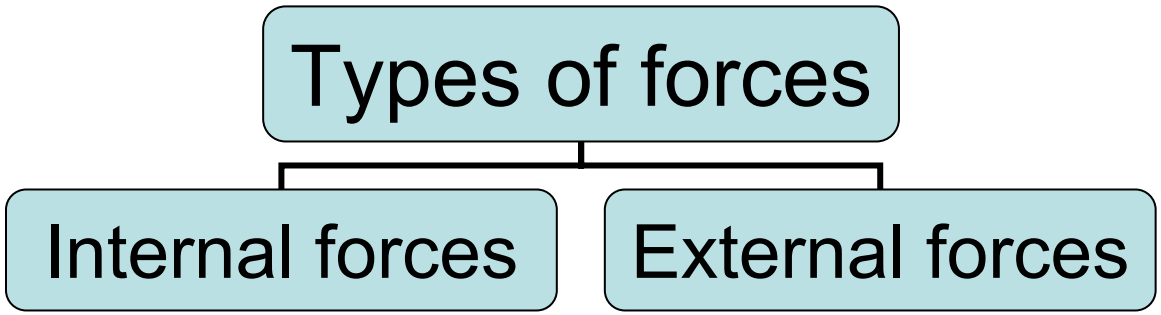
Introduction to Force

Kinesiology
RHS 341
Lecture **6**
Dr. Einas Al-Eisa

Definition

- Force = a physical quantity that tends to change the state of an object (e.g., accelerate or decelerate) or change the shape of an object

  - Force can either be a push (compression) or a pull (tension)
  - Fore may cause (start), prevent (stop), or modify motion


Types of forces
Internal forces
External forces

Internal forces

- = forces inside the body

  - **Muscle** force: produced by muscle contraction
  - **Ligament** force: produced by ligament pull (when the ligament is stretched)
  - **Joint reaction force**: between the articular surfaces of a joint

External forces

- = outside forces acting upon the body
- can be used to assist or resist the patient's own muscle contraction

External forces

- **Gravitational force**: tends to pull the body downwards
- **Ground reaction force**: exerted on the body by the ground
- **Friction**: between contact surfaces
- **Pressure**: exerted over the area of contact between two bodies
- **Resistance**: such as water resistance

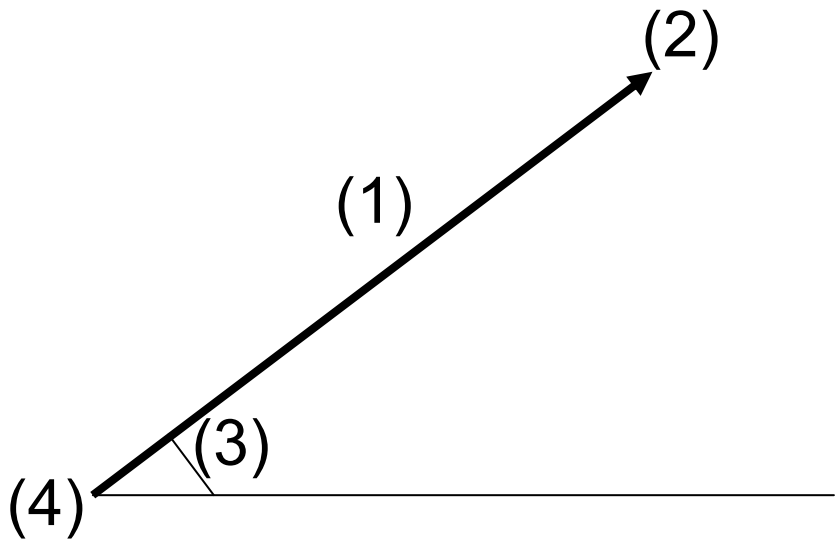
Force

- Force is a **vector** quantity (because it has both magnitude and direction)
- Force can be represented graphically by an arrow (like other vectors)

Force

- To describe force, it is necessary to describe its:
  1. **Magnitude**: which is proportional to the length of arrow
  2. **Direction**: indicated by the arrow head
  3. **Action line** (angle of pull): indicated by the angle of the arrow with the horizontal line
  4. **Point of application**: indicated by the tail of the arrow

(1) Magnitude
(2) Direction
(3) Angle (action line)
(4) Point of application



Force systems

- Force system = any group of two or more forces

- Two or more forces may be:
  - **Colinear**: acting along the same action line
  - **Coplanar**: acting in the same plane
  - **Concurrent**: acting in the same point

Composition of forces

- Usually, many forces act on the human body simultaneously (at the same time)

- It is important to know the final (combined) effect of these forces, so it is described as a single force called the ***resultant force***

Resultant force

- = the simplest force that can produce the same effect as all the forces acting together

- = the sum of all forces acting on the body or body segment

Composition of forces

- Composition of forces = the process of finding the resultant force, which can be expressed using the equation:

$$\vec{R} = \vec{F1} + \vec{F2} + \vec{F3} + \ldots\ldots \vec{Fn}$$
$$= \sum \vec{F}$$

R means the resultant

F means force (the arrow indicates vector quantity)

∑ means “the sum of”

