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Planal Dominance

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Planal dominance of the individual foot is important to the evaluation of the function of the foot. The direction in which an individual foot can compensate is important. Some feet may have a great deal of transverse plane motion available, and very little frontal plane motion. Others may be able to compensate mainly in the sagittal plane. The primary plane of compensation and the amount of available range are important considerations when evaluating foot function. The authors present a simplified approach to understanding planal dominance.

In our discussion about subtalar joint motion,[1] the *average* axis of the subtalar joint was used as described by Manter[2] and confirmed by Root et al.[3] This axis was located 42° from the transverse plane and 16° from the sagittal plane. The axis ran from inferior posterolateral to superior anteromedial (Fig. 1).

The different authors have used different reference lines for the sagittal plane of the foot. Manter[2] used a line extending from the bisection of the calcaneus out between the first and second toes. Root et al.[3] used the longitudinal axis of the rearfoot as measured by a line passing from the bisection of the posterior aspect of the calcaneus and the anterodorsal medial aspect of the calcaneus, and extending out to the front of the foot. Isman and Inman[4] used the "midline of the foot" which seemed to extend from the bisection of the heel out between the second and third toes. For consistency and simplicity, we have depicted the bisection of the second metatarsal as our reference for the sagittal plane of the foot.

However, even in their original papers, no specimen actually had an axis of motion which was aligned *exactly* on the average axis. We can assume that any individual patient's subtalar joint may and

probably does deviate from this average. The amount of this deviation from the average axis can greatly affect the motion of the foot around the subtalar joint.

When discussing a hinge-type of motion in the three-dimensional environment in which we live, it is important to understand that the axis of motion (an imaginary hinge around which the motion occurs) lies at the junction of the two planes perpendicular to the plane of motion. For example, if pure sagittal plane *motion* occurs, then the axis of this motion lies at the junction of the frontal and transverse planes (Fig. 2). If pure frontal plane motion occurs, the axis lies at the junction of the transverse and sagittal planes (Fig. 3). Even when motion occurs outside of a cardinal body plane, the axis remains perpendicular to that motion in the remaining two dimensions (Fig. 4).[5]

The average axis of the subtalar joint is located 42° up from the transverse plane (or 48° down from the perpendicular). This is approximately 45°, or one-half the way up from the transverse plane and one-half the way down from the vertical plane (Fig. 5).

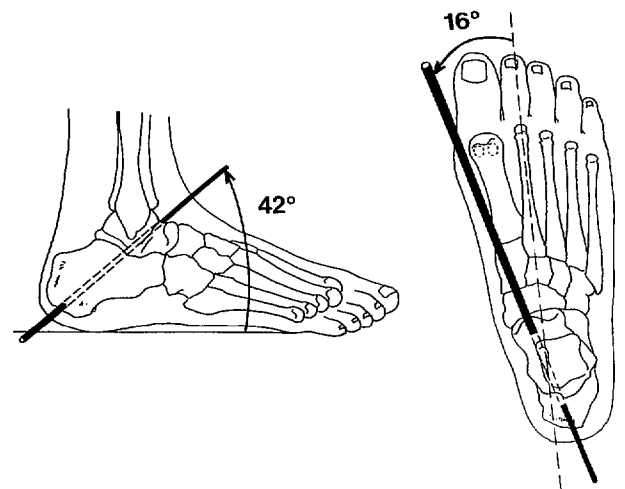If the axis falls parallel to the transverse plane,

