Original Article

POSI
IJPO
ISSN Online 2455-3905

Frontal Plane Angular Knee Deformities in School Children in Kribi, South Region of Cameroon

Jean GustaveTsiagadigui[1,3] MD, PhD, Robinson Mbako Ateh[2] MD, Marie-Ange Ngo Yamben[1] MD, Franck Olivier Ngongang[1] MD, Daniel Handy Eone[1] MD, Maurice