Influence Of Body Positions On Tibio-Femoral Angle Measurement In Children

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Citation

A O Akinpelu, B A Tella, O O Oyewole, A C Odole. *Influence Of Body Positions On Tibio-Femoral Angle Measurement In Children*. The Internet Journal of Orthopedic Surgery. 2013 Volume 21 Number 1.

Abstract

Purpose: Tibio-Femoral Angle (TFA) may be clinically measured in supine or standing positions, but the influence of these positions on TFA measurement has not been extensively investigated. This study was therefore conducted to determine the influence of body positions on TFA measurement in children.
Methods: A cross sectional survey was carried out to assess the knee angle of children, ages 1-10 years. The TFA of 1903 children was measured using clinical methods.
Results: The mean valgus angle rose steeply from -10.3±9.30 (supine) and -10.1±8.80 (standing) at one year to -15.0±5.50(supine) and -14.7±5.30 (standing) at 3 years, then fell steeply to -10.1±4.70 and -9.6±4.60 at 6 years after which it rose to -10.6±3.00 (supine) and -10.3±3.10 (standing). Measurement of intercondylar/intermalleoli distances showed a similar trend from minimum valgus at one year (-0.1±0.4cm) to a maximum valgus (-2.2±0.1cm) at age 3 years, then falling steeply to -0.7 cm at age 6 years with little change thereafter. Values of TFA measured in standing were significantly lower than those measured in supine ($t = 16.5$; $p = 0.00$) but no gender difference.
Conclusion: our sample showed a valgus knee angle with minimum values at age 1 year, peak at age 3 years and decreases thereafter. The TFA measurement in standing gives lower values than in supine. Body positions should be considered in interpreting TFA values reported by different studies.

INTRODUCTION

The development of the knee angle from varus alignment in the infant to valgus alignment in early childhood as a part of normal and physiological development is well documented [1-6]. This physiological variation in knee angle often causes apprehension among the parents [5, 6]. Knowledge of normal variations is useful in alleviating the apprehension of these parents. Such normal ranges have been reported in studies from various regions, some of which suggest that there is regional variation [1-4, 7-9].

The knee angles are often assessed by radiologic, photographic, and clinical techniques [such as Tibiofemoral Angle (TFA), intercondylar distance (ICD) or intermalleoli distance (IMD)] [3-6, 9, 10]. These techniques have been used to assess the normal limits of the TFA in the previous studies. It is important to have a thorough understanding of normal lower limb development and lower extremity examination so that referrals of true pathologic variants to the specialist may be optimized.

Five studies have reported patterns of TFA development in Nigerian children and adolescents [4, 9, 11-13]. In most of these studies, TFA was measured using clinical methods to establish normal values, but participants were placed in different positions, such as supine, long sitting and standing. The different positions might be one of the reasons for the different values reported for the same age by these studies. This study was undertaken to determine the influence of two positions (supine and standing) on TFA measurement in Nigerian children age 1-10 years. We hypothesized that body positions would not have any influence on TFA in Nigerian children age 1-10 years. We also assessed pattern of development and the gender variations.

METHODS

This cross-section survey was approved by the University of Ibadan and University College Hospital Research Ethics Committee. Nine schools (5 private and 4 public) were selected using a table of randomized numbers from the list of 47schools in Ojo Local Education District of Lagos state. The 5 private schools also day care and play group classes from where children ages 1-4 were sourced. Participants were 1903 children between ages 1 and 10 who had no

obvious deformities and whose parents gave consent. The sex and age in year as at last birth day of each child were recorded.

Measurements
Intercondylar and intermalleoli distances were measured with non-elastic tape measure (butterfly brand, China) in non-weight bearing position. Each child assumed a supine position with the extended knees, the patella facing vertically upward, the feet dorsiflexed to right angle and medial malleoli or condyles just touching. These were measured in centimeters (cm). The Inter-Condylar Distance (ICD) gave value for varus and Inter-Malleoli Distance (IMD) for valgus.

Tibiofemoral angle was taken with universal goniometer. Each participant was examined in supine and standing positions. In supine position, the hips and knees were extended, the patella facing vertically upward, and the feet dorsiflexed to right angle. One arm of the goniometer was align to an imaginary line drawn from the anterior superior iliac spine to the middle of the patella (femoral alignment) and the second arm was aligned to a line joining the middle of the patella to the middle of the ankle (centre point between medial and lateral malleoli), tibia alignment. The centre of patella served as fulcrum for the goniometer. The acute angle sustained between the femoral shaft (femoral alignment) and the tibia shaft (tibia alignment) was recorded as the tibiofemoral angle in degrees. The varus and valgus angles were assigned positive and negative values respectively.

