Gait

Kinesiology
RHS 341
Lecture **12**
Dr. Einas Al-Eisa

Definitions

- **Locomotion** = the act of moving from one place to the other

- **Gait** = the manner of walking

Definitions

- **Walking** = a **smooth**, highly **coordinated**, **rhythmical**, undulating, **reciprocal** movement by which the body moves step by step in the required direction at the necessary speed

Gait

- = a form of **bipedal locomotion**
- The result of a series of **rhythmic alternating movement of the legs** (arms, and trunk) which creates forward movement of the body

Prerequisites of gait

- Maintenance of the position of the head, arms, and trunk against gravity
  (head, trunk, and arms constitute about 75% of the total body weight)

- Maintenance of upright posture and balance

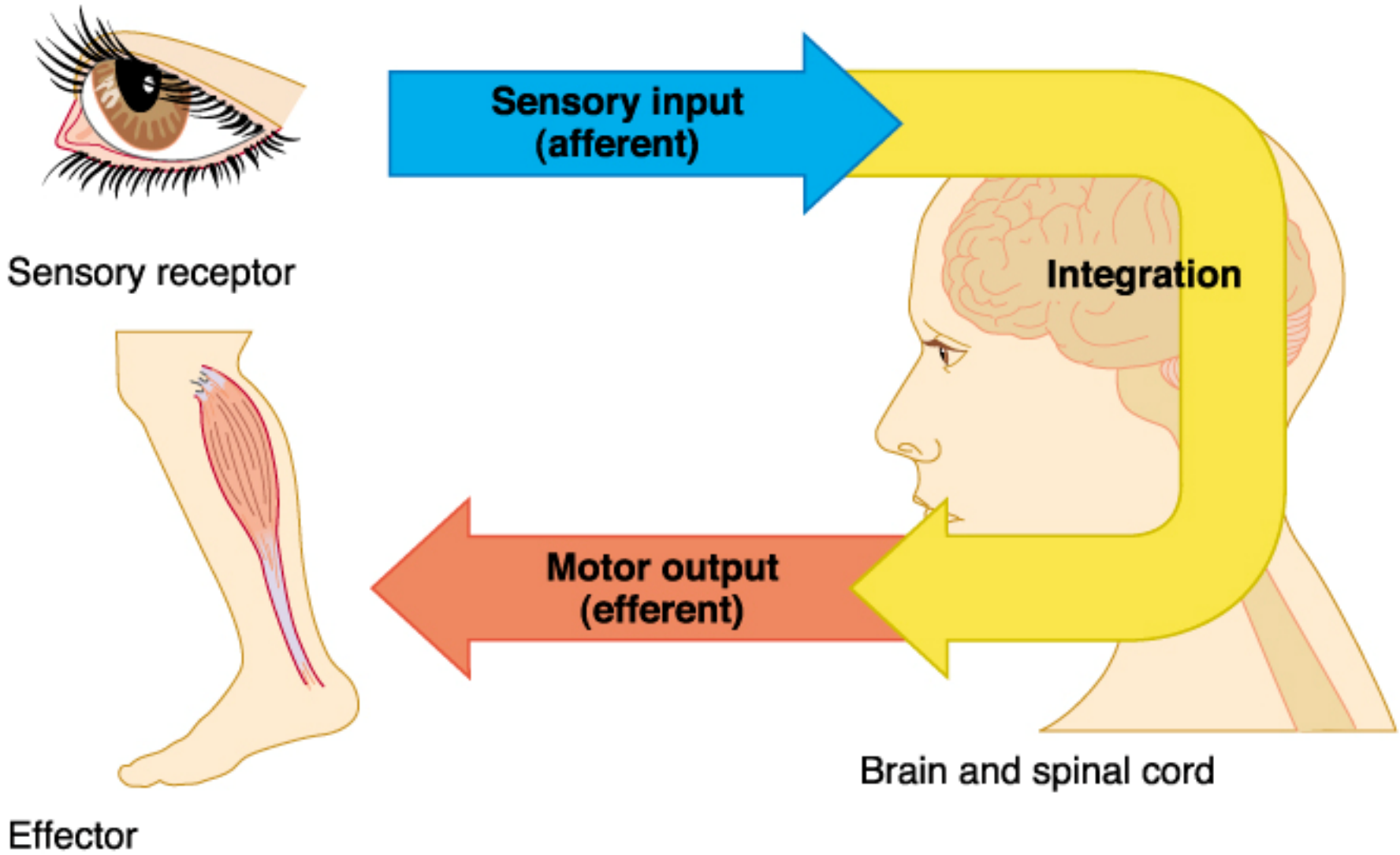
- Control of foot movement for safe ground **clearance** and gentle heel **contact**