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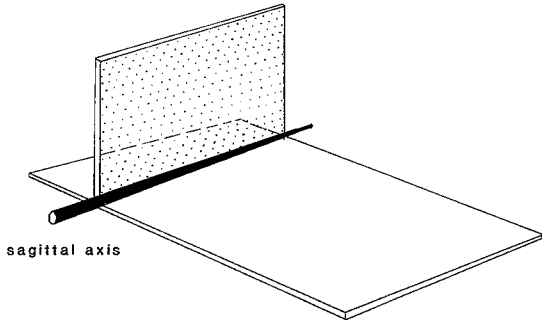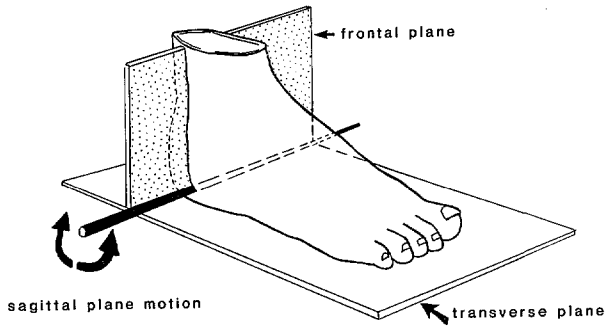
Figure 1. Average subtalar joint axis.

sagittal plane motion

frontal plane

transverse plane

sagittal axis

Figure 2. Sagittal plane motion and axis.

sagittal plane

transverse plane

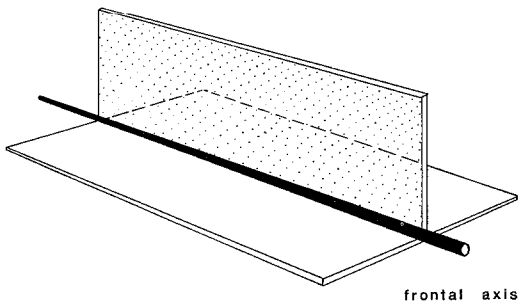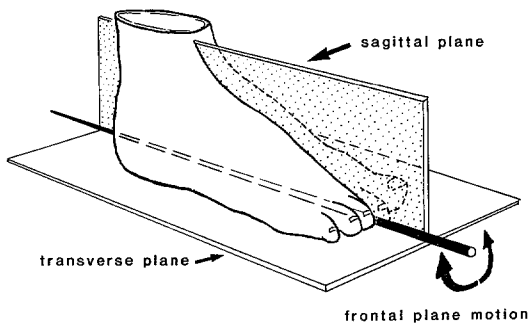frontal plane motion

frontal axis

Figure 3. Frontal plane motion and axis.

motion around that axis will be primarily in the frontal plane (inversion-eversion) with no transverse plane motion (abduction-adduction) (Fig. 6). If the axis falls parallel to the frontal plane (or

vertical), primarily transverse plane motion (abduction-adduction) occurs and no frontal plane motion (inversion-eversion) occurs (Fig. 7). Thus, the more vertical the subtalar joint axis is for an indi-
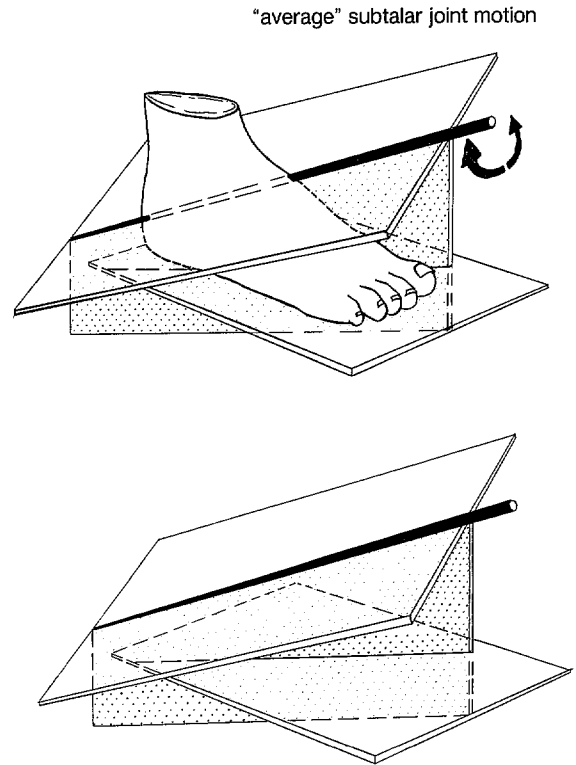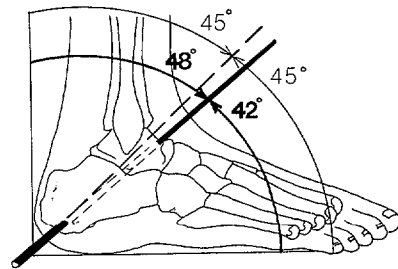
"average" subtalar joint motion

"average" subtalar joint axis

Figure 4. Average subtalar joint motion and axis.

