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RESEARCH / ARAŞTIRMA

Correlation of Radiological and Pedobarographic Evaluations in the Presence of Foot Sole Pain

Ayak Taban Ağrısı Varlığında Radyolojik ve Pedobarografik Değerlendirmelerin Korelasyonu

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Abstract

Objective: One of the reasons for foot pain is the changes in the structure of the medial longitudinal arch. Assessment of medial longitudinal arch height is often made with foot radiographs and pedobarographic measurements. The relationship between these methods in the presence of foot sole pain has not been examined yet. This study aims to investigate the relationship among these measurement methods in adults with foot sole pain.

Materials and Methods: 60 adults with foot sole pain were included in this study. The talohorizontal, talocalcaneal, talo1.metatarsal, and calcaneal inclination angles were measured in the lateral weight bearing foot radiographs. The arch index was calculated in static, dynamic pedobarographic measurements. The agreement of radiological and pedographic measurements among themselves and with each other was determined.

Results: The mean age of 60 participants was 45.32 ± 13.64 . Agreement among foot classifications of radiologic measurements was poor Gwet's agreement coefficient = -0.198 with a 95% confidence interval (-0.315, -0.080); percent agreement = 0.167 with a 95% confidence interval (0.099, 0.234) and Kappa = -0.047 with a 95% confidence interval (-0.083, -0.01) were found. The agreement between pedobarographic classifications was fair Gwet's agreement coefficient = 0.486 with a 95% confidence interval (0.355, 0.617); percent agreement = 0.65 with 95% confidence interval (0.563, 0.737) and Kappa = 0.453 with a 95% confidence interval (0.324, 0.583) were found. Among radiological measurements, the calcaneal inclination angle showed the highest coefficients of agreement with pedobarographic measurements. The extent of its agreement was fair.

Conclusion: Pedobarography is a simple, reliable, inexpensive, and noninvasive method. The calcaneal inclination angle which is used in radiological imaging can give an idea about the height of the medial longitudinal arch.

Keywords: Foot pain, medial longitudinal arch, pedobarographic arch index, radiologic measurements

Öz

Amaç: Ayak ağrısının nedenlerinden biri medial longitudinal arkın yapısındaki değişikliklerdir. Medial longitudinal arkın yüksekliğinin değerlendirilmesi sıklıkla ayak grafileri ve pedobarografik ölçümlerle yapılır. Ayak tabanı ağrısı varlığında bu yöntemlerin ilişkisi henüz incelenmemiştir. Bu çalışmanın amacı ayak taban ağrılı erişkinlerde bu yöntemler arasındaki ilişkiyi araştırmaktır.

Gereç ve Yöntem: Bu çalışmaya ayak taban ağrılı 60 yetişkin dahil edildi. Lateral yüklenmede ayak grafilerinde talohorizontal, talocalcaneal, talo1.metatarsal, kalkaneal eğim açıları ölçüldü. Ark indeksi, statik, dinamik pedobarografik ölçümlerde hesaplandı. Radyolojik ve pedografik ölçümlerin kendi aralarında ve birbirleri ile uyumu belirlendi.

Bulgular: 60 katılımcının yaş ortalaması 45.32 ± 13.64 idi. Radyolojik ölçümlerin ayak sınıflandırmaları arasındaki %95 güven aralığı ile (-0.315, -0.080) Gwet'in uyum katsayısı = -0.198; %95 güven aralığı ile uyum yüzdesi = 0.167 (0.099, 0.234) ve %95 güven aralığı ile Kappa = -0.047 (-0.083, -0.01) uyum zayıftı. Pedobarografik sınıflandırmalar arasındaki uyum, %95 güven aralığı ile (0.355, 0.617) Gwet'in uyum katsayısı = 0.486; %95 güven aralığı ile (0.563, 0.737) uyum yüzdesi = 0.65 ve %95 güven aralığı ile Kappa = 0.453 (0.324, 0.583) uyum orta düzeyde idi. Radyolojik ölçümler arasında kalkaneal eğim açısı, pedobarografik ölçümlerle en yüksek uyum katsayılarını sahipti. Kendi içindeki uyum "zayıf"tı.

Sonuç: Pedobarografi basit, güvenilir, ucuz ve girişimsel olmayan bir yöntemdir. Radyolojik görüntülemelerde kullanılan kalkaneal eğim açısı, medial longitudinal arkın yüksekliği hakkında fikir verebilir.

Anahtar Kelimeler: Ayak ağrısı, medial longitudinal ark, pedobarografik ark index, radyolojik ölçümler.

