Treatment of Progressive First Metatarsophalangeal Hallux Valgus Deformity: A Biomechanically Based Muscle-Strengthening Approach

Hallux valgus is a common foot deformity, presenting in 35% of women over 65 years of age. The progression of deformity is seen as an offset in first metatarsophalangeal (MTP) joint alignment, whereby the hallux shifts laterally and the first metatarsal medially. Other alterations may include collapse of the arch and rolling of the hindfoot. If left untreated and allowed to progress to its eventual end stage, the deformity renders the truss mechanisms of the foot ineffective and impairs gait.

Hallux valgus deformity is typically accompanied by an overgrowth of bone (exostosis) and tissue that develop on the dorsomedial eminence of the first metatarsal head. The enlargement is called bunion. The swollen area may be painful and may aggravate the condition. The growth in combination with the progressive first MTP joint malalignment may further disrupt gait, and, for these reasons, the terms bunion and hallux valgus are often used interchangeably to describe the comorbid nature of the foot disorder.

Although the exact etiology of hallux valgus is not understood, its prevalence is highest in females with symptoms of deformity exacerbated by fashion-shoe wear. Alterations in the alignment of the medial arch may be a modifiable risk factor, as research has identified version of the calcaneus and addition of the first metatarsal as causal factors. This has prompted new ideas for treatment. This clinical commentary describes an exercise approach, premised on slowing the progression of deformity by optimizing the length-tension relationship of muscle. Because muscle generates its greatest tension at ideal resting length and less tension when stretched or shortened, deformity reduces the capacity of muscle to produce the force needed to support weight. In building a case for intervention with exercise, this clinical commentary informs a rationale for prevention instead of delaying care until after impairments become severe and surgery is required.

The article is organized in 4 parts. Part 1 establishes the operational definition of the terms associated gait impairments that affect the mobility of people who live with the disorder. This review is organized in 4 parts. Part 1 defines the terms of foot motion and posture. Part 2 details the anatomy and biomechanics of the foot and describes how the foot is changed with deformity. Part 3 details the muscles targeted for strengthening; the intrinsics being the abductor hallucis, adductor hallucis, and the flexor hallucis brevis; the extrinsics being the tibialis posterior and fibularis longus. Part 4 instructs the reader to perform the short-foot, the toe-spread-out, and the heel-raise exercises. The routine may be performed by almost anyone at home and may be adopted into physical therapist practice, with intent to strengthen the foot muscles as an adjunct to almost any protocol of care, but especially for the treatment of hallux valgus deformity. J Orthop Sports Phys Ther 2016;46(7):596-605. Epub 6 Jun 2016. doi:10.2519/jospt.2016.6704

KEY WORDS: first ray, foot bunion, hallux, therapeutic exercise

SYNOPSIS: Hallux valgus is a progressive deformity of the first metatarsophalangeal joint that changes the anatomy and biomechanics of the foot. To date, surgery is the only treatment to correct this deformity, though the recurrence rate is as high as 15%. This clinical commentary provides instruction in a strengthening approach for treatment of hallux valgus deformity, by addressing the moment actions of 5 muscles identified as having the ability to counter the hallux valgus process. Unlike surgery, muscle strengthening does not correct the deformity, but, instead, reduces the pain and associated gait impairments that affect the mobility of people who live with the disorder. This review is organized in 4 parts. Part 1 defines the terms of foot motion and posture. Part 2 details the anatomy and biomechanics, and describes how the foot is changed with deformity. Part 3 details the muscles targeted for strengthening; the intrinsics being the abductor hallucis, adductor hallucis, and the flexor hallucis brevis; the extrinsics being the tibialis posterior and fibularis longus. Part 4 instructs the exercise and reviews the related literature. Instructions are given for the short-foot, the toe-spread-out, and the heel-raise exercises. The routine may be performed by almost anyone at home and may be adopted into physical therapist practice, with intent to strengthen the foot muscles as an adjunct to almost any protocol of care, but especially for the treatment of hallux valgus deformity.
The foot may be divided into local regions called the hindfoot, midfoot, and forefoot. The hindfoot comprises the calcaneus and talus. The midfoot contains the navicular, cuboid, and 3 cuneiforms. The forefoot has 5 metatarsals and the attached phalanges. The osseous structures (Figure 1) are then supported by ligaments, the plantar fascia, and intrinsic and extrinsic muscles. The muscles (Tables 1 and 2) work together to control balance, propel gait, and stiffen the foot in response to external forces.29,49,53,73

