Foot Posture Index: A Reliable, Valid, Simple to Use Measure of Static Alignment and Foot Type

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Abstract

The objective of this review paper was to provide an evidence-informed overview and update of current literature on foot posture and foot posture index (FPI), its measurement properties, with implications for podiatric research and practice. The FPI had moderate to good reliability and its content, construct, criterion and predictive validity was acceptable as a simple-to-use, cost-effective, clinical measurement tool that can be used for screening, diagnosis and prognosis for most disorders of the foot and ankle.

Keywords: Foot posture index; Foot alignment; Physical examination; Clinical scoring

Introduction

The human foot is much different from other animals in that it had evolved over three-and-a-half million years [1] through a process of phylogenetic development, with bipedal stance the very unique distinguishing feature [2]. This bipedal stance and the ontogenetic development that ensues [3], along with physical and psychosocial development of the individual combined with the use of barefoot-walking, walking on uneven surfaces [4], and occupational/ recreational demands from sports and/or injuries result in foot shape which is recognized as foot type [5].

Anatomically, the complex articular structure of the human foot consists of thirty four synovial joints, of which eighteen have curved surfaces and sixteen plane surfaces [6]. The human foot has extensive sympathetic innervation that enables it to control visceral functions and fright-fight-flight response in an event of actual or perceived injury [7] and in postural vasoconstriction [8]. This fact is often exploited in foot reflexology which indicates that alterations in foot structure and function are interdependent on the body’s structure and function.

Pathoanatomically, congenital abnormalities of the foot are common, which lead to alterations in foot shape and structure [9,10]. The other reasons for changes in foot shape are dysfunctional venous pump mechanism, which manifest as pedal edema due to high interstitial fluid pressure [11].

Morphologically, the foot had four arches (medial longitudinal, lateral longitudinal, anterior transverse and posterior transverse arches) which produce the foot shape that is inherent and indicative for each and every individual [12]. The shape of the foot- both static and dynamic has to possess qualities of adaptability during weight-bearing activities such as standing, walking, running, jumping and sports activities [13].

Biomechanically, the foot consisted of distinct functional units with the mobile functional unit being navicular to first metatarsal and rigid functional unit being navicular and cuboid [14]. Kinetic evaluations of different foot types showed the differences in pressure distribution beneath the foot, both static and dynamic, for presumably efficient foot function [15].

There are primarily two abnormal foot types- classified according to the shape of the medial longitudinal arch of the foot: supinated foot (increased MLA) and pronated foot (decreased MLA), apart from normal foot, all of which are maintained by a complex interlinked inter-relationship between bones, ligaments, muscles and joints [16]. The supinated foot is described as rigid foot while pronated foot is described as mobile or loose foot, which further depends upon the structural and functional organization of connective tissue in feet [17].

The foot posture bears a direct influence on the loads distributed through the plantar fascia, which in turn acts as a ‘shock absorber’ to twist and untwist the foot during functional weight-bearing activities [18]. Olson and Seidel [19] rightly pointed out, “the modern human foot is structurally so well adapted to prolonged bipedal walking and standing that even slight deviation from its evolutionarily established pattern will produce debilitating clinical manifestations”. Many clinical measures of foot posture such as navicular height and drift [20], arch height and index, foot posture index (FPI) [21], longitudinal arch angle [22] and radiological measures such as talus-second metatarsal angle, talo-navicular coverage angle, calcaneal inclination angle and calcaneal-first metatarsal angle were reported in the literature [23].

The objective of this paper was to provide an evidence-informed overview and update of current literature on foot posture and foot posture index (FPI), its measurement properties, with implications for podiatric research and practice.

Reliability of FPI

Evans et al. [24] found the intra-rater and inter-rater reliability of FPI-8 and found that total score showed moderate reliability overall, demonstrating better reliability than most other measures such as navicular height. Cornwall et al. [25] utilized ratings of three different raters who evaluated both feet in 46 individuals, and found that intra-rater reliability was high but inter-rater reliability was only moderate.

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Morrison and Ferrari [26] studied inter-rater reliability in 30 healthy children and found excellent inter-rater reliability with almost perfect between-testers agreement (K= .86). Evans et al. [27] found good inter-rater reliability for FPI (ICC=.93-.94) in 30 healthy children.