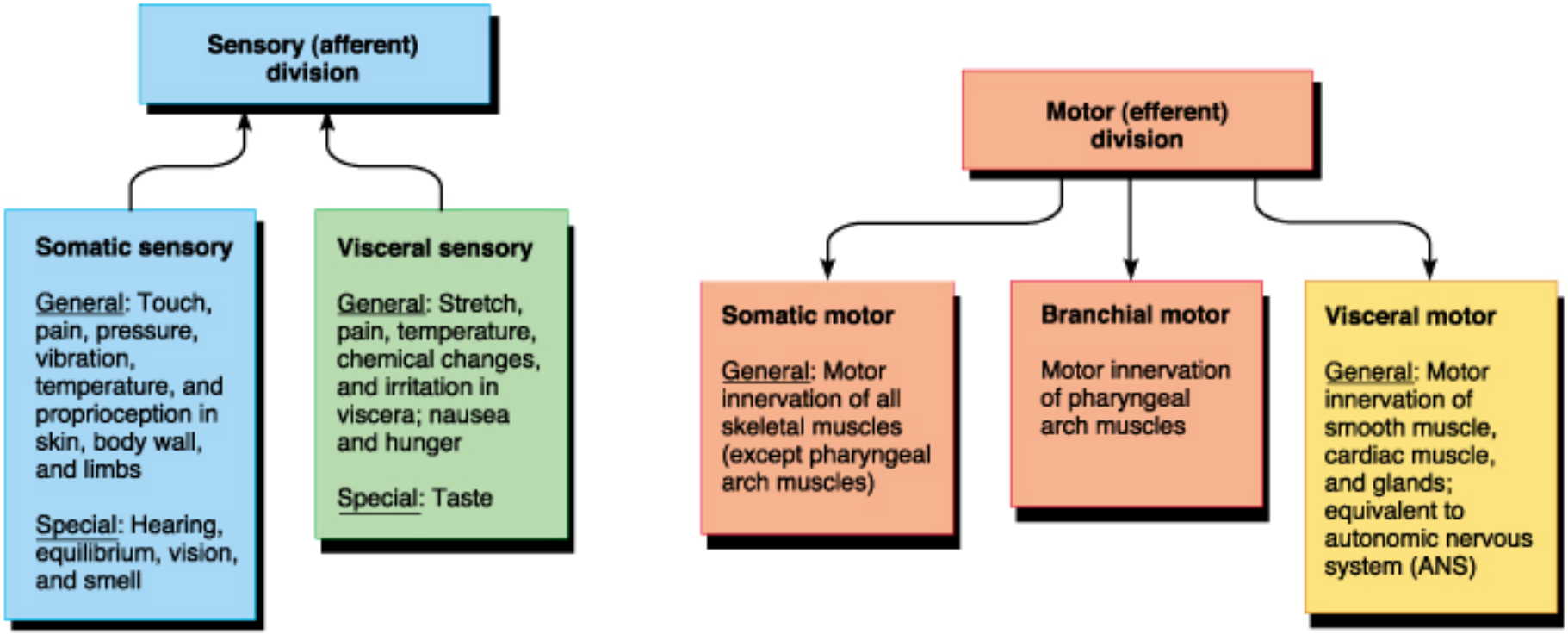
Gait

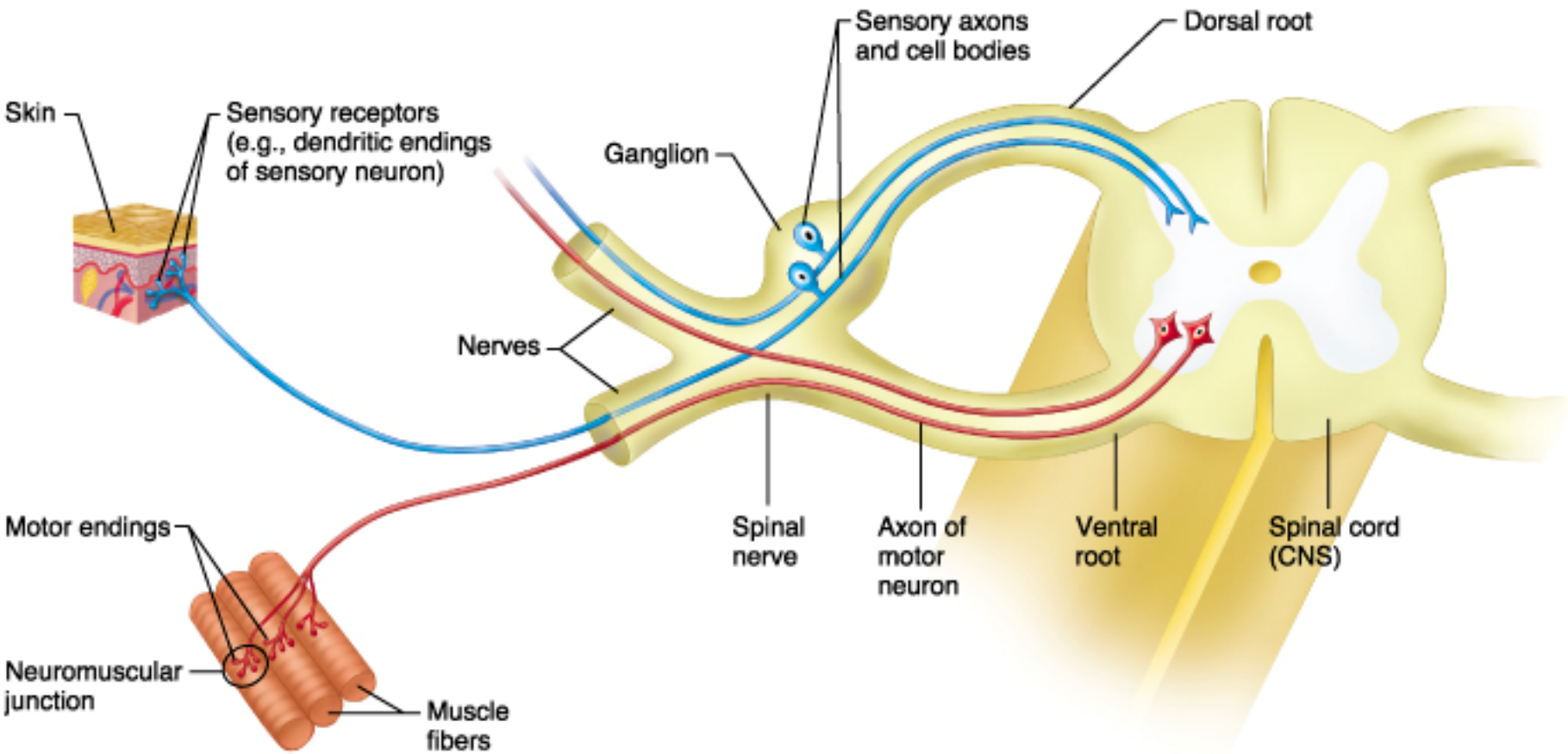
- Controlled by the central nervous system (postural reflex activity)

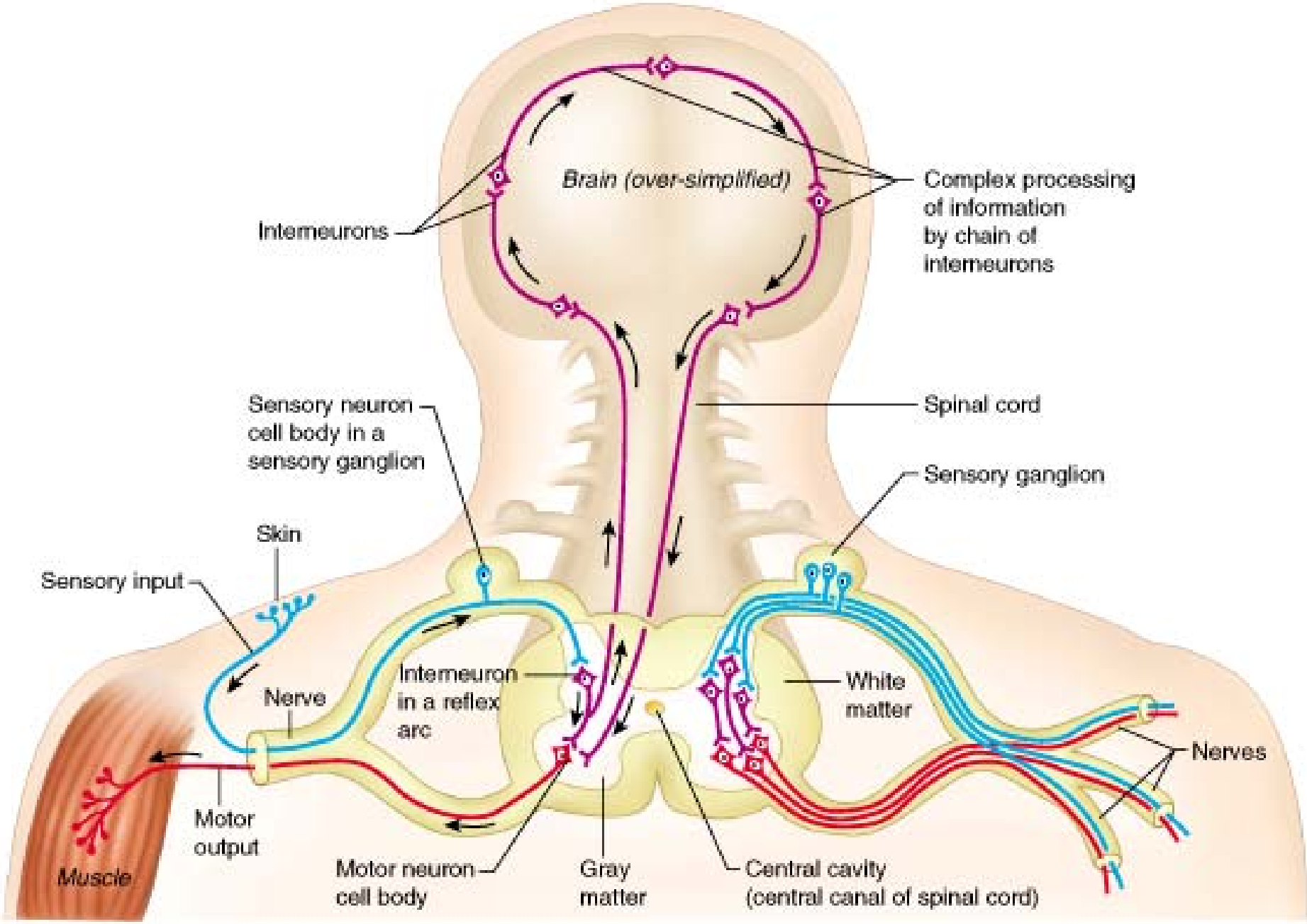
- Major ***afferent*** stimuli is provided by:

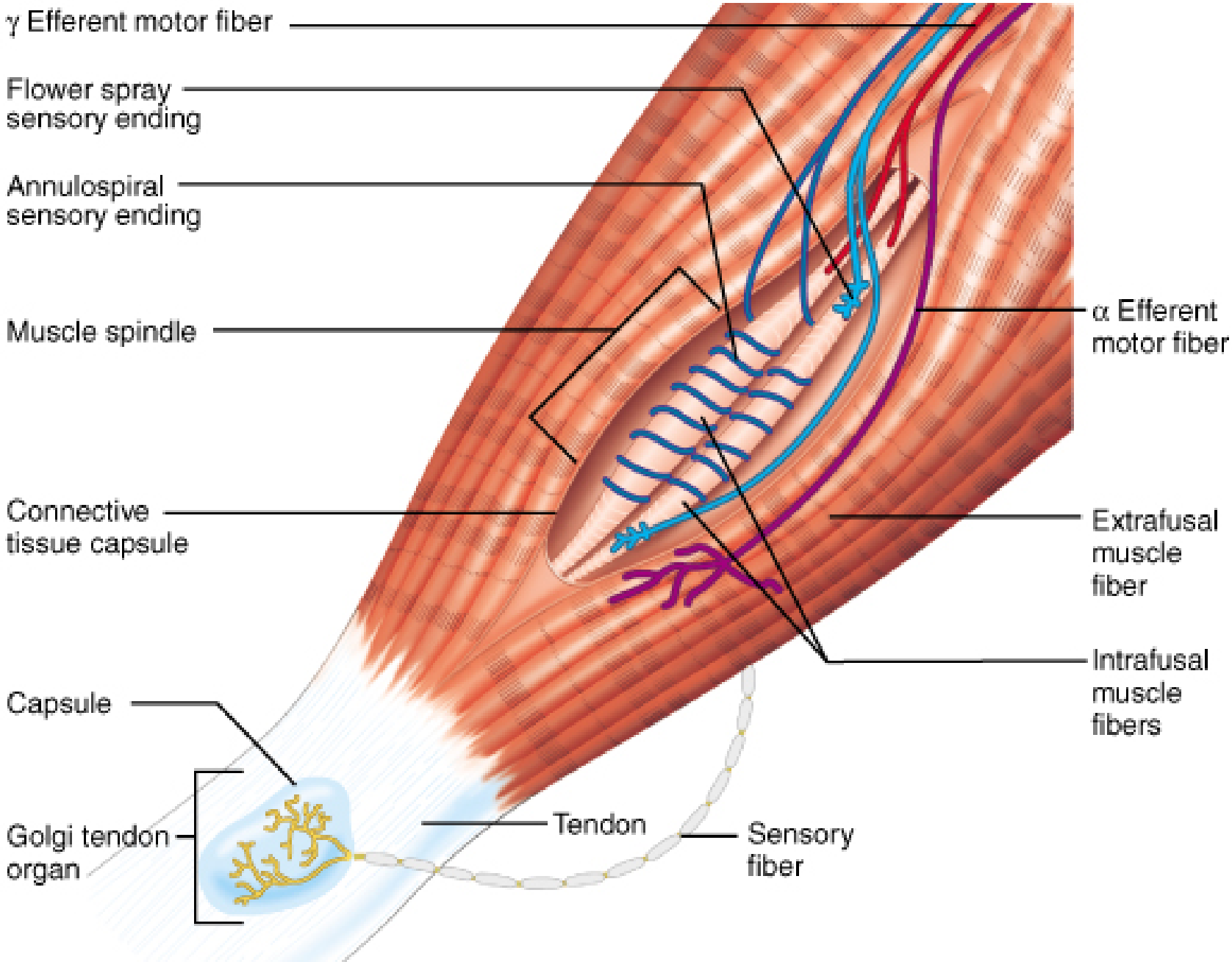
  - **Tactile** impulses from the sole of the foot
  - **Proprioceptive** impulses (from the lower limb, trunk, and neck)

