Pathomechanics of gait

Overview

- Human locomotion requires the integration of numerous physiological systems .
- **Normal gait requires:**

1) stability to provide antigravity support of body weight,
2) Mobility to allow smooth motion as body segments pass through a series of positions, and
3) Motor control to sequence multiple segments while transferring body weight from one limb to another.

Overview

- The resultant gait pattern is a mixture of deviations caused by the primary dysfunction as well as the compensatory motion dictated by residual function.
- Appropriate intervention depends on the clinician differentiating the two mechanisms .

Specific gait abnormalities

- Abnormal movement may be performed for one or two reasons :

1) The subject has no choice, the movement being " forced" on them by weakness, spasticity or deformity.The movement is a compensation, which the subject is using to correct for same abilities or disabilities.

2) Other problem, which therefore needs to be identified. Variations in the normal pattern other the normal expected differences among individuals can be classified into:

- **I - Borderline gaits**
- **II - Pathological gaits**

I - Borderline gaits

- These gaits differ from the average gaits merely by peculiar exaggeration or suppression of one or the other of the phases of the gait. Borderline gaits is still considered within the physiological limits.
- (e.g.), gait of fatigue

II - Pathological gait

- **Causes of pathological gait:**

1. **Musculoskeletal Impairments including:** Muscle weakness , Joint deformity due to soft tissue contracture and bony constriction.
2. **Effect of Sensory Impairments on gait:** somatosensory, visual, vestibuler.
3. **Effect of Cognitive and Perceptual Impairments on Gait and motor control problem.**
4. **Pain**

1) Musculoskeletal Impairments

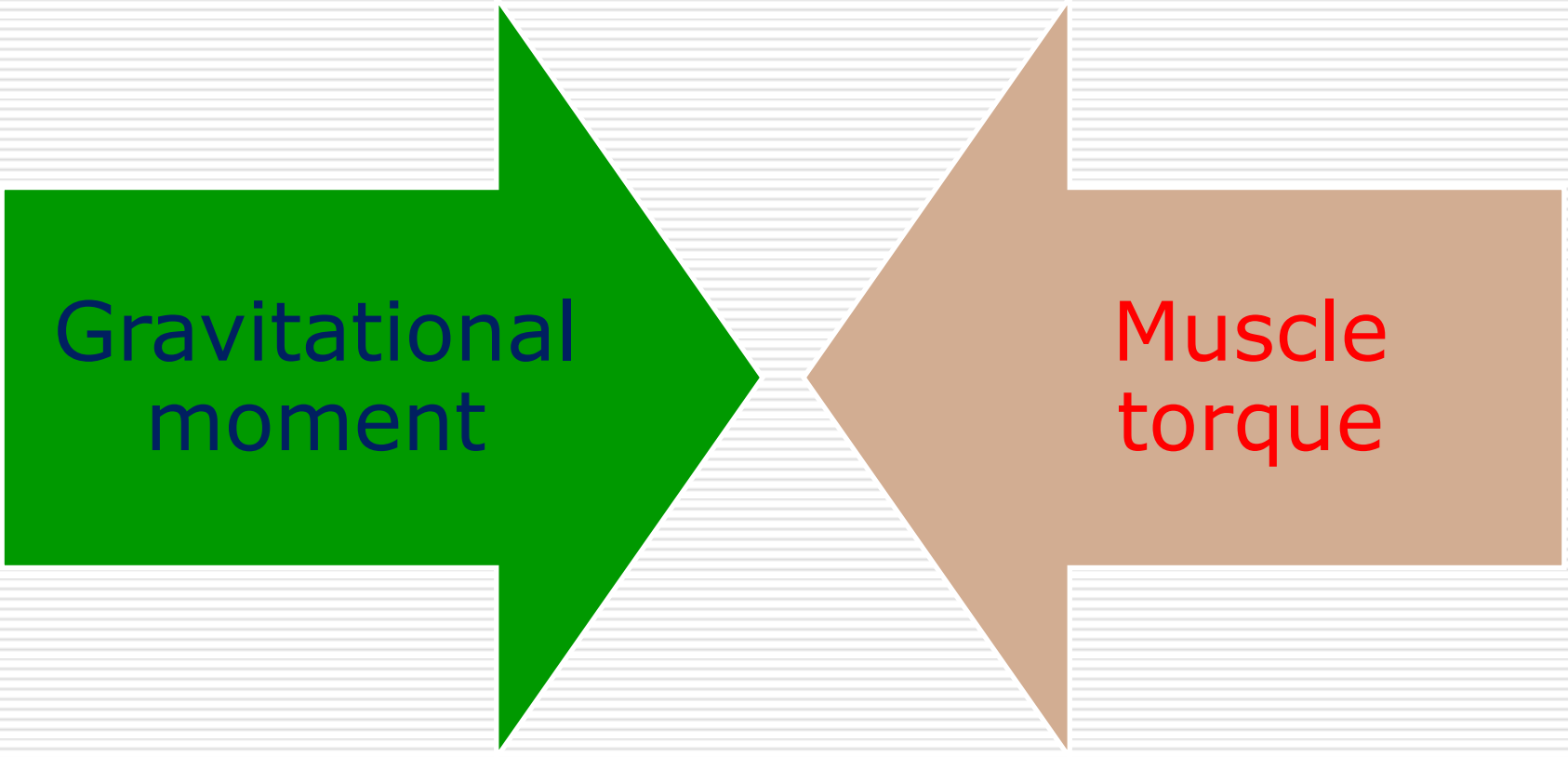
- Problems in the musculoskeletal system include **weakness**, **loss of range of motion** and **contractures**, and **changes in alignment.**
- Thus, abnormal joint stiffness and limited range of motion not only reduce joint motion but also affect the ability of muscles to generate power at various speeds.

