The Ministry of Education

Plan for the Promotion of the Improvement of Campus Occupational Safety – knowledge and education training

Laboratory Safety and Hygiene Managemen

A3 Ergonomics

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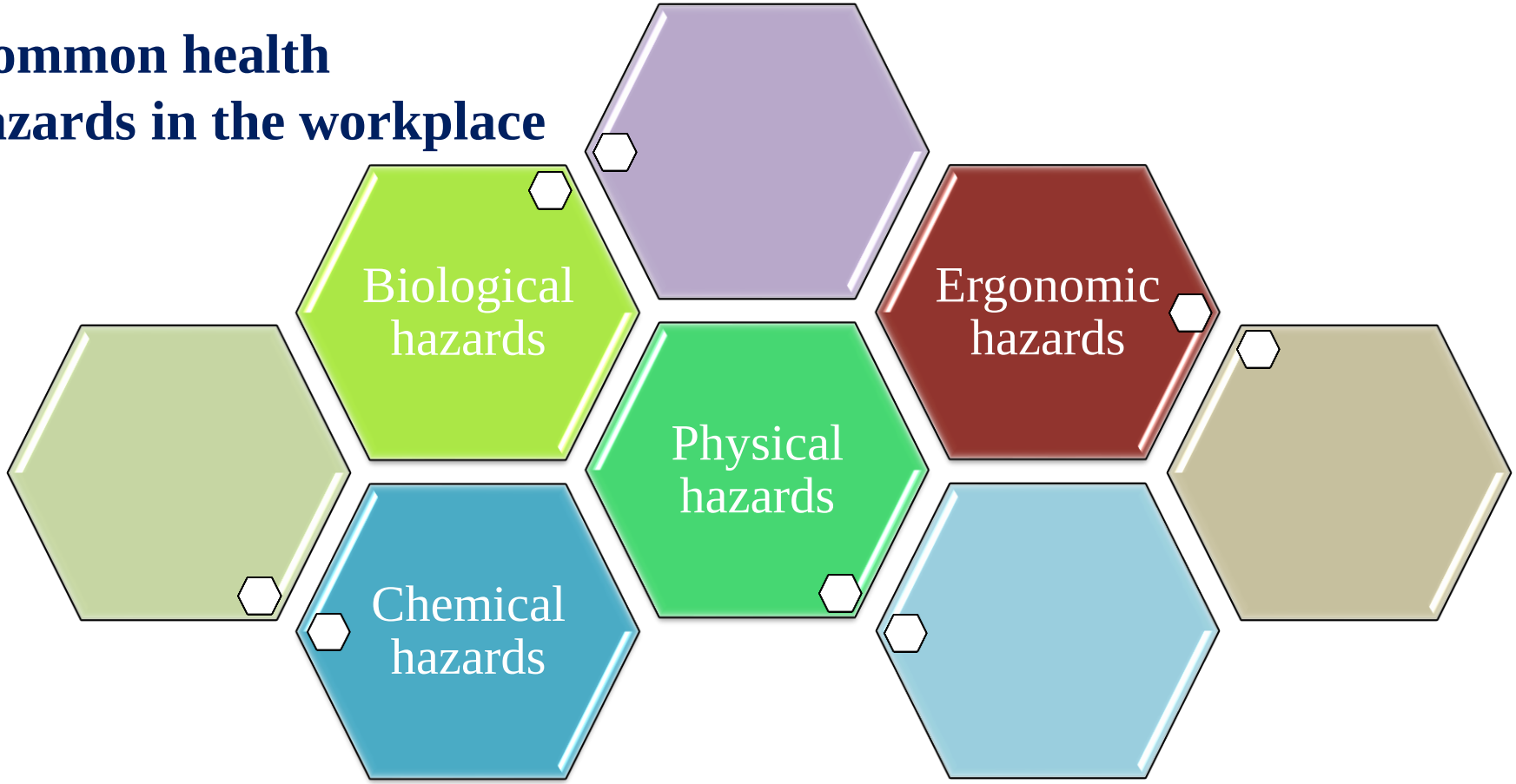
Content

1. The characteristics of ergonomics
2. Mechanisms of musculoskeletal system injury and protective measures it
3. Anthropometry measurements and workstation planning
4. Protection against accidents caused by human error
5. Other ergonomic hazards and management mechanisms

1. The characteristics of ergonomics

The characteristics of ergonomics and recognition concerning ergonomic hazards

Common health hazards in the workplace



The characteristics of ergonomic work

- Definition: Design

– Tools

– Workstation

– Work methods

– Working environment

★**let the work accommodate the people**★

★**do not require the people to accommodate the work**★

To meet HUMAN abilities

Major types of ergonomic hazards

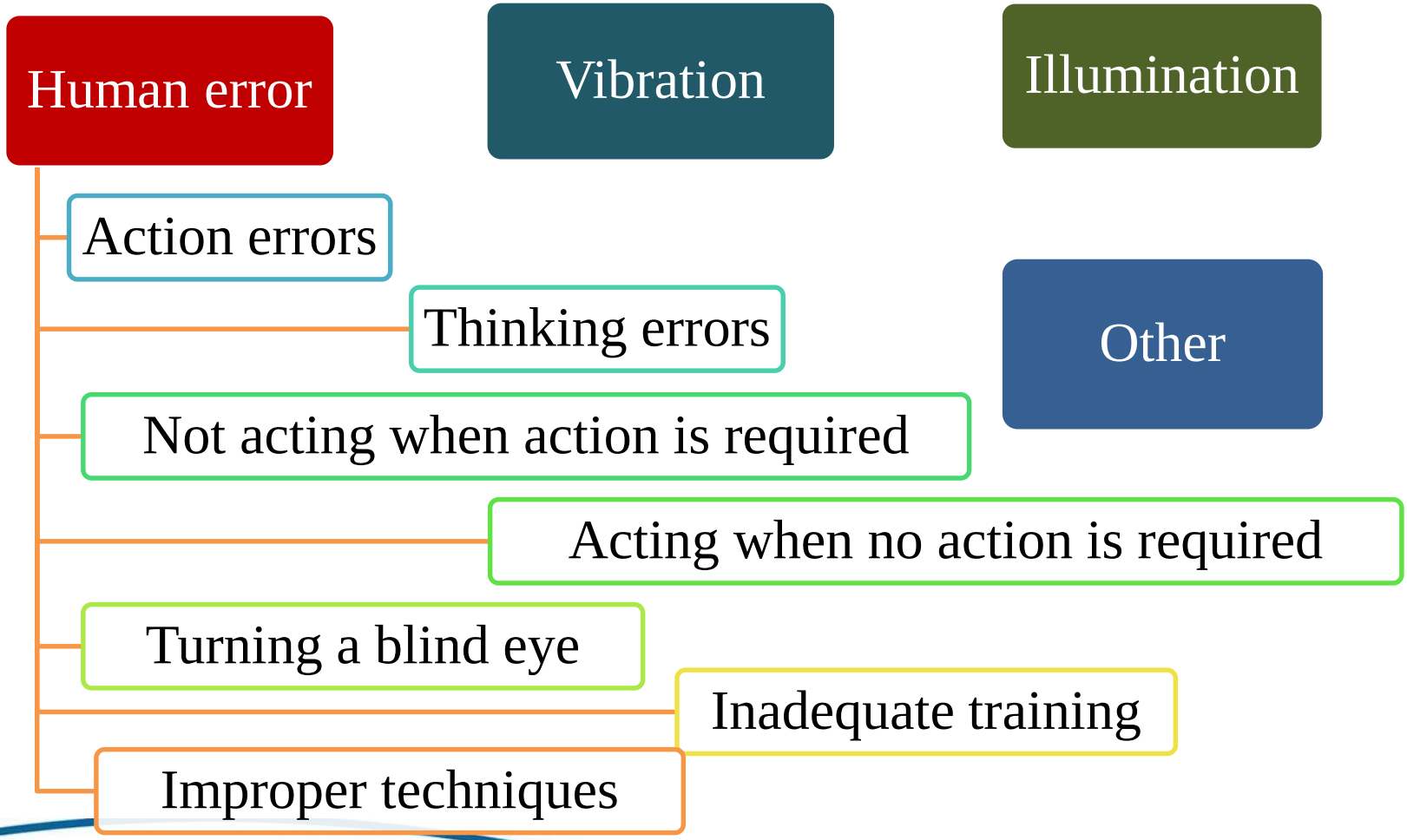
Poor human–machine interface

- Although there are many reasons for the core-meltdown accident that happened at the Three Mile Island nuclear reactor in the USA, one major reason was the poor design of the dashboard, which resulted in an improper emergency response by the personnel.

Cumulative trauma disorder (CTD)

- Major ergonomic hazards can cause cumulative injuries.
- Prolonged exposure to occupational hazards can affect the musculoskeletal and peripheral nervous systems, inducing disease.

Major types of ergonomic hazards



2.Mechanisms of musculoskeletal system injury and protective measures it

The importance of preventing musculoskeletal disorder

- Of the total number of people paid by labor insurance for occupational disease, the percentage claiming for occupational musculoskeletal injuries is increasing every year.

- It increased from 58% in 2000 to 86% in 2008 (statistics from the Bureau of Labor Insurance, Ministry of Labor).

- Hotel and catering industry workers: 61.76% experienced pain in some part of their bodies.
  – Occurrence sites: mainly shoulder, neck, lower back, and waist.

- The most serious ergonomic hazard for healthcare workers is lower back pain.
  –The prevalence rate in the 1990s was 60–80% (Nian Qiugui et al. 1996)
  –The prevalence rate in the 1970s was 40–50% (Dehlin et al. 1976)

Common causes of musculoskeletal injuries in the laboratory

- Cumulative musculoskeletal hazards
- Computer workstations
- Manually transportation and lifting of objects
- Operation of machines and equipment by hand

Cumulative trauma disorder

- Cumulative trauma disorder (CTD)
  - When unnatural postures are repeatedly adopted for prolonged periods, muscle contractions cause strain and damage in the tendons, tendon sheaths, ligaments, nerves, and muscles. This often occurs in the shoulders, neck, and upper extremities (Armstrong, 1986).

Causes	Symptoms
• Work environment • Excessive force • Unnatural working posture • Repetitive work • Lack of appropriate rest	• Pain • Numbness or loss of feeling • Muscle weakness • Reduced ability to work • Reduced leisure activity • Loss of self-worth

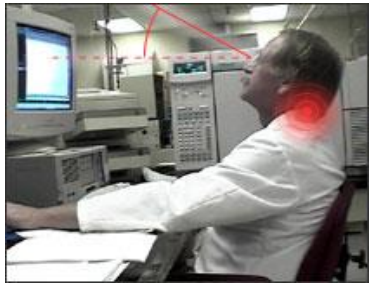
Relevant regulations for preventing CTD

- Occupational safety and health equipment and measure regulation Article 324-1 requires:
  - When employers ask laborers to perform repetitive work, to avoid musculoskeletal illness in the employees as a result of poor posture, excessive force, highly frequent work, etc., the following hazard-prevention measures shall be implemented and records shall be kept for three years:
    - Analysis of work procedures, content, and actions
    - Identification of ergonomic hazard factors
    - Evaluation, selection, and implementation of improvement measures
    - Evaluation of the effectiveness of the implementation and improvement thereof
    - Other relevant safety and hygiene matters.