1. Introduction

As an important burden in health insurance systems, foot sole pain (FSP) is defined as a risk factor for decreased walking distance, loss of balance, increased risk of falling, and poor quality of life. Gates et al. (1) found the incidence of foot pain in society to be between 13% and 36% in their study. One of the causes of foot pain is changes in medial longitudinal arch (MLA) height (2). MLA consists of static and dynamic components such as muscles, bones, tendons, and ligaments (3). This structure reminds the arrangement of stones forming a Roman arch and so this formation is quite rigid (4). While MLA adapts to the ground in the mid-stance phase of walking (4) and takes the task of shock absorption and force transmission (2) it is highly important as it allows (in providing) the foot to act like a rigid lever during toe lift (5). Changes in MLA height are thought to trigger the injuries (6). The increase in MLA height creates a pes cavus (PC) deformity in the sagittal plane of the foot (7). In PC feet, the contact of the middle of the foot with the surface of the ground decreases (8). Pes planus (PP) is characterized by a decrease in the height of MLA (9). PC is seen in 10.5-25% and PP in 19-37% of the adult population (10,11). While injuries are assumed to occur in the bony structures on the lateral side of the foot in PC feet, they are thought to possibly occur in the soft tissues in the medial side of the foot in PP (12). Therefore, MLA should be evaluated accurately and easily. Many different methods are used in the evaluation of MLA height directly and indirectly. Visual observation, clinical measurements, radiograms, and footprints are among these methods (2,12,13). Among all these methods, there is no evaluation technique that is the gold standard (13). Many angular measurement techniques in weight-bearing foot X-rays are accepted as a direct evaluation method in the literature (14). These measurements help evaluate bone alignment and identify pathologies that cause foot pain. However, the overlapping of bone structures in radiological imaging is misleading due to the extreme sensitivity to beam angle deviation during distortion and imaging (15). Moreover, it does not allow dynamic evaluation of the foot (16,17). Today, the frequency of the use of pedobarographic devices has increased to better understand foot, and ankle pathologies (16). In measurements made with pedobarography devices, it transfers three-dimensional images and pressure distributions of the foot sole during standing and especially walking to the computer system with electronic sensors placed on the platform. Objective measurements made with the use of these data are called arch index measurements (18, 19). In addition, pedobarographic measurements provide objectivity, patient-specific assessment, and specific diagnosis (17). In this study, we hypothesized that in the presence of FSP, there is a difference between pedobarography, a dynamic method, and radiographic MLA evaluation methods, a static method. We tried to determine the difference between measurements by investigating the compatibility between static, dynamic pedobarographic arch index (AI) measurements and the lateral talocalcaneal (TC), talo1. metatarsal (T1M), talohorizontal (TH), and calcaneal inclination angle (CIA) that can be measured by x-rays. To increase the reliability of the findings, we also included the correlation between the lateral foot radiographs and the pedobarographic measurements within themselves in the study. As far as we know, there is no other comparison in the literature in adults with FSP complaints. In addition, another aim of this study is only x-ray, only clinical, only pedobarographic examination

that is not conclusive and sometimes contradictory in making a diagnosis inpatient treatment. For this reason, this study, is to reveal this contradiction, if any, and to investigate the reliability of these examination methods. As a result, it is to prevent unnecessary examinations in diagnosis and to provide the right treatment, physiotherapy, and orthotics by reducing time, cost, and labor.

2. Materials and Methods

60 adult patients (39 women, 21 men) who applied to the Orthopedics and Traumatology Clinic of our hospital with the complaint of pain in the foot sole were retrospectively investigated. All radiological and pedobarographic examinations of the patients were performed in the clinic on the same day. The inclusion criteria of the study was higher than 18 years, admitted to our hospital with foot pain, available weight-bearing lateral view foot radiograph, available pedobarographic measurement, pedobarographic measurement and radiological imaging performed on the same day, and able to stand and walk unsupported. Patients with standing congenital deformity, previous fracture history of the lower extremity, and neurological and metabolic diseases were excluded from our study. The demographic and foot pain characteristics of the patients were as shown in Table 2. In the literature, lateral foot radiographs have been used in the evaluation of MLA height (5,6,12,20-25). For this reason, we measured four different angles on the lateral weight-bearing foot radiographs (Figure 1). Lateral radiographs of the weight-bearing feet were evaluated by standardizing as described by Simons et al. (26). All angles were performed twice by the second author at different times, according to the methods described by Simons et al. (26) and Vanderwilde et al. (27). The values were recorded by taking the average of the two measurements.

