ON –LINE LECTURE

Course Code : FMPE-510

Course Title : Ergonomics and Safety in Farm Operations

for

M. Tech and Ph.D Students of CAET Godhra

By

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Muscular system

- It provides power for performing mechanical work.
- The muscles transform chemical energy into physical activities.
- Efficiency of the system is about 20 -25%.
- In combination with skeletal system it's perform various work like moving parts of the body, carrying loads and manipulating objects.

Muscular System…

- **Muscles** – They are made up from several to thousands or millions of muscle fibers (ligaments) when bound together in bundles.
- The bones of our body are held together at their joints by means of these ligaments (muscles).
- A single motor nerve fiber which innervates a group of muscles fibers within a muscle is called a motor unit.
- All the muscle fibers served by same motor nerve contract and relax at the same time working as a unit.

➢ Classification of muscle

- **Smooth muscle:** (stomach muscles) which are automatic, contract and extend without requiring an external nerve supply and relatively slow in contracting.
- **Cardiac muscle :** (muscles of the heart) are also automatic and contract more rapidly than smooth muscle. Important property of self exciting.
- **Skeletal muscle :** (biceps muscles) contract and extend voluntarily under some external stimuli and hence called voluntary muscles. They are more rapid in contracting than cardiac and smooth muscles. They are more important in locomotion and movement and hence more interested to the ergonomist.

- **Chemical reactions during muscular contractions**
  - ✓ **Anaerobically (i.e. in the absence of oxygen)**
  - ✓ **Aerobically (i.e. in the presence of oxygen)**

- **The anaerobic breakdown of adenosine triphosphate (ATP) in the muscle generates the energy for muscle contraction to take place.**
- **There are several sources of ATP available for the muscles.**

1. **ATP stored in the cell:** **A small amount of ATP is stored in the cell and readily available to support muscle contraction.**

✓ **It support approximately 1 second of muscle contraction.**

$$ATP \longrightarrow ADP + P + Energy$$

2. **ATP-CP system:** **A small amount of creatine phosphate (CP) is also stored in the cells.**

✓ **It support approximately 2-3 second of muscle activity.**

$$CP \longrightarrow P + C + Energy$$

$$ADP + P + energy \longrightarrow ATP$$

3. **Anaerobic glycolysis:** **Glucose stored in the cell or diffused into the cell from the circulatory system can be broken down anaerobically (without oxygen) to generate ATP for muscle contraction.**

$$\text{Glucose} + P + ADP \longrightarrow ATP + \text{lactic acid}$$

- ✓ **The body has tolerance limit for lactic acid accumulation. It is reached in 35-45 s.**
- ✓ **The body has less than 1 min to generate maximal level of muscle contraction.**

4. **Aerobic glycolysis:** For most activities, glycogen (or fats or proteins) are broken down chemically with oxygen to generate ATP.

$$\text{Glucose + free fatty acids + P + ADP + } O_2 \rightarrow$$

$$CO_2 + H_20 + \text{ATP}$$

- ✓ This process can continue for a few seconds to several hours depending on the level of demand of the activity.
- ✓ The fuels normally used for aerobic glycolysis is carbohydrates and fats.

Fuel source	Stored energy potential	Stored energy capacity
Fats	9.1 Kcal/ g	50,000 – 75,000 kcal
Carbohydrates	4.3 Kcal/g	1200 – 1500 Kcal

- **Functional characteristics of muscle tissues:**
  1. **Conductivity: ability to transmit impulse**
  2. **Irritability: ability to respond to a stimulus**
  3. **Extensibility: ability to stretched**
  4. **Elasticity: ability to return to their original length when stretching force is removed**
  5. **Contractibility: ability to contract or shorten**

