THE EFFECT OF FOOT TYPE OF NORMAL SUBJECTS ON FOOT CONTACT DYNAMICS

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INTRODUCTION

It is well documented that human movement is influenced by foot structure. Pes cavus is characterized by an excessively high arch and pes planus is characterized by the flattening out of the arch of the foot. Pes cavus is associated with clawing of the great and lesser toes [1, 2], and sometimes with pain. [3] Neurologic and idiopathic pes cavus have significantly different foot posture indices compared to the normal foot. [4] Pes planus is associated with increased plantar surface contact area and can be a risk factor in the development of overuse injuries [5, 6]. Foot type was found to affect the center of pressure excursion index (CPEI), which is the lateral displacement of center of the pressure curve from the line constructed between the initial and the final center of pressure values, normalized by the foot width at the anterior one third of foot. [7] Stance phase may be broken into three subphases: contact, midstance, and propulsion. Contact is the percentage of stance from heel strike (or initial contact) and the first midfoot/forefoot loading. Midstance is the percentage of stance from the end of contact to heel off (ie end of rearfoot loading). Propulsion is the percentage of stance from the end of midstance till toe-off (or final contact).

The effects of foot type on foot contact dynamics and function are not well understood. This information is important when planning treatment for pes cavus and pes planus feet. Hence, the aim of this study was to develop a normative dataset of temporal sequence of loading, CPEI, and the transverse foot angle of healthy subjects with pes planus, rectus, and pes cavus foot types. We hypothesized that subjects with different foot types have significant different temporal sequence of loading, CPEI, and transverse plane foot angles.

METHODS

Sixty-one healthy asymptomatic test subjects were recruited with the following inclusion/exclusion criteria: (1) no current symptoms of pain, (2) no other symptoms suggesting a pathology involving the foot and ankle, and (3) no hallux valgus or other visible pedal deformities (e.g. hammertoes). The foot type of each test subject was determined based on resting calcaneal stance position and forefoot-to-rearfoot alignment. The pes planus group had a (1) resting calcaneal stance position (RCSP) ≥ 4° of valgus, and (2) a forefoot-to-rearfoot relationship (FF-RF) ≥ 5° of varus. The rectus group had a (1) a RCSP between 0° and 2° of valgus, and (2) a FF-RF between 0° and 4° of varus. The pes cavus group had a (1) RCSP > 1° of varus and (2) a FF-RF > 1° of valgus. This resulted in a foot classification of 22 pes planus, 27 rectus and 12 pes cavus individuals (Table 1).

Temporal sequence of loading (contact, midstance and propulsion phases of stance), CPEI, and the transverse plane foot angle were calculated from plantar pressure distributions. The emed X system (Novel gmbh, Germany), consisting of 4 sensors per cm2 (475 mm x 320 mm) was employed to measure each individual's dynamic plantar pressure distribution. Custom software was developed in C++ to calculate each of these parameters.

The effect of foot type was tested for each parameter, using a mixed effect analysis of variance (ANOVA) model. The fixed effect was 'foot type' and the random effect was 'trial' (replications)

Significance was set at $p< 0.05$. A trend was operationally-defined at $p<0.1$. Post hoc t-tests were performed using the Bonferroni method ($P<0.0167$).

RESULTS AND DISCUSSION

The anthropometric information and clinical foot type classification of the subjects is summarized in Table 1. The temporal sequence of loading (contact, midstance, and propulsion) was not significantly different across foot type. Note that midstance on the left was nearly significant. CPEI demonstrated significant differences across pes planus and rectus as well as pes planus and cavus foot types. The transverse plane foot angle was significantly different across foot types on the right and was nearly significantly different on the left.

CONCLUSIONS

The temporal sequence of loading was not significantly different across foot types. CPEI and transverse plane foot angles did demonstrate differences between the rectus and planus and cavus and planus groups. No parameter in the study could distinguish the pes cavus from rectus foot types.

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Table 1: Test subject anthropometrics

	Pes Planus	**Rectus**	**Pes Cavus**
Subjects	22	27	12
Males (Females)	10 (12)	8 (19)	6 (6)
Body Weight (N)	641.3 ± 128.1	662.8 ± 138.8	721.1 ± 155.1
Height (m)	1.71 ± 0.08	1.66 ± 0.11	1.74 ± 0.12
BMI	22.2 ± 3.2	24.4 ± 4.1	24.0 ± 3.5
RCSP (°)	-6 ± 2	-1 ± 1	0 ± 1
FF-RF (°)	-7 ± 4	3 ± 1	-2 ± 1

Table: Foot Contact Dynamic Results

Parameters	Pes Planus	Rectus	Pes Cavus	ANOVA	Post Hocs
Contact (%St)-R	9.74(1.69)	9.81(1.54)	9.13(2.29)	0.137	
Contact (%St)-L	9.64(1.73)	9.71(1.55)	9.19(2.30)	0.330	
Midstance (%St)-R	49.93(5.64)	48.91(5.13)	50.25(7.67)	0.426	
Midstance (%St)-L	50.74(5.71)	49.03(5.14)	51.21(7,59)	0.096	
Propulsion (%St)-R	39.65(5.30)	41.36(4.82)	40.50(7.21)	0.176	
Propulsion (%St)-L	39.58(5.62)	41.16(5.03)	39.58(7.47)	0.189	
CPEI (%)-R	18.73(5.84)	22.08(5.16)	24.45(7.76)	<0.001	1, 2
CPEI (%)-L	18.57(5.65)	21.30(5.02)	24.01(7.47)	<0.001	1, 2
Foot Angle (°)-R	7.36(3.94)	9.81(3.48)	10.03(5.21)	<0.001	1, 2
Foot Angle (°)-L	7.22(4.86)	8.64(4.32)	9.35(6.43)	0.084	

Note: %ST = %Stance, CPEI=Center of Pressure Excursion Index

Bonferonni post-hoc significance set at $p<0.0167$

1 = Cavus vs Planus; 2 = Rectus vs. Planus; 3 = Cavus vs. Rectus