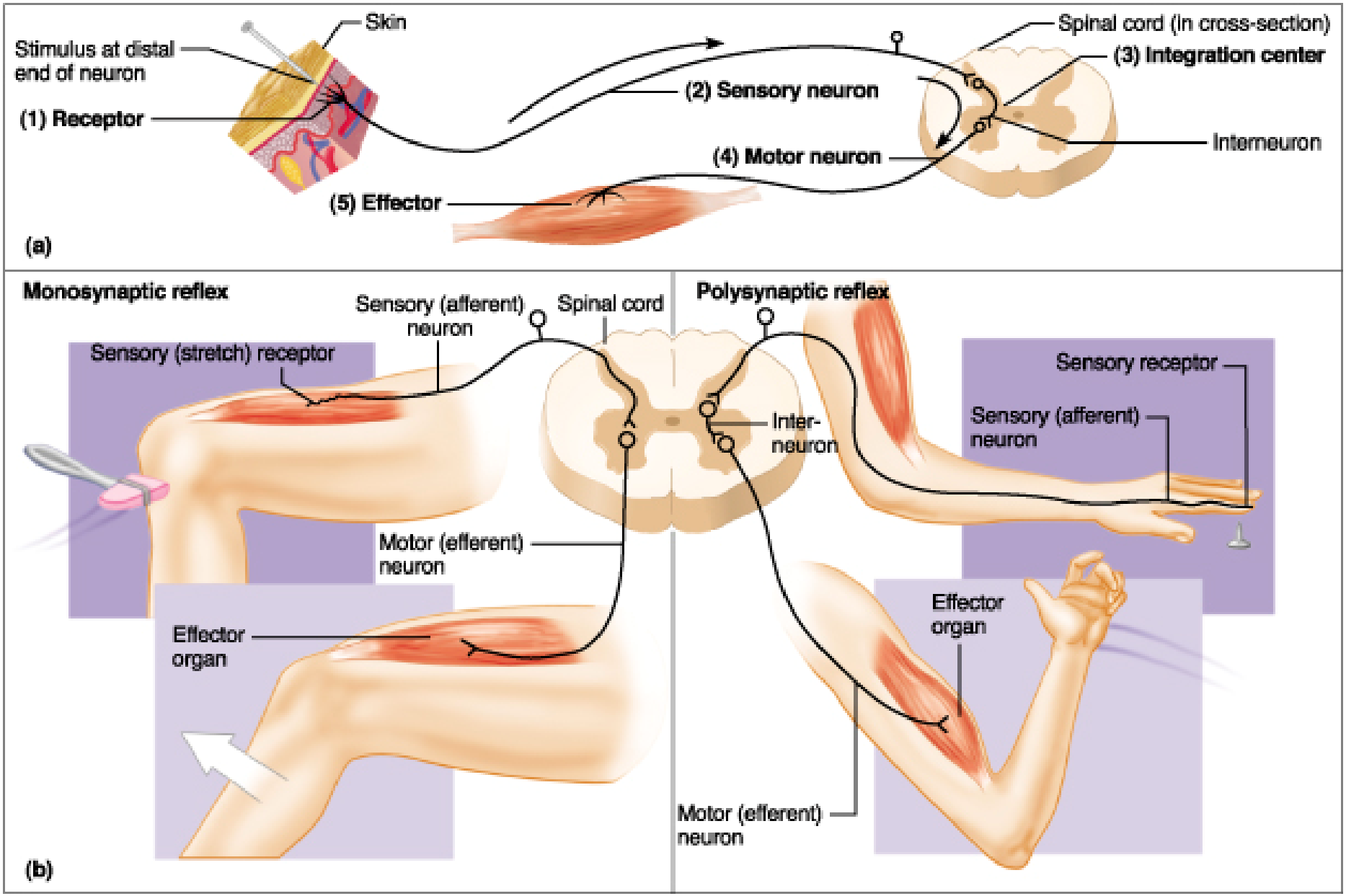












Essentials for normal gait

1. The body can **stand upright** and bear the weight evenly on both lower limbs

2. The body can alternately **maintain weight on one limb** while bringing the other limb forward

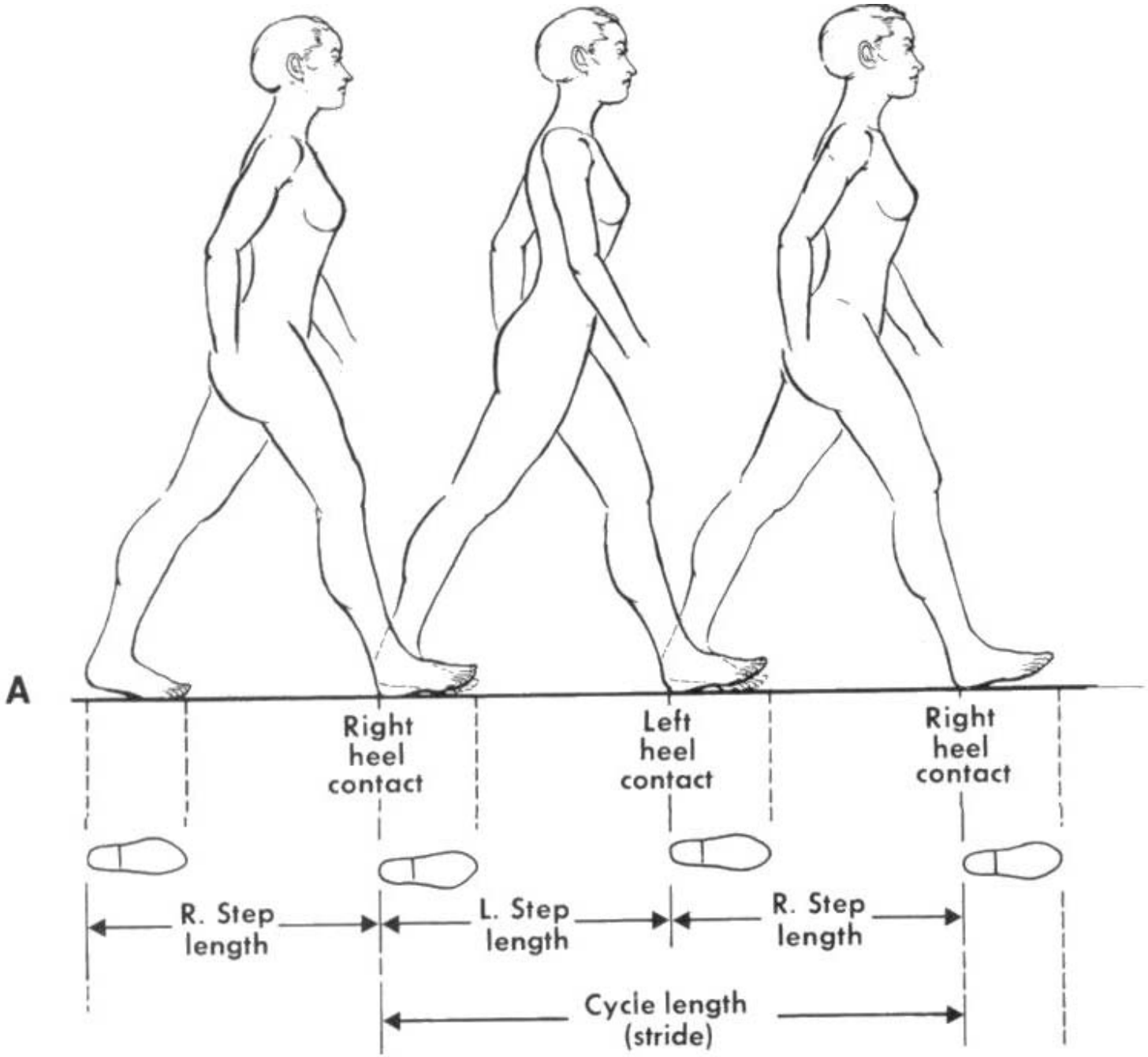
Essentials for normal gait

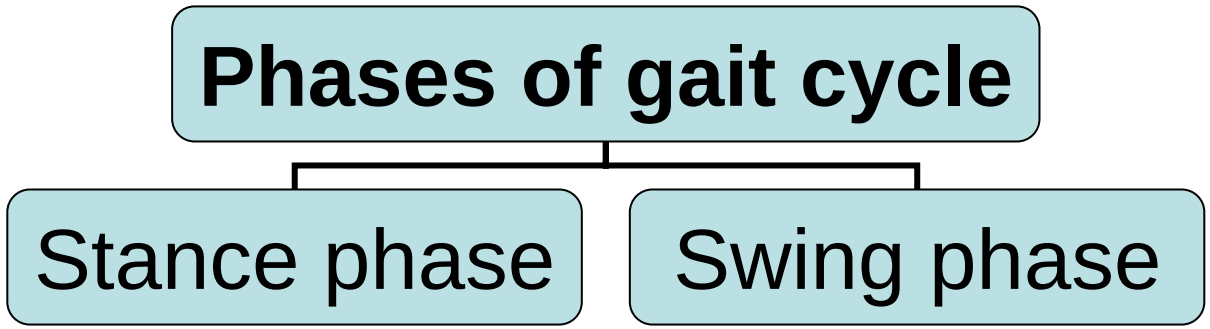
3. The movements necessary for walking are present and coordinated (such as **movement of trunk and arms**)

