

# Growth pattern of genu varum and valgum in Indian tribal children of Jharkhand state

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## Abstract

**Background:** Genu varum- valgum can be determined by measuring tibiofemoral angle (TFA), intercondylar distance (ICD) and intermalleolar distance (IMD). Current study establishes the reference values of TFA (degrees) in normal healthy tribal population of Ranchi district. Previous studies have noted the regional differences in TFA. Despite its clinical importance and social relevance, literature is scanty in Indian population especially in northern Indian tribal children. **Material and Methods:** A cross sectional study is performed to assess the knee angle. 360 tribal children aged between 2-14 years were recruited in this study. TFA of children was measured using clinical methods with the help of universal goniometer. Anthropometric variables like height, weight and body mass index (BMI) were noted for all subjects to establish their relationship with TFA. **Results:** Mean TFA was  $4.84^{\circ} \pm 2.39^{\circ}$  (Min=-0.75°, Max 12°) with range (4.59° to 5.08°). The knee angle at the age of 2 years was 1.21° mean valgus with range 0.82° to 1.59°, min -0.75° and max 2.25°, thereafter a progressive increase, with peak mean valgus of 6.63° ranging 5.91° to 7.34° at 7-8 years of age was noted. Later, there was notable decrease in TFA, which ultimately stabilized to a mean value of around 5°. Maximum mean valgus was 12° at 7-8 years of age group. **Conclusion:** This study provides age wise baseline data and range of physiological TFA. This data of 2 to <14 years age group tribal children of JH is helpful to the orthopaedic surgeons, physicians, paediatricians, radiologists, and physiotherapists for reconstruction and management of genu varus and valgus deformities.

**Key Word:** Genu varus, Genu valgus, Anterior superior iliac spine (ASIS), Intermalleolar Point, Tribal Children.

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## INTRODUCTION

The mid longitudinal axes between femur and tibia form an angle, which changes from birth to age of 9-10 years (yrs). The angulation between femur and tibia presents genu varum at birth, which changes to genu valgum as the child starts to walk. Genu varum (GVR) is also termed as 'bowleg'. It is an outward curvature of both femur and

tibia, marked by medial angulation of the leg in relation to the thigh. Genu valgum (GVL), commonly called as 'knock-knees' is a condition where both knees touch one another when the legs are straight. GVR and GVL are relatively common among all angular deformities of lower limb in children. Mild to moderate bowlegs in newborn and knock-knees in early childhood are well-defined common orthopaedic problems. Both paediatricians and paediatric orthopaedic surgeons are frequently encountering these situations. Even though these conditions are benign and self-limiting, these deformities cause a great concern to the parents and relatives,<sup>1</sup> such apprehension among parents forces the physicians to conduct physical or radiological examinations.<sup>2</sup> The amount of varosity and valgosity is age specific, gender specific and racial specific.<sup>3</sup> It also depends on daily habits of the child. GVR and GVL are measured in either terms of tibiofemoral angle (TFA) in degrees (°) or intercondylar distance (ICD) and

intermalleolar distance (IMD) in centimetres (cm). Knowledge of normal limits of the TFA in specific population is important for explanation of informative details to parents. Radiologic, photographic and clinical techniques have been used to assess the normal limits of TFA. Current study establishes the reference values of TFA ( $^{\circ}$ ) in normal healthy tribal population in Ranchi district of Jharkhand (JH) state. A tribe is a group of individuals with common verbal communication, parlance, territory and monetary system. They have unique oral traditions and customs of antiquity, which is entirely different from civilized societies. There are 32 identified tribal groups in JH as per the constitutional criteria of Scheduled Tribal act. Tribal people of JH belong to Proto-Australoid race. Baraik, Bedia, Bhagat, Gudia, Hembrom, Kachhap, Khelko, Kujur, Lohra, Munda, Mahli, Oraon, Pahan, Sinku, Tirkey, Toppo are the main tribal groups of Ranchi district. Their physical features represent short stature, long cephalus, broad flat nose and dark skin. They mostly reside in villages, consists of many tolas. Their houses are mostly made of mud with thatched roofs. Their staple food is rice, fruits, flesh of animals and birds. Beer prepared from rice called Haria is their favourite drink. Physical and socio-cultural aspects of tribals have great importance, as they are the true representatives of our past sequence of development. They can be considered as 'living history or living fossils' of our early stages of development. Despite its clinical importance and social relevance, literature is scanty in Indian population especially in north Indian tribal children.

