Problems in Family Practice

Limp in Childhood

Isadore G. Yablon, MD
Boston, Massachusetts

A method is presented to assist the physician in diagnosing the cause of a limp in a child. This is based on how diseases alter locomotion. The normal gait can be affected in any one of five ways: shortened extremity, contracture, loss of supporting structures, pain, and paralysis. Each of these pathological states produces a characteristic limp which can be observed and recorded by noting the movements of the pelvis and the trunk, and the position of the joints of the lower extremities. Once the examiner has determined how the gait is affected, it becomes less difficult to determine the causative condition, based on the history, physical examination, and ancillary studies which would be ordered.

One of the most perplexing problems a practitioner encounters is responding to distraught parents who ask the physician to determine why their child walks with a limp. Because the physician may feel that this entity or the conditions causing it are beyond his domain, the patient is generally referred to an orthopedic surgeon without an examination or any preliminary investigations. This may further heighten the parents' anxieties since they conclude that the condition is too serious for their doctor to diagnose.

The study of gait disorders and the treatment of these problems usually falls to the orthopedic surgeon, the physiatrist, and the biomechanical engineer. However, the physician who can appreciate the basic rudiments and significance of a limp is able to reassure the patient, perform the initial examination, and order the preliminary investigations which will be particularly helpful to the consultant if the patient is referred for treatment. In some instances, complicated treatment may not be necessary and in such cases the physician may treat the condition in his office. This paper will attempt to assist the physician in developing an approach to and an understanding of the factors causing abnormal locomotion.

From the Department of Orthopedic Surgery, Boston University School of Medicine, Boston, Massachusetts. Requests for reprints should be addressed to Dr. Isadore G. Yablon, Associate Professor of Orthopedic Surgery, Boston University Hospital, 75 East Newton Street, Boston, Mass 02118.

The Normal Gait

A limp is either an exaggeration of, or a deficiency in, one or more of the components of normal gait. The gait of a patient can be studied by observing three portions of the body – the lower extremities, the pelvis, and the trunk.

Lower Extremities

In normal locomotion, the lower extremities go through a cycle consisting of a stance phase and a swing phase.[1] The stance phase begins when the heel strikes the ground and persists throughout the period during which the foot is in contact with the ground. The swing phase occurs the moment the foot leaves the ground and lasts until the next heel strike. The ankle is dorsiflexed and the knee and hip are in flexion at heel strike. At push-off there is extension of the ankle, knee, and hip.

Pelvis

The pelvis moves in two planes during normal locomotion. The frontal plane is what we see when observing the patient as he walks towards the examiner, the motions taking the form of vertical or up-and-down displacements of the pelvis. The horizontal plane is that plane in which the pelvis rotates forwards and backwards around an imaginary body midpoint. During the swing phase, the pelvis is elevated by the hip abductors of the opposite side and rotates forward. In the stance phase, the pelvis drops slightly and rotates backwards as the opposite side rises and moves forward.

Trunk

Shortly after heel strike, the trunk is deflected slightly to the side of the extremity which is in contact with the ground. It is then deflected to the opposite side when the heel strike occurs there. The trunk also rises slightly during the swing phase as the pelvis rises.

The History and Physical Examination

Prior to examining the patient, a detailed history should be obtained. It is essential to know how long the limp was present, whether a specific incident occurred to cause it, such as a fall or an illness, whether a limp is present constantly or only at certain times, as in running or when the child is tired. It is also important to establish whether pain is present and to obtain information concerning the birth history, age at which milestones were reached, past health, previous surgical procedures, and whether any other members in the immediate, maternal, or paternal families had a limp.

Having obtained this information one can then proceed to the physical examination. Preferably, the examination should be carried out with the patient completely undressed. The first thing is to observe the patient as he stands normally. Throughout, one constantly keeps one's attention focused on the lower extremities, the pelvis, and the trunk. One looks to see whether the knees are at the same level, whether the pelvis is level, and whether the trunk sits directly over the pelvis. The patient should also be observed from the side in order to determine if there is an abnormal pelvic tilt or change in the lumbar lordosis. Note should be taken whether both knees are fully extended and what position the feet assume as they rest on the ground. One should also look to see if any notable atrophy or increase in size of the lower extremities is present.

When these observations have been recorded, the patient is asked to walk normally from the examiner to a given point at the far end of the room, and then to return. Occasionally, small children may have to be coaxed to walk and this can be done by having a parent walk with the child, but the hand of the child should not be held.

