Ergonomics
人类工效学

Contents
目录

Ergonomics Definition
人类工效学定义

Operator and equipment are a unified system.

操作人员和设备是一个统一的系统。

…The application of human biological science in conjunction with the engineering sciences to achieve the optimum mutual adjustment of man and his work, the benefits being measured in terms of human efficiency and well-being.

——International Labor Office (ILO)

人类生物科学与工程科学相结合的应用，以实现人与工作的最佳相互调整，其效益以人的效率和福祉来衡量。

——国际劳工局

Ergonomics Hazards
人类工效学危害

- Ergonomic stresses can impair the health & efficiency of the worker
  人类工效学压力会损害工作者的健康和工作效率

- Such stresses can also render workers more prone to major accidents
  这种压力也会使工人更容易发生重大事故

Common Activities Where Ergonomics is Important
人类工效学重要的常见活动

Manual handling of heavy loads
手工搬运重物

- Every year, at least 10 million workers in China suffer back injuries, which account for about one-fifth of all work-related accidents.
  每年我国至少有1千万工人背部受到伤害，此类伤害大约占到工伤事故的五分之一。

- Most lifting accidents result in back muscle strains or sprains due to improper posture, prolonged exertion, or repetitive movements.
  大部分搬运事故导致背部肌肉扭伤或拉伤，由于用力姿势不当/长时间/过度重复性动作。

- The key point in manual handling is to maintain the body's normal four physiological curves and minimize pressure on the spine.
  手工搬运中的关键要点就是要保持身体的正常四个生理弯曲，尽量减少对脊柱的压力。

Repetitive motions
重复动作

- Tasks that involve repeated movements can lead to disorders of the muscles, joints and tendons, even when the individual actions do not involve excessive load or force.
  涉及重复动作的任务可能导致肌肉、关节和肌腱失调，即使单个动作不涉及过度负荷或力量。

Use of display screens
使用屏幕

- Many types of computerised equipment used in laboratories, offices incorporate a display screen and some kind of data entry device such as a keyboard or mouse.
  在实验室、办公室工作中使用的许多类型的计算机化设备都包括一个显示屏和某种数据输入设备，如键盘或鼠标。

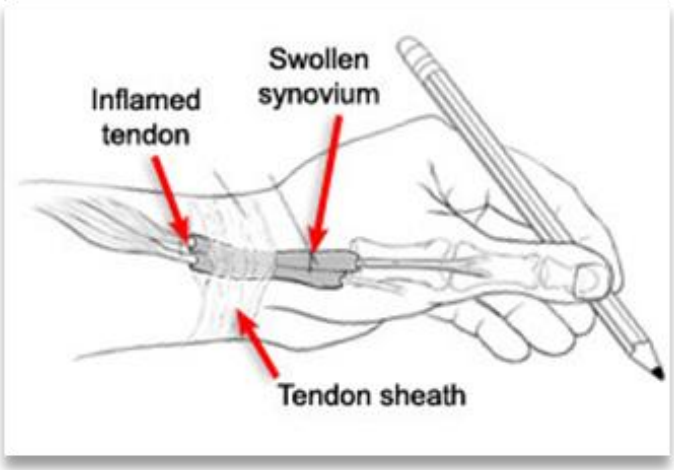
- These range from fatigue or soreness in the arm, hand and shoulder areas to chronic soft tissue disorders like carpal tunnel syndrome - inflammation of the sheath surrounding the tendons that flex the fingers.
  产生的症状包括手臂、手部和肩部的疲劳或疼痛，以及腕管综合征等慢性软组织疾病—指屈肌腱周围的腱鞘发炎。

