POSTURE

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POSTURE

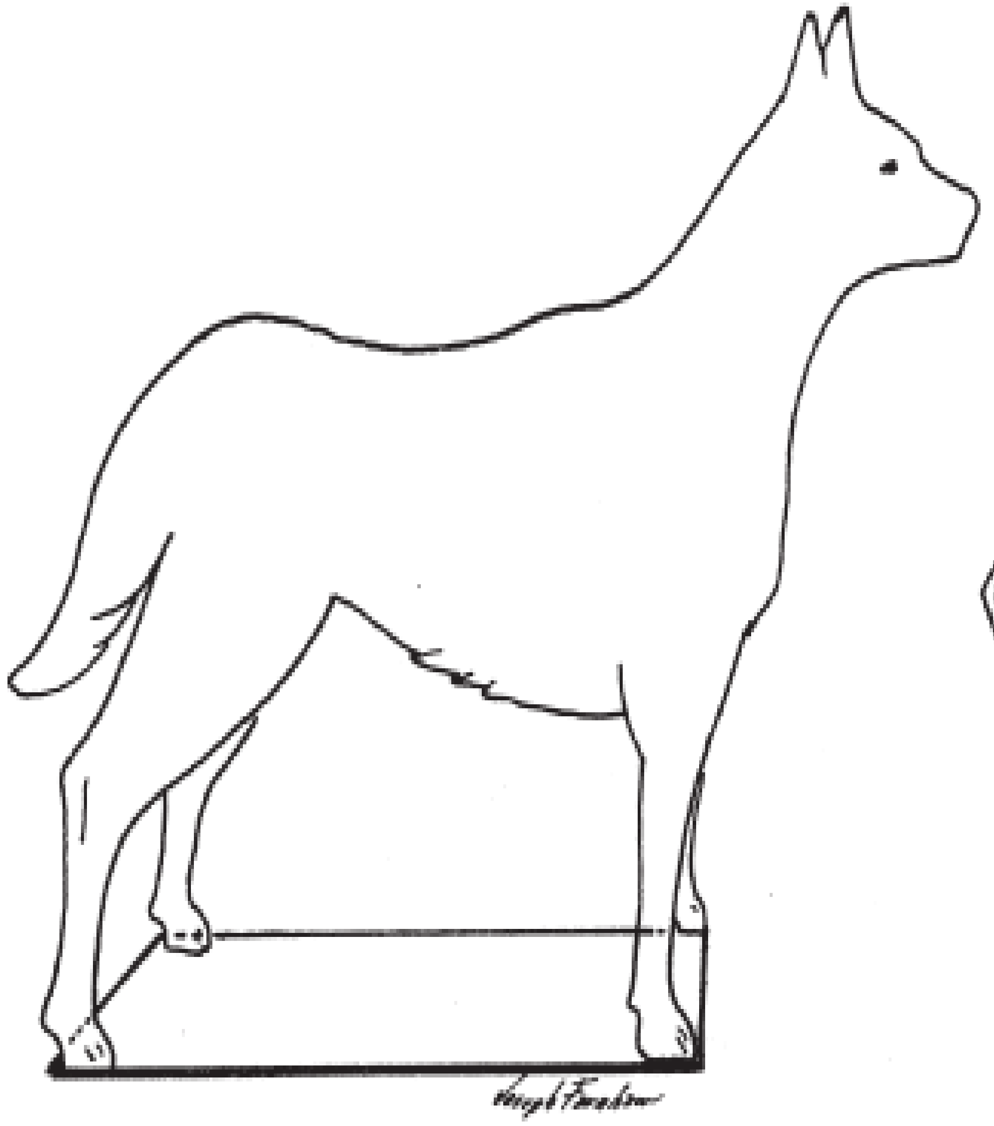
- The posture is alignment of the body parts whether upright, sitting, or recumbent. It is described by the positions of the joints and body segments and also terms of the balance between the muscles crossing the joints.
- There are two main classification of posture, they are as follows,

  - Static Posture

  - Dynamic Posture

- In ***static posture,*** the body and its segments are aligned and maintained in certain positions.
- Examples of static postures include standing, sitting, lying, and kneeling.
- ***Dynamic posture*** refers to postures in which the body or its segments are moving. Examples of dynamic postures including walking, running, jumping, throwing, and lifting.

- Humans and other living creatures have the ability to arrange and rearrange body segments to form a large variety of postures, but the sustained maintenance of erect bipedal stance is unique to humans.



- The erect standing posture allows persons to use their upper extremities for the performance of large and small motor tasks.
- If the upper extremities need to be engaged by the use of crutches, canes, or other assistive devices to maintain the erect posture.
- Erect bipedal stance gives us freedom for the upper extremities, but in comparison with the quadrupedal posture, erect stance has certain disadvantages.