Musculoskeletal Impairments

1)Impact of muscle weakness (lab activity)

The problem of patient with muscle weakness is inability to generate appropriate torques needed to meet the demand of walking.

Equilibrium



Weakness of gluteus Maximus:

A - Normally:

- The GRFV in early stance lies in the front of the hip as the hip joint continuously extends, and the body moves forward
- GRFV creates flexion moment which will be compensated by the action of the gluteus maximus of the supporting leg.

Weakness of gluteus Maximus:

B - Result of weakness :

- There's tendency for excessive hip flexion(jack knifing of hip) and anterior pelvic tilting.
- Inability to counteract flexion moment as a result of muscle weakness.

Weakness of gluteus Maximus:

C - Possible compensation:

- The patient will lean the trunk backward (backward thrust of trunk) to shift the FRFV behind the axis of the hip joint. This gait called gluteus maximus gait or backward lurching gait.
- So GRFV itself will act as extensor force and is balanced by tension of iliofemoral ligament.

Weakiness of gluteus medius

A- Normally

- The GRFV in single limb stance passes medially to the hip joint creating moment in clockwise direction (adductor moment)around hip. So , there is tendency of the pelvis to drop laterally towards non stance limb.
- This moment is compensated by another moment which will be created by abductor muscles in other direction in order to stabilize the pelvis in the frontal plane.

Weakiness of gluteus medius

B- Result of weakness

- Inability to counteract adduction moment.
- Increase tendency of pelvis to dip on the side of the foot which is off the ground
- In case of unilateral weakness , this cause lateral trunk lean towards non stance limb
- In case of bilateral weakness this cause alternate lateral trunk lean on both sides.(waddling gait).