Validity of FPI

Content validity: Redmond et al. [28] performed a four-phase development process: (i) to derive a series of candidate measures, (ii) to define an appropriate scoring system, (iii) to evaluate the validity of components and modify the instrument as appropriate, and (iv) to investigate the predictive validity of the finalized instrument relative to static and dynamic kinematic models. The authors proposed a final 6-item measure which predicted 64% of the variance in static standing posture, and 41% of the variance in midstance posture during normal walking.

Construct validity: Keenan et al. [29] performed a Rasch analysis of baseline scores at two institutions involving 143 participants and evaluated differential item functioning for each item of FPI-8. The study found that two items were problematic: Achilles' tendon insertion (Helbing's sign), which showed illogical response ordering and 'congruence of the lateral border of the foot,' which showed misfit. The revised FPI-6, after removing the above two items indicated a good overall fit to the model, and was thus recommended for clinical and research use.

Criterion validity: Scharbillig et al. [30] evaluated FPI with angulations measured from dorsoplantar and lateral radiographs as a 'criterion tool' in 31 subjects and found that FPI could broadly classify foot postures, but was not sensitive to small movements and malalignments.

Predictive validity: Sanchez-Rodriguez et al. [31] determined the ability of FPI to predict the pattern of plantar pressures at 10 different zones of the foot in 400 healthy subjects and they found that the talonavicular prominence and the calcaneal frontal plane position was the most influential criterion with moderate or low plantar pressures variability, explaining 8.5% of the hallux pressure and 11.1% of the fifth metatarsal head pressure.

Nielsen et al. [32] assessed the use of FPI for predicting midfoot kinematics during walking measured using Video sequence analysis (VSA) in 280 healthy adults and found that navicular drop was significantly positively correlated with FPI scores while minimal navicular height decreased with increasing FPI.

Applicability of FPI

Normative value: Redmond et al. [33] performed a systematic review to establish normative FPI reference values which included nine studies comprising 1648 observations, and found that foot posture was related to age and the presence of pathology, but not influenced by gender or BMI, and thus derived scatterplot and boxplot for clinical use.

Foot kinematics in gait: Barton et al. [34] evaluated the relationship between FPI and foot kinematics in 26 individuals with patellofemoral pain syndrome and 20 control subjects, and they found that pronated foot type was associated with greater peak forehead abduction and earlier peak rearfoot evasion, with the symptom group having greater rearfoot evasion than the control group.

Discussion

This study aimed at providing an evidence-informed update on development of foot posture, and the use of FPI in assessment of foot posture, and the recent research though less in number, suggest and recommend the use of FPI with cautious interpretation of its subjectivity. The lesser number of studies on reliability and validity of FPI is not surprising considering the overall lesser studies on physical examination techniques of foot and ankle [35].

There were many other methods of evaluating foot posture such as digital photography [36], simple semantic classification using visual observation [37]; and, foot line test [38]. Comparative studies between FPI and these measures are essential for an evidence-informed choice in clinical decision-making.

The causes for altered foot posture are multifactorial- ranging from congenital foot deformities like equinovarus deformity (clubfoot), metatarsus adductus, calcaneovalgus, congenital vertical talus, polydactyly (supernumerary digits), and syndactyly (webbed toes) [39], neurological disorders like stroke [40] to orthopedic disorders such as knee osteoarthritis [41], medial tibial stress syndrome [42]; and, patellofemoral pain syndrome [43].

Foot posture was an independent risk factor for heel ulcerations [44] and it was shown to influence fifth metatarsal fracture healing [45]; foot mobility [46], lower limb muscle activity in walking [47,48] and in running [48].

Assessment and treatment of painful ankle and foot conditions based upon findings of FPI and other measures should be done along a knowledge generation to knowledge transfer continuum from clinical anatomy and pathomechanics [49], examination, interpretation and management [50]. Although postural assessment is an important part of comprehensive clinical examination of foot and ankle [51], Treatment methods for correcting foot posture include footwear modification [52], orthoses [53], physical therapy [54] and surgery [55].

Although FPI is a measure of static foot alignment, the ability to predict dynamic foot posture would be very valuable in clinical and research settings [56].

Limitations of this study

Some of the limitations of this review being narrative and focused on measurement properties of one single measure of foot posture, rather than the myriad of tools available for screening, examination and measurement for use in practice, education, and research in the field of Podiatry.

Implications for the future

Future studies on evaluation of disease-specific and population-specific measurement properties are needed prior to extending and extrapolating the use of FPI as a gold standard measure of foot posture.

References


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