The examiner then positions himself directly behind the patient and asks the individual to first stand on one foot and then on the other. Normally, when the foot is off the ground the abductors of the opposite side maintain the pelvis in a level, horizontal position. Weakness of the abductors or deficiency of the supporting structures around the hip will prevent normal leveling of the pelvis when the opposite foot is raised, and dropping will occur.

The patient is then placed on the examining table lying comfortably on his back. Any gross abnormalities observed at this time, or while the patient was walking, are carefully noted.

The range of motion of the joints of the lower extremities is now tested. This must include the active range, in which the patient is asked to move the extremity using his musculature, and the passive range in which the examiner moves the joint without muscular contraction on the part of the patient. The hips are tested for flexion, extension, internal and external rotation, abduction, and adduction. Active motion should be checked for first, followed by the passive component. Abduction is carried out with the hip in extension. If the hip is in flexion, abduction can be simulated by the flexors which flex and externally rotate the hip. A false conclusion will be made regarding the strength of the hip abductors if this point is not observed. During abduction and adduction, one hand of the examiner should be on the ipsilateral side of the pelvis to make sure that no abnormal pelvic motion takes place. To test extension, the patient is asked to turn prone and raise the extended lower extremity from the table.

If a contracture of the hip exists, it may be masked unless one looks for it carefully. Because the pelvis can tilt forward, a flexion contracture may not be visible when the patient lies supine. Both lower extremities can be made to rest perfectly flat on the table because the pelvis will rotate forward and increase the lumbar lordosis. In order to detect such a contracture, the opposite knee is flexed and the thigh is brought up onto the patient's abdomen. This maneuver places and locks the pelvis in a neutral position and one then observes whether the opposite extremity can be fully extended. A flexion contracture will prevent the opposite hip from coming into full extension and the amount by which this hip cannot be brought into extension determines the flexion contracture. A contracture in another plane will become evident as a decrease in the range of motion in that plane. The stability of the hip is tested by holding the thigh in one hand and placing the other hand over the iliac crest on the side being examined. One then alternately pushes and pulls on the thigh in a cephalad and caudal direction, and also in a medial and lateral direction. Any abnormal motion, clicks, or excursions should be noted.

The knees are examined to note the range of flexion and extension. With the knee in full extension, a valgus and varus strain is applied by the examiner. Any abnormal mobility denotes absence or laxity of the collateral and the cruciate ligaments. The knee is then flexed 15 degrees and the same maneuver carried out. Laxity here denotes abnormal function of the collateral ligaments only. The knee is then flexed 90 degrees and the foot placed flat on the table. The examiner pulls the tibia towards him and pushes the tibia away from him. Abnormal excursions in this plane denote laxity of the cruciate ligaments.

At the ankle, the range of dorsiflexion and plantar flexion are recorded. One should always compare the affected side to the normal one. The foot is checked for inversion and eversion.

Leg length discrepancy is determined with the pelvis being level. This is measured from the anterior superior iliac spine to the tip of the medial malleolus. Muscle strength is tested by asking the patient to move the extremity against the resistance supplied by the examiner's hand. The circumference of the thigh and calf should be measured to ascertain atrophy and hypertrophy. This is done by choosing a fixed point on each limb above the superior border of the patella for the thigh, and below the tibial tuberosity for calves. Sensation can be briefly tested by running a tongue depressor over the skin of the lower extremities and noting whether there is any difference in the two lower extremities. To test proprioception the patient can be asked to determine the position of the great toe as the examiner moves it. If there is pain during any motion this should be recorded. It should be ascertained if this pain is mild and allows the motion to be completed or whether the patient inhibits further movement once the pain is experienced. It should also be recorded whether the pain is present during passive motion and at what degree of motion. One should look for areas of local heat, redness, tenderness, and swelling.

The Differential Diagnosis of a Limp

Basically, there are two ways in which the diagnosis of a limp may be made. One method is to diagnose the disease which caused the limp. Since any condition which disturbs or alters the sequence of normal locomotion can produce a limp, it follows that using this method one would have to know every disease capable of causing a dysfunction of the nervous or locomotor systems. This can be quite a formidable task as illustrated by Table 1 which lists only the more common diseases on an etiological basis. An easier, more practical method would be to determine how these conditions affect the gait. Diseases can alter locomotion by causing any of the following: (1) leg length inequality, (2) joint contracture, (3) instability of the supporting structures, (4) pain, and (5) paralysis – spastic or flaccid.

Thus, by knowing whether a limp is caused by a short extremity or by paralysis of a group of muscles, the initial examiner can determine the mechanical cause of the limp utilizing a diagnostic method which is practical and not too difficult, can answer some of the parents' questions, and can be more helpful in the follow-up care of the patient.

