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Radiographical Evaluation of the Tibiofemoral Angle among Bini Tribe in Southern Nigeria and Assessment of its Significance

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ABSTRACT

Introduction: the tibiofemoral angle (TFA) is an anthropometric parameter used to describe the lower limb alignment and to determine the degree of deformity during malalignment of the knee. This study aimed to evaluate the TFA and its significance among the Bini tribe in Nigeria.

Materials and Methods: this study was conducted using the anterior-posterior hip-to-ankle radiographs of 200 adults (100 males and 100 females) between 25 to 55 years. The TFA was evaluated as the angle between the intersection of longitudinal axes of femoral and tibial bones bilaterally. Data was statistically analyzed and presented as mean and standard deviation (SD). Statistical comparisons were conducted across bilateral values and sex groups using t - test with $P < 0.05$ regarded as statistically significant level.

Results: among the study population, the mean TFA values for the the male subjects - 169.76 ± 4.23 (right TFA) and 170.42 ± 3.79 (left TFA) were significantly ($p < 0.05$) lower than the values for the female subjects - 174.07 ± 3.55 (right TFA) and 175.44 ± 3.32 (left TFA). The bilateral (combined) mean TFA value among males was 169.58 ± 4.15, among females was 175.26 ± 3.64 while the total mean value among the entire study population was 173.92 ± 3.93. The comparison with other study population indicated alternating outcomes.

Conclusion: this significant sex-linked variation in the bilateral TFA values bilaterally indicates the significance of the TFA as a parameter for sexual distinction among the study population. This study further presents the reference TFA values for the study population which offers great significance during clinical procedures involving the lower limb or knee articulation and alignment.

Keywords: Tibiofemoral angle; Knee alignment; Bini tribe; Anthropometry; Nigeria.

Introduction

The knee region comprised the largest synovial joint in the body which is a modified hinge joint that mainly allows the flexion and extension movements of the leg. In addition, the knee joint is a compound joint made up of three distinct joints which include two (lateral and medial) tibiofemoral or condylar joints formed between the medial and lateral condyles of the femur and tibia as well as the saddle joint formed between the patella and the femur[1]. The lateral and medial articular surfaces of the femur and tibia are asymmetrical with the distal surface of medial femoral condyle narrower than the lateral femoral condyle while the medial and lateral tibial articular surfaces are oval and circular respectively[2,3].

The condylar articulations between the femur and tibia create an angular alignment between the axes of the bones known as the tibiofemoral angle (TFA), an important anthropometric parameter with diverse applications and clinical significance. Generally, anthropometric parameters are scientifically evaluated measurements of different parts of the body which offer wide range of applications in clinical diagnosis and treatment planning, plastic and reconstructive surgery, forensic medicine and physical anthropology[4-6]. The TFA is an important anthropometric parameter used to describe the axial alignment of the lower limb and to determine the degree of deformity during malalignment of the knee[7]. It also provides relevant information to distinguish individuals that require further clinical examination to determine the correct procedures for deformity correction.

Previous study had described the application of preoperative tibiofemoral angle in predicting the outcome of proximal tibial osteotomy[8]. According to the findings of the study, the preoperative varus alignment of 9^0 or less and medial compartment osteoarthritis were indicated as bases for proximal tibial osteotomy while arthroplasty was prescribed when the preoperative varus alignment was more than 9^0. In another study, the TFA was described as a clinically significant parameter due to its variability following

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the tibial dome osteotomy[9]. The postoperative TFA was used to categorize the valgus angle of patients into three categories including angle of < 8^0, 8^0 - 12^0 and > 12^0.

According to a study conducted among adult Malawians, the TFA is clinically significant in the diagnosis and management of deformities associated with knee joint alignment including genu varum and valgus[10]. Furthermore, the TFA has been reported to exhibit racial differences in its developmental pattern with the age of peak valgus angulation varying among children of different races and population[11].

The diverse scientific and clinical applications of the TFA necessitated this study which was aimed to evaluate the anatomical TFA among the Bini tribe in southern Nigeria and to elucidate its significance.

Methods

Study population

This cross-sectional study was carried out among subjects from the Bini ethnic group in the southern part of Nigeria. The Bini ethnic group is one of the Nigeria's minority ethnic groups that is predominantly resident in the ancient Benin City (6^0 20' 17.34" N and 5^0 37' 32.70" E), Edo State. This study was conducted using the anterior-posterior (AP) hip-to-ankle (HTA) radiographs of 200 participants including 100 males and 100 females. The age of the study participants ranged from 25 to 55 years.

Ethical considerations

The ethical approval for the study was obtained from the research and ethical committee, the school of basic medical sciences, Igbinedion University, Okada, Edo State, Nigeria (Ref. No: 08/009225/HSC). The informed consent of the participants was obtained prior to the participation in the study.

