

Original Article**The angular profile of the knee in Iranian children: A clinical evaluation***Mojtaba Heshmatipour¹, Mohammad Taghi Karimi²***Abstract**

BACKGROUND: Intercondylar (IC) and intermalleolar (IM) distance measurements are appropriate modalities for screening angular deformities but the values are not the same in all ethnics. This study was conducted to assess the mean values and normal limits of IC and IM distances in Iranian children.

METHODS: A total of 2268 children aged eight to eleven years were recruited in this research project. The IC and IM distances were measured and recorded according to a special procedure in standing and supine positions.

RESULTS: The mean values of IC distance were 2.4 ± 6.05 and 3.83 ± 8.1 mm in supine and standing positions, respectively, while the corresponding IM distances were 5.63 ± 10.74 and 7.51 ± 11.22 mm. There was no significant difference among the age groups. Moreover, the mean values of these parameters did not differ significantly between two genders.

CONCLUSIONS: With respect to reported values, IC and IM measurements, especially when selected according to age, can be used for screening angular deformities of lower limbs.

KEYWORDS: Intercondylar Distance, Intermalleolar Distance, Knee, Genu Varum, Genu Valgum.

J Res Med Sci 2011; 16(11): 1430-1435

Bowlegs and knock-knees are the most common pediatric orthopedic problems that can cause great concern to parents and relatives.^{1,2} In an attempt to alleviate such anxieties and to rule out any abnormality, physicians usually use radiologic examinations, ranging from simple plain radiographs to more sophisticated techniques of imaging. This may be an admirable approach, but all too often undue pathologic importance is attached to the wide variety of anatomic and physiologic variants that can occur in the rapidly changing musculoskeletal system of the growing child. Thus, costly, time-consuming therapeutic procedures that may be entirely unnecessary, and in certain instances harmful, might be initiated.

Although most of these pediatric orthopedic problems represent normal physiologic developments that will correct themselves in time without treatment, it is important for the physi-

cian to differentiate between physiologic angular variations and pathologic deformities. Therefore, many studies have employed clinical or radiologic techniques to monitor the leg deformities.³⁻⁶ For day-to-day practice, a feasible and inexpensive method such as clinical evaluation of tibiofemoral (TF) orientation by measuring intercondylar (IC) and intermalleolar (IM) distances is preferred to the costly and time-consuming assessment of TF angle by radiography. Moreover, this method eliminates the disadvantage of X-ray exposure. These modalities measure the TF angle, and the IC and IM distances to establish norms for the angular profile of the lower limb. The norms have been determined for some populations,^{4,7-10} but data for other ethnic groups including Iranian children are not readily available. However, the normal development of the TF angle is influenced by racial factor.^{3,4,11-13}

1- Lecturer, Department of Physical Therapy, School of Rehabilitation, Isfahan University of Medical sciences, Isfahan, Iran.

2- Assistant Professor, Department of Orthotics and Prosthetics, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran.

Corresponding author: Mohammad Taghi Karimi

E-mail: mohammad.karimi.bioengineering@gmail.com

It has been found that although American children less than one year old had genu varum, it was spontaneously corrected during the second year of life. The TF angle peaked at a mean of 9 degree of valgus at 6 years old and changed to 6 from 7 to 8 years of age. In contrast, European children showed a valgus angle of 5 degrees between 10 and 16 years age.¹³ No research has been done regarding the measurement of IC and IM distances among Iranian children. Therefore, the present study was conducted to determine the mean values and normal limits of IC/IM distances in normal Iranian children aged from eight to eleven years using clinical methods. It was aimed to produce a benchmark regarding IC and IM distances in Iranian children aged between 8 and 11 years which can be used to diagnose the lower limb deformities and to monitor the efficiency of various therapeutic methods on the lower limb deformities.

Methods

The current study was conducted on 2268 children during 2008-2009. The subjects were recruited from primary school pupils in Isfahan through a multistage sampling method (first step: cluster sampling, second step: simple random sampling). The number of the subjects was determined based on the data collected from the same studies conducted in other countries.⁴ Based on the past medical records, the children with evidence of having a deformity or any particular disease involving lower extremities were excluded. Table 1 shows the characteristics of the participants.