Gait cycle

- Includes the activities that occur from the point of **initial contact** of one lower extremity to the point at which **the same extremity contacts the ground again**

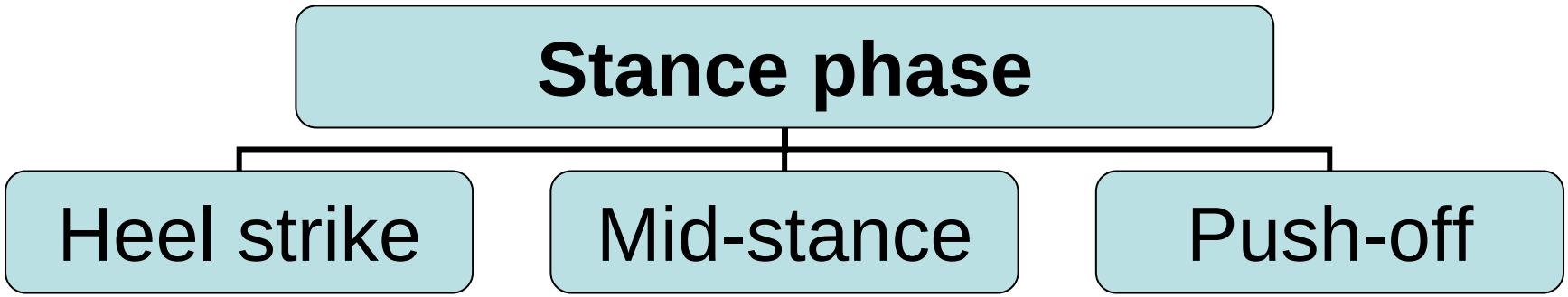
- **From heel contact of one foot to the next heel contact of the same foot**


A
Right heel contact
Left heel contact
Right heel contact
R. Step length
L. Step length
R. Step length
Cycle length (stride)


Phases of gait cycle
Stance phase
Swing phase

Phases of gait

- In normal walking: approximately 50-60 steps are taken per minute
- The ***stance*** phase constitutes 60% of the gait cycle
- The ***swing*** phase constitutes 40% of the gait cycle

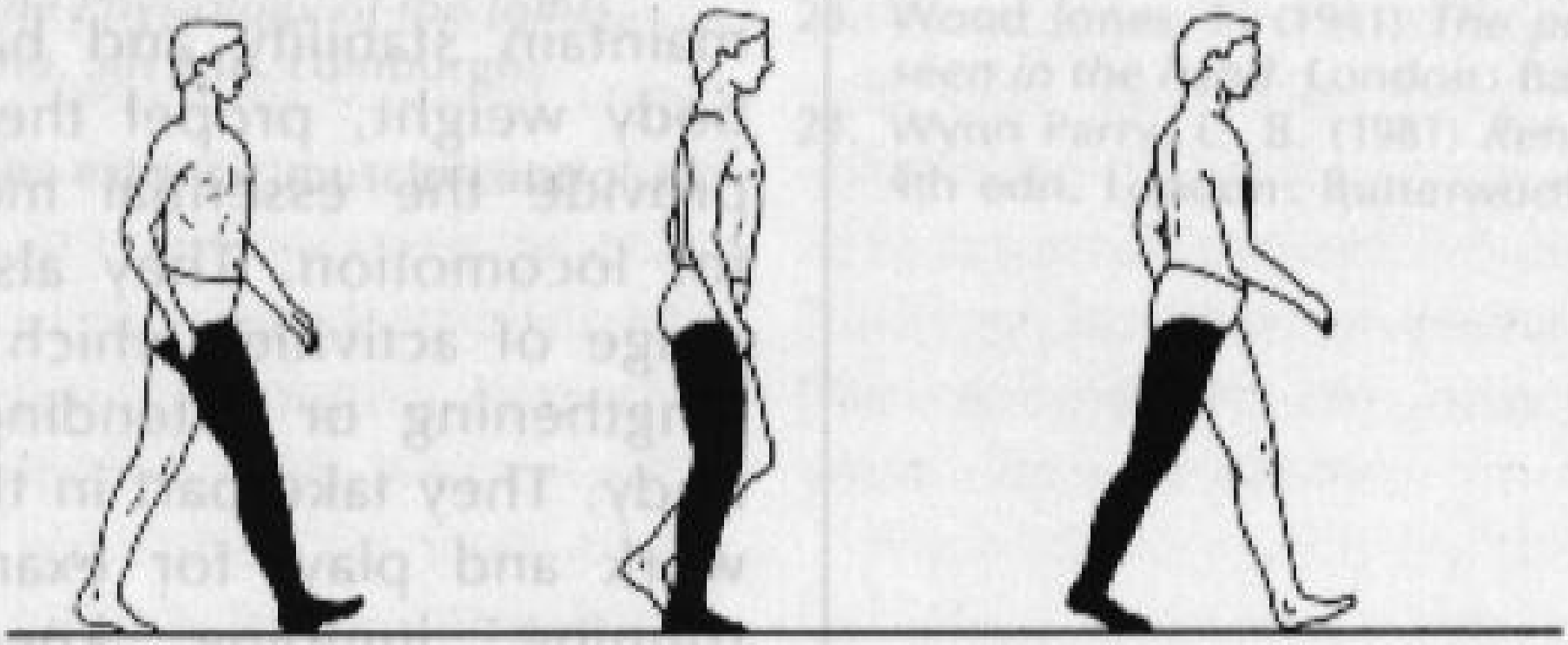

Stance phase
Heel strike
Mid-stance
Push-off

STANCE PHASE

heel-strike

mid-stance

push-off



Stance phase

- Begins at the instance that one extremity contacts the ground (**heel strike**) and continues as long as some portion of the foot is in contact with the ground

- Ends when the reference foot lifts off the ground (**toe off**)

Stance phase

- The “weight bearing” phase
- Provides the stability of the gait
- Necessary for accurate swing phase to take place

Stance phase

1. Heel strike:

- Position of “double support”: the heel of the leading stance foot and the toes of the other foot both on the ground

Stance phase

1. <u>Heel strike:</u>

On the leading stance limb:

- the hip is flexed (approximately 30-35^{o})
- the knee is extended
- the foot at right angle to the leg
- the heel in contact with the floor

Stance phase

2. Mid-stance

- Foot flat on the floor
- A stable position

Stance phase

2. Mid-stance

- The body is carried forward over the stance limb with the hip extending and the foot gradually placed on the floor