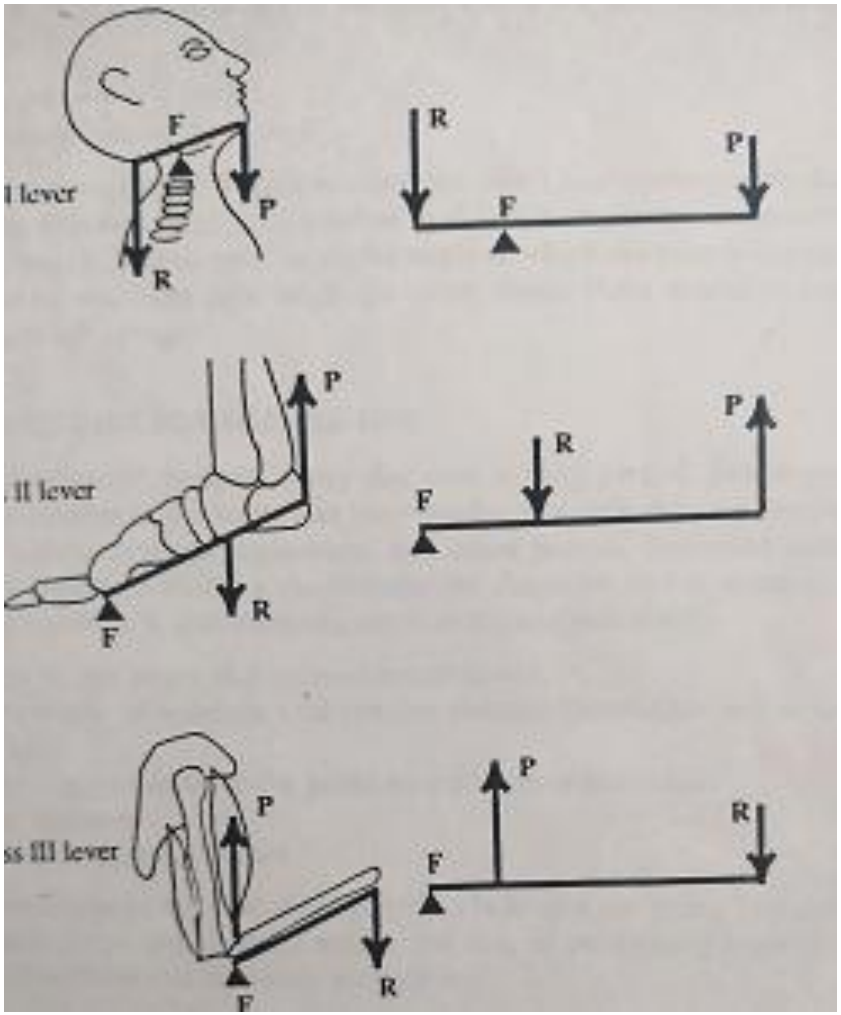
➢ Types of muscle contraction

1. **Isometric (static)**
2. **Isotonic (Dynamic)**
3. **Isokinetic (dynamic)**
4. **Isoinertial (dynamic)**
5. **Fibrillation:** abnormal contraction of the cardiac muscle without producing effective movement
6. **Convulsion:** abnormal or uncoordinated smooth contraction of a group of muscle.

First four are of concern in ergonomics and biomechanics.

Muscular System…

- **Musculoskeletal system as a lever system**
- ✓ **Class I: The joint (fulcrum)'F' lies between the force point (Where the muscle pulls on the lever) 'P' and resistance point 'R' (i.e. weight to be lifted).**
- ✓ **Class II: The resistance is between the joint (fulcrum) and the force (insertion) point.**
- ✓ **Class III: the force point is lies between the joint (fulcrum) and the resistance.**



➢ Mechanical Advantage

- ✓ **The segment of lever between the point of force exertion and the fulcrum is called the force arm.**
- ✓ **The segment between resistance and the fulcrum is called the resistance arm.**
- ✓ **The mechanical advantage (MA) is the measure of the efficiency of the movements of parts of the body which is computed as the ratio of the resistance overcome (R) to the force exerted (P).**

MA= Resistance overcome (R) / Force exerted (P)