Measurement of parameter

The anatomical TFA was measured as the angle formed by intersection of longitudinal axes of femoral bone and the tibial bone using the goniometer (Figure 1). The longitudinal axis of the femoral bone was determined by joining the midpoint of the widest part of the distal end of femur and centre of the shaft up to 10 cm proximally while the longitudinal axis of the tibial bone was determined by joining the midpoint of widest proximal end of tibia and centre of the shaft up to 10cm distally[12]. The TFA value on each side was measured twice to minimize measurement error and average value recorded. In addition, the average TFA value for the two sides of each participant was evaluated and recorded.

Inclusion and exclusion criteria

In this study, only the radiographs that show the characteristic alignment along the medial and lateral tibiofemoral articulations were included in this study. The radiographs showing unilateral or bilateral knee joint dislocation, distal femoral fractures, proximal tibial fractures or other trauma were excluded from this study.

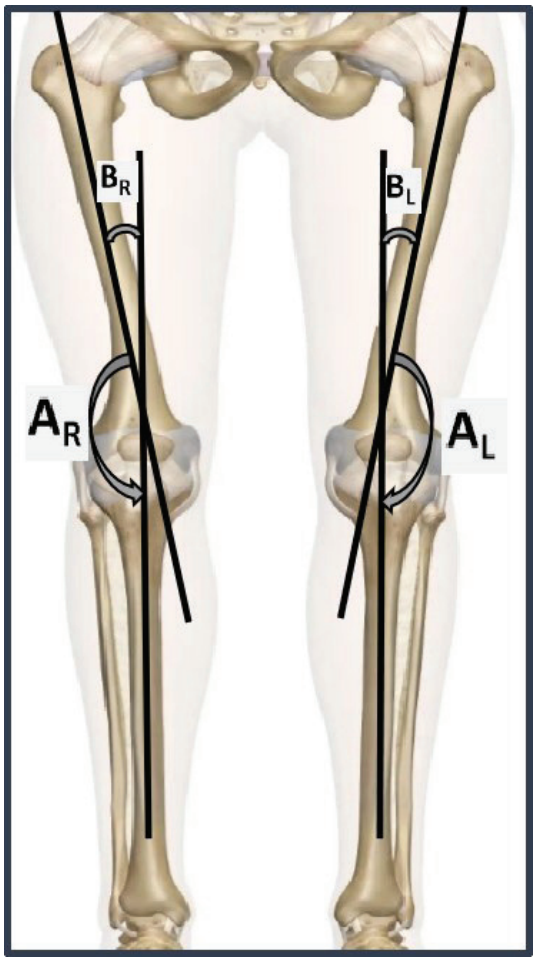

Figure 1. Schematic representation of right anatomical TFA (A_R) or valgus TFA (B_R) and left anatomical TFA (A_L) or valgus TFA (B_L).

Statistical analysis

Data was statistically analyzed using IBM-SPSS software (version 23) and presented as mean and standard deviation (SD). Statistical comparisons were conducted across bilateral values and sex groups using t-test with $p < 0.05$ regarded as statistically significant level.

Results

According to the results of this study (Table 1), the anatomical TFA values among the male and female participants showed no significant difference bilaterally. However, there exist significant ($p < 0.05$) sexual dimorphism in the TFA with the values among the males (right TFA - 169.76 ± 4.23 and left TFA - 170.42 ± 3.79) significantly lower than the values among the females (right TFA - 174.07 ± 3.55 and left TFA - 175.44 ± 3.32). The results of the study (Table 2) further reveal that the total TFA values among the overall

study participants showed no significant difference bilaterally. However, there exist sexual dimorphism in the bilateral (combined) TFA values whereby the mean value among males (169.58 ± 4.15) was significantly ($p < 0.05$) lower than the mean values among females (175.26 ± 3.64) (Table 3). The comparison of the TFA values among the study population and other population and age groups are presented in Table 4.

Table 1. The bilateral anatomical TFA values among male and female participants.

Variables	Right TFA (n =100) Mean ± SD. (^{0})	Left TFA (n =100) Mean ± SD. (^{0})
Male (n = 100)	169.76 ± 4.23	170.42 ± 3.79
Female (n = 100)	174.07 ± 3.55	175.45 ± 3.32
p value	0.037	0.031

n: Number of participants; TFA: Tibiofemoral angle; SD: Standard Deviation.

Table 2. The total bilateral TFA values among the study participants.

Variables	Total Right TFA (n =200)	Total Left TFA (n =200)
Mean ± SD. (0)	172.95 ± 3.23	172.98 ± 4.39
p value	0.065	

n: Number of participants; TFA: Tibiofemoral angle; SD: Standard Deviation.

