

- **Better employee productivity**
  A second economic benefit often associated with lighting improvements is better employee productivity.

- Lighting improvement projects often do not improve productivity as dramatically as in the Lockheed and West Bend Mutual Insurance examples described above. One reason is that numerous factors other than lighting also affect productivity. Personal factors such as one's relationship with the boss, problems at home, the car breaking down, bills, and lack of sleep can have a profound negative effect on productivity. When present, these factors may offset the beneficial effects due to lighting improvements.

- Another reason that productivity improvements associated with lighting changes may be underestimated may be attributable to the way some researchers measure productivity. By focusing on performance over relatively short periods of time, longer term effects may not be noticed.

What economic benefits can businesses expect if they improve workplace lighting?

- **Improvement in employee well-being**
- A third benefit frequently associated with lighting upgrades is an improvement in employee well-being, which often leads to a reduction in absenteeism and employee turnover. “Employee well-being” in this context refers to the overall quality of working life in general but more specifically to job satisfaction.

- Lighting affects our subjective impressions of our working environment, which ultimately affect our behavior and job satisfaction. Studies showed that certain types of lighting contributed to anxiety, stress, and depression.

Hazardous working conditions

- At-risk workers without appropriate safety equipment Physical hazards are a common source of injuries in many industries. They are perhaps unavoidable in certain industries, such as construction and mining, but over time people have developed safety methods and procedures to manage the risks of physical danger in the workplace.

- Falls are a common cause of occupational injuries and fatalities, especially in construction, extraction, transportation, healthcare, and building cleaning and maintenance.

Hazardous working conditions

- An engineering workshop specialising in the fabrication and welding of components has to follow the Personal Protective Equipment (PPE) at work regulations 1992. It is an employers duty to provide ‘all equipment (including clothing affording protection against the weather) which is intended to be worn or held by a person at work which protects him against one or more risks to his health and safety’. In a fabrication and welding workshop an employer would be required to provide face and eye protection, safety footwear, overalls and other necessary PPE.

Hazardous working conditions

- Machines are commonplace in many industries, including manufacturing, mining, construction and agriculture, and can be dangerous to workers. Many machines involve moving parts, sharp edges, hot surfaces and other hazards with the potential to crush, burn, cut, shear, stab or otherwise strike or wound workers if used unsafely.

- Various safety measures exist to minimize these hazards, including lockout-tagout procedures for machine maintenance and roll over protection systems for vehicles.

Hazardous working conditions

- Confined spaces also present a work hazard. The National Institute of Occupational Safety and Health defines "confined space" as having limited openings for entry and exit and unfavorable natural ventilation, and which is not intended for continuous employee occupancy.

- Spaces of this kind can include storage tanks, ship compartments, sewers, and pipelines. Confined spaces can pose a hazard not just to workers, but also to people who try to rescue them.

- Noise also presents a fairly common workplace hazard. Noise is not the only source of occupational hearing loss; exposure to chemicals such as aromatic solvents and metals including lead, arsenic, and mercury can also cause hearing loss.

Hazardous working conditions

- Temperature extremes can also pose a danger to workers. Heat stress can cause heat stroke, exhaustion, cramps, and rashes. Heat can also fog up safety glasses or cause sweaty palms or dizziness, all of which increase the risk of other injuries. Workers near hot surfaces or steam also are at risk for burns.
- Electricity poses a danger to many workers. Electrical injuries can be divided into four types: fatal electrocution, electric shock, burns, and falls caused by contact with electric energy.

- Vibrating machinery, lighting, and air pressure (high or low) can also cause work-related illness and injury. Asphyxiation is another potential work hazard in certain situations. Musculoskeletal disorders are avoided by the employment of good ergonomic design and the reduction of repeated strenuous movements or lifts. Ionizing (alpha, beta, gamma, X, neutron), and non-ionizing radiation (microwave, intense IR, RF, UV, laser at visible and non-visible wavelengths), can also be a potent hazard.

Psychosocial hazards

- Psychosocial hazards are related to the way work is designed, organised and managed, as well as the economic and social contexts of work and are associated with psychiatric, psychological and/or physical injury or illness. Linked to psychosocial risks are issues such as occupational stress and workplace violence which are recognized internationally as major challenges to occupational health and safety.

- According to a survey by the European Agency for Safety and Health at Work, the most important emerging psychosocial risks are:
- Precarious work contracts
- Increased worker vulnerability due to globalization
- New forms of employment contracts
- Feeling of job insecurity
- Aging workforce
- Long working hours
- Work intensification
- Lean production and outsourcing
- High emotional demands
- Poor work-life balance

Ergonomic Principles

The goal for the design of workplaces is to design for as many people as possible and to have an understanding of the Ergonomic principles of posture and movement which play a central role in the provision of a safe, healthy and comfortable work environment.

