*Artikel Penelitian*

# Evaluation of Tibiofemoral Angle And Intermalleolar or Intercondylar Distance Within Young Adult Population: A Preliminary Study

**Julius Albert Sugianto,* Tri Wahyu Martanto,** Paulus Rahardjo*****

**Medical Faculty of Airlangga University*
***Orthopaedic and Traumatology Department of Airlangga University*
****Radiology Department of Airlangga University*

***Abstract***
***Introduction****: Clinical measurement of Tibiofemoral (TF) angle and Intermalleolar/Intercondylar (IM/IC) distance are quick, low cost, reliable, and radiation-free way to screen for pathological genu varus/valgum. TF Angle and IM/IC distance varied between countries and races. Meanwhile, research regarding normal TF Angle and IM/IC distance in Indonesia has not been reported before.Aim: To find the average TF angle and IM/IC distance on medical students of Medical Faculty of Airlangga University batch 2013.*
***Methods****: Descriptive epidemiologic study were conducted. The data is collected by direct measurement on the sample.*
***Results****: We measured 168 students which fulfilled the inclusion criteria. 65% of the samples were 20 years old and 61% of the samples were females. Amongst the samples, 64% had normal BMI, 11% were underweight, and 26% were overweight and obese. Average BMI is 22,9 ± 4,1. The average TF angle were -7,50 ± 3,350 valgum while the average IM/IC distance were -4,4 ± 33,09 mm intermalleolar. Compared to previous studies, there is slight differences in TF angle and IM/IC distance but were comparable.*
***Conclusion****: Amongst medical students of Faculty of Medicine Airlangga University, the TF angle and IM/IC distance were comparable to other studies and mostly had valgus angle.*

***Key words:*** *Angular deformity, Genu Varum, Genu Valgum, Tibiofemoral Angle, Intermalleolar distance, Intercondylar distance*

**Korespondensi**: Julius Albert Sugianto
Email: julius_albert14@yahoo.com

# Evaluasi Sudut Tibiofemoral dan Jarak Intermalleolar atau Interkondilar Pada Populasi Dewasa Muda: Sebuah Studi Pendahuluan

Julius Albert Sugianto,* Tri Wahyu Martanto,** Paulus Rahardjo***

**Fakultas Kedokteran Universitas Airlangga*
***Departemen Ortopedi dan Traumatologi, Fakultas Kedokteran Universitas Airlangga*
****Departemen Radiologi, Fakultas Kedokteran Universitas Airlangga*

***Abstrak***
***Latar Belakang:*** *Pengukuran sudut Tibiofemoral (TF) dan jarak Intermaleolar/ Interkondilar (IM/IC) secara klinis merupakan cara yang cepat, murah, simpel, reliabel, dan bebas radiasi untuk melakukan skrining genu varum atau valgum patologis. Sudut TF dan jarak IM/IC normal berbeda antar negara. Sedangkan penelitian mengenai sudut TF dan jarak IM/IC normal di Indonesia belum pernah dilaporkan sebelumnya.*
***Tujuan:*** *Mengetahui rata-rata sudut TF dan jarak IM/IC pada mahasiswa pendidikan dokter di Fakultas Kedokteran Universitas Airlangga angkatan 2013.*
***Metode:*** *Penelitian ini menggunakan metode deskriptif epidemiologis. Data yang digunakan diambil langsung dari sampel.*
***Hasil:*** *Peneliti mengukur 168 mahasiswa yang memenuhi kriteria inklusi. 65% dari sampel berumur 20 tahun dan 61% dari sampel adalah wanita. Diantara seluruh sampel, 64% memiliki BMI yang normal. Underweight sebanyak 11% dan total overweight dan obese adalah 26%. Rata-rata BMI adalah 22,9 ± 4,1. Rata-rata sudut TF adalah -7,50o ± 3,350o valgum sedangkan rata-rata jarak IM/IC adalah -4,4 ± 33,09 mm intermaleolar. Sudut TF lebih valgus dan jarak IM/IC lebih varus dengan sedikit perbedaan dibandingkan studi sebelumnya.*
***Kesimpulan:*** *Dari studi ini, peneliti menyimpulkan bahwa diantara pendidikan dokter di Fakultas Kedokteran Universitas Airlangga angkatan 2013, sudut TF dan jarak IM/IC memiliki perbedaan yang sedikit dibanding studi sebelumnya dengan dominasi memiliki genu valgus.*