    For these prevention measures, when the total number of laborers in a business entity exceeds 100, the employer shall formulate and execute ergonomic-hazard-prevention plans based on the characteristics and risks of the work, according to the relevant guidelines announced by the relevant central authority. When the total number of employees is less than 100, the employer can substitute the prevention plan with execution records or documents.

Common hazards related to computer work

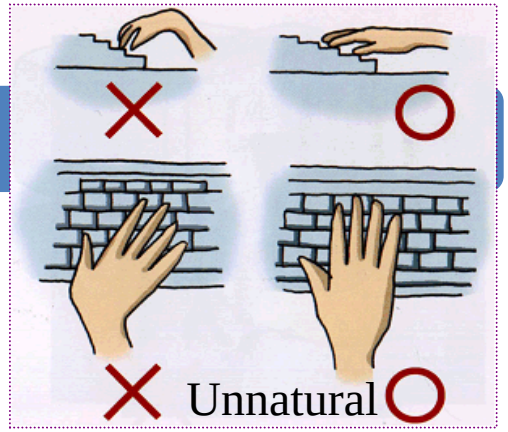
Cumulative trauma disorder (CTD)



- Pain in shoulders and neck: monitor height, chair height, etc.
- Lower back pain: choice of chair, posture, etc.
- Hand injuries: mouse, keyboard, wrist support, etc.
- Prevention: step away from computer regularly, adjust body posture, take breaks regularly.

Visual damage

- Prolonged focusing on nearby objects
- Monitor distance, monitor quality, light-source position, glare
- Prevention: rest the eyes regularly



Unnatural postures

Image source: Institute of Labor, Occupational Safety and Health

Musculoskeletal hazards related to the computer workstation

Muscle and nerve damage

- Trigger finger
- Carpal tunnel syndrome
- Myofascial pain syndrome in the neck
- Lower back pain

from www.allaboutarthritis.com

Carpal tunnel syndrome

- The “carpal tunnel” is a passageway formed by fibers and bones and it is located on the palm side of the hand. The upper part of the carpal tunnel is covered by the transverse carpal ligament. If the cover is too tight, it can compress the median nerve, leading to carpal tunnel syndrome.
- Symptoms: pain, sensation of heat, tingling, and numbness in index finger, middle finger, and thumb.
- Treatments: medication, wrist splinting, and physiotherapy. In severe cases surgery is required.

Hazards related to manual operation or handling

Back

- Back muscle strain
- Intervertebral disc deformation

Shoulders

- Rotator cuff tendinitis
- Bicep tendinopathy
- Thoracic outlet syndrome

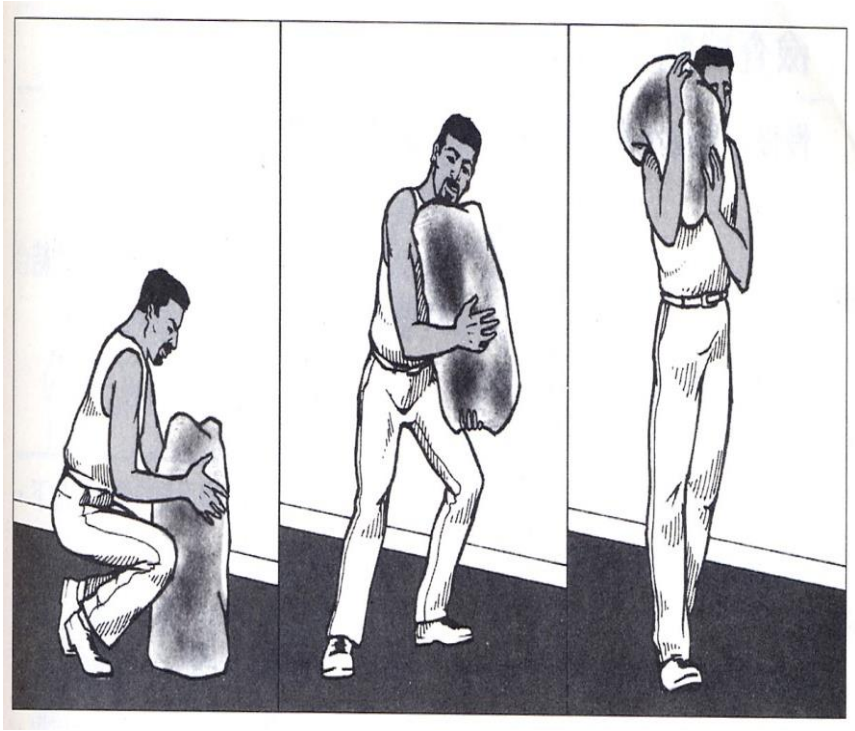
from www.allaboutarthritis.com

(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

Postures that avoid hazards related to manual equipment operation and transportation

Safe and effective handling

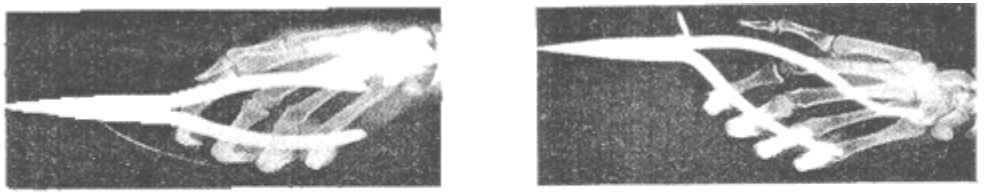
- Straighten the back and bend the knees
- Hold objects close to the torso
- Do not lift from below the height of the knees
- Provide handles
- Avoid twisting the body
- use assistive devices
- Change the direction of the force



(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

Design principles for hand-operated equipment

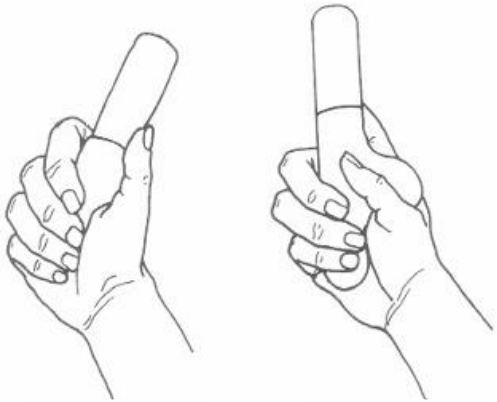
- Keep wrist straight
- Avoid tissue compression and repetitive finger motions
- Pay attention to safety procedures
- Do not overlook women
- Do not overlook left-handed personnel



(a) Traditional design (b) Improved design

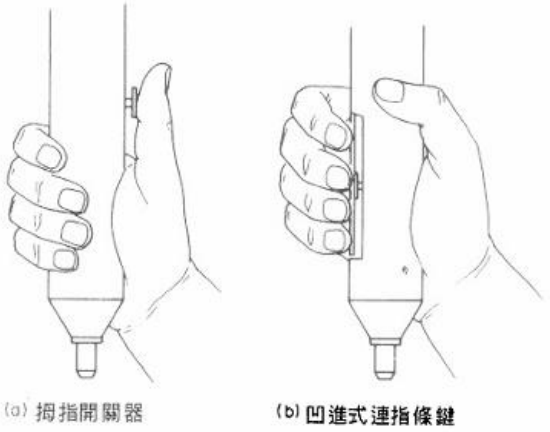
圖 12-4 An X-ray image of a hand performing wiring work (a) Using traditional needle-nose pliers, and (b) using improved needle-nose pliers. The latter are more anatomically correct. (Taken from Damon,1965;Photographs provided by Western Elactric Company,Kansas City)

from Sanders & McCormick (1993)



(a) Traditional grip (b) Improved grip

from Sanders & McCormick (1993)

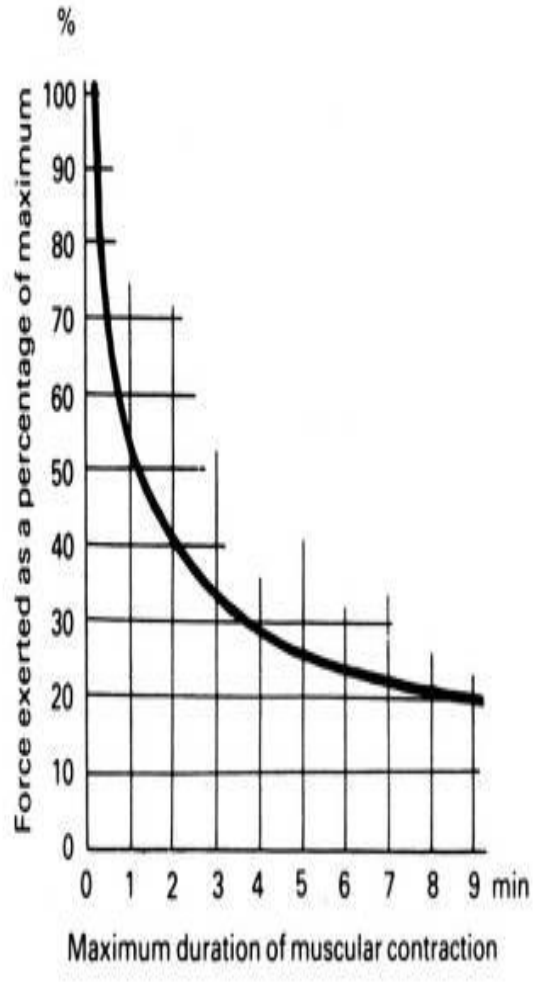


(a) 拇指開關器 (b) 凹進式連指條鍵

from Sanders & McCormick (1993)

Effective use of muscle power

- Avoid prolonged application of static force
- Maintain natural posture
- Take proper breaks



from Kroemer & Grandjean (1997)

3. Anthropometry measurements and workstation planning

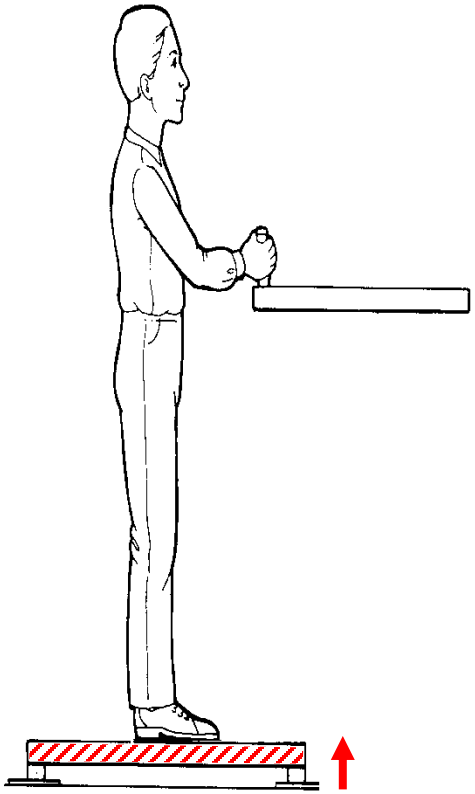
Principles of anthropometric measurement

