In a cohort of 372 subjects over age 65 enrolled in health management plans, only 57 had documented falls. Yet, the number of actual falls doubled when the patients were eventually interviewed. More disturbingly, only 7% of the patients had their gait and balance checked; 28% received a neurologic assessment; 25% had their vision tested; and only 6% were evaluated for orthostatic changes in blood pressure. The authors concluded that "Community physicians appear to underdetect falls and gait disorders. Detected falls often receive inadequate evaluation, leading to a paucity of recommendations and treatments."

In a commentary to this study, Dr. Joseph H. Friedman (Gait Abnormalities Are Too Hard To Evaluate, So Why Bother? Medicine and Health Rhode Island, Feb 2005) concluded that "gait is not assessed in either the hospital or the outpatient setting simply because doctors have not been taught how to do this. [In fact] gait is not simple to assess. It is a motor program that is altered by an infinite number of combinations of disturbances."

He also urged "...teaching doctors how to assess gait, and hopefully recognizing the more common abnormalities. I am specifically asking every doctor to acknowledge that gait, especially in the elderly, is a major aspect of health and should be checked."
GAITS – WHY BOTHER?

- Gait disturbances are common.
- They are especially common in the elderly, affecting 15% of subjects above 60, 25% of those older than 80, and 50% of people above 85.
- In fact, half of all nursing home residents have problems walking.
- In Göteborg, Sweden, one in four 79-year-olds had to use a mechanical aid, and none could comfortably walk at 1.4 m/sec, which is the norm for street crossing.
- Hence, gait disturbances are a common risk factor for falls, injuries & loss of independence.
- In a study of more than 1,000 community-living residents older than 72 years of age, 50% had suffered at least one fall during a 2.5 year period.
- Of these, 25% experienced a serious injury, and 5% had a fracture.
- In fact, gait disturbances are an important contributor to hip fractures — the sixth leading cause of death in the elderly.
- There are good historical precedents for this.

“NORMAL” GAIT IN THE ELDERLY
THE “CAUTIOUS” GAIT

- Wider base
- Shorter stride
- Slower speed (10-20%), mostly because of a reduced step length rather than cadence
- Expanded double-support period
- Trepidation
- Hence, the “Marche à petits pas” of Karl Petrén.
**GAIT – WHY BOTHER (cont.)?**

- Old people fall... old people have more gait disorders than young people... hence old people fall more than young people.
- Moreover, by compromising independent ambulation abnormal gaits are often a reason for nursing home admission.
- Finally, they provide an augenblick diagnose (instant diagnosis).

**GAIT NEUROPHYSIOLOGY – A PRIMER**

- **Stance** is the position assumed by a standing person, or station (from the French derivative of the Italian “stanza”). It is also one of the phases of ambulation.
- **Gait** is instead the individual’s ambulating style (from the Old Norse “gata”, path), which is often so unique to be recognizable from a distance.
- In fact, gaits can say a lot not only about neuromuscular (patho)physiology, but also about mood (like depression), occupation, and even character.

- Stance begins when one heel strikes the ground and it lasts for the entire period during which that foot stays grounded.
- Hence, it is a weight-bearing phase.
Swing is instead the interval between the lifting of that foot's toes off the floor and the time the heel of the same foot strikes the ground again.

Since during this time the foot is airborne, "swing" is the non-weight-bearing phase of the cycle.

Swing is instead mostly due to contraction of the flexors: iliopsoas (for hip), hamstrings (for knee), and tibialis anterior (for ankle).

Through it all the Long Extensors dorsiflex foot for toe clearance.

Stance is mostly due to contraction of the extensors: the gluteus maximus early on, quadriceps in the middle, and plantar flexors (soleus and gastrocnemius) towards the end.

Swing is instead mostly due to contraction of the flexors: ilopsoas (for hip), hamstrings (for knee), and tibialis anterior (for ankle).

Through it all the Long Extensors dorsiflex foot for toe clearance.

Stance and swing make up a stride, which corresponds to the interval between the time one heel hits the floor until it strikes it again.