The Short-Leg Gait

When the patient is viewed from the front, the pelvis on the side of the shortened extremity tilts downwards.[2] This is also seen when the patient walks. When shortening exceeds 1½ inches, the patient attempts to equalize the discrepancy by placing the foot in an equinus position during the stance phase. When shortening amounts to more than three inches, the patient attempts to shorten the normal extremity as well, by flexing the hip and knee. This is seen in both the stance and swing phases. Because of this, the trunk and pelvis have an excessive backward swing during the stance phase of the sound extremity. This gait is quite easy to detect.

The Contracture Limp

The lower extremity is usually ankylosed in flexion at the hip or knee. This has the effect of shortening that extremity so that most of the features seen in the short leg gait are observed here as well.[3] If the flexion contracture is at the hip, observing the patient from the side will reveal certain features which will distinguish this from the short-leg gait. Because the affected hip cannot move into extension, the movements during the stance and swing phase are taken up by the pelvis and lumbar spine. Therefore, in the swing phase there will be an abnormal tilting of the pelvis when observed from the side with the anterior portion riding upwards and the posterior pelvis tilting downwards. In order for the center of gravity to remain over the hip, the trunk compensates by curving forward, thus eliminating the lumbar lordosis. During the stance phase, the reverse occurs with the pelvis rotating forward and the lumbar lordosis increasing.

With a flexion contracture of the knee, the push-off on the affected side is weakened since this requires extension of both the ankle and the knee. During walking it will be seen that the affected knee does not fully straighten during push-off. This limp will become more marked as the speed of the gait increases.

Limp Caused by the Instability of the Supporting Structures

This gait is caused by conditions of the hip in which there are altered relationships of the acetabulum to the femoral head and neck. Because of this, the abductors are unable to stabilize the pelvis in the stance phase and the opposite pelvis drops during the swing phase of that extremity.[4] This is called the Trendelenburg Sign. The patient must therefore utilize other muscles to raise the pelvis in order for the opposite leg to clear the ground. Thus, the trunk tilts laterally over the affected hip utilizing the abdominal muscles which are attached to the rim of the opposite pelvis to elevate that side and allow for swing phase to occur. In addition, the hip extensors are also unable to work efficiently and this causes the trunk to sway backward at heel strike and during the early stance phase of the affected extremity. This gait is characteristic and is easily recognized.

The Antalgic Gait

The basis for this limp is the fact that the patient attempts to stand on the painful extremity for as short a time as possible.[5] Therefore, the stance phase is considerably shortened. Any condition which causes pain in the hip will cause the hip to assume a position in which the volume of the joint is greatest – slight flexion, abduction, and external rotation. The affected limb is therefore placed on the ground in that position, and this should immediately arouse suspicion that an inflammatory condition is present. The patient will also attempt to eliminate all muscular forces acting upon the hip since this will decrease the pain. As he walks, he therefore tends to eliminate the action of the abductors and extensors so that the trunk swings toward the affected side during the stance phase. In order to further minimize hip pain while walking, the patient tends to plantar flex the foot so that the toes, rather than the heel, meet the ground at the end of the swing phase. This maneuver acts as a shock absorber for the inflamed and sensitive tissues of the hip. Since plantar flexion tends to lengthen the extremity, the knee is flexed in order to compensate for the increased length. As the opposite extremity is brought forward during its swing phase, the patient tends to pivot on the ball of his foot which leads to a weak push-off.

A limp due to pain in the knee causes essentially the same features of

Table 1. Etiological Classification of the More Common Conditions Causing Limp[11-13]

Congenital
- Spina bifida and meningomyelocele
- Scoliosis
- Neurological disorders
  - Cerebral palsy
  - Spinal muscular atrophies
- Congenital dislocation of hip (CDH)
- Clubfoot
- Short extremity
- Absence or maldevelopment of part of an extremity (Focal deficiency)
- Pseudarthrosis of tibia
- Hemiatrophy or hemihypertrophy

Vascular
- Hemangiomatosis
- A-V malformations
- Coagulopathies

Neoplastic
- Osteosarcoma
- Ewing's sarcoma
- Enchondromatosis

Traumatic
- Fractures
  - Complete
  - Incomplete (Greenstick)
- Fracture complications
  - Angulation
  - Shortening
- Epiphyseal injuries

Neurological
- Polio
- Muscular dystrophy
- Cerebral palsy

Infections
- Osteomyelitis
- Septic arthritis

Metabolic
- Rickets
- Scurvy
- Morquio's disease
- Hurler's disease

Hyperimmune
- Rheumatoid arthritis

Ideopathic
- Legg-Perthe's disease
- Slipped capital femoral epiphysis
- Transient synovitis