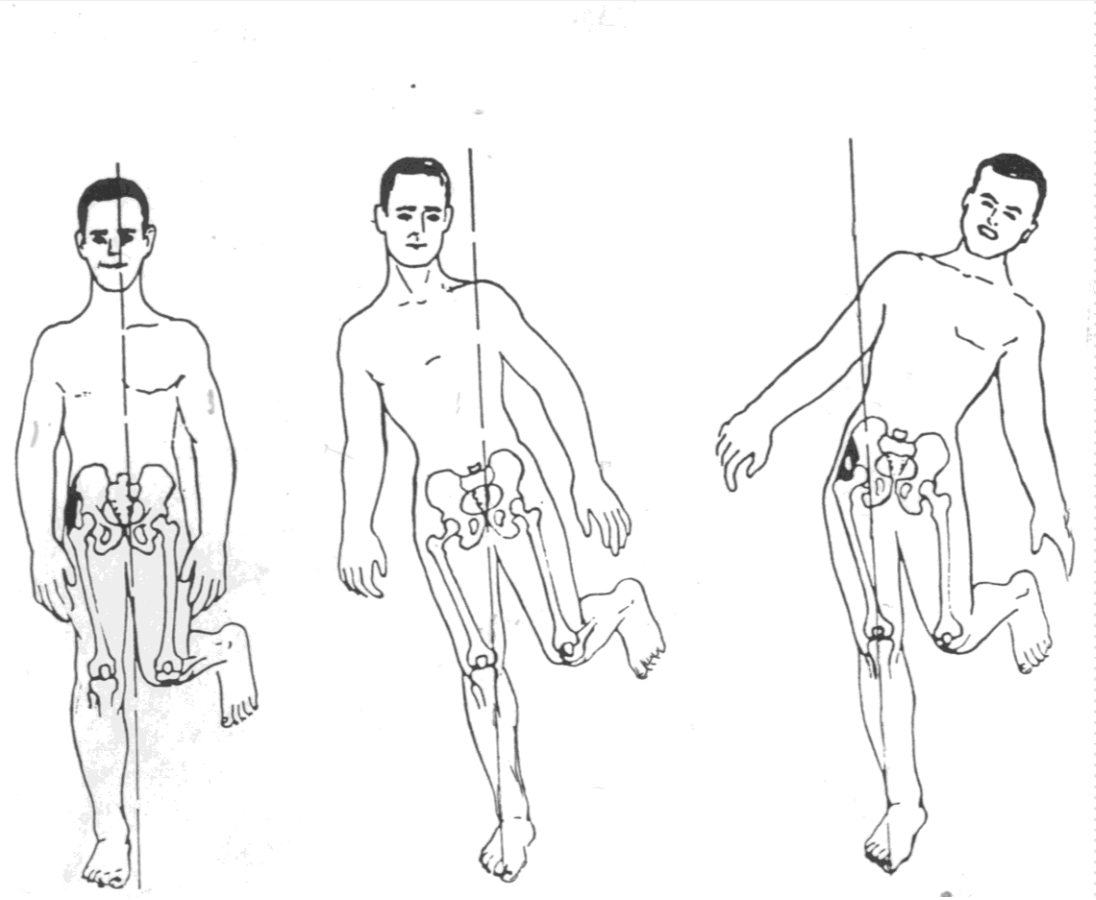
Weakiness of gluteus medius

C- Possible compensation:

- Unilateral weakness causes the trunk to be displaced towards the affected side every time it contacts the ground that will decrease the moment arm of the gravitational force and decrease demands on abductor group.
- This is called gluteus medius gait or lurching gait.
- If GRFV passes via hip joint, no moment will be created.
- If GRFV passes lateral to the hip joint, it will act itself as abductors. But it will lead to scoliosis later on.

Weakiness of gluteus medius

N.B. If there is a lack of body image the compensatory mechanism will occur



Hip Flexor Weakness

A-Normally

- Walking requires grade 2 +, (poor plus) muscle strength in the hip.
- Flexors used during the swing phase of gait primarily affects progression. by producing a hip flexor moment at the initiation of swing continues through the other subphases of swing till initial contact.

Hip Flexor Weakness

b-Effect of weakness

-In initial swing there is inadequate hip flexion
- inability to develop sufficient momentum reduce the limb advancement, limit the knee flexion.
As a result toe clearance is reduced or lost result in **toe dragging**
-In terminal swing to initial contact a shortened step length is evident
- At the same time, placement of the foot in preparation for weight acceptance is affected, challenging stability.

Hip Flexor Weakness

c- Possible compensations

- There are several compensatory strategies to achieve foot clearance during swing despite inadequate hip flexion; these are shown in.
- Voluntary posterior tilt of the pelvis to advance the swing limb using abdominal muscles.