For 20–25% of the cycle the stance of the two legs overlaps, insofar as both feet are on the ground (double-limb support). This time increases with age.
**GAIT – IMPORTANT DIAGNOSTIC CLUES**

- Symmetry versus asymmetry
- Height, length and cadence of steps (length of stride)
- Presence of muscle weakness (hypotonia)
- Presence of stiffness in the limbs (hypertonia)
- Presence of bladder or bowel dysfunction (spastic paraplegia)
- Difficulty in initiating or terminating walking (Parkinson’s)
- Association with vertigo or light-headedness (cerebellar, vestibular)
- Association with pain, numbness, or tingling in the limbs (neuropathy)
- Worsening of disturbance at night (posterior column disease)
- Acute onset — suggesting vascular disease versus drugs (alcohol, benzodiazepines, neuroleptics, and orth. hypotension-inducing agents)

**Neuro-muscular Causes of Gait Impairment**

- Ataxic (Sens/Cereb/Tox)
- Spastic - Diplegic
- Spastic - Hemiplegic
- Rigid (Parkinsonian)
- Apraxic (NPH)
- Neuropathic
- Choreiform
- Myopathic

**GAIT – AUGENBLICK ASSESSMENT**

From front, back and side, assess:

- Posture (normal, stooped, kyphotic /simian-like and swaying)
- How the patient gets up from a chair (Parkinson’s or myodystrophy)
- How the patient initiates walking (also useful in Parkinson’s)
- How the patient walks at a slow pace
- How the patient walks at a fast pace
- How the patient turns
- How the patient walks on toes (Parkinson’s can’t do it, but also sensory ataxia, spastic hemiplegia, or paresis of the soleus/gastrocnemius)
- How the patient walks on heels (diagnostic in foot drop, spastic paraplegia or motor ataxia)
Gaits – An Augenblick Approach

**GAIT – AUGENBLICK ASSESSMENT**

- How the patient stands (normal vs wide-based)
- How the patient stands with eyes first open and then closed (Romberg’s)
- How the patient walks with eyes first open and then closed (sensory ataxia worsens with closed, whereas cerebellar ataxia does poorly either way)
- How the patient copes with sudden postural challenges, such as modest nudging or pull from behind after adequate warning; inadequate postural reflexes (as often seen in nursing home residents) will cause a few steps of retropulsion, and even a tendency to fall backward.
- How the patient walks a straight line in tandem (i.e., heel to toe) – this is useful in all gait disorders because it narrows the base.

**ANTALGIC GAIT**

- From the Greek “against the pain”, this is a “limp” caused by discomfort on weight bearing.
- It is an antalgic strategy used by patients with either:
  - Hyperesthesia of neurologic disease
  - Pain in one of the weight-bearing joints (hips, knees, ankles, or just the bottom of the feet)
- The latter is very common, since by age 75, 85% of the population will have osteoarthritic changes of the large joints.
- These typically present in a unique (and thus diagnostic) fashion:
  1) **Coxarthrosis** causes a coxalgic gait, characterized by limited range of hip extension and a “lateral (or adductor) lurch.” This is an excessive lateral shift of the patient’s upper body toward the affected side when standing on the painful limb, which effectively relocates the center of gravity, thus reducing the weight load.
  2) **Gonarthrosis** is instead associated with an antalgic gait wherein the knee is stiff and there is inability to flex or extend the leg.
  3) Finally, if the pain originates in the foot, there will be an incomplete (and very gentle) contact with the ground.
- Gait of knee or foot pain are mostly antalgic, insofar as they are characterized by a shortened stance on the affected limb, but not as much by the lateral lurch that characterizes coxalgic gait.
PATHOLOGICAL GAITS
“THE MAGNIFICENT 7”
Antalgic – Joint/Skeleton

Ataxic Gait

ATAXIC GAIT
- This is the unsteady and uncoordinated walk of ataxia, with a wide base and feet that are thrown outward.
- An ataxic gait can be sensory or cerebellar.
- In sensory ataxia, the cerebellum is intact while the afferent input is compromised.
- This is usually sensory (dorsal columns), but could also be visual, vestibular, and even auditory.
ATAXIC GAIT – SENSORY ATAXIA

- More typically, patients with sensory ataxia have simple loss of proprioceptive and sensory input in lower extremities.
- In syphilis' days this was pathognomonic of tabes dorsalis, but now it is mostly due to neuropathy of large afferent fibers, often from diabetes or B12 deficiency polyneuropathy (HIV).
- Patients with sensory ataxia are unaware of their limbs' position.
- Hence, they walk by taking steps that are higher than necessary, while at the same time carefully monitoring the ground.