- The knee is in slight knee flexion

Stance phase

3. Push-off

- The heel is raised as the body moves forward over the stance limb

- The end of the stance phase and beginning of swing phase

Stance phase

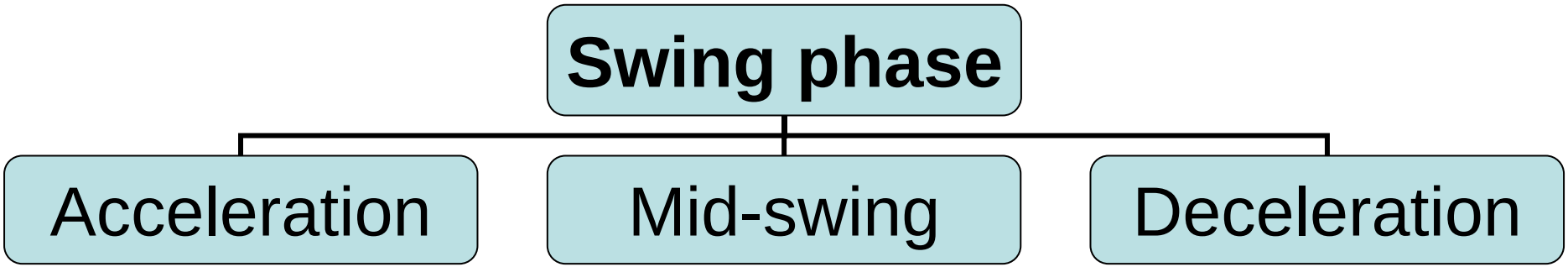
3. Push-off

- The hip is in hyperextension, internal rotation, and adduction
- The knee is extended

Swing phase

- Begins as soon as the big toe of one limb leaves the ground (after toe off), and finishes just prior to heel strike or contact of the same limb

- The “non-weight bearing” phase

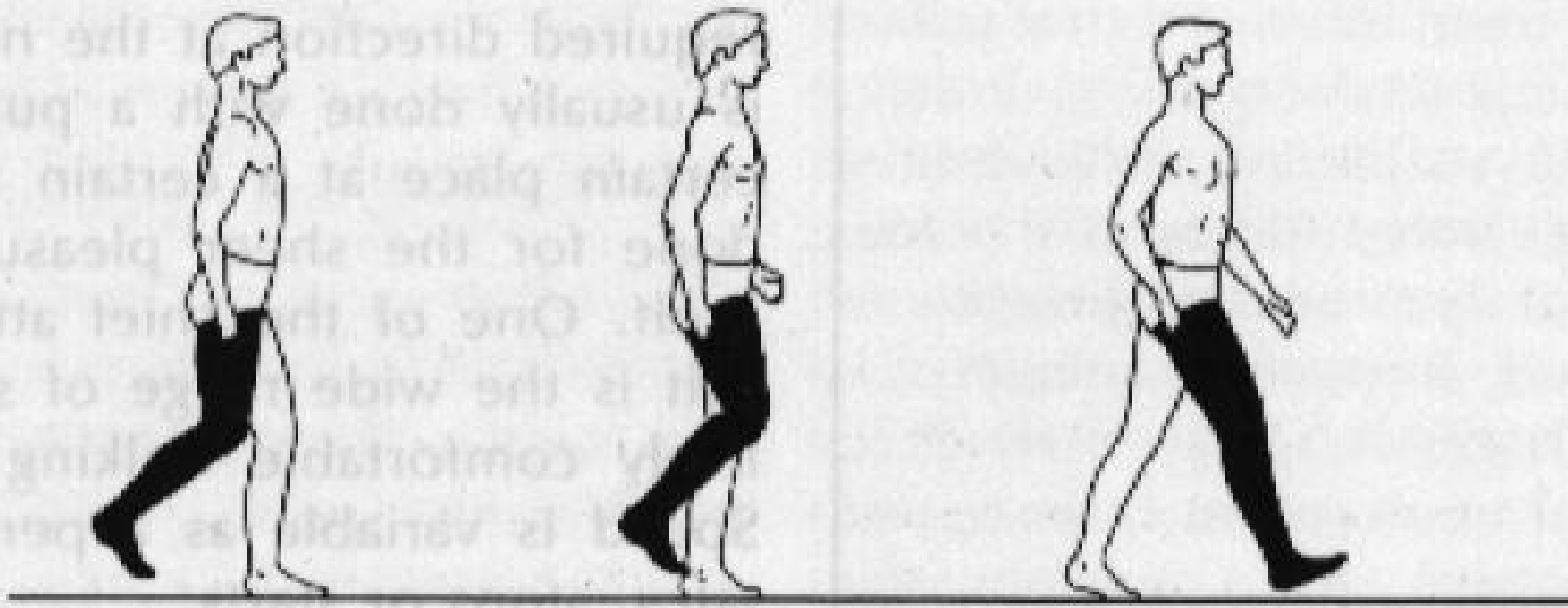

Swing phase
Acceleration
Mid-swing
Deceleration

SWING PHASE

acceleration

swing-through

deceleration



Swing phase

1. Acceleration (initial swing):

- Begins once the toe of the swing limb leaves the ground until the point at which the swing limb is directly under the body or at maximum knee flexion

Swing phase

1. Acceleration (initial swing):

- Forward momentum is provided by the ground reaction to the push-off action (when the heel is off the ground but the toes are in strong contact with the ground)

Swing phase

1. Acceleration (initial swing):

- The hip is in flexion and external rotation
- Flexion of the knee is necessary for the swinging limb to clear the ground as it moves forward

Swing phase

2. Mid-swing (swing through):

- Begins from maximum knee flexion (when the swing limb is under the body) until the swing limb passes the stance limb and the tibia becomes in a vertical position

Swing phase

3. Deceleration (terminal swing):

- From the point at which the tibia is in a vertical position to the point just prior to initial contact

- The momentum slows down as the limb moves into the stance phase again

Swing phase

3. Deceleration (terminal swing):

- The knee is extending in preparation for heel strike
- The hip becomes more flexed

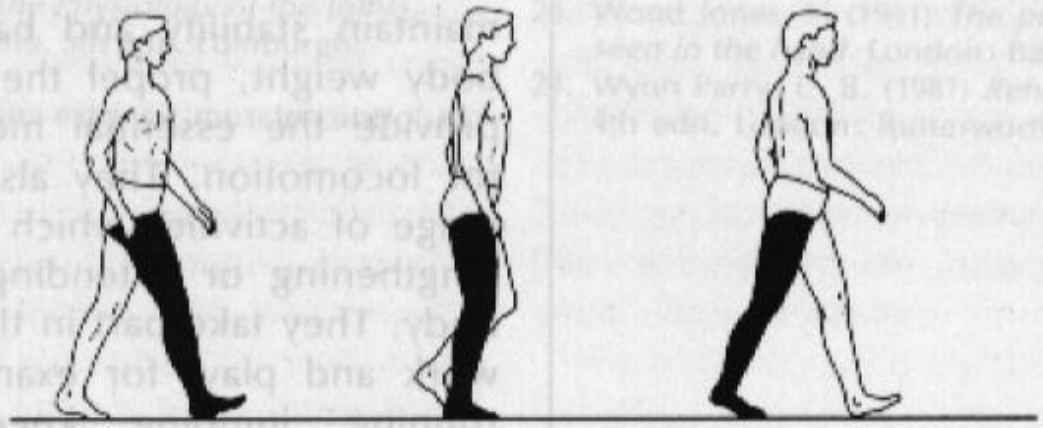
Swing phase

3. Deceleration (terminal swing):

- The foot in neutral position
- As the heel touches the ground, the foot moves into plantar flexion (by the controlling action of the dorsiflexors)

