HUMAN KINETICS

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Question 1: Patterns of Ankle Motion During Stance Phase of Gait

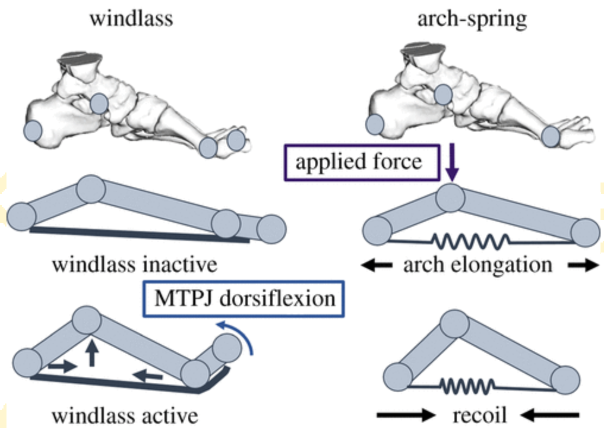
Ankle motion occurs mainly in the sagittal plane with dorsiflexion and plantar, occurring mostly at the tibiotalar joint. According to past research, it has been proved that an overall Range of motion (ROM) in a sagittal plane is between 65-75°. Its movement of it is 10-20°. This movement is done through dorsiflexion, which is 40–55° of plantarflexion. In the frontal plane, the total range of motion is nearly 35°. This motion includes 12° eversion and 23° inversion. In everyday activity, the Range of motion (ROM) needs a reduction in the sagittal plane. This reduction must be at least 30° for walking and 56° and 37° for stairs ascending and descending (Lazzarini et al., 2019).

The knee extends the lower leg swings forward during a normal gait pattern with the upward raised and foot flexed to clear the ground. This helps the simultaneous contraction of both feet to touch the ground and gives double float to two periods in the starting and ending of the gait swing phase (Drukarch et al., 2021). The walking sequence occurs by gait command activation and Registration within the central nervous system. After the transmission of gait systems to the peripheral nervous system, the contraction of the muscles occurs, and several forces are generated. The ground reaction forces generate the ground reaction forces and regulation across skeletal segments and synovial joints. The ankle motion consists of two phases (Welte et al., 2018).

These phases include the swing phase and stance phase. Gait cycle, 60 per cent part is occupied by the stance phase. In which one foot and leg bear nearly full body weight (Behling et al., 2020). At the same time, the swing phase occupies 40% of the gait cycle in which the weight of the body is borne by the other foot and leg. Hence, in both gait cycle steps, the contraction of the feet with the ground is done 25 per cent of the time. This part of the gait cycle is also known as the double-support phase. There are generally 8 phases of the gait cycle, including terminal stance, loading response, mid-swing, pre swing, midstance, late swing, initial contract and initial swing (Lai et al., 2019).

Question 2: Hicks Windlass Mechanism

The ligaments as a truss or triangular structure arch and feet are usually used to describe the Hicks. The truss's arch is formed by the midtarsal joint, calcaneus and metatarsals. The formation of the tie-rod is done by the plantar fascia. The Tie rod runs from the calcaneus to the phalanges. The bodyweight travels downward because of the vertical forces. On the other hand, the reaction forces travel upward on the metatarsal heads and calcaneus. According to Yazdani et al. (2019), it is flattening the attenuate effect because the forces reduce both anterior and posterior to the tibia. The mechanism of Hick's windlass suggested that during late stance produces winding of the plantar fascia around the metatarsal head, the dorsiflexion of the metatarsophalangeal joint (MTPJ). It is the essential movement of the medial longitudinal arch for shock dissipation and absorption of forces with the help of the foot. It describes the movement of the foot that can act as both an adaptable shock absorber and rigid level during the gait stance phase (Pabón-Carrasco et al., 2020).



Question 3: Define the Following

Angle of Gait

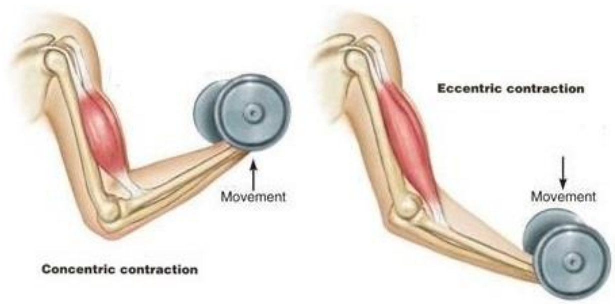
The measured angle that is formed by the help of median line through line bisecting and imprints longitudinally platform is known as angle of gait (Lazzarini et al., 2019).