- Although their gait is as wide as that of cerebellar ataxia, only patients with sensory ataxia typically slap the foot (to increase sensory input).
- And although their stance is as wide-based as that of cerebellar ataxia, only sensory ataxia patients present with positive Romberg's (swaying and falling after loss of compensatory visual input).
- This is also why they have difficulty walking at night.

* Only two gaits "slap the ground" – sensory ataxia and foot drop.

ATAXIC GAIT – CEREBELLAR ATAXIA

- This is the unsteady, staggering, and cautious gait of cerebellar compromise; totally irregular in rate, range and direction.
- It is accompanied by swaying to one side or the other, so that pts often look for something to lean on – a cane, a bed rail, or even the wall.
- Balance typically fails when attempting to walk tandem (heel to toe).
- Stance is also widened, but this is not enough to prevent staggering.
- Titubation while standing (fore-and-aft tremor of head and trunk) worsens considerably when patients are asked to close feet and narrow base, causing wobbling and even falling.
ATAXIC GAIT – CEREBELLAR ATAXIA

- In contrast to sensory ataxia, opening (or closing) the eyes neither improves nor worsens stance (negative Romberg's).
- Since the cerebellum is responsible for proper balance and posture, a cerebellar gait results from either primary cerebellar disease or alcohol intoxication.
- Hence, it differs from sensory ataxia since it is associated with other signs of cerebellar deficit, such as dysmetria, dysarthria, nystagmus, hypotonia, and intention tremor.

PATHOLOGICAL GAITS
"THE MAGNIFICENT 7"

- Antalgic – Joint/Skeleton
- 1. Ataxic – Sensory/Cerebellar/Toxic

PATHOLOGICAL GAITS
"THE MAGNIFICENT 7"

- Antalgic – Joint/Skeleton
- 1. Ataxic – Sensory/Cerebellar/Toxic
- 2. Diskinetic/Choreiform – Basal Ganglia
Gaits – An Augenblick Approach

PARKINSONIAN GAIT

- Common (1.5% of the population older than 65.)
- Rigidity, bradykinesia and tremor are the hallmark.
- The frozen posture and the shuffling gait are its hallmarks.
- In fact, they are so typical that in the absence of tremor they provide the most reliable sign of the disease.
- The main features are axial rigidity and shuffling.

Shoe Pattern of Wear-and-Tear

- This results in a slow walk characterized by a series of small (reduced stride), and narrow-based steps that barely clear the ground (reduced height).
- As a result, gait is very slow.
- Patients find it especially difficult to initiate the gait, not only when trying to rise from a chair, but also when starting to walk after long standing.
- Very characteristic are also the freezing episodes, which typically occur when crossing a threshold, facing a door, turning a corner, or simply transitioning from hardwood to carpet floor.
- Turns are also rather slow (en bloc) due to bradykinesia and postural instability.
**Gaits – An Augenblick Approach**

**PARKINSONIAN GAIT**

- Overall, patients walk with trunk leaning forward, arms immobile at the side (or flexed ahead of the body—but never swinging), and legs bent at the hips, knees, and ankles.
- Feet are dragged on the ground and scrape it.
- Other typical features include:
  - *Festination* (progressively shorter and accelerated steps after the walk has finally begun, from the Latin *festino*, to accelerate; an attempt to maintain the feet beneath the forward moving trunk. Often on tip toe.)
  - *Propulsion* (a tendency to fall forward, and the main reason for festination)
  - *Retropulsion* (a tendency to involuntarily fall and walk backward)

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**1) NPH – MAGNETIC GAIT**

- The first and cardinal sign of NPH.
- May be progressive, as hydrocephalus expands into the lateral ventricles.
- It’s caused by traction on periventricular lumbosacral motor fibers.
- Often presenting as unsteadiness and imbalance, especially on stairs and curbs.
- Typically bradykinetic (very slow), wide-based, short-stepped, shuffling (little knee flexion), and “magnetic”.
- Patients don’t lean forward but backward, and they may swing arms.

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**PATHOLOGICAL GAITS “THE MAGNIFICENT 7”**

- Antalgic – Joint/Skeleton
  1. Ataxic – Sensory/Cerebellar/Toxic
  2. Diskinetic/Choreiform – Basal Ganglia
  3. Hypokinetic/Rigid (Parkinsonian/Apraxic – Extra-Pyramidal/NPH)
Hemiplegic Gait

- This is the stiff and foot-dragging walk of patients who have suffered a hemispheric stroke.
- On the affected side there will be:
  - Upper extremity adduction and flexion at all levels (elbow, wrist, and fingers).
  - Lower extremity extension at all levels (hip, knee, and ankle.)
  - The foot is internally rotated.
  - There is no arm swing.