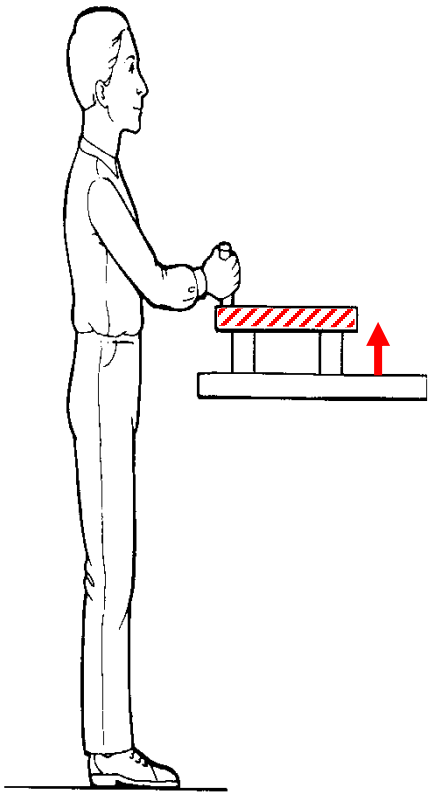
- Measure the size of parts of the human body

Static anthropometric data	Dynamic anthropometric data
• Static anthropometric data refers to the size of the human body measured in a static state with a fixed posture.	• Dynamic anthropometric data refers to distances between body parts measured during dynamic action, when joints and torso are cooperatively stretching and twisting. Also called functional anthropometry

Planning and designing standing workstations

- Extreme design
- Adjustable design
- Average design

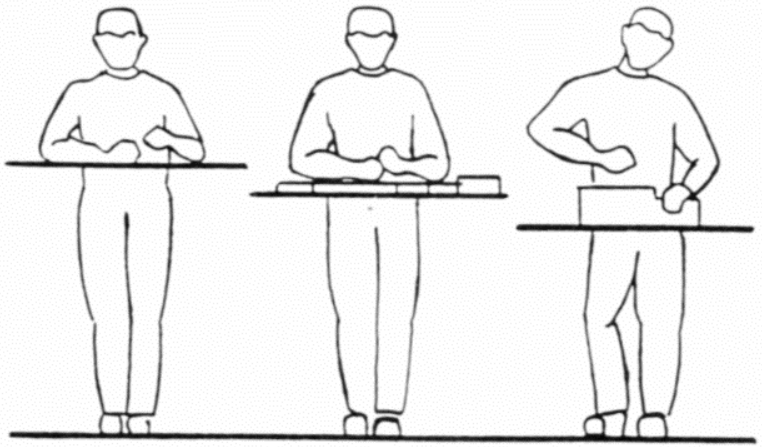




Improvement (1) **Improvement (2)**

(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

Planning and designing standing workstations (Ref: Lee)



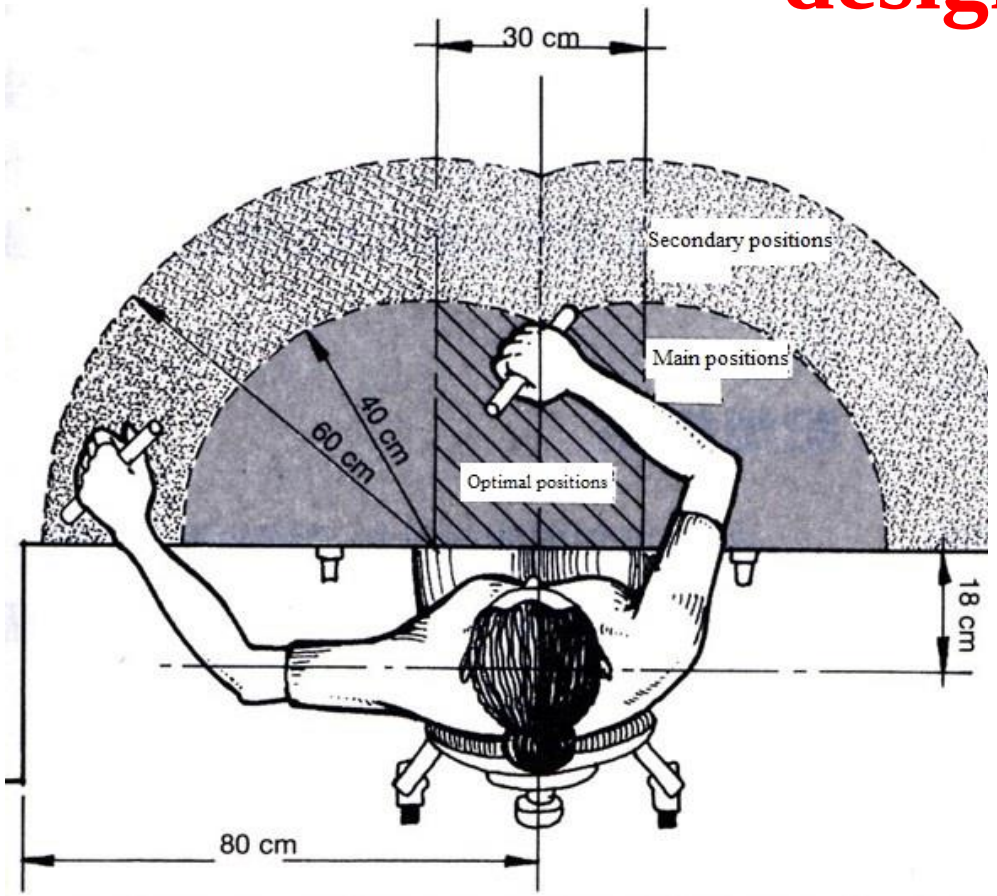
Working height for precision assembly	Working height for light work	Working height for heavy work
Male : 94.9-99.9cm	Male : 89.9-99.9cm	Male : 84.9-94.9cm
Female : 87.3-92.3cm	Female : 82.3 -92.3cm	Female : 77.3-87.3cm

(The Complete Handbook of Ergonomics, translated by the Taiwan Environmental and Occupational Medicine Association, TTV Cultural Enterprise, 1998.)

Institute of Labor, Occupational Safety and Health website

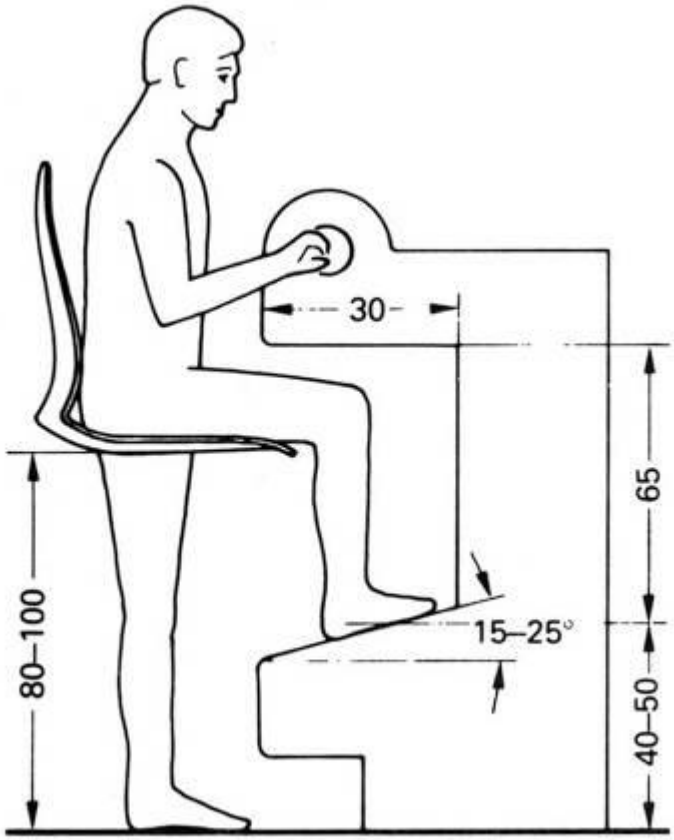
www.ilosh.gov.tw presents relevant information for Taiwanese citizens

Sitting workstation planning and design



(The Complete Handbook of Ergonomics, translated by the Taiwan Environmental and Occupational Medicine Association, TTV Cultural Enterprise, 1998.)

Sit–stand chairs



- Advantages

– The standing and sitting positions are supported by different muscle groups, so changing postures gives these muscle groups a chance to rest.

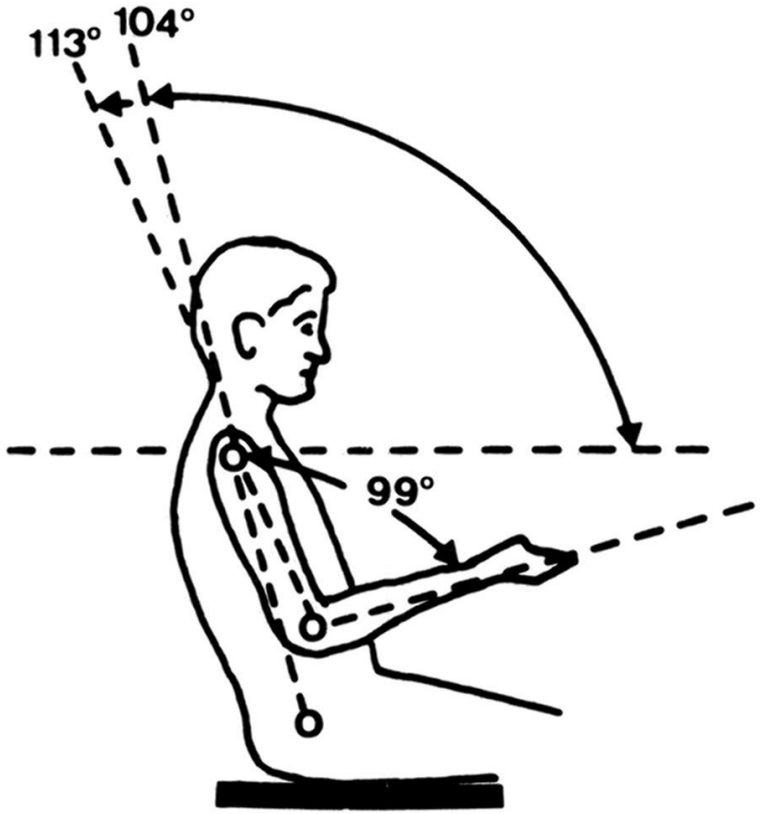
– Changing postures also helps to ensure nutrient supply to the intervertebral disks.