***Kata Kunci:*** *Kelainan Angular, Genu Varum, Genu Valgum, Sudut Tibiofemoral, Intermalleolar distance, Intercondylar distance*

## Introduction

Genu varum or genu valgum can be physiological or pathological depending on the tibiofemoral angle or intermalleolar/intercondylar distance of a subject compared to the average normal population's distance/angle. Previous studies have evaluated tibiofemoral angle both clinically,[1–4] and radiologically.[5–7] Intermalleolar/ intercondylar distance have been evaluated previously too using measurement tape, commonly measured as a complement to clinical tibiofemoral angle.[1–4] Aside for screening purposes, studies evaluating tibiofemoral angle and intermalleolar/ intercondylar distance is also important for managing angular deformity and its reconstruction.[7]

Radiological measurement of tibiofemoral angle tends to be more accurate and can be used as a definitive diagnosis but clinical measurement is a good alternative because it does not expose the patient to radiation, cheap, easy, and reliable.[1] Clinical measurement is especially useful in rural areas where there is no radiological imaging instruments available.

Previous studies have found that there is a variation between race and/or countries. Big differences was found in Arazi's study in Turkey,[2] compared to Matthew's study in Southern India.[1] Arazi et al found that in individuals aged 15-17 years, clinical tibiofemoral angle had an average of 7°. Meanwhile, Matthew & Madhuri found that amongst individuals aged 14-18 years, clinical tibiofemoral angle had an average of 4°. This difference made the authors wanted to know: what

is the average tibiofemoral angle and intermalleolar/intercondylar angle in Indonesian population. Within the author's knowledge, there are no other similar study conducted in Indonesia previously. Therefore, with this research, the authors aimed to know the average tibiofemoral angle and intermalleolar/intercondylar distance amongst medical students of medical faculty of Airlangga University batch 2013. The authors hope that it can give a small depiction of the tibiofemoral angle and intermalleolar/intercondylar distance's average in Indonesia and it may be used as a guideline for further studies in larger scale in Indonesia or for the radiological measurement.

## Material And Methods

We conducted a descriptive epidemiologic study aiming to know the average tibiofemoral angle and intermalleolar/intercondylar distance amongst medical students of medical faculty of Airlangga University batch 2013.

The population of the study is all of the students which is 288 students. The author used Slovin formula to know the amount of sample needed to get 95% confidence interval (CI):

$$n = \frac{N}{(1+Ne^2)}$$

n = Amount of sample needed
N = Amount of population = 288 students
e = margin of error = 1 – CI = 1 – 0,95 = 0,05

From the formula, it is found that the amount of sample needed are 168 students

The authors used incidental sampling to gain samples. The research was taken within Airlangga University's vicinity between October 2015-January 2016. Only students of medical students in the medical faculty of Airlangga University batch 2013 were included. Students with a history of musculoskeletal system disorder on their lower extremity such as fracture, congenital deformity, or muscular injuries were excluded from this research as it may alter the parameters that were measured.[8]

Basic data (weight, height, age, and gender), tibiofemoral angle, and intermalleolar/intercondylar distance were noted from each sample. Measurement will be made after each samples have stood up straight with their hip and knee fully extended and in neutral rotation. Tibiofemoral angles were measured using standardized goniometer. Tibiofemoral angle is the angle between Superior Anterior Iliac Spine, center of the patella (as the pivot point), and the center of lateral malleolus and medial malleolus. Valgus angle were described as negative meanwhile, varus angle were described as positive. The procedure in measuring tibiofemoral angle is as previously described. Intermalleolar/intercondylar distance was measured using a measuring tape between the most medial point of the femoral condyle. If the distance between the femoral condyle is zero then we measure the distance between the most medial point of medial malleolus. Intermalleolar distance were described as negative meanwhile, intercondylar distance were described as positive. The procedure in measuring intermalleolar/intercondylar distance is as previously described as well.[4]

After the data from 168 samples were gathered, we calTculated the average value and standard deviation of BMI, tibiofemoral angle, and intermalleolar/intercondylar distance using Microsoft Excel 2013. Comparison between gender were also made.

