will be further addressed through an examination of their role in walking, the negative implications of excessive pronation, and the coupling of the lower leg and foot with these movements.

**Foot Pronation and Supination in Walking**

The interplay of pronation and supination can be easily illustrated with walking gait. Walking is classically divided into two phases—the stance phase, or support phase, and the swing phase. During the **stance phase** the foot is in contact with the ground, while during the **swing phase** the foot is being swung forward in space to reach an appropriate position for the next step. The stance phase is the phase that places the weight-bearing demands on the ankle and foot and will be the focus of this discussion. The stance phase can be further subdivided into three periods—the contact period, midstance period, and propulsive period. The foot initially contacts the ground (heel strike, or contact, period) on the lateral heel with the foot in a position of slight supination (Taunton, Clement, and Webber, 1981). This puts the foot in a stable position for transfer of weight onto the foot. Then as the body weight begins to shift over the foot, the tibia quickly begins to internally rotate on this fixed foot, producing pronation; a shift of the body weight medially. This foot position allows the foot to adapt to the surface and a with shock absorption. Then, as the body moves farther over the foot in midstance, the foot begins to resupinate and body weight is shifted slightly laterally toward the head of the second metatarsal (Sammacco, 1980). This resupination stabilizes the forefoot and allows the foot to serve as a rigid lever upon which the plantar flexors can act to help push the body forward (propulsive period).

**Excessive Pronation**

Although as just described, pronation is an essential element of normal foot mechanics, excessive pronation may increase the risk for some types of injuries (Hall, 1999). When pronation is of high velocity or is excessive in amount, it is believed to place undue stress on the medial foot and the ligaments, fascia, and muscles that help support the medial longitudinal arch. Furthermore, when pronation is prolonged and extends into the propulsive period of gait when the foot should be resupinating, the foot is unstable rather than stable when propulsive forces are applied, placing undue stresses on the foot and decreasing the effectiveness of the push. Over time, repetitive abnormal pronation is also believed to cause stretching of tissues that support the arch and to contribute to the production of pes planus.

Excessive pronation can come from many causes including malalignment, muscle imbalances, and technique. In regard to malalignment, rearfoot varus and tibial varum require more pronation before the inner portion of the foot can contact the ground (Taunton, Clement, and Webber, 1981). In terms of muscle imbalance, if the triceps surae is tight, compensatory pronation will occur to unlock the transverse tarsal joints in order to gain the necessary apparent dorsiflexion. Inadequate strength in the extrinsic inverters of the foot and the intrinsic muscles that help maintain the medial longitudinal arch may also be a factor in failing to adequately limit extent or duration of pronation. With regard to technique, failing to maintain adequate turnout at the hip, such that the knees “fall inside the feet” during movements like pliés, can cause relative
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Foot Pronation and Supination in Walking

- Identify normal foot mechanics in walking. Walking very slowly, mark on your body the normal foot mechanics during the stance phase of walking that were just described in the text and that are shown in A.

**PERIOD OF GATE:**

<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact Period</td>
<td>(0-25% stance phase)</td>
</tr>
<tr>
<td>Midstance Period</td>
<td>(25-75% stance phase)</td>
</tr>
<tr>
<td>Propulsive Period</td>
<td>(75-100% stance phase)</td>
</tr>
</tbody>
</table>

**MOTION OF FOOT**

<table>
<thead>
<tr>
<th>Function</th>
<th>Pronation</th>
<th>Supination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability</td>
<td>(shock absorber, mobile adaptor)</td>
<td>(rigid lever for propulsion)</td>
</tr>
</tbody>
</table>

**POSITION OF FOOT**

(From posterior view of right foot)

A. Normal position

- Observe three to five individuals walking. Position yourself so that a dancer walks directly toward you and then directly away from you. Observe the mechanics listed in the text and notice if supination—pronation—supination occur and to what extent and with what timing. Notice differences between sides in the same individual and any malalignments in the knees, hip, and spine that might influence this gait.

B. Observe yourself walking. Now observe yourself walking by walking toward a mirror or keying in to internal cues. Make the same observations as just described. Also note your shoe wear pattern. Look at the ideal pathway of the center of pressure on the foot shown in B, and consider what clues shoe wear can give regarding foot mechanics in walking.
internal rotation of the lower legs and compensatory pronation of the feet.

**Coupling of the Leg and Foot**

Due to the oblique axis of the subtalar joint, the shapes of various bones, and soft tissue interaction, there is a coupling of movements between the leg and foot when the foot is fixed and weight bearing as shown in figure 6.39 (Hintermann, 1999). Since the ankle joint is a hinge joint that does not allow much rotation, rotation of the lower leg is translated to the foot; and conversely, rotation (abduction and adduction) of the foot is translated to rotation of the lower leg. This coupling is such that supination is accompanied by external rotation of the leg, and external rotation of the leg is accompanied by mandatory supination (Soderberg, 1986). Conversely, pronation is accompanied by internal rotation of the leg, and internal rotation of the leg produces pronation of the foot.

During walking, this coupling is important for absorbing the rotations of the lower leg as the tibia internally and externally rotates at the beginning and end of stance, respectively (Hamill and Knutzen, 1995). If this mechanism were not available, these rotations of the lower leg would tend to spin the foot on the ground or disrupt the integrity of the ankle joint by causing the talus to rotate within the mortise (Levangie and Norkin, 2001). This coupling is also important for the dancer to keep in mind in regard to technique, as rotation of the leg can be used to place body weight appropriately over the axis of the foot, such that excessive pronation or supination can be avoided. On the other hand, the common tendency of allowing the foot to pronate during standing will produce internal rotation of the tibia with resultant loss of turnout if the whole limb is allowed to follow, or knee stress if turnout of the femur is maintained at the hip while the tibia rotates internally.

**Special Considerations for the Ankle and Foot in Dance**

When one is trying to apply the mechanics of the ankle and foot to dance, there are several technique areas that deserve more discussion. One of these is the issue of achieving the desired aesthetics and placement in demi-pointe and pointe positions. Another issue is achieving desired foot placement when the knee bends, such as in pliés. In ballet, still another important concern is the introduction of pointe work.

**Demi-Pointe, Pointe, and the Stirrup Muscles**

The repetitious use of demi-pointe and pointe in dance places great demands on the foot and requires specialized strength, flexibility, and technique development. In terms of flexibility, extreme ankle-foot plantar flexion is required to achieve the desired aesthetic of these positions and allow the dancer to get high enough to allow the body weight to be appropriately placed over the ball of the foot (demi-pointe) or toes (pointe). For proper mechanics and aesthetics on pointe, it is recommended the dancer have 90° to 100° of ankle plantar flexion (Hamilton et al., 1992). About 90° of extension of the hallux at the MTP joint (figure 6.40) is also necessary for a desired high demi-pointe position (Sammarco, 1980).

In terms of plantar flexion strength and range, the ankle-foot plantar flexors have to contract forcefully to achieve and maintain this position of the foot, and ballet dancers have been reported to have very high