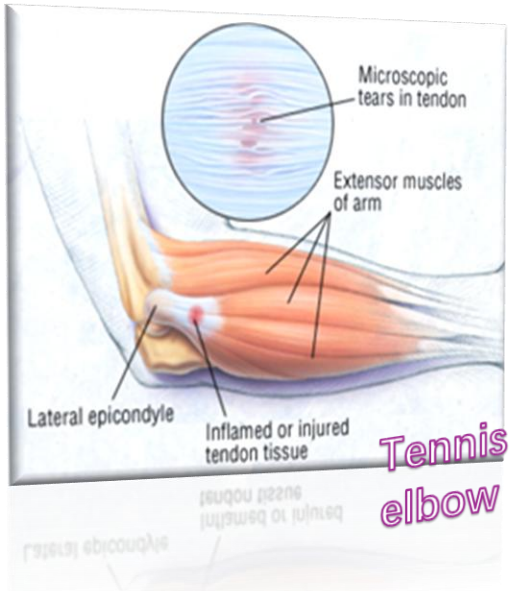
- Other Symptoms described by DSE（Display Screen Equipment）users reflect stresses arising from the user's task. May be secondary to upper limb or visual problems but more likely caused by poor job design or work organisation, lack of control of the work by the user, under-utilisation of skills, high-speed repetitive working or social isolation.
  其他由显示屏设备（DSE）用户描述的症状反映了用户任务带来的压力。这些症状可能与上肢或视觉问题有关，但更可能是由工作设计或工作组织不佳、用户对工作缺乏控制、技能利用不足、高速重复性工作或社交孤立引起。

Ergonomic Injuries
人类工效学损伤

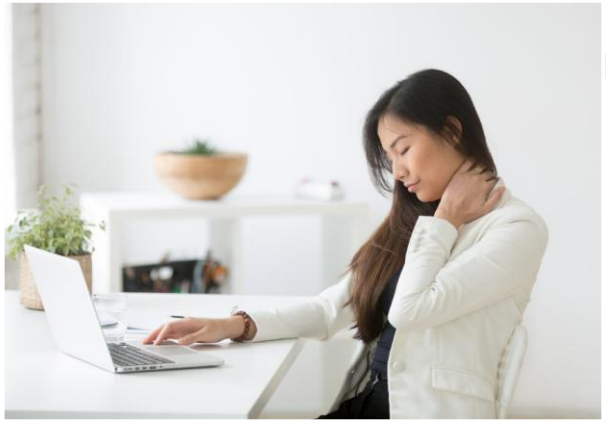
- **Mechanical Stresses/ Stretches**
  机械应力/拉伸
  - Back injuries
    背部受伤
  - Slipped (vertebrate) discs
    （脊椎动物）椎间盘滑动
  - Ligament (bone to bone) sprain
    韧带（骨头间）扭伤
  - Muscle and tendon (muscle to bone) strain
    肌肉和肌腱（肌肉和骨头间）拉伤

- **Occupational Cumulative Trauma Disorders (CTD) or Repetitive Strain Injury (RSI)**
  职业性累积创伤障碍（CTD）或重复性劳损（RSI）
  - Tendon disorders: Inflammation of tendon sheath
    肌腱疾病：肌腱鞘炎症
  - Nerves disorders: Carpal tunnel syndrome
    神经障碍：腕管综合征
  - Vessel disorders: Raynaud's syndrome
    血管疾病：雷诺氏综合征





Factors Contributing to Work-related Musculoskeletal Disorders (WMSDs)
导致与工作相关的肌肉骨骼失调证的因素



Static neck, back, and shoulder postures
静止的颈部、背部和肩部姿势

Grasping small instruments for prolonged periods
长时间握住小仪器

Prolonged use of vibrating hand tools
长时间使用振动手动工具

《职业病分类和目录》国卫职健发〔2024〕39号

◆ **Occupational diseases caused by physical factors**
物理因素所致职业病

- Arm vibration disease
  手臂振动病

◆ **Occupational musculoskeletal disorders**
职业性肌肉骨骼疾病

- Carpal tunnel syndrome (limited to manufacturing workers who perform repetitive or strenuous tasks involving the wrist for long periods of time)
  腕管综合征（限于长时间腕部重复作业或用力作业的制造业工人）
- Bursitis (limited to underground workers)
  滑囊炎（限于井下工人）