## Results

From the measurements done, the authors had asked 189 students to be the sample but only 168 were measured, the details are as follow:

**Table 1. Details of Students Who were Asked to be The Sample**

| Students of Medical Faculty of Airlangga University batch 2013 | Amount | F | M |
|---|---|---|---|
| Declined to participate | 7 | 6 | 1 |
| Have had a musculoskeletal system disorder | 14 | 9 | 5 |
| Eligible to be measured | 168 | 103 | 65 |
| Total | 189 | 116 | 73 |

From 189 students that were asked to be the sample, 7 students declined to participate, 14 stated that he/she have had a history of musculoskeletal system disorder, and 168 were eligible and willing to participate.

Basic demographic data were recorded from the samples. On average, the sample were aged 19,9 ± 0,7 (range= 17-22). Most of the samples were 20 years old (n= 110; 65%). Followed by 19 years old (n= 28; 17%), 21 years old (n= 20; 12%), 22 years old (n= 5; 3%), 18 years old (n= 4; 2%), and, the least, 17 years old (n= 1; 1%). Regarding gender, the samples were dominated by female subjects (n=103; 61%).

**Table 2. Body Mass Index (BMI) Distribution of the Samples Measured**

| BMI | Male | Female | Total |
|---|---|---|---|
| *Underweight* (<18,5) | 3 (5% | 15 (15%) | 18 (11%) |
| Normal (18,5-24,9) | 30 (46%) | 77 (75%) | 107 (64%) |
| *Overweight* (25,0-29,9) | 24 (37%) | 11 (11%) | 35 (21%) |
| *Obese* (>30,0) | 8 (12%) | 0 (0%) | 8 (5%) |

BMI were calculated using the formula = $\frac{(BB\ (kg)}{TB\ (m)^2}$

The result were interpreted using the classification as elaborated by the Centers for Disease Control and Prevention (CDC 2015): underweight (<18,5), normal (18,5-24,9), overweight (25,0-29,9), dan obese (>30,0). From the table above, we can see that, overall, samples in this research have a normal BMI (64%). Meanwhile, the others were overweight (21%) and obese (5%). Additionally, amongst the male subjects the normal BMI's percentage is lower (46%) compared to the total of overweight dan obese (49%).

**Table 3. Average Tibiofemoral Angle, Intermalleolar/ Intercondylar Distance, and Amount of Varus-valgum**

| | TF Angle Average | IM/IC Distance Average (mm) | Amount of Genu Varus | Amount of Genu Valgum |
|---|---|---|---|---|
| Male | $-6,3^0 \pm 3,17^0$ | -6,4 ± 37,71 | 4 Knees | 130 Knees |
| Female | $-8,2^0 \pm 3,25^0$ | -3,2 ± 29,95 | 0 Knees | 202 Knees |
| Total | $-7,5^0 \pm 3,35^0$ | -4,4 ± 33,09 | 4 Knees | 332 Knees |

From the table above we can see that the TF angle average in females were more valgus ($-8,2^0 \pm 3,25^0$) compared to the male subject ($-6,3^0 \pm 3,17^0$) with the overall average of $-7,5^0 \pm 3,35^0$. In contrast, IM/IC distance of the male samples (-6,4 ± 37,71 mm) tends to be bigger or less valgus compared to the female samples (-3,2 ± 29,95 mm) with the average IM/IC distance of -4,4 ± 33,09 mm. Looking at the amount of genu varus and valgum, we can see that most of the samples had genu valgum on both male and female subjects.