## MATERIALS AND METHODS

A total sample size of 360 children of JH state were considered in current study with 180 girls and 180 boys from 2 to 14 years age groups. Subjects were classified into twelve specific age groups. Each age group comprised 30 children with 15 girls and 15 boys. They were randomly selected from different Aanganwadi, primary and middle schools. In case of younger children, age was verified by documents from the schools or immunization cards. In case of lack of proper documentation, regional festivals or lunar aspects described by parents regarding date of birth were taken into consideration.

**Exclusion criteria:** Children <2 years (yrs) and >14 yrs, Other than tribals of JH states, children with musculoskeletal system disorders (developmental dislocation of hip, skeletal dysplasia, cerebral palsy, neuromuscular disorders, foot deformities, leg length discrepancy of >2cm) or with surgery of lower limb were excluded from this study. Parents who did not give written consent were also excluded.

## Measurements:

Approval by the Institutional ethical committee was obtained in priori. The letter was presented to the school head/principal of each school visited. The methodology, aims and objectives of the study were explained to Head Teacher/Principal in simple terms. Skin marker was used to mark dots over the anterior superior iliac spine (ASIS), centre of patella and the intermalleolar point (midpoint between the tibial and fibular malleoli). Then two longitudinal lines were drawn using the marker and the ruler- one connecting ASIS and the centre of patella (femoral axis) and the other connecting the centre of patella and the intermalleolar point (tibial axis). TFA was measured with a goniometer. The fulcrum of goniometer was placed on the centre of patella; the stationary arm was on femoral longitudinal axis and the movable arm on tibial longitudinal axis. The angle between them was measured (Figure-1). TFA was assessed as neutral, varus and valgus knee when values were zero, negative and positive respectively. Height and weight were measured with subject in light clothes and barefooted, using standard apparatus. Weight was measured to the nearest 0.5 kilogram (kg) using a weighing scale which was set to zero reading before each measurement. Height was measured to the nearest 0.1 cm using a measuring tape.



Figure 1: Goniometric measurement of TFA

## RESULTS

The knee angle at the age of 2 yrs was mean valgus of  $1.17^{\circ}$  and  $1.25^{\circ}$  in male and female children respectively. Thereafter, a progressive increase with peak mean valgus of  $6.17^{\circ}$  in males at 8 to < 9 yrs of age and  $7.47^{\circ}$  in females at 7 to < 8 yrs of age was noted. Later it decreased and ultimately stabilized to a mean of around  $5^{\circ}$  in males and  $6^{\circ}$  in females. Overall mean was  $4.57^{\circ}$  and  $5.10^{\circ}$  in males and females respectively. Maximum

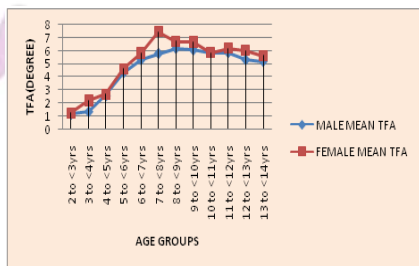
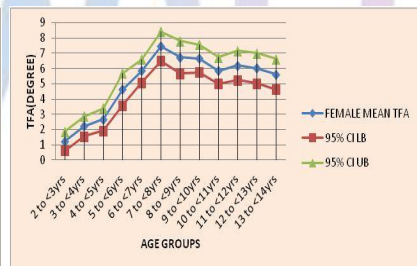
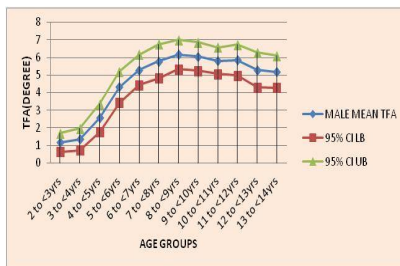
mean valgus was 9.50° at 6 to < 7 yrs in males and 12° at 7 to < 8 yrs of age group in females (Table-1, Figures-2 & 3). There were significant gender differences at 3 to < 4, 7 to < 8 yrs age group and in overall study population at p= 0.022. Girls had higher valgus than boys in each age

group, but results were not statistically significant (Table-1, Figure-4). Significant gender differences were noted between BMI and TFA at p<0.05 (Table-2). TFA established significant positive correlation between age, height, weight and BMI at p = 0.001 (Table-3).

