# Fall Prevention by Ankle/Foot Orthotics (AFOs)

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# Postural Control Strategies Used to Control Balance

## Controlling Postural Sway to Avoid Falls

There are at least three distinct postural control strategies:[32]

- Ankle strategy
- Hip strategy
- Step strategy

An individual's risk for falling is associated with a variety of sensory, motor, cognitive, and environmental variables. The ability to recover from a loss of balance decreases with age.

Younger people rely more often on an ankle strategy to recover from loss of balance.[16,17,18] In use of the ankle strategy, the upper and lower body move in the same direction or in phase with one another. Because the amount of force that can be generated by the muscles surrounding the ankle joint is relatively small, this strategy is generally used to control sway when we are standing upright or swaying through a very small range of motion.[10]

The ankle strategy is also used at a subconscious level to restore balance following a small nudge or push.[8]

In contrast to the ankle strategy, the hip strategy involves activation of the larger hip muscles. This strategy is used when the center of gravity must be moved more quickly back over the base of support as the speed or distance of sway increases. When using the hip strategy, the upper body moves in a direction opposite to that of the lower body.[38] The body favors the hip strategy when its feet are longer than the surface upon which one is standing. There's simply not enough surface area upon which to push with the muscles surrounding the foot and ankle joint.

The final postural control strategy used to maintain balance is the step strategy. This strategy comes in to play when the center of gravity is displaced beyond our maximum limits of stability or the speed of sway is so fast that the hip strategy is insufficient to maintain the center of gravity within its stability limits. The body, in this situation, must seek a new base of support to prevent a fall. In using the step strategy a person takes at least one or more steps in the direction of the loss of balance.

What factors limit our ability to use each of the three movement strategies?[26]

An effective ankle strategy requires:

- Adequate range of motion and strength in the ankle joints[32]

- a firm, broad surface below the feet
- an adequate level of sensation in the feet and ankles[9]

An effective hip strategy requires adequate range of motion and strength in the hip region.

An effective step strategy requires:

- adequate lower body muscle strength, power, and range of motion
- adequate central processing speed
- the ability to move the limb rapidly during step initiation

All three strategies are modifiable by training and conditioning.

## Functional Fitness and Its Importance in Preventing Falls

Functional fitness can be defined as having the physiological capacity to perform normal everyday activities safely and independently without undue fatigue. The phrase "without undue fatigue" is included in the definition to emphasize the importance of maintaining an adequate physiological reserve.

Forty percent of older Americans cannot walk one quarter mile without becoming fatigued. It's important to assess physical declines early enough not only to prevent disability but to detect and treat the decline in function before reserves have been depleted and the threshold is reached at which activities of daily living are affected.

## Custom-Made AFO Reduces Fall Risk

The ability to maintain a stable upright posture is an important factor, not only in the initiation and the control of voluntary movement, but also in the prevention of injury. Decreased postural control can occur because of ankle instability. Loss of normal sensation, such as in diabetes and other causes of peripheral neuropathy, also lead to a loss of postural control.

Numerous studies have reported that a localized fatigue of the ankle muscles, known to alter the force-generating capacity of the ankle joint, also affect the function of the proprioceptive system.[44]

The use of an AFO has been reported to improve postural control under both monopedal (standing on one foot) and bipedal (standing on both feet).[5,41] The visual system is very important to the maintenance of balance. Tests of balance include the measurement of postural sway, with poor performance indicating a high risk of falling. Proprioceptive information at the level of the foot/ankle, the vestibular or balance system within the inner ear, and vision are all important factors in the measurement of postural sway.

During the test of postural sway, we will remove information coming from the foot/ankle by having the participant stand on a compliant surface such as a foam pad. We'll remove the vision component by having the participant close his/her eyes.[22,33]

The AFO stabilizes the foot/ankle even in the absence of visual information by providing:

- increased sensorimotor function offered by the ankle support
- postural control is improved when ankle movement is controlled by the use of an AFO
- use of an AFO is important when ankle/foot fatigue exists

Postural control, therefore, requires the interaction of multiple sensory inputs from either the same or different sensory systems. When sensory information is missing or altered, cooperation and the gathering of other pieces of sensory information by the brain is used to maintain balance and posture.

For example, allowing the use of vision and even the use of a light finger touch to maintain balance compensates for muscular fatigue of the calf muscles.[19] Using these two additional sensory inputs can overcome the loss of sensory cues from fatigued musculature.

Recent experiments have shown that an AFO can actually stimulate cutaneous (skin) mechanoreceptors (cells in the skin that respond to mechanical stimulation). The stimulation by the pressure contact of the material on the skin leads to additional nervous information sent to the brain and central processing center.[43]

Now, the AFO becomes another source of sensory information and improves balance under conditions in which other sensory cues are eliminated. For example, with eyes closed, or in a dark environment such as walking in a dark room, the additional sensory information because of the physical contact of the AFO can provide more stability in the absence of the other sensory cues.