Iatrogenic
- Avascular necrosis
- Premature epiphyseal closure
- Tight casts

Miscellaneous
- Skin infections of the foot
- Improperly fitting shoes
- Calluses and corns
- Ingrown toenails
- Psychological limp

Table 2. Probable Causes of Limp According to Age Groups

Age in years at which limp presents	Short Leg Gait	Contracture Gait	Instability of Supporting Structures	Antalgic Gait	Paralytic Gait
Birth – 4	Congenital absence or shortening Coxa vara CDH Hemiatrophy Infection	Spina bifida Cerebral palsy CDH Infection	Focal femoral deficiency Coxa vara Spina bifida CDH Trauma	Infection Trauma	Spina bifida Spinal muscular atrophies Cerebral palsy
5 – 10	Spina bifida CDH Rheumatoid arthritis Trauma Infection	Trauma Legg-Perthe's disease CDH Rheumatoid arthritis Infection	Trauma Infection Muscular dystrophy Polio	Trauma Infection Rheumatoid arthritis Hemophilia Legg-Perthe's disease	Muscular dystrophy Spina bifida Polio Cerebral palsy
11 – 14	Trauma Slipped capital femoral epiphysis Infection Neoplastic	Trauma Legg-Perthe's disease Infection Slipped capital femoral epiphysis	Trauma Slipped capital femoral epiphysis Inadequate treatment of CDH (subluxating hip)	Trauma Transient synovitis Slipped capital femoral epiphysis Legg-Perthe's disease	Muscular dystrophy Neoplasm of central nervous system Peripheral nerve trauma Polio Ischemic contracture

plantar flexion of the ankle and pivoting on the ball of the foot. Because the hip is normal, however, the Trendelenburg lurch is absent and the pelvis does not drop to the opposite side. In addition, the trunk shows no abnormal oscillations. The ankle, however, is held in equinus and the knee in about 15 degrees flexion and does not extend during push-off. The stance phase is markedly shortened.

The Gait in Paralysis

In these conditions a muscle, or group of muscles, concerned with locomotion is paralyzed. In order for the patient to maintain his gait, he utilizes secondary movements which are so typical that the muscle involved can frequently be determined by careful observation.

1. Gluteus Maximus Paralysis – The gluteus maximus is an extensor of the hip and helps to maintain the erect position of the trunk during locomotion. When this muscle is paralyzed one sees a backward thrust of the trunk which begins shortly after heel strike on the affected side and reaches its maximum when the pelvis comes to lie vertically over the ankle joint.[6] The patient does this in order to keep the center of gravity behind the hip because if the center of gravity passed in front of the hip, the patient would fall forward since the stabilizing effect of the gluteus maximus is lost.

2. Gluteus Medius Gait – The gluteus medius is the chief abductor of the hip. Paralysis of this muscle results in the same gait as that seen when there is deficiency of the hip supporting structures.[7] The opposite side of the pelvis drops during the swing phase of the limb and the trunk tilts towards the affected side in order for the abdominal muscles to raise the opposite pelvis. In order to distinguish between these two conditions, x-ray examination is helpful since this would denote a structural abnormality when deficiency of the supporting structures exists. One is unable to feel the gluteus medius contract during active abduction in paralysis of this muscle, while in structural abnormalities, although the abnormal gait results in the inability of the muscles to stabilize the pelvis, one can nevertheless palpate the contracting muscle.

3. The Quadriceps Gait – The quadriceps muscle extends the knee. Ordinarily, paralysis of this muscle alone does not cause a noticeable limp. The reason for this is that the knee is locked in extension because the posterior capsular structures become taut and further extension of the knee is prevented. If the gluteus maximus and soleus muscles are functional, the patient will walk with little disability because, as the gluteus maximus extends the hip and as the soleus brings the tibia backward with the foot placed on the ground, the combined effect of these two muscles causes the knee to go into extension.[8] If, however, the gluteus maximus and soleus muscles are weakened, as may occur in muscular dystrophy, polio, and some demyelinating diseases, the patient develops a limp. There are three ways in which the patient attempts to stabilize his knee in extension and, therefore, this limp has three variations.[8] The most common is the one is which the patient induces his center of gravity to fall anterior to the knee. This will cause the knee to go into extension and lock. The patient does this by tilting his trunk and pelvis forward. Thus, when the patient is observed from the side, the trunk is erect until heel strike of the affected extremity. At this moment the patient leans forward until the knee goes into extension. In the swing phase, the trunk assumes the erect position. Some patients may find this particular gait tiring and so they develop an alternative one. This consists of placing the ipsilateral hand on the distal thigh just above the knee on heel strike and pushing backwards. This maneuver forces the knee into extension. In effect, the patient's arm is now acting as his quadriceps. A third method is for the patient to externally rotate the affected lower extremity 90 degrees so that the medial aspect of the knee faces in a forward direction. Since the knee cannot flex in the medial plane, but only in the frontal plane, the knee is stable in this position. If any of these limps is apparent, this should alert the physician to the presence of more serious disease since the gluteus maximus and soleus are also affected and, indeed, the physician may be dealing with a rather wide-spread condition.

