Human Gait

Kinesiology, as well as motion picture photography of human subjects at rest and in motion, is required for a detailed study and application of the knowledge of human gait. For an average clinician these studies are neither easily available nor understandable. With these facts in mind this chapter is entirely devoted to "Human Gait" as a clinician should know it.

Gait is defined as the rhythmic movements of the joints of the lower extremity, resulting in forward propagation of the body. Thus it differs from spot march - as in exercises - where rhythm is essential, but there is no forward propagation.

Human gait is a *biped gait* whereas animal gait is *quadruped*[1]. . In quadrupeds, the hind limbs are used for propulsion and the fore limbs are meant for restriction. The extension of the hind limbs imparts momentum and the fore limbs restrict this momentum when they touch the ground. In human beings, each leg performs these functions alternately. Thus human gait may be described as *Alternate Bipedalism*. It is essentially a "Heel-Toe" gait, with the heel touching the ground first, followed by the toes, and, again, the heel leaving the ground before the toes.

Human gait is a *biphasic gait* wherein there is a *stance phase* and a *swing phase*. In the stance phase, both feet are on the ground and in the swing phase alternate lower limbs swing forward. Tension in the hamstring muscles restricts the extent of the swing, and the heel strike restricts forward momentum. Thus the stance phase starts at *heel strike,* and lasts through *foot flat* and *toes strike* before ending after *toe rise* when the swing phase starts. In the complete stance both feet are flat on ground.

When we look at various people walking, each of them seems to have a gait that is different from the others, yet all of them are deemed to have a normal gait. It must, however, be understood that the visible differences among the gaits is essentially in movement, sway or attitude of torsos, or gestures by the movement of the upper limbs. *Normal Gait,* therefore, is rhythmic movement of the lower limbs.

Now, let us consider the movements of the joints of the lower extremity in a normal gait. In the swing phase, there is obviously flexion of the hip joint. When one stands on one leg, the unsupported pelvis would be expected to fall because of gravity. However, this does not happen; the unsupported pelvis is actually elevated by the abductor muscles of the supported limb, which are abducting the supported hip. This is demonstrated

[1] Exceptions include frogs and toads, who have biped gait, though it is unlike human gait

by the rise of the anterior superior iliac spine or of the gluteal crease on the unsupported side. This is “Trendelenberg’s Test” for assessing hip stability.

1 a)  1 b) 

1 a) Trendelenberg’s Test Positive

1b)Trendelenberg’s Test Negative

At every swing there is abduction of the opposite hip; to neutralize this, during the swing phase there is an adduction of the ipsilateral hip. This movement occurs even if the adductor muscles are paralysed because the hip joint is of the ball and socket variety, and the limb adducts due to gravity. Again, in the swing phase, the pelvis is oblique in the sagittal plane; the ipsilateral half being anterior to the contralateral half, resulting in the internal rotation of the supported hip. To neutralize this, there is an external rotation of the ipsilateral hip. To summarise - there is flexion, adduction and external rotation of the ipsilateral hip during the swing phase.

During the swing phase, after initial flexion there is gradual extension of the knee joint till it is fully extended at heel strike. This initial flexion is necessary to clear the ground, and is secondary to the plantar flexion at the ankle.

At the onset of the swing phase, there is plantar flexion of the ankle joint, resulting in push off. Later on, there is dorsiflexion of the ankle to help clear the ground. The swing phase ends upon heel strike.

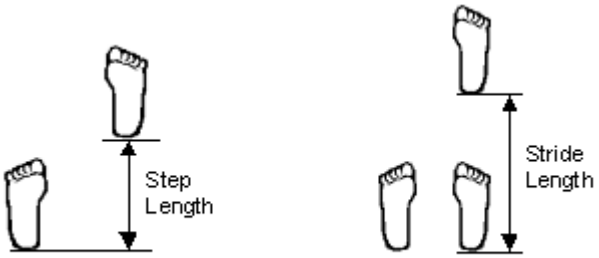
To summarise, during swing phase, there is

Flexion, adduction and external rotation of the hip,

After initial flexion, extension of the knee and
After initial plantar flexion, dorsiflexion of the ankle.

These are the movements in the lower limb that characterize normal gait. Any variation from these will result in an abnormal gait. A minor variation may be termed a limp. A major deviation may result in a visible body shift – i.e a lurch - to neutralise various other forces.

Step length is the distance between the right and left heels when a step is taken. It corresponds to the length of the foot and about an additional twenty-five cms. In an average adult this works out to between forty-five and fifty cms. *Stride length* is the distance covered by the same heel after a stride. It varies according to the length of the lower limb and consequently upon the height of an individual. A tall person covers more ground than a short person in a given period of time. Each individual usually takes a certain number of steps per minute. This is known as his/her *cadence*, and varies with individuals. An altered cadence cannot be sustained for a long time as it causes fatigue, and one may not be able to walk continuously faster or slower than one's own style without becoming tired. There is a thin margin of difference between a fast walk and a slow run. During a walk, there is always a stage when both feet are on ground – this is called the *stance*. During a run, there is always a phase when both feet are off the ground. Thus feet should be closely watched to differentiate between these two.



