Demographic, physical and radiographic factors associated with functional flatfoot deformity

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Purpose
Posterior tibial tendon pain is commonly associated with pes planus, however not all flat feet are symptomatic. The purpose of this study is to identify medical, physiological and radiographic conditions that are associated with symptomatic and non-symptomatic flatfoot, with flatfoot being defined as over-pronation and medialization of plantar pressure excursion during gait. By understanding these risk factors clinicians will be able to predict symptoms rather than architectural mal-alignments in the flat foot patient.

Methodology

Inclusion Criteria
1. Subject able to understand and sign the consent form.
2. Age between 18
3. Subject has or will be needing a weight bearing gait analysis.
4. History of amputation proximal to the tarsal tunnel (L5-S1 nerve root).
5. Though there are many physical and radiographic examinations that we used to define flatfoot, the plantar pressure pattern during gait. Specifically, the center of pressure excursion index (CPI) and the angle of gait during stance phase were measured (Figure 1).

To identify the risk factors associated with flatfoot deformity, the data was modeled using odds-ratios for, or differences in distribution of occurrence of flatfoot between strata of categorical variables of interest, or to determine differences in means for continuous variables. These analyses were first done in a bivariate fashion (chi-squared test or Fisher’s exact for categorical or ordinal variables, t-test for continuous variables), and then variables which had a value of (of the appropriate bivariate) test of less than 0.2 were put into a logistic regression model, to assess risk factors while controlling for other potentially confounding factors.

Literature Review

Though there are many physical and radiographic examinations that we utilize in practice when working up a patient with presumed adult flatfoot deformity, we have no clear understanding of what physical and radiographic factors are associated with this deformity and medically deviated weight distribution due to over-pronation during gait.

Understanding physical and radiographic factors responsible for the pronated gait would allow us to focus on specific problem areas when treating flatfoot. Our previous analysis of National Health Survey data uncovered multiple factors that were independently associated with flatfoot; however, in order to identify people with flatfoot, we had to rely on self-reported survey data. That study showed that the occurrence of self-reported flatfoot was associated with self-reported age, gender, Asian and African American races, veteran status, poor health, body mass index, carpal tunnel, hamstring, and arthritis (1).

Results

Ninety-four patients were enrolled in this study. Of these patients, 71 were male and 23 were female (Table 2). The mean age was 47.4 (SD = 11.1). There were 39 people who had a CPI of greater than or equal to 1.6 (non-flatfoot group) and 55 who had CPI less than 1.6 (flatfoot group). In nine, the data was missing. In the bivariate analyses, tibialis posterior pain (P = 0.015), calcaneal inclination (P = 0.001), talonavicular (P = 0.016), intermetatarsal (P = 0.027), hallux abducto (P = 0.049), and medial cuneiform cubitus (P = 0.017) and exact center position (P = 0.009) were statistically significantly different between the two groups. After adjusting for covariates, no factors were statistically significantly associated with a CPI of less than 16% (flatfoot group).

Analysis and Discussion

The commonly measured radiographic angles, such as calcaneal inclination, talar declination, and calcaneal cuboid angles were statistically significantly different between the flatfoot and non-flatfoot groups. This confirms that the adult flatfoot are affected in multiple planes and that correction of the planes may be necessary to restore a functional gait. In addition, we found that measurements, often used in assessing bunion deformity, such as intermetatarsal and hallux abducto angles were also greater in the flatfoot group. These findings may suggest that conservative and surgical treatments aiming to restore the pronated foot type may or may not be as effective in eliminating median arch or sinus tarsi pain due to possible alternative or additional causes for pain in these areas.

Only the tibialis posterior and the calcaneal stance position were significant (P <0.05) in the bivariate analysis. We suspect that both of these factors are strongly related to the angular deformity of flatfoot. Factors such as, BMI, sinus tarsi pain, ankle dorsiflexion and genu varum were included in the final model (in the bivariate analysis), but none of the factors became significantly associated with the flatfoot group. A larger sample size may be needed to construct a more stable model.

We believe that many disabilities due to flatfoot are preventable by early diagnosis and are treatable; therefore, effective and systematic clinical and radiographic examinations are critical to prevent and treatment of flatfoot deformity. While quantitative analysis of plantar pressure distribution during normal gait is valuable, it is not always available to many practitioners. This study identified the clinical and radiographic factors that are unique to a flatfoot. These factors are easily obtained in an average practice and systematic evaluation of these factors can help understand functional status of the flatfoot deformity without digital assessment of force distribution during gait.

One weakness of our study is that we did not differentiate symptomatic from non-symptomatic flatfoot. Differentiating these types of flatfoot would provide further factors that are clinically important, and supplement the factors mentioned above.

Another weakness to this study was that the control or non-flatfoot cohort also came from our clinic. Every patient who was enrolled in the study was symptomatic. In fact, most of the subjects had musculoskeletal complaints. This oversampling of patients with musculoskeletal problems is due to the fact that one of our inclusion criteria was availability of weight-bearing plain radiographs. While this is a weakness of the study, the results of the study are still useful in the average foot and ankle clinic where many different musculoskeletal problems manifest, and the clinician would like to differentiate between them. While arch pain and sinus tarsal pain, for example, may not be frequent in the general public, our study question was to identify factors uniquely associated with flatfoot among people who present to the foot and ankle clinic.

Conclusion

Paintal tibialis posterior tendon was associated with a pronated gait. Calcaneal inclination angle was decreased while talar declination, intermetatarsal, hallux abducto, and calcaneal cuboid angles, and static calcaneal stance elevation were elevated in the flatfoot group compared to the non-flatfoot group. A systematic evaluation of these associated factors can be valuable for a comprehensive assessment of flatfoot.

Table 2: Comparison of factors between flatfoot and non-flatfoot groups. P-values computed with the Student’s t-test for the continuous variables and chi-squared test for the categorical variables.

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Figure 1: The center of pressure excursion index (CPI) shows the amount of deviation of the center pressure excursion from a reference line (CPIREF). The reference line is created by the intersection of the minimum pressure points at the heel strike and toe off. Progression of plantar pressure in the flatfoot patient changes the center of pressure excursion. Therefore, the reference curve (CPI) is measured at the anterior third of the foot.

References