The names of the muscles merit further discussion. The names of most of the intrinsics (Table 1) are based on how the given muscle pulls on a single toe in reference to the midsagittal line of the foot.55 By contrast, the names of the extrinsics (Table 2) are based on where a muscle is located in the leg, or according to how the muscle moves the hallux or lesser toes.66 Despite differences in the naming conventions of these muscles, movements of the foot joints are described relative to the body.8,9,20,55 The language, unfortunately, contradicts itself when describing the direction of pull of the abductor and adductor intrinsics (Table 2), as the abductor hallucis is said to adduct the hallux in relation to the body (not in relation to the midline of the foot), while the adductor hallucis is said to abduct the hallux.55 Albeit confusing, this paradigm of name versus motion follows accepted standards,55 and was clarified here only because the abductor and adductor hallucis intrinsics exert a moment of pull on the hallux and first metatarsal, and both muscles are targeted for strengthening in the treatment of first MTP hallux valgus deformity.23,24,42

The system of muscles complement each other in supporting and propelling weight.25,38,73 The extrinsics power gait accelerations,73 while the intrinsics, having both attachments within the foot, act to stiffen the arch and assist in holding the toes on the ground.25,59 Hallux valgus deformity alters these actions, as the offset in first MTP joint alignment redirects the net internal muscle moment away from plantar flexion and toward abduction.64 Such imbalances in muscle torque may be correctable with resistive exercise.1,38,52,53

In regard to the movement of the foot joints, rotations occur around a joint axis.8,9,14,20,57 A joint axis can be modeled as a line in 3-D space, and as having the physical properties of location and orientation.14 Inversion and eversion occur in the frontal plane around an axis that runs longitudinal through the foot, abduction and adduction occur in the transverse plane around a vertical axis, and dorsiflexion/plantar flexion occur in the sagittal plane around a horizontal axis.57 These same words also describe alterations in foot posture.57 Hallux valgus deformity presents as eversion of the hindfoot (inward rolling of the calcaneus),67 abduction of the first ray, and abduction (lateral shift) of the hallux at the first MTP joint.56,62

Because the tarsals do not align with the cardinal planes, the foot joints move in patterns that lie oblique to the body planes.30,57 The out-of-plane movements are either biplanar or triplanar. Biplanar refers to joint rotations that pass diagonally through 2 planes. Triplanar refers to rotations that pass diagonally through 3 planes.57 The first ray, for example, rotates in a biplanar pattern about a joint axis that runs horizontal through the navicular at an angle oblique to the sagittal and frontal planes.14,30 The subtalar joint exhibits a triplanar pattern, whereby the talus rotates in relation to the calcaneus about an axis that inclines from the horizontal at an angle oblique to the sagittal and frontal planes.31 Though the proportion of the underlying component motions that constitute biplanar or triplanar joint rotations is unique to each person,

PART 1: OPERATIONAL DEFINITIONS

Theosseous structures (Figure 1) are then supported by ligaments, the plantar fascia, and intrinsic and extrinsic muscles. The muscles (Tables 1 and 2) work together to control balance, propel gait, and stiffen the foot in response to external forces.25,38,73 The names of the muscles merit further discussion. The names of most of the intrinsics (Table 1) are based on how the given muscle pulls on a single toe in reference to the midsagittal line of the foot.55 By contrast, the names of the extrinsics (Table 2) are based on where a muscle is located in the leg, or according to how the muscle moves the hallux or lesser toes.66 Despite differences in the naming conventions of these muscles, movements of the foot joints are described relative to the body.8,9,20,55 The language, unfortunately, contradicts itself when describing the direction of pull of the abductor and adductor intrinsics (Table 2), as the abductor hallucis is said to adduct the hallux in relation to the body (not in relation to the midline of the foot), while the adductor hallucis is said to abduct the hallux.55 Albeit confusing, this paradigm of name versus motion follows accepted standards,55 and was clarified here only because the abductor and adductor hallucis intrinsics exert a moment of pull on the hallux and first metatarsal, and both muscles are targeted for strengthening in the treatment of first MTP hallux valgus deformity.23,24,42