Standard methods were also used to assess body weight (kg) and body height (m) with electronic weighing scale (Kenwell Model EB600) and a plastic height meter (Invicta Plastic Limited, England) respectively. All measurements were carried out by one of the author (BAT) to minimise interobserver differences; however, intraor inter-observer variation were not assessed due to logistic reasons.

Data Analysis
Data were summarised using mean and standard deviation, charts and frequencies. Pearson's correlation was used to determine the relationship between the TFA and the ICD/IMD while t-test was used to assess the influence of gender and body position on TFA at $\alpha < 0.05$.

RESULTS

The results from 1903 paired limb measurements of tibio-femoral angle of normal children (940 measurements from boys and 963 measurements from girls) aged 1 -10 years are presented. The left and right knee angles were very highly correlated in supine (r=0.956) and standing (r=0.959), so the average of both limbs were calculated for each subject and used for analysis. There was no gender difference of TFA in supine (t=0.18, p=0.86) and standing (t=0.56, p=0.96) position. Thus, combined data for both sexes were presented in charts and reference values generated.

Figure 1 show the pattern of development of tibio-femoral angle in supine and standing positions. Only 50 children showed varus pattern of knee angle with majority (29 children) of them in ages 1 and 2 years. None of the children exhibit varus pattern in ages 8 and 10 years. The mean valgus angle rose steeply from -10.3±9.30 (supine) and -10.1±8.80 (standing) at one year to -15.0±5.50(supine) and -14.7±5.30 (standing) at 3 years, then fell steeply to -10.1±4.70 and -9.6±4.60 at 6 years after which it rose to -10.6±3.00 (supine) and -10.3±3.10 (standing). Measurement of intercondylar/intermalleoli distances showed a similar trend of development from minimum valgus at one year (-0.1±0.4cm) which rose steeply to -2.2±0.1cm at age 3 years (Fig.2). Then, fell steeply to -0.7cm at 6 years with little changes thereafter.

Figure 1

Figure 1 show the pattern of development of tibio-femoral angle in supine and standing positions

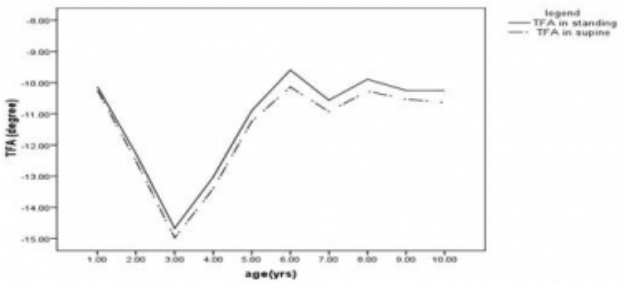
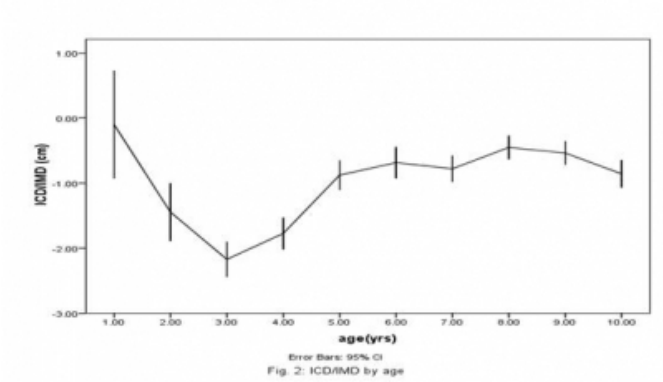


Fig. 1: Tibiofemoral Angle by Age in Supine and Standing Positions

Figure 2

ICD/IMD by age



There was significant difference between TFA measured in supine and standing positions, p=0.00 (Table 1). When it was adjusted for age, there was no significant difference in age 1 year (p=0.32). Thus age reference was presented in table 2. The correlation between tibiofemoral angle and intercondylar/intermalleoli distances measurements was significant in supine and standing positions, with a Pearson correlation coefficient r = 0.84 (p=0.00) and r= 0.84 (p=0.00) respectively.

Table 1

Influence of Position on Tibiofemoral Angle by Age.

Age (year)	n	Supine X±SD	standing X±SD	t-value	p-value
1	101	-10.3±9.3	-10.1±8.8	0.99	0.32
2	200	-12.5±8.5	-12.3±8.3	2.88	0.01
3	202	-15.0±5.5	-14.7±5.3	4.03	0.00
4	200	-13.4±5.1	-13.0±5.0	5.76	0.00
5	200	-11.2±4.4	-10.9±4.4	5.51	0.00
6	199	-10.1±4.7	-9.6±4.6	7.27	0.00
7	201	-10.9±3.0	-10.6±3.0	7.08	0.00
8	200	-10.3±2.9	-9.9±3.0	7.00	0.00
9	200	-10.5±3.3	-10.3±3.3	7.22	0.00
10	200	-10.6±3.0	-10.3±3.1	7.49	0.00
All	1903	-11.6±5.4	-11.2±5.3	16.5	0.00

Table 2

Reference Ranges for Knee Angle in Normal Children.