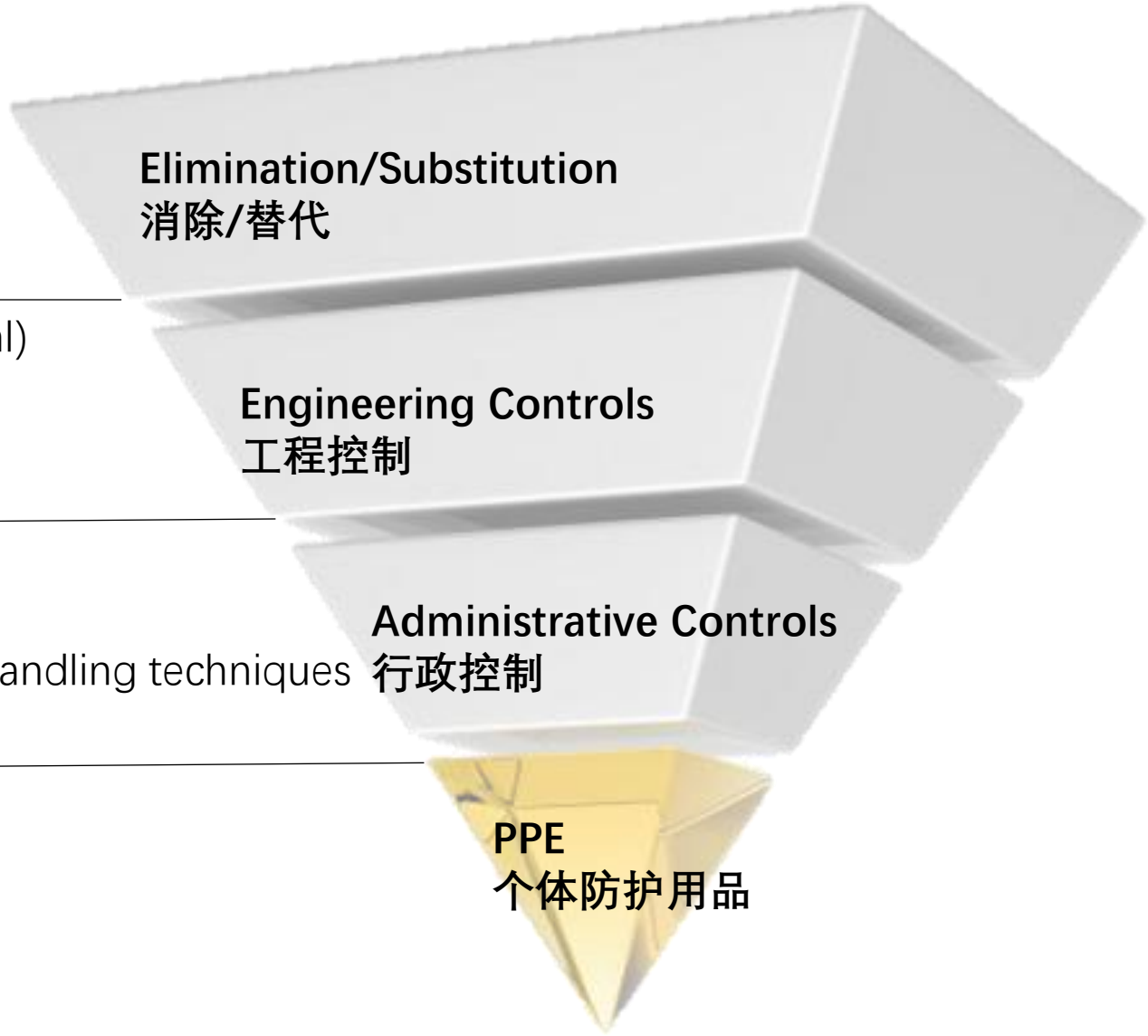
Ergonomic Hazard Controls
人类工效学危害控制

Avoided the task
避免任务

Equipment design (biomechanical & behavioral)
设备设计（生物力学和行为学）
Work station design
工作区设计

Work-rest scheduling
作息安排
Training on correct postures and manual handling techniques
训练正确的姿势和手动操作技巧

To support the body
用来支持身体



- The task
  任务
- The load
  负荷
- The working environment
  工作环境
- The capabilities of the individual
  个人能力