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the patterns tend to be similar across foot postures.9

Pronation and supination describe the opposing directions of triplanar joint motion, or the related manifestations in abnormal posture.7 Pronation, in the context of posture, indicates a flat or planus foot, and supination indicates a high or cavus foot.24-27 Because overpronation accelerates the hallux valgus process,19,24 treatment generally bolsters the hindfoot and arch to limit pronation.24,70,71

PART 2: ANATOMY
AND BIOMECHANICS

The hallux is called the great toe due to its large size and importance in weight bearing. Comprising a distal and proximal phalanx, the hallux articulates with the first metatarsal (FIGURE 1) to form the first MTP joint. The joint is reinforced with collateral ligaments, a plantar plate, the plantar fascia, and 2 sesamoid bones.64 The sesamoids sit just proximal to the joint beneath the head of the first metatarsal.2,5 Encased within the flexor hallucis brevis tendons, the sesamoids distribute weight and provide leverage essential for increasing the torque production of the attached intrinsics.35 Additionally, the flexor hallucis longus tendon passes between the sesamoids and inserts on the distal phalanx of the hallux.72 Stiffness of the joint tissues combines with the tensile action of the plantar fascia to counter the external-loading forces that dorsiflex the hallux during gait.35 Approximately 50° of first MTP joint motion is required for walking,8,9,20 whereby the hallux serves as the fulcrum of forward propulsion.35

The first MTP joint is condyloid in design, and allows the hallux freedom to rotate in the sagittal and transverse planes, while simultaneously constraining it from rotating independent of the first metatarsal in the frontal plane.20 As deformity progresses, overpronation culminates in rolling the first metatarsal off the sesamoids.44,60 The hallux follows, turning onto its side.44,60 This inclines the first MTP joint axis, which redirects motion away from the sagittal and toward the transverse plane.64 Weight now borne on the medial aspect of the hallux (FIGURE 2) contributes a lateral push,44,60,64 The sequelae of events also lengthen or shorten the attached muscles, thus reducing their ability to produce or sustain force.160 Without adequate support from the muscles, the hallux and sesamoids may sublux or even dislocate. This releases tension from the plantar fascia.44,64 Should the plantar fascia fail and the arch collapse,60 surgery becomes the only viable option for treatment.20 Unfortunately, surgery does not always solve the problem, as the rate of recurrence is almost 15%.19,61

The first ray is the proximal member of the first MTP joint. Comprising the first metatarsal and first cuneiform,30 the first ray behaves as a single segment, because the metatarsocuneiform joint surfaces interlock72 and the first metatarsal moves independent of the second metatarsal and navicular about its own axis.29,33,30 The joint union is reinforced with a plantar ligament and by surrounding muscles (FIGURE 2).77 Irrespective of the anatomic design, the first ray may become unstable due to trauma,63 in arthritic disease states,18,26 with hallux valgus,59 or with generalized joint laxity.11,15,26

### TABLE 1

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Main Origin</th>
<th>Main Insertion</th>
<th>Primary Action*</th>
</tr>
</thead>
<tbody>
<tr>
<td>First layer of the foot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abductor hallucis1</td>
<td>Calcaneus</td>
<td>Proximal phalanx hallux</td>
<td>Adduct and flex hallux</td>
</tr>
<tr>
<td>Flexor digitorum brevis1</td>
<td>Calcaneus</td>
<td>Middle phalanx lesser toes</td>
<td>Flex lesser toes</td>
</tr>
<tr>
<td>Abductor digiti minimi</td>
<td>Calcaneus</td>
<td>Proximal phalanx small toe</td>
<td>Abduct and flex small toe</td>
</tr>
<tr>
<td>Second layer of the foot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadratus plantae</td>
<td>Calcaneus</td>
<td>Flexor digitorum longus tendons</td>
<td>Flex lesser toes</td>
</tr>
<tr>
<td>Lumbinals</td>
<td>Flexor digitorum longus tendons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third layer of the foot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexor hallucis brevis1</td>
<td>Lateral cuneiform, cuboid</td>
<td>Proximal phalanx hallux</td>
<td>Flex hallux</td>
</tr>
<tr>
<td>Adductor hallucis, oblique head1, transverse head</td>
<td>Base and heads of lesser metatarsals</td>
<td>Lateral sesamoid, proximal phalanx hallux</td>
<td>Abduct first ray; stabilize forefoot, transverse arch</td>
</tr>
<tr>
<td>Flexor digiti minimi</td>
<td>Fifth metatarsal</td>
<td>Proximal phalanx small toe</td>
<td>Flex small toe</td>
</tr>
<tr>
<td>Fourth layer of the foot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantar interossei</td>
<td>Shaft of metatarsals 3-5</td>
<td>Proximal phalanges toes 3-5</td>
<td>Stabilize lesser toes</td>
</tr>
<tr>
<td>Dorsal interossei</td>
<td>Shaft of metatarsals 1-5</td>
<td>Proximal phalanges toes 2-4</td>
<td>Stabilize lesser toes</td>
</tr>
<tr>
<td>Dorsum of the foot</td>
<td>Extensor digitorum brevis</td>
<td>Long extensor tendons 2-4</td>
<td>Extend lesser toes</td>
</tr>
<tr>
<td>Extensor hallucis brevis</td>
<td>Calcaneus</td>
<td>Long extensor tendons 2-4</td>
<td>Extend hallux</td>
</tr>
</tbody>
</table>