Age ICD/IMD(cm) (year)	Tibiofemoral Angle (degree)						
	supine			standing			
	mean	-2SD	+2SD	mean	-2SD	+2SD	
mean	-2SD	+2SD					
1	-10.3	-12.1	-8.4	-10.1	-11.9	-8.4	-
0.1	-0.9	-0.7					
2	-12.5	-13.7	-11.3	-12.3	-13.4	-11.1	-
1.5	-1.9	-1.0					
3	-15.0	-15.7	-14.2	-14.7	-15.4	-13.9	-
2.2	-2.4	-1.9					
4	-13.4	-14.1	-12.7	-13.0	-13.7	-12.3	-
1.8	-2.0	-1.5					
5	-11.2	-11.8	-10.6	-10.9	-11.5	-10.3	-
0.9	-1.1	-0.7					
6	-10.1	-10.8	-9.5	-9.6	-10.2	-9.0	-
0.7	-0.9	-0.5					
7	-10.9	-11.3	-10.5	-10.6	-11.0	-10.1	-
0.8	-1.0	-0.6					
8	-10.3	-10.7	-9.9	-9.9	-10.3	-9.5	-
0.5	-0.6	-0.3					
9	-10.5	-11.0	-10.1	-10.3	-10.7	-9.8	-
0.5	-0.7	-0.4					
10	-10.6	-11.1	-10.2	-10.3	-10.7	-9.8	-
0.9	-1.1	-0.7					

DISCUSSION

Findings from both goniometric and intercondylar/intermalleoli measurements of TFA in this study indicate that the pattern of TFA in Nigeria children is valgus from ages 1- 10 years. Only 2.6% of the children involved in this study presented a varus angle. Our findings are different from previous studies from Nigeria and some other parts of the world who reported preservation of varus angle between 1½ and 2 years [1-5,9,12]. However, the valgus pattern observed was similar to the findings of Sabharwal et al [14]. In that study, the ages of the participants were stratified in a similar way as what we did in this present study. The observed differences between our study and previous studies from Nigeria and some other parts of the world might be due to the way age was statified in the various studies. Age in year was rounded up to the last birth in the present study whereas ages were statified at 1 or 6 months interval in those previous studies. It should be noted that the ages within each age cohort were not evenly distributed and this might also partly explain the difference between our study and previous studies. About 60% of children that demonstrated varus pattern in the present study were in ages 1 and 2 years. The peak valgus at age 3 years in the present study is similar to those of white, American and Saudi children [1, 2, 15]. We observed mean peak valgus of 150. Our results showed significantly higher degrees of mean peak valgus angle than did previous reports [2-8, 15].

The finding that there is no gender difference in TFA implies that the same reference values can be used for both sexes. This observation was similar to that from previous studies [2-5, 15] where their findings reported no gender difference in TFA of children. On the other hand, in adolescence gender differences in the values of TFA have been reported [6, 8, 13]. The high correlation between TFA and IMD/ICD implies that either of these two measurements can be used to document the status and monitor the progress of the children for knee alignment. We observed mean peak IMD of -2.2cm at 3 years. This value was significantly lower than the values of IMD/ICD reported in previous studies [2, 6,8,16]. The differences in our findings from those of previous studies might be due to different method of measurement or racial differences.

The present study shows that the value of TFA measured in standing differs from that measured in supine. This finding is important as TFA has been measured in supine or standing in previous studies without concern for possible influence of body positions on the values. This finding implies that body position assumed during TFA measurement must be considered when comparing TFA values from different studies. The present study is one of the few studies investigating or probably the first attempt at investigating the influence of body position on TFA. Therefore, comparison with previous studies was limited. However, the study which used the two positions for measuring knee angles (supine and standing position) in 12 children showed good agreement ($r2 = 0.995$, slope = 1.03, intercept = 0.21) [4].

We also propose reference values which may guide in screening the children for mal-alignment of the knee and to avoid unnecessary radiation exposure and therapeutic interventions such as orthotics or bracing. It will also help the health workers to reassure or alleviate the tension of the parents worried about the “bending of the knees” of their children.

CONCLUSION

Values of tibio-femoral angle measured in supine differ from that measured in standing.

Our findings suggest that tibiofemoral angle of Nigerian children ages 1-10 years is valgus with minimum values at age 1 year, peak at 3 years and decreases thereafter.

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