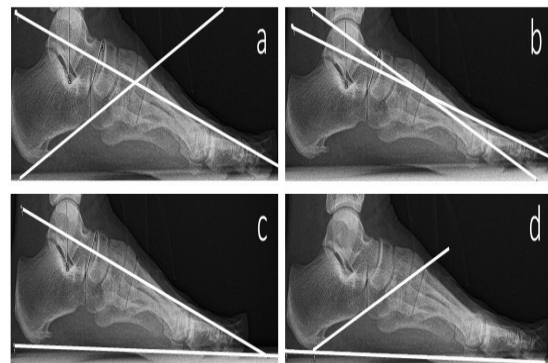


Figure 1. The Angles Measured on a Lateral Roentgenogram.

a: Talocalcaneal Angle, b: Talo-first Metatarsal Angle, c: Talohorizontal Angle, d: Calcaneal Inclination Angle

Lateral Talocalcaneal angle: It is the angle between the midpoint of the lines drawn from the neck and body of the talus and the lines drawn from the plantar edge of the calcaneus. While the value of this angle decreases with the varus and appendix angulation of the hind foot, it increases with heel valgus and pes calcaneus. Normal 25°-45°, PC<25°, PP>45° (28).

Talo-first metatarsal angle: It is the angle between the midpoint of the inclination angle formed by the lines drawn from the neck and body of the talus and the first

metatarsal. While an increase is seen toward positive values in PP, values towards negative values are seen as the degree of deformity increases in PC. An angle that is greater than 4° convex downward is considered PP with an angle of 15°- 30° considered normal. An angle greater than 4 degrees convex upward is considered a PC (28).

Talo-horizontal angle: It is the angle between the inclination angle of the talus and the horizontal support surface. It gives information about the inclination of the talus. Normal 15°-25°, PC<15°, PP>25 (23).

Calcaneal inclination angle: It is the angle between the calcaneal inclination axis and the supporting horizontal surface. While decreasing in pes planus and it increases in PC. Normal 18°-20°, PC>20°, PP<18° (28).

The patient's foot sole pain was measured with a VAS of 10. It was graded by using a VAS pain Score ranging from 0 (no pain) to 10 (maximum pain).

Pedobarographic measurements were made by using a 6-meter-long pedobarography device (RsScan-Footscan® International Belgium, 40x100 cm, 8192 sensors, 253 Hz) embedded in the platform. The patient's height and weight were recorded before the measurements. Then, she/he was asked to step on the platform barefoot with both feet. In order to distribute the body weight equally on both feet and to provide the ideal step range, the patient was asked to step where she/he was. Afterward, the patient was told to look straight ahead and stand still with his hands on either side of her/his body. In this way, the static measured value was recorded. For dynamic measurement, the patient was asked to walk constantly at a comfortable walking speed, looking straight ahead. The measurement was terminated when both feet' soles were wholly seen on the screen 3 times. MLA height was evaluated in recorded static and dynamic pedobarographic measurements. A method similar to the AI method described by Cavanagh and Rodgers was used in the evaluation (29). The foot was divided into three plantar regions (fore, mid and hind feet) excluding the toes. The area covered by the midfoot was calculated with lines drawn from 50% and 69% of the total foot length measured from the toes to the heel (13). The AI value was found by dividing the midfoot area by the foot sole. (Figure 2). Matlab 2015 b Mathworks® software was used to record and analyze the data. AI calculation was performed with this software. Normal 0.21-0.26, PC≤0.21, PP≥0.26 (13).

2.1. Statistical Analysis

The frequencies and percentages were given for categorical variables, and mean, standard deviation (SD), and range (minimum-maximum) values were given for numerical variables as descriptive statistics. Spearman correlation was used to investigate the linear relationship between numerical variables. The agreement of radiological and pedobarographic measurements among themselves and with each other was determined using the "Gwet AC1, Percent agreement (PA) and Cohen's / Conger's κ" coefficients of agreement (30,31). All agreement coefficients were presented with 95% confidence intervals (CI). Due to the problems associated with the Kappa coefficient (31), the Gwet AC1 coefficient,

which gives more consistent and reliable results, was preferred, but according to the published guide (32), other two coefficients were also given in order to present more than one coefficient of agreement. The magnitudes of the agreement coefficients were interpreted according to the Landis and Koch benchmark scale (33). The benchmark interval to which an agreement coefficient belongs was determined with Gwet's probabilistic method.

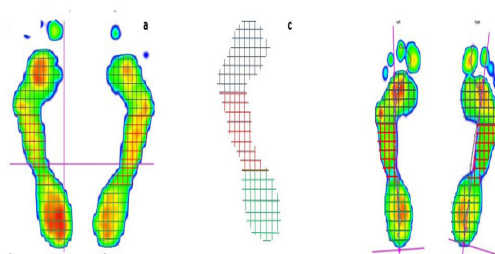


Figure 2. Arch Index Method Measurement with Matlab 2015 b MathWorks® software

a; Static Arch Index, b; Dynamic Arch Index,

$$c; \text{Arch Index Method} = \frac{\text{Red Area}}{\text{Green Area} + \text{Red Area} + \text{Blue Area}}$$

Statistical significance was assessed at $p < 0.05$ and all statistical analyses were performed using R software (R software, version 4.0.5, packages: arsenal-irrcac-ggplot2, R Foundation for Statistical Computing, Vienna, Austria; <http://r-project.org>).