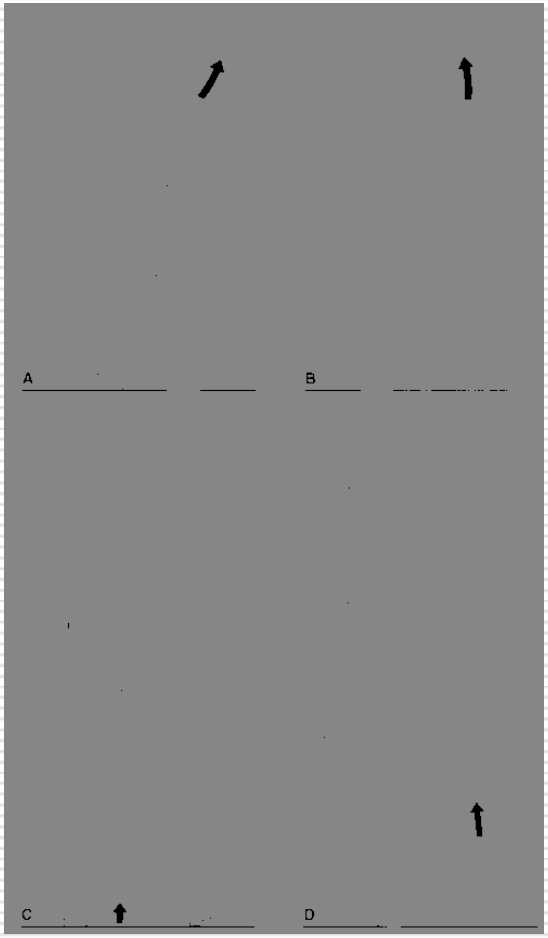
Hip Flexor Weakness

c- Possible compensations

- Voluntary excessive knee flexion to flex the hip joint by changing the limb's COG . As posterior malignment of shank and foot weight introduce passive thigh advancement to balance total limb weight under the hip joint.
- circumduction.
- contralateral vaulting.
- contralateral trunk lean.

Hip Flexor Weakness

Compensatory strategies used to advance used to advance the swing leg despite inadequate hip flexion



Weakness of quadriceps

A - normally:

- The GRFV during standing passes anterior to knee joint and acts itself as extensor
- During loading response, it passes posterior to the knee joint and generate external moment which attempts to flex it
- This moment will be opposed by contraction of quadriceps muscle to prevent falling (contract eccentrically).

Weakness of quadriceps

B - Result of weakness:

- Inability counteract flexion moment.
- Increase excessive knee flexion during loading response(jackknifing). And tending to collapse.

Weakness of quadriceps

C - Possible compensation:

- Patient will bend body forward to move FRFV anterior to knee joint axis to act itself as a moment. Producing external extension moment to provide stabilization of the knee
- The patient places his hand on the thigh, presses it backward and lets his arm act as a quadriceps

Weakness of quadriceps

C - Possible compensation:

- The patient contacts the ground with flat plantar flexed foot, GRFV moves anterior to the joint axis to prevent uncontrolled flexion of the knee joint.
- The patient will turn the limb outward to prevent jackknifing so the joint axis moves in a direction that is locked against flexion.

Weakness of quadriceps

N.B. Placing in the shoe a cushion under the heel is another compensation designed to aid a patient with knee instability by moving the GRFV anteriorly.

Weakness of hamestrings

A - Normally:

- GRFV passes anterior to the knee joint so it acts itself as a moment. That leads to little or no need for hamstring muscles.

Weakness of hamestrings

B - Result of weakness:

- Progressive genu recurvatum
- Short leg gait in stance phase.
- Slow gait in swing phase
- Decrease restraining force at initial contact
- Lack of control of swinging leg.
- Inadequate knee flexion in swing phase.

Weakness of hamestrings

C - Possible compensation

- Increase hip flexion in swing phase.
- Circumduction or hiking in swing phase.

Weakness of pretibial group

A - Normally:

- GRFV passes posterior to ankle joint during initial contact and loading response and that creates plantar flexion moment.
- This moment will be compensated by action of anterior tibial group during initial contact and then eccentrically to control movement and prevent foot slap.

Weakness of pretibial group

B - Result of weakness:

- Inability to counteract planter flexion moment and that causes excessive plantar flexion.
- Slopping of foot on the floor or the foot advances rapidly to the floor in loading response.
- Foot drop and or toe dragging in swing phase.

Weakness of pretibial group

C - possible compensation:

1 - In stance phase:

- Patient may contact the ground with the foot flat to allow the GRFV to pass neutral or anterior to ankle joint.
- Patient will place the foot with toes first at heel strike to avoid foot slap and eliminate plantar flexion moment by **moving GRFV anterior to ankle joint so that the heel strike will be decreased and restraining force will be decreased as well. This is called " TOE - HEEL GAIT** ".
- Another possible compensation is decreasing the speed of walking.

