

# Normal Values of Tibio-Femoral Angle in Nigerian Adolescents

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## Abstract

Normal values of Tibio-Femoral Angles (TFAs) for children from different populations have been established. Equivalent data for adolescents are few. The aim of this study was to establish normal values of TFAs of Nigerian adolescents. Using the systematic random sampling method, 5,466 adolescents were recruited into this cross-sectional survey from 20 secondary schools in Educational District V of Lagos State, Nigeria. Age was recorded and anthropometric data were measured using international standards. TFA was measured clinically using the universal goniometer. The 95% confidence interval of the mean was used as the range for normal Tibio-Femoral Angle values. TFAs of males and females were compared using independent t-test. Level of significance was set at  $p < .05$ . Participants (2718 males, 2,748 females) were aged  $14.6 \pm 2.6$  years and BMI was  $19.7 \pm 4.4 \text{ kg/m}^2$ . Most participants (92.6%) had genu valgus. The normal valgus angle values were  $11.06^\circ - 11.20^\circ$  for males and  $11.62^\circ - 11.79^\circ$  for females. Females had significantly higher valgus angle than the males ( $p < .05$ ). The TFA in these Nigerian adolescents is predominantly valgus and the normal values range from  $10.8^\circ - 12.1^\circ$ .

## INTRODUCTION

The patterns and development of age-referenced normal values of Tibiofemoral Angle (TFA) described for many different populations vary. Studies on the Caucasians have described the pattern as a varus presentation at age 0-3 years, with a mean varus angle of  $16.5^\circ$  at birth decreasing to  $10-12^\circ$  at 1 year<sup>[1-4]</sup>. At age 3 years, valgus angle predominates with a mean valgus angle of  $12.0^\circ$ . There was a preservation of  $5-6^\circ$  of valgus in children aged between 7-12 years<sup>[2-3,6]</sup>. At birth, Chinese children have varus presentation of 3cm intercondylar distance and also preservation of  $5^\circ$  of varus angle at age 3-11 years<sup>[7]</sup>. Nigerian children have been observed to present a valgus angle at age 1 - 10 years with the highest valgus of  $14.1^\circ \pm 5.8^\circ$  observed at age 3 years<sup>5</sup>, while another study by Oginni et al.<sup>[8]</sup>, on children aged 0-12 years, observed a smooth and gradual change from varus to valgus after 23 months. Unlike the Chinese children, developmental/physiological genu valgus is more common than genu varus among the Caucasians and Nigerian children. However the valgus angle reported for Caucasian children is much lower ( $5.8^\circ$ )<sup>[3]</sup> than  $11.0^\circ$  valgus reported for the Nigerian children<sup>[5]</sup>.

In many populations, Nigerian inclusive, normal values of

the tibiofemoral angles in children have been established<sup>[3,5,8-11]</sup>, however equivalent data for adolescents (11 and 19 years of age) is not readily available. Studies on TFA on American and European adolescents have reported predominance of valgus angle as a measurable varus angle at this period of age is considered abnormal<sup>[10]</sup>. For European adolescents reported values were  $5.5^\circ$  for females and  $4.4^\circ$  for males<sup>[9]</sup>; for Turkish adolescents, values were  $6.6^\circ$  for males and  $7.5^\circ$  for females<sup>[10]</sup>. For the American adolescents,  $5-6^\circ$  has been reported<sup>[6]</sup>. Normal values of TFA in Nigerian adolescents have not been previously documented. This study was therefore conducted to determine the normal values of tibiofemoral angles of Nigerian adolescents.

## METHODS

One out of the six education districts in Lagos state, Nigeria was randomly selected by balloting. Twenty secondary schools were selected from the 66 schools in the district using a table of random numbers<sup>[12]</sup>. Three hundred students (50 students from each of the six classes) were selected from each school, using the systematic sampling method. A total of 5,466 (whose parents gave consent in addition to their own consent) out of 6,000 randomly selected students, aged 11-19 years participated in this cross sectional survey.