**Table1:** Independent t- test between male and female TFA

Age Group	Male TFA			Female TFA			t- value	p- value
	Mean±SD	95%CI		Mean±SD	95%CI			
		LB	UB		LB	UB		
2 to <3yrs	1.17±0.94	0.65	1.69	1.25±1.15	0.62	1.88	-.218	.829
3 to <4yrs	1.35±1.10	0.74	1.96	2.22±1.18	1.56	2.87	-2.084	<b>.046</b>
4 to <5yrs	2.57±1.46	1.76	3.37	2.67±1.32	1.94	3.40	-.197	.845
5 to <6yrs	4.32±1.60	3.43	5.20	4.63±1.90	3.58	5.69	-.493	.626
6 to <7yrs	5.30±1.55	4.44	6.16	5.85±1.40	5.08	6.62	-1.019	.317
7 to <8yrs	5.78±1.76	4.81	6.76	7.47±1.73	6.51	8.42	-2.646	<b>.013</b>
8 to <9yrs	6.17±1.50	5.34	7.00	6.73±1.94	5.66	7.81	-.897	.377
9 to <10yrs	6.05±1.47	5.24	6.86	6.67±1.65	5.75	7.58	-1.080	.289
10 to <11yrs	5.82±1.37	5.06	6.57	5.87±1.57	5.00	6.74	-.093	.927
11 to <12yrs	5.85±1.58	4.97	6.73	6.20±1.74	5.24	7.16	-.576	.569
12 to <13yrs	5.30±1.79	4.31	6.29	6.03±1.79	5.04	7.02	-1.124	.271
13 to <14yrs	5.18±1.64	4.28	6.09	5.63±1.80	4.64	6.63	-.717	.479
Total (360)	4.57±2.28	4.24	4.91	5.10±2.47	4.74	5.46	-2.128	<b>.034</b>

TFA-Tibio femoral angle; yrs- Years; SD- Standard Deviation; CI- Confidence Interval; LB- Lower Bound; UB-Upper Bound; t- Independent t-test value; p- probability



**Figure 2:** Baseline data of TFA in male children **Figure 3:** Baseline data of TFA in female children **Figure 4:** Comparative baseline data of TFA

**Table 2:** Independent t- test of all Parameters

Variables	Gender	Number	Mean	SD	t- value	df	P value
Height	Male	180	120.45	20.37	1.733	358	.084
	Female	180	116.86	18.84			
Weight	Male	180	20.87	8.46	.068	358	.946
	Female	180	20.80	9.46			
BMI	Male	180	13.76	1.50	-3.161	358	.002
	Female	180	14.40	2.27			
TFA	Male	180	4.57	2.27	-2.118	358	.035
	Female	180	5.10	2.47			

TFA- Tibio femoral angle; BMI- Body Mass Index; SD- Standard Deviation; df- degree of freedom; t-Independent t-test value; p- probability

**Table 3:** Correlation of TFA with other parameters

TFA	Age	Parameters		
		Height	Weight	BMI
Pearson's Value	.557	.584	.459	.179
Approx. Sig	.000	.000	.000	.001

TFA- Tibio femoral angle; BMI- Body Mass Index; Sig. - Significance

## DISCUSSION

Somatometric parameters in terms of standing height, body weight were measured. BMI was calculated to understand growth patterns. Mean height and weight of male children was more than that of females. The sexual dimorphism observed in this study was in consonance with the previous study conducted by Vangara *et al.*<sup>4</sup> There was significant gender differences in BMI and TFA at  $p < 0.05$ . Physiological varus is a normal condition most commonly observed in children of  $< 2$  yrs.<sup>5,6</sup> In this study physiological varus beyond 2 yrs of age was found to be minimal. It was seen up to 3 to  $< 4$  yrs of age in female children while male children were noted to have varus till 4 to  $< 5$  yrs. According to our previous study physiological varus in case of Andhra Pradesh tribal children was seen up to 3 to  $< 4$  yrs of age in females and 5 to  $< 6$  yrs in males.<sup>3</sup> The mean TFA at 2 yrs of age group was positive, representing mean valgus alignment. This study found 2.8% and 2.2% GVR, 3.3% and 2.2% neutral in male and female children respectively. Our previous study reported 2% and 1% varus, 2% and 3% neutral in male and female children respectively.<sup>3</sup> Current study is in agreement with previous Indian study conducted by Mathew *et al.*<sup>7</sup> However they pointed out 2.7% of varus between 4-17 yrs age and they considered it as pathological. This variation may be due to heterogeneous samples selected by them from a tertiary hospital. In the intrauterine life due to the constraint of space within the uterus, lower extremity is forced to lie in "Buddha" position with flexed hips and knees, internally rotated tibia and feet. It causes contracture of the medial knee capsule. In postnatal life during first year of age when children try to stand and walk, they rotate the tibia externally to put the foot straight ahead. Due to the external rotation of tibia, there is obligatory external rotation of femur. This position of femur makes the bowleg more exaggerated. The peak mean GVL of  $6.17^\circ$  was reached at 8 to  $< 9$  yrs of age in males, while in females it was  $7.47^\circ$  observed at 7 to  $< 8$  yrs (Table-1). Maximum mean knee valgus observed was of  $7.6^\circ$  in girls at 6-7 yrs and  $6.46^\circ$  in boys at 7-8 yrs and  $6.6^\circ$  at 7-8 yrs in overall study population of Andhra Pradesh tribal children.<sup>3</sup> Saini *et al.*<sup>8</sup> found mean peak knee valgus of  $8^\circ$  at approximately 6 yrs of age in mixed population of Indian children from a tertiary hospital. Cheng *et al.*<sup>9</sup> also observed same peak mean valgus as Saini *et al.*<sup>8</sup>, but it was in early life at 3.5 yrs age in