Spastic hemiplegic patients have great difficulty in flexing the involved hip and knee, and also in dorsiflexing the ankle (which thus remains fixed downward and inward — equinovarus deformity).

As a result, they do not drag the foot limply behind them, but they swing it onto the affected side in a half circle (circumduction).

Thus, the foot scrapes the ground on its lateral edge, in a typical equinovarus wear-and-tear of the shoes.

Given the inability to flex the knee, the upper body lurches to the opposite side (compensating for circumduction), and the walk is overall difficult and slow.
Gaits – An Augenblick Approach

PATHOLOGICAL GAITS
"THE MAGNIFICENT 7"

Antalgic – Joint/Skeleton

1. Ataxic – Sensory/Cerebellar/Toxic
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3. Hypokinetic/Rigid (Parkinsonian/Apraxic – Extra-Pyramidal/NPH)
4. Spastic/Hemiplegic – Pyramidal

SPASTIC/DIPLEGIC GAIT

● This is the stiff-legged gait of patients with myelopathy.
● It is characterized by reduced toe clearance in the swing phase, requiring symmetric circumduction of the lower extremities.
● Later it becomes wide-based, unsteady, shuffling, jerky, and spastic.

Diplegic Gait

SPASTIC/DIPLEGIC GAIT

1. In a myelopathic gait, degenerative osteophytes and ligamentous hypertrophy narrow the cervical spinal canal causing mechanical compression of the cord.
2. In the stooped (simian) gait of lumbar spinal stenosis they narrow instead the lumbar canal, thus compressing the cauda equina.

Diplegic Gait
STOOPED GAIT OF LUMBAR SPINAL STENOSIS

- Dull or aching back pain spreading to legs
- Numbness/paresthesias in legs, calves or buttocks
- Weakness or loss of balance
- Exercise tolerance (neurogenic claudication)
- Symptoms worsened by walking/standing
  - Symptoms relieved by:
    - Bending over or leaning forward
    - Lying down
    - Sitting
    - Put feet on a raised rest

SPASTIC/DIPLEGIC GAIT (Myelopathic) – CAUSES

- Cervical spondylosis (++++)
- B12 deficiency a distant second (+)
- Other causes include multiple sclerosis and thoracic disk herniation

- Osteophytic protrusions are epidemic in the elderly, causing cervical cord impingements in one tenth of patients older than 70, with no neck discomfort or radicular pain in 15% of the cases.
- Eventually, chronic compression of the cord (spinal stenosis) may lead to spas ticity and hyperreflexia in the lower extremities, urinary urgency, and posterior column signs.

SPASTIC DIPLEGIC GAIT

- In contrast to spastic hemiplegia, the arms of spastic diplegia are essentially normal.
**Gaits – An Augenblick Approach**

**SPASTIC DIPLEGIC GAIT**
- In contrast to spastic hemiplegia, the arms of spastic diplegia are essentially normal.
- And in contrast to Parkinson’s, toes of spastic paraplegia always stay on the ground.
- Parkinson also lacks the back pain.

**PATHOLOGICAL GAITS**

**“THE MAGNIFICENT 7”**

- Antalgic – Joint/Skeleton
  1. Ataxic – Sensory/Cerebellar/Toxic
  2. Diskinetic/Choreiform – Basal Ganglia
  3. Hypokinetic/Rigid (Parkinsonian/Apraxic – Extra-Pyramidal/NPH)
  4. Spastic/Hemiplegic – Pyramidal
  5. Spastic/Diplegic (Myelopathic) – Pyramidal

- This is a “foot drop” gait, caused by inability of weak tibialis anterior and toe extensions to dorsiflex the ankle while walking.
- It has two unique features:
  - Foot drop with High Slagpage Gait
  - Neuropathic Gait
Gaits – An Augenblick Approach

“FOOT DROP” (HIGH STEPPAGE GAIT)

1) **High Steppage:**
   - Knees are raised unusually high to allow the drooping foot to clear the ground.
   - Yet, since the toes of the lifted foot remain pointed downward, they may still scrape the floor, thus resulting in frequent stumbles and falls.
   - A foot drop can often be diagnosed by simply looking at the patient’s shoes, since wear-and-tears will be typically asymmetric, and affecting especially the toes.