Now we look at some abnormal gaits.

Antalgic Gait: Any gait, which relieves pain, is known as an Antalgic Gait. Its visual characteristics cannot be described as they depend upon the source of the pain and the way of obtaining relief from it.

High Stepping Gait: As mentioned earlier, there is dorsiflexion of the ankle joint during the swing phase. If there is loss of dorsiflexion due to a plantar flexion deformity or loss of muscle power, there will be difficulty in

being clear of the ground during the swing. To avoid this, one has to flex one's hip more than usual, thus raising the knee and the foot off the ground. This gait is common in foot drop due to muscle paralysis.

High Step with Foot Drop

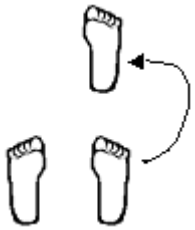
Stamping Gait: In affections of the posterior column of the spinal cord, there is loss of joint and vibration sense. Thus one is not able to perceive the distance of the floor from the feet, resulting in a hard thump. The same can occur when one goes down the steps in total darkness being unable to gauge the end of the steps.

Broad Based Gait: In earlier times when boats were used at sea, there was always a sense of instability due the swaying and tossing of the boat when the sea was rough. To overcome this and to prevent accidental falls, sailors would walk with their feet fairly wide apart. This served to keep the center of gravity within the base and helped avoid falls. This habit at sea also manifested itself when the sailors walked on land. Such a gait is rarely seen in the present environment.

Broad Based Gait

Hemiplegic Gait: In ambulatory hemiplegic patients there is rigidity in the lower limb muscles because of an upper motor neuron lesion. Due to this, extension at the knee and plantar flexion at the ankle prevail. As stated

earlier, during the swing phase there is flexion at the knee and dorsiflexion at the ankle. The swing of lower limb, therefore, becomes difficult. In such cases, there is circumduction of the limb at the hip while swinging the limb to achieve forward propulsion.



Hemiplegic Gait

Scissor's Gait: In lesions resulting in spastic paraparesis, each lower limb crosses in front of the other lower limb due to a marked adduction spasm as is commonly seen in cerebral palsy patients.

Scissor's Gait

Ataxic Gait: In cerebellar lesions there is loss of a sense of balance. Such loss prevents righting reflexes from coming into play. The patient is unable to balance himself and sways in various directions during ambulation.

Trendelenberg Gait: In cases of malunited or ununited fractures of neck of femur, dislocations or subluxations of the hip joint, coax vara and paralysis of hip abductors, there is a loss of hip stability due to an inefficient abductor lever. As a result of this, there is a drooping of the opposite half of the pelvis when the weight is borne on the affected limb. This will render ground clearance by the opposite limb difficult. To overcome this problem, when the weight is borne on the affected side, the body or torso swings on the same side and the help of the Quadratus Lumborum muscle is taken to lift the opposite half of the pelvis. Thus the pelvis dips on the opposite side

and the trunk swings on the same side. This is also known as the *Gluteus Medius* gait

If such lesions are bilateral, the same sequence occurs on both sides and the "Waddling Gait" results. The same type of gait is present in Osteomalacic patients due to a muscle weakness secondary to calcium deficiency.

Short limb Gait: Due to obvious reasons, the pelvis dips and the trunk swings on the same side when weight is borne on the affected side. If there is an associated hip instability, the Gluteus Medius gait prevails.

Gluteus Maximus Gait: In paralysis of the Gluteus Maximus muscle, it is not possible to extend the supported hip in the swing phase. This is overcome by a backward lurch of the trunk.

In-toeing Gait: In cases of increased anteversion of the femoral neck, there is internal rotation of the hip joint to contain the femoral head in the acetabular cavity. This results in an internal rotation of the whole limb as noted by inward pointing toes. Such in toeing may persist or compensatory changes occur to offset this disability. There is external torsion of the tibia and toes point forward. However, persistent femoral torsion is evident by both patellae pointing inwards rather than forwards – this is referred to as *Kissing Patellae*. At the time of correcting this deformity, care should be takes to note if corrective changes have occurred. If so, corrective derotation osteotomy of both the femur and the tibia will be necessary. If both bones are not attended to, out-toeing will result – a Charlie Chaplin type of gait.

Intoeing

Shuffling Gait: In this type of gait, slow and short steps are taken. This can be due to arthrosis of the hips and spine, which prevents any compensatory mechanisms to overcome loss of movements. Such a gait can also result from marked rigidity as in Parkinson's disease. Thus there may be an *Arthritic shuffle* or a *Parkinsonion shuffle*.