Computer workstation planning

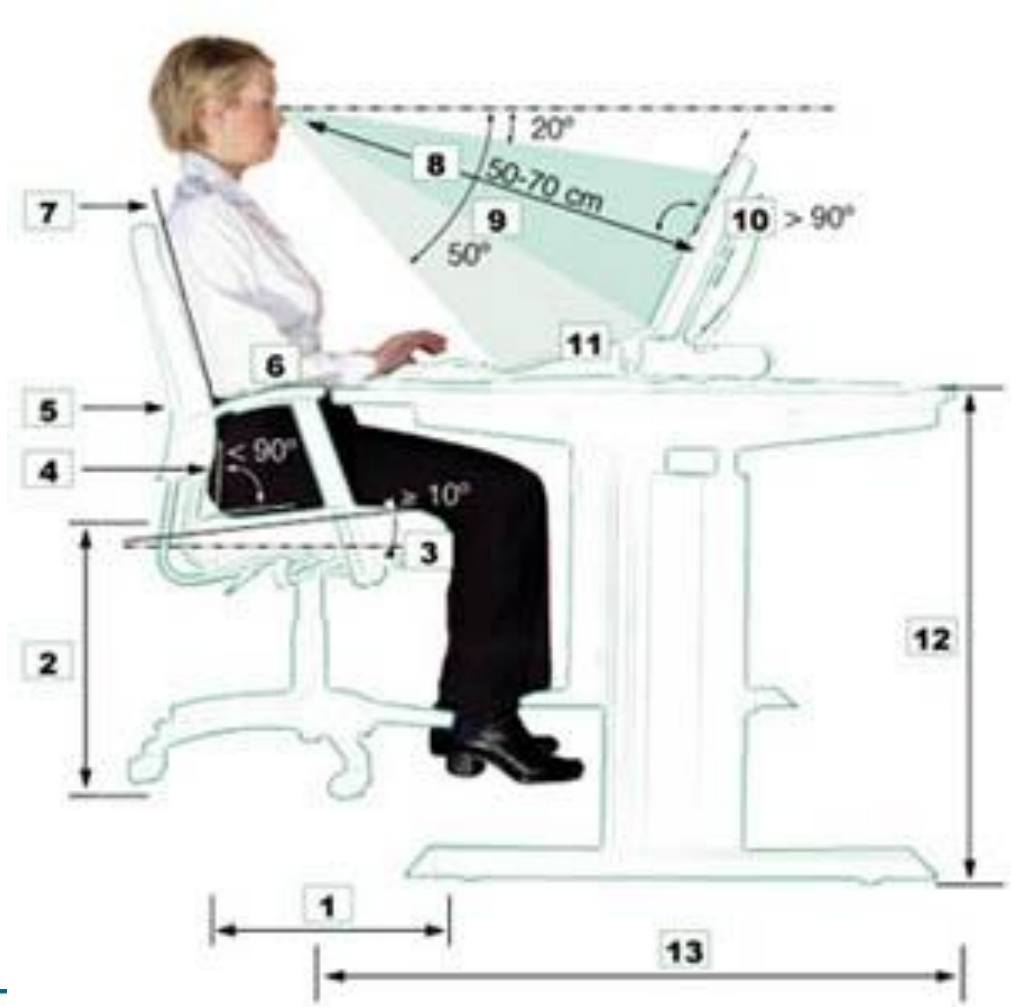
- Principles

– Reduce unnatural postures

– Reduce fatigue resulting from loading of the shoulders, neck, elbows, wrists, waist, and back, as well as tissue compression.



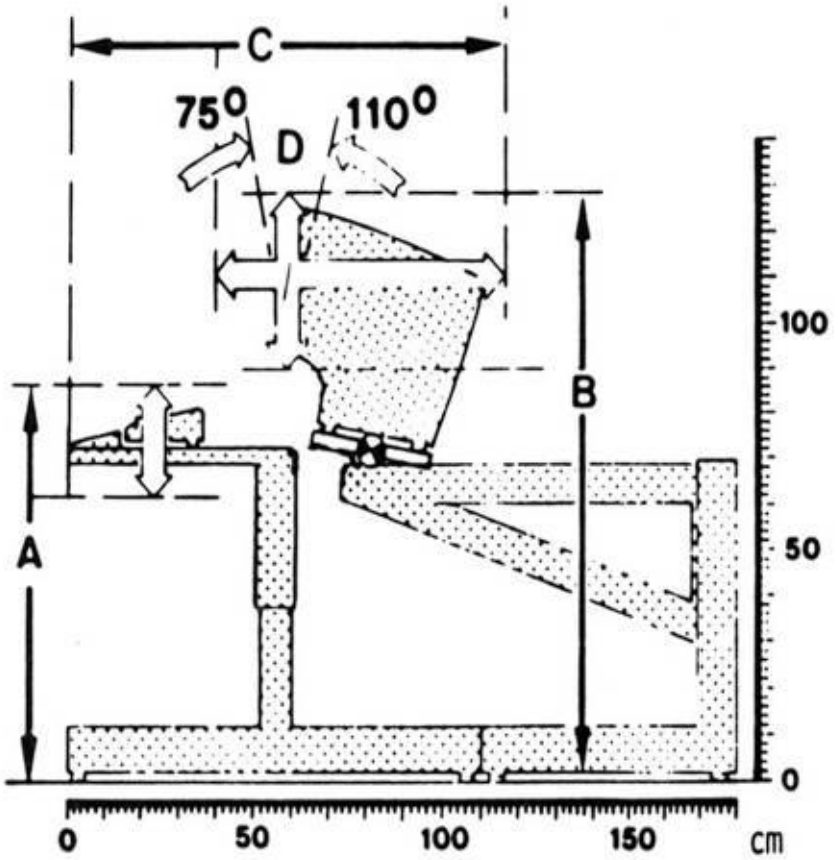
Computer workstation planning



from www.usernomics.com

Computer workstation planning

- Adjustable
- Support
  - Waist and back
  - Head and neck
  - Elbow and wrist
- Space for movemen



A =	keyboard height above floor	620–880 mm
B =	screen height above floor	900–1280 mm
C =	screen distance from table edge	400–1150 mm
D =	screen inclination	75–110°
	source document holder inclination	0–90°

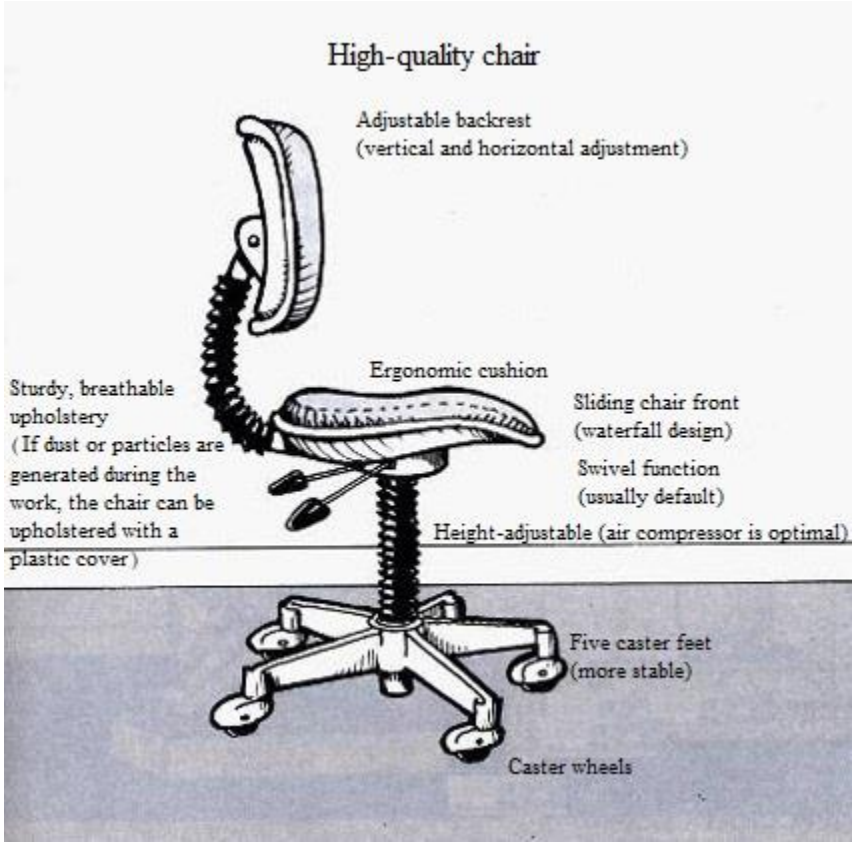
Workstation chairs

Tilting chair with high backrest

Backrest:

- height (above seat) 50 cm
- lumbar pad
- slightly concave at thorax level
- adjustable inclination (104–120°) with locking device

(do not forget a footrest)



(The Complete Handbook of Ergonomics, translated by the Taiwan Environmental Occupational Medicine Association, TTV Cultural Enterprise, 1998.)

