

## Clinical Note

### The role of radiological and gravity axis parameters in the assessment of the arch of the foot

The vault structure of the foot conceived as 2 longitudinal and one transverse arches that are designed as a shock absorbers for sporting the weight of the body and for propelling it during movement. The integrity of arches is mainly dependent on the shape of the interlocking bones and ligamentous ties, and secondarily on the functional roles of the muscles. The longitudinal arch is composed of medial and lateral parts but the transverse arch has one part. The medial arch contains the calcaneus, talus, navicular, cuneiform and medial 3 metatarsal bones. This arch is higher, more mobile and resilient than the lateral arch. Clinically observed pes planus by the fallen medial longitudinal arch may be determined by the measure angle on the feet graph.<sup>1</sup> The calcaneal pitch angle (CPA) is formed by the intersection of a line drawn tangentially to the inferior surface of the calcaneus and one drawn along the plantar surface of the foot, (Figure 1), which is considered to be low when it is between  $10^{\circ}$  and  $20^{\circ}$ , moderate when between  $20^{\circ}$  and  $30^{\circ}$ .<sup>2</sup> Additionally the calcaneus-navicular-metatarsal (medial arch) angle (CNMA), used in our laboratories for the evaluation of medial arches, is defined as the angle formed by the inferior surface of the calcaneus, the posterior-inferior surface of navicular and the head of the first metatarsal. According to our observations, it is thought to be moderate when it is between  $120^{\circ}$  and  $130^{\circ}$ , low when above  $130^{\circ}$ . The conservation of bipedal upright position is related to the position of the gravity axis (GA) in relation to the floor supporting area.<sup>3</sup> In addition, for the subjects with

normal feet the situation of the line of the GA on the sagittal plane touches the floor at 30-40 mm in front of the ankle and 100-115 mm in front of the heel. The present work was undertaken to determine the statistical relationship between the CPA, CNMA and GA in the sagittal plane for normal and pes planus of the arch of the foot. To this end, both radiological investigations and the measurements related to the determination of the GA in the sagittal plane were evaluated together.

In the study, 40 normal feet (20 male and 20 female) and 39 pes planus feet (20 male and 19 female) were examined. The age of all the subjects ranged from 20 to 25 years. Standing lateral radiographic films of the feet were taken for normal and pes planus of the arch of the foot prior to measuring the CNMA and the CPA, reference points were marked on each lateral radiographic films of the feet (Figure 1). Using these reference points, angles were measured using a universal goniometer. The situation of the line of the GA on the sagittal plane (Figure 2) was determined by the method of Lovett-Reynolds.<sup>3</sup> Each measurement was repeated 3 times and the statistical analysis was carried out with SPSS 9.0 statistical software. Mean measurement results of the CPA obtained from males and females with normal feet were found to be similar to those of the normal feet between  $20^{\circ}$  and  $30^{\circ}$  degrees observed by other researchers.<sup>2,3</sup> With the same subjects, the CNMA was  $124.47^{\circ}$  and  $124.31^{\circ}$  in females and  $124.02^{\circ}$  and  $124.12^{\circ}$  in males for the right and left normal feet (Table 1). The pearson correlation coefficient values between the CNMA and the CPA were  $-0.80^{**}$  and  $-0.75^{**}$  in females for the left and right normal feet, and  $-0.90^{**}$  and  $-0.87^{**}$  in males for the right and left normal feet, and the results obtained in the males and females showed a

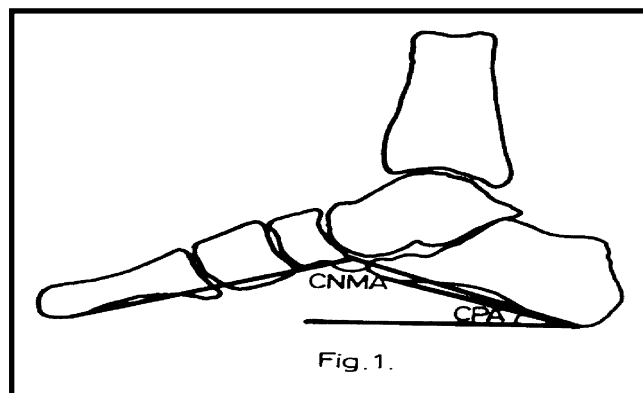


Figure 1 - Schematic representation showing the calcaneus-navicular-metatarsal angle (CNMA), and the calcaneal pitch angle (CPA).