Base of Gait

The base of gait is referred to as a distance between the contact of the rearmost point of the right and left heels. The base of gait is measured by the use of right angle (Bennett et al., 2021).

Question 4: Concentric and Eccentric in Muscle Contraction

To meet the resistance, the tension of muscles rises and remains muscles shorten stability. This phenomenon is known as a concentric contraction. During this contraction, the muscle lengthens as the resistance becomes higher than the muscle force production. An example of it is the upward biceps curl phase which is in concentric contraction (Shorter and Rouse, 2019). On the other hand, the eccentric contraction occurs when the muscle's total length increases in response to tension production. Its basic example of it is lowering the biceps curl phase. The capability of muscles to generate higher forces under eccentric conditions (Behling et al., 2020).



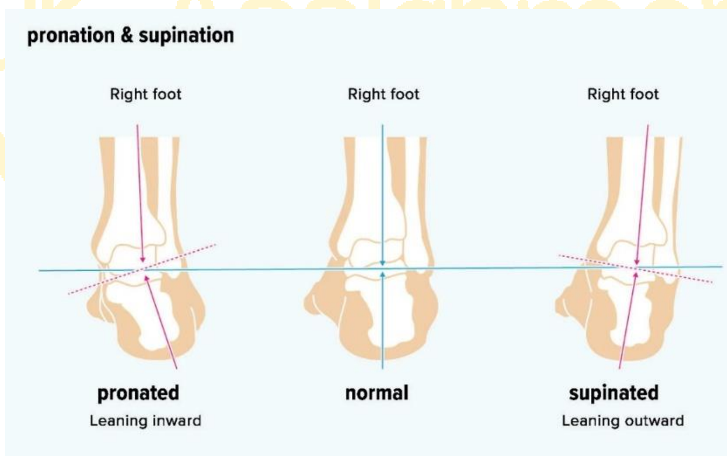
Question 5: Measuring Range of Dorsiflexion

The first motion metatarsophalangeal joint range becomes the cause of varying values for joint dorsiflexion (Yim et al., 2020). The first metatarsophalangeal joint's dorsiflexion is assisted by these values. The range of these values is from 60 to 90 degrees. The 1st MTP joint maximum dorsiflexion's clinical measurement shows valuable dynamic functions insights of the ankle and foot during the propulsive gait phase. For the weight and height measurement, they use body mass index (BMI), digital scales and a stadiometer, which helps them in calculating the height and weight (Drukarch et al., 2021).

Question 6: Motions During Pronation and Supination

Supination and pronation are the two primary movements that let the foot, and lower extremity adapt to uneven terrain, absorb stress, and turn into a strong lever for forwarding propulsion. Supination may range between 45 and 60 degrees, whereas pronation can vary between 15 and 30 degrees. Assess the patient's mobility on their dominant side. Supination leads the foot to become rigid by means of inversion, adduction, and plantar flexion, while pronation allows the foot to absorb stress and adapt to the terrain. Pronation is defined by inversion, abduction, and dorsiflexion of the foot and ankle. When the foot absorbs weight and pronates during midstance, the midtarsal joint relaxes to allow for maximum pronation (Welte et al., 2018).

As the foot travels toward supination, the midtarsal joint locks (closure pack), providing a strong push-off lever. During the exercise, the examiner should seek subluxated tendons. During eversion, the peroneal tendons are more susceptible to subluxation, as illustrated. Supination is difficult because the anterior tibial tendon is weak. When the peronei muscles or tendons are weak or subluxated, pronation is impaired (Wagner and Wagner, 2020).



Question 7: Medial Malleolus

The posterior tibialis tendon, Flexor digitorum longus and Posterior tibial artery and nerve are among the structures that extend behind the medial malleolus and into the flexor retinaculum. The posterior tibial tendon is one of the most important leg tendons (Shorter and Rouse, 2019). Tissues link the calf muscle to the inner foot bones through the posterior tibial tendon. During walking, the tendon's primary purpose is to support the foot and preserve the arch. Flexor digitorum longus resides in the deep posterior compartment of the tibial side of the lower leg (FDL). As the muscle descends, it starts small and eventually grows in size. A posterior tibial nerve block is guided via the posterior tibial artery. Behind the medial malleolus, near the Achilles tendon, the needle is inserted into the posterior tibial artery (Behling et al., 2020).

