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Ultrasound evaluation of foot muscles and plantar fascia in pes planus

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ABSTRACT

Background: Multiple intrinsic and extrinsic soft tissue structures that apply forces and support the medial longitudinal arch have been implicated in pes planus. These structures have common functions but their interaction in pes planus is not fully understood. The aim of this study was to compare the cross-sectional area (CSA) and thickness of the intrinsic and extrinsic foot muscles and plantar fascia thickness between normal and pes planus feet.

Methods: Forty-nine adults with a normal foot posture and 49 individuals with pes planus feet were recruited from a university population. Images of the flexor digitorum longus (FDL), flexor hallucis longus (FHL), peroneus longus and brevis (PER), flexor hallucis brevis (FHB), flexor digitorum brevis (FDB) and abductor hallucis (AbH) muscles and the plantar fascia were obtained using a Venue 40 ultrasound system with a 5–13 MHz transducer.

Results: The CSA and thickness of AbH, FHB and PER muscles were significantly smaller (AbH −12.8% and −6.8%, FHB −8.9% and −7.6%, PER −14.7% and −10%), whilst FDL (28.3% and 15.2%) and FHL (24% and 9.8%) were significantly larger in the pes planus group. The middle (−10.6%) and anterior (−21.7%) portions of the plantar fascia were thinner in pes planus group.

Conclusion: Greater CSA and thickness of the extrinsic muscles might reflect compensatory activity to support the MLA if the intrinsic foot muscle function has been compromised by altered foot structure. A thinner plantar fascia suggests reduced load bearing, and regional variations in structure and function in feet with pes planus.

1. Introduction

The pes planus foot type is present in 10–25% of the adult population [1] and has been associated with greater incidence of musculoskeletal symptoms including knee and back pain [2]. It is typically characterised by a lowered medial longitudinal arch (MLA), an everted rearfoot, and dorsiflexed and abducted midfoot [3,4]. An explanation of the causes and consequences of pes planus lies in the complex interaction between external ground reaction forces and internal forces in ligaments, joint capsules, intrinsic and extrinsic muscle-tendon units and forces across articular facets [5,6].

The contribution of muscles to foot posture and thus pes planus has been the focus of several studies. Anaesthetic paralysis and deliberate fatiguing of plantar intrinsic muscles result in reduced MLA height [5,7], though these experimental approaches do not indicate how individual plantar structures contribute to arch integrity. Previous studies have shown that abductor hallucis (AbH) and flexor digitorum brevis (FDB), and plantar fascia each make specific contributions to supporting the MLA [8,9]. The AbH muscle has been described as a dynamic elevator for the MLA and loss of its function has been shown to lower medial arch height [10]. However, it has also been suggested that pretensioning of the fascia in late swing resists lowering of the MLA in early stance [11] and almost 80% of the force resisting further lowering of the arch was provided by plantar fascia [6]. These prior studies illustrate the importance of understanding interactions between different soft tissue structures that have common functions in the foot (e.g. supporting the MLA). For example, changes in the forces experienced by one plantar structure influence the forces experienced by other structures with the same function [6].

Thickening of plantar fascia has been reported in cases of plantar fasciitis in those with pes planus [1], implying that the fascia bears greater load, and adapts to become thicker and stiffer as a result. Indeed, in the absence of the recognisable signs of fascia inflammation, Huang's et al. [1] observation of thicker plantar fascia in cases of pes planus is not easily explained unless the