## Discussion

The 7 samples who declined to participate mostly because of religious reason where they were not allowed to be touched on the knee by the opposite sex. Meanwhile, the 14 samples who claimed to have had a history of musculoskeletal system disorder were not included in this study because it might alter the parameter's value that are measured in this study. Moreover, it is also to follow the previous study's standard so the author may compare it directly to the previous study (1–3). At some occasion, the musculoskeletal system disorder were found by the author themselves. The most common musculoskeletal disorder that was found is overt deviation of the patellae to the medial side. In such case, considering that the center of the patella is the pivot point to measure the tibiofemoral angle, the author decided to exclude such samples.

Most of the samples were 20 years old (65%) and 19 years old (17%). This proportion is normal considering that most of the students on 2013 batch within the period are 19-20 years old. This is also in conjunction with the aim of this study. Where we would like to know the average TF angle and IM/IC distance amongst adult population whose growth is minimum or has stopped and, therefore, can represent the average value throughout their adult age.

Gender distribution amongst the samples are dominated by female subjects which are 103 students (61%) compared to the male subjects of 65 students (39%). This unequal proportion is expected since the author used incidental sampling and, therefore, would matches the overall population which has female population of 154 students (64%) and male population of 87 students (36%).

Comparing with previous studies, the table below summarizes the result of our literature review. The studies below measured the same parameter on adult population using similar method to this study:

**Table 4. Average TF Angle Comparison to Previous Studies**

| Main Author | Sample Age | Sample Amount | Research Location | Male Average TF Angle | Female Average TF Angle | Overall TF Angle |
|---|---|---|---|---|---|---|
| Arazi et al (2) | 17 | 20 | Turkey | -6,6 | -7,5 | -7,05 |
| Cahuzac et al (3) | 14-16 | 56 | Europe | -4,41 | -5,53 | -4,89 |
| Matthew & Madhuri (1) | 18-22 | 60 | Southern India | -3,18 | -4,43 | -3,81 |
| Current Study | 19-20 | 168 | Indonesia | -6,3 | -8,2 | -7,5 |

This study found that the average TF angle in female samples are more valgus compared to the male samples. The result are similar to the result of previous studies. Other authors hypothesized that this is because females have wider hips compared to males. After statistical analysis, Cahuzac JP et al (3) did not find significant difference between both sexes. Arazi M et al (2) and Matthew SE & Madhuri (1) did not do a statistical analysis regarding difference between sexes. Additionally, overall, the average TF angle found in this study is more valgus compared to previous studies. The result might be caused by differences in sample's race and the location where the study is conducted.

The table below also summarized the differences with previous study which had similar method, parameter, and age of sample but on IM/IC distance:

**Table 5. Average IM/IC Distance Comparison to Previous Studies**

| Main Author | Sample Age | Sample Amount | Research Location | Male average IM/IC Distance | Female average IM/IC Distance | Overall IM/IC Distance |
|---|---|---|---|---|---|---|
| Arazi M (2) | 17 | 20 | Turkey | -9 mm | -5 mm | -7 mm |
| Cahuzac JP (3) | 15-16 | 56 | Europe | 3 mm | -25mm | -9 mm |
| Current Study | 18-22 | 168 | Indonesia | -6,4 mm | -3,2 mm | -4,4 mm |

This study found that, on average, both male and female samples had intercondylar distance instead of intermalleolar distance which, in overall, is less compared to previous studies. The difference might be caused by differences in sample's race and the location where the study is conducted. Wider hip could cause smaller intermalleolar distance despite larger TF angle but more study is needed to ascertain this hypothesis. Literature review conducted by Arazi et al[2] found that there is significant differences on IM/IC distance in studies conducted in different countries.

Evidences regarding the correlation between weight and IM/IC distance differed on previous studies. Cahuzac et al[3] found that obesity does not increase TF angle and IM/IC distance but the study by Arazi et al[2] found that the correlation does exist with the bigger IM distance are measured on samples who were overweight or obese. Cahuzac et al[3] stated that the difference in overweight samples can be caused by differences in soft tissue thickness on the sample's knee which would affect the measurement. We also think that the soft tissue thickness of the sample's knee is a hindrance in acquiring an accurate measurement on intercondylar distance because it is harder to palpate the most medial point of the condyle.