Age as at last birthday and gender were recorded. Body weight was measured with students bare-footed in school uniform standing on a scale (Seca, Germany) looking straight forward<sup>[13]</sup>. Height was measured with each participant standing upright, barefooted, heels together, knees straight with the back against the height meter (Seca, Germany), looking straight forward. The horizontal projection of the height meter was adjusted to touch the vertex of the subject without exerting undue pressure. The height was then recorded in meters (m) to the nearest whole number<sup>[13]</sup>.

The body mass index of participants was calculated. The tibiofemoral angle was measured with the subjects standing in anatomic position, with hips and knees in full extension. All landmarks (anterior superior iliac spine, apex of the patella, mid-point of the ankle and the second toe) were identified by palpation and marked with the skin marker. A piece of an embroidery thread was attached with cellotape to the identified body landmarks, this showed the line of the TFA. The goniometer was then placed, with the centre on the apex of the patella and the arms aligned to the thread. The acute angle between the shafts of the femur and the tibia was then measured in degrees and recorded as the genu valgus/genu varus present<sup>[4]</sup>.

**DATA ANALYSIS**

The mean and percentile of tibiofemoral angles were calculated. The 95% confidence interval was used as range for normal value { $X \pm 1.96SE(X)$ }. Independent t-test was used to compare the tibiofemoral angles in males and females.

**RESULTS**

Participants’ (2,718 males and 2,748 females) mean age was  $14.7 \pm 2.2$  years, mean weight was  $48.4 \pm 11.8$ kg and mean height was  $1.6 \pm 0.1$ m. Their body mass index averaged  $19.7 \pm 4.4$ kg/m<sup>2</sup>.

Majority (92.6%) of the participants had valgus angle while only 7.4% had varus angle presentation. The normal values of valgus angle at 95% CI ranged from 10.8°–12.1° (mean value  $11.4 \pm 1.9$ °). The frequency distribution of the participants in percentiles is presented in table 1. One thousand, five hundred and fifty one participants (32.6%) out of the all the participants with genu valgus were within 2<sup>nd</sup> quartile while only 831 (16.4%) were in the 1<sup>st</sup> quartile.

**Figure 1**

Table 1: Frequency Distribution of Valgus Angle in Quartiles

Quartile (angle)	n	%
1 <sup>st</sup> Quartile (<9.5°)	831	16.40
2 <sup>nd</sup> Quartile (9.5°-11.0°)	1651	32.60
3 <sup>rd</sup> Quartile (11.0°- 12.0°)	1053	20.80
4 <sup>th</sup> Quartile (12.0°+)	1527	30.20

Table 2 presents the summary data for genu valgus by gender and age. The highest mean valgus angle of  $11.4 \pm 2.1$ ° degrees was observed at age 16 years in males and  $12.5 \pm 2.2$ ° degrees in females at age 18 years. In age 11 years through 19 years, valgus angles for male and female differed significantly (Table 3).

**Figure 2**

Table 2: Mean and Percentile Data of Valgus Angle of Participants by Age and Gender

Age (yrs)	Gender	n	Mean±SD (°)	25 <sup>th</sup> Percentile (°)	Median (°)	75 <sup>th</sup> Percentile (°)	95% CI (°)
11	M	230	11.07±1.16	11.00	11.50	12.00	10.91 – 11.22
	F	213	12.43±2.24	11.00	13.00	14.00	12.12 – 12.73
12	M	367	11.36±1.75	10.00	11.50	12.00	11.18 – 11.54
	F	280	10.44±2.73	7.63	10.00	13.00	10.12 – 10.76
13	M	301	10.94±1.87	10.00	10.50	11.50	10.73 – 11.15
	F	338	12.03±2.73	11.00	12.00	13.00	11.87 – 12.13
14	M	302	11.20±1.54	10.00	11.25	12.50	11.02 – 11.37
	F	339	11.52±2.36	10.00	11.00	13.00	11.27 – 11.77
15	M	251	11.31±1.76	10.00	11.50	12.50	11.09 – 11.53
	F	400	12.38±2.23	10.50	12.00	13.00	12.16 – 12.61
16	M	367	11.43±2.12	10.00	11.50	12.50	11.22 – 11.65
	F	585	11.94±1.67	11.00	12.00	13.00	11.80 – 12.08
17	M	248	10.46±1.60	9.50	11.00	11.50	10.26 – 10.66
	F	307	10.62±1.76	9.50	10.50	12.00	10.42 – 10.81
18	M	285	11.08±1.52	10.00	11.00	11.50	10.91 – 11.26
	F	158	12.49±2.22	10.50	12.50	14.00	12.14 – 12.84
19	M	64	11.10±1.69	10.00	11.50	12.00	12.14 – 12.84
	F	27	10.39±0.95	10.00	10.00	10.00	10.00 – 10.75
Total	M	2415	11.13±1.74	10.00	11.00	12.00	11.06 – 11.20
	F	2647	11.71±2.17	10.50	11.50	13.00	11.62 – 11.79
All		5062	11.43±1.99	10.00	11.50	12.50	10.80 – 12.06