- Is the operation essential? Can it be avoided?
  搬运是必要的吗？可以避免吗？
- Consider the shape, size, weight and special difficulties of a load.
  考虑负载的形状、大小、重量和特殊困难。
- How can it be handled?
  怎么搬运？
- Where is it moved from and to, and how often? Repetitive bending, twisting movements increase the risk.
  从哪里移动到哪里，频率？重复的弯曲、扭转动作会增加风险。
- Does the working environment add to the risk of injury?（e.g., Slippery floors，cramped environment）
  工作环境会增加受伤的风险吗？（如：湿滑的地面，环境拥挤）
- Are the task and the workplace adapted to the individual? （e.g., Working heights of benches）
  任务和工作场所是否适合个人？（如：工作台的工作高度）
- Consider possible remedial measures (e.g. it may be possible to use mechanical aids or breakdown the load)
  考虑可能的改进措施（如，可使用机械辅助设备或分解负荷）

Where it is reasonably practicable to do so, people involved in manual handling operations should be provided with precise information about the weight of each load, and about the heaviest side of any load whose centre of gravity is not positioned centrally.
在合理可行的情况下，应向从事手工搬运作业的人员提供准确的资料，说明每件货物的重量，以及任何货物的重心不在中央的最重一侧。

表 C.1　不同人群的参考质量(m_{ref})

应用范围	m_{ref} kg	受保护人群的比率 %			人群	
		男和女	女	男		
非职业的	5	无可用数据			儿童与老人	总人群
	10	99	99	99	普通居家人群	
职业的	15	95	90	99	包括年轻人与年老人的普通工作人群	普通工作人群
	20					
	23	85	70	95	成年工作人群	
	25	见注			专职工作人群	特殊情况下的专职工作人群
	30					
	35					
	40					

注：特殊情况。即使已尽全力避免手工操作或是风险已降低至最低水平，仍可能出现参考质量超过 23 kg 的特殊情况(例如，技术发展或是干预手段不够先进)。在这些特殊情况下，应重点关注与考虑对操作者的培训和训练(例如，有关风险识别和风险减小的专业知识)，以及常见的工作条件与操作者的个人能力。

CF=670 N　　CF=2 080 N

a)　符合工效学要求的提举方法　　b)　存在风险的提举方法

图 B.2　一个人从地面抱起一个小孩

Manual lifting and moving: To reduce the risk to people at work, especially those with weak physical capabilities, the recommended weight limit should not exceed 15 kg.
手工操作提举与移送：为减小人们工作中的风险，尤其是身体能力较弱的人，质量推荐限值不宜超过 15 kg。

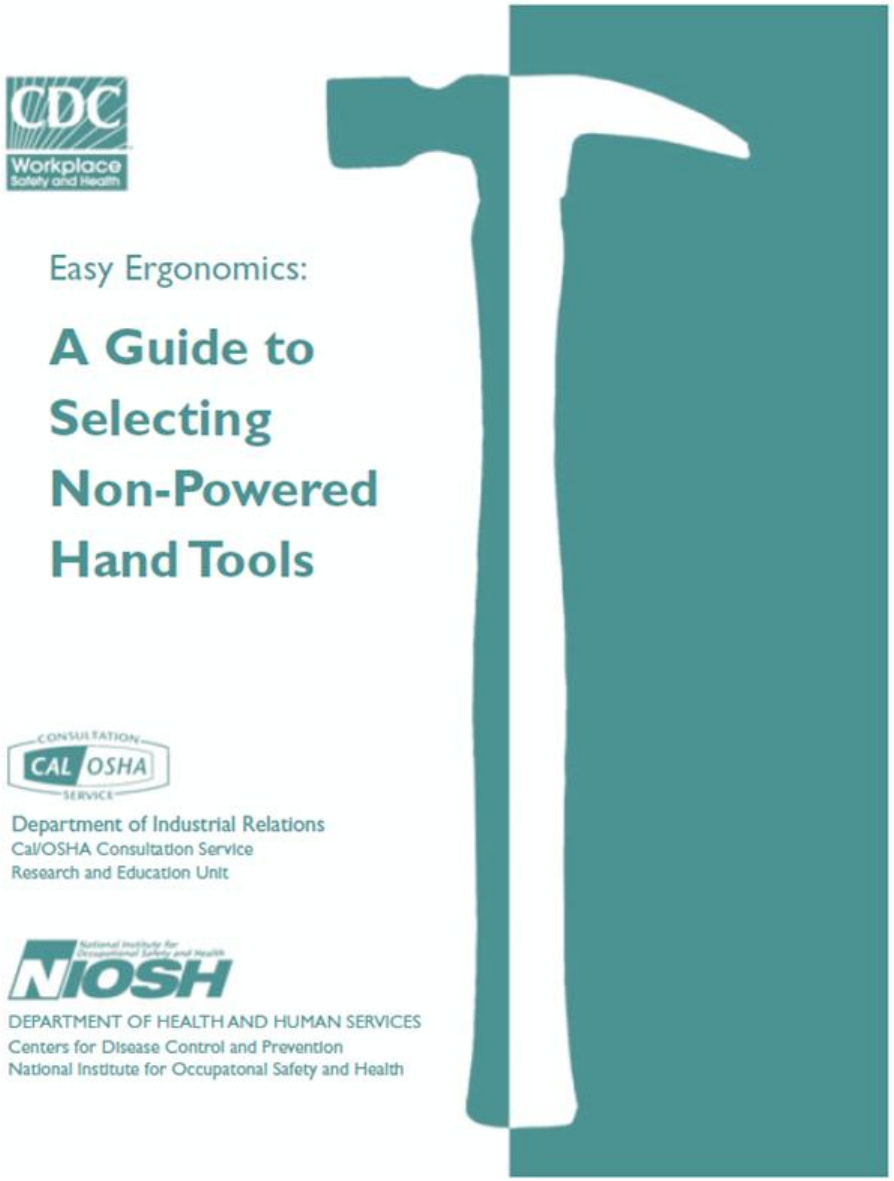
《人类工效学 手工操作 第1部分：提举与移送》（GB/T 31002.1-2014）