- Erect bipedal stance increases the work of the heart; places increased stress on the vertebral column, pelvis, and lower extremities; and reduces stability.
- In the quadrupedal posture, the body weight is distributed between the upper and lower extremities.
- In human stance, the body weight is borne exclusively by the two lower extremities.

- The human's **base of support (BoS)**, defined by an area bounded posteriorly by the tips of the heels and anteriorly by a line joining the tips of the toes, is considerably smaller than the quadrupedal BoS.
- The human's **center of gravity (CoG)** is the point where the mass of the body is centered and will be referred to in this chapter as the center of mass (CoM).

- In the young child in the standing posture, the CoM is located within the body about at the level of the 12th vertebra.
- As the child becomes less “top heavy,” the CoM moves lower to a location in the standing adult at about the level of the second sacral segment in the midsagittal plane.

POSTURAL CONTROL

- Postural control, which can be either static or dynamic, refers to a person's ability to maintain stability of the body and body segments in response to forces that threaten to disturb the body's equilibrium.
- The ability to maintain stability in the erect standing posture is a skill that the **central nervous system** learns, using information from passive biomechanical elements, sensory systems, and muscles.

- The central nervous system interprets and organizes inputs from the various structures and systems and selects responses on the basis of past experience and the goal of the response.
- **Reactive (compensatory)** responses occur as reactions to external forces that displace the body's CoM.
- **Proactive (anticipatory)** responses occur in anticipation of internally generated destabilizing forces such as raising arms to catch a ball or bending forward to tie shoes.

MAJOR GOALS AND BASIC ELEMENTS OF CONTROL

- The major goals of postural control in the standing position are to control the body's orientation in space, maintain the body's CoM over the BoS, and to stabilize the head with regard to the vertical so that the eye gaze is appropriately oriented.
- Maintenance and control of posture depend on the integrity of the central nervous system, visual system, vestibular system, and musculoskeletal system.

- In addition, postural control depends on information received from receptors located in and around the joints (in joint capsules, tendons, and ligaments), as well as on the soles of the feet.
- The central nervous system must be able to detect and predict instability and must be able to respond to all of this input with appropriate output to maintain the equilibrium of the body.

ABSENT OR ALTERED INPUTS AND OUTPUTS:

- When inputs are altered or absent, the control system must respond to incomplete or distorted data, and thus the person's posture may be altered and stability compromised.
- Alteration or absence of inputs may occur for a number of reasons, including, among others, the absence of the normal gravitational force in weightless conditions during space flight or decreased sensation in the lower extremities.

- A more common example of altered inputs occurs when a person attempts to attain and maintain an erect standing posture when a foot has "fallen asleep."
- Attempts at standing may result in a fall because input regarding the position of the foot and ankle, as well as information from contact of the "asleep" foot with the supporting surface, is missing.
- Another instance in which inputs may be disturbed is after injury.

- A disturbance in the kinesthetic sense about the ankle and foot after ankle sprains has been implicated as a cause of poor balance or loss of stability.
- In addition to altered inputs, a person's ability to maintain the erect posture may be affected by altered outputs such as the inability of the muscles to respond appropriately to signals from the central nervous system.

- In sedentary elderly persons, muscles that have atrophied through disuse may not be able to respond with either the appropriate amount of force to counteract an opposing force or with the necessary speed to maintain stability.
- In persons with some neuromuscular disorders, both agonists and antagonists may respond at the same time, thus reducing the effectiveness of the response.

MUSCLE SYNERGIES

- Postural control researchers have suggested that for any particular task such as standing on a moving bus, standing on a ladder, or standing on one leg, many different combinations of muscles may be activated to complete the task.
- A normally functioning central nervous system selects the appropriate combination of muscles to complete the task on the basis of an analysis of sensory inputs.

- Monitoring of muscle activity patterns through **electromyography (EMG)** and determinations of muscle peak torque and power outputs are some of the methods used to study postural responses during perturbations of upright postural stability.
- A **perturbation** is any sudden change in conditions that displaces the body posture away from equilibrium.

- The perturbation can be sensory or mechanical.
- A **sensory perturbation** might be caused by altering visual input, such as might occur when a person's eyes are covered unexpectedly.
- **Mechanical perturbations** are displacements that involve direct changes in the relationship of the body's CoM to the BoS.
- These displacements may be caused by movements of either body segments or the entire body.

- Even breathing can displace the CoM. Perturbations in standing that result from respiratory movements of the rib cage are counterbalanced by movements of the trunk and lower limbs.
- One method of studying how people respond to naturally occurring perturbations is to produce mechanical perturbations experimentally by placing subjects on a movable platform.
- The platform can be moved forward, backward, or from side to side. Some platforms can be tipped, and the velocity of platform motion can be varied.