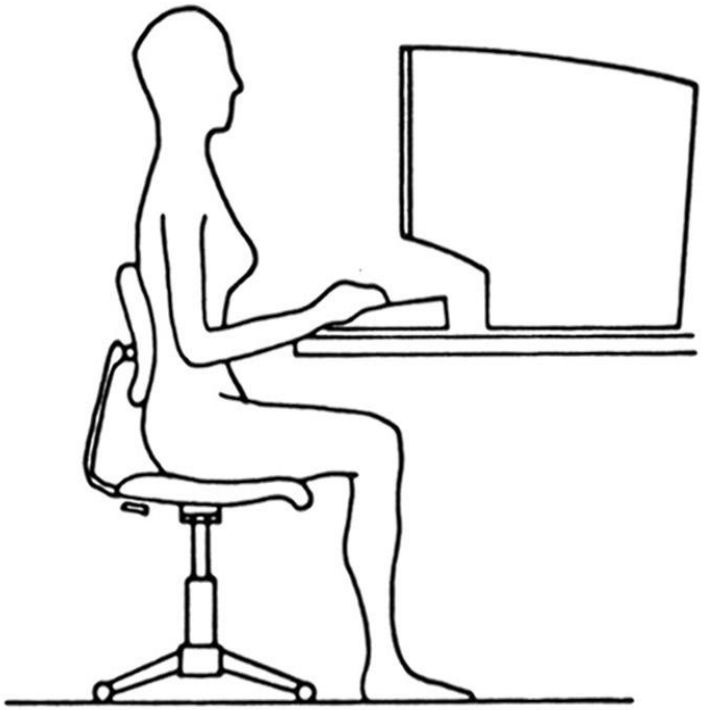
Keyboards

- Main problems
  - Forearm pronation
  - Ulnar deviation

From www.usernomics.com

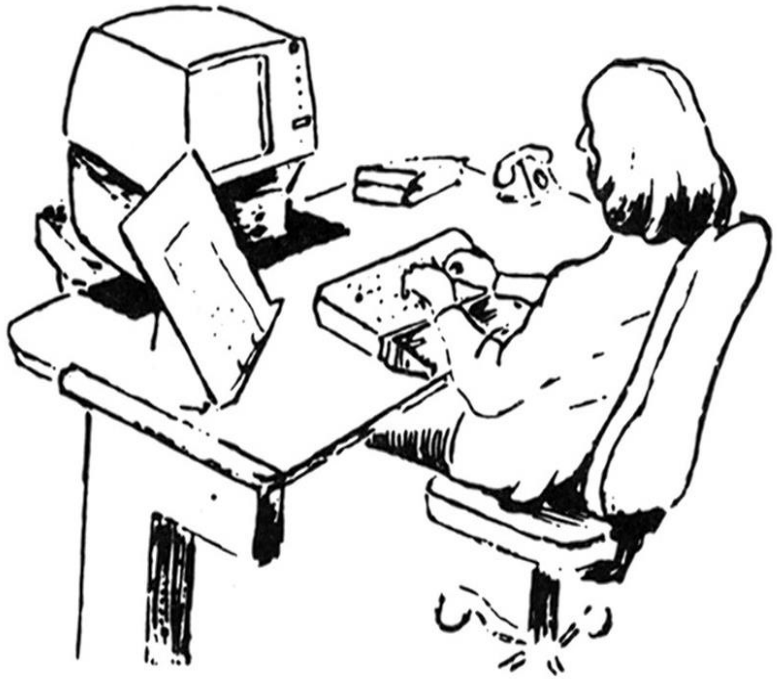
Ideal vs realistic situation?