Ethical Aspect of the Research

The study's ethical approval was obtained from the relevant hospital (2018/05-38).

3. Results

In the study a total of 60 patients with foot pain were included, 65% of them were female and the patients' mean age was 45.32 ± 13.64 . The mean height, weight, and body mass index of study the sample was 165.88 ± 8.08 he cm, 75.27 ± 15.31 , and 27.61 ± 5.95 kg/m². The mean FSP according to the VAS was 2.98 ± 1.24 (Table 1).

Table 1. Demographic and Foot Pain Characteristics of The Patients (n=60)

	Mean (SD)	Range
Age (years)	45.32 (13.64)	18–69
Height (cm)	165.88 (8.08)	150–182
Weight (kg)	75.27 (15.31)	45–115
Body mass index (kg/m ²)	27.61 (5.95)	16.65–46.06
Gender, Female: n (%)	39 (65.0)	
VAS	2,98 (1,24)	1-6

Abbreviation: VAS; Visual Analog Scale

The mean/median and range of the calcaneal pitch-angle, talocalcaneal angle, talohorizontal angle, talo-first metatarsal angle, static arch index, and dynamic arch

index for both right and left feet were given in Table 2.

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Abbreviation: VAS; Visual Analog Scale

The relationships between radiological and pedobarographic measurements in the left (upper triangular) and right foot (lower triangular) were shown in Figure 3. The pattern of the colored correlation matrix was symmetric between the left and right foot as expected. Among the correlations of radiological measurements (4x4 part of the lower left corner of Figure 3 the weakest correlations, ranging from 0.022 to 0.156, were observed between TC and TM1, and TH. On the other hand, the strongest correlations were observed between TM1 and TH (Left: $r=-0.792$ and Right: $r=-0.666$, for both $p<0.001$) and TC and CIA (Left: $r=0.575$ and Right: $r=0.675$, for both $p<0.001$). Static and dynamic indices showed a strong positive correlation with each other (Left: $r=0.800$ and $p<0.001$, Right: $r=0.825$ and $p<0.001$). CIA showed the strongest correlations, not exceeding 0.546, with static and dynamic measurements among radiological measurements in both feet (Figure 3).

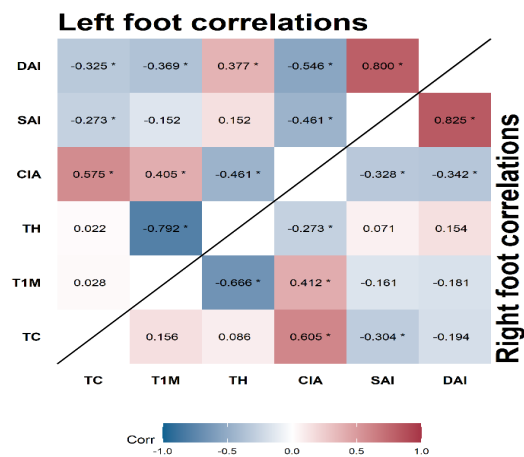


Figure 3. The Relationships Among Radiological, Pedobarographic Measurements and Demographic Data in Left (Upper Triangular) and Right Foot (Lower Triangular)

Abbreviations: DAI; Dynamic arch index, SAI; Static arch index, CIA; Calcaneal inclination angle, TH; Talo-horizontal angle, TM1; Talo-first metatarsal angle, TC; Talocalcaneal angle

Agreement among foot classifications of radiologic measurements was poor AC= -0.198 with 95% CI (-0.315,-

0.080); PA = 0.167 with 95% CI (0.099,0.234) and $k=-0.047$ with 95% CI (-0.083,-0.01) considering all feet (n=120) (Table 3.1 and 3.2). While this agreement was moved one