*Action described in relation to the body (not the midline of the foot).
Muscle having potential to counteract hallux valgus deformity.
**TABLE 2**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Main Origin</th>
<th>Main Insertion</th>
<th>Primary Action*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior compartment leg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(superficial layer)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>Distal femur</td>
<td>Calcaneus</td>
<td>Plantar flex foot</td>
</tr>
<tr>
<td>Plantaris</td>
<td>Distal femur</td>
<td>Calcaneus</td>
<td>Plantar flex foot</td>
</tr>
<tr>
<td>Soleus</td>
<td>Tibia and fibula</td>
<td>Calcaneus</td>
<td>Plantar flex foot</td>
</tr>
<tr>
<td>Posterior compartment leg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(deep layer)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibialis posterior†</td>
<td>Tibia and fibula</td>
<td>Navicular and the central midfoot and forefoot tarsals</td>
<td>Plantar flex and invert foot</td>
</tr>
<tr>
<td>Flexor digitorum longus</td>
<td>Tibia</td>
<td>Distal phalanges lesser toes</td>
<td>Flex lesser toes</td>
</tr>
<tr>
<td>Flexor hallucis longus</td>
<td>Fibula</td>
<td>Distal phalanx halluc</td>
<td>Flex halluc</td>
</tr>
<tr>
<td>Lateral compartment leg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibularis longus†</td>
<td>Proximal fibula</td>
<td>First cuneiform-metatarsal</td>
<td>Plantar flex and invert foot and first ray</td>
</tr>
<tr>
<td>Fibularis brevis</td>
<td>Distal fibula</td>
<td>Fifth metatarsal</td>
<td>Plantar flex and invert foot</td>
</tr>
<tr>
<td>Anterior compartment leg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibialis anterior</td>
<td>Proximal tibia</td>
<td>First cuneiform-metatarsal</td>
<td>Dorsiflex and invert foot</td>
</tr>
<tr>
<td>Extensor digitorum longus</td>
<td>Tibia and fibula</td>
<td>Phalanges lesser toes</td>
<td>Extend lesser toes</td>
</tr>
<tr>
<td>Extensor hallucis longus</td>
<td>Middle fibula</td>
<td>Distal phalanx halluc</td>
<td>Extend halluc</td>
</tr>
<tr>
<td>Fibularis tertius</td>
<td>Distal fibula</td>
<td>Fibula</td>
<td>Dorsiflex and invert foot</td>
</tr>
</tbody>
</table>

*Action described in relation to the body.

†Muscle having potential to counteract hallux valgus deformity.

Stress testing is performed in clinical practice to screen for instability. However, subjectivity in the delivery of force and the assessment of motion may account for the wide range (10%-64%) of instability reported in patients with hallux valgus. Despite the discrepant range of reported cases, instability of the first ray is associated with and possibly precursor to the formation of deformity. Therefore, exercises that strengthen the muscles that support the first ray and hallux (FIGURE 3) may delay the onset and progression of hallux valgus deformity.