Good practice – Moving Centrifuge Rotors
良好实践——搬运离心机转子

Use tools such as wheeled carts to make heavy objects easier to move and reduce manual handling time.
使用带轮子的车等工具，使重物易移动，减少手工搬运时间。

Use the appropriate tools to lift heavy objects, distribute the weight evenly between your arms and waist, and keep the back of your waist straight when lifting heavy objects.
使用恰当工具提起重物，使双臂和腰部受力均衡，提起重物时腰背挺直。

Prepare the rotor for use to avoid increasing the number of times of lifting.
做好使用转子的准备工作，避免增加提起的次数。



https://www.cdc.gov/niosh/docs/2004-164/default.html

A. Know your job

Before you select a tool, think about the job you will be doing. Tools are designed for specific purposes. Using a tool for something other than its intended purpose often damages the tool and could cause you pain, discomfort, or injury. You reduce your chances of being injured when you select a tool that fits the job you will be doing.

The list of tools in each category shows a few examples of tools that are most frequently used.

Cutting, pinching, gripping tools

Examples:

- Pliers
- Snips
- Cutters

Striking tools

Example:

- Hammers

Driving tools

Examples:

- Screwdrivers
- Hand wrenches
- Nut drivers
- T-handle wrenches

Struck or hammered tools

Examples:

- Punches
- Chisels
- Nail sets

Next, consider whether you need the tool to provide power or precision. Then select the tool with the correct handle diameter or grip span.

For POWER tasks

Single-Handle Tools

HANDLE DIAMETER for power tasks is 1 1/4 inches to 2 inches

Double-Handle Tools

OPEN GRIP SPAN for power tasks is not more than 3 1/2 inches

CLOSED GRIP SPAN for power tasks is not less than 2 inches

For PRECISION tasks

Single-Handle Tools

HANDLE DIAMETER for precision tasks is 1/4 inch to 1/2 inch

Double-Handle Tools

OPEN GRIP SPAN for precision tasks is not more than 3 inches

CLOSED GRIP SPAN for precision tasks is not less than 1 inch

B. Look at your work space

Now look at your work space. Awkward postures may cause you to use more force. Select a tool that can be used within the space available. For example, if you work in a cramped area and high force is required, select a tool that is held with a **power grip**. A **pinch grip** will produce much less power than a power grip. Exerting force with a pinch grip means you will work harder to get the job done.

pinch grip

power grip

If you work in a cramped space, you may not be able to use a long-handle tool. Use of a long-handle tool may cause awkward postures or harmful contact pressure on your hand as you use more force. Instead, use a tool that fits within the work space. A short-handle tool can help you reach your target directly as you keep your wrist straight.

long-handle tool

short-handle tool

C. Improve your work posture

Awkward postures make more demands on your body. In some cases, the placement of the work piece will affect your shoulder, elbow, wrist, hand, or back posture. Whenever possible, choose a tool that requires the least continuous force and can be used without awkward postures. The right tool will help you to minimize pain and fatigue by keeping your neck, shoulders, and back relaxed and your arms at your sides.