45°

48°

45°

42°

Figure 5. Average subtalar joint axis is close to one-half the way up from the transverse plane.
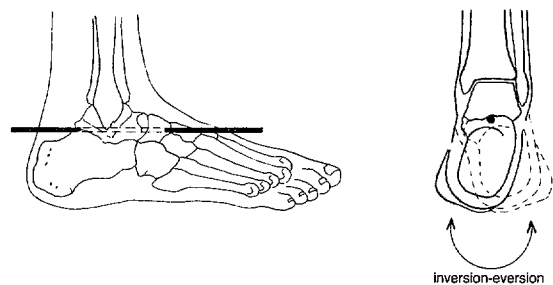

inversion-eversion

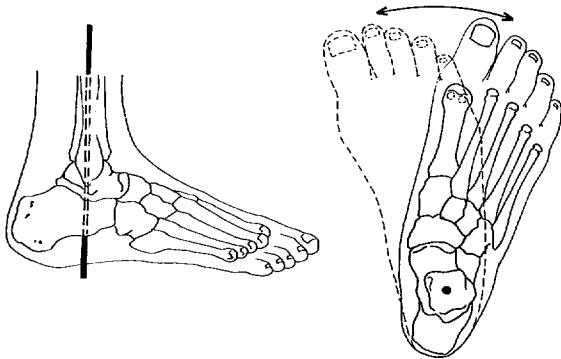**Figure 6.** If the axis falls in the transverse and sagittal planes, the motion will occur in the frontal plane.

Figure 7. If the axis falls in the frontal (vertical) and sagittal planes, the motion will occur in the transverse plane.

from the bisection of the tibia and 84° from the sagittal plane of the foot. The axis runs from plantar posterolateral to dorsomedial anterior, which is the same general direction of the subtalar joint (Fig. 14). The ankle joint actually functions in the direction of supination and pronation, but the motion is primarily sagittal plane motion. Thus, the foot can move readily in the sagittal plane, but this motion primarily occurs at the ankle joint and not at the subtalar joint.
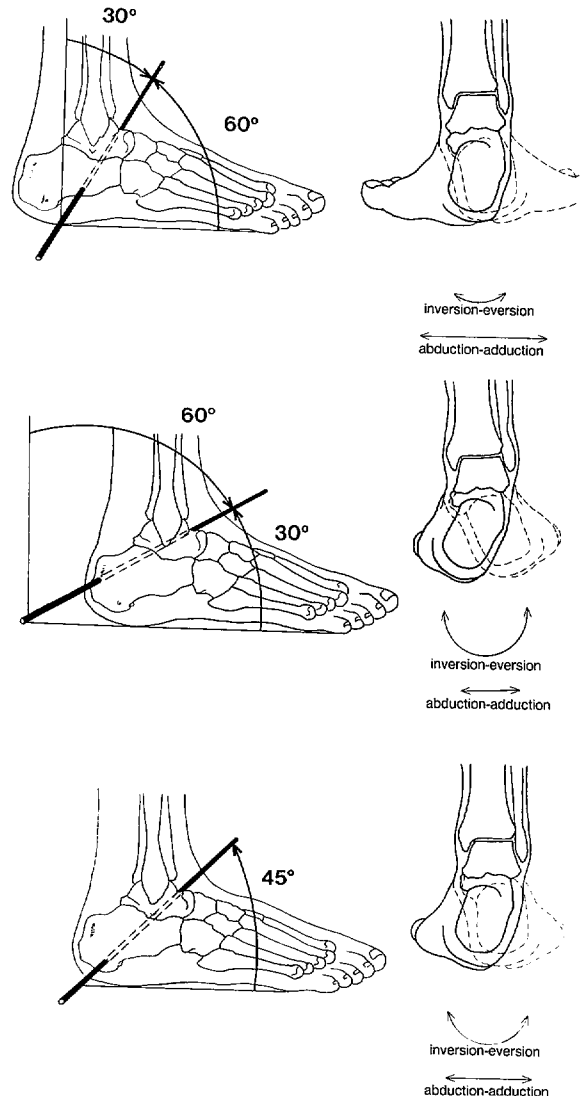
vidual, the greater will be the percentage of transverse plane motion. The more horizontal the subtalar joint axis is for an individual, the greater will be the percentage of frontal plane motion.