Table 3.1. Agreement Between Radiologic Indices and Pedobarographic Indices

		Dynamic			Static				
		Normal	PP	PC	Normal	PP	PC	Total	
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
Left	TC	Normal	11 (84.6)	30 (90.9)	14 (100.0)	18 (100.0)	22 (88.0)	15 (88.2)	55 (91.7%)
		PP	2 (15.4)	2 (6.1)	0 (0.0)	0 (0.0)	2 (8.0)	2 (11.8)	4 (6.7%)
		PC	0 (0.0)	1 (3.0)	0 (0.0)	0 (0.0)	1 (4.0)	0 (0.0)	1 (1.7%)
	T1M	Normal	3 (23.1)	13 (39.4)	3 (21.4)	6 (33.3)	8 (32.0)	5 (29.4)	19 (31.7%)
		PP	10 (76.9)	20 (60.6)	11 (78.6)	12 (66.7)	17 (68.0)	12 (70.6)	41 (68.3%)
		PC	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0%)
	TH	Normal	7 (53.8)	27 (81.8)	3 (21.4)	10 (55.6)	18 (72.0)	9 (52.9)	37 (61.7%)
		PP	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0%)
		PC	6 (46.2)	6 (18.2)	11 (78.6)	8 (44.4)	7 (28.0)	8 (47.1)	23 (38.3%)
	CIA	Normal	4 (30.8)	5 (15.2)	1 (7.1)	3 (16.7)	5 (20.0)	2 (11.8)	10 (16.7%)
		PP	2 (15.4)	20 (60.6)	2 (14.3)	8 (44.4)	13 (52.0)	3 (17.6)	24 (40.0%)
		PC	7 (53.8)	8 (24.2)	11 (78.6)	7 (38.9)	7 (28.0)	12 (70.6)	26 (43.3%)
Total		13 (21.7)	33 (55.0)	14 (23.3)	18 (30.0)	25 (41.7)	17 (28.3)		
Right	TC	Normal	18 (85.7)	24 (85.7)	8 (72.7)	15 (93.8)	24 (88.9)	11 (64.7)	50 (83.3%)
		PP	3 (14.3)	3 (10.7)	3 (27.3)	1 (6.2)	2 (7.4)	6 (35.3)	9 (15.0%)
		PC	0 (0.0)	1 (3.6)	0 (0.0)	0 (0.0)	1 (3.7)	0 (0.0)	1 (1.7%)
	T1M	Normal	9 (42.9)	14 (50.0)	4 (36.4)	7 (43.8)	13 (48.1)	7 (41.2)	27 (45.0%)
		PP	12 (57.1)	14 (50.0)	7 (63.6)	9 (56.2)	14 (51.9)	10 (58.8)	33 (55.0%)
		PC	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0%)
	TH	Normal	12 (57.1)	21 (75.0)	10 (90.9)	9 (56.2)	21 (77.8)	13 (76.5)	43 (71.7%)
		PP	1 (4.8)	0 (0.0)	0 (0.0)	1 (6.2)	0 (0.0)	0 (0.0)	1 (1.7%)
		PC	8 (38.1)	7 (25.0)	1 (9.1)	6 (37.5)	6 (22.2)	4 (23.5)	16 (26.7%)
	CIA	Normal	6 (28.6)	5 (17.9)	1 (9.1)	3 (18.8)	7 (25.9)	2 (11.8)	12 (20.0%)
		PP	5 (23.8)	9 (32.1)	1 (9.1)	7 (43.8)	7 (25.9)	1 (5.9)	15 (25.0%)
		PC	10 (47.6)	14 (50.0)	9 (81.8)	6 (37.5)	13 (48.1)	14 (82.4)	33 (55.0%)
Total		21 (30.0)	28 (46.7)	11 (18.3)	16 (26.7)	27 (45.0)	17 (28.3)		

Abbreviations: TC; Talocalcaneal angle, T1M; Talo-first metatarsal angle, TH; Talo-horizontal angle, CIA; Calcaneal inclination angle, PP; Pes planus, PC; Pes cavus

Table 3.2. Coefficients of Agreement Between Radiologic Indices and Pedobarographic Indices

		Gwet's AC			Percent Agreement			Kappa		
		AC	95% CI*	Int.	PA	95% CI*	Int.	κ	95% CI*	Int.
Dynamic	Left	TC	-0.094	(-0.266,0.077)	Poor	0.217	(0.109,0.324)	Slight	-0.030	(-0.118,0.059)
		T1M	0.158	(-0.042,0.358)	Poor	0.383	(0.257,0.51)	Fair	-0.110	(-0.28,0.06)
		TH	-0.041	(-0.221,0.138)	Poor	0.300	(0.181,0.419)	Fair	0.099	(-0.021,0.219)
		CIA	0.393	(0.199,0.588)	Fair	0.583	(0.455,0.712)	Moderate	0.352	(0.171,0.532)
	Right	TC	0.107	(-0.089,0.302)	Poor	0.350	(0.226,0.474)	Fair	-0.023	(-0.146,0.099)
		T1M	0.136	(-0.053,0.324)	Poor	0.383	(0.257,0.51)	Fair	-0.053	(-0.251,0.146)
		TH	-0.124	(-0.306,0.057)	Poor	0.217	(0.109,0.324)	Slight	-0.131	(-0.249,-0.013)
		CIA	0.103	(-0.088,0.295)	Poor	0.400	(0.272,0.528)	Fair	0.158	(0.001,0.315)
Static	Left	TC	0.081	(-0.118,0.28)	Poor	0.333	(0.211,0.456)	Fair	0.037	(-0.026,0.1)
		T1M	0.130	(-0.068,0.328)	Poor	0.383	(0.257,0.51)	Fair	0.006	(-0.159,0.171)
		TH	-0.026	(-0.212,0.16)	Poor	0.300	(0.181,0.419)	Fair	0.009	(-0.133,0.151)
		CIA	0.210	(0.011,0.408)	Slight	0.467	(0.337,0.597)	Fair	0.193	(0.009,0.376)
	Right	TC	-0.013	(-0.206,0.18)	Poor	0.283	(0.166,0.401)	Slight	-0.016	(-0.099,0.067)
		T1M	0.070	(-0.123,0.263)	Poor	0.350	(0.226,0.474)	Fair	-0.028	(-0.197,0.142)
		TH	-0.142	(-0.313,0.028)	Poor	0.217	(0.109,0.324)	Slight	-0.079	(-0.208,0.05)
		CIA	0.111	(-0.085,0.308)	Poor	0.400	(0.272,0.528)	Fair	0.115	(-0.048,0.279)
120 feet	Left	Static-Dynamic	0.464	(0.273,0.654)	Fair	0.633	(0.508,0.759)	Moderate	0.427	(0.243,0.611)
		Among Radio.	0.018	(-0.082,0.118)	Poor	0.322	(0.267,0.377)	Fair	-0.094	(-0.141,-0.046)
	Right	Static-Dynamic	0.510	(0.324,0.695)	Fair	0.667	(0.544,0.789)	Moderate	0.483	(0.3,0.666)
		Among Radio.	0.122	(0.004,0.24)	Slight	0.383	(0.317,0.449)	Fair	-0.035	(-0.1,0.029)
		Static-Dynamic	0.486	(0.355,0.617)	Fair	0.65	(0.563,0.737)	Moderate	0.453	(0.324,0.583)
		Among Radio.	-0.198	(-0.315,-0.08)	Poor	0.167	(0.099,0.234)	Slight	-0.047	(-0.083,-0.01)