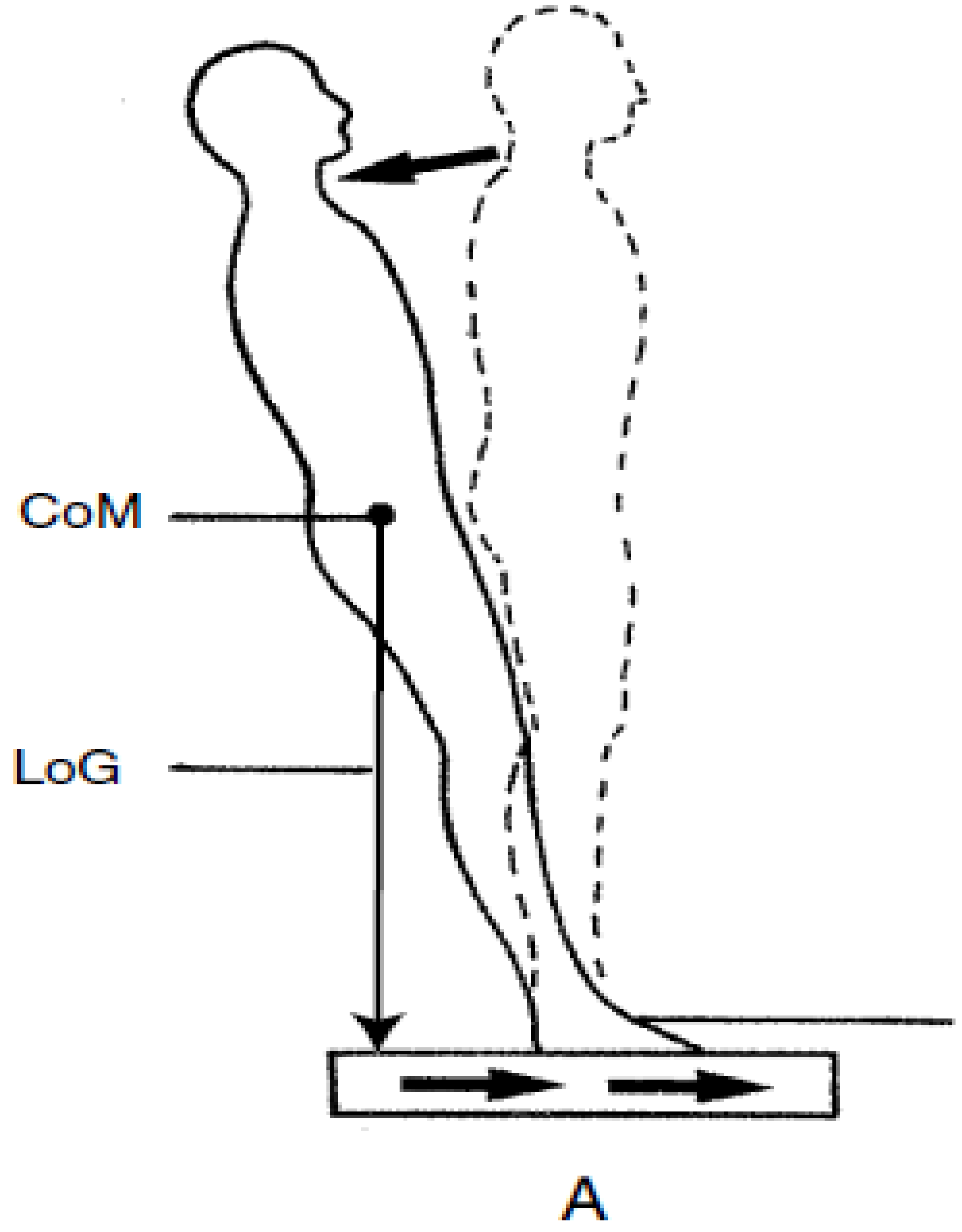
- These postural responses are referred to as either ***synergies or strategies.***

FIXED-SUPPORT SYNERGIES:

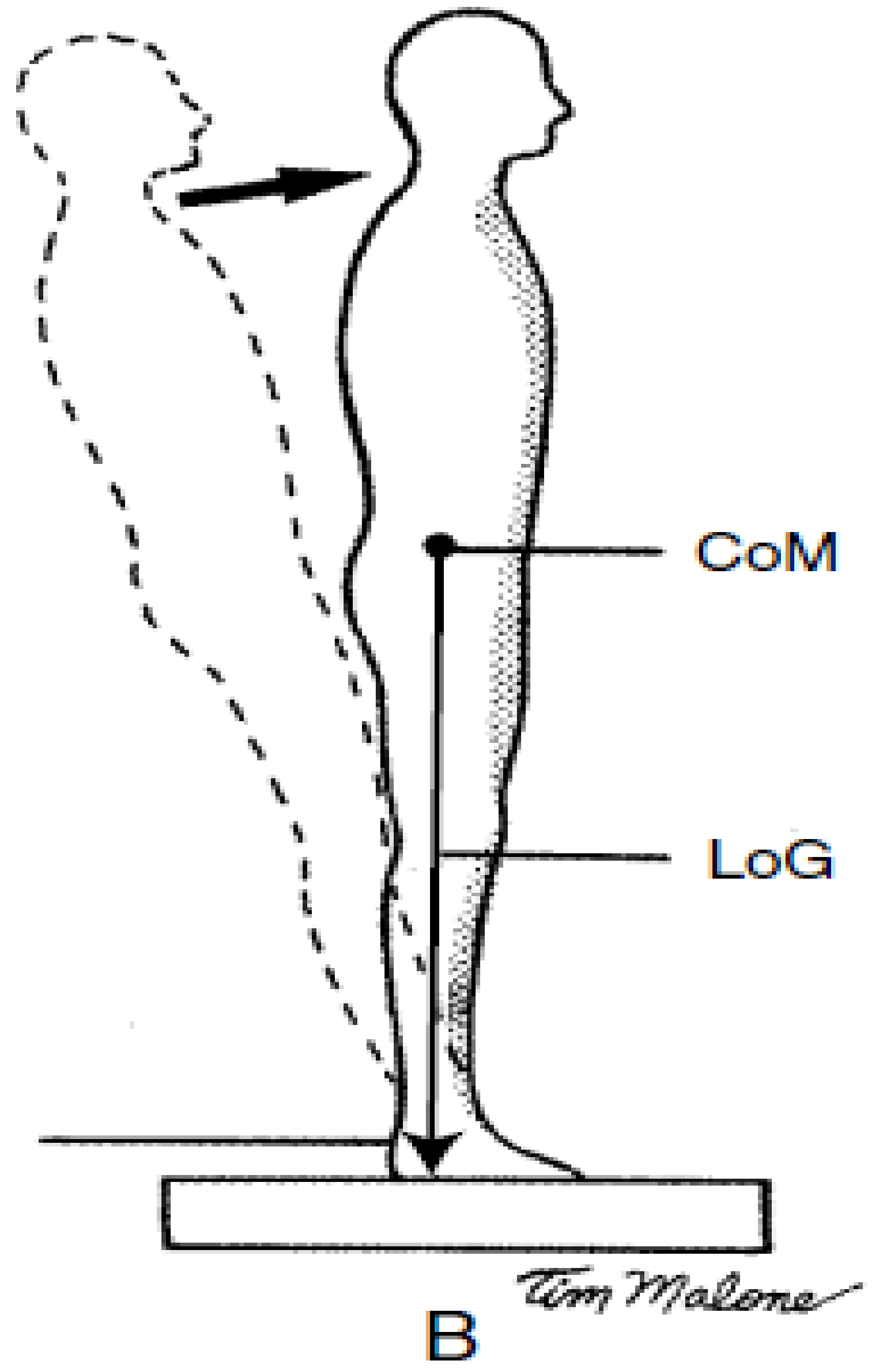
- **Fixed-support synergies** are patterns of muscle activity in which the BoS remains fixed during the perturbation and recovery of equilibrium.
- Stability is regained through movements of parts of the body, but the feet remain fixed on the BoS.

- Two examples of fixed-support synergies are the **ankle synergy and the hip synergy.**
- The **ankle synergy** consists of discrete bursts of muscle activity on either the anterior or posterior aspects of the body that occur in a distal-to-proximal pattern in response to forward and backward movements of the support platform, respectively.