The IC and IM distances were measured by a

slide-caliper in supine and standing positions. All measurements were done by examiners using a standard technique to minimize inter- and intra-examiner variations. The mean values of both measurements were used for the final analysis. The weight and height of the students were also measured and recorded along with other demographic variables. The children were asked to stand with hip and knee joints in full extension. The IC distance was measured while the ankles touched each other. Similarly, the knee epicondyles were touching each other when the IM was measured. Then, the same procedures were used to measure the IC and IM distances in supine position. The length of lower limb was measured in standing position, based on the distance between the anterior superior iliac spine and the ground surface.^{4,12} In order to evaluate the repeatability and accuracy of this method, the IC and IM distances were measured repeatedly in a small group of subjects (100 participants) with one week intervals. The interclass correlation coefficients (ICC) coefficient was used to represent the repeatability of the method. The ICC correlation coefficient was 0.96 ($p < 0.01$).

The difference between IC and IM distances in various age groups was evaluated by analysis of variance (ANOVA). The IC and IM distances between boys and girls were compared with student t-test. The correlation between IC and IM distances and weight, standing height and length of lower limbs were studied by Pearson's correlation test. Statistical analyses were conducted using SPSS version 15 developed by IBM Company. In all statistical tests, the null hypothesis was rejected at $p < 0.05$.

Table 1. The characteristics of the participants

Age	Gender	Weight (kg)	Number	Leg length (mm)	Height (mm)
8	Male	23.2 ± 3.4	388	625 ± 23	1200 ± 30
	Female	23.8 ± 4.0	348	620 ± 43	1140 ± 25
9	Male	26.7 ± 4.0	320	648 ± 56	1290 ± 25
	Female	26.4 ± 3.7	330	645 ± 53	1278 ± 34
10	Male	28.9 ± 2.4	210	680 ± 60	1330 ± 24
	Female	27.9 ± 3.0	180	668 ± 58	1297 ± 36
11	Male	32 ± 3.5	221	730 ± 63	1420 ± 45
	Female	31.5 ± 2.9	271	723 ± 62	1390 ± 32

Mean values of weight, leg length, and height for both genders were 28.47 ± 6.76 , 700.32 ± 56 , and 1331 ± 85.4 , respectively.

Results

A total number of 2268 children were studied with boys comprising 49.8% and girls 50.2% of the study population. The mean values of IC and IM distances are shown in Table 2. No significant difference regarding the aforementioned parameters was found between males and females (Table 3). The IC and IM values versus age are shown in Figures 1 and 2. Al-

though IC distance in children at the age of 10 and 11 looks greater than younger children, this difference was not statistically significant. We found significant correlations between IM measurements and weight ($r = 0.38$; $p < 0.001$), standing height ($r = 0.16$; $p < 0.001$) and the average length of the lower limb ($r = 0.19$; $p < 0.001$). However, the Pearson correlation coefficients were not high.

Table 2. Mean values of intercondylar and intermalleolar distances.

Age	ICSU	ICST	IMSU	IMST
8	2.02 ± 5.30	3.6 ± 7.7	6.57 ± 9.30	4.70 ± 8.70
9	2.42 ± 5.60	3.8 ± 7.3	7.2 ± 11.2	5.45 ± 10.80
10	2.50 ± 5.60	4.0 ± 8.2	7.2 ± 10.0	5.48 ± 10.50
11	2.60 ± 6.60	3.9 ± 8.5	8.9 ± 12.0	6.48 ± 12.20

ICSU = Intercondylar distance measured in supine position

ICST = Intercondylar distance measured in standing position

IMSU = Intermalleolar distance measured in supine position

IMST = Intermalleolar distance measured in standing position

Mean values of ICSU, ICST, IMSU, and IMST for both genders were 2.40 ± 6.05 , 3.83 ± 8.10 , 7.50 ± 11.22 , and 5.63 ± 10.74 , respectively.