For example, avoid raising your shoulders and elbows. Relaxed shoulders and elbows are more comfortable and will make it easier to drive downward force.

If you are sitting ...

Stand

If you are standing ...

Reposition your work piece

Work on a lower work surface

D. Select the Tool

Over time, exposure to awkward postures or harmful contact pressures can contribute to an injury. You can reduce your risk of injury if you select hand tools that fit your hand and the job you are doing.

Tips for Selecting Hand Tools

Tools used for **power** require **high force**. Tools used for **precision or accuracy** require **low force**.

1 For single-handle tools used for power tasks: Select a tool that feels comfortable with a handle diameter in the range of 1 1/4 inches to 2 inches. You can increase the diameter by adding a sleeve to the handle.

Tool with sleeve

2 For single-handle tools used for precision tasks: Select a tool with a handle diameter of 1/4 inch to 1/2 inch.

3 For double-handle tools (plier-like) used for power tasks: Select a tool with a grip span that is at least 2 inches when fully closed and no more than 3 1/2 inches when fully open. When continuous force is required, consider using a clamp, a grip, or locking pliers.

Closed grip span

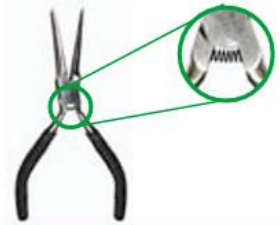
Open grip span

4 For double-handle tools (plier-like) used for precision tasks: Select a tool with a grip span that is not less than 1 inch when fully closed and no more than 3 inches when fully open.

Closed grip span

Open grip span

5 For double-handled pinching, gripping, or cutting tools: Select a tool with handles that are spring-loaded to return the handles to the open position.



6 Select a tool without sharp edges or finger grooves on the handle.

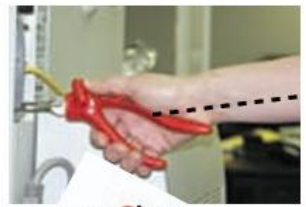
7 Select a tool that is coated with soft material. Adding a sleeve to the tool handle pads the surface but also increases the diameter or the grip span of the handle (see 1, 2, 3, or 4 above).

8

Select a tool with an angle that allows you to work with a straight wrist.

Tools with bent handles are better than those with straight handles when the force is applied horizontally (in the same direction as your straight forearm and wrist).

Straight handle



Bent handle

Tools with straight handles are better than those with bent handles when the force is applied vertically.

Straight handle

Bent handle

9

Select a tool that can be used with your dominant hand or with either hand.

10

For tasks requiring high force: Select a tool with a handle length longer than the widest part of your hand – usually 4 inches to 6 inches.

Prevent contact pressure by making sure the end of the handle does not press on the nerves and blood vessels in the palm of your hand.

If the handle is too short, the end will press against the palm of your hand and may cause an injury.