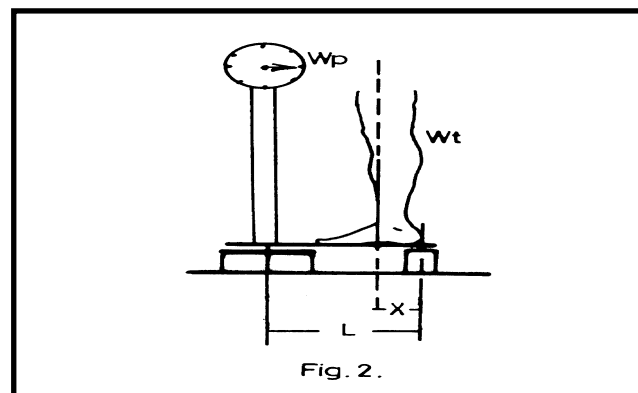


Figure 2 - Lovett and Reynold's method of determining the situation of the line of gravity axis. Wt (total weight); Wp (Partial weight as read from the scale); L (Total distance of the prismatic support); X (Distance from the line of gravity axis on sagittal plane).

# Clinical Note

**Table 1** - The mean of the measurements taken from normal (20 males and 20 females) and pes planus (20 males and 19 females) feet.

Variable	CNMA		CPA		GA	Wt
	Right	Left	Right	Left		
<b>Normal</b>						
Mean male	124.02 ± 2.14	124.12 ± 1.91	22.90 ± 1.27	22.75 ± 1.01	111.05 ± 8.15	64.65 ± 7.38
Mean female	124.47 ± 1.50	124.31 ± 1.49	23.10 ± 0.87	23.26 ± 0.77	102.73 ± 2.53	53.00 ± 5.40
<b>Pes Planus</b>						
Mean male	134.75 ± 2.51	134.57 ± 2.25	16.60 ± 0.94	16.65 ± 0.82	112.55 ± 4.77	64.10 ± 4.02
Mean female	133.31 ± 1.76	134.15 ± 1.59	16.52 ± 0.63	16.31 ± 0.55	101.42 ± 2.87	51.57 ± 4.10
CNMA = Calcaneus-navicular-metatarsal (medial arch) angle; CPA = Calcaneal pitch angle; GA = Gravity axis Wt = Weight						

significant ( $p < 0.001$ ) correlation between the CNMA and the CPA.

The "pes planus" term is generally used for fallen or decreased medial longitudinal arches. This situation may be easily observed clinically. However, what is thought to be pes planus clinically requires radiological examinations.<sup>4</sup> In our study, in both males and females pes planus was observed clinically and as a result of the radiological examinations. The mean CPA for pes planus in males and females in our study (Table 1) was observed to be similar to the pes planus feet CPA values (between 10°-20°) reported in previous studies.<sup>2,3</sup> As to the mean CNMA, the values obtained in our study were 133.31° and 134.15° in females of the right and left normal feet, and 134.75° and 134.57° in males for the right and left normal feet (Table 1). The clinically observed pes planus was also determined radiologically as a result of the measurement of the above angles. The Pearson correlation coefficient between the CNMA and the CPA were -0.83\*\* and -0.87\*\* in females, -0.91\*\* and -0.94\*\* in males for the right and left pes planus feet and the results obtained from the males and females showed a significant ( $p < 0.001$ ) correlation between the CNMA and the CPA.

In our study, the mean of the situation of the line of the GA on the sagittal plane was found to be similar for females and males with normal and pes planus feet (Table 1). These results are similar to those obtained in the previous studies on normal feet.<sup>5</sup> According to our findings, the GA on the sagittal plane does not seem to be a solution for the

evaluation of the arch of the foot. However, a significant correlation was observed between the weight of the subjects and the GA, while there was no correlation between the CNMA and the GA, and between the CPA and the GA. As a result, the CNMA and the CPA were found to play a significant role in determining whether the arch of the foot is normal or pes planus. It was also observed that there is a significant correlation between both angles.

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