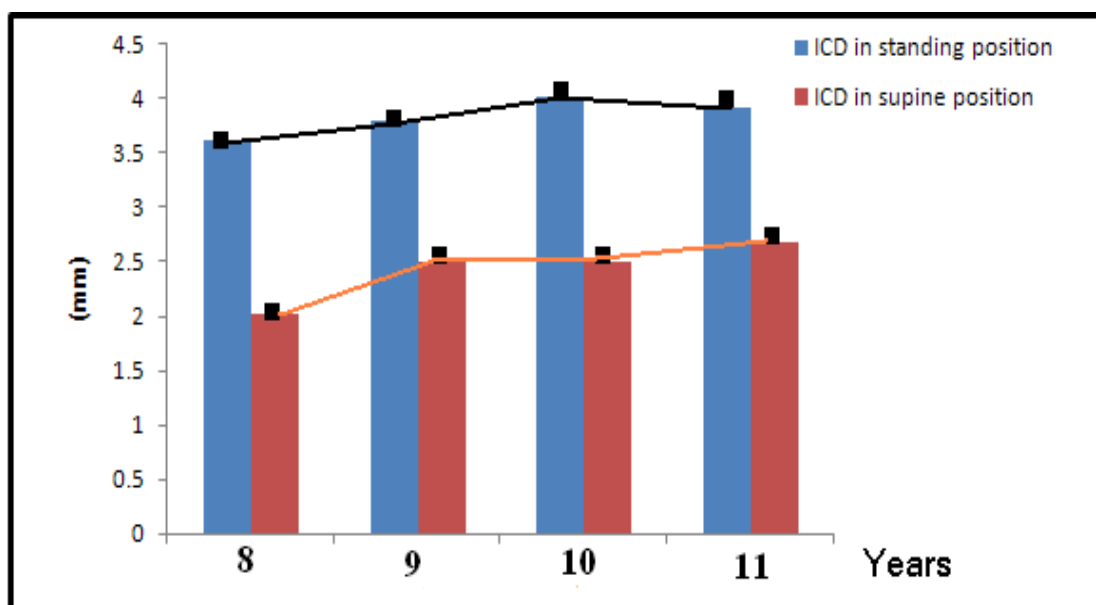


Figure 1. The correlation between IC distances (ICD) measured in supine and standing positions with age

Table 3. Mean values of intercondylar and intermalleolar distances in male and female subjects

Parameters	ICST	ICSU	IMST	IMSU
Female	3.25 ± 7.16	2.20 ± 6.09	5.88 ± 7.80	7.26 ± 9.50
Male	4.35 ± 8.60	3.04 ± 5.93	6.89 ± 12.82	7.74 ± 12.67

ICSU = Intercondylar distance measured in supine position

ICST = Intercondylar distance measured in standing position

IMSU = Intermalleolar distance measured in supine position

IMST = Intermalleolar distance measured in standing position

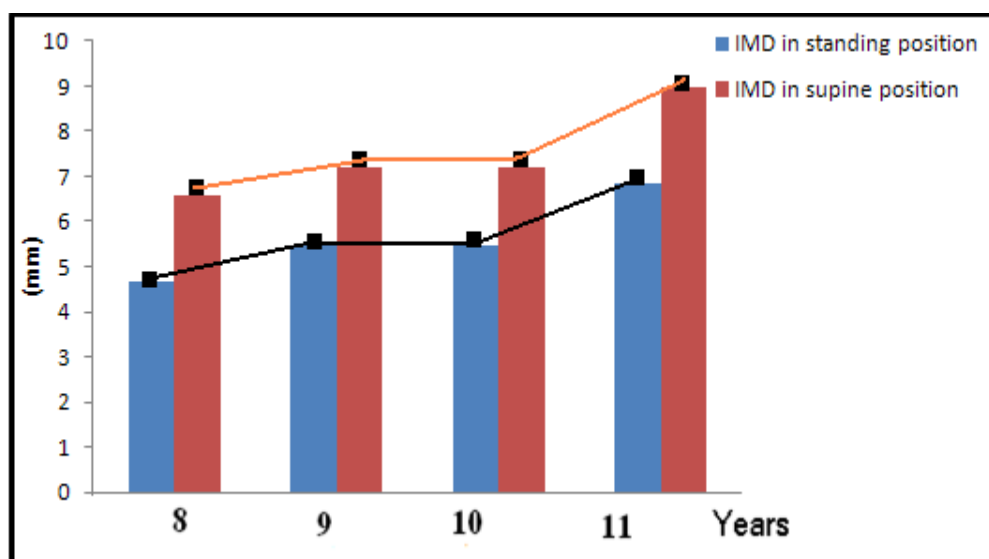


Figure 2. The correlation between IM distances (IMD) measured in supine and standing positions with age

Discussion

Several methods have been defined for evaluating angular deformities of the knee in growing children. Although radiographic technique is one of the oldest methods used in this regard,^{2,6} it is not now widely used due its high cost and also to avoid radiation exposure. Additionally, limb malrotation during the radiography may affect the radiologic measurements.¹⁴

Recently, clinical examinations have become more popular due to their applicability and reproducibility.^{4,5,11} Up to now, several studies have been conducted by this method but the results and norms were widely different because of racial and geographical variations.^{3,6} Omololu et al. studied nearly the same number of subjects and determined the IC distance of 8, 9, and 10 year old children as 7.3 ± 11.7 , 8.1 ± 11.67 and 10 ± 13.8 mm, respectively. In addition, the corresponding values for IM dis-

tance were 2.2 ± 6 , 1.6 ± 6.4 and 1 ± 4.3 mm.¹² The contrasting results of the current research represent the influence of geographical and ethical parameters.