Abbreviations: PA: percent agreement, CI*: Confidence interval, K: kappa, Int.:interpretation TC; Talocalcaneal angle, T1M; Talo-first metatarsal angle, TH; Talo-horizontal angle, CIA; Calcaneal inclination angle

degree higher on the right foot as “slight”, the degree of the agreement remained the same on the left foot (as “poor”) (Table 4.1 and 4.2). The agreement between static and dynamic classifications was fair AC=0.486 with 95% CI (0.355,0.617); PA =0.65 with 95% CI (0.563,0.737) and k=0.453 with 95% CI (0.324,0.583) considering 120 feet. When the agreement between radiologic and pedobarographic measurements was examined CIA showed the highest coefficients of agreement among other radiological measurements. However, the extent of an agreement reached a “fair” level only for the agreement with the dynamic measurement in the left foot (Table 3.1 and 3.2).

4.Discussion

The aim of this study was to determine the relationship between two methods that are frequently used in the measurement of MLA height in patients with FSP. In our study, all cases with a certain etiology that caused foot pain were excluded from the study. Only cases with idiopathic FSP were included in the study. The reason for this was to investigate the relationship between X-ray images and pedobarographic AI measurements objectively. We also

included the relationship between lateral foot radiographs taken under weight-bearing and static and dynamic pedobarographic measurements in order to increase the reliability of these findings.

When we look at the correlation of the radiological measurements within themselves, we found a positive relationship between the TC and CIA angles and a negative relationship between the T1M and TH angles. While the inclination angle of the talus increases, the angle of the 1st metatarsal decreases. We think that this situation occurs due to the anatomical structure of the foot. Even in the study of Agoada et al. (5), they found the CIA and TC angle to be related but did not find a relationship between the CIA and TH angle. Radiological measurements are extremely important in terms of detecting bone pathologies in the foot. However, its two-dimensional nature and difficulties in the applicability of imaging standards create disadvantages (34). It is not possible to be sure that sufficient body weight is carried due to avoidance of pain in the imaging process performed when there is foot pain. This situation makes the use of images in the determination of MLA height controversial.

