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REGIONAL AND GENDER-BASED NORMATIVE VALUES OF THE TALOCALCANEAL ANGLE IN AN AFRICAN POPULATION

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ABSTRACT

Background: The talocalcaneal angle (TCA) is an important radiographic parameter used to evaluate hindfoot alignment and diagnose various foot deformities. While extensive data exist for non-African populations, research on normal TCA ranges for African populations remains limited, despite their importance for region-specific diagnostic and surgical planning.

Objective: This study aimed to establish a nomogram for the TCA in an African population, evaluating potential gender and age differences and comparing findings with non-African studies.

Methods: A prospective cross-sectional study was conducted with 120 participants (60 males, 60 females) aged 19–70 years. Standardized lateral weightbearing foot radiographs were obtained following clinical examination to exclude pathological conditions. The TCA was measured three times by two independent raters, and the intraclass correlation coefficient (ICC) was used to assess inter- and intra-rater reliability. Statistical analyses, including independent t-tests and ANOVA, were performed to evaluate gender and age effects.

Results: The mean ± 2SD TCA was 39.20 ± 6.76 degrees, with a normal range of 32.44 to 45.96 degrees. No significant differences were observed between genders or across age groups ($p > 0.05$). ICC analysis demonstrated excellent reliability for averaged measures ($p < 0.001$). The TCA was significantly higher than reported values in non-African populations ($p < 0.05$).

Conclusion: This study provides a population-specific normal range for TCA in an African cohort, emphasizing the importance of regional norms for clinical and surgical decision-making. Future research should explore factors influencing TCA and validate these findings across diverse African populations.

Keywords: Talocalcaneal angle, Hindfoot alignment, Radiographic measurements, African population, Foot deformities.

Introduction

The talocalcaneal angle (TCA) is a key radiographic measurement used to evaluate hindfoot alignment and diagnose various foot disorders (1). It is used for evaluating hindfoot alignment, diagnosing causes of foot pain, and other disorders such as pes planus, pes

cavus, pes planovalgus, calcaneal spur, and talocalcaneal coalitions (2–4). Angular measurements of the ankle are very critical for surgical planning during the preoperative, intraoperative, and postoperative phases (5). This angle, formed by the bisection of the talar neck and the lateral calcaneal border, is critical in assessing calcaneal-talar alignment and guiding surgical management (5). The talocalcaneal angle shows the alignment of the calcaneus with the talus with respect to the ankle joint, and deviations from the normal value are implicated in various congenital and acquired foot deformities. An optimally positioned and exposed anteroposterior and lateral radiograph of the ankle and foot with weightbearing remains the best imaging method for assessment of these angles since it provides the physiological loading conditions of the bones of the foot.

Existing studies report a wide range of normal TCA values, from 20.00 degrees (6) to 31.21 degrees (7), highlighting variability across populations and methodologies. The study by Lamm(5) and Carrara(1) provides an almost exhaustive list of normal ranges for the talocalcaneal angle as well as other angles measurable from the foot and ankle. Studies in Africa are very few, but existing ones appear to demonstrate that the talocalcaneal angle is higher in the African population. A study of the Nigerian population recorded mean values of 32.83 degrees (7) and 38.85 degrees (8) . A Ugandan study also reported values of 35.1 for males and 37.1 degrees for females (9), while establishing significant sex and regional differences when compared to the Nigerian population. These findings suggest potential regional and gender differences; however, current data remain limited and inconsistent. For instance, a Nigerian study using retrospective radiographs reported significantly lower mean values (22.58 ± 5.28)(10), raising questions about measurement validity. With very few studies reporting normal ranges of the talocalcaneal angle in Africa and considering the pivotal role angle measurements play in the surgical management of foot disorders for the African population, it may not be adequate to rely on existing data.

This study aims to establish a reliable nomogram for TCA values in an African population and comparing its findings with other TCA measurements in African and non-African regions.

Methods:

This prospective cross-sectional study involved 72 males and 66 females aged between 19 and 70 years. Participants were referred across five radiography units for ankle x-ray examinations following outpatient consultations to rule out possible foot pathology. Ethical clearance was obtained from a national research and ethics body (NHRECIO5/01/2008B-FWA00002458-1RBO0002323), and all participants provided informed consent. Excluded from the study were subjects with arthritis, a history of trauma, and postsurgical procedure, or those booked for surgery for an identified congenital or acquired pathology. Radiographs obtained were reviewed by a consultant radiologist prior to acceptance, and those with identifiable pathologies were excluded.

Radiographs were obtained in accordance with Lamm et al.'s protocol for lateral weightbearing foot radiographs (5). Patients were positioned with a slight forward lean (approximately 10 degrees) to shift body weight onto the foot being examined. Adequate radiation protection in line with departmental protocols was given to the subjects.