Using which clinical measure (TF angle or IM/IC distance) to screen or determine pathological genu varus or valgus has been a subject of debate. We believe that TF angle is the more reliable indicator because the points used to measure the angle are more specific and less likely to be skewed by other factors such as weight or soft tissue thickness. Therefore, in our discretion, TF angle tends to have more consistent result and are more likely to be similar to the radiographic TF angle value. Despite so, TF angle also have a downside. The procedure elaborated on previous studies only states "center of the patella" as the pivot point but there are neither further explanation nor specific guideline regarding how the researcher should determine the exact "center of the patella. Without a specific guideline, inter-observer measurement result would be very likely to vary widely. We think that further research which compares the clinical measurement technique to the radiologic measurement is necessary to make the measurement more specific and reliable for daily practice. Moreover, the diameter of the goniometer that were used in this research were quite small and had the smallest measurable angle of 0,5$^{o}$ increment, hindering a more specific measurement.

IM/IC distance measuring had its own downside also. Aside from the thickness of the soft tissue around the knee on overweight/obese patients, the authors also found that asking the patient to have their leg close enough until either "the knee or ankle touch each other" is very subjective and

tends to be misinterpreted by the samples. Opening up a possibility for false measurement.
To overcome those potential pitfalls in measuring TF angle and IM/IC distance, the authors suggest using a modified goniometer or other more sensitive goniometer that enables the measurement to be more accurate than 0.5° increment. Regarding the center of the patella, the authors suggested using plastic concentric plate as elaborated by Matthew & Madhuri.[1] Lastly, regarding the subjectivity having only their "knee or ankle just touching each other", we suggest rechecking by palpating or inspecting whether the samples have truly had their knee or ankle touch each other without force.

## Conclusion

Out of 168 samples, which are dominated by females (61%) and 20 years old (65%), the average TF angle were -7,50 ± 3,350 valgus. The TF angle is more valgus in comparison to previous studies. Meanwhile, the IM/IC distance amongst medical student of medical faculty of Airlangga University batch 2013 were -4,4 ± 33,09 mm which is less valgus compared to previous studies.

During applying the procedure as previously described to assess Tibiofemoral angle and IM/IC distance, the authors see that the "center of the patella" might be a source of measurement error in measuring TF angle. Meanwhile, on IM/IC distance, the instruction of "knee or ankle just touching each other" and the thickness of soft tissue on the knee as the source of measurement error

## Acknowledgements

The authors would like to thank all subjects who were willing to participate in this research

## Reference

1. Mathew SE, Madhuri V. Clinical tibiofemoral angle in south Indian children. Bone Jt Res. 2013;22(8):155–61.
2. Arazi M, Oğün 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. Vol. 21, Journal of pediatric orthopedics. 2001. p. 264–7.
3. Cahuzac JP, Vardon D, Sales de Gauzy J. 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 [Internet]. 1995;77(5):729–32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7559698
4. MI M-K, AR S, I M, AH S. Clinical Measurement of the Tibio-femoral Angle in Malay Children. Malaysian Orthop J [Internet]. 2015;9(2):9–12. Available from: http://morthoj.org/2015/v9n2/Tibio-femoral-Angle.pdf
5. Salenius P, Vankka E. The development of the tibiofemoral angle in children. J Bone Jt Surg Am . 1975;57(20):259–61.
6. Jae HY, In HC, Cho TJ, Chin YC, Won JY. Development of tibiofemoral angle in Korean children. J Korean Med Sci. 2008;23(4):714–7.
7. El Fouhil AF, Khoshhal KI, Al-Nakshabandi NA, Al-Boukai AA, Atteya M. Normal knee angles in the adult saudi population. Saudi Med J. 2011;32(11):1143–8.
8. Espandar R, Mortazavi SMJ, Baghdadi T. Angular deformities of the lower limb in children. Asian J Sports Med. 2010;1(1):46–53.