Composition of forces

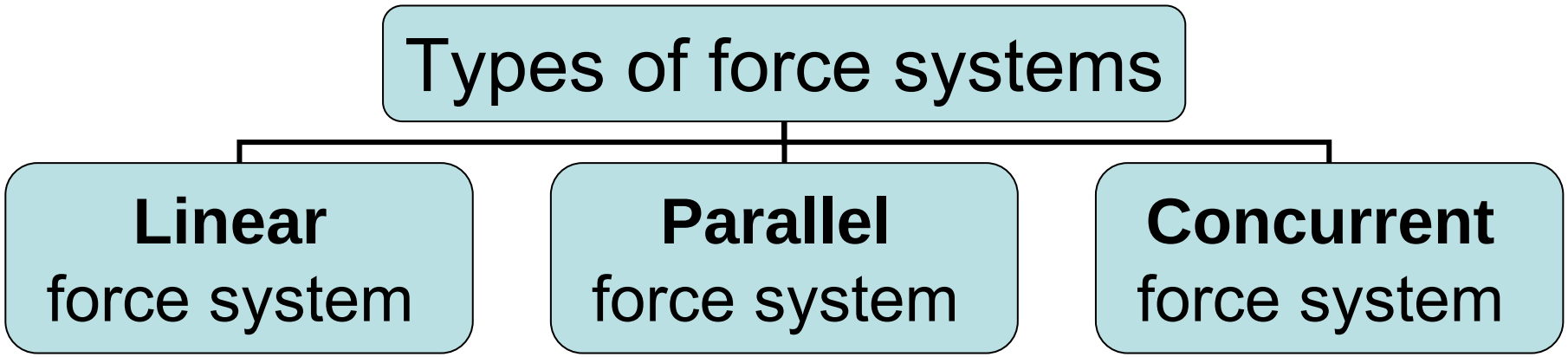
- When the resultant force is zero ⟶

  the force system is said to be in equilibrium

⟶ no motion (no change in position)

- When the resultant force is not zero

⟶ motion occurs


Types of force systems
Linear force system
Parallel force system
Concurrent force system

Linear force system (colinear)

- When all the forces occur along the same action line
- Forces may act in the same direction or opposite direction
- May produce tension or compression effects

Linear force system (colinear) Example

- Cervical traction –

  2 forces in opposite direction:

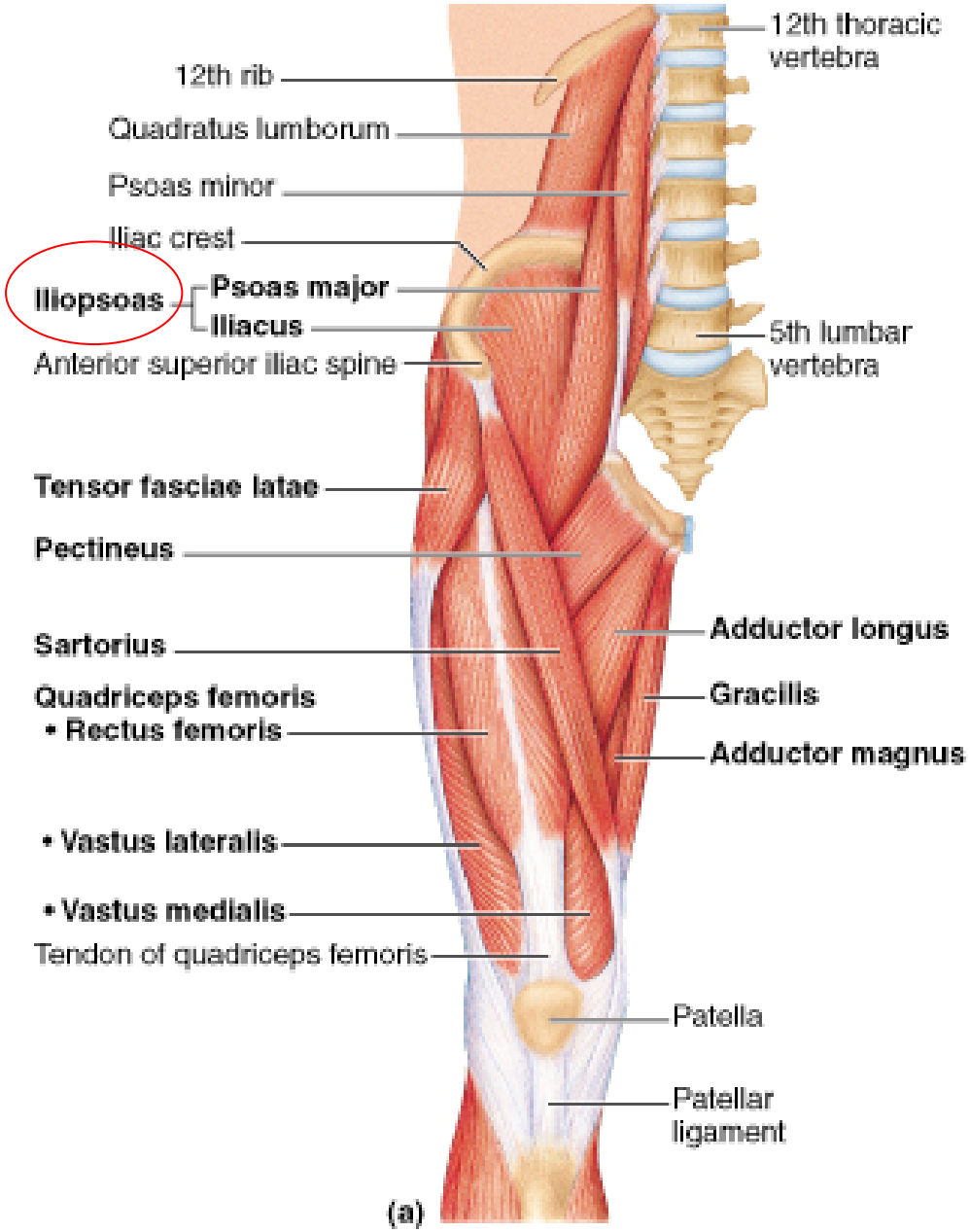
  - Traction force by the machine
  - The weight of the head

Linear force system (colinear) Example

- P**soas major** and **iliacus** muscles act along the same action line, point of application, and *same direction*.