Chinese children. Salenius *et al.*<sup>10</sup> observed peak mean valgus of  $12^\circ$  at 3 yrs in Finland children. Engel *et al.*<sup>11</sup> found that knee angle reached to peak mean valgus of  $6^\circ - 7^\circ$  at 2-3 yrs age, while Sabharwal *et al.*<sup>12</sup> noted peak mean TFA of  $9^\circ$  valgus in American children of 6 yrs age. Kaspiris *et al.*<sup>13</sup> observed peak mean TFA around  $7^\circ$  at 3 yrs of age using clinical methods in 3-9 yrs age group normal South-West Greece children. Yoo *et al.*<sup>5</sup> recorded peak mean valgus alignment of  $7.8^\circ$  at 4 yrs in Korean children. Bafor *et al.*<sup>14</sup> found peak valgus of  $7.87^\circ$  TFA in 3 yrs old Nigerian children of 3-10 yrs age group. Arazi *et al.*<sup>15</sup> observed peak mean valgus of  $9.8^\circ$  and  $9.6^\circ$  at 6 yrs in girls and 7 yrs in boys respectively using the goniometric method in 3-17 yrs age group Turkish children. In this study population, 93.9% and 95.6% were GVL in male and female children respectively. Our previous study in Andhra Pradesh found 96% and 97% cases of valgus in male and female tribal children respectively.<sup>3</sup> These results were in consonance with the fact that peak mean valgus was observed prior in females than in males. It was also observed that female attains peak valgus one year earlier than male children do. As children start to walk, they like to hold their feet wide apart to increase stability, which exerts pressure on the lateral side of knees. It results in medial part of the epiphyseal plate to grow faster, causing laxity in medial ligament of knee and thus the amount of valgus increases. Due to this medio-dorsal beaking in metaphysis of proximal tibia and distal femur, thickening in cortex, reduction in size of epiphysis of distal femur occurs. Maximum valgus angle of  $12^\circ$  was noted at 7 to  $< 8$  yrs of age group children. In this age group  $9.50^\circ$  and  $12^\circ$  TFA was found in male and female children respectively. As reported previously, valgus angle of up to  $12^\circ$  to  $14^\circ$  might be normal for the age groups of 6 to  $< 7$  yrs and 7 to  $< 8$  yrs in male and female respectively of Andhra Pradesh tribal children and needs only observation.<sup>3</sup> Heath *et al.*<sup>2</sup> found maximum valgus of  $8.7^\circ$  at the age of 4 yrs. Mohd-Karim *et al.*<sup>16</sup> measured TFA clinically on normal healthy Malaysian children and observed maximum valgus angle at 3 yrs of age. The maximum mean TFA noted by them for boys, girls and all children were  $8.91^\circ$ ,  $8.56^\circ$  and  $8.73^\circ$  respectively. Saini *et al.*<sup>8</sup> noted maximum valgus angle of  $11^\circ$  in 5-6 yrs age group children in India. Reports of this study were in concordance with that of Saini *et al.*<sup>8</sup> who observed a maximum valgus angle of