4. Paralysis of the Hamstrings – Paralysis of these muscles does not cause a limp. However, the posterior knee capsule is repeatedly stretched and over a period of time a recurvatum deformity will develop. This deformity can be due to other conditions such as a congenitally lax capsule and growth disorders, but nevertheless, a patient who is otherwise healthy and does not give a history suggestive of epiphyseal injury should have a careful neurological examination lest the beginning of an insidious neurological disease be missed.

5. The Calcaneus Gait – This is a gait in which the Achilles tendon is weakened or paralyzed. In observing the patient one notes failure of a normal push-off on the side of the involved extremity. In observing the patient from behind and watching the heel, it will be apparent that instead of the heel leaving the ground followed by push-off on the toes, the whole foot leaves the ground as a unit. In addition, there is an abnormal upward rise of the affected pelvis so that the foot clears the ground by being lifted up rather than by pushing off. There is also some external rotation of the affected extremity during the end of the stance phase combined with pronation of the foot so that the medial or inside border of the foot comes in contact with the ground in an attempt to use the peroneal muscles for push-off.

6. The Dropfoot Gait – This occurs when the dorsiflexors of the foot and ankle are paralyzed. The first thing one notes is that in the swing phase the affected foot is raised to a higher degree than the normal one. This is because dorsiflexion of the ankle is absent and, therefore, the leg must be raised higher in order for the toes to clear the ground. In this condition there is no heel strike since the ankle cannot be dorsiflexed. This is the main clue to this type of gait. The toes, rather than the heel, strike the ground first and as the patient's center of gravity moves forward the rest of the foot comes into contact with the ground, starting with the toes and moving progressively backwards. This is rather characteristic and is called the steppage gait.

7. The Spastic Gait – Spasticity, a condition in which the muscles display an increased tone, is secondary to an upper motor neurone lesion.[9] This is commonly seen in cerebral palsy and in conditions affecting the brain and spinal cord such as neoplasms, trauma, and certain demyelinating diseases. Although the lower extremity may be affected in a variety of different ways, the most common position is for the hip to be held in adduction, internal rotation, and flexion. The foot and ankle are held in equinus and the knee is held in slight flexion. The reason for this position is that the stronger muscles predominate causing the deformity in the direction of their pull. The diagnosis can often by made by observing the patient as he stands and noting the abnormal position. In milder cases, the limb may appear normal when standing but in walking, the hip, knee and ankle assume their abnormal positions. Asking the patient to increase the rate of his gait will accentuate the deformities.

Determination of the basic mechanism underlying limp is particularly useful in diagnosing the etiology of limp in children when correlated with the child's age. Table 2 shows probable causes of limp for various age groups in childhood.

Miscellaneous Features

As with everything else in medicine, there are exceptions to the rule. There are cases in which the limp does not fall into any of the classical patterns just described because more than one abnormal condition is operative. For example, a child with a paralytic dislocation of the hip would show features of both the paralytic gait and the gait due to lack of supporting structures.[10] The solution is almost always found in a careful history and physical examination and, if done in the way described, these procedures will usually uncover the cause of the abnormal gait.

If a history and physical examination do not reveal anything unusual, one should examine the patient's gait with his clothes on and with them off. Frequently, tight fitting clothing causes sufficient discomfort so that a limp ensues. Chaffing in the groin and poor personal hygiene may also cause discomfort resulting in limp. The feet and toes should be observed for evidence of fungal or infectious diseases. One should also remember to take a good look at the footwear. Children frequently neglect to tell their parents and the examiner that a shoe is uncomfortable. Indeed, there have been cases where a child has been hospitalized because of a limp when all that was required was removal of a small nail which had penetrated the sole of the shoe. Finally, one must bear in mind the psychogenic gait. Although rare in children, it does occur on occasion. The child may mimic the limp of a friend or relative, and for this reason it is important to ask in the history if the child has been near anyone who has an abnormal gait.

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