Posture and movement at work will be dictated by the task and the workplace, the body's muscles, ligaments and joints are involved in adopting posture, carrying out a movement and applying a force.

The muscles provide the force necessary to adopt a posture or make a movement. Poor posture and movement can contribute to local mechanical stress on the muscles, ligaments and joints, resulting in complaints of the neck, back, shoulder, wrist and other parts of the musculoskeletal system.

Ergonomic principles

- Ergonomic principles provide possibilities for optimising tasks in the workplace These principles are summarised.

Ergonomic principles

Ergonomic Principle		Description
Joints must be in a neutral position		In the neutral position the muscles and ligaments, which span the joints, are stretched to the least possible extent
Keep work close to the body		If the work is too far from the body, the arms will be outstretched and the trunk bent over forwards

Ergonomic principles

Ergonomic Principle		Description
Avoid bending forward		The upper part of the body of an adult weighs about 40kg on average. The further the trunk is bent forwards, the harder it is for the muscles and ligaments of the back to maintain the upper body in balance
A twisted trunk strains the back		Twisted postures of the trunk cause undesirable stress to the spine

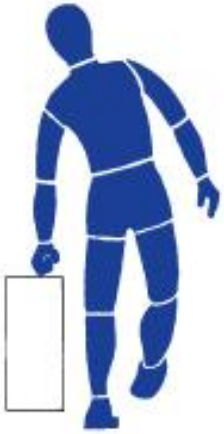
Ergonomic principles

Alternate posture as well as movements		No posture or movement should be maintained for a long period of time. Prolonged postures and repetitive movements are tiring.
Avoid excessive reaches		It is necessary to limit the extent of forward and sideways reaches to avoid having to bend over or twist the trunk

Ergonomic principles

Avoid carrying out tasks above shoulder level		The hands and elbows should be well below shoulder level when carrying out a task
Limit the weight of a load that is lifted		There are guidance weight limits for both males and females detailed in Figure 2 of this document

Ergonomic principles

Use mechanical aids		Many lifting accessories are available to help lift and move loads
Avoid carrying loads with one hand		When only one hand is used to carry a load, the body is subject to mechanical stress

Ergonomic principles

Use transport accessories		There are a large number of accessories such as roller conveyors, conveyor belts, trolleys and mobile raising platforms, which eliminate or reduce manual handling.

Biomechanics

- **Biomechanics has been defined as the study** of the movement of living things using the science of mechanics. Mechanics is a branch of physics that is concerned with the description of motion and how forces create motion.

- Forces acting on living things can create motion, be a healthy stimulus for growth and development, or overload tissues, causing injury.

- Biomechanics provides conceptual and mathematical tools that are necessary for understanding how living things move and how kinesiology professionals might improve movement or make movement safer.

Biomechanics

The applications of biomechanics to human movement can be classified into two main areas:

- the improvement of performance
- and the reduction or treatment of injury

Improving Performance

- Human movement performance can be enhanced many ways. Effective movement involves anatomical factors, neuromuscular skills, physiological capacities, and psychological/ cognitive abilities.
- Most kinesiology professionals prescribe technique changes and give instructions that allow a person to improve performance.
- Biomechanics is most useful in improving performance in sports or activities where technique is the dominant factor rather than physical structure or physiological capacity.
- Since biomechanics is essentially the body arch are performed poorly.

Improving Performance

- The coach's experience tells him that this athlete is strong enough to perform this skill, but they must decide if the gymnast should concentrate on her takeoff angle or more back hyperextension in the block.

- The coach uses his knowledge of biomechanics to help in the qualitative analysis of this situation.
- Since the coach knows that a better arch affects the force the gymnast creates against the mat and affects the angle of takeoff of the gymnast, he decides to help the gymnast work on her “arch” following the round off.