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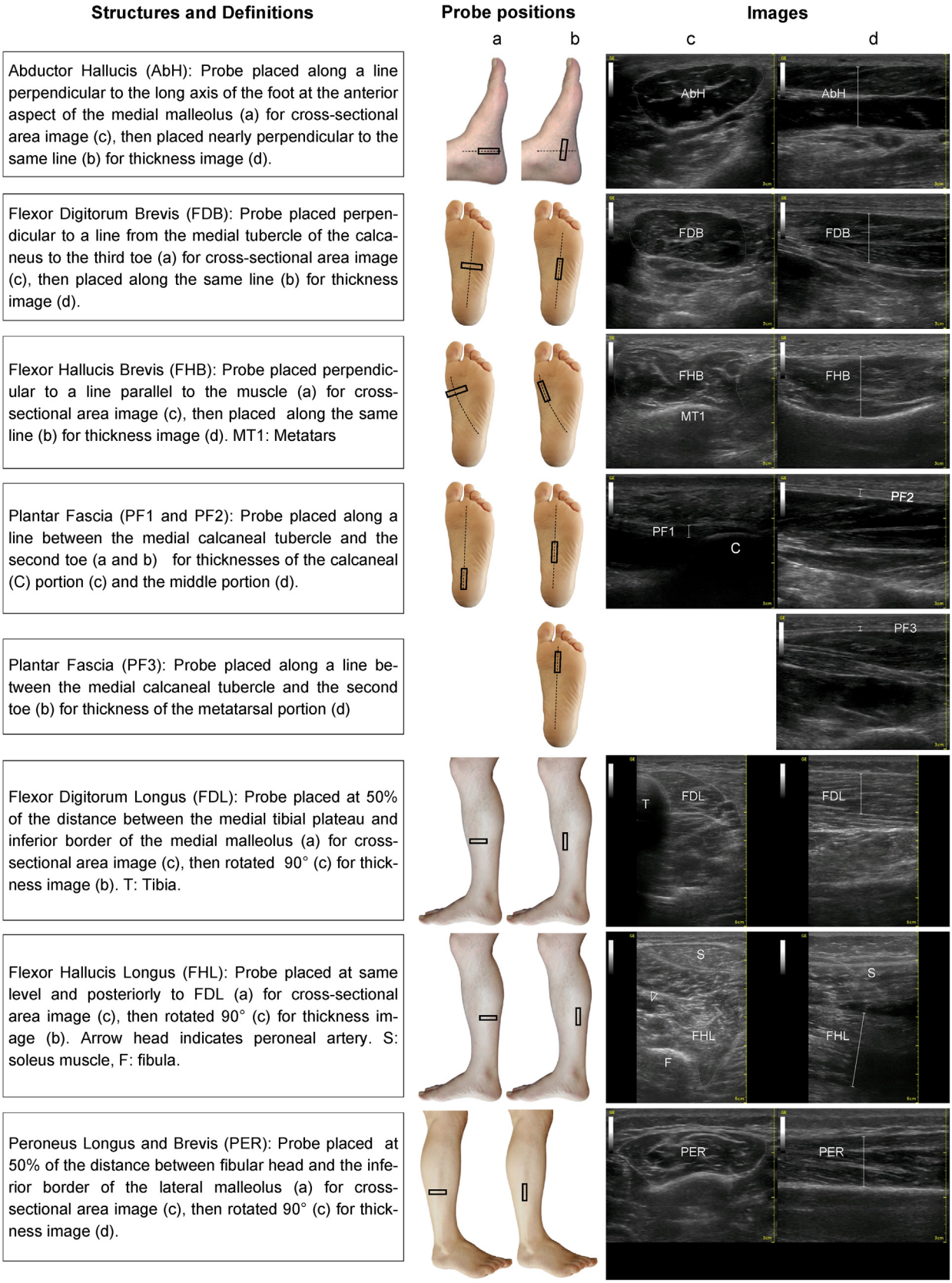

Fig. 1. The scanned structures and scanning protocol definitions with probe position, and corresponding sample images.

assumption that fascia thickness is a surrogate of tensile strength is generally true. To date however, measures of plantar fascia structure have focused on the calcaneal attachment site [12,13] and little is understood of mid and forefoot fascia structures in cases of pes planus [14]. This is important since at the mid foot the fascia divides into various digital slips that will have different moment arms with respect to the MLA and might have different functional roles with respect to MLA height.