Question 8: Tissue Stress

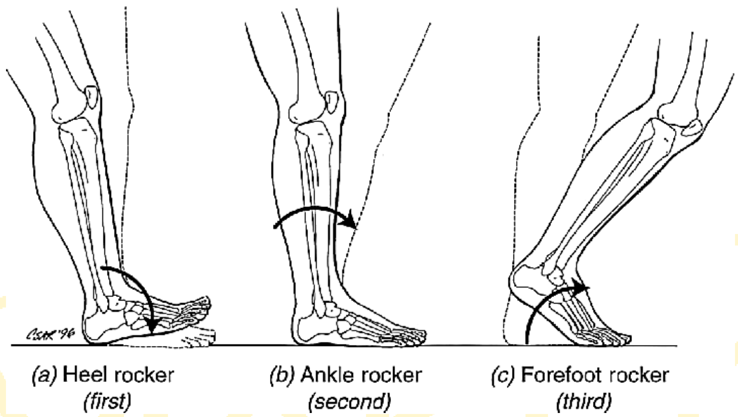
According to the idea of tissue stress, mechanical foot and lower limb problems are the results of very high levels of stress in the structural components of the foot and lower limbs. Stress, which is calculated by dividing an object's cross-sectional area by the loading force, is an internal measure of an object's resistance to a loading force (McSwiggen et al., 2019). Axial (tension or compression) or tangential (shearing) stress may exist (shearing). When a thing opposes being pushed apart, tension stress arises, and when it resists being compressed, compression stress develops. When parallel or tangential strains are applied to a load, shear stress results when one component of an item resists the movement of another (Bennett et al., 2021).

Viscoelasticity is essential to comprehending the mechanical basis of tissue damage. All living tissues display viscoelastic characteristics. When stress is eliminated, the body's tissues may return to their former shape due to their elasticity (Welte, 2020). Viscosity generates time-dependent load-deformation features in biological tissues, leading to strain rate dependence and tissue hardening when tissues deform more rapidly. Clinical assessments were performed utilising a tissue model of a patient under stress in a demanding environment. The patient's medical history was utilised to establish which tissues had been overstressed, and the physical examination was used to administer controlled stresses to specific tissues and discover the cause of their sickness (Lazzarini et al., 2019).

When it was determined that the plantar fascia of the patient had been exposed to excessive mechanical stress, the therapy focused on lowering discomfort, inflammation, and stress on the plantar fascia, followed by a gradual return to running while minimising symptoms. The patient reported being pain-free throughout the 11-week phone follow-up, seven weeks after the first physical therapy exam. Despite the lack of experimental proof, this patient reacted well to therapy based on tissue stress (Iannaccone et al., 2020).

Question 9: Rocker Theory

Due to their simplicity, rocker models are useful for investigating the functional activities of the human lower leg. A recent study indicates that the roll-over shape (ROS) is an enduring characteristic of able-bodied walking. The lower limb system adheres to the ROS when walking between first and contralateral first contact. However, it is unclear if rocker designs are best for forward-aft swaying. With greater knowledge of these forms, it may be possible to build better prostheses for this function, so boosting the balance and confidence of lower limb prosthesis users and reducing their risk of falling (Yim et al., 2020).