Ideal state



Wishful thinking

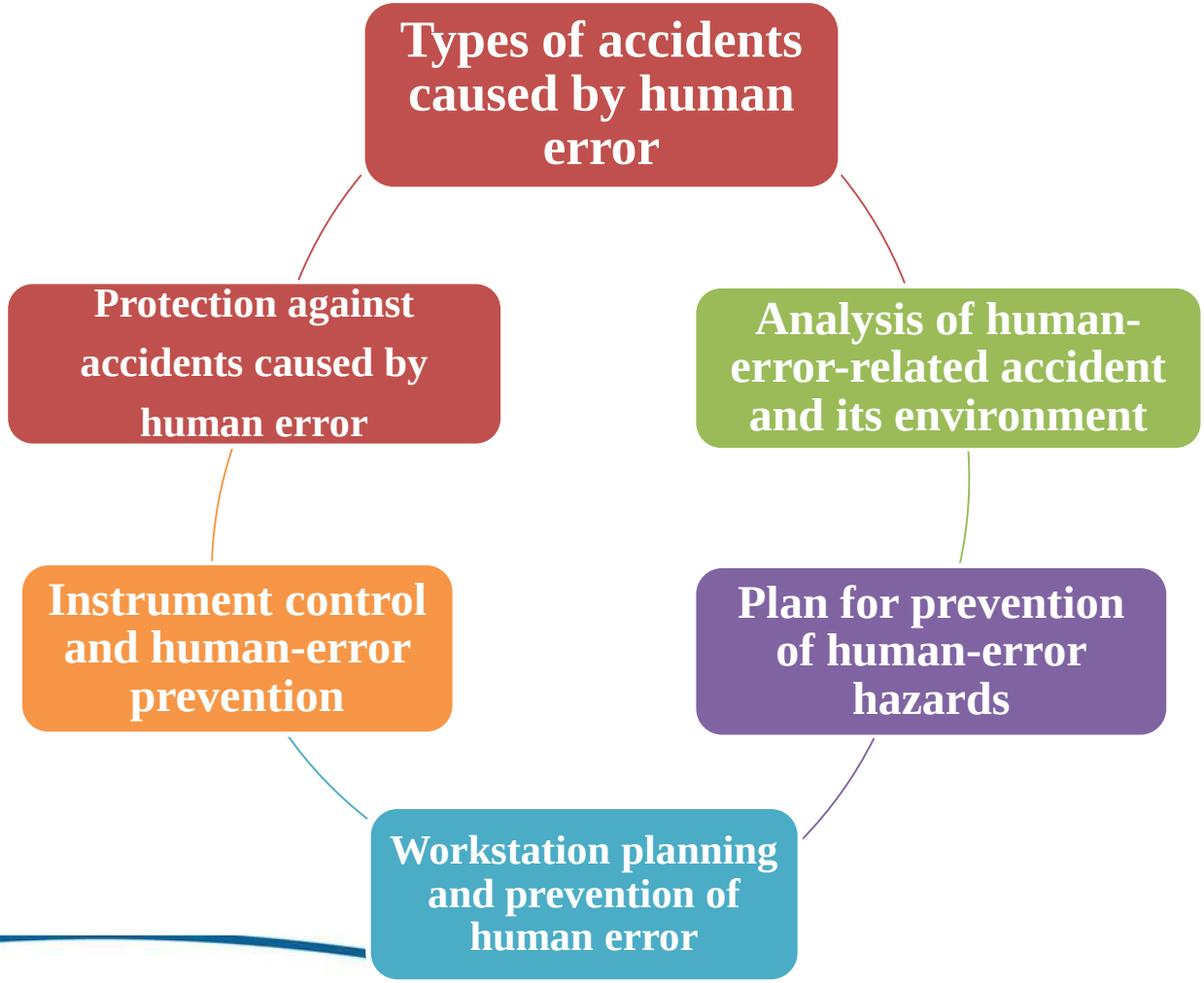
Acceptable posture



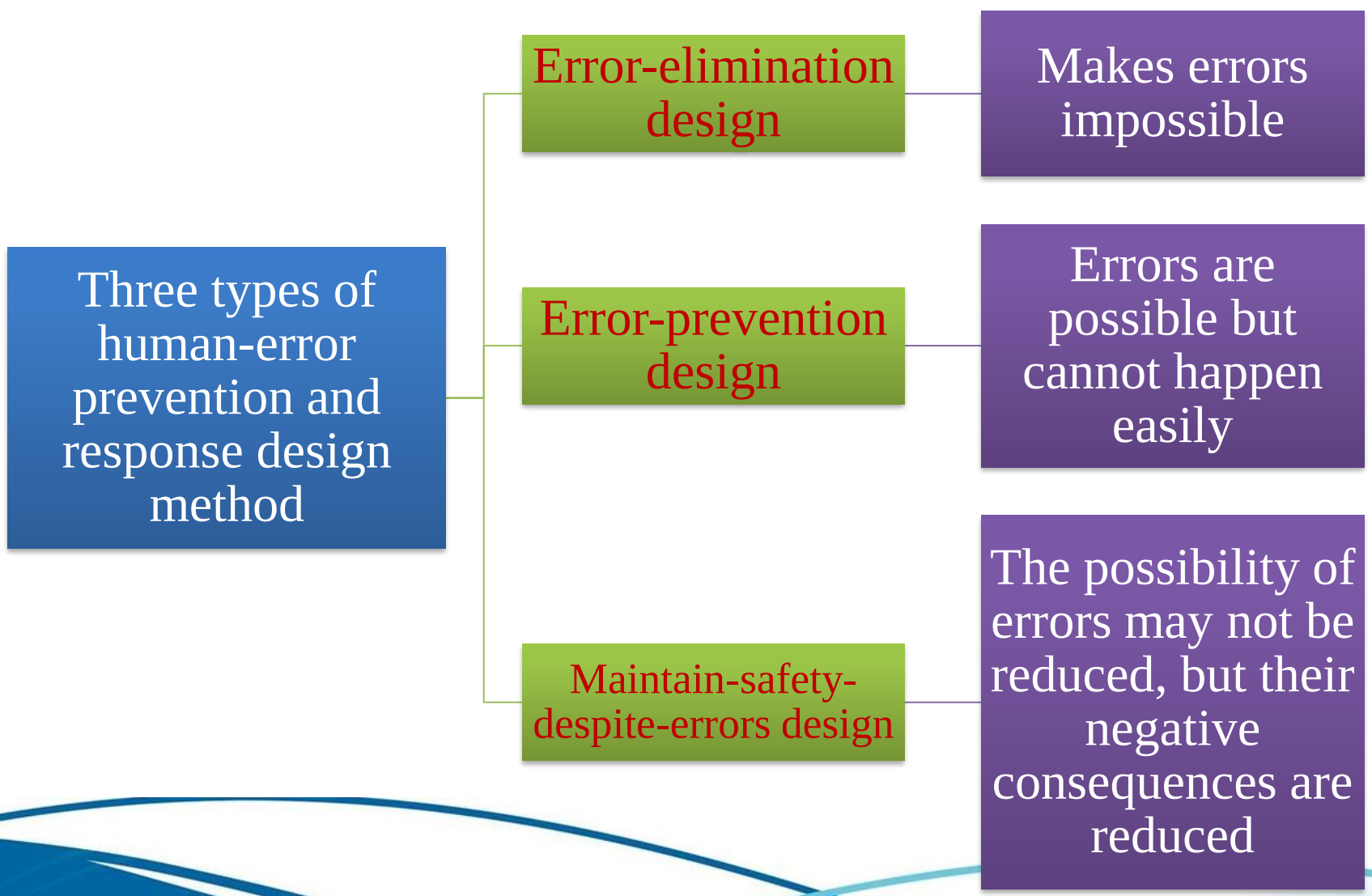
Preferred body posture

4. Protection against accidents caused by human error

Protection against accidents caused by human error



Prevention of and responding to human error



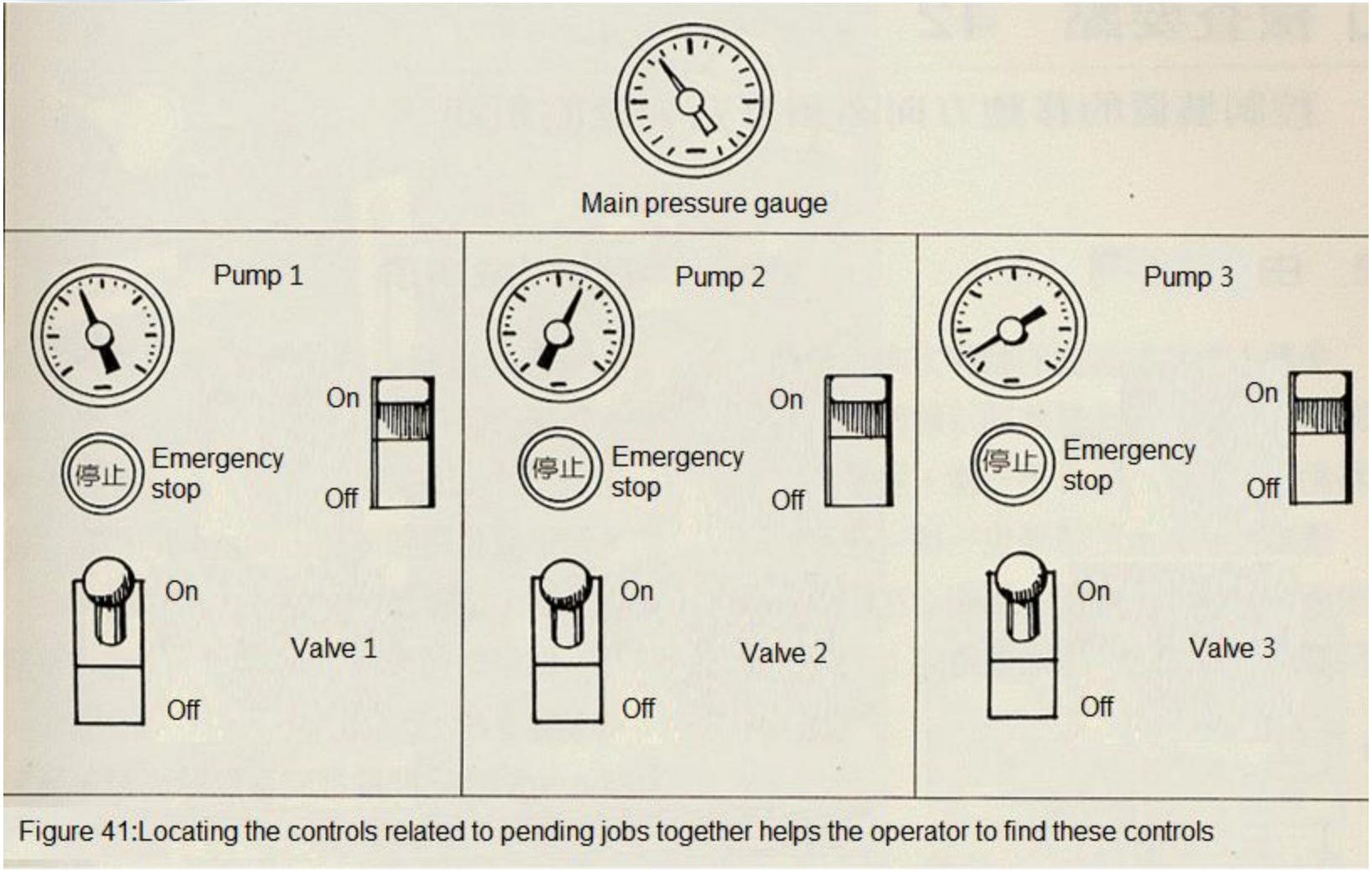
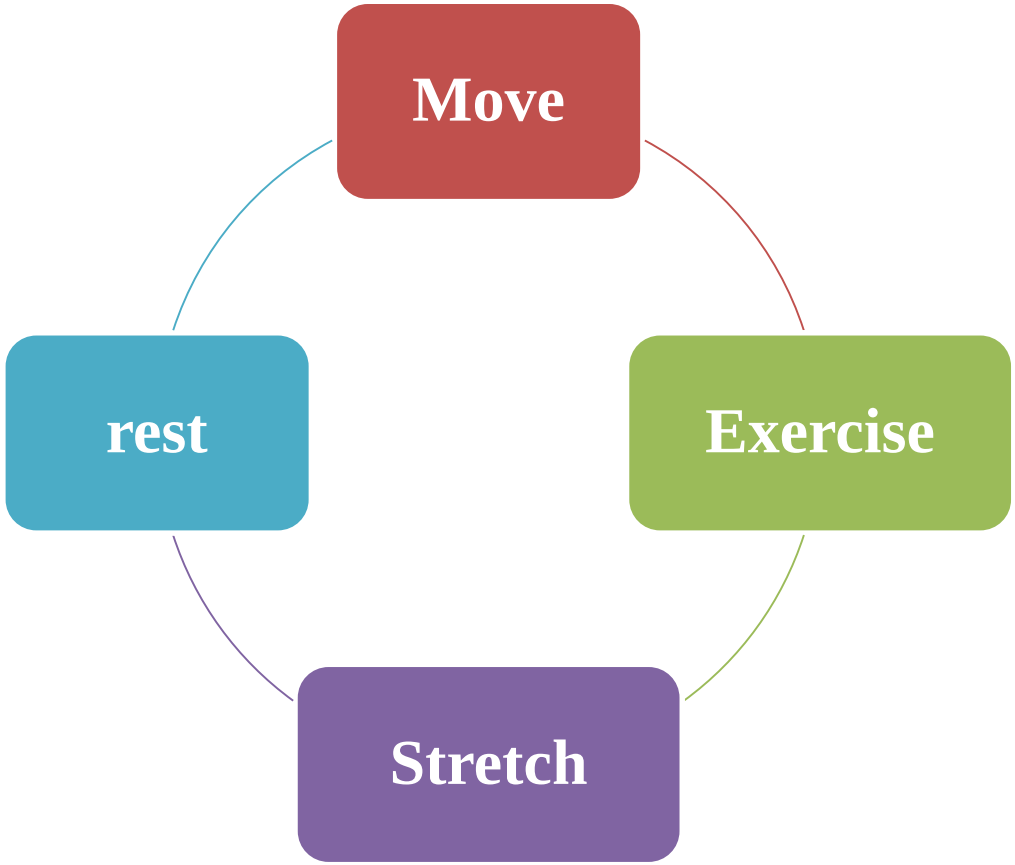


Figure 41:Locating the controls related to pending jobs together helps the operator to find these controls

(The Complete Handbook of Ergonomics, translated by the Taiwan Environmental Occupational Medicine Association, TTV Cultural Enterprise, 1998.)

Other ergonomic–human factors



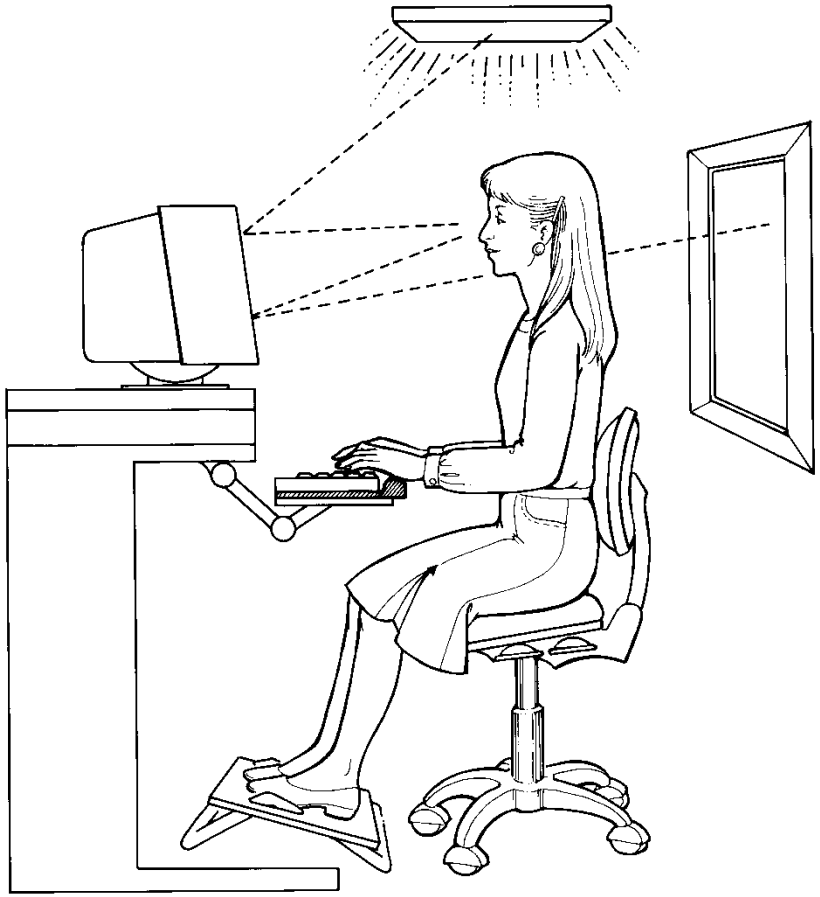
(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