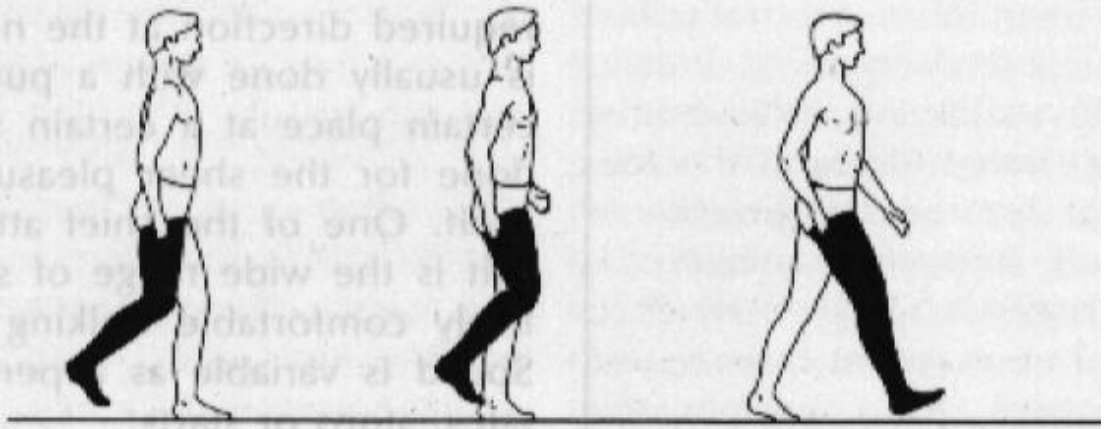
STANCE PHASE

heel-strike mid-stance push-off



SWING PHASE

acceleration swing-through deceleration



Muscle activity in walking

- As a principle to identify the acting muscles and type of muscular contraction during gait, follow those steps:

1. If the ground reaction force vector is anterior to the joint, then the muscles in the opposite direction are acting to counterbalance the effect of gravity

Muscle activity in walking

2. Determine the normal joint motion (desired motion) during each sub-phase of the gait

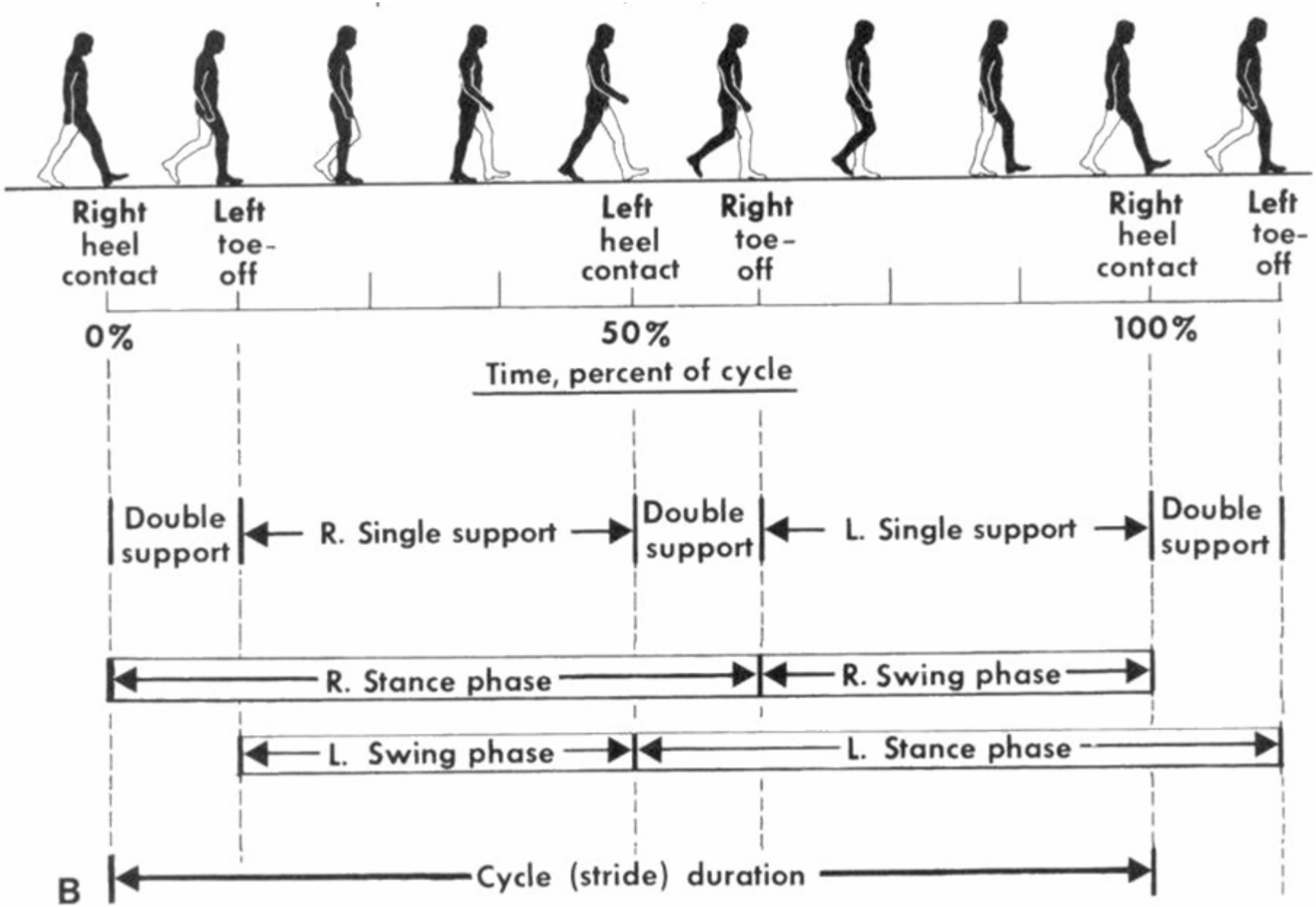
3. If the joint motion occurs in one direction (e.g., flexion), and the acting muscles work in opposite direction (e.g., extension), then the type of contraction is eccentric

Ground reaction force vector (GRFV)

- The force that acts on the body as a result of interaction with the ground
- Equal in magnitude but opposite in direction to the gravitational force in the erect standing posture

Ground reaction force vector (GRFV)

- The GRFV and line of gravity form a common line in the static erect posture
- But during gait and other dynamic activities, the line of gravity may not coincide with the GRFV



Time Dimensions of Walking Cycle

Hip joint

- **At initial contact** (in the stance phase, heel strike):
  - GRFV passes anterior to the hip joint creating flexion moment
  - this moment is counterbalanced by the action of the hip extensors (gluteus maximus and hamstrings)
  - the desired movement is flexion and the acting muscles are extensors: so the contraction is eccentric

Hip joint

- **At loading:**

  - the contraction changes to be concentric as the limb moves from flexion to extension

  - the gluteus maximus increases its activity while the hamstrings reduces its activity

Hip joint

- **At mid-stance, terminal stance, and pre-swing:**
  - the GRFV passes posterior to the hip joint creating extension moment
  - this extension moment is counterbalanced by the action of the flexors (iliopsoas, tensor fascia lata, and rectus femoris)
  - the contraction is eccentric at mid-stance and terminal stance, then it becomes concentric to initiate the swing phase

Hip joint

- **At initial swing:**
  - hip flexors (mainly iliopsoas, gracilis, and sartorius) contract concentrically to initiate swing
  - the gracilis and sartorius show small levels of activity at the knee (induce knee flexion at the same time?)