Stiff Knee Gait: When a person has loss of movements at the knee joint, the gait looks like that of a German soldier marching.

Flexed Knee Gait: The gait is a short limb gait with the knee flexed.

Hand to Knee Gait: In a two-leg stance the line of gravity passes from posterior to the hip, anterior to the knee and through the ankle joint. When there is a quadriceps deficiency, one would expect the knee to buckle down during the stance phase. However, this does not happen because gravity does not cause knee flexion. As a corollary to this it can be stated that quadriceps function deficiency will not affect ambulation. As a matter of fact ambulation is possible with accessory muscles.

In the one leg stance with the affected limb in front, there is always the possibility of the knee buckling down when the opposite limb starts swinging because the body mass is largely posterior. If the affected limb is rotated externally at the hip, knee flexion due to gravity cannot occur because it would cause knee abduction, which is not possible at that joint. Thus in extensor weakness at the knee there will be an external rotation gait. If there is paralysis of the quadriceps femoris muscle, other muscles are used to prevent buckling down. Extensors of the hip joint move the femur backwards. The soleus muscle moves the tibia backwards when the foot is on the ground. Thus the gluteus acting from above, and the soleus acting from below, moves the femur and the tibia respectively backward to cause hyperextension at the knee to prevent buckling down. Hyperextension gait then results.

When either or neither of these muscles is functioning well, the patient bodily pushes the lower end of the femur backwards with his hand to achieve hyperextension. This results in the "Hand to Knee" Gait.

Hand to Knee Gait

Calcaneus Gait: Just before the limb swing there is a push off at the ankle joint by plantar flexion. This push off is absent in paralysis or rupture of the Tendo-Achillis. The weight is largely borne by the heel and there is a widening and thickening of the heel. The gait is slower and is without heel push off; the foot is flat on the ground.

Calcaneus

Flat Foot Gait: When there is affection of the arches of the foot, the foot is flat on the ground and there is no spring in the gait. The speed is slower and occasionally there is pain.

At times one comes across a gait which looks abnormal but is really not so because one is observing the body and not the lower limbs.

In cases with a rigid lumbar spine, the gait resembles that of the Lord Mayor of London marching on a ceremonial occasion.

In tuberculous disease of the dorsal spine, the patient often walks with hands on the thighs to off-load his/her body weight and to bypass the affected spine.

In tuberculous disease of the cervical spine, the patient holds his head and neck in his hands to bypass the affected spine.

There are variations of normal gait, which may look abnormal, but are not so.

Athlete's Gait: One would have noticed a difference in the gait of players before and after the game. When they are returning at the end of game, their attitude shows crouching. This attitude is adopted to keep center of gravity as low as possible. It prevents fatigue.

Exaggeration of normal oscillations: As stated earlier, there is forward and sideward swing of the body during walking. This swing keeps the center of gravity shifting within the body. Such a shift results in oscillations of the body. Exaggeration of these oscillations is often resorted to artificially to draw attention.

Mourner's Gait: At a solemn occasion like a funeral, there are mourners of various heights walking at different speeds. However, the whole crowd moves together and none become separated from the rest. One may expect a short person to walk fast by increasing cadence. This will cause fatigue and hence is not practical. One may expect a tall person to walk slower by altering his or her cadence. Again, this is not practical. Altered cadence cannot be sustained for long time, as it will produce fatigue. To maintain a semblance of order, a tall person shortens his step length without altering his cadence. He takes a forward stride but brings his foot slightly back to shorten his step length. There is a lot of mechanical disadvantage and loss of energy during this gait. It is, however, necessary in paying respect to a departed soul and on solemn occasions.

Mourner's Gait

Crutch Gait: When using crutches, we need to consider crutches and legs as four points. Either crutches move together or legs move together. Also there are occasions when all these four points move separately.

Two Point Gait: When a double amputee walks with crutches there is a two-point gait. Crutches are put forward and then swinging moves body forwards. One may swing up to the crutches or swing through them – *Swing to* or *Swing through* gait.

Two Point Gait

Three Point Gait When weight is allowed only on one leg, crutches are put forward and the limb follows with the other limb off the ground. This is the Three Point Gait. It could also be a Swing to or a Swing through gait.

Three Point Gait

Four Point Gait: When limbs are allowed to bear weight but are not strong enough to do so unaided, a pair of crutches is used for ambulation. Crutches and legs are alternately put forwards singly to achieve the four point gait.

Four Point Gait

Knowledge of gait helps one to arrive at a diagnosis and to assess the degree of disability before a detailed examination is done. The patient must be examined by gait inspection before palpation, motion estimation, measurements are undertaken and the rest of the body is examined.

Acknowledgements: I highly appreciate the help of Dr. Niraj L. Vora for taking all the photographs and drawing the diagrams used in this paper.

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