5. Other ergonomic hazards and management mechanisms

Other ergonomic hazards and management mechanisms

Other ergonomic hazards

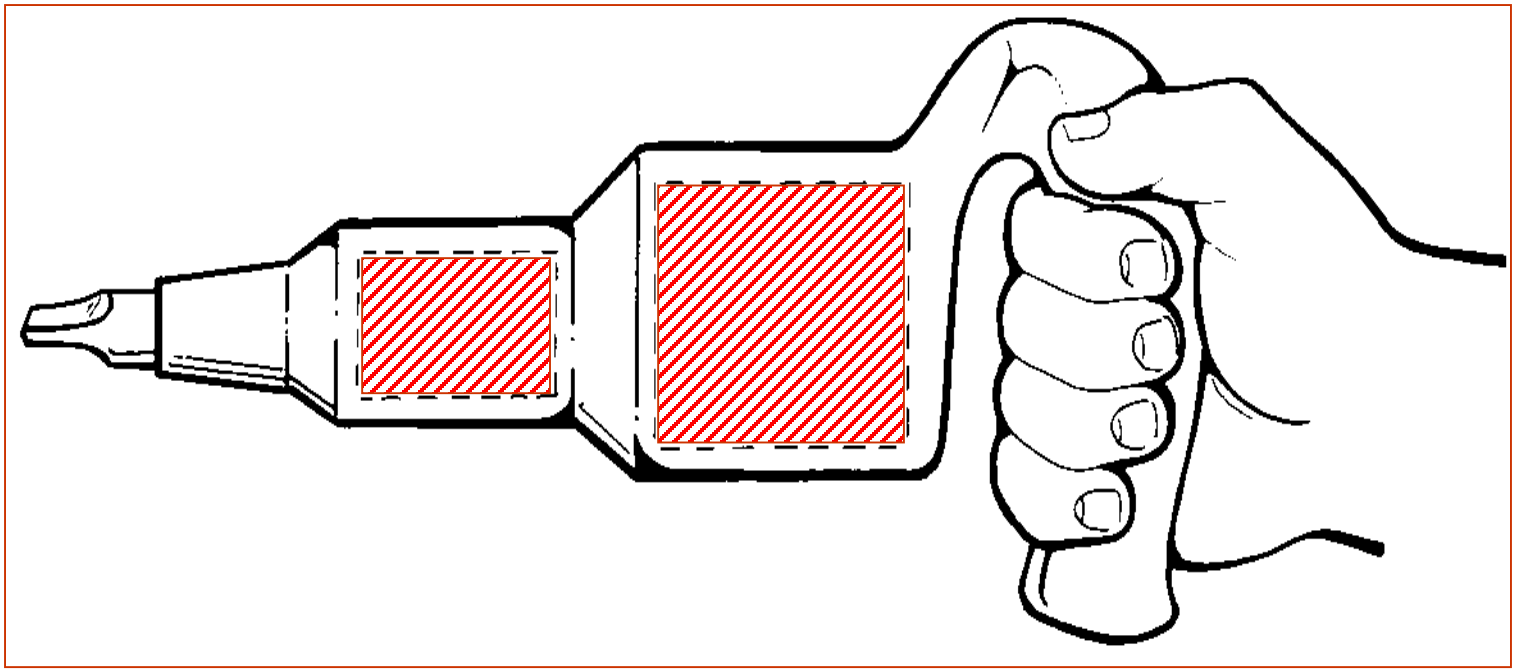
- Poor lighting



(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

Other ergonomic hazards

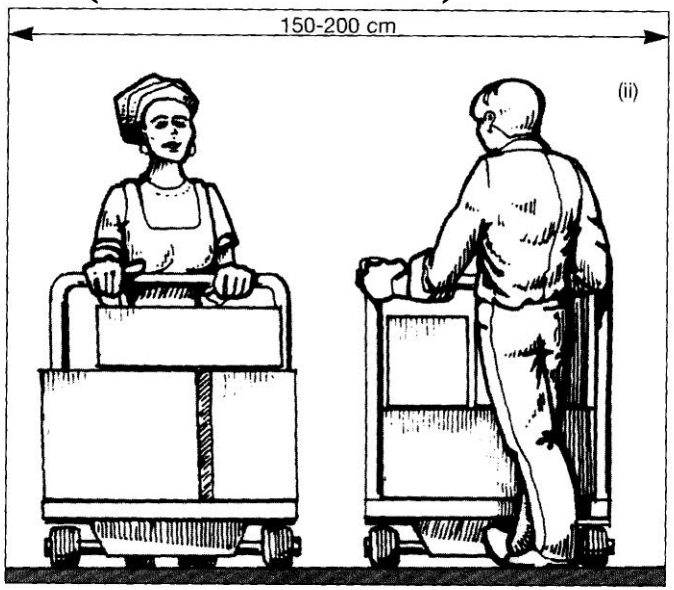
- Vibration (musculoskeletal injury)

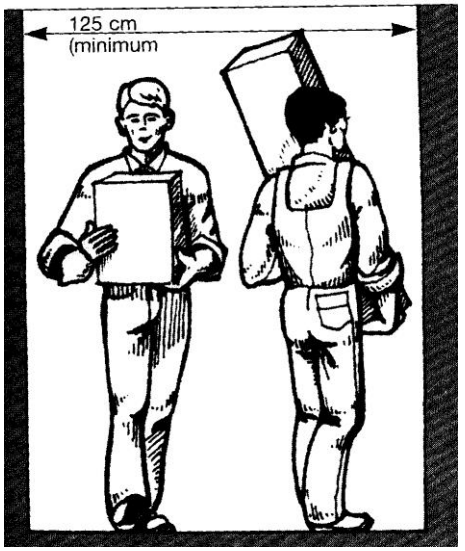


(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

Other ergonomic hazards

- Corridors that do not comply with regulations (human error)





(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

Human-error hazard-prevention planning

Engineering

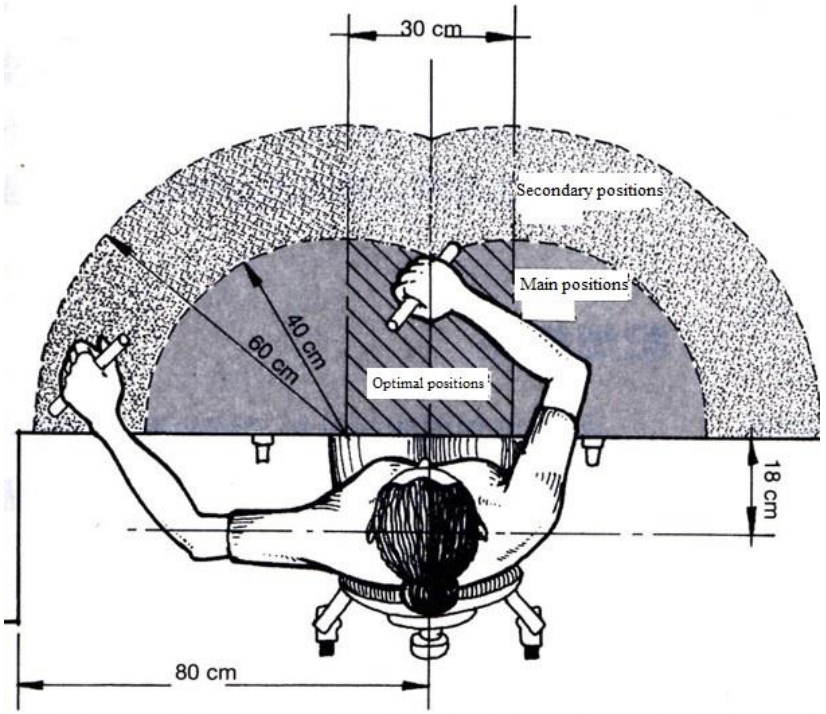
- Mechanical materials: safe material design
- Controller: Fool-proof (error-prevention) safety design

Management

- Suitable personnel
- Suitable time
- Suitable work
- Suitable regulations

Workstation design and human-error prevention

- Engineering
  - Mechanical materials: safe material design
  - Controller: Fool-proof (error-prevention) safety design
- Prevents fatigue
  - Reduces unnecessary actions
- Prevents errors
  - Reduces erroneous actions



(The Complete Handbook of Ergonomics, translated by the Taiwan Environmental Occupational Medicine Associatio
TTV Cultural Enterprise, 1998.)

Instrument control and human-error prevention

Compatibility

- Compatibility of space
  - Whether the spatial correspondence between the display and the control is consistent with the user's perception
- Compatibility of motion
  - Whether the directions of movement of the pointer or the scale of the gauge, knob, or joystick are consistent.
- Compatibility of culture
  - Whether the conceptual models of the designer and the user are consistent.

Functions of division of labor, specialization, and consultative organization

Leadership management and employee participation

- Good leadership management
- Employees participate and communicate adequately
- Assignment of responsibilities
- Consultative organization

(Dan Macleod, *The Ergonomics Kit for General Industrial with Training Disc* , Lewis Co. 1999.)

Mechanisms for inspecting the effectiveness of ergonomic-hazard prevention

- Safety inspection
  - Mutual inspection
  - Internal inspection
  - External inspection

Ergonomic-hazard identification checklist

Items		Score				
Essential items	Reference details	Needs to be improved urgently (0)	Needs to be improved (1)	Acceptable (2)	Good (3)	Excellent (4)
Ergonomic factors	1. Is the height of the equipment platform appropriate ?					
	2. Is the height of the rack for transporting or placing carts appropriate ?					
	3. Are the positions of the controls within the normal range of motion of the controller's arms ?					
	4. Is it possible to operate or carry in a normal posture without bending over ?					
	5. Do tools, chairs, or workbenches fit the body sizes of most people ?					
	6. Is the staff's working space sufficient and not crowded ?					
	7. Is there enough space for employees with a large build to operate ?					

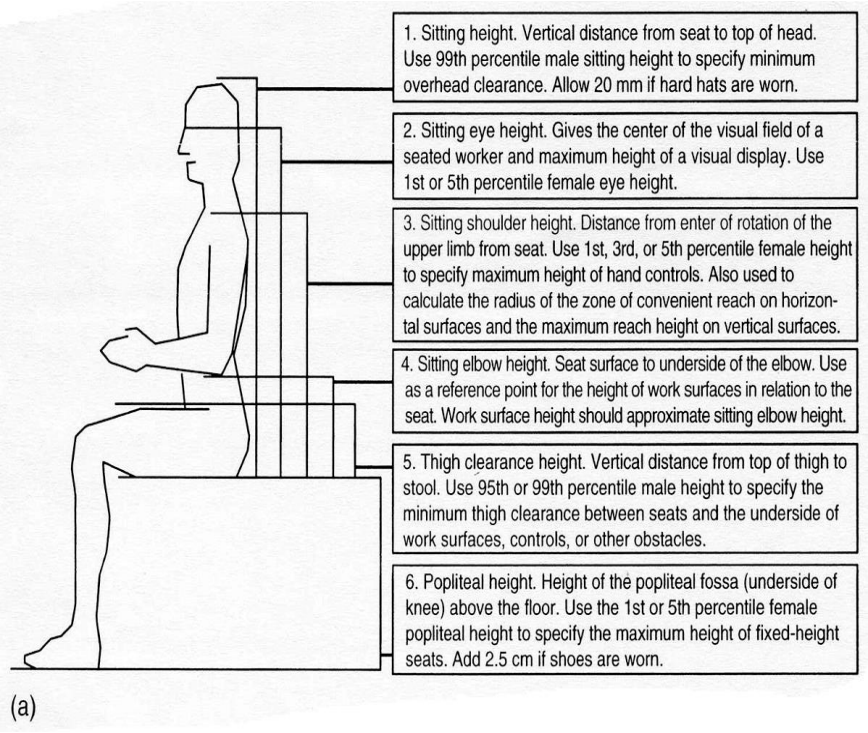
- Checklist

An example of ergonomics : designing a laboratory platform

- In-class project: design the height of the laboratory platform
- Use anthropometric methods
- Calculate the height of the laboratory platform

Answers: designing a laboratory platform (1)

- Use anthropometric methods to calculate the anthropometric data for the entire class
  1. Use a measuring tape to measure the height of the elbow when sitting down. This is the sitting height for the work platform.
  2. Find the average for the group.



Ref: R.S.Bridger 2009

Answers: designing a laboratory platform (2)

- Calculate the anthropometric data for the entire class
  1. Use a measuring tape to measure the height of the elbow when standing. This is the standing height for the work platform.
  2. Find the average for the group.