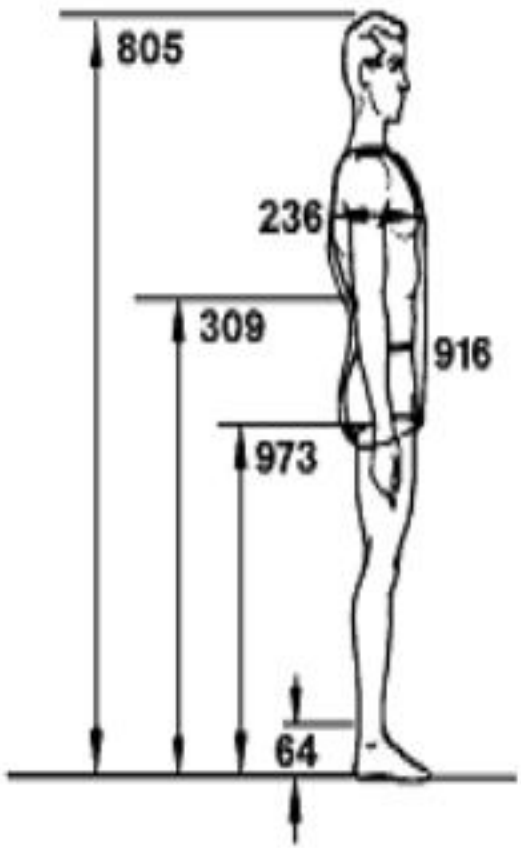
Anthropometry

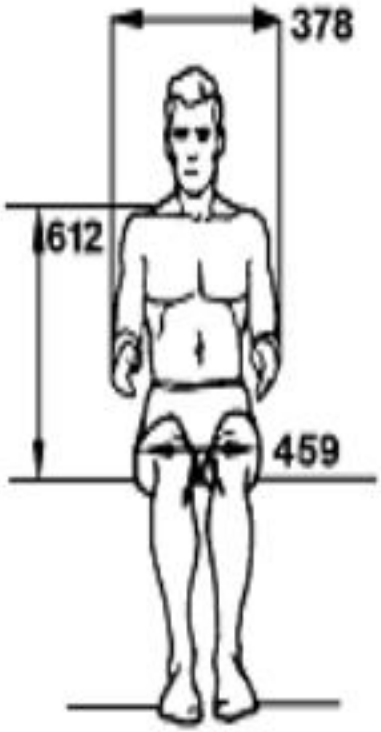
- **Anthropometry refers to the measurement of the human individual.**
- Anthropometry involves the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape.

- Today, anthropometry plays an important role in industrial design, clothing design, ergonomics and architecture where statistical data about the distribution of body dimensions in the population are used to optimize products.

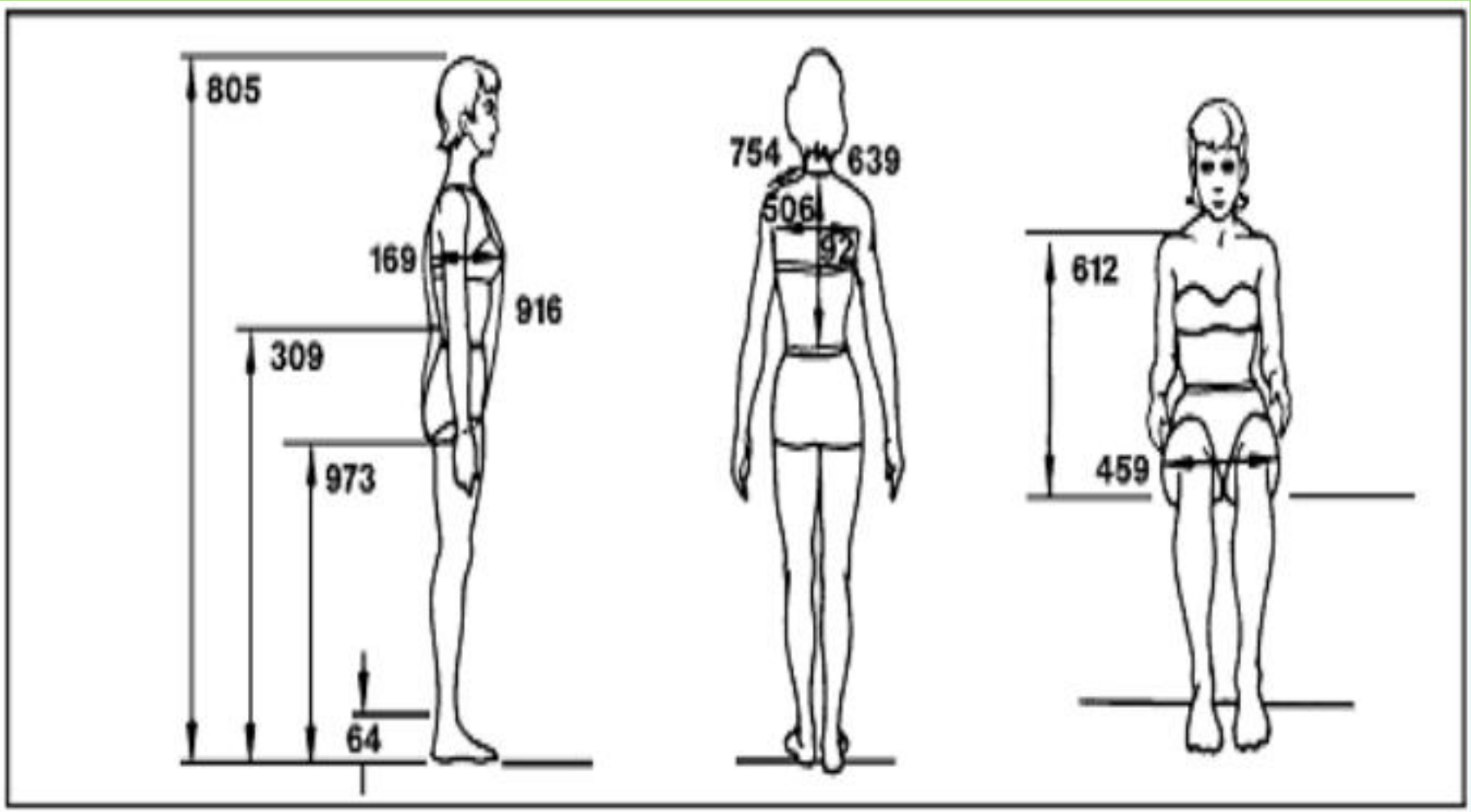
- Changes in lifestyles, nutrition, and ethnic composition of populations lead to changes in the distribution of body dimensions (e.g. the obesity epidemic), and require regular updating of anthropometric data collections.