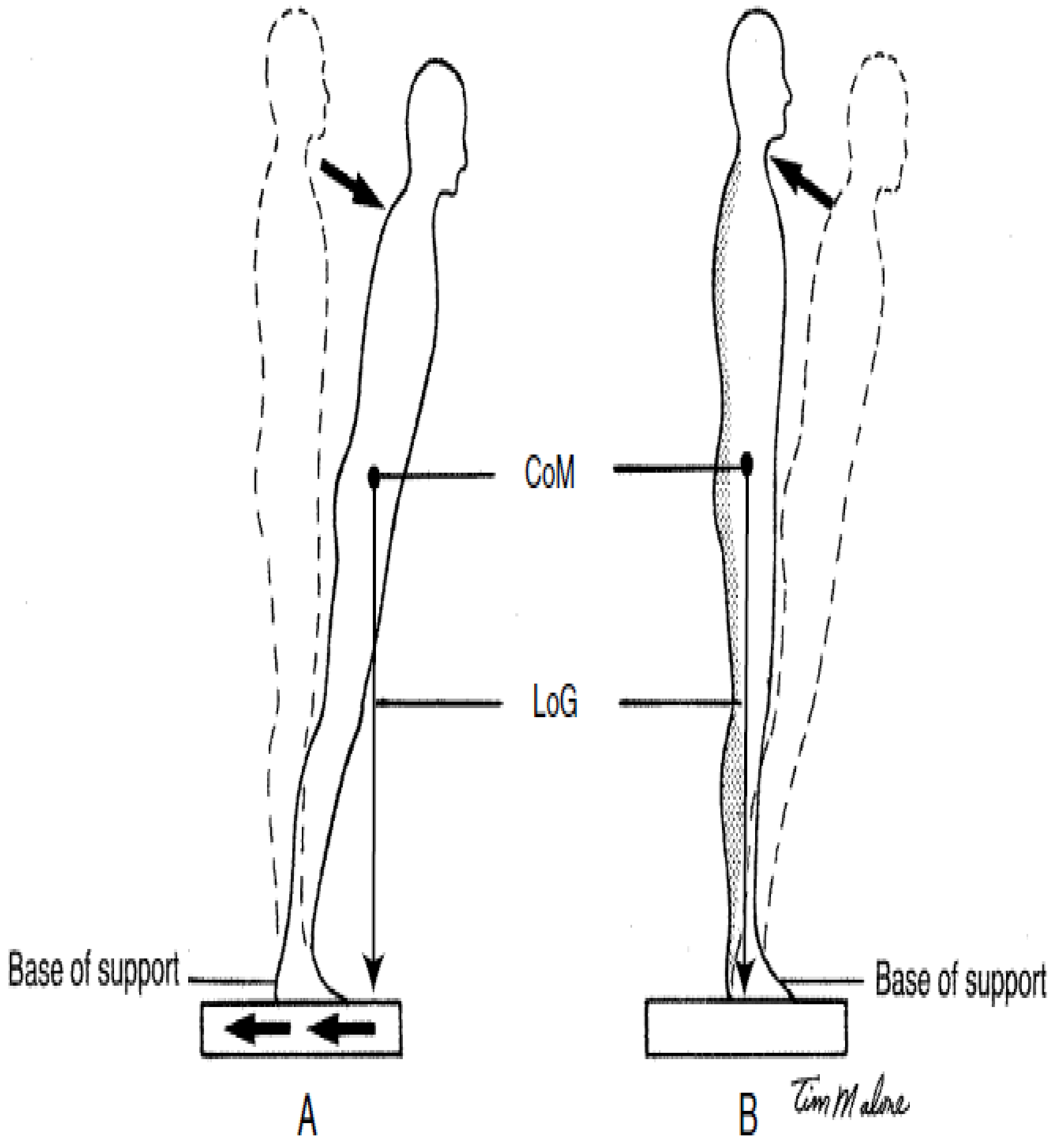
- Forward motion of the platform results in a relative displacement of the line of gravity (LoG) posteriorly and would be similar to starting to fall backward in a free-standing posture.
- The group of muscles that responds to the perturbation is activated in an attempt to restore the LoG to a position within the BoS.



- Bursts of muscle activity occur in the ankle dorsiflexors, hip flexors, abdominal muscles, and possibly the neck flexors.
- The tibialis anterior muscle contributes to the restoration of stability by pulling the tibia anteriorly, and hence the body forward, so that the LoG remains or centers within the BoS



- Backward motion of the platform results in a relative displacement of the LoG anteriorly and is similar to starting to fall forward in a freestanding posture.
- Bursts of activity in the plantarflexors, hip extensors, trunk extensors, and neck extensors are used to restore the LoG over the BoS