Hip joint

- **<u>At mid-swing:</u>**
  - momentum of the flexors effort is the prime mover

- **<u>At terminal swing:</u>**
  - the hamstring and gluteus maximus contract eccentrically to control the forward progression of the limb

Knee joint

- **<u>At initial contact:</u>**

  - <u>concentric</u> contraction of quadriceps as a continuation to their role during terminal swing

Knee joint

- **At loading response** (after heel strike):
  - the GRFV passes posterior to the knee joint creating flexion moment
  - this moment is counterbalanced by the eccentric action of the quadriceps
  - this action serves as a shock absorber

Knee joint

- **<u>At mid-stance and terminal stance:</u>**

  - the GRFV passes anterior to the knee joint, thereby the quadriceps relaxes

Knee joint

- **<u>At mid-stance and terminal stance:</u>**
- Knee extension stability is provided by 3 mechanisms:
  1. swing limb momentum
  2. strong plantar flexion provides a stable tibia over which the femur continues to advance
  3. passage of the GRFV anterior to the axis of the knee joint provides a small passive extensor force

Knee joint

- **At pre-swing:**

  - the GRFV passes posterior to the knee creating flexion moment

  - this moment is counterbalanced by the eccentric contraction of the quadriceps (rectus femoris) to prevent excessive knee flexion

Knee joint

- **At initial swing:**

  - concentric contraction of knee flexors (biceps femoris, gracilis, and sartorius) is necessary to lift the leg and allow for sufficient foot clearance

Knee joint

- **<u>At mid-swing:</u>**

  - no muscle action is needed and the limb advances by the effect of momentum generated by the continuing hip flexion

Knee joint

- **At terminal swing:**
  - concentric contraction of quadriceps is necessary to lift the weight of the tibia and foot
  - excessive hyperextension is prevented by the eccentric action of the hamstrings to control the forward motion of the limb

Ankle joint

- **At initial contact:**

  - the desired motion is dorsiflexion produced by the concentric action of the dorsiflexors

Ankle joint

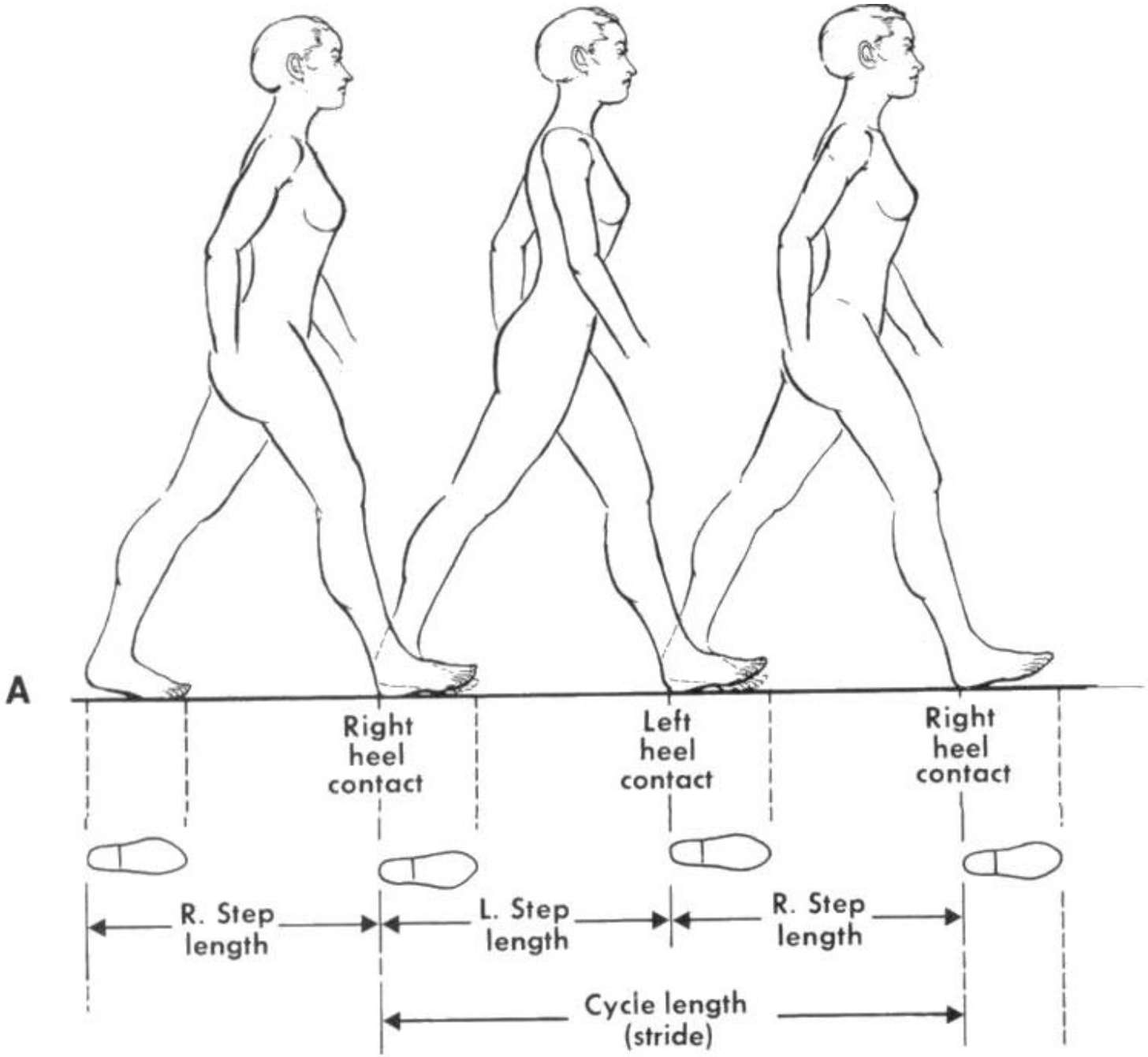
- **At loading response:**
  - the GRFV passes posterior to the ankle creating plantar flexion moment
  - the moment is counterbalanced by the eccentric action of the dorsiflexors to control the lowering of the foot to the ground

Ankle joint

- **At mid-stance:**
  - the GRFV passes anterior to the ankle creating dorsiflexion moment
  - the moment is counterbalanced by the eccentric action of the plantarflexors to restrain the forward movement of the tibia on the foot

Ankle joint

- **At initial swing and mid-swing:**
  - the dorsiflexors contract concentrically for toe clearance and to move the foot from plantar flexed position at pre-swing to neutral position in mid-swing
  - the dorsiflexors then act isometrically to maintain the ankle in neutral position throughout the swing phase


A
Right heel contact
Left heel contact
Right heel contact
R. Step length
L. Step length
R. Step length
Cycle length (stride)