Measurements

All digital images were analysed using Carestream Image Suite (version 4.0.4.0.254) on a Samsung S24D300 workstation. Two lines were drawn on each radiograph: one through the long axis of the calcaneus and the other through the long axis of the talus (Figure 1). The acute angle at the intersection of these lines was measured. Measurements were performed independently by the principal investigator and a reporting radiographer, both with more than 10 years of clinical experience and blinded to the measurements of the other. Each rater measured each image three times over two sessions, and the mean of these values was calculated.

The average of the measurements for each rater was obtained and used for ICC assessment, while the final

talocalcaneal angle was the average of the measurements of the two raters. The acceptable ICC threshold was set at >0.75.

Data Analysis

Data were recorded in a Microsoft Excel sheet and imported to SPSS version 21. Results were displayed in tables. The inter- and intraclass correlation coefficient was used to assess the level of agreement within and between the two raters. Histogram plots with a normal curve were used to assess for normality, and an independent sample t-test was used to check for possible gender differences in talocalcaneal angles. The significant level was set at 0.05.

Figure 1: Measurement of the talocalcaneal angle

Results:

A total of 138 subjects were examined. Seventeen of the subjects were excluded from the study as a result of various pathologies observed in the radiograph (n = 5) and previous trauma/surgery (n = 12), leaving 121 radiographs. A boxplot identified an outlier value, a 21-year-old male with a talocalcaneal angle of 24.0, and the data was also removed as it was likely a result of measurement error, leaving a total of 120 subjects for analysis, comprising an equal number of males and females. A histogram plot confirmed normally distributed talocalcaneal angle measurements.

Reliability analysis

The intraclass correlation coefficient (ICC) for individuals and both raters is shown in Table 1. They indicate good reliability when measures are single and excellent reliability when the measures are averaged. Both values were statistically significant (F test, $p < 0.001$), confirming consistency in the measurements.

Gender and age analysis

The age distribution of the subjects is shown in Table 2. The mean + SD of the talocalceneal angle for males (32.66 + 3.27 degrees) was slightly higher than the females (32.42 + 3.51 degrees). Levene's test for equality of variances indicated no significant difference in variances between genders (Table 3). Therefore, equal variances were assumed for the t-test. The independent samples t-test showed no statistically significant difference in the talocalcaneal angle between males and females. Also, an analysis of variance also demonstrated that there was no significant difference in the mean talocalcaneal angle across the age groups (Table 4). A test of linearity also suggested a very weak relationship between age and talocalcaneal angle.

Normal range

To include 95% of the population under study, the mean +2SD of the talocalaneal angle studied is 39.20 + 6.76 degrees, with a normal range of 32.44 to 45.96 degrees.

Population comparisons

When compared to other mean values from other studies, grouping them into African and non-African studies (Table 5), an independent samples t-test comparing mean TCA between African (mean ± SD = 34.36 ± 6.25) and non-African populations (mean ± SD = 24.02 ± 5.27) revealed a statistically significant difference ($p = 0.02$).

Table 1: Inter- and Intraclass correlation for single and both raters

Interclass Correlation		95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	0.869	0.818	0.907	14.324	119	119	0.000
Average Measures	0.930[c]	0.900	0.951	14.324	119	119	0.000
Intraclass Correlation		95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	0.875	0.835	0.907	21.964	119	238	0.000
Average Measures	0.954[c]	0.938	0.967	21.964	119	238	0.000

Table 2: Age distribution of participants

		Talocalcaneal angle (degrees)					
		Male			Female		
		n	Mean (deg)	SD	n	Mean (deg)	SD
Age group (years)	<= 28	13	32.22	3.09	15	32.81	3.28
	29 - 38	10	31.64	2.75	14	31.36	2.35
	39 - 48	14	32.46	2.70	12	32.97	4.00
	49 - 58	10	30.90	3.32	10	33.84	3.36
	59 - 68	10	36.48	2.62	6	29.90	4.97
	69+	3	32.07	0.31	3	33.53	3.23
	Total	60	32.66	3.27	60	32.42	3.51

Table 3: Independent samples t-test for talocalcaneal angle of both gender

			Talocalcaneal angle (degrees)	
			Equal variances assumed	Equal variances not assumed
Levene's Test for Equality of Variances	F		0.398	
	Sig.		0.529	
t-test for Equality of Means	t		0.387	0.387
	df		118	117.396
	Sig. (2-tailed)		0.699	0.699
	Mean Difference		0.24000	0.24000
	Std. Error Difference		0.61962	0.61962
	95% CI of the Difference	Lower	-0.98702	-0.98709
		Upper	1.46702	1.46709

Table 4: ANOVA test for talocalcaneal angle across age groups.