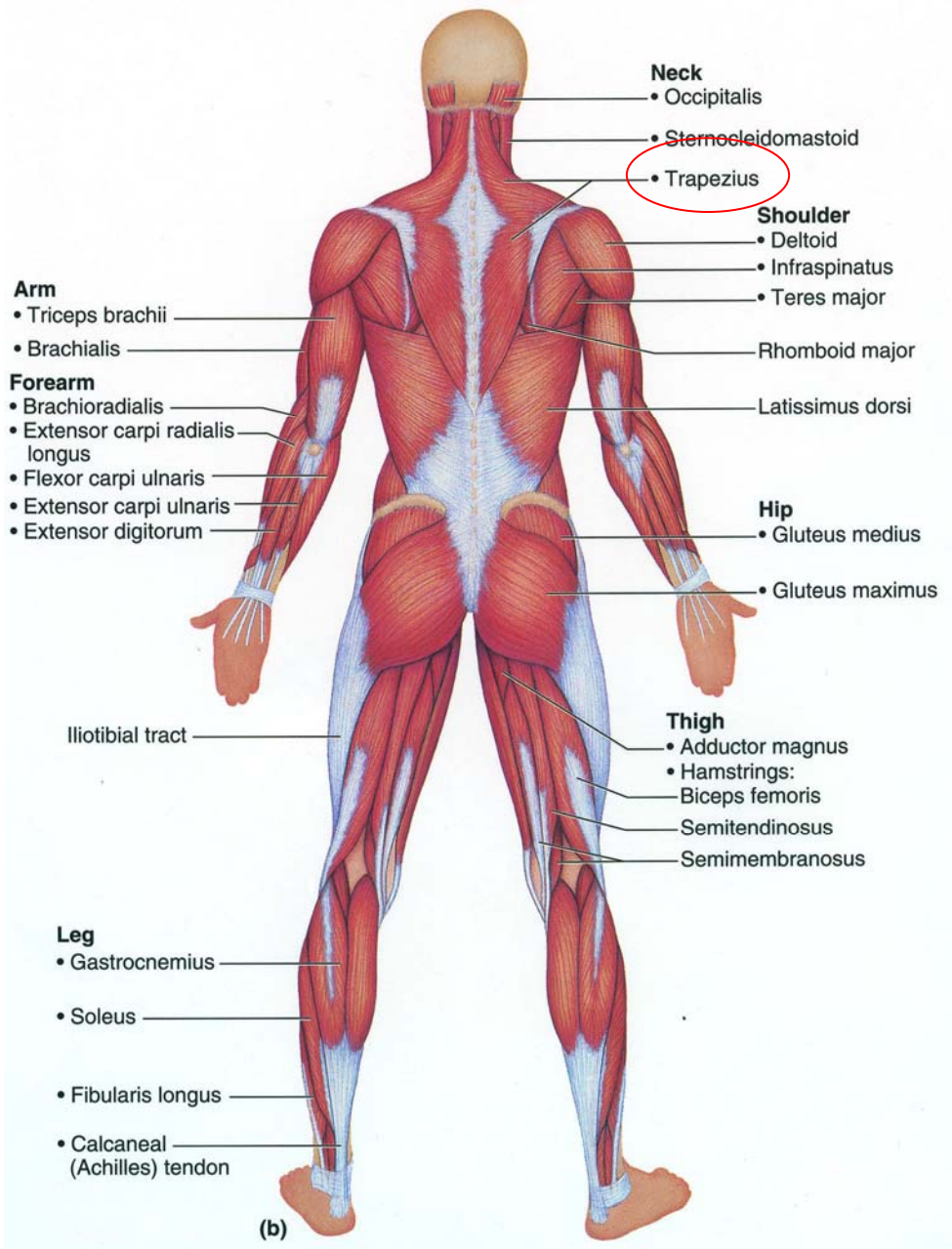
- The resultant force equals the magnitude of the two forces.