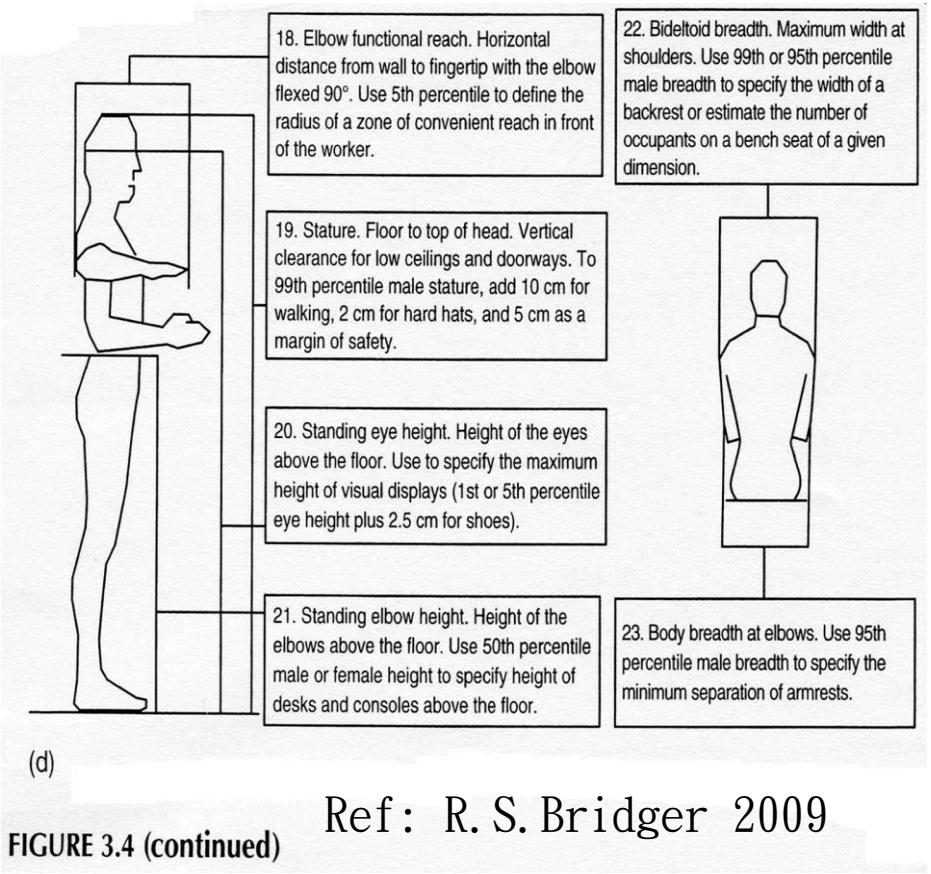


FIGURE 3.4 (continued)

Ref: R.S.Bridger 2009

An example of ergonomics: designing a computer workstation

- In-class project: computer workstation height
- Use anthropometric methods
- Calculate the following for computer workstations:
  - Height: Monitor, chair, desk
  - Size: Seat depth, other space

Sources

- Authors: Chih-Wei Lu, associate professor, Department of Industrial and Systems Engineering, Chung Yuan Christian University;Yung-Hui Li, visiting professor, Department of Industrial Engineering and Enterprise Information, Tunghai University (2017/3/16)

- References:

1. Chih-Wei Lu, Ergonomics, ROC year 100. Department of Industrial and Systems Engineering, Chung Yuan Christian University.
2. Chin-Shun Cheng, Brief description of hazard identification and operation evaluation, 2011. Head of the Labor Inspection Office, Department of Labor, Taipei City Government.
3. Bridger R.S., Introduction to Ergonomics,2009, Third Edition, CRC Co.
4. US Department of Health and Human Service, National Institute of Environment Health Science, NIEHS, Safety, Health and Safety Guide to Laboratory Ergonomics

Laboratory ergonomics self-checklist (1/5): computer workstation

		Yes	No
1.	Is there a chair?.....	[ ]	[ ]*
2.	Can the chair height be adjusted to the standard height? ...	[ ]	[ ]*
3.	Is there a lumbar support on the chair?.....	[ ]	[ ]*
4.	Is there foot support for the chair?.....	[ ]	[ ]*
5.	Is there sufficient space to place the feet?.....	[ ]	[ ]*
6.	Is the adjustment mechanism of the chair easy to use? …	[ ]	[ ]*
7.	Is there enough space on the desk to place the keyboard and the computer?…….....	[ ]	[ ]*
8.	Is the monitor placed at arm's length?.....	[ ]	[ ]*
9.	Is the monitor placed at the suggested height?.....	[ ]	[ ]*
10.	Is there a document stand?	[ ]	[ ]*

Source : NIEHS, Safety, Health and Safety Guide to Laboratory Ergonomics

Laboratory ergonomics self-checklist (2/5): standing workstation

	Yes	No
1. If it is a standing workstation, is an anti-fatigue mat provided?.....	[ ]	[ ]*
2. Is the height of the working platform appropriate for the user's height?...	[ ]	[ ]*
3. Is there proper space for placing the feet?	[ ]	[ ]*
4. Does the desk have sharp edges that cause pressure on the forearm?.....	[ ]	[ ]*

Source:NIEHS, Safety, Health and Safety Guide to Laboratory Ergonomics

Laboratory ergonomics self-checklist (3/5): microscope workstation

		Yes	No
1.	Does the user have to bend down or hunch?.....	[ ]*	[ ]
2.	Does the user's neck bend forward at > 25°?……..	[ ]*	[ ]
3.	Is the forearm in contact with sharp desk edges that can cause pressure?.....	[ ]*	[ ]
4.	Is the microscope placed on the edge of the desk?.....	[ ]	[ ]*
5.	Is there support for the forearm, or is a soft cushion provided? ...	[ ]	[ ]*
6.	Is there sufficient space for placing the legs and feet?.....	[ ]	[ ]*
7.	Is there proper foot support?……..…	[ ]	[ ]*
8.	Did the user receive training in the operating posture for the microscope?.....	[ ]	[ ]*
9.	Is appropriate rest time specified?…….....	[ ]	[ ]*

Source:NIEHS, Safety, Health and Safety Guide to Laboratory Ergonomics

Laboratory ergonomics self-checklist (4/5): micropipette workstation

		Yes	No
1.	Is a manual micropipette used?.....	[ ]*	[ ]
2.	Is an electronic micropipette used? ……	[ ]	[ ]*
3.	Is a batch-type micropipette used?.....	[ ]	[ ]*
4.	Is there any design feature on the micropipette to prevent contact pressure?.....	[ ]	[ ]*
5.	Has the user been trained in micropipette-operating postures?.....	[ ]	[ ]*
6.	Does the user use the micropipette for more than two hours per day?…….....	[ ]*	[ ]
7.	Are there frequent breaks during operation?…….	[ ]	[ ]*
8.	Is the drip volume of the micropipette controlled by a machine or manually?.....	[ ]	[ ]*

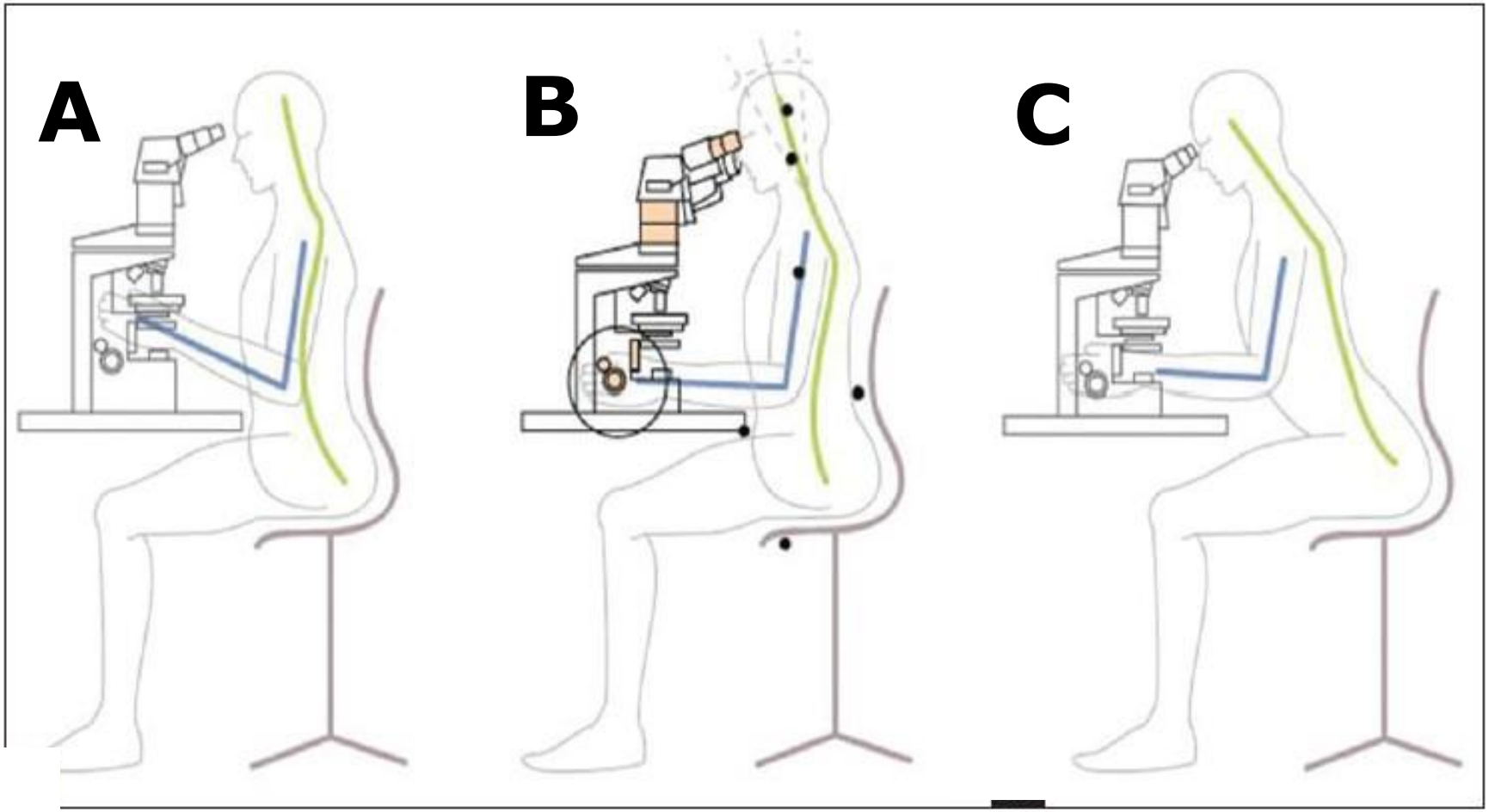
Source: NIEHS, Safety, Health and Safety Guide to Laboratory Ergonomics

Laboratory ergonomics self-checklist (5/5): precision work workstation

		Yes	No
1.	Is the minimum processing quantity allowed for various types of solutions?.....	[ ]	[ ]*
2.	Does the number of hours of operating slicers or microprocessors exceed five per week?	[ ]*	[ ]
3.	Are there regular breaks during operation?.....	[ ]	[ ]*
4.	Is there contact compression between the forearm and the operation platform?.....	[ ]*	[ ]
5.	Does the microtome or cryostat force the wrist to bend or stretch excessively?	[ ]*	[ ]
6.	Does the height of the working surface reduce the abduction angle of the upper arm?.....	[ ]	[ ]*
7.	Is a mechanical microtome or cryostat used?….	[ ]	[ ]*
8.	Is an adjustable chair used?.....	[ ]	[ ]*

Source:NIEHS, Safety, Health and Safety Guide to Laboratory Ergonomics

Spot the differences (2/3)



Spot the differences (3/3)

A

B

Sources

- Author: Chih-Wei Lu, Chung Yuan Christian University Team
- Editor: Yung-Hui Li, Chang Jung Christian University Team