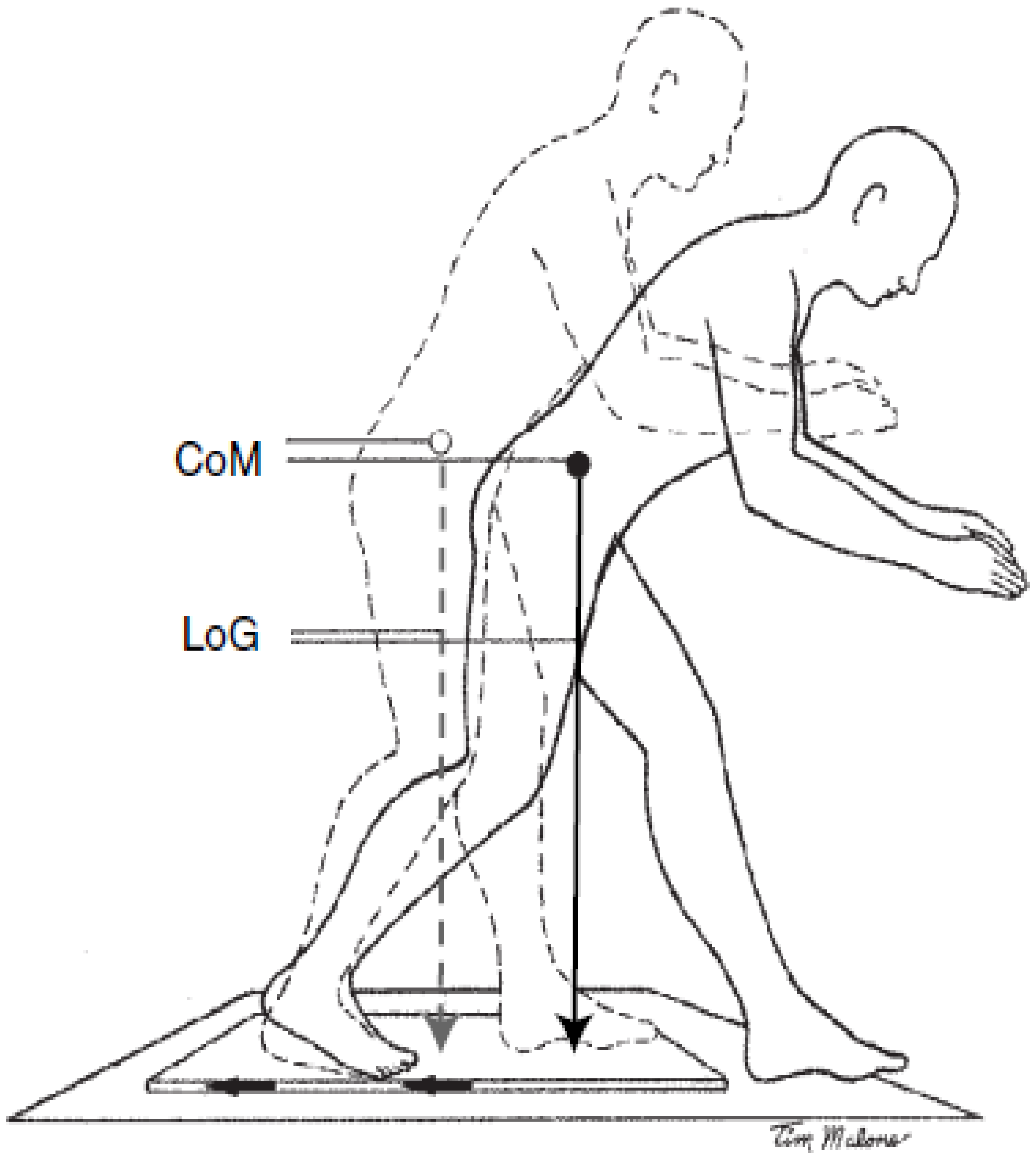


- The **hip synergy** consists of discrete bursts of muscle activity in a proximal-to-distal pattern of activation.
- The fixed-support hip synergy may be used primarily in situations in which **change-in-support strategies** (**stepping** or **grasping synergies**) are not possible.

CHANGE-IN-SUPPORT STRATEGIES

- The change-in-support strategies include **stepping (forward, backward,** or **sidewise)** and **grasping** (using one's hands to grab a bar or other fixed support) in response to shifts in either the BoS or the entire body.
- Stepping and grasping differ from fixed-support synergies because stepping/grasping either moves or enlarges the body's BoS so that it remains under the body's CoM

- It was thought that the stepping synergy was used only as a last resort, being initiated when ankle and hip strategies were insufficient to bring and maintain the CoM over the BoS.
- Change-in-support strategies are common responses to perturbations among both the young and the old.



- Change-in-support synergies are the only synergies that are successful in maintaining stability in the instance of a large perturbation.
- Comparisons of the stepping strategies used by the young and the old show that the younger subjects have a tendency to take only one step, whereas the elderly subjects have a tendency to take multiple steps that are shorter and of less height than those of their younger counterparts.

HEAD-STABILIZING STRATEGIES:

- The head-stabilizing strategies are used to maintain the head during dynamic tasks such as walking, in contrast to ankle and hip strategies, which are used to maintain the body in a static situation.
- The following two strategies for maintaining the vertical stability of the head: **head stabilization in space (HSS)** and **head stabilization on trunk (HST).**

- The HSS strategy is a modification of head position in anticipation of displacements of the body's CoG.
- The anticipatory adjustments to head position are independent of trunk motion.
- The HST strategy is one in which the head and trunk move as a single unit.

KINETICS AND KINEMATICS OF POSTURE

- The **external forces** that will be considered are **inertia, gravity,** and **ground reaction forces.**
- The **internal forces** are produced by **muscle activity and passive tension in ligaments, tendons, joint capsules, and other soft tissue structures.**
- The sum of all of the external and internal forces and torques acting on the body and its segments must be equal to zero for the body to be in equilibrium.