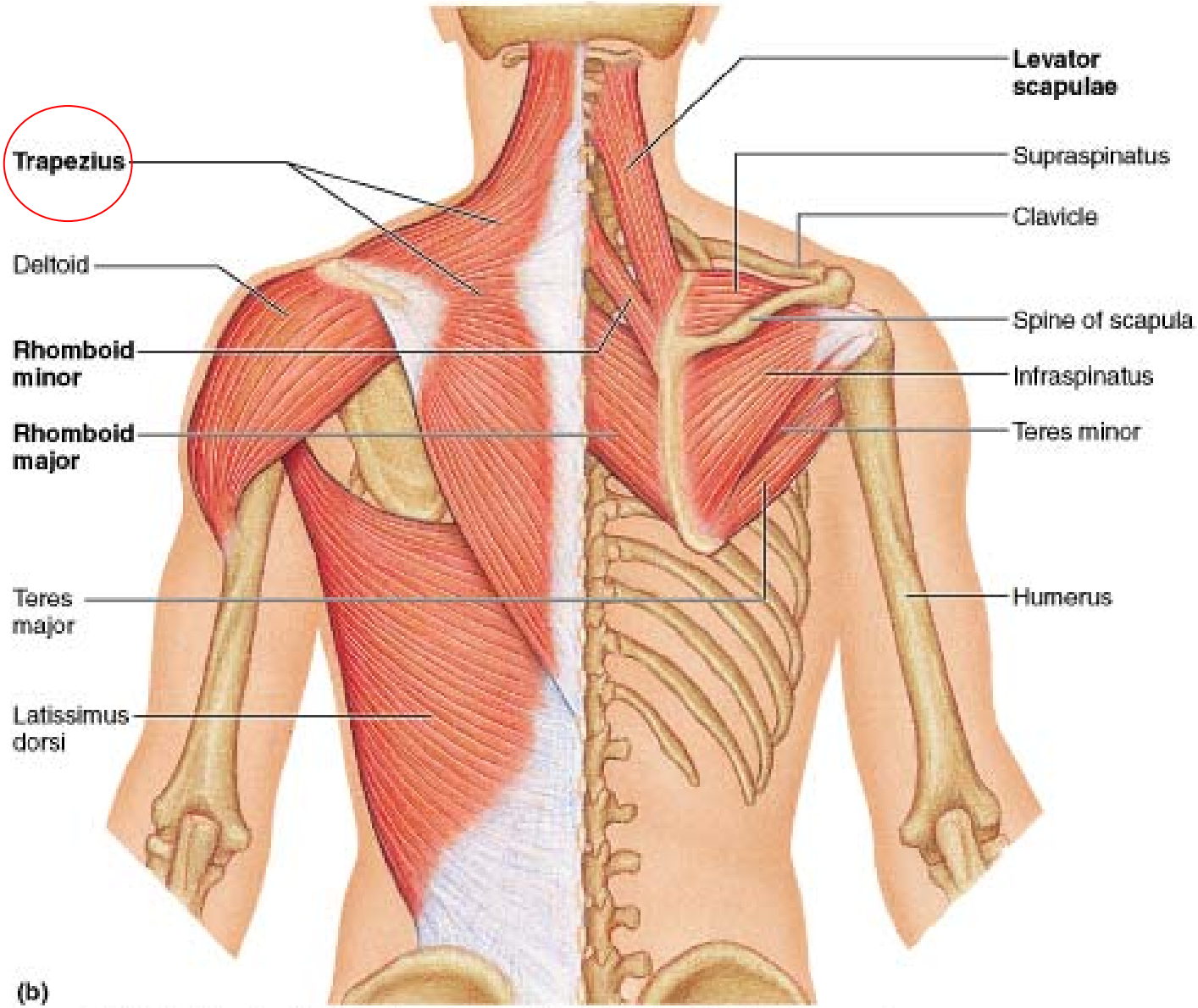
- Weakness of one muscle will reduce the magnitude of the resultant force.



Linear force system (colinear) Example

- **Trapezius** muscle on both sides act along the same action line, but in *opposite directions*.
- Equilibrium occurs when muscle forces are equal in both sides.
- Weakness on one side causes the resultant force to be bigger on the other side, resulting in lateral deviation of the spine (scoliosis).


Neck
• Occipitalis
• Sternocleidomastoid
• Trapezius
Shoulder
• Deltoid
• Infraspinatus
• Teres major
Rhomboid major
Latissimus dorsi
Arm
