Gait

The Role of the Ankle and Foot in Walking

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KEYWORDS

• Gait • Ankle • Foot • Walking

KEY POINTS

- Common comorbidities that may hamper gait include, neurologic, orthopedic, cardiac, and pulmonary issues. As such, evaluation of gait and its associated deviations from normal requires an in-depth evaluation of the patient and an appreciation for the complexity of the task.
- Understanding gait starts with an appreciation of the basic determinants of gait. Functionally, the determinants of gait serve to optimize energy expenditure by either limiting the vertical excursion of the subject's center of gravity (COG), or optimizing stance phase limb position.
- Foot drop is a common gait deviation. It can result from a sciatic nerve neuropathy affecting the peroneal division, fibular nerve neuropathy at the level of the fibular head, or when symmetric, may be part of the manifestation of a polyneuropathy. Functionally, a foot drop results in a long limb. This will result in alterations of the gait cycle during swing phase.
- The common compensations for a foot drop include steppage gait, circumduction, and a persistently abducted limb. In all instances, these compensations serve to functionally shorten the long limb.
- Noninterventional options for management of common gait deviations secondary to ankle/foot dysfunction present challenges, but ultimately can be rewarding for both the patient and the treating physician. Before considering any treatment option, understanding the patient's needs and wishes is paramount.

For most people, walking, is a given and something that is taken for granted. It is a motor milestone that is typically acquired between 12 and 18 months of age. It is highly reproducible, with little variation in its subcomponents by 5 years of age.

Despite the outward appearance of simplicity, gait is a complex process. Many issues must be resolved for ambulation to become a practical form of mobility. Failure to meet certain criteria will typically result in people choosing alternate forms of mobility. The ankle–foot mechanism is a critical component of gait. The joints that comprise the ankle and the foot allow for full weight bearing through the stance phase

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limb, while at the same time dynamically adjusting to any alterations in terrain. The ability of the foot to adjust and respond to terrain perturbations optimizes people's ability to mobilize. Unfortunately, it also increases the risk of trauma to the ankle/foot mechanism.[1–4]

For ambulation to be considered the preferred form of mobility, several parameters need to be satisfied. They include: minimization of energy expenditure, maintenance of safety, and adequate speed to make walking practical over community-based distances; additionally, the activity must be painless. Failure to achieve any of these requirements will serve to either limit the distances walked, require the addition of an assistive device, or in extreme cases may cause to patient to choose an alternate form of mobility, such as a wheelchair or power-operated vehicle (POV). Common comorbidities that may hamper gait include, neurologic, orthopedic, cardiac, and pulmonary issues. As such, evaluation of gait and its associated deviations from normal requires an in-depth evaluation of the patient and an appreciation for the complexity of the task.[1,3,5]

Understanding gait starts with an appreciation of the basic determinants of gait. Functionally, the determinants of gait serve to optimize energy expenditure by either limiting the vertical excursion of the subject's center of gravity (COG), or optimizing stance phase limb position. A quick review of basic mechanics and physics reminds one that potential energy (PE) = mass $\times$ gravity $\times$ height (mgh). As such, anything that decreases the height function (vertical excursion) of the COG will conserve energy. The determinants of gait include, pelvic rotation, pelvic tilt, knee flexion at midstance, foot mechanisms, knee mechanisms, and lateral pelvic displacement. Pelvic rotation of 4° is responsible for functionally lengthening the swing phase limb, thereby preventing a sudden drop in the COG as the swing phase limb transitions to the stance phase limb. Pelvic tilt of 4 to 5° of the swing phase limb functionally lowers the COG, further decreasing its vertical excursion. The third determinant is knee flexion at stance (heel strike). Knee flexion in this case serves to decrease the vertical elevation of the COG during midstance, by shortening the hip to ankle distance. Additionally, this determinant will smooth the gait cycle by acting as a shock absorber at heel strike through eccentric loading of the quadriceps mechanism. It is critical to understand the role of eccentric loading during the gait cycle. From an energy expenditure standpoint, eccentric loading is an energy efficient form of muscle action. Foot mechanisms, from ankle dorsiflexion at heel strike to graded plantar flexion at foot flat, back to dorsiflexion at midstance and rollover, serve multiple purposes. The phase of heel strike to foot flat requires the ankle to progress from dorsiflexion to a plantar flexed posture. This serves to smooth the descent of the falling pelvis or COG. The controlled plantar flexion of the foot occurs through controlled eccentric action of the tibialis anterior as well as the common toe extensors and great toe extensor. The utilization of an eccentric action serves to minimize energy expenditure. Knee mechanisms serve to control the excursion of the COG. After midstance, the knee extends as the foot plantar flexes and supinates to lengthen the stance phase leg. This serves to lessen the fall of the pelvis at contralateral heel strike. The final determinant of gait is lateral displacement of the pelvis. This causes displacement of the COG toward the stance phase limb. This brings the COG over the base of support, in this case the stance phase foot. This serves to limit the activation of musculature needed to maintain stance phase stability. This last determinant serves to optimize the biomechanical function of the hip abductors, thereby minimizing energy expenditure. In summary, determinants 1 through 5 all reduce the vertical excursion of the COG. Determinant 6 controls the horizontal displacement of the COG, optimizing stance phase limb loading.[1,3,6–8]