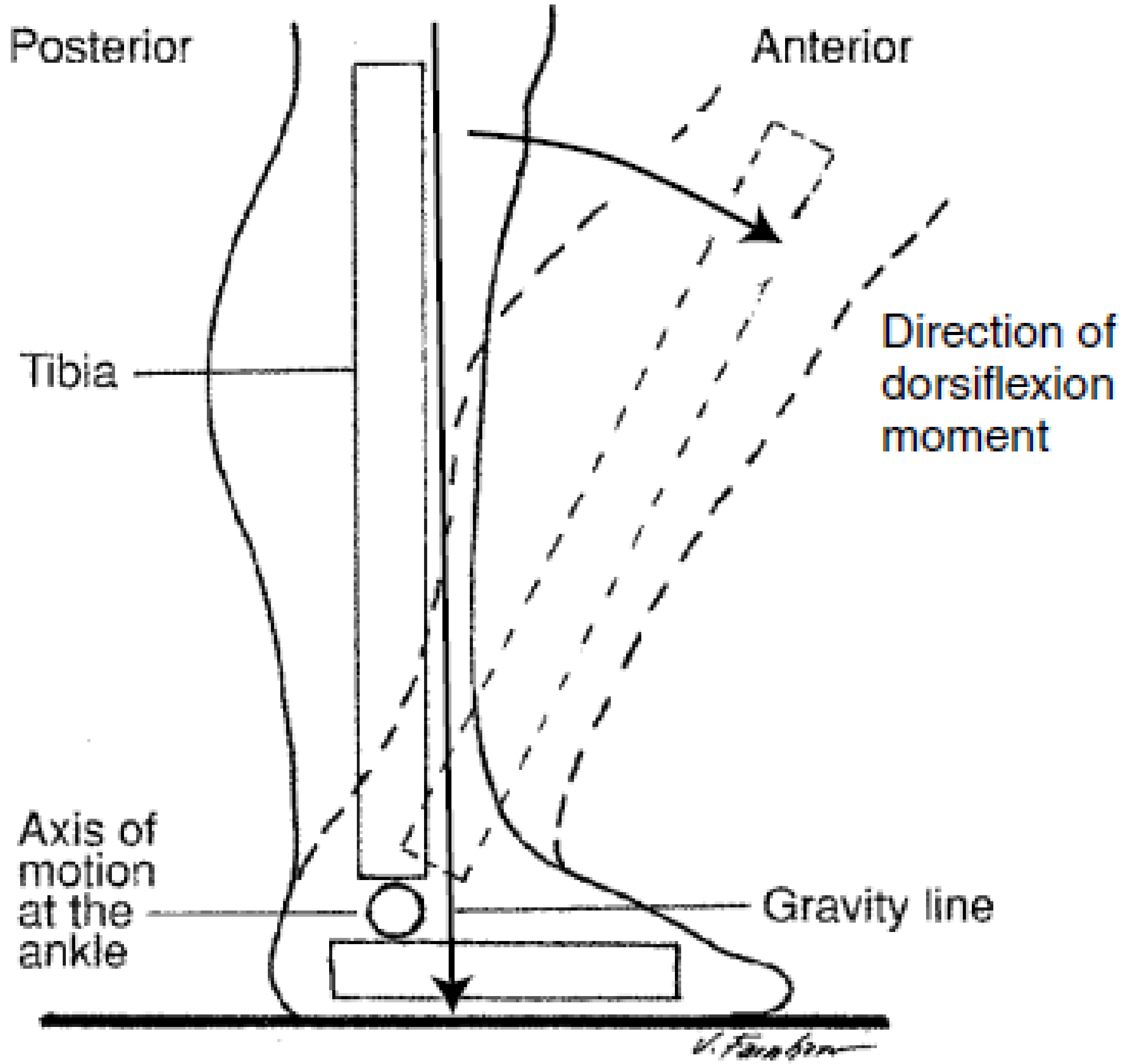
EXTERNAL AND INTERNAL MOMENTS

- The effect of external forces on body segments during standing is determined by the location of the LoG in relation to the axis of motion of body segments.
- When the LoG passes directly through a joint axis, no external gravitational torque is created around that joint.
- However, if the LoG passes at a distance from the axis, an **external gravitational moment** is created.