2) **‘Foot slap’** After the heel touches the ground the forefoot is brought down suddenly and in a slapping manner. This “stamping gait” creates a typical double loud sound of contact (first heel, then forefront).

*FOOT DROP* (HIGH STEPPAGE GAIT)

*Only two gaits “slap the ground”: sensory ataxia and foot drop.*

CAUSES OF “FOOT DROP”

- The most common are lower motor neuron diseases, peripheral neuropathy, peroneal injury, and muscular atrophies.
- This often cause a unilateral foot drop.
- Another major cause of (high) steppage gait is Charcot-Marie-Tooth.
- This often causes a bilateral foot drop.
- In earlier forms, CMT can be easily identified by having the patient run, and by noticing how the knees are raised high in order for the drooping toes to clear the ground.
- Walking on toes and heels can also unmask it.
- If the proximal (girdle) muscles are also affected, then the patient acquires a waddling (anserine) gait.
Gaits – An Augenblick Approach

PATHOLOGICAL GAITS
“THE MAGNIFICENT 7”

Antalgic – Joint/Skeleton

1. Alaseic – Sensory/Cerebellar/Toxic
2. Diskinetic/Choreiform – Basal Ganglia
3. Hypokinetic/Rigid (Parkinsonian/Aparkic – Extra-Pyramidal/NPH)
4. Spastic/Hemiplegic – Pyramidal
5. Spastic/Diplegic (Myelopathic) – Pyramidal
6. Neuropathic – Motor (Weak gait)
7. Myopathic – Muscular (weak gait)

ANSERINE (WADDLING) GAIT

- Bilateral pelvic girdle weakness, resulting in a waddling (or anserine) gait.
- Note the lumbar hyperlordosis, with shoulders thrust backwards and abdomen being protuberant.
- This places the center of gravity behind the hips, so that the patient does not fall forward as a result of weak back and hip extensors.

Myopathic (Anserine/Waddling) Gait

ANSERINE (WADDLING) GAIT – ROLE OF HIP ABDUCTORS

- The gluteus medius originates on the ilium (between ant. and post. gluteal lines), eventually terminating on the lateral surface of the greater trochanter.
- Its contraction pulls the two insertion sites toward one another, thus elevating the opposite side of the pelvis.
- Its weakness causes contralateral sagging of the pelvis (Trendelenburg Sign).
Gaits – An Augenblick Approach

TRENDELENBURG SIGN

- It is a phenomenon that typically occurs when the subject stands on one leg.
- Contraction of the gluteus medius of the weight-bearing limb prevents the pelvis from tipping toward the opposite (and unsupported) side, thus keeping it level.
- When the gluteus medium is weak, the contralateral hemipelvis tips instead down, the buttock sags, and the unsupported leg hangs lower.
- That's a positive Trendelenburg sign.

TRENDELENBURG SIGN

To elicit it, stand behind the patient, and look at the dimples of Venus (i.e., the dimples of sacroiliac joints).

In patients who are standing upright, with feet together and weight evenly distributed between legs, the two DV should be symmetric and at the same level.

Symmetric and leveled should also be the two iliac crests and the two buttocks.

Then ask the patient to lift one foot off the ground and stand on only one leg with the other flexed at 90°.
Gaits – An Augenblick Approach

**TRENDELENBURG SIGN**
- Ask the patient to maintain this stance for at least 30 seconds, so as to induce fatigue.

**TRENDELENBURG - CAUSES**
- The two most common causes are:
  1) Weak hip abductors:
     - Muscular atrophy / dystrophy
     - Spinal nerve root lesions (paralyzing the superior gluteal nerve — horsee, l5)
     - Polymyositis
     - Nowadays mostly hip arthroplasty
  2) Hip disease (especially congenital dislocation, but also fracture of the greater trochanter, which is the distal insertion site for the gluteus medius)

- The Trendelenburg gait is very similar in appearance to a coxalgic gait, with one main distinguishing feature—the tilt of the pelvis. In Trendelenburg, the contralateral hemipelves slips during the single-limb stance phase on the affected side because of severe abductor insufficiency. In the coxalgic gait, the pelvis remains level.