

Freeing the Foot

Integrating the Foot Core System into Rehabilitation for Lower Extremity Injuries



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KEYWORDS

- Foot control • Dynamic systems • Neuromuscular electrostimulation
- Overuse injury • Muscle training

KEY POINTS

- The foot core system is the integration of active, passive, and neural structures within the foot to provide dynamic foot control during functional activities.
- Lower extremity overuse injuries may be the result of a loss or restriction within one of the subsystems of the foot core, which results in increased stress on the remaining structures.
- The intrinsic foot muscles provide sensory and motor contributions to the foot core system and their dysfunction may contribute to the development of lower extremity overuse injuries.
- Training the foot muscles through a progression of isolation to integration provides a means to increase the functional variability of the foot core system in dynamic foot control.
- Neuromuscular electrostimulation of the intrinsic foot muscles provides a means of isolating these muscles for patient education and enhanced performance.

INTRODUCTION

Dynamic foot control arises from the complex interaction between active and passive structures, and the corresponding orchestration of sensory and motor information to control the configuration of the bones within the foot.¹ The unique shape and alignment of the tarsals and metatarsals coalesce into the longitudinal and transverse arches with ligamentous support from the long and short plantar ligaments, the plantar calcaneonavicular ligament, and the plantar aponeurosis.^{2,3} These passive structures are also supported dynamically through the tendons of the extrinsic foot muscles and

Disclosure Statement: The authors have agreed on all content associated with this article. The authors report no conflicts of interest with any of the material presented in this article.

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Clin Sports Med 34 (2015) 347–361

<http://dx.doi.org/10.1016/j.csm.2014.12.002>

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the intrinsic foot muscles.⁴ The intrinsic foot muscles are those that have origin and insertion sites within the foot. The extrinsic foot muscles are those whose muscle bellies reside proximal to the foot, but tendons directly insert into the bones and ligaments. These muscles are considered to be the prime movers of foot function, whereas the intrinsic foot muscles have typically been thought to play more of a supporting role in dynamic foot control.⁵ The passive and active structures work together producing a unique ability of the foot to absorb and propel the body using the resultant forces from the foot-ground interaction.¹

A major structure within the foot that integrates the passive and active contributions is the plantar aponeurosis.⁶ Its primary function is to provide rigid support of the arches during the propulsion phase of gait, referred to as the windlass mechanism,³ which transitions the foot from absorption to propulsion demands during stance. Although this structure and mechanism are essential for the foot, the passive nature of the plantar aponeurosis makes it difficult to detect deformation and respond to foot deformation demands. The tendons of the extrinsic foot muscles also control deformation longitudinally and rotationally during absorption. When looking at the alignments of the plantar intrinsic foot muscles, it is apparent that these muscles must provide redundancy in function to the plantar aponeurosis and the extrinsic muscle tendons providing resistance to medial arch deformation in a similar fashion, but their muscle bellies are directly aligned with the pattern of foot deformation.¹

According to the dynamic systems theory of sensorimotor control,⁷ the sensorimotor system is composed of multiple interacting components that can be organized in a variety of ways to accomplish movement goals. Within the sensorimotor system, sensory information tunes motor output and motor output tunes the subsequent change in sensory information. The foot has multiple interacting systems of passive, active, and neural components, which are integrated into the foot core system (Fig. 1).¹ The unique interactions of passive subsystem (eg, ligaments, plantar aponeurosis) and active subsystem (extrinsic and intrinsic foot muscles) with the

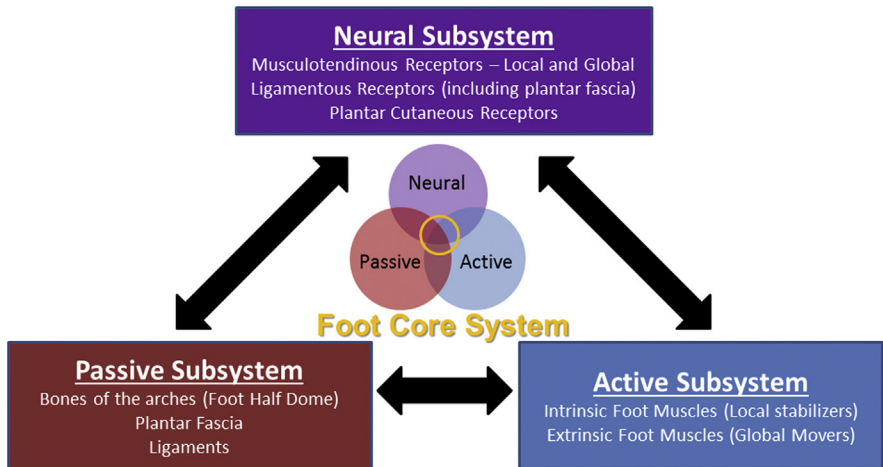


Fig. 1. The foot core system is the integration of passive, active, and neural subsystems, which provide functional variability in adapting to changing task and environmental demands during functional activities. (From McKeon PO, Hertel J, Bramble D, et al. The foot core system: a new paradigm for understanding intrinsic foot muscle function. *Br J Sports Med* 2014 Mar 21. <http://dx.doi.org/10.1136/bjsports-2013-092690>. [Epub ahead of print].)

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