Table 4.1. Agreement Between Radiologic Indices and Pedobarographic Indices

		Dynamic			Static			
		Normal	PP	PC	Normal	PP	PC	Total
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Left	TC							
	Normal	11 (84.6)	30 (90.9)	14 (100.0)	18 (100.0)	22 (88.0)	15 (88.2)	55 (91.7%)
	PP	2 (15.4)	2 (6.1)	0 (0.0)	0 (0.0)	2 (8.0)	2 (11.8)	4 (6.7%)
	PC	0 (0.0)	1 (3.0)	0 (0.0)	0 (0.0)	1 (4.0)	0 (0.0)	1 (1.7%)
	TIM							
	Normal	3 (23.1)	13 (39.4)	3 (21.4)	6 (33.3)	8 (32.0)	5 (29.4)	19 (31.7%)
	PP	10 (76.9)	20 (60.6)	11 (78.6)	12 (66.7)	17 (68.0)	12 (70.6)	41 (68.3%)
	PC	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0%)
	TH							
	Normal	7 (53.8)	27 (81.8)	3 (21.4)	10 (55.6)	18 (72.0)	9 (52.9)	37 (61.7%)
	PP	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0%)
	PC	6 (46.2)	6 (18.2)	11 (78.6)	8 (44.4)	7 (28.0)	8 (47.1)	23 (38.3%)
	CIA							
Normal	4 (30.8)	5 (15.2)	1 (7.1)	3 (16.7)	5 (20.0)	2 (11.8)	10 (16.7%)	
PP	2 (15.4)	20 (60.6)	2 (14.3)	8 (44.4)	13 (52.0)	3 (17.6)	24 (40.0%)	
PC	7 (53.8)	8 (24.2)	11 (78.6)	7 (38.9)	7 (28.0)	12 (70.6)	26 (43.3%)	
Total		13 (21.7)	33 (55.0)	14 (23.3)	18 (30.0)	25 (41.7)	17 (28.3)	
Right	TC							
	Normal	18 (85.7)	24 (85.7)	8 (72.7)	15 (93.8)	24 (88.9)	11 (64.7)	50 (83.3%)
	PP	3 (14.3)	3 (10.7)	3 (27.3)	1 (6.2)	2 (7.4)	6 (35.3)	9 (15.0%)
	PC	0 (0.0)	1 (3.6)	0 (0.0)	0 (0.0)	1 (3.7)	0 (0.0)	1 (1.7%)
	TIM							
	Normal	9 (42.9)	14 (50.0)	4 (36.4)	7 (43.8)	13 (48.1)	7 (41.2)	27 (45.0%)
	PP	12 (57.1)	14 (50.0)	7 (63.6)	9 (56.2)	14 (51.9)	10 (58.8)	33 (55.0%)
	PC	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0%)
	TH							
	Normal	12 (57.1)	21 (75.0)	10 (90.9)	9 (56.2)	21 (77.8)	13 (76.5)	43 (71.7%)
	PP	1 (4.8)	0 (0.0)	0 (0.0)	1 (6.2)	0 (0.0)	0 (0.0)	1 (1.7%)
	PC	8 (38.1)	7 (25.0)	1 (9.1)	6 (37.5)	6 (22.2)	4 (23.5)	16 (26.7%)
	CIA							
Normal	6 (28.6)	5 (17.9)	1 (9.1)	3 (18.8)	7 (25.9)	2 (11.8)	12 (20.0%)	
PP	5 (23.8)	9 (32.1)	1 (9.1)	7 (43.8)	7 (25.9)	1 (5.9)	15 (25.0%)	
PC	10 (47.6)	14 (50.0)	9 (81.8)	6 (37.5)	13 (48.1)	14 (82.4)	33 (55.0%)	
Total		21 (30.0)	28 (46.7)	11 (18.3)	16 (26.7)	27 (45.0)	17 (28.3)	

Abbreviations: TC; Talocalcaneal angle, T1M; Talo-first metatarsal angle, TH; Talo-horizontal angle, CIA; Calcaneal inclination angle, PP; Pes planus, PC; Pes cavus

In the static and dynamic pedobarographic analysis, we found that the AI value was poorly correlated with only CIA. In their study, Yalçın et al. (20) found CIA incompatible with AI. Kanatlı et al. (24) found a correlation between AI and T1M and TH. Cavanagh et al. (29) found that the navicular height and AI in radiological measurements were 50% compatible. Agoada et al. (5) also stated that CIA should be used for MLA height determination in radiological

measurements. We also agree with this view. Although the talus is an important bone in the foot structure, it cannot be effective in determining the height of the MLA. Because of the lack of talus muscle, it determines its position relative to the calcaneus and navicular bone. The positions of the calcaneus and navicular bone during walking and standing give direction to the movement of the talus. In fact, while the talus transfers body weight to other muscle and bone

Table 4.2. Coefficients of Agreement Between Radiologic Indices and Pedobarographic Indices

