7 Summary

Merton L. Root created his functional foot typology some decades ago, creatively bringing together his knowledge of foot biomechanics and clinical experience with that of his forerunners and colleagues. His primary purpose was to introduce distinct, consistent and accurate typology. He defined the basic “intrinsic foot deformities” based primarily on structural findings in physical examinations, however his strong accent on related foot biomechanics allows us to call his system “functional”. The Root system evolved over time and different variations emerged as well as the alternative concepts and systems.

Root´s method of foot typology and functional orthotics is based on principles of foot biomechanics and particularly on the joint coupling in the lower extremity (Root´s biomechanics). Although it has been used worldwide for decades, it is almost unknown in our country. Our purpose is to fill in that gap.

Within a Root biomechanics framework we can describe four basic foot types: *neutral foot*, when the axis of the shank’s lower third continues as the heel axis and the forefoot plantar plane is parallel to the heel plantar plane; *rearfoot varus,* when the heel axis is supinated in relationship to the axis of the shank’s lower third; *forefoot varus,* when the forefoot plantar plane is supinated with regard to the heel plantar plane and *forefoot valgus,* when the forefoot plantar plane is everted with regard to the heel plantar plane. The fifth one – rearfoot valgus – is extremely rare. Rearfoot and forefoot varus could be subdivided into subtypes according to the degree of compensation – compensated, partially compensated and uncompensated. Forefoot valgus has the flexible, semiflexible and rigid subtypes. These types and subtypes have various degrees of incidence. In women, the forefoot valgus as well as the rearfoot varus were significantly more frequent than the forefoot varus or neutral type. In men the rearfoot varus was significantly more frequent than all the other types. The most frequent subtypes were flexible forefoot valgus and compensated rearfoot varus in women and compensated rearfoot varus in men. From the biomechanical point of view these foot types and their subtypes differ in many ways, e.g. in the height of the longitudinal foot arch when loaded. The compensated, respectively, the flexible subtypes with lower longitudinal foot arch, are on one end of the spectrum. On the other end of spectrum are the uncompensated, respectively the rigid subtypes, with a high arch. In the central part of the spectrum there are the intermediate subtypes.

Root´s biomechanics, as a framework of Root´s foot typology, is based on three main principles. The first one is the so-called *hinge mechanism* of the subtalar joint, thus the coupling of the calcaneal pronation (resp.

supination) with the shank internal (resp. external) rotation moreover coupled with that of the knee flexion (resp. extension). The second one is a coupling of the calcaneal supination and midtarsal joint locking with the participation of the calcaneocuboid close-packed mechanism. The third one is the *windlass mechanism* of the plantar fascia, that accentuated medial foot arch and supinated rearfoot when the first metatarsophalangeal joint dorsiflexes. These mechanisms are linked to the developmental pronation of the lower extremity during phylogenesis as well as individual ontogenesis. As a result the two main foot rays move differently when loaded in a closed kinetic chain. The first one, going proximomedially, consists of the talus, navicular, and cuneiform bones and three medial metatarses, the second one, going distolaterally, is built by the calcaneus, cuboideum and two lateral metatarses. In the course of developmental foot pronatory torsion, the pronation in the proximal part stopped sooner so the talus ended up above the calcaneus. The pronation development continued further in the distal foot part and both the rays lay side-by-side there. This pronatory torsion forms the basis for foot-arch development and this torsion is the reason why the calcaneus – when loaded- pronates more than talus, whereas the talus rather adducts in the transversal plane – so the relative position of these bones changes.

The above-mentioned mechanisms are involved in the stance phase of the gait cycle as well. The attenuation of the heel strike at the beginning of the stance phase is based on the excentrically decelarated knee flexion with shank internal rotation alongside decelerated calcaneus pronation and the unlocking of the midtarsal joint. The excentrically decelerated plantar flexion in the ankle joint participates in the impact attenuation at the start of the stance phase as well. The under calcaneus fibrous-fat tissue is of a great importance, too. However, during the midstance phase, the knee moves into relative extension accompanied by more or less prominent shank external rotation, that induces calcaneus supination and the locking of the transversotarsal joint including the calcaneocuboid locking. The tension of the plantar fascia participates in calcaneal supination by means of the so-called *windlass mechanism* during the dorsiflexion in the first metatarsophalangeal joint. Thus, in the course of push-off, the foot is prepared to function as a rigid lever and the forefoot is protected against load damage. The specific range of movement and the phase-coincidence thereof are individual, depending on the functional foot type and other factors. In various foot types that are clinically evaluated, we can expect various results in the laboratory examination of kinematics, pressure distribution under the foot sole as well as the dynamics of the force magnitude and vector, etc. Moreover no cyclic movement is performed identically in repetition. The changes in the foot under conditions of static load are conformable to the early midstance phase of the gait cycle – the longitudinal arch flattens and the rearfoot pronates. The forefoot pronates less than the rearfoot so the forefoot goes to relative supination to the rearfoot. The specific changes and their range depend on the functional foot type and subtype as well.

The biomechanics of the lower extremity and particularly the foot is an important part of kinesiology and pathokinesiology. The knowledge of the above-mentioned functional interactions is beneficial for the evaluation of gait analysis in physical examinations as well as by modern, sophisticated laboratory systems.