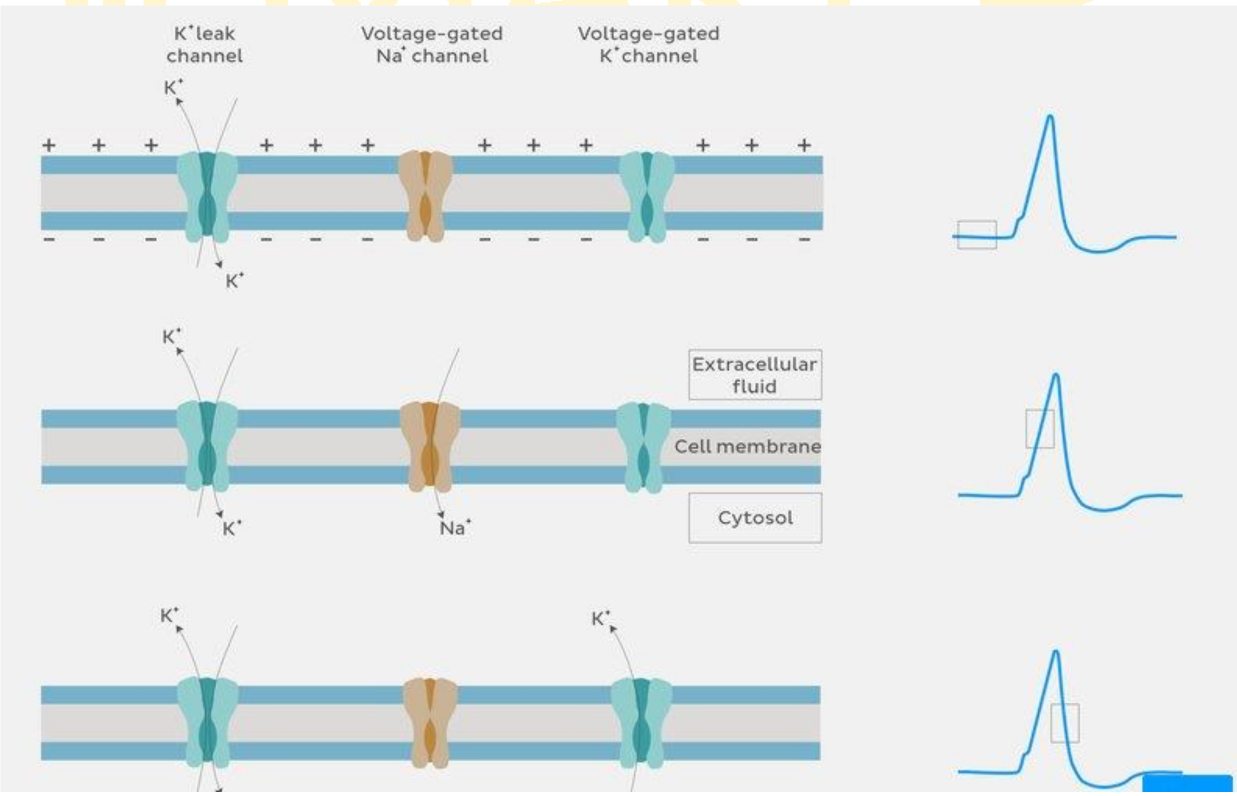


Eleven healthy individuals' effective rocker forms while walking and swaying forward and backwards were measured. It has been expected that the curvature of the swaying forms would be less (radius greater) than that of the walking forms, leading to more stable ground contact during swaying. When walking, the radius (measured as the inverse of the shape's curvature) was around one-third of the leg length; however, when swaying, the radius was more than twice the leg length. A model that examined the effective ankle stiffness required to achieve these curvatures determined that a biomimetic prosthetic ankle would need three times the stiffness of walking. In order to simulate the physiological system, a prosthetic ankle-foot would need two distinct modes for walking and swinging (Shorter and Rouse, 2019).

Question 10: Action Potential

A neuron's action potential is triggered by threshold or suprathreshold stimuli. In the presence of diffusible ions, temporary variations in membrane permeability create an action potential. As a consequence of these changes, ion channels become permeable, and ion concentration gradients vanish (Nigg et al., 2019). The threshold potential is affected by membrane permeability, internal and extracellular ion concentrations, and features of the cell membrane. An action potential consists of three steps: depolarisation, overshoot, and repolarisation. The membrane potential contains two more states besides the action potential. The first happens before depolarisation, while the second takes place during repolarisation. The initial increase in membrane potential to its threshold potential is hyperpolarization (Yazdani et al., 2019).

The threshold potential activates voltage-gated sodium channels, resulting in a significant sodium ion inflow. The word "depolarisation" is used to characterise this phase. With increased depolarisation, the inside of the cell approaches the sodium electrochemical equilibrium potential of +61 mV. The overshoot phase is characterised by excessive optimism. As its channels shut, the sodium permeability drops fast after an overshoot (Pabón-Carrasco et al., 2020). When the cell potential is exceeded, voltage-gated potassium channels are activated, resulting in a considerable potassium outflow and a decrease in electropositivity. During the repolarisation phase, the membrane's resting potential is restored. The first phase of repolarisation is often hyperpolarisation, which occurs when the membrane potential is more negative than the normal potential. In contrast, membrane potential levels are rapidly restored (Lai et al., 2019).



References

Behling, A.V., Manz, S., von Tscharner, V. and Nigg, B.M., 2020. Pronation or foot movement—What is important. Journal of Science and Medicine in Sport, 23(4), pp.366-371.

Bennett, H.J., Valenzuela, K.A., Lynn, S.K. and Weinhandl, J.T., 2021. Foot rotation gait modifications affect hip and ankle, but not knee, stance phase joint reaction forces during running. Journal of Biomechanical Engineering, 143(2).

Drukarch, B., Wilhelmus, M.M. and Shrivastava, S., 2021. The thermodynamic theory of action potential propagation: a sound basis for unification of the physics of nerve impulses. Reviews in the Neurosciences.

Iannaccone, S., Castellazzi, P., Tettamanti, A., Houdayer, E., Brugliera, L., de Blasio, F., Cimino, P., Ripa, M., Meloni, C., Alemanno, F. and Scarpellini, P., 2020. Role of rehabilitation department for adult individuals with COVID-19: the experience of the San Raffaele Hospital of Milan. Archives of Physical Medicine and Rehabilitation, 101(9), pp.1656-1661.

Lai, Y.R., Huang, C.C., Chiu, W.C., Liu, R.T., Tsai, N.W., Wang, H.C., Lin, W.C., Cheng, B.C., Su, Y.J., Su, C.M. and Hsiao, S.Y., 2019. Close relationship between cardiovagal function and sural sensory nerve action potential in type 2 diabetes. Clinical Neurophysiology, 130(7), pp.1160-1165.

Lazzarini, P.A., Crews, R.T., van Netten, J.J., Bus, S.A., Fernando, M.E., Chadwick, P.J. and Najafi, B., 2019. Measuring plantar tissue stress in people with diabetic peripheral neuropathy: a critical concept in diabetic foot management. Journal of diabetes science and technology, 13(5), pp.869-880.

McSwiggen, D.T., Mir, M., Darzacq, X. and Tjian, R., 2019. Evaluating phase separation in live cells: diagnosis, caveats, and functional consequences. Genes & development, 33(23-24), pp.1619-1634.

Nigg, B., Behling, A.V. and Hamill, J., 2019. Foot pronation. Footwear Science, 11(3), pp.131-134.

Pabón-Carrasco, M., Castro-Méndez, A., Vilar-Palomo, S., Jiménez-Cebrián, A.M., García-Paya, I. and Palomo-Toucedo, I.C., 2020. Randomized clinical trial: The effect of exercise of the intrinsic muscle on foot pronation. International journal of environmental research and public health, 17(13), p.4882.

Shorter, A.L. and Rouse, E.J., 2019. Ankle mechanical impedance during the stance phase of running. IEEE Transactions on Biomedical Engineering, 67(6), pp.1595-1603.

Wagner, E. and Wagner, P., 2020. Metatarsal pronation in hallux valgus deformity: a review. JAAOS Global Research & Reviews, 4(6).

Welte, L., Kelly, L.A., Lichtwark, G.A. and Rainbow, M.J., 2018. Influence of the windlass mechanism on arch-spring mechanics during dynamic foot arch deformation. *Journal of the Royal Society Interface*, *15*(145), p.20180270.

Welte, L.K., 2020. Arch-rivals? The roles of the windlass and arch-spring mechanisms in running (Doctoral dissertation, Queen's University (Canada)).

Yazdani, F., Razeghi, M., Karimi, M.T., Bani, M.S. and Bahreinizad, H., 2019. Foot hyperpronation alters lumbopelvic muscle function during the stance phase of gait. Gait & Posture, 74, pp.102-107.

Yim, J.K., Singh, B.R.P., Wang, E.K., Featherstone, R. and Fearing, R.S., 2020. Precision robotic leaping and landing using stance-phase balance. IEEE Robotics and Automation Letters, 5(2), pp.3422-3429.