If the subtalar joint axis is two-thirds the way up from the transverse plane (60°), we will see twice as much abduction-adduction as inversion-eversion at the subtalar joint (Fig. 8). If the subtalar joint axis is one-third the way up from the transverse plane (30°), we will see twice as much frontal plane motion (inversion-eversion) as transverse plane (abduction-adduction) at the subtalar joint (Fig. 9). An axis of motion that is located at 45° from the transverse plane allows equal amounts of motion in the transverse (abduction-adduction) and frontal (inversion-eversion) planes (Fig. 10).

The average subtalar joint axis is located 16° adducted from the sagittal plane (74° abducted from the frontal plane). This is very close to the sagittal plane (Fig. 11). If the axis falls parallel to the sagittal plane, motion around that axis will be primarily in the frontal plane (inversion-eversion) with no sagittal plane motion (dorsiflexion-plantarflexion) (Fig. 12). If the axis falls parallel to the frontal plane, primarily sagittal plane motion (dorsiflexion-plantarflexion) occurs and no frontal plane motion (inversion-eversion) occurs (Fig. 13).

Thus, the more parallel the subtalar joint axis is to the sagittal plane for an individual, the greater will be the percentage of frontal plane motion. The more parallel the subtalar joint axis is to the frontal plane for an individual, the greater will be the percentage of sagittal plane motion. Since the subtalar joint axis usually deviates very little from the sagittal plane, there is little dorsiflexion-plantarflexion motion available in most subtalar joints.

However, independent sagittal plane motion (dorsiflexion-plantarflexion) can and does occur at the ankle joint. Inman[6] demonstrated that the average axis of the ankle joint is located 82° down

Figure 8 (Top). When the axis is twice as close to the vertical plane as to the horizontal plane, twice as much motion occurs in the transverse plane as the frontal plane.
Figure 9 (Middle). When the axis is twice as close to the horizontal plane as to the vertical plane, twice as much motion occurs in the frontal plane as in the transverse plane.
Figure 10 (Bottom). When the axis is located halfway between the vertical and horizontal planes, equal amounts of transverse and frontal plane motion occur.
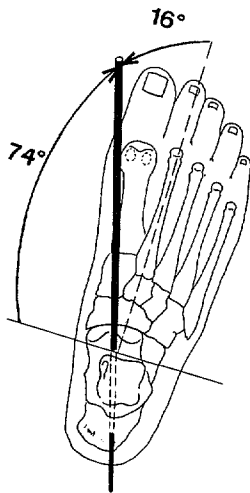
Figure 11. The average axis of the subtalar joint in the transverse plane.
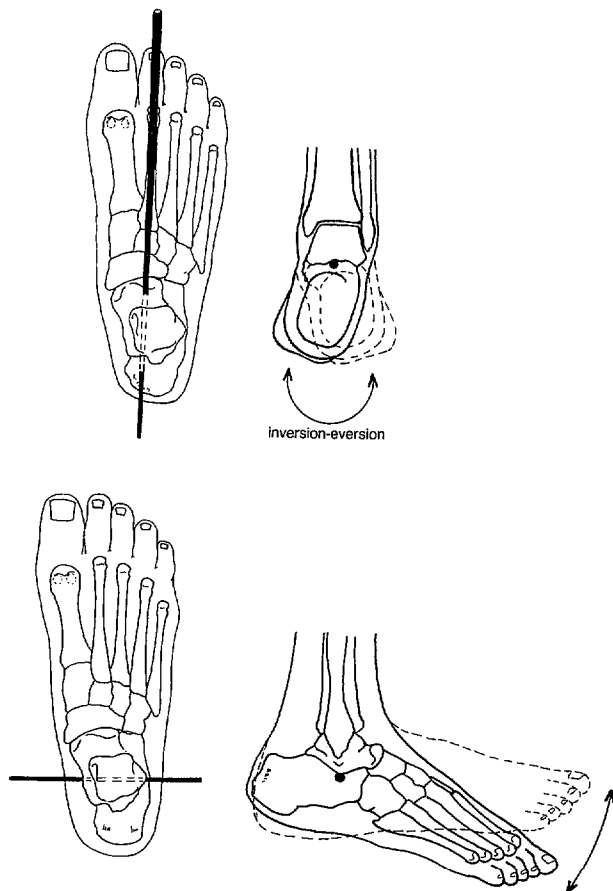

