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Gait Analysis in Osteoarthritis Gait Analysis in Osteoarthritis

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Gait Biomechanics
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The following material is accurate but very heavy going. It is normally presented during a full semester course on either gait or basic functional biomechanics.

In order to understand specific lower extremity problems encountered in patients with OA, it is necessary to have a thorough understanding of normal lower extremity biomechanical abnormalities and specific lower extremity problems. Unnecessary following is a review of the gait cycle, starting simply with a review of the phases of gait, then a review of the kinematics and kinetics of normal gait. There will then be a review of a simple clinical approach to the lower extremity examination, as it pertains to mechanically caused foot and knee problems.

Many specific foot problems are caused by biomechanical faults within the lower extremity. Although the foot is the most distal lower extremity segment, one must understand the normal anatomy, function and biomechanics of the lower extremity. It is important to be able to visualize the events of the lower extremity during the gait cycle in three dimensions.

The gait cycle can be divided into different phases and subphases, each each action of the foot and leg can be evaluated at specific sequential time periods.

Anatomy

Before discussing the specifics of gait let's take a quick look at the bones of the foot and ankle. The foot is made up of 26 bones, 7 of which are located at the ankle. The first ankle joint formed by these two bones is called the subtalar joint. Other key bones include the navicular (Latin) cuboid (?), the three cuneiforms and the five metatarsals. The metatarsals are the long tubular and flat bones of the forefoot and cuboid make up what is known as the mid-tarsal joint. The key bones of significance include the fibrous which is the lateral bone of the lower leg, the talus, which is the ankle bone and the calcaneus, which is the heel bone. In front of the tibia is the patella or knee cap. We will not review the anatomy in detail.

Phases of Gait

The gait cycle of each leg is divided into the stance phase and the swing phase. The stance phase is the period of time when the foot is in contact with the ground. The swing phase is the period of time in which the foot is off the ground and swinging forward. In walking, the stance phase occupies approximately 60% of the gait cycle and the swing phase 40% of the gait cycle. The proportion of time in stance phase changes as the speed of walking or running increases. As the speed is increased the percentage of time in stance phase decreases. In walking, there is a period of time when both feet are in contact and there is an increase in the importance of swing phase muscles. An important point to note is that in running an added subphase is introduced, the stance phase is broken down into two, neither foot is on the ground.

Stance Phase

Stance phase can be broken down into a series of phases. In walking, 60% of the complete gait cycle is spent in stance phase while walking and 40% in swing phase. In running, the stance phase is broken down into several subs with the swing phase remaining in one description. Difference between running and walking. A walker moving at a comfortable speed of walking, 1.3 meters per second, 4.7 km/hr, 2.9 miles per hour, spends approximately 0.6 seconds per leg in contact with the ground. However, the stance phase has decreased from .62 second to 0.2 seconds.

Stance Phase: Contact Subphase

The stance phase can further be subdivided into its three component phases. The first portion of the stance phase is contact. This phase begins with the contact of the heel to the ground. This phase is completed when the opposite foot leaves the ground. In walking, the contact phase is a double phase the foot is presenting the ground with its lateral aspect initially posterior and the foot is absorbing shock and functioning as a mobile adaptor to the impact of the lower extremity with the ground. In running, this phase is very brief.

Stance Phase: Midstance Subphase

Midstance Phase begins when the entire foot has contacted the ground. The leg weight is passing over the foot and the knee is moving over the foot and moving forward. The opposite leg is off the ground and the foot, in this phase, is in a position to assume the role of the mobile adaptor to shock and the lower extremity. This phase is completed when the heel rises from the ground. It is undergoing a change from being a mobile adaptor to becoming a rigid lever. In running, this phase is prolonged during the foot-ground contact period.

Stance Phase: Propulsion Subphase

Propulsion begins when the heel rises and with toe off. This phase constitutes the final 33% of stance phase. The body is propelled forward during this phase. The knee is in a position of flexion. The ankle is in dorsiflexion and the foot must be in a supinated position in order for this phase to be normal and efficient. If abnormal pronation is occurring, the midstance phase will last longer and the propulsion phase will be prolonged and the foot will not be normal. The opposite leg is beginning its initial contact with the ground. In running, the foot simply strikes the ground with the heel and the knee is flexed. The ankle is in dorsiflexion and the foot is in a supinated position. The knee is flexed and the foot is being positioned in preparation for weight bearing and the initial contact phase of the gait cycle. In running, the knee is flexed and the foot is in a supinated position and is being positioned for initial contact.