**Figure 3**

Table 3: Independent T-Test of Valgus Angle of Male and Female Adolescents by Age

Age (yrs)	Male Mean±SD	Female Mean±SD	t-value	p-value
11	11.07±1.16	12.43±2.24	-8.087	0.000
12	11.36±1.75	10.44±2.73	5.220	0.000
13	10.94±1.94	12.03±1.46	-8.225	0.000
14	11.20±1.54	11.52±2.36	-2.022	0.000
15	11.31±1.76	12.38±2.23	-6.475	0.000
16	11.43±2.12	11.94±1.67	-4.096	0.000
17	10.46±1.60	10.62±1.76	-1.095	0.000
18	11.08±1.52	12.49±2.22	-7.893	0.000
19	11.10±1.69	10.37±0.95	2.105	0.000
Mean	11.13±1.74	11.71±1.99	-10.345	0.000

**DISCUSSION**

The predominant TFA in the adolescents is valgus angle and a measurable varus angle at this period of age might be considered as abnormal. This finding is in agreement with many previous studies on the pattern of development of tibiofemoral angle in children in many populations e.g Americans, Nigerians, Europeans, Turkish and Iranians<sup>[2-3,5,9-11]</sup>. These authors all reported preservation of valgus angle in the late childhood. A few of these studies which were on the adolescents also agrees with this study as they also observed a valgus presentation in the adolescents. Arazi et al.,<sup>[10]</sup> who evaluated the normal development of the tibiofemoral angle in Turkish children aged 3-17 years reported that a measurable varus angle at this period of age is considered abnormal.

The normal values of valgus angle were 11.1° - 11.2° for boys and 11.6° - 11.8° for girls. The values of the valgus angle obtained in this study were higher than the values obtained in many studies on tibiofemoral angle in many populations but similar to the value obtained by Arazi et al., in their study of Turkish adolescents<sup>[10]</sup>. Arazi et al.,<sup>[10]</sup> reported 11° of physiologic genu valgus in children aged between 3 and 17 years, whereas majority of the studies on tibiofemoral angle reported a lower value of valgus angle<sup>[2,6,7,9]</sup>. This difference in the observed value of valgus can be attributed to racial differences.

Girls presented with significantly higher valgus angle than the boys, this pattern is similar to those obtained by some of the previous authors who also observed a higher value of valgus angle in the females than the males<sup>[7,9-11]</sup>. This higher value of valgus can be attributed to the shape of the female

pelvis, as female true pelvis differs from the male in being shallower, having straighter sides, a wide angle between the pubic rami at the symphysis and a proportionately larger pelvic outlet<sup>[14]</sup>.

The establishment of a normal age and gender- referenced value of the knee angle in adolescents is of paramount clinical importance, as such knowledge would allow orthopaedic surgeons and physiotherapists to determine whether the knee alignment in a specific patient represents physiologic development or not. Moreover, a relevant and correct understanding of the development of the knee angle and limb alignment would prevent unreasonable apprehension by parents and relatives, and unnecessary diagnostic measurements, such as repeated exposure to radiation, and the inappropriate application of orthotics or bracing, which are not often cost-effective and might even hinder natural development<sup>[3,7,15]</sup>. In addition, this understanding would help diagnose, evaluate, and treat pathologic conditions, such as, infantile tibia vara or Blount's disease<sup>[15,16]</sup>.

**CONCLUSION**

The predominant tibio-femoral angle among adolescents in Nigeria is valgus and the normal values are between 10.8° – 12.1° at 95% CI. In general females had significantly greater valgus angle than males.

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