inversion-eversion

Figure 12 (Top). If the axis falls on the sagittal and transverse planes, the motion will occur in the frontal plane.
Figure 13 (Bottom). If the axis falls on the frontal and transverse planes, the motion will occur in the sagittal plane.

Around the *average* subtalar joint axis, the motion primarily occurs in the frontal and transverse plane in about equal proportions and there is little motion in the sagittal plane (Fig. 15).

In clinically examining each individual patient, it may be necessary to estimate the primary plane of motion of the subtalar joint to predict your ability to functionally control or surgically control the subtalar joint.

1. When examining the individual subtalar joint, the amount of motion that the foot goes through in any given plane can be estimated. If there is more frontal plane motion (inversion-eversion), then the axis of this subtalar joint lies closer to the horizontal and sagittal planes. Thus, a planal dominance around this subtalar joint axis would be in the frontal plane (Fig. 16).

2. If the majority of motion is in the transverse plane, then the axis of the subtalar joint lies closer to the vertical and sagittal planes. Planal dominance would be in the transverse plane (Fig. 17).

3. If the majority of motion is in the sagittal plane, then the axis of the subtalar joint lies closer to the frontal and horizontal planes. Planal dominance would be in the sagittal plane (Fig. 18).

Subtalar joint motion is closely tied up with the motion of the remainder of the foot. All joints distal to the subtalar joint depend upon the subtalar joint for stability. Conversely, the subtalar joint stability depends upon the structure and stability of the distal joints.
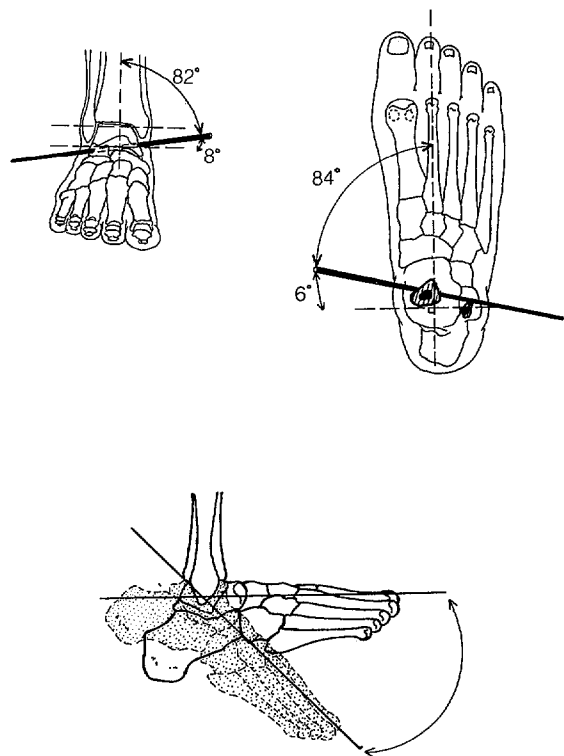
The planal dominance of the midtarsal joint can