• Triceps brachii
• Brachialis
Forearm
• Brachioradialis
• Extensor carpi radialis longus
• Flexor carpi ulnaris
• Extensor carpi ulnaris
• Extensor digitorum
Hip
• Gluteus medius
• Gluteus maximus
Iliotibial tract
Thigh
• Adductor magnus
• Hamstrings:
Biceps femoris
Semitendinosus
Semimembranosus
Leg
• Gastrocnemius
• Soleus
• Fibularis longus
• Calcaneal (Achilles) tendon
(b)



Parallel force system

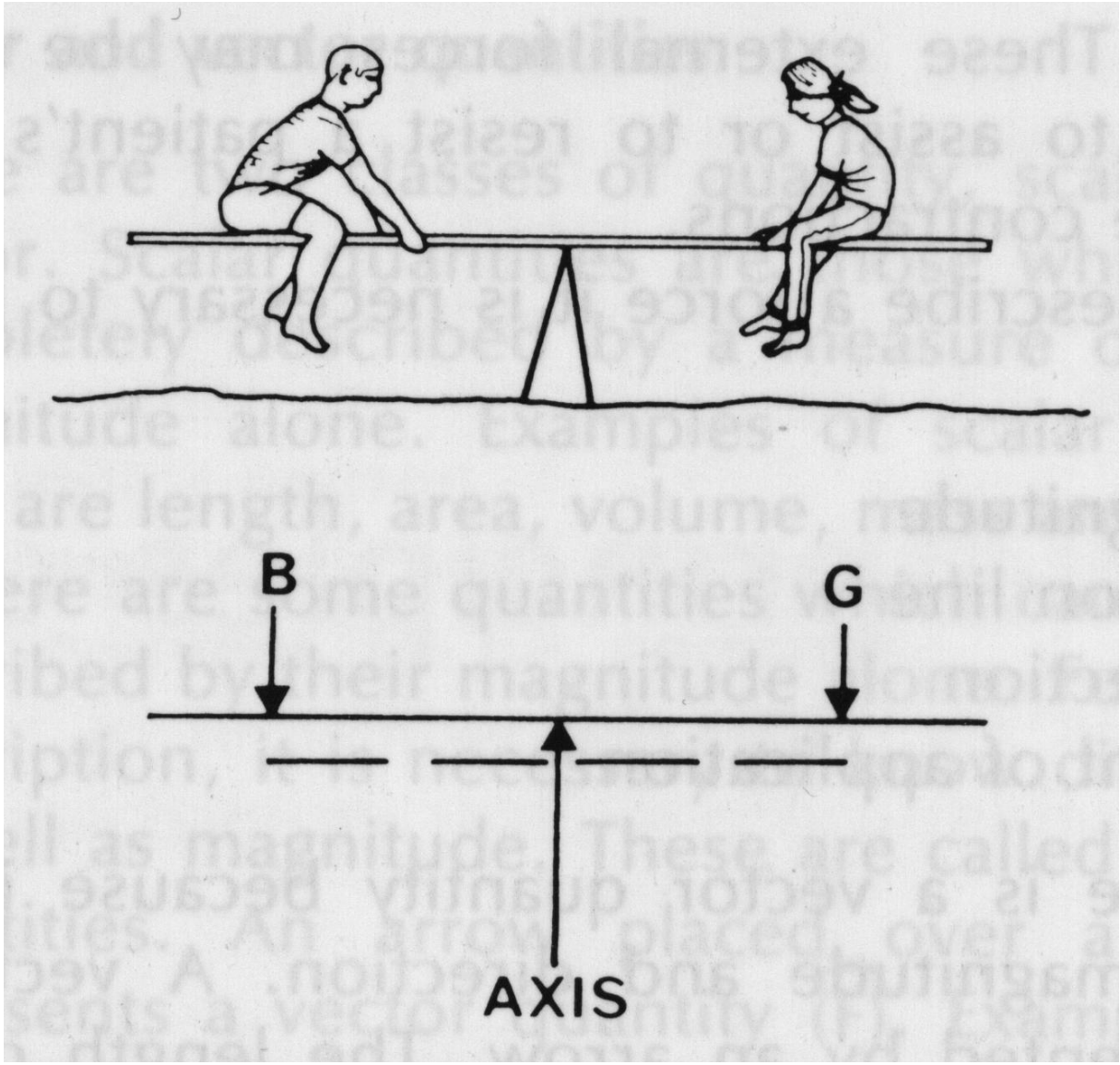
- When all the forces are **coplanar** (acting at the same plane), at **two different points**, and **parallel** to each other, but do **not** share the same action line