Anthropometric Dimensional Data for American Male





Anthropometric Dimensional Data for American Female



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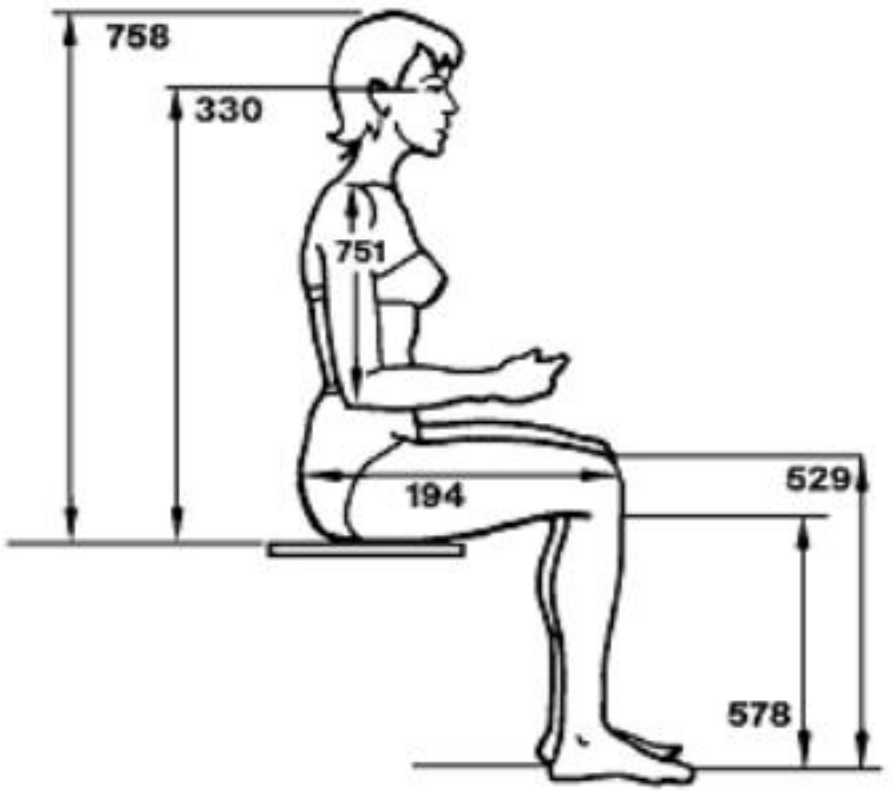
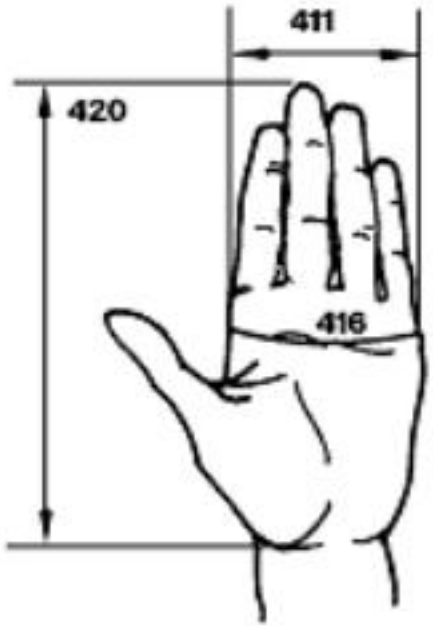
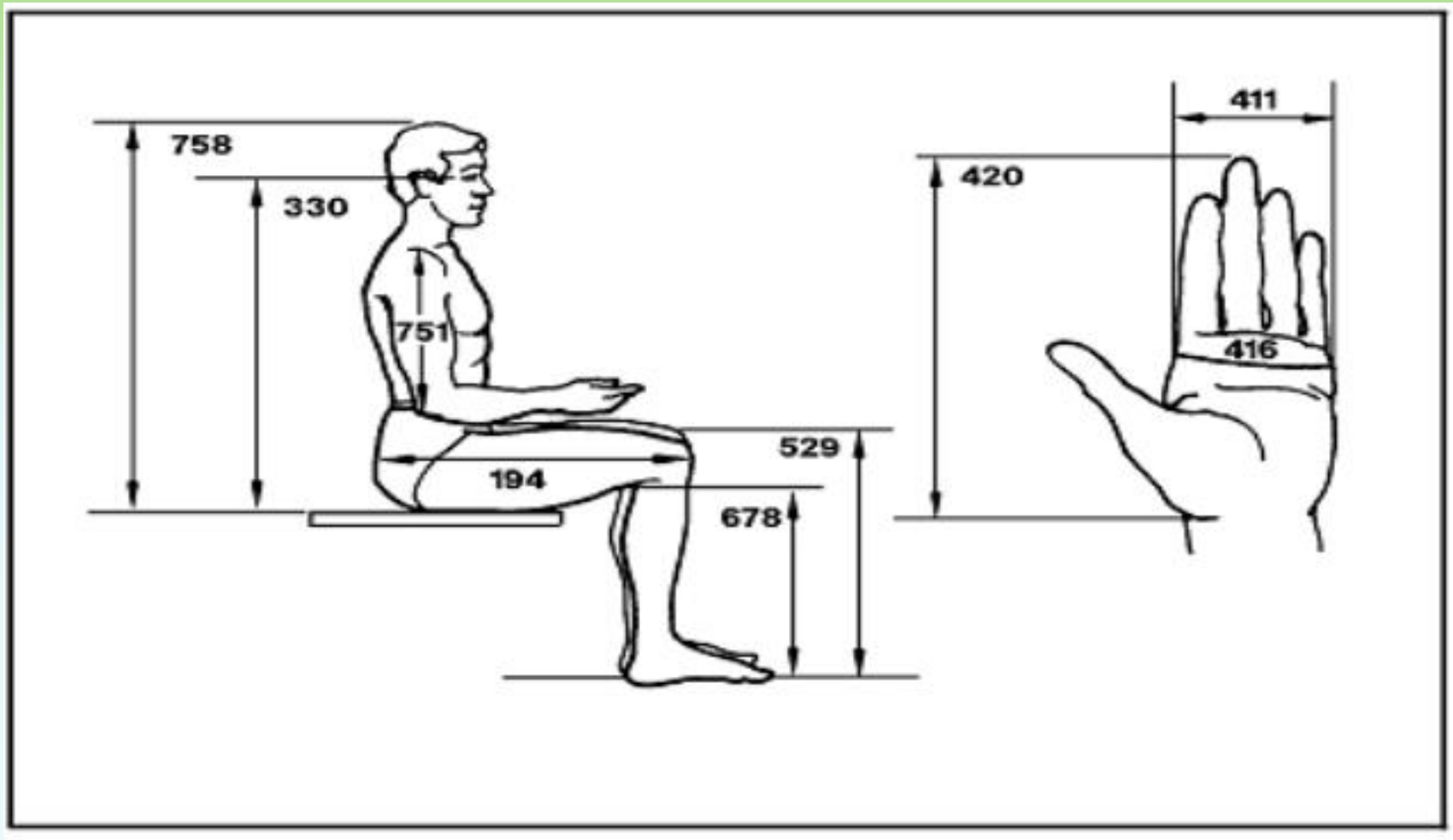




