

# A PRELIMINARY ASSESSMENT OF THE EFFECTS OF FOOT TYPE ON THE MOVEMENT COUPLING OF THE FOOT AND SHANK DURING THE STANCE PHASE OF BAREFOOT RUNNING

<sup>1</sup>Caroline J Digby\*, <sup>2</sup>Mark J Lake, and <sup>2</sup>Adrian Lees

<sup>1</sup>Dept. of Sport Science, Tourism and Leisure, Canterbury Christ Church University College, Canterbury, UK, [c.digby@canterbury.ac.uk](mailto:c.digby@canterbury.ac.uk)

<sup>2</sup>Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK;

## INTRODUCTION

Kinematic coupling of the foot and shank has been highlighted as a potential factor in lower limb overuse injury aetiology, particularly if excessive eversion motion of the rearfoot is transferred to rotation of the tibia [1,2]. It has been speculated that the height of the medial longitudinal arch of the foot may play a role in the amount of movement transfer present [2,3,4] and so researchers have attempted to classify foot type [5,6,7] in an attempt to understand the effects of foot structure on dynamic foot function. Recently, a foot posture index (FPI) was devised based on a number of observational tests during normal static stance to classify feet [8]. However, it has been suggested that traditional static measurements appear not to predict dynamic function accurately [7,9,10]. The aim of this study was to examine a number of simple static parameters of foot arch structure at three different loading conditions, and several dynamic measures of foot type obtained during barefoot running to characterise foot type, and examine the relationship to movement coupling of the foot and shank during running.

## METHODS

Using callipers and a ruler, repeated anthropometric measurements were recorded on the right foot of 27 healthy male subjects in static non weight bearing (NWB), normal partial weight bearing (PWB) and full weight bearing (FWB). They included truncated foot length (TFL), dorsum height (DH), and soft tissue arch height (AH). Retro-reflective markers were glued to anatomical landmarks on the foot (medial calcaneus (MED\_CALC), medial aspect of the navicular tubercle (NAV\_TUB), and medial aspect of the first metatarsal head (MTH1)) and tibia. At each weight-bearing condition, the Arch Ratio (AR) was calculated by DH/TFL [6]. Static relative arch deformation (SRAD) was calculated based on NWB and FWB measurements of soft tissue arch height [11]. Dynamically, min. vertical height of the NAV\_TUB marker during stance and average height at NWB stance were used. A further method of classification, Arch Deformation Ratio (ADR), was developed by combining SRAD and AR [12]. From marker position data average vertical height of the NAV\_TUB marker (NTMH), average Infra-Navicular Angle (INA) and navicular height (NH) [13] were calculated.

The subjects ran barefoot ( $3.35\text{ms}^{-1}$ ) whilst the landing kinematics of the right foot and shank were recorded by 8 ProReflex cameras (Qualisys, Sweden) at 1000Hz. An individually moulded plate was used to track rapid movements of the tibia [14], and foot pressure data was collected at 500Hz (RSscan Ltd., Belgium). For running trials, min. NTMH and NH, and max. INA during the stance phase were calculated (indicating the arch is at its flattest), along with the total deformation of the arch, and velocity of the deformation. Dynamic RAD (DRAD), Dynamic Arch Ratio (DAR) and Dynamic Arch Deformation Ratio (DADR) were calculated. A Dynamic Arch Index (DAI) (% midfoot contact) was

obtained from the pressure data. Ratios of the range of motion (ROM Ratio), peak angular velocity (VEL Ratio) and time to peak velocity (TIME Ratio) for rearfoot eversion and tibial internal rotation were used to characterise movement coupling. Pearson's correlations were used to identify any significant relationships.

## RESULTS AND DISCUSSION

There was no significant correlation between ROM Ratio and VEL ratio with any of the static or dynamic parameters. The DAI obtained from the pressure mat was negatively correlated with AH at all loading conditions (NWB = -0.576,  $p=0.002$ ; PWB = -0.546,  $p=0.004$ ; FWB = -0.563,  $p=0.003$ ). SRAD was not correlated at any loading condition to any AH or AR measure or to DRAD. Equally, DRAD was not correlated to DAR. In general, the static measures were not strongly correlated to any of the dynamic parameters, with the exceptions of INA at PWB was strongly correlated to max INA (0.952,  $p=0.012$ ) and min NH (-0.948,  $p=0.014$ ), NH at PWB was strongly correlated to DAR (0.889,  $p=0.044$ ), and NTMH at PWB was strongly correlated to DAR (0.895,  $p=0.040$ ), and min NTMH (0.944,  $p=0.016$ ).

Traditional static measurements do not predict dynamic function accurately [7,9,10], as observed in this study by the lack of correlation between static and dynamic parameters. It appears that static measures taken during PWB are the most accurate predictor of dynamic function, however some information about deformation of foot during locomotion is needed to improve classification of foot arch type [5,6].

Although both include valuable information about the foot, SRAD and Arch Ratio were not correlated. We must consider the amount of static deformation as well as the height of the MLA, as these may not be well correlated [15]. A more comprehensive categorisation of foot type may be achieved when static and dynamic measures are combined. This will be attempted in an extension of this study by combining the parameters measured into a single foot index.

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