- Forces produce rotatory effects

Parallel force system

- Two children on a teeter-totter exert downward forces that are parallel to one another.

- At equilibrium, the sum of their combined weights must be opposed by the upward force at the axis of the board.



Parallel force system

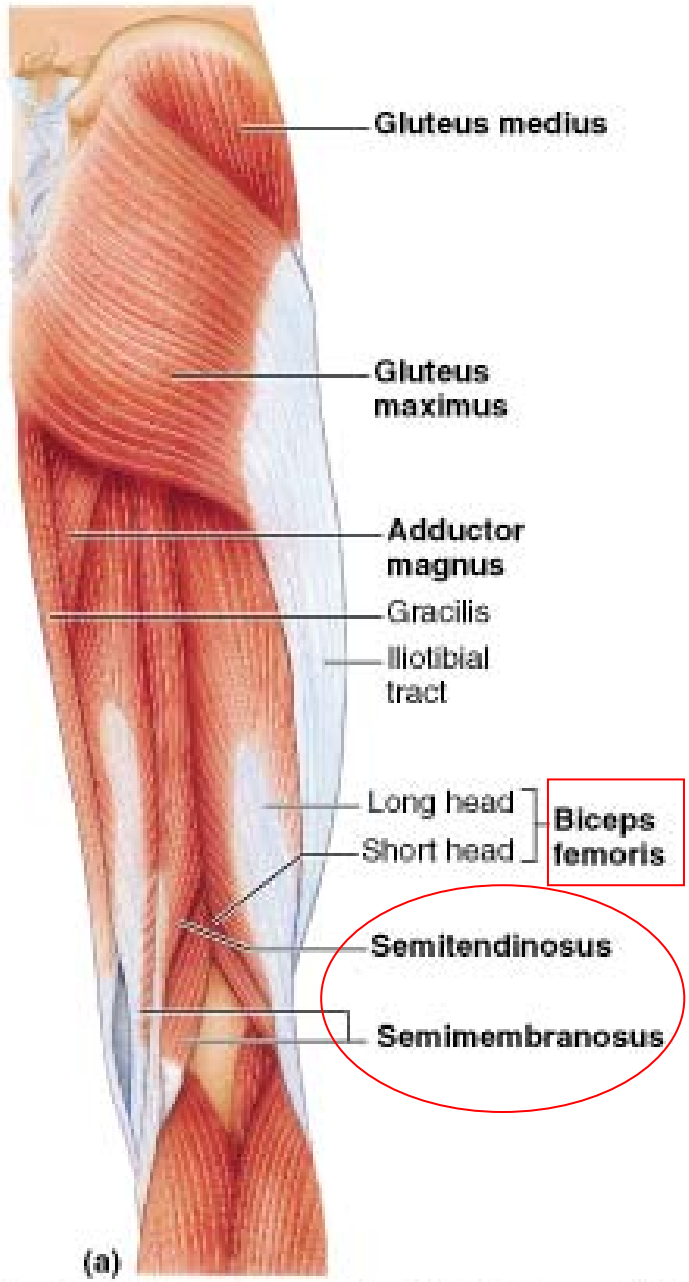
Parallel force system

- A force acting on a rigid body at a distance from a fixed point tends to **rotate** the body

- Moment arm (lever arm) = the distance from the point of application of force to the axis of rotation

Parallel force system Example

- **Hamstring** muscles components: medial (semitendinosus & semimembranosus) and lateral (biceps femoris)
- The medial and lateral forces act in the same direction to produce knee flexion
- If the forces are equal to each other ⟶ the resultant is located in the middle producing pure knee flexion



Medial

Lateral

Parallel force system
Example

- If the medial hamstring is weak and the lateral hamstring is strong ⟶
  the resultant force is directed towards the lateral hamstring ⟶
  the person tends to flex the knee with the leg directed laterally

Parallel force system
Force couple

- A special type of parallel force system in which the forces are equal in magnitude but opposite in direction