Anthropometric Dimensional Data for American Male



Effective visual displays

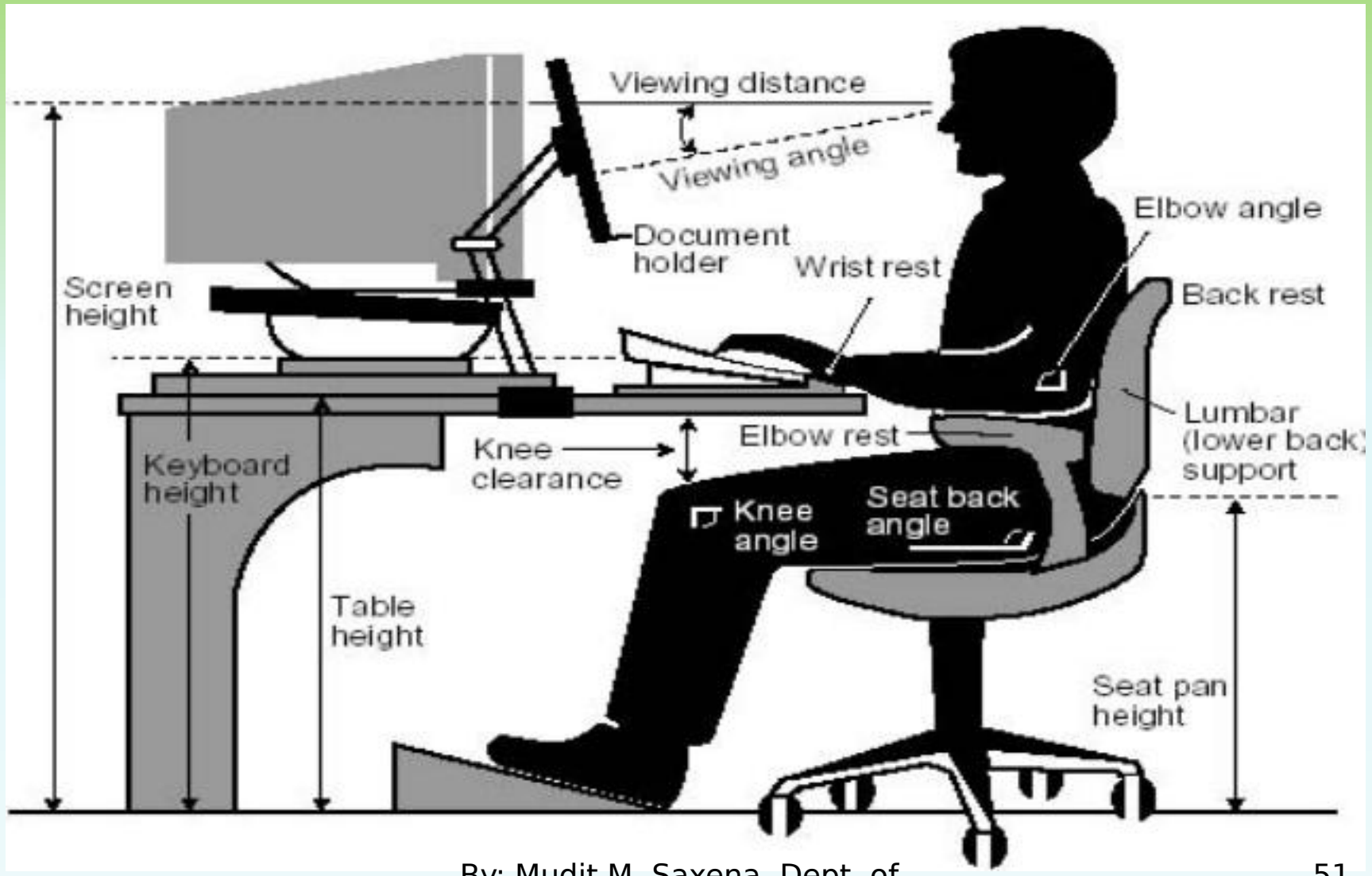
What is a visual display?

- A visual display is a device that presents information about objects, events or situations, to you through your eyes. Sometimes the display will be used in addition to information gained by observing the event or situation directly, but in some circumstances the display may be the only source of information available to you.

  Examples include TV, your computer screen, thermometers, car instruments, charts, graphs, maps and other forms of printed or written material.

- There are also displays that make use of your other senses:

Effective visual displays



Effective visual displays

Displays will generally be effective if they have:

- **Good visibility** - you can easily and clearly see the displays. To attract attention visually, the display must be within your field of vision and should flash or change in some other way. Humans are very good at detecting movement.
- **Good comprehension –** you can make the correct decisions and control actions with minimum effort and delay, and with as few errors as possible, because you have understood the displayed information.

- **Good compatibility -** the display can be used easily with others and you are not confused by any different types used. It can easily be seen and understood in the space and lighting in which it is used. The movement and layout of displays matches those of their controls.