Weakness of pretibial group

C - possible compensation:

2 - In swing phase:

- High steppage gait as a result of increasing hip and knee flexion to prevent toe drag.
- Hip hiking
- Circumdution of the hip joint.
- Sometimes vaulting on the contralateral limb may occur
- Increase in length of leg

Weakness of calf muscles

A - Normally:

- GRFV passes anterior to the ankle joint in mid stance terminal stance and preswing creating dorsiflexion moment.
- This moment will be compensated by action of plantar flexors which first contract eccentrically to oppose dorsiflexion moment and control tibial advance
- Calf muscle contract fastly to planter flex the ankle joint (concentrically)

Weakness of calf muscles

B-Result of weakness :

- Inability to counteract dorsiflexion moment
- Excessive dorsiflexion and uncontrolled tibial advancement

Weakness of calf muscles

C- Possible compensation:

- Ankle may be maintained in planter flexion to avoid excessive dorsiflexion
- Keep the foot flat to eliminate dorsiflexion moment
- Planter flexion of the ankle with foot flat tends to align GRFV behind the ankle joint., so eliminate dorsiflexion moment (Step to gait)

2-Effect of deformities

- Both soft-tissue contractures and bony constrictions limit joint range of motion, constrain movement, and increase the workload on the muscles, thus affecting a patient's ability to meet the requirements of gait.

2-Effect of deformities

a-Hip flexion contractures:

- Result in inadequate hip extension, which can affect both stability and progression.

2-Effect of deformities

b-Knee flexion contractures

- Result in inadequate knee extension that will keep the knee from fully extending in terminal swing. This will affect placement of the foot in preparation for stance.

2-Effect of deformities

c-Plantar flexor contractures

- limit tibial advancement over the stationary foot during stance.depending on its severity it may affect all the suphases of the stance or just later on.

3-Functional leg length discrepancy

- The legs are not necessarily different lengths when measured on the examination table, but that one or both are unable to adjust to the appropriate length for a particular phase of gait cycle.
- The way that a leg is functionally lengthened is to extend at the hip and knee, and to plantar flex at the ankle.

Effect of Sensory Impairments on Gait

a-Somatosensory Deficits:

- Abnormal somatosensory inputs resulting in uncoordinated gait.

Effect of Sensory Impairments on Gait

Loss of proprioceptive inputs:

Results in reduced modulation throughout the gait cycle and leads to:

- decreased angular excursion.
- increased stride width.
- uneven step and stride length.

Effect of Sensory Impairments on Gait

b-visual deficit:

- Vision is critical to the feedforward control of equilibrium during gait.
- Visual inputs are used to regulate gait on a local level (step-by-step basis) and on a more global level (route finding).
- Loss of vision affects the stability and adaptation aspects of gait.

Effect of Cognitive and Perceptual Impairments on Gait

Body Image/ Scheme Disorders:

- **Impaired body image** :

when a person has impaired body image , he will be unable to substitute for functional hip abductor muscle and he will lean to the unsupported side (positive Trendlen berg) .

Effect of Cognitive and Perceptual Impairments on Gait

Cognitive Impairment:

- Cognitive impairments have an impact on mobility function, specifically, the ability to initiate gait, to adapt gait patterns to changing environmental demands, and to navigate to both familiar and unfamiliar locations.
- Cognitive impairments include deficits affecting memory, attention, and executive functions.

Effect of Motor control impairments on Gait

- Upper motor neurone lesions affect walking through:

a- Spasticity

b- impaired selective control

c- Emergencies of primitive locomotor patterns change in phasic muscle activity

- spasticity obstruct the yielding quality of eccentric muscle action during stance.

Effect of Pain on Gait

- **Compensatory strategies used in the presence of pain are movements that:**

(1) reduce weight bearing time on the painful limb (e.g., shortening stance phase of gait),

(2) avoid impact of loads

(3) reduce joint excursion (e.g., limiting knee flexion during the stance phase of gait),

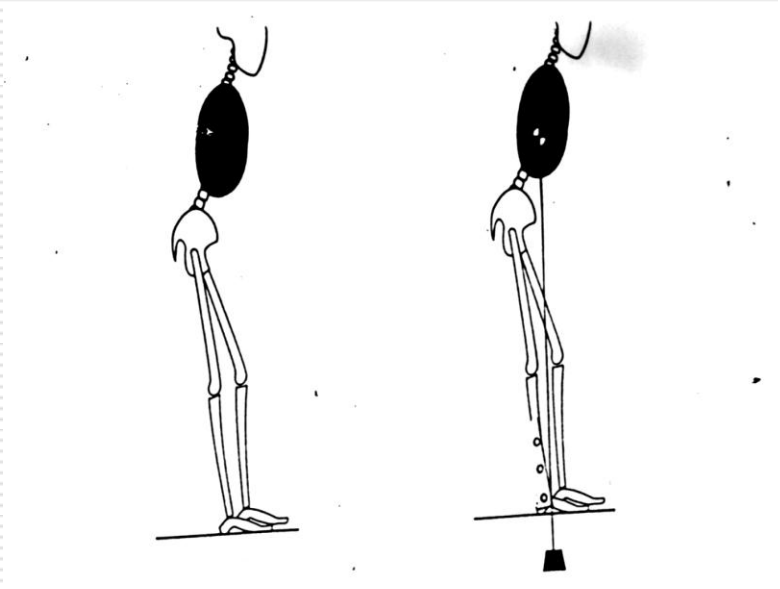
(4) decreasing joint compressive forces by minimizing activity in muscles that cross the joint .