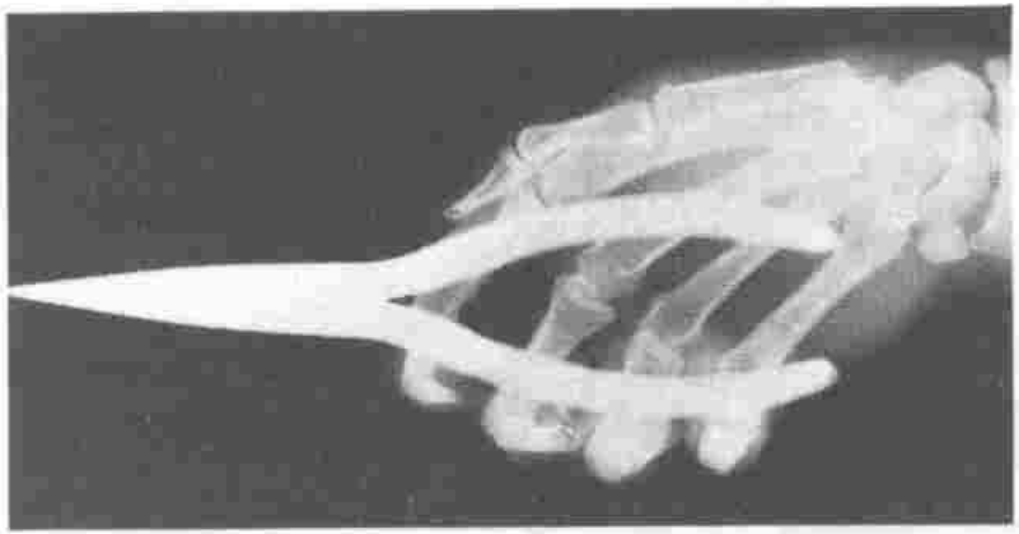
11

Select a tool that has a non-slip surface for a better grip. Adding a sleeve to the tool improves the surface texture of the handle. To prevent tool slippage within the sleeve, make sure that the sleeve fits snugly during use.

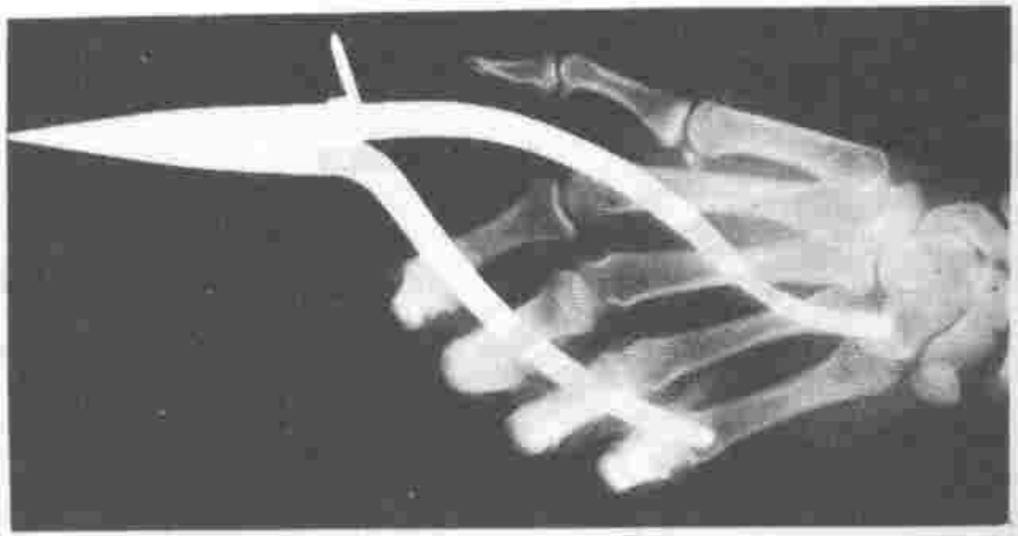
Remember: A sleeve always increases the diameter or the grip span of the handle (see 1, 2, 3, or 4 above).