Figure 14. The average ankle joint axis allows pronation and supination but primarily allows sagittal plane motion.
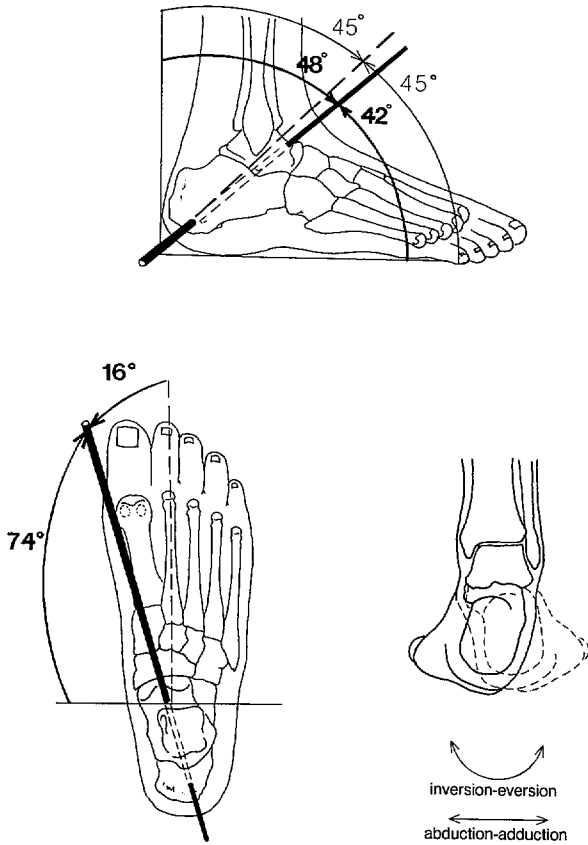
Figure 15. The average subtalar joint axis allows almost equal amounts of frontal and transverse plane motion, while allowing little sagittal plane motion.
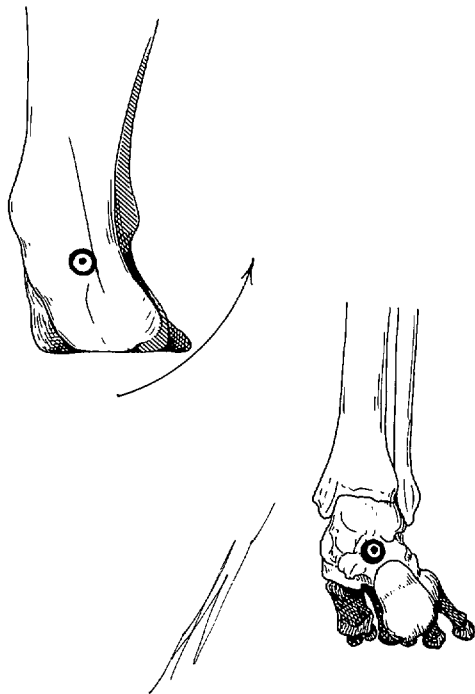

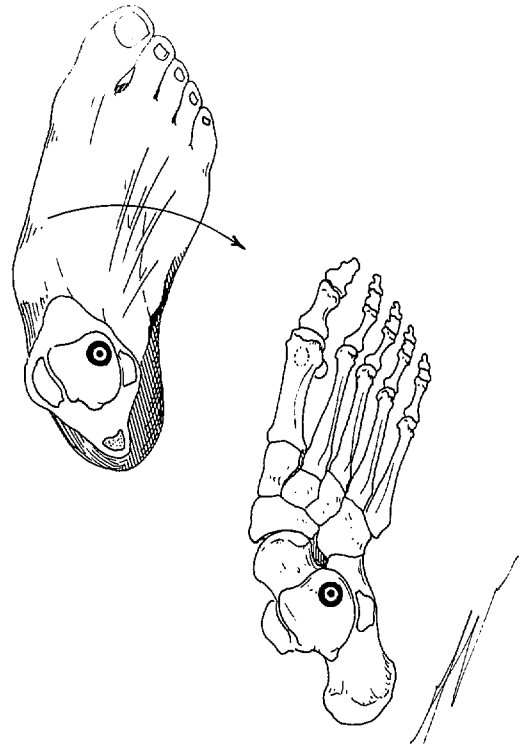**Figure 17.** Primary transverse plane compensation.