Table 3. The bilateral (combined) TFA values among the male and female participants

Variables	Bilateral Male TFA (n = 100)	Bilateral Female TFA (n = 100)	Total TFA (n = 200)
Mean ± SD. (^{0})	169.88 ± 4.15	175.26 ± 3.64	173.92 ± 3.93
p value	0.029		

n: Number of participants; TFA: Tibiofemoral angle; SD: Standard Deviation.

Discussion

The TFA is an important clinical anthropometric parameter that defines the tibiofemoral alignment at the knee. According to the results of the current study, the males participants have significantly lower mean anatomical TFA (169.88 ± 4.15) than the values among the females participants (175.26 ± 3.64). The normal knee alignment is usually defined by valgus TFA values between 5^0 - 7^0 and deviations from these values result into genu vara or bow-legged (< 5^0) and genu valga or knocked-knee (> 7^0) conditions[17]. This implies that the decreased anatomical TFA is usually associated with coxa vara and genu valgum while increased tibiofemoral angle is associated with coxa valga and genu varum. The findings of this study further implies the prominence of valgus knee alignment among the males while the normal knee alignment is more prevalent among the females.

Moreover, the TFA is a crucial quantitative parameter of knee kinematics that is used to describe the knee alignment and knee joint function as well as the diagnosis of knee pathologies such as angular deformities, osteoarthritis and patellar instability[18-20]. It is also vital for preoperative knee surgical planning and verification of reconstruction postoperative[21,22]. Other previous studies have highlighted the relationship between the tibiofemoral geometry and musculoskeletal function during normal activity[23,24]. According to their findings, the geometric variations of the tibiofemoral alignment determine the associated motion and are crucial in the assessment of musculoskeletal function in different individuals. In addition, angular deformities such as knee malalignment can result into walking gait impairment, difficulty in running and sport activities[25]. Hence, genu varum can be associated with toeing-in gait while genu valgus can be associated with toeing-out.

Table 4. Comparison of the TFA in some study population.

Country (Demographics)	Valgus/Anatomical TFA (0)	Authors
Nigeria (3-10 years old)	7.87 (at 3 years) 1.00 (at 10 years)	Bafor *et al.*[7]
India (2 - 18 years old)	8.55 (at 7 years) 3.18 (at 18 years)	Baruah *et al.*[11]
Iran (Adult)	10.38 ± 3.43	Daneshmandi *et al.*[13]
Malaysia (children)	6.84 (at 6 years - boys) 6.59 (at 6 years - girls)	Mohd-Karim *et al.*[14]
Turkey (3 - 17 years old)	9.60 (at 7 years - boys) 9.80 (at 6 years - girls)	Arazi *et al.*[15]
Malawi (Adult)	174.14 ± 3.47 (males) 174.46 ± 4.30 (females)	Igbigbi & Msamati [16]
Nigeria (Adult Bini Tribe)	169.88 ± 4.15 (males) 175.26 ± 3.64 (females)	Current Study

Furthermore, the TFA is a parameter of importance during unicompartmental or total knee arthroplasty which are procedures usually carried out to restore the physiologic knee kinematics and to reduce the propensity for knee implants failure[26,27]. Tibiofemoral malalignment has also been implicated as one of the predisposing factors for the development of knee osteoarthritis[28]. The tibiofemoral alignment determines postural stability and the distribution of transmitted weight during the gait cycle[13,29]. During walking, over 70% of the transmitted force passes to the medial compartment in normal knee alignment. However, the varus or valgus knee alignment will have moments that increase the transmitted force on the medial and lateral compartments of the knee respectively[30]. This predisposes varus knee alignment to increased risk of medial compartment osteoarthritis (OA) while valgus knee alignment have increased risk of lateral compartment OA.

Anthropometric measurements often exhibit variations across different population, age groups and bilaterally[31-33]. Accordingly, the TFA values among the study population showed alternating variation compared to values among other population and age groups accessed (Table 4). Conversely, contrary to the findings of this study, the study conducted among adult Malawians reported no significant sexual dimorphism in the TFA[16]. In addition, bilateral variations commonly characterize paired body structures or morphological features. However, the findings of this study (Tables 1 and 2) showed no significant bilateral TFA variation among both male and female subjects. This thereby indicated significant bilateral symmetry regarding the TFA and tibiofemoral alignment among the study population.

Conclusion

The TFA demonstrated sexual dimorphism among the study population with the values among the females significantly higher than those among males. The findings of this study also present the reference mean TFA values for the study population which would be of great significance in the assessment of and planning for various related clinical procedures.

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