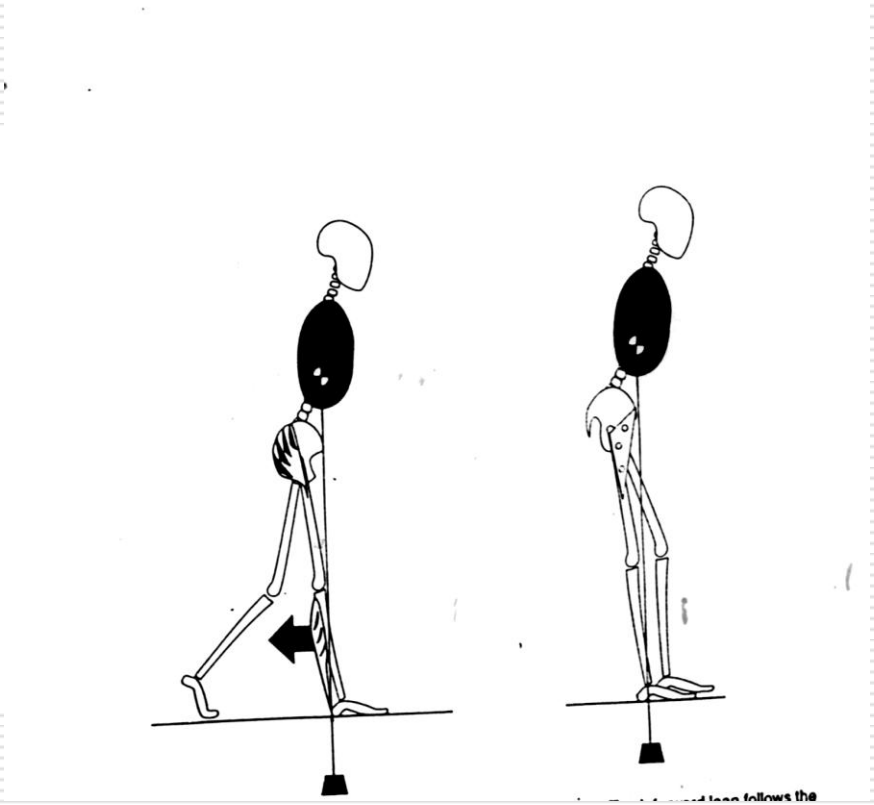
Effect of Pain on Gait

- Antalgiec gait is often characterized by decreased gait velocity, shortened stance phase on the painful limb, a tendency to stiffen the limb in order to minimize joint motion and a reduction in forceful foot contact or push-off.

Common gait deviations and their possible causes (lab activity)

- **Anterior trunk bending**





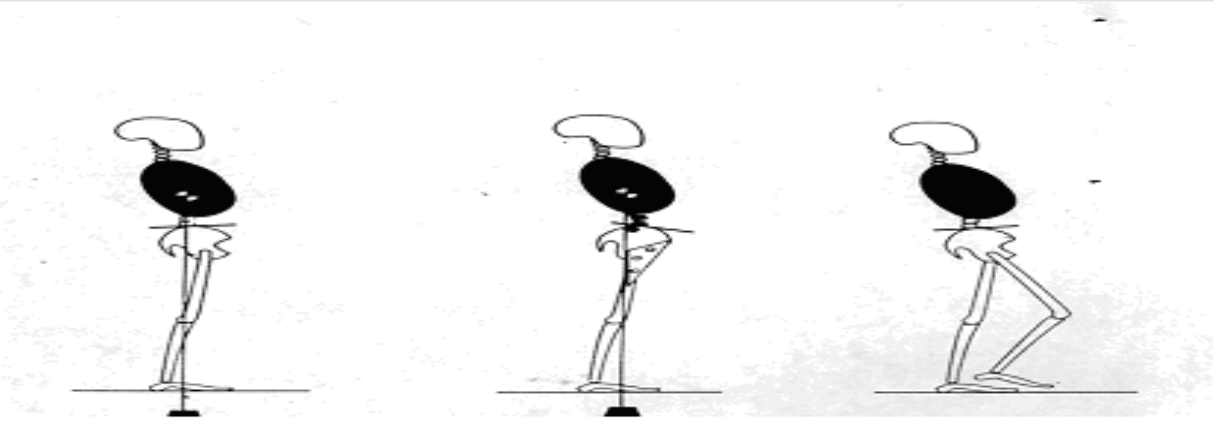
Common gait deviations and their possible causes