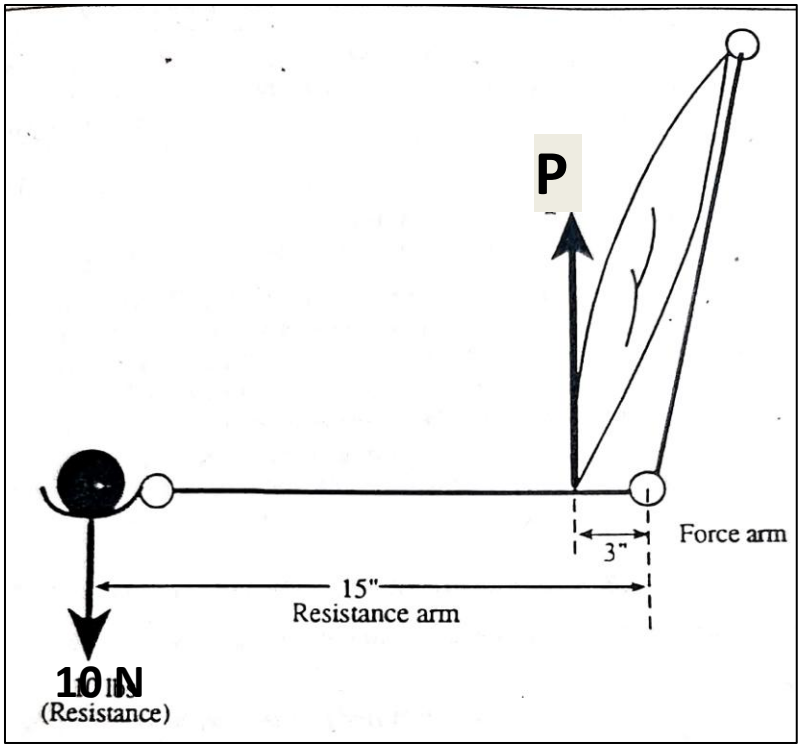
MA = Force arm / Resistance arm

Muscular System...

- MA = Force arm / Resistance arm

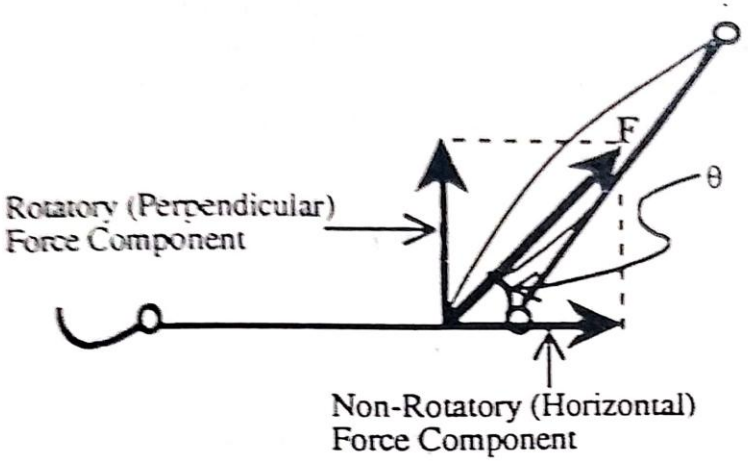
  = 3/15 = 0.2
- MA= Resistance overcome (R) / Force exerted (P)
- Force exerted (P)= Resistance overcome (R) /MA

  =10/0.2 =50 N



Muscular System…

- **Force Components**
  - ✓ **Rotary component:** Perpendicular to lever and contributing to the lever's movement
  - ✓ **Non- Rotary component:** Directed towards the fulcrum, parallel to the lever and not contributing to the lever movement



If we let θ be the angle between the direction of the force and the lever axis, then

Rotary Force= P Sin θ

Non- Rotary Force = P Cos θ

➢ Guidelines for muscle use in sitting posture

- **The hand is significantly stronger in pronation than during supination.**
- **The hand is significantly stronger when it is pulling downwards than when it is pulling upwards.**
- **The hand is more powerful when pushing than when pulling.**
- **Pulling strength is greatest at a grasping distance of 70 cm.**
- **Pushing strength is greatest at a grasping distance of 50 cm in front of the axis of the body.**

➢ Guidelines for muscle use in standing posture

- **The pushing force is greater than the pulling force.**
- **Both pushing and pulling forces are greater in the vertical plane than the horizontal plane.**
- **A pushing and pulling forces are of the same order of magnitude whether the arms are held out side ways or forwards.**

THANK YOU