PART 2

It is All About the Foot:

Articulation

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In this issue of Current Pedorthics, we continue with our educational refresher series to re-acquaint you with the basic and advanced anatomy and physiology of the foot. In part two we will discuss articulation.

The Foot Bone is Connected to the … Ankle Bone

Human locomotion is unlike the movement of any other species on earth. Humans walk upright where other species tend to remain primarily quadripedal. Surely, some species of the great apes walk short distances on two limbs, however, not exclusively.

Humans are of the simian class, which includes monkeys and apes. There are twenty-four species of apes and two hundred sixty-four of monkeys. Opposable thumbs primarily differentiate the anatomy of humans from the lower species.

Bipedal locomotion is inherently unstable due to the ischium being forced to move inferiorly (downward) and anteriorly (forward), causing strain on the tendons connecting the hip to the ischium. In the great apes, the spine is relatively straight. Bipedal movement with a straight spine causes specific strain on the pelvis, causing the instability. With the passage of time, humanoids' spines adapted to the upright position by the development of the lordotic and kyphotic curves. This is all about balancing weight and body parts against the forces of gravity.

When a baby is born, none of the structures that support the body are strong enough to do their jobs. The head is extremely large in relation to the body, and the torso is long in relation to its ultimate length. The lower body is comparatively short to the entirety and the spine is completely straight. The infant's head and neck must be constantly supported as the musculature is too immature.

As the child matures, it eventually is capable of holding its head up. The muscles of the upper spine and head now handles the weight of the skull. It is at this point that the kyphotic curve (in the T3-4 region, though it can also present in the cervical or thoracic region) develops. A curve of between 20-40 degrees is considered normal. This allows the spinal column to bear the weight of the skull and its contents. Abnormality in this curve (over 40 degrees) is called kyphosis, and can be a serious structural and health problem.

When the child nears the time to take its first steps, the lower extremities are beginning to elongate. The child holds onto furniture to provide stability as their lower spinal region and leg musculature are still a bit immature. The first steps normally conclude with a fall to the ground, mostly due to the immaturity of the musculature. With time, the muscle groups begin to strengthen and coordinate the actions that lead to smooth ambulation. To put it simply, the legs tend to be in a "running" mode as the legs are working hard to hold up the weight of the torso and skull.

As the child reaches the age of three or so, the lordotic curve fully develops. This convex curve takes strain off the hip structures and the combination of these curves allows what we call bipedal ambulation. As we all know, anything other than normal can be problematic. Any abnormality in the support structures can cause a problem somewhere else.

Now, what does all this have to do with articulations of the feet? Feet are THE support structure of the human body. They hold up our weight, allow smooth movement over various terrains, and allow us to go where we wish.

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Triplanar motion would be impossible if the foot did not have the articulations that it does. The ability to transfer front to back forces into side to side and inward and outward movements is what allows locomotion as we know it. Imagine a rigid, locked foot (perhaps a nice pes cavus type) attempting to walk on uneven ground. We all have. Without the ability to "dodge and weave" the foot/ankle is subject to a lateral ankle fracture.

On the other hand, a sloppy "bag of bones" foot, think pes planus, is just as bad. While the cavus is highly structured, the planus allows bones and soft tissues to go where they want, and cause its own set of problems.

An articulation is simply the contact point of one bone with another. Some are fixed and some are moveable. There are three main articulations to consider here: Talus and Calcaneus, Navicular and Cuboid, and Metatarsal and Phalangeal.

Talus and Calcaneus

The talus and calcaneus are both the keys and the lock for movement in the foot. Locomotion is a complex series of locking and unlocking of joints, contracting and relaxing of muscle and tendon, interactions of all these systems from the foot to the pelvis. Any treatment of this subject will never do it justice in a small forum. With that said, let us turn to the three main articulations that are instrumental in our ambulation.

The majority of the articulations, defined as the space where two bones meet, have little if no movement. In fact, if there are abnormal movements, such as in the cuneiforms, they may be due to injury or trauma.

The principal source of movement in the foot begins with the talo-calcaneal articulation. The interactions of the four principal bones of the hind-foot and mid-foot allow locomotion as we know it to occur. It is the convex/concave shaping of these bones that perform the magic of the foot.

Upon heel strike, the calcaneus is in the locked position to support the weight of the body. It then moves into a valgus position which unlocks the mid-tarsal joint thus initiating shock absorption for the decelerating foot. As the heel lifts, the calcaneus moves back into varus position, locking the mid-tarsal joint, and allowing for toe-off and propulsion of the body forward. Simple, isn't it?

While the calcaneus is the real work horse of locomotion, the unsung hero is the talus. It is a most curiously shaped bone that articulates at several spots with the neighboring bones. On the upper surface, it has facets which articulate with the tibia and fibula on the upper surface, with the calcaneus on the underside, and on the anterior surface with the navicular. It has the unique property of being the only bone that has no muscle attached to it. While the talus is the true "ankle" bone, common understanding of the "ankle" is the malleoli that protrude, not the bone that makes it all work. When one fractures their ankle, it is actually the separation of the distal protuberances of the tib/fib from the long bone that fracture. There is a host of ligaments that hold all these together and make the structure of the foot as we know it.

Navicular and Cuboid

The navicular and cuboid are the bones of the midfoot and together with the talus and calcaneus form the transverse tarsal joint (the Universal Joint of the foot). This is also known as the mid-tarsal joint. This is where the concave portions of the navicular and cuboid join with the convex surfaces of the talus and calcaneus to provide the lock/unlock of the foot and the power to absorb forces and propel the body forward.

There are three, and sometimes understood as four arches in the foot. In architecture, an arch is a rigid structure that supports the weight of a wall or a bridge. In the foot, the many articulations of these arches function as a flexible lever rather than a rigid construct. The three most commonly known arches are the medial longitudinal ("the arch"), the lateral longitudinal, and metatarsal. The fourth can be understood as the mid-tarsal joint. The structure of the arches raise the bones in an arch like manner which allows for shock absorption and propulsion. We commonly term the "arch" of the foot as the medial longitudinal arch. This is the structure that can cause plenty of problems for persons with deficits in them to develop the pathologies that we treat. Without the connective tissues, covered in a later article, the whole foot collapses. With the exceptions of trauma and congenital abnormalities, there are few issues with the bones themselves; the connective tissues and their abnormalities are what create the pathology we are called upon to manage.

The main actors in the medial longitudinal arch are the calcaneus-talus-navicular. There is significantly more motion in this arch. The lateral longitudinal arch has the calcaneus and cuboid as its main players. The metatarsal arch is composed of the articulations of the cuneiforms and the cuboid. With their supporting tissues attached, each of these arches form unique structures that allow us to walk.

Metatarsal and Phalangeal

The most fluid of the articulations occur in the digits (toes). The lesser digits (2-5) have three articulations, the hallux has two. It is the digits that cause the most numerous foot maladies: bunions/bunionette, hammertoes and callusing. And these most often occur because some condition proximal to them has its result in the digits. It is tough being at the end of the line. The hallux is the foot's rudder and steers the body in its forward propulsion. The lesser digits provide stability on a variety of surfaces and the lever that allows propulsion.

Anytime something is amiss from nature's normal, there will be a deformity that will develop that a pedorthist is uniquely trained to manage so that our patients can lead a normal lifestyle. Pedorthists need to understand what normal so in order that we can work our magic and replicate the state of normal while the foot does as it pleases.