- Forces produce rotatory effect

- Example: when turning steering wheel with two hands

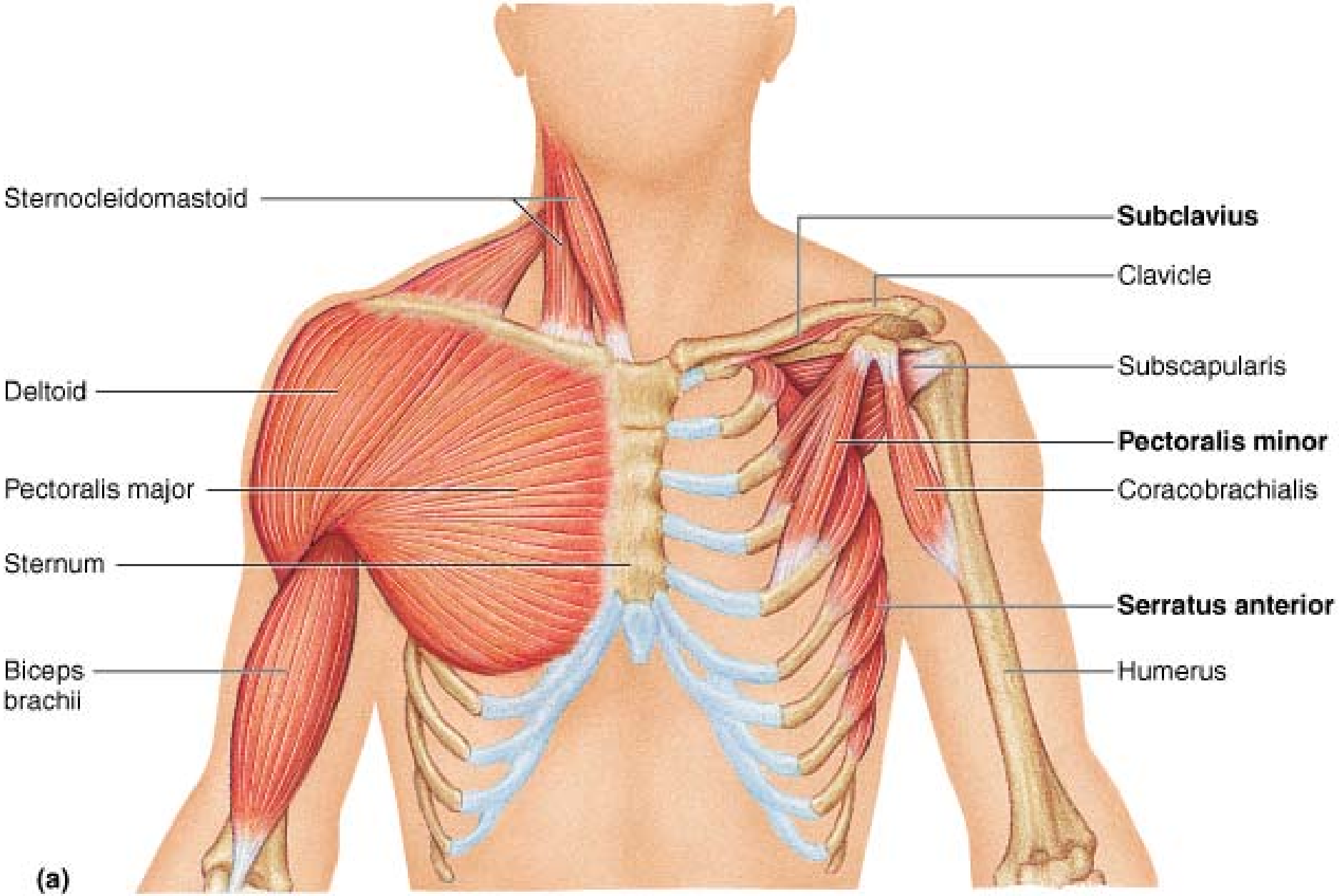
Force couple
Example

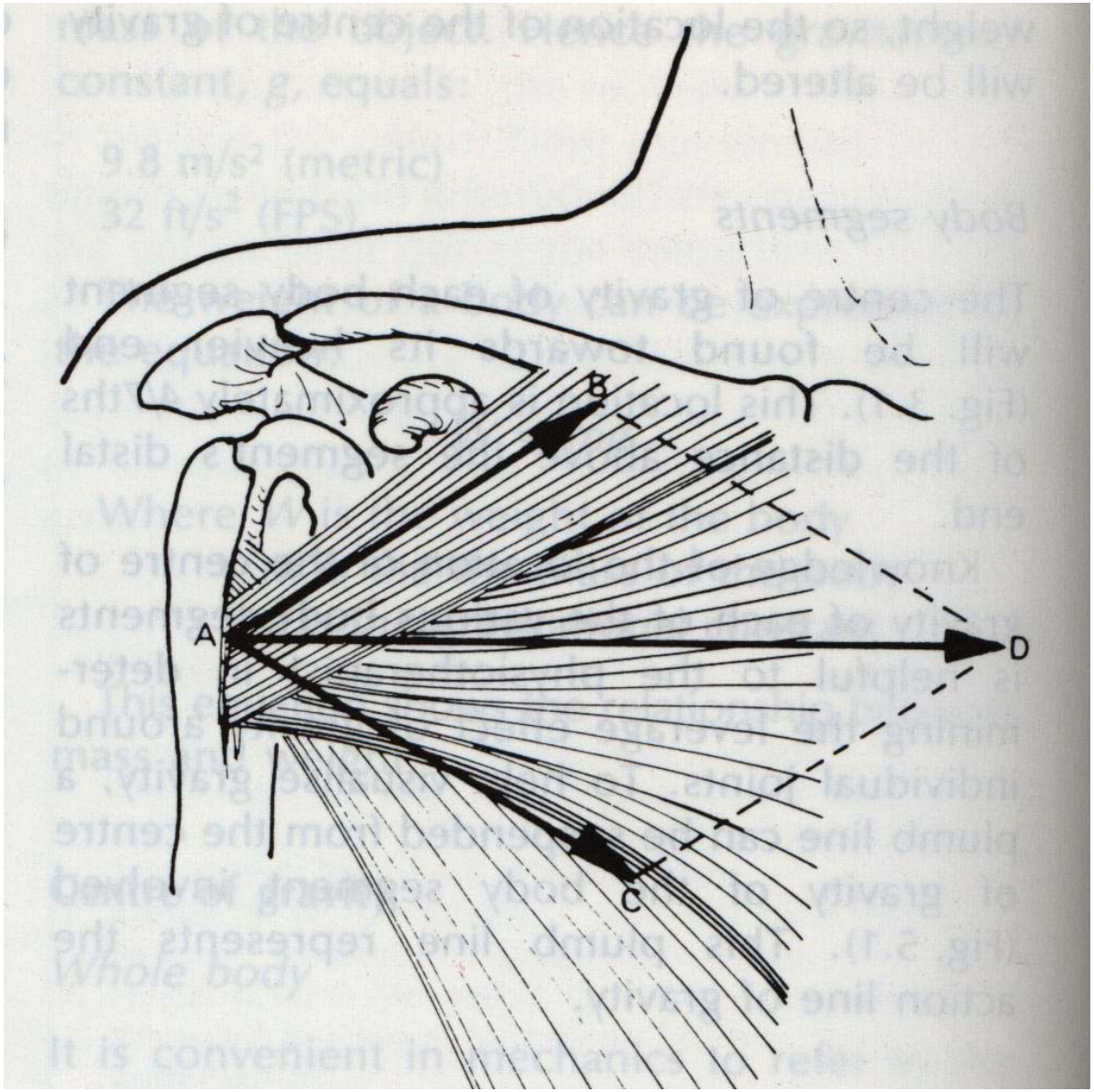
- Rotation of the pelvis in the sagittal plane:
  - **Anterior pelvic tilt**: hip flexors and back extensors
  - **Posterior pelvic tilt**: abdominal muscles and hip extensors

- Weak abdominals → inability to tilt the pelvis posteriorly → excessive anterior pelvic tilt (lordosis)

Concurrent force system

- When all the forces meet at the same point of application
- Forces do not lie along the same line of action, but form an angle with each other
- Example: sternal and clavicular parts of the **pectoralis major**