11° during 5-6yrs. Maximum valgus angle noted was more in comparison to all other previous studies mentioned. The varus - valgus alignment depends on growth of its articular cartilages and growth plates in the adjacent femur and tibia. The plates typically grow faster than the articular cartilages. Varus develops if the lateral side of plates grow faster than the plate of medial side. Variation in bone morphology from region to region specifically at proximal tibia, distal femur, patellar grooves are the reasons for these racial variation. After attaining peak valgus, TFA decreased continuously beyond 8 to <9yrs to a mean value of 5.18° in males and 5.63° in females. After 7 to <8yrs it reached up to 5.63° in female and 5.18° in male children. Yoo *et al.*<sup>5</sup> recorded the same pattern of adult valgus in children older than 4 yrs. TFA decreased slowly to 5°-6° at 7-8yrs of the age in Korean children. Saini *et al.*<sup>8</sup> observed that beyond 6yrs of age, the valgus angle decreased and stabilised around 4°-5° in most children after the age of 10yrs. Salenius *et al.*<sup>10</sup> observed constant mean valgus of 5°-6° between 7 and 12yrs among 0-16yrs age group of Finland children. Engel *et al.*<sup>11</sup> found that knee angle in American children remained as constant valgus of 4°-5° between 5-12yrs of age. Kaspiris *et al.*<sup>13</sup> in 3-9yrs age group normal children of South-West Greece found that the TFA was around 4° at the age of 7-8yrs. Sabharwal *et al.*<sup>12</sup> noted constant 5°-7° valgus from the age of 7-18yrs in American children. Oginni *et al.*<sup>6</sup> observed TFA of 6° among children of 4-12yrs age. Cheng *et al.*<sup>9</sup> found that in Chinese children of age group greater than 3.5yrs, valgus angle gradually decreased up to 1° by 8.5yrs age. Cahuzac *et al.*<sup>17</sup> studied TFA in European children of 10-16yrs age group. They observed stable valgus angle of 5.61° to 5.53° in 10-16yrs female children. In boys, the valgus gradually decreased to a mean of 4.4° TFA. Omololu *et al.*<sup>18</sup> noted that valgus angle remained constant throughout 1-10yrs of age with a mean angle of 11°. Akinpelu *et al.*<sup>19</sup> studied knee angle in 1-10yrs age group Nigerian children. They found that valgus angle steeply decreased after 3yrs until 6yrs of age from 14.7°-9.6°. Later it was stabilised with increment to 10.3° at 10yrs of age. Fakoor *et al.*<sup>20</sup> carried out cross-sectional study in Ahwaz, Iran, on 3-16yrs age group and observed that TFA after 3yrs decreased continuously up to 4.7° and 4.22° in males and females respectively up to 16yrs of age group. This study showed greater knee angle during stabilization when compared to other Indian studies. Tribials are the true representatives of our past sequence of development because of their physical and socio-cultural activities. Their muscle strength may be a cause for this variation. Higher degree of adult valgus is better than lesser degree of adult valgus because the chance of shifts from adult valgus angle to pathological varus is common in old age. This is due to the overweight

and adoption of static lifestyle like pooja and namaz for a longer duration. TFA established weak and positive correlation between age, height, weight and BMI at  $p < 0.001$ . Current study is in well agreement with Fakoor *et al.*<sup>20</sup> who found positive correlation of TFA with age ( $r=0.845$ ), weight ( $r=0.55$ ), height ( $r=0.769$ ). Cahuzac *et al.*<sup>17</sup> found no correlation between TFA and height ( $r=0.031$ ), weight ( $r=0.064$ ). Bafor *et al.*<sup>14</sup> found significant negative correlation between the TFA and BMI as well as with weight. Arazi *et al.*<sup>15</sup> also reported negative correlation between TFA and standing height as well as for weight in both boys and girls at  $p < 0.000$ . Mathew *et al.*<sup>7</sup> found significant negative correlation between TFA and age, standing height at  $p < 0.001$  after 5yrs of age.

## CONCLUSION

We have provided 95% confidence interval of the mean TFA for each age group. These values can be used as a range of reference for Indian tribal children in future follow up studies. Children after 3yrs with varus alignment of the knee may be atypical and requires radiological evaluation, regular follow-up and proper management. We conclude that a valgus angle of up to 12° and 14° might be normal in Indian children in the age group of 6 to <7yrs and 7 to <8yrs in males and females respectively and needs only observation. Age from 2yrs onwards till 6 to <7yrs should be considered as transitory period because there will be significant variation in valgus angle. It also indicates the stabilization of knee angle after 6 to <7yrs of age. Data also suggests that 7 to <11yrs is a safe period where no much variation in TFA can be noted. By 11 to <14yrs age variations in TFA between races and gender are noted. Children of 2 to <7yrs and 11 to <14yrs age groups are under transitory period and must be taken care of.

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