THE HUMAN foot is a complex structure that serves as the foundation of support and that generates the necessary forces to produce locomotion. During normal walking, each foot bears more than 150% of bodyweight as it adapts to uneven terrain, aids in the attenuation of forces associated with gait, and functions as a lever for propulsion. Foot dysfunction may create a predisposition to injury further up the kinetic chain. Clinicians who work with physically active individuals need a thorough understanding of normal foot function to effectively manage foot dysfunction.

Many foot and ankle rehabilitation protocols include progressive resistance strengthening exercises for the motions of inversion, eversion, dorsiflexion, and plantarflexion, which strengthen the extrinsic muscles. Toe-curling exercises (e.g., towel crunches, marble pick-ups) are often prescribed to strengthen the intrinsic foot muscles (IFMs), but such exercises tend to recruit the flexor digitorum longus (an extrinsic muscle) to a greater extent than the IFMs. In fact, toe-curling exercises may contribute to dominance of the extrinsic toe flexors over the IFMs. Strengthening exercises chosen for rehabilitation of the foot and ankle should not result in development of a strength imbalance between muscle groups.

Electromyography (EMG) studies have established the important role of IFMs in dynamic activities, such as level and sloped walking. Recent research has demonstrated that the IFMs play a critical role in supporting the medial longitudinal arch. Fiolkowski et al. and Headlee et al. have demonstrated that impairment of IFMs (anesthetized or fatigued) results in increased navicular drop. Other researchers have identified performance deficits in the IFMs of individuals with chronic ankle instability and have postulated that impairment of the IFMs may contribute to impaired postural stability.

Deficits of the IFMs have been linked to claw toe deformity and hammer toe deformity in the diabetic foot. Bernstein described the “intrinsic minus foot” as having extension of the metatarsal-phalangeal (M-P) joints with concomitant inter-phalangeal (I-P) flexion, which is an indication of loss of function of the IFMs. Garth and Miller observed an association between claw toe deformity and postero-medial leg pain in otherwise healthy runners and suggested that it was a result of increased tone of the extrinsic flexor muscles and a decrease in tone of the IFMs.

A custom pulley system that facilitates isolated M-P flexion (without associated I-P flexion) has been advocated for activation of the IFMs. An alternative to this approach to strengthening of the IFMs is the short foot exercise (SFE), described by Janda and Vaurova. The exercise is based on the theory developed by Freeman et al., which sug-
gests that functional instability of the foot is attributable to articular deafferentiation (i.e., proprioceptive deficit). The SFE is believed to stimulate proprioceptors on sole of foot, thereby increasing afferent input to the spinal cord, which enhances voluntary muscle activation and improves stability while standing.\textsuperscript{12-14}

SFE has been incorporated into some rehabilitation protocols, but its effectiveness has not been clearly established. A recent investigation of the effect of a four-week trial of daily SFE demonstrated an improvement in self-reported function and improvement in performance of two functional tests, but no change was evident in lower extremity alignment.\textsuperscript{15}

\textbf{Performance of the Short Foot Exercise}

The therapeutic goal for performance of the SFE is to “shorten the foot” by drawing the heads of the metatarsals toward the calcaneus, without curling the toes. This exercise elevates the medial longitudinal arch. Patients may experience some level of frustration when learning the proper technique for performance of the SFE, particularly those who are accustomed to success in performance of physical skills. The clinician should anticipate this frustration with the exercise difficulty and use teaching techniques that are appropriate for acquisition of a new physical skill. Initial instruction should emphasize proper exercise technique, rather than power production or a high volume of repetitions. The amount of mental effort required for proper performance of SFE can create frustration. Fortunately, most athletic patients learn to perform the SFE with proper technique after a few minutes of guided instruction. Instructional strategies include the following:

1. An active assisted technique may be utilized as the patient attempts to draw the heads of the metatarsals toward the calcaneus, while avoiding extraneous motion. The clinician provides tactile input while verbally reinforcing the importance of avoiding toe curling (Figure 1).

2. The patient can be instructed to raise the toes from the floor while leaving the heads of the metatarsals in contact with the floor and then slowly lowering the toes to the floor while maintaining the height of the medial longitudinal arch (Figure 2).

3. A passive technique has been described by Page\textsuperscript{16} that utilizes an elastic band to facilitate maintenance of medial longitudinal arch elevation (Figure 3).

4. External rotation of the tibia may be used initially to elevate the medial longitudinal arch; however, the patient should strive to eventually perform SFE without extraneous leg motion.

SFE has been recommended as part of a sensorimotor rehabilitation strategy (Table 1).\textsuperscript{14} Because the IFMs are active during endurance activities, a high number or SFE repetitions should be performed.

\textbf{Figure 1a, 1b, 1c} The clinician provides tactile input while verbally reinforcing the importance of avoiding toe curling.
Table 1. Exercise Progression for SFE

1. Seated bare feet; carpeted surface
2. Standing bare feet; carpeted surface
3. Single leg stance*
   a. eyes open
   b. eyes closed
4. Standing, labile surface*
   a. rocker board, parallel stance
   b. rocker board, staggered stance
   c. parallel and staggered stance, arms crossed
   d. above with eyes closed
5. Single leg stance on rocker board*
   a. adjustments include eyes open/closed and arms at side/crossed
6. Tandem walk*
   a. adjustments include eyes open/closed
7. Backward tandem walk*
   a. Adjustments include eyes open/closed

*Short foot position is maintained during all activities
Adapted from Greenman, 2003

Conclusions

The role of the IFMs may be underappreciated in terms of their importance for injury prevention and complete rehabilitation. A review of the literature suggests that the IFMs are important for support of the medial longi-
tudinal arch and may enhance sensory motor training protocols. Although the research evidence is limited, SFE has been demonstrated to be an effective method for strengthening the IFMs. Clinicians should consider the inclusion of SFE when developing a lower extremity rehabilitation plan.

References

Kitty Newham is with the Department of Physical Therapy and Athletic Training at Saint Louis University.