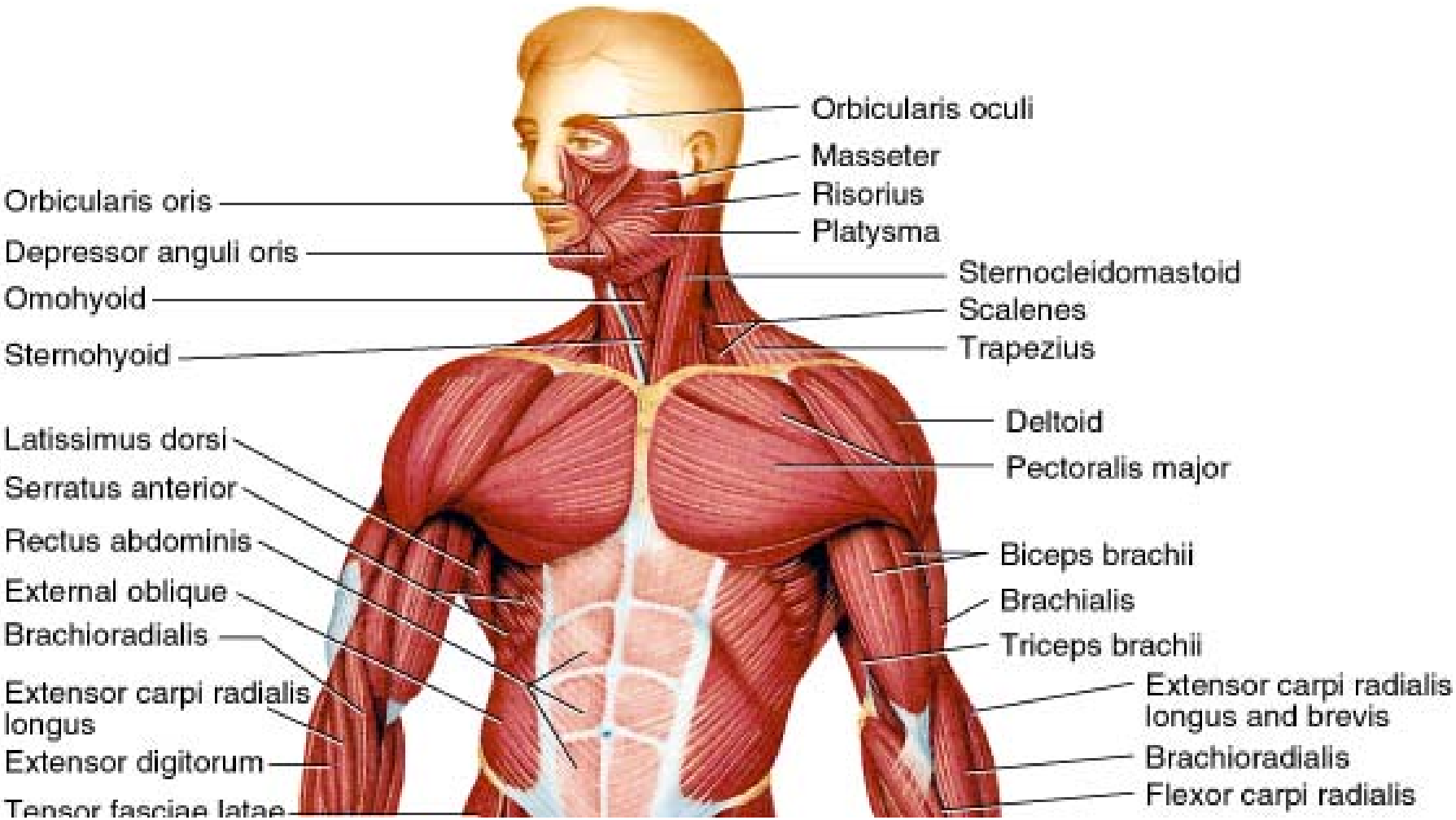
Concurrent force system

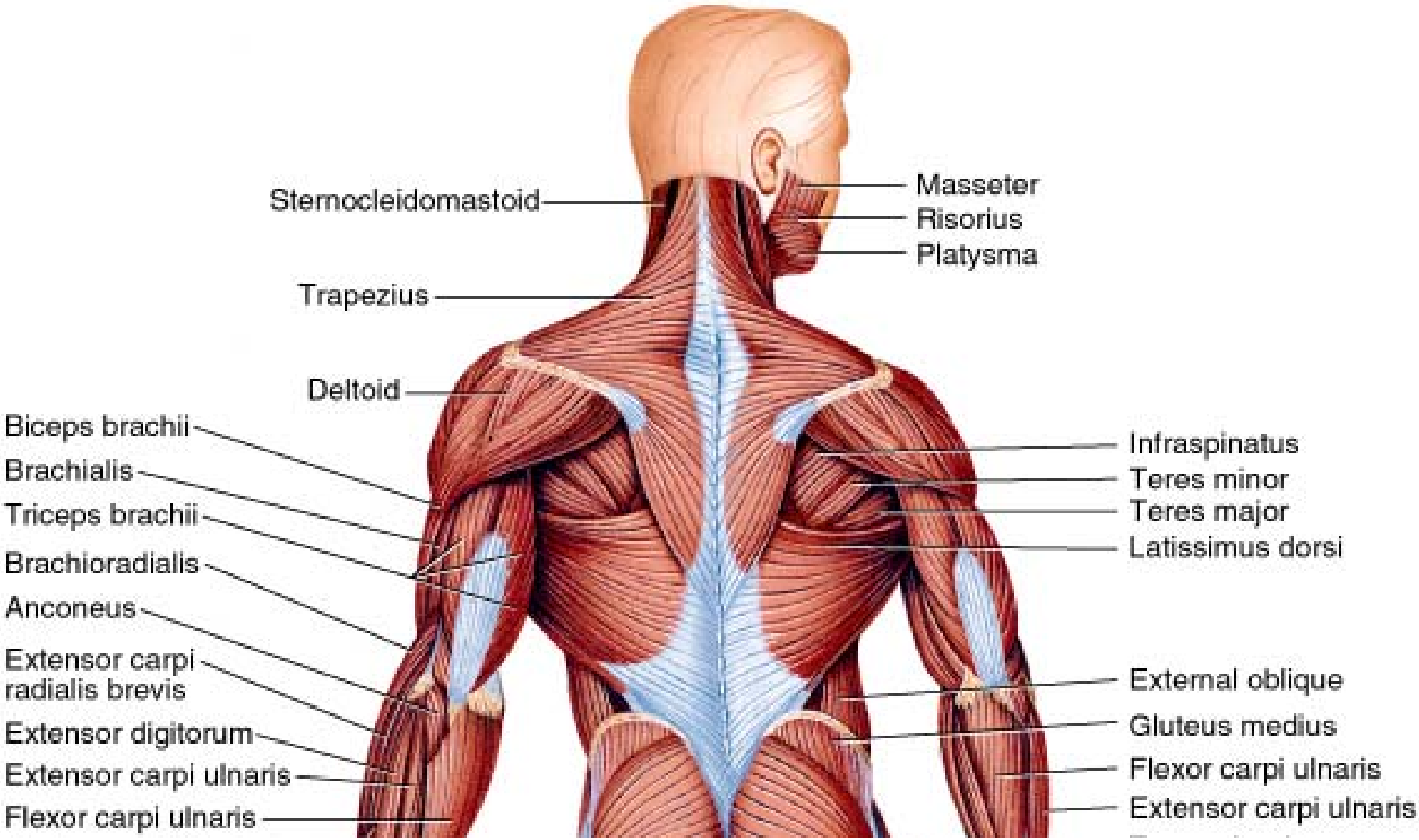
Example: Pectoralis major

Concurrent force system Example

- **Deltoid** muscle:
  - Anterior fibers: flex the arm
  - Posterior fibers: extend the arm

- The combined action of the anterior and posterior fibers will abduct the arm


Orbicularis oculi
Masseter
Risorius
Platysma
Orbicularis oris
Depressor anguli oris
Omohyoid
Sternohyoid
Sternocleidomastoid
Scalenes
Trapezius
Deltoid
Pectoralis major
Latissimus dorsi
Serratus anterior
Rectus abdominis
External oblique
Brachioradialis
Extensor carpi radialis longus
Extensor digitorum
Biceps brachii
Brachialis
Triceps brachii
Extensor carpi radialis longus and brevis
Brachioradialis
Flexor carpi radialis


Sternocleidomastoid
Trapezius
Deltoid
Biceps brachii
Brachialis
Triceps brachii
Brachioradialis
Anconeus
Extensor carpi radialis brevis
Extensor digitorum
Extensor carpi ulnaris
Flexor carpi ulnaris
Masseter
Risorius
Platysma
Infraspinatus
Teres minor
Teres major
Latissimus dorsi
External oblique
Gluteus medius
Flexor carpi ulnaris
Extensor carpi ulnaris