Studies clearly show that an AFO can lead to sensory reorganization for postural control as a function of the neuromuscular constraints acting on the subject's foot/ankle. An AFO can provide significant improvement in postural control and, in aging, help to reduce the risk of falling and its potential for injury. I described how 40% of older Americans cannot walk one quarter mile. I said

previously, without fatigue, when, in reality, they can't walk that far, at all. Fatigue, therefore, occurs way before the quarter mile mark. Certainly many of the additional 60% of older persons who may be able to walk a quarter of a mile, or more, suffer from similar physical limitations including loss of muscle, reduced sensory input, and many additional factors which put them at significant risk of falling.

The AFO we use is manufactured with the highest Orthotics & Prosthetics standards. The product is paid for by Medicare Part B and has five recognized codes for billing purposes. The product is within the category of Durable Medical Equipment and is strictly a custom-made product that does not affect any billing procedures for rehabilitation and therapy provided by clinicians and therapists.

Since it is custom-made, fabricated from a cast taken from the individual's foot/ankle, it guarantees maximum cutaneous mechanoreceptor sensory activity. It also covers part of the foot sole, part of the upper part of the foot, both ankle bones medially and laterally, and several inches of the leg above the ankle bones. This provides a significant amount of surface area and covers key areas of the foot/ankle to maximize skin mechanoreceptors.

# Additional Physiological Information on an AFO

It's now generally understood that human standing posture is maintained through a central postural program assisted by various types of sensory feedback.[25] Although the use of external ankle support is effective in providing joint mechanical stability its effect on sensorimotor function is less well understood.[45] Signals coming from these multiple sensory sources co-vary with every postural change. This redundancy in the use of multiple sensory sources provides a functional purpose for postural equilibrium. This explains the fact that postural balance is not fatally impaired after the definitive loss or the suppression of one sensory channel. Depending on their location within the body, the different kinds of receptors provide much complementary sensory information.

The musculature controlling the ankle and foot has an important stabilizing role offering dynamic restraint against external forces.[18] The plantar sole (bottom of the foot) has been deemed a "dynamo-metric map" for human balance control.[46] The multiple supporting zones of the foot have sufficient spatial relevance to inform the CNS about the body's position with respect to a vertical reference and consequently to induce adaptive changes in response to postural changes.

The foot sole, therefore, contributes to the coding and the spatial representation of body posture. Any loss of sensation from the foot due to nerve problems, calluses, bunions, structural abnormalities, and other disturbances of normal foot architecture will reduce the powerful sensory information provided by the foot sole to the CNS.

Sensory information from the foot soles is mainly used to set a background for muscle activity for a given posture and surface support characteristics. Reduced plantar sensitivity produces a relative shift in compensatory action from the ankles and trunk to the hips. Plantar cutaneous nerve firing plays an important role in the shaping of postural responses. The results of many studies showed loss of plantar sensation is an important contributor to balance deficits and increased risk of falls associated with peripheral neuropathies.[27,28,31]

An AFO intervention significantly reduces postural sway.[2] A custom fit AFO restricts undesirable motion at the foot and ankle and enhances joint mechanoreceptors to detect disturbances and provide structural support for controlling postural sway. Again, increased postural sway is a significant risk factor for falling.

Ankle joint position sense is also improved by the use of the AFO. Multiple studies have shown that ankle joint proprioception and its afferent feedback to the central nervous system comes from skin, muscle, and other joint receptors to help in the control of balance and body position. Force plate studies have clearly shown the reduction in postural sway provided by the use of an AFO. Under fatigue conditions the use of an AFO is even more important.

Ankle stiffness is an important component in undisturbed upright postural regulation. An AFO contributes to increased ankle stiffness and stability.[36]

# Summary

The most interesting aspect of research into the use of an AFO is the finding of the importance of cutaneous mechanoreceptors and their contribution to the maintenance of balance and their contribution to fall prevention.[44]

Clearly, appropriate exercise and training programs to reduce the risk of falls is something that every aging person should do. There are, however, impediments to following a program. Conventional strength and aerobic exercise programs have been shown to be ineffective for fall prevention. An appropriately designed program must include functional training, balance training, and mobility training.

Another difficulty with exercise intervention is adherence and compliance. There's also a time factor in play until the effects of an exercise intervention program can be realized. The use of an AFO, however, provides instantaneous results as soon as it's placed on the foot/ankle. Further, with increased aging, the number of frail individuals increases. Some are so frail and weak they cannot stand from a chair without assistance. The use of an AFO assists them to begin following a training program to improve the weaknesses in their system.

Based on these recent findings about the cutaneous mechanoreceptors in the foot/ankle, ***we now have the means to stimulate a whole new additional***

***sensory system to compensate for reductions in other senses involved in the prevention of falls.***

People usually walk more quickly with an AFO and walking speed affects most gait variables including step length, foot clearance of the walking surface, and body stability. An AFO has been demonstrated to be useful to stroke patients.[13] It changes muscle activity of the lower limbs and stabilizes ankle dorsiflexion during the foot swing. The use of an AFO leads to more activity of the quadriceps muscle in the upper thigh during the early stance when it helps with weight acceptance. When stepping, and during mid-stance, the increased quadriceps activity because of the AFO will help with load bearing. Leg swing symmetry improved when subjects used an AFO and a balanced gait is a hallmark of healthy subjects.

The scientific literature confirms the considerable value of using an AFO particularly in those aged 50 years old and above who have risk factors for falling which we can evaluate through the Fall-Prevention-Institute.org balance testing and fall risk assessment program.

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