Similar to how overpronation affects the alignment of the hallux, a pronated foot posture alters the kinematic behaviors of the first ray. Glasoe et al. found an inverse relationship \( r = -0.73 \) between the orientation of the first-ray axis and arch height in cadavers \( n = 9 \), such that when the arch flattened, the first-ray axis inclined and the first ray adducted under an imposed load. These researchers next investigated women with hallux valgus, and found increased eversion of the calcaneus (6° or greater) and adduction of the first ray (5° or greater) compared to a control group. Additionally, the first-ray axis inclined by an average of 30° in the group having deformity compared to 6° in controls, and eversion of the calcaneus was found to be moderately predictive \( r = 0.42 \) of inclination of the first-ray axis. Glasoe et al’s theory and cumulative research results would suggest that treatment that limits pronation may level the first-ray axis. This fortifies the arch and may provide anatomical resistance to reorient the first ray from adducting into deformity.

Proximal to the first ray, the first cuneiform articulates with the navicular, the navicular articulates with the talus, and the talus sits atop the calcaneus (FIGURE 1). The calcaneus carries the majority of weight in standing. Weight borne by the calcaneus anchors the intrinsics, plantar ligaments, and plantar fascia. Most of these tissues originate from the calcaneus and span the arch lengthwise.

The strain energy afforded the intrinsics and plantar ligaments, but especially the plantar fascia in supporting the arch, depends on the alignment of the first MTP joint. Comprising distinct connective tissue bands that project from the calcaneus to the toes, the medial band of plantar fascia inserts on the hallux. Dorsiflexion of the first MTP joint winds the fascia around the first metatarsal. Called the windlass mechanism, the strain produced by the plantar fascia relies on the radius of curvature of the first metatarsal head. When deformity rolls the first metatarsal sideways (FIGURE 2), the curvature of the cam-shaped metatarsal head is reduced, as is strain on the plantar fascia. Hence, treatment that preserves the alignment of the first MTP joint confers maximal tension on the plantar fascia in support of the arch.

Strain produced by the plantar fascia also relies on activation of the foot’s truss mechanism to keep weight from collapsing the arch. A truss is a triangular framework. In the foot, the calcaneus and first ray function as the upright supports that are connected together by the plantar fascia. Provided the first ray acts as a rigid pillar, as weight presses down, the truss mechanism converts the compressive force into tensile strain along the plantar fascia. Strain placed on the plantar fascia supports the arch. The medial arch is also reinforced by a network of muscles (FIGURE 3), and their collective line of pull has potential to counter deformity.
PART 3: THE MUSCLES

The intrinsics stiffen the joints of the foot, while the extrinsics power and control gait accelerations. Though this characterization understates the complexity of the neuro-muscular processes that govern standing balance and gait, that is how McKeon et al. defined the actions of these muscles when calling on clinicians to incorporate strength training into most protocols of care. The abductor hallucis, adductor hallucis, and flexor hallucis brevis intrinsics all insert into the first MTP joint (FIGURES 3) and exert opposing moment actions that support the hallux and first ray in carrying weight (TABLE 2). As well, the tibialis posterior and fibularis longus extrinsics work in synergy to stabilize the midfoot and arch, and limit pronation. Limiting pronation underlies most treatment strategies.

The abductor hallucis originates on the calcaneus and fills the arch (FIGURES 1 through 4). Distally, the muscle attaches on the side of the first metatarsal head and inserts on the proximal phalanx. This muscle adducts the hallux, The action is unique, as the adductor hallucis is the only muscle that can directly keep the hallux from abducting (displacing laterally) into deformity. Stewart et al. found the muscle atrophied in patients with hallux valgus, and called for clinicians to intervene with strengthening exercise. The short-foot exercise and the toe-spread-out exercise are advocated for this purpose. The short-foot exercise, in particular, has been demonstrated to be effective in increasing the cross-sectional area of the adductor hallucis and other intrinsics. Both exercises are instructed in Part 4 of this paper.

The adductor hallucis provides the counter balance to the abductor hallucis in supporting the alignment of the first MTP joint. Comprising 2 heads, the oblique head originates from the lateral cuneiform, the base of the lesser metatarsals, and the fibularis longus tendon. The transverse head originates from the lesser metatarsals and the transverse intermetatarsal ligament. The heads then converge to surround the lateral sesamoids. Notably, only a slip from the transverse head travels beyond, where it merges with the flexor hallucis brevis tendon and inserts on the proximal phalanx (FIGURE 3). The 2 heads also differ in size and in primary actions (TABLE 2).