Design guidelines for displays
GENERAL GUIDELINES

Viewing distance

The maximum display viewing distance should be determined by the size of details shown on a display. The reading distance for displays is usually 300-750mm, as many displays have to be read at arm's length and must allow you to reach or adjust controls. Displays must be optimally positioned within your field of view.

Illumination

Displays may have their own internal or back-lighting, but if not, their design should be suited to the lowest expected lighting level.

Angle of view

The preferred angle of view for displays (the angle at which the display plane is positioned with regard to the person monitoring it) should be 90 degrees. This is especially important with large picture displays as positioning them at an angle may cause parts of the display to be hidden from your eyes.

Combinations of displays

For these complex displays you will almost invariably have to divide attention between a number of tasks, as well as the displays themselves. Any inconsistencies in the manner of information-representation among the displays will be confusing, and will reduce your speed of reaction to a change indicated by a display, or even cause reading or decision errors. If a number of displays look alike, you may interpret data incorrectly. Each display should be easily distinguishable, and its information not easily confused with that on any other display.

- **Compatibility with related controls**
  Displays and their associated controls should be designed and located so that you can select the correct control and operate it effectively and without error.

SPECIFIC GUIDELINES Quantitative displays

The scale must be legible and you should avoid multiple or non-linear scales. Scale numbers, marking strokes, pointers, etc., should contrast well in tone and colour with the display face.

This should be combined with good illumination and the absence of glare or reflections. You should also position the dial near eye level and approximately at 90 degrees to your angle of view. Scale numbers should increase clockwise, left to right, or upward.

SPECIFIC GUIDELINES
Quantitative displays

Legibility is the most important design factor. A simple rule of thumb which works well for average quality of lighting and eyesight and with sensible typefaces, is the '1 to 200 rule'. Estimate where the display is to be read from, measure the distance from the eye to the display and divide by 200. You now have the height of the capital 'E' you need. So if a display is to be read from 5m then the letter height should be 5000/200mm = 25mm.

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- If the distance is 400mm, as might be the case for a computer screen, then 2mm will work fine. This rule-of-thumb can also be used to establish the lettering size and the significant divisions for analogue displays.

- Create a document containing different sizes of random letters and numbers and print out. Hold this up towards the end of a corridor and see when people can accurately read what you are displaying.

- Don't forget to use some older people as their eyesight (even when 'corrected' with glasses or contact lenses) is not as good as yours! The reason for random letters is that we read and predict words and 'fill in' for anything that is not clear.

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- You should also note that people are not reliable in reading and remembering long strings of digits. Therefore you should limit a digital display to 6 or 7 numbers, and for repeated observation, to 4 numbers. Perception and memorability of digits can also be enhanced by grouping them into pairs, leaving space between adjacent digits. (This 'chunking' of numbers helps you to remember your telephone number.)

Qualitative Displays

- Each of the displayed conditions should be as distinctive as possible, through differences in position, colour, shape or size on the display.
- You should integrate more than one of these means on the display, for example, by using lights Straight, vertical dials are recommended for observing qualitative direction of change.
- Circular dials seems to be better for observing rate of change because the angle of the pointer will quickly tell you information about the rate of change.
- If designing in a complex environment, such as a power station control room, you must make sure that only the minimum of audio warnings and alarms are triggered.
- Too many can be confusing and can increase the time taken to react to what could be a critical situation.