	Talocalcaneal angle (degrees) * Age group (years)				
	Between Groups			Within Groups	Total
	(Combined)	Linearity	Deviation from Linearity		
Sum of Squares	63.501	20.155	43.346	1297.347	1360.848
df	5	1	4	114	119
Mean Square	12.700	20.155	10.836	11.380	
F	1.116	1.771	0.952		
Sig.	0.356	0.186	0.437		

Table 5: Independent samples t test for TCA for African and non-African regions

			mean	
			Equal variances assumed	Equal variances not assumed
Levene's Test for Equality of Variances	F		0.045	
	Sig.		0.836	
t-test for Equality of Means	t		2.842	2.870
	df		9	8.901
	Sig. (2-tailed)		0.019	0.019
	Mean Difference		10.33600	10.33600
	Std. Error Difference		3.63661	3.60115
	95% CI of the Difference	Lower	2.10942	2.17580
		Upper	18.56258	18.49620

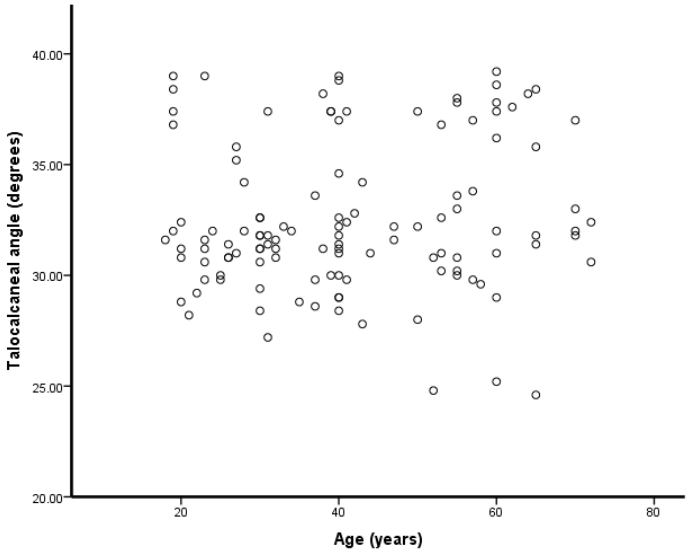

Figure 2: Scatterplot between Age of subjects and talocalcaneal angle.

Discussion:

We report a mean + 2SD of the talocalcaneal angle as 39.20 + 6.76 degrees. This is the highest mean talocalcaneal angle measured for an African population. Our values are closer to earlier reported values in the same region (7–9) when compared with values reported in non-African studies (5,6,11–13). A similar study to ours reported a very low talocalcaneal angle of 22.58 degrees, but the study utilised retrospective data, and the authors relied only on radiological and not clinical findings to exclude cases. Dahiru and colleagues also did a similar study in the same region and reported a value of 38.85 + 8.2, which is closer to our findings.

The mean values of studies from the non-African population had a range of 20 to 33.8 degrees, and they are significantly different from measurements from the African population. The significant difference in TCA measurements between African and non-African populations may be influenced by anatomical or genetic factors, but further research is needed to determine the precise contributors. However, till possible confounding variables are identified, we are of the opinion that regional variations of TCA should be considered when pre-, inter-, and post-surgical interventions are being discussed. Age and gender had no effect on the talocalcaneal angle, though Igbigbi held to the contrary that Ugandan females had a wider angle than males (9). However, other studies maintained there was no significant difference between both genders (8,10). We further observed that it is better for talocalcaneal angle measurements to be used for critical surgical or clinical decisions to be measured at least 2 times by two different raters since a combination of measurements had a higher reliability than single measurements.

The strength of our study is that we tried to address limitations identified in previous studies by using a large sample of 120 participants equally distributed across genders. We used a prospective rather than a retrospective study to ensure that the subjects were examined by a clinician and the clinical history obtained. Additionally, the positioning technique for lateral radiographs was closely monitored to ensure that the same technique and centering point were used for all the studies. All radiographs were reviewed by

reporting radiographers, further ensuring that non-pathological ones were used for measurements. While our study addressed several limitations of prior research, it was limited by the exclusion of confounding variables such as BMI or activity levels of subjects, which may influence TCA. Additionally, the findings may not be generalizable to all African populations due to regional anatomical variability

In conclusion, our reported mean talocalcaneal angle is 39.20 + 6.76 degrees, with a normal range of 32.44 to 45.96 degrees. The angle is independent of gender and age but is significantly different from measurements outside the African population. We therefore maintain that surgical decisions requiring use of talocalcaneal angle should rely on regional normal ranges rather than generic normal ranges.

Conflict of interest

None

Generative AI Declaration

During the preparation of this work the authors used Microsoft Copilot to check for syntax and grammatical errors. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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