		Gwet's AC			Percent Agreement			Kappa		
		AC	95% CI*	Int.	PA	95% CI*	Int.	κ	95% CI*	Int.
Dynamic	Left	TC	-0.094	(-0.266,0.077)	Poor	0.217	(0.109,0.324)	Slight	-0.030	(-0.118,0.059)
		T1M	0.158	(-0.042,0.358)	Poor	0.383	(0.257,0.51)	Fair	-0.110	(-0.28,0.06)
		TH	-0.041	(-0.221,0.138)	Poor	0.300	(0.181,0.419)	Fair	0.099	(-0.021,0.219)
		CIA	0.393	(0.199,0.588)	Fair	0.583	(0.455,0.712)	Moderate	0.352	(0.171,0.532)
	Right	TC	0.107	(-0.089,0.302)	Poor	0.350	(0.226,0.474)	Fair	-0.023	(-0.146,0.099)
		T1M	0.136	(-0.053,0.324)	Poor	0.383	(0.257,0.51)	Fair	-0.053	(-0.251,0.146)
		TH	-0.124	(-0.306,0.057)	Poor	0.217	(0.109,0.324)	Slight	-0.131	(-0.249,-0.013)
Static	Left	CIA	0.103	(-0.088,0.295)	Poor	0.400	(0.272,0.528)	Fair	0.158	(0.001,0.315)
		TC	0.081	(-0.118,0.28)	Poor	0.333	(0.211,0.456)	Fair	0.037	(-0.026,0.1)
		T1M	0.130	(-0.068,0.328)	Poor	0.383	(0.257,0.51)	Fair	0.006	(-0.159,0.171)
		TH	-0.026	(-0.212,0.16)	Poor	0.300	(0.181,0.419)	Fair	0.009	(-0.133,0.151)
	Right	CIA	0.210	(0.011,0.408)	Slight	0.467	(0.337,0.597)	Fair	0.193	(0.009,0.376)
		TC	-0.013	(-0.206,0.18)	Poor	0.283	(0.166,0.401)	Slight	-0.016	(-0.099,0.067)
		T1M	0.070	(-0.123,0.263)	Poor	0.350	(0.226,0.474)	Fair	-0.028	(-0.197,0.142)
		TH	-0.142	(-0.313,0.028)	Poor	0.217	(0.109,0.324)	Slight	-0.079	(-0.208,0.05)
	120 feet	CIA	0.111	(-0.085,0.308)	Poor	0.400	(0.272,0.528)	Fair	0.115	(-0.048,0.279)
		Static-Dynamic	0.464	(0.273,0.654)	Fair	0.633	(0.508,0.759)	Moderate	0.427	(0.243,0.611)
		Among Radio.	0.018	(-0.082,0.118)	Poor	0.322	(0.267,0.377)	Fair	-0.094	(-0.141,-0.046)
		Static-Dynamic	0.510	(0.324,0.695)	Fair	0.667	(0.544,0.789)	Moderate	0.483	(0.3,0.666)
120 feet	Right	Among Radio.	0.122	(0.004,0.24)	Slight	0.383	(0.317,0.449)	Fair	-0.035	(-0.1,0.029)
		Static-Dynamic	0.486	(0.355,0.617)	Fair	0.65	(0.563,0.737)	Moderate	0.453	(0.324,0.583)
120 feet	Left	Among Radio.	-0.198	(-0.315,-0.08)	Poor	0.167	(0.099,0.234)	Slight	-0.047	(-0.083,-0.01)
		Static-Dynamic								

Abbreviations: PA: percent agreement, CI*: Confidence interval, K: kappa, Int.:interpretation TC; Talocalcaneal angle, T1M; Talo-first metatarsal angle, TH; Talo-horizontal angle, CIA; Calkaneal inclination angle

structures, it transfers the ground reaction force to the upper segments to be absorbed in the opposite direction. Therefore, though it is an important bone in the foot structure, its importance in terms of functionality are less.

Another reason for us to think that the use of the talus in radiological measurements to determine the MLA height will lead to a mistake is its two-dimensional evaluation. The accurate evaluation of the talus can only be possible with three-dimensional images. The decrease in MLA height during walking and standing increases the pressure area in the foot. It also causes the pronation center of gravity in the talus to be transferred to the medial aspect of the foot. This situation is realized by the movement behavior of the Subtalar joint (STJ).

The position of the STJ in pedobarography can only be possible by determining the foot pressure area. The reason for the high correlation between static and dynamic measurements is to ensure equal full-weight bearing feet during static imaging. However, this may not be possible

in radiological imaging. For this reason, STJ evaluation can be achieved with pedobarographic static measurement, not as much as dynamic evaluation though.

In dynamic images, all of the body weight is carried on the feet. In this way, the effects of the ground reaction force in walking on foot can be fully and truly evaluated.

5. Conclusion and Recommendations

As a result, pedobarographic measurements are non-invasive, easy, inexpensive, and have no radiation exposure. It will be the gold standard in the future due to its dynamic evaluation of the foot.

In addition to all these, the level of pain during the imaging should be evaluated very well. Since high pain will cause an antalgic gait, it will cause errors in the measurements. It should also be kept in mind that the experience and knowledge of the person making the measurements will also be an important factor. All findings of MLA in pedobarography are consistent with CIA that is measured

radiographically. In the absence of pedobarography, the CIA may provide insight into the arch. If the static evaluation of pedobarography is realized in accordance with the standards, it can provide the correct evaluation. Number of the patients should be increased in future studies. Pedobarography should be compared with dynamic x-ray. In painful feet, the degree of pain between both feet should be evaluated and foot dominance should be taken into consideration.

6. Contribution to the Field

Our study can give clinicians an idea that pedobarographic measurement, a non-invasive, inexpensive, and fast method, is a reliable method for diagnosing foot pain.

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Competing interests

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