Tools and sleeves

Equipment Design Example
设备设计实例

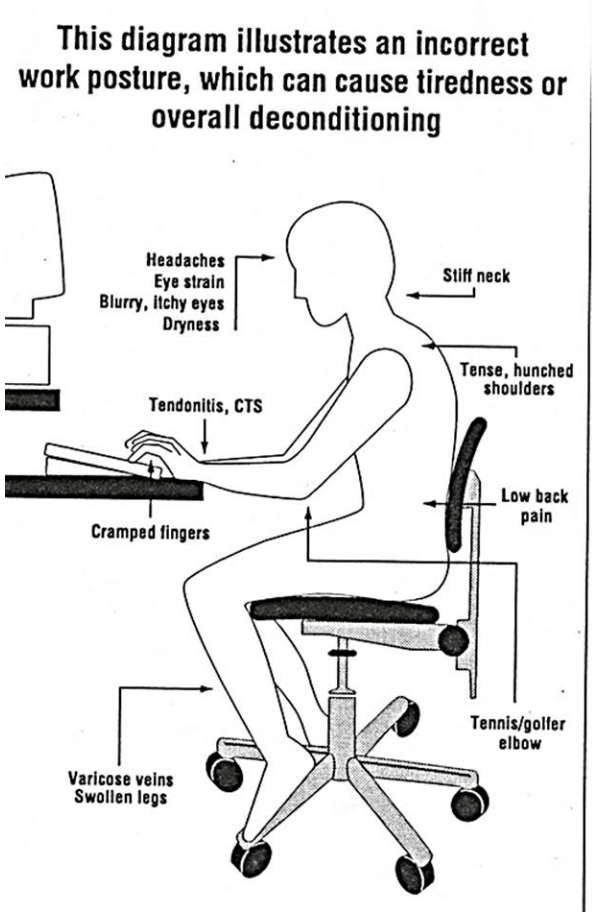


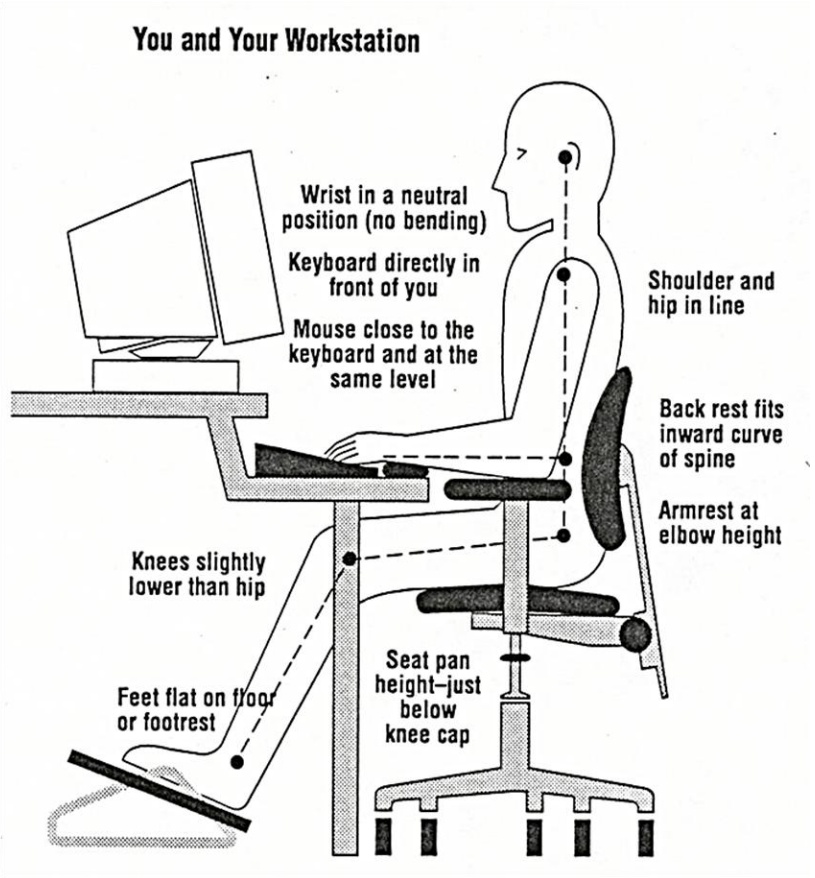
(a) Conventional design



(b) Redesigned pliers

Work station design
工作区设计





Office equipped with ergonomic chairs
办公室配备符合人类工效学椅

Neck support, shaped to fit the neck
颈部支撑，形状贴合颈部

Waist support, shaped to fit the waist
腰部支撑，形状贴合腰部

The seat is adjustable in height and suitable for desks of different heights
座椅可升降，适用于不同高度的桌面

手臂支撑
Arm support

PPE Against Ergonomic Hazards
防止人体工程学危害的个人防护装备

Reference
参考

- 《人类工效学 手工操作 第1部分：提举与移送》（GB/T 31002.1-2014）
- 《职业病分类和目录》（国卫职健发（2024）39号）
- A Guide to Selecting Non-Powered Hand Tools （NIOSH）