The oblique head is 6 times larger and acts primarily to plantar flex and abduct the first ray, whereas the smaller transverse head acts only in reinforcement to the transverse intermetatarsal ligament to stabilize the foot and transverse arch. A study of the anatomy by Arakawa et al. concluded that the oblique head was developmentally large due to its moment of action, which supports the first ray in carrying weight, while the transverse head was left to degenerate due to disuse. Evolution, Arakawa et al. surmised, had reduced the ability of the transverse head to move the hallux with any real independence. An inference drawn here is that “activation dominance” of the adductor hallucis could not initiate halluc valgus deformity, as has been suggested. Because the transverse head is the only part of the muscle that inserts on the halluc directly, the moment exerted by this small and mostly tendinous head could never overpower the opposing abductor hallucis (the largest intrinsic in the foot) and pull the hallucus laterally into deformity. Pull from the transverse head, however, does increase as the first ray shifts medially into deformity and, for this reason, the transverse head is sometimes released during surgery. Because the oblique head is the second largest intrinsic and because the muscle supports the first ray in carrying weight, the oblique head of the adductor hallucis should be strengthened with exercise.

The flexor hallucis brevis originates from the cuboid, the lateral 2 cuneiforms, and the tibialis posterior tendon. The muscle has 2 bellies (FIGURE 3) that encase the sesamoids, and 2 tendons that project distally and insert on the proximal phalanx. The muscle plantar flexes the halluc (TABLE 2), unless the sesamoids carry weight. Loading, in essence, transforms the muscle into a plantar flexor of the first ray, whereby contraction lifts and supports the arch.

The tibialis posterior originates in the leg. The tendon travels behind the medial
Resistive exercise training increases strength and the rate of muscle force development.\textsuperscript{1,39} While keeping these goals in mind, this section instructs an exercise approach for treatment.\textsuperscript{24,42,53} The instructions are written in lay language so individuals can perform the routine on their own. Though the exercises look easy (FIGURE 4), McKeon and Fourchet\textsuperscript{52} recommend augmenting strength training of the foot muscles with electrostimulation, because of the challenges of voluntarily recruiting the intrinsics.

Exercise Guidelines

The routine (FIGURE 4) is performed barefoot. To learn the exercises, begin in sitting,\textsuperscript{24} but quickly transition to standing on both feet and then onto 1 foot if able, as the activation of the muscles is enhanced with weight bearing.\textsuperscript{40} While the time spent exercising should be tailored to each individual, published guidelines\textsuperscript{4,41} call for resistive training to be performed at least once a day, repeating each exercise until fatigued. In this routine, all repetitions are held with maximal effort for 5 seconds. While holding the exercise, focus on what the activation of muscles feels like, and strive to reproduce this same feeling periodically throughout the day by contracting the muscles during normal activities. The instructions are narrated in the next 3 paragraphs, and each paragraph concludes with a synopsis on what the literature reports about the exercise.

The short-foot exercise (FIGURE 4A) recruits the muscles inside the foot.\textsuperscript{26,53} To perform this exercise, shorten the foot, while keeping the heel and forefoot on the ground, without curling your toes into the floor. Do this by forcefully pushing the base of the toes, especially the great toe, into the ground, while simultaneously pulling the forefoot back toward the heel. When done correctly, the toes are held suspended above the malleolus and inserts on the navicular. Slips of the tendon then continue distally and insert into the midfoot tarsals, the flexor hallucis brevis,\textsuperscript{12} and, sometimes, the fibularis longus tendon (FIGURE 3).\textsuperscript{65} The muscle inverts and plantar flexes the hindfoot,\textsuperscript{46} lifts the midfoot, and, working with the flexor hallucis brevis, stiffens the first ray.\textsuperscript{35} Strengthening the tibialis posterior promotes a more stable foot posture.\textsuperscript{18,21,35}