A general design checklist for displays

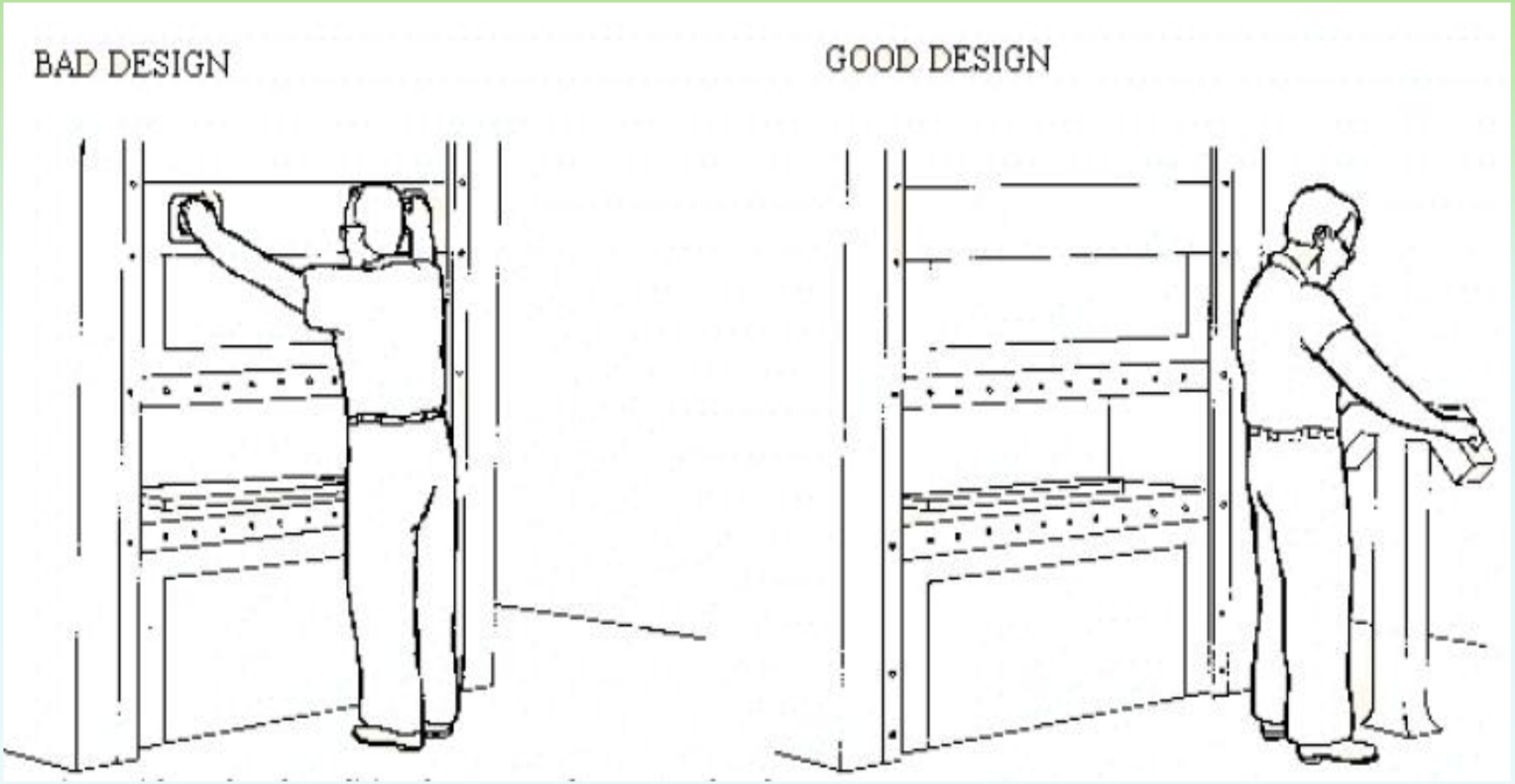
- What is the overall objective of the display?
- What information is needed to support the objective?
- What is important about the displayed information?
- Is the information used directly with other information?
- What type of technology will be used for the display (mechanical, electrical)?
- What levels of details and accuracy are required for the displayed information?
- How often will the information change?
- Does the display need to be continuously monitored?
- Is the display output directly influenced by operator input?
- Under what environmental conditions will the display be used/viewed (lighting, noise, distance)?
- What else will the operator be doing while viewing the displays?
- What are the physical and cognitive characteristics of the operators?
- With what other equipment will the display be housed/viewed?
- What sort of errors are likely to be made by the operator? Does the design help to reduce them?

Controls

Control switches, levers, and knobs also need to be designed with the worker and the task in mind. Here are some guidelines for the design of controls:

- Control switches, levers and knobs should be within easy reach of the machine operator from a normal standing or sitting position. This is particularly important for frequently used controls.
- Select controls that are appropriate for the job task. For example, choose hand controls for precision of high-speed operation and foot controls, such as pedals, for operations that require more force. Two or more pedals should not be used per operator.
- Design or redesign controls for two-handed operation.
- Triggers should be operated by several fingers, not just one.
- It is important to show a clear distinction between emergency controls and those which are used in normal operations. Such distinctions can be marked by physical separation, colour coding, clear labelling or machine guarding.
- Design controls to prevent accidental activation. This can be done by proper spacing, adequate resistance, recesses or shields.
- It is important that operating procedures for controls are easy to understand using common sense. Common sense reactions may differ among countries and these differences should be taken into consideration, especially with imported equipment.

Controls



Point to remember about hand tools and control

1. Hand tools should be designed according to ergonomic requirements. Poorly designed hand tools, or tools which do not fit the individual worker or the task can cause negative health effects and decrease a worker's productivity. In order to prevent health problems, as well as to maintain the worker's productivity, hand tools should be designed so that they fit both the individual and the task.

2. There are a number of ergonomic factors to consider when designing or redesigning hand tools.

3. Control switches, levers, and knobs also need to be designed with the worker and the task in mind.