There is controversy over is the easiest and most accurate routine for physical examinations to evaluate the TF angle or IC and IM distances in children. While Cahuzac et al. reported the TF angle measurement to be more accurate than distance measurement,³ other studies suggest IC and IM measurements as more reliable and easier to clinically apply.¹¹ On the other hand, a nearly identical trend, with a high correlation coefficient of more than 0.7, was found when comparing TF angle changes with the IC and IM distances.⁴ This correlation indicates that either of these two measurements can be used to document the status of angular profile.

The IC and IM distances in our children and their variation among different age groups and

sexes are comparable with previous reports in different ethnics.^{4,11} Our findings showed IC and IM distances to be correlated with weight, height and length of lower extremity. Arazi et al. also reported a significant correlation between tibiofemoral angle, height and weight.^{11,15} These findings suggest that standardized parameters with respect to weight and height may be better indices for angular deformities than IC and IM measurements alone. Undoubtedly, establishing these parameters needs further investigations with larger sample size.

The results of this study present the statistical normal ranges of IC and IM distances, which are thought to be reliable and valid indexes for screening angular deformities. Nevertheless, decision on the need for treatment

should be made considering other clinical and paraclinical modalities.

Conclusion

Amongst various parameters which can be used to monitor the deformities of lower extremities, IC and IM distances are reliable and easy to measure. The results of this research established a range of normal values of IC and IM distances to determine whether the knee angle is within the normal limit or not. This method is inexpensive and the clinicians do not need to expose the children to radiation.

Acknowledgment

The authors wish to thank all subjects who kindly participated in this research.

Conflict of Interests

Authors have no conflict of interests.

Authors' Contributions

The authors had the same contribution in various procedures performed in this project.

References

1. Engel GM, Staheli LT. The natural history of torsion and other factors influencing gait in childhood. A study of the angle of gait, tibial torsion, knee angle, hip rotation, and development of the arch in normal children. *Clin Orthop Relat Res* 1974; (99): 12-7.
2. Hachiya M. A roentgenographical study on chronological changes in genu varum and valgum in children (author's transl). *Nihon Seikeigeka Gakkai Zasshi* 1981; 55(1): 31-43.
3. Cahuzac JP, Vardon D, Sales de GJ. Development of the clinical tibiofemoral angle in normal adolescents. A study of 427 normal subjects from 10 to 16 years of age. *J Bone Joint Surg Br* 1995; 77(5): 729-32.
4. Cheng JC, Chan PS, Chiang SC, Hui PW. Angular and rotational profile of the lower limb in 2,630 Chinese children. *J Pediatr Orthop* 1991; 11(2): 154-61.
5. Heath CH, Staheli LT. Normal limits of knee angle in white children--genu varum and genu valgum. *J Pediatr Orthop* 1993; 13(2): 259-62.
6. Salenius P, Vankka E. The development of the tibiofemoral angle in children. *J Bone Joint Surg Am* 1975; 57(2): 259-61.
7. Staheli L. Report of the pediatric orthopaedic Society (POS) subcommittee on torsional deformity. *Orthop Trans* 1980; 4: 64-5.
8. Staheli LT. Torsional deformity. *Pediatr Clin North Am* 1977; 24(4): 799-811.
9. Staheli LT, Corbett M, Wyss C, King H. Lower-extremity rotational problems in children. Normal values to guide management. *J Bone Joint Surg Am* 1985; 67(1): 39-47.
10. Staheli LT, Engel GM. Tibial torsion: a method of assessment and a survey of normal children. *Clin Orthop Relat Res* 1972; 86: 183-6.
11. Arazi M, Ogun TC, Memik R. Normal development of the tibiofemoral angle in children: a clinical study of 590 normal subjects from 3 to 17 years of age. *J Pediatr Orthop* 2001; 21(2): 264-7.
12. Omololu B, Tella A, Ogunlade SO, Adeyemo AA, Adebisi A, Alonge TO, et al. Normal values of knee angle, intercondylar and intermalleolar distances in Nigerian children. *West Afr J Med* 2003; 22(4): 301-4.

13. Samia A, Rahman A, Badahdah W. Normal development of tibiofemoral angle in Saudi children from 2 to 12 years of age. *World Applied Sciences Journal* 2011; 12: 1353-61.
14. Stricker SJ, Faustgen JP. Radiographic measurement of bowleg deformity: variability due to method and limb rotation. *J Pediatr Orthop* 1994; 14(2): 147-51.
15. Lin CJ, Lin SC, Huang W, Ho CS, Chou YL. Physiological knock-knee in preschool children: prevalence, correlating factors, gait analysis, and clinical significance. *J Pediatr Orthop* 1999; 19(5): 650-4.