The fibularis longus originates in the leg. The tendon passes behind the lateral malleolus, around the cuboid, and, after crossing along the plantar surface of the midfoot (FIGURE 3), inserts on the first metatarsal.\textsuperscript{52,65} The muscle everts and plantar flexes the hindfoot. It also plantar flexes and holds the first ray against the second metatarsal in response to external loading.\textsuperscript{25,35,73}

FIGURE 3. Five muscles are illustrated on the plantar surface of the foot. The abductor hallucis runs from the calcaneus along the medial arch, the flexor hallucis brevis sits beneath the first metatarsal, and the oblique and transverse heads of the adductor hallucis project from the base and heads of the lesser metatarsals, respectively. All 3 intrinsics insert into the first metatarsophalangeal joint (see blow-up) directly. Also illustrated are the tendons of the tibialis posterior on the navicular and where it travels distally, and the fibularis longus on the cuboid and where it crosses the midfoot before inserting on the base of the first metatarsal. Illustration ©Megan O’Connell. Used with permission.
ported that an 8-week period of exercise combined with taping reduced pain, and, anecdotally, improved the patient’s ability to walk. Aside from this study, pragmatic recommendation supports exercise treatment. To comply with best-practice guidelines, strength training of the foot muscles should be incorporated into physical therapy programs whenever weakness disrupts function. Specific to bunion, epidemiological research reports that the severity of
deformity corresponds with a reduction in health quality, and that disablement extends far beyond pain\textsuperscript{44} and muscle weakness.\textsuperscript{12,13} Therefore, intervention with exercise\textsuperscript{12,37,42,43} may not only reduce gait impairments,\textsuperscript{9} but may also improve the overall health and social function of people who live with the disorder.\textsuperscript{32,34,36}

While this commentary advocates for self-care intervention with exercise, research is needed to investigate the beneficial effects of treating hallux valgus with a muscle-strengthening approach, and whether exercise performed at home without direct supervision may provide results comparable to those of exercise delivered as part of physical therapy management. In addition, randomized controlled trials could assess whether strengthening exercise improves pain and standing or walking function, while longitudinal studies could be conducted to assess whether intervention with exercise may delay or prevent the progression of deformity. Future research is warranted.

SUMMARY

RODDY ET AL.\textsuperscript{62} ESTIMATED THAT OVER 64 million people in the United States have hallux valgus, and the number of surgeries performed each year to correct deformity exceeds 200 000.\textsuperscript{62} This review detailed how effective first MTP hallux valgus deformity changes the anatomy and biomechanical behaviors of the foot. Five muscles were then identified as having potential to counteract hallux valgus, and a strengthening exercise routine was presented. Based on the rationale put forth in this commentary, future research should investigate the efficacy of strengthening exercise as a stand-alone treatment or as an adjunct treatment to other therapies (eg, orthoses\textsuperscript{76,77} and taping\textsuperscript{46,47}) prescribed for the management of hallux valgus deformity.

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REFERENCES


Bunion

Strengthening Foot Muscles to Reduce Pain and Improve Mobility


Foot pain discourages physical activity, and less activity harms overall health. Bunion, extra bone and tissue at the base of the big toe, is a frequent cause of foot pain. More than 64 million Americans have bunions that can lead to painful walking. Bunions affect some 35% of women over the age of 65. Bunions can be removed by surgery, which can reduce pain and improve your ability to walk and exercise, but up to 15% of bunions return. Weak muscles may play a role in bunion-related pain and movement problems. In a review of prior research and commentary on this topic published in the July 2016 issue of JOSPT, the author identifies muscle-strengthening exercises that may help people with bunions.

EXERCISES TO STRENGTHEN FOOT MUSCLES. (A) Short-foot exercise: shorten your foot while keeping your heel and front of your foot on the ground. Do not curl your toes. (B) Toe-spread-out exercise: lift and spread your toes while keeping your heel and the front of your foot on the ground. While your toes are spread out, push your little toe down and out to the floor. Then, push your big toe down toward the inside of the foot. (C) Heel-raise exercise: stand with your knees bent. Elevate your arch while keeping your heel turned in. Then, raise your heel off the floor while keeping pressure on your big toe. Perform all exercises barefoot. Hold each repetition for 5 seconds. Repeat each exercise until you feel the muscles becoming tired. Exercises are progressed from sitting, to standing on both feet, to performing the exercises on just 1 leg. Perform exercises daily.

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