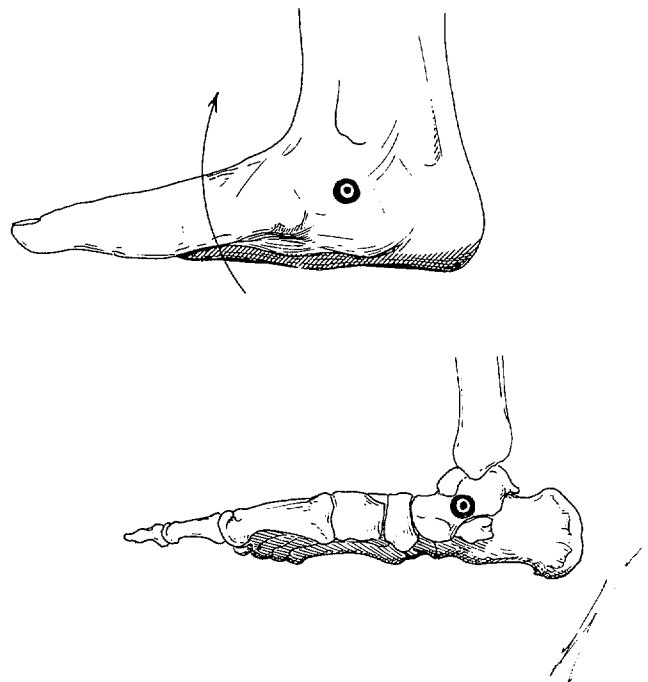**Figure 18.** Primary sagittal plane compensation.

Figure 16. Primary frontal plane compensation.

be similarly determined by observing the motion of the forefoot around a stationary calcaneus. Manter[2] suggested that there are two axes of motion around the midtarsal joint. The average *oblique axis* is 57° from the sagittal plane of the foot and 52° up from the transverse plane. This axis runs from plantar
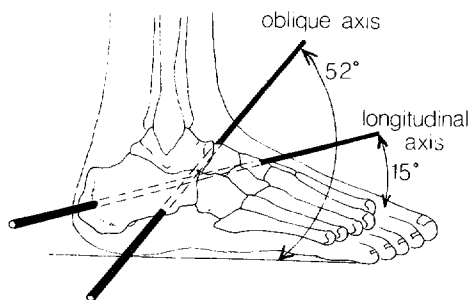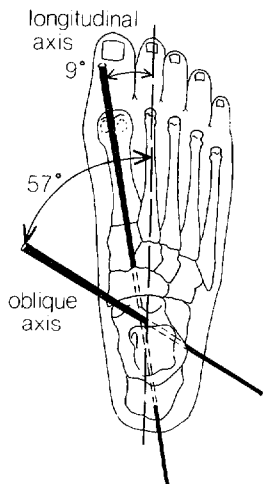
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Figure 19. The average midtarsal joint axis; oblique axis and longitudinal axis.

posterolateral to dorsomedial anterior in the general direction of the subtalar axis. Thus, motion around this axis will be supination and pronation (Fig. 19). The average *longitudinal axis* is 9° from the sagittal plane of the foot and is 15° up from the transverse plane. The motion around this axis will be primarily inversion and eversion (Fig. 19).

The resultant planal dominances of the subtalar, ankle, and midtarsal joints will determine the primary plane of compensation of the foot as a unit. The clinical significance of determining dominant plane of motion in any individual foot becomes obvious when selecting surgical procedures for the sophisticated correction of severe flexible flatfoot. However, even in our everyday attempts to control the variety of foot types seen in our offices, planal dominance can play a major part in our success. Controlling those foot types that have a large degree of transverse plane motion is difficult. Even Whitman plates with a high lateral flange are often inadequate. Yet it is easy to control a foot with a major degree of frontal plane motion. Even off-the-shelf arch supports are somewhat helpful in decreasing the symptoms in these patients. As we become more sophisticated in our understanding of foot function, the determination of planal dominance will take on added significance.

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