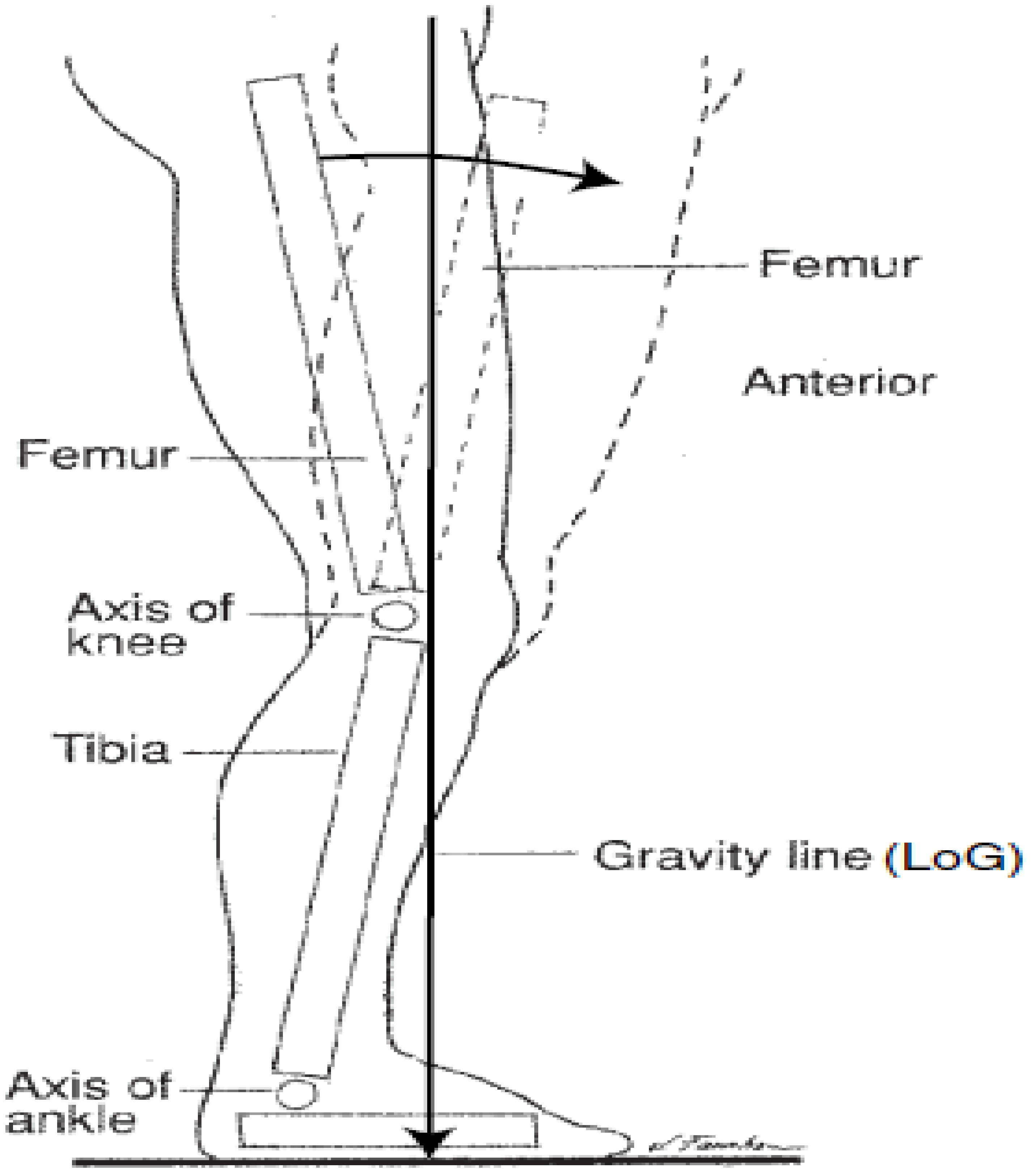
- This moment will cause rotation of the superimposed body segments around that joint axis unless it is opposed by a **counterbalancing internal moment** (a muscle contraction).
- The direction of the external gravitational moment of force depends on the location of the LoG in relation to a particular joint axis.
- If the LoG is located anterior to a particular joint axis, the gravitational moment will tend to cause anterior motion of the proximal segment of the body supported by that joint.

- If the LoG is posterior to the joint axis, the moment will tend to cause motion of the proximal segment in a posterior direction.
- In a postural analysis viewed from the side, external gravitational torques producing anterior and posterior motion of the proximal joint segment are referred to as either flexion or extension moments.

- If the LoG passes anterior to the ankle joint axis, the external gravitational moment will tend to rotate the tibia (proximal segment) in an anterior direction.
- Anterior motion of the tibia on the fixed foot will result in dorsiflexion of the ankle.
- Therefore, the moment of force is called a **dorsiflexion moment.** An **internal plantarflexion moment** of equal magnitude will be necessary to oppose the external dorsiflexion moment and establish equilibrium.


Posterior
Anterior
Tibia
Direction of dorsiflexion moment
Axis of motion at the ankle
Gravity line

- If the LoG passes anterior to the axis of rotation of the knee joint, the external gravitational moment will tend to rotate the femur (proximal segment) in an anterior direction.
- An anterior movement of the femur will cause extension of the knee.
- Therefore, the moment of force is called an **extension moment**. An internal **flexion moment** of equal magnitude will be necessary to balance the external extension moment.


Femur
Anterior
Femur
Axis of knee
Tibia
Gravity line (LoG)
Axis of ankle