The purposes of Anterior trunk bending:

- Weakness of the knee extensors.
- Hip flexion contracture without compensatory lordosis.
- Rigid ankle planter flexion contracture.

Common gait deviations and their possible causes

- **Posterior trunk bending**



Common gait deviations and their possible causes

- **Lateral trunk lean**

Common gait deviations and their possible causes

- -Circumduction

Common gait deviations and their possible causes

Hip hiking:

- Is a rather ugly gait modification, in which the pelvis is lifted on the side of the swinging leg, by contraction of the spinal muscles and the lateral abdominal wall.

Common gait deviations and their possible causes

Steppage :

- is very simple swing phase modification, consisting of exaggerated knee and hip flexion to lift the foot higher than usual for increased ground clearance. It is best observed from the side.

Common gait deviations and their possible causes

Vaulting :

- The ground clearance for the swinging leg will be increased if the subject goes up on the toes of the stance phase leg, a movement known as vaulting.
- This causes an exaggerated vertical movement of the trunk, which is both ungainly in appearance and wasteful of energy.

Common gait deviations and their possible causes

Vaulting :

Common gait deviations and their possible causes

Excessive knee extension(hyper extension)

- is common in spasticity, due to over activity of the quadriceps. This may be accompanied by spasticity of the triceps surae, which plantarflexes the ankle and causes the body weight to be taken on the toes.
- Shortness of one leg may cause the person to stand on the other leg alone, with the knee hyperextended. This is because it is uncomfortable to stand on both legs, since the knee on the longer side would have to be kept flexed.

Common gait deviations and their possible causes

- **Inadequate dorsiflexion control**:

1-weakness or paralysis of the anterior tibial muscles, or from the dorsiflexion being overpowered by spasticity of the triceps surae.

2-An inability to dorsiflex the foot during the swing phase is a functional leg length discrepancy .

3-Toe drag will only be observed of the subject fails to compensate.

4-Toe drag may also occur if there is delayed flexion of the hip or knee at the beginning of swing, causing the foot to touch on the ground despite adequate dorsiflexion at the ankle

Common gait deviations and their possible causes

- **Insufficient push off:**

1-A problem with calf muscles that it prevents adequate weight bearing on the forefoot.

2-Rupture of the Achilles tendon, or weakness of the soleus and gastrocnemius, are typical causes.

3- Any foot deformity if the anatomy is so distorted that it prevents normal forefoot loading.

4-pain under the forefoot, if the amount of pain is affected by the degree of loading.

Common gait deviations and their possible causes

- **Abnormal walking base:**
- **A- an increased walking base caused by:**

1-instability and fear of falling, the feet being placed wide apart to increase the area of support.

2-deficiency in the sensation of proprioception of the legs.

3-In addition to the widened walking base, the use of one or two canes will considerably aid stability.

Common gait deviations and their possible causes

- **Abnormal walking base:**
- **B- A narrow walking base usually results from:**

1-an adduction deformity at the hip or a varus deformity at the knee.

2- adductor spasticity.

Common gait deviations and their possible causes

Limping Mechanism:

- While walking , the step times or step lengths or both are unequal
- Pain or muscle weakness in a lower limb usually provokes a symptomatic change in gait.

Effects of using a walking stick:

- The purpose, of the stick is to relieve part of the body weight by transferring it to the ground,
- so reducing the muscular forces needed to counterbalance the force of the body weight and
- thus reducing the compressive forces on the affected joints.

Another gait abnormalities

- Abnormal attitude or movements of the upper limb, including a failure to swing the arms
- Abnormal attitude or movements of the head and neck
- Sideways rotation of the foot following heel strike
- Rapid fatigue.


Thank you