

## BACKGROUND

Weightbearing radiographs are routine diagnostic exams used to evaluate pathology and anatomy of the foot and ankle. Often, patients are instructed to place 50% of their weight on the limb being imaged to most closely reproduce normal load. Studies have shown a high variability of the actual percentage of weight patients place on the imaged limb. The purpose of this study was to evaluate the effect various weightbearing statuses had on different radiographic measurements used to diagnose pathology and plan for surgery.

## METHODS

Nine volunteers (18 feet) were enrolled in the study. Dorsal-plantar and lateral x-rays were taken of the foot with three weightbearing statuses: 25%, 50%, and 100% body weight (+/- 5lbs). Body weight was obtained with a scale and percentages were calculated. The scale was placed under the cassette and weightbearing was adjusted to the desired percentage. Radiographs were obtained and uploaded to the PACS system. The following angles were measured: 1<sup>st</sup> intermetatarsal (IM) angle, 1st-5th IM angle, hallux abductus (HA) angle, metatarsus adductus angle (MAA), Kite's angle, Meary's angle (MA), Calcaneal Inclination angle (CA), Talar declination (TD), and Cuboid height (CH). All measurements performed by a single qualified individual in the typical technique described in the literature. After acquiring all radiographic measurements from our 12 feet across the three weightbearing statuses, a paired *t*-test was used to analyze the data.



Left: Clinical images showing the standing AP X-ray (left), and our set up (right) with a scale under the cassette to calculate percentage of weightbearing at the time of imaging.  
 Right: Sequential AP and Lateral images showing changes in our radiographic angles with increased weightbearing.

## RESULTS

Statistically significant differences ( $p \leq 0.05$ ) were found between: 25-50% with MAA & CI; between 25-100% with HA, Kite's angle, CH, TD, and CI; and between 50-100% with 1st IM, HA, CH, CI, and Kite's angle. MAA, CI, and CH were found to be inversely related to WB status, as they decreased with increased weightbearing. Meary's, 1st-5th metatarsal, and Talar declination angle did not statistically decrease. P values are shown in the chart above, with statistically significant values in bold.

## REFERENCES

- Dominguez G, et al. *Metatarsus adductus angle in male and female feet: normal values with two measurement techniques.* J Am Podiatr Med Assoc. 2008 Sep-Oct;98(5):364-9
- Miller CP, et al. *High Variability of Observed Weight Bearing During Standing Foot and Ankle Radiographs.* Foot and Ankle International. 2017, Vol. 38(6): 690-693.
- Fuhrmann RA, et al. *Radiographic Changes in Forefoot Geometry With Weightbearing.* Foot and Ankle International. 2003, Vol. 24(4): 326-331.
- Ito H, et al. *Clinical Significance of Increased Mobility in the Sagittal Plane in Patients with Hallux Valgus.* Foot and Ankle International. 1999, Vol. 20(1): 29-32.
- Tanaka Y, et al. *Radiographic analysis of hallux valgus in women on weightbearing and nonweightbearing.* Clinical Orthopaedics and Related Research. 1997, Mar. 336: 186-94.
- Shelton T, et al. *Influence of Percentage Weight-Bearing on Foot Radiographs.* Foot & Ankle Specialist. 2018, Vol 20(10): 1-7.

## DISCUSSION

Radiographic measurements are routinely utilized to evaluate deformity in the foot and ankle. These values can help surgeons in choosing the correct procedure during surgical planning. In our study, measurements that were positively correlated with increased weightbearing included 1st IM, HA, and Kite's angle. MAA, CI, and CH decreased significantly with increased weightbearing. Shelton et al. found similar results finding a significant increase in talocalcaneal angle and decrease in CH upon increased weightbearing. Our results suggest that certain radiographic measurements may change significantly based upon percentage of weightbearing. This variable should be taken into consideration during surgical planning, especially in patients with injuries that prevent them from fully bearing weight. Limitations of our study include subjective nature of radiographic measurements and the limitations in reproducibility in transfer to weightbearing percentage. Further studies are needed to determine the clinical significance of these changes and whether or not they would alter preoperative planning significantly. Studies such as this can help foot and ankle surgeons understand the impact of proper weightbearing films, and come up with the best way to standardize foot and ankle radiographs. Furthermore, the use of more accurate equipment and methods of reproducing percentages of weightbearing is needed to help standardize the process. In conclusion, the percentage of true weightbearing has significant impact on common radiographic measurements of the foot.

Measurement	P value	25% to 50%	25% to 100%	50% to 100%
1st Intermetatarsal angle	0.57	0.34	<b>0.004</b>	
Hallux Abductus angle	0.86	<b>0.05</b>	<b>0.03</b>	
1st-5th Metatarsal angle	0.50	0.06	0.09	
Metatarsus Adductus angle	<b>0.03 (decreased)</b>	0.43	0.58	
Kite's angle	0.08	<b>0.0002</b>	<b>0.00003</b>	
Meary's angle	.115	.474	.125	
Calcaneal Inclination	.041	<b>.00003</b>	<b>.00003</b>	
Cuboid Height	.099	<b>.001</b>	<b>.0002</b>	
Talar Declination	.133	.201	.056	