In normal walking, the foot initially contacts at the heel. Usually, the initial contact is midstance and which results in posterior lateral heel wear. The foot then pronates to absorb shock and to become a mobile adaptor. This motion can be determined by the transverse plane motion of the tibia and the amount of calcaneal eversion that occurs during the stance phase. The tibia will internally rotate approximately 8 degrees. The calcaneal eversion will be about half of this amount. In normal walking, there is no initial heel contact. An individual may contact at the midfoot and then rock backward onto the heel or not touch the heel at all. In running, the initial contact is usually at the midfoot or forefoot. Following an understanding of the basic phases of gait, one can proceed to the examination of the lower extremity. Before doing so, a review of the muscles of the lower extremity is in order.

This image summarizes the stance and swing phases of gait and the interrelationships between both phases. The period of double support, during which both feet are on the ground, occurs during 2 time periods in the gait cycle. The first period occurs during the initial and final 10% of the stance phase.

The normal knee double knee phase has implications for the final portion of stance phase - the propulsion phase. The propulsive phase may be divided into two phases. The initial portion of the propulsive phase is characterized by hallux the supination foot function leads and terminal double support phase. The passive portion of terminal double support begins with the toe-off. The ankle is in dorsiflexion and the knee is in a flexed position. Terminal double support ends with the initial contact of the opposite leg.

We will next discuss transverse plane rotations occurring in the limb. At heel strike, the foot is in a position of 10 degrees of supination. The ankle is in a position of dorsiflexion. The knee is in a position of flexion. The femur is in a position of before low-off. It rotates externally, where it remains during the swing phase. Internally, if a runner swings his arm across his body, there is a compensatory increase in pelvic rotation. It is more efficient and better for the runner to keep the arms moving in a straight line and not to cross the midline of the body.

Forward rotation within the hip joint correlates precisely with pelvic rotation. Pelvic rotation is a compensatory motion for the lower extremity. Approximately 10 more back to external rotation from left and vice versa alternately related until heel contact.

The knee rotates relatively more rapidly than the femur. This assists the unlocking of the knee joint. Its medial rotation is accomplished by the popliteus muscle. Its lateral rotation is accomplished by the biceps femoris muscle. The foot has rotations for alternate and lose functions.

An important muscle function during the contact phase and midstance phase is the tibialis anterior muscle. This muscle is a dorsiflexor of the ankle joint. The STJ also functions to slow the internal rotation of the tibia and to keep an action on the leg. When the STJ supinates during what is called the propulsive phase, it is a rigid lever. The STJ is a mobile adaptor to shock and a stable action on the leg. Dorsiflexion ankle is lacking in the foot is prevented, the action is referred to the tibia, which slows its internal rotation. Pronation of the foot is a normal motion. Pronation of the foot is a normal motion.

The key to the relationship of abnormal foot function to lower extremity biomechanics is understanding the STJ axis. The STJ axis is oriented in a manner that allows pronation and supination. Motion at the ankle joint occurs in a complete triplanar multiaxial motion. The motion that occurs at this joint is a combination of motion in the sagittal, frontal and transverse planes. The STJ axis is oriented in a frontal plane. The normal range of motion of the subtalar joint is approximately 30 degrees. 2/3 of this motion is normally pronation and 1/3 is supination. The STJ pronation motion allows the calcaneus to add by adding 10% of the rotation needed to bring the forefoot into position of the joint or determined by palpation. Motion at this joint is accomplished by the talus. The talus is a wedge shape bone and is wedged posterior to the long axis of the tibia. In many cases in which there is abnormality of the foot, the neutral position is in a varus relation to the leg. The talus is a wedge shape bone and is wedged posterior to the long axis of the tibia. In many cases in which there is abnormality of the foot, the neutral position is in a varus relation to the leg.

A normal range of motion of the subtalar joint is approximately 30 degrees. 2/3 of this motion is normally eversion and 1/3 is excursion from its neutral position. Motion at this joint is accomplished by the talus and the neutral position of the foot. Motion at this joint is measured by movement of the calcaneus.

Pronation of the foot is ideally based upon the long axis of the leg. In many cases in which there is abnormality of the foot, the neutral position is in a varus relation to the leg. Pronation of the foot is a normal motion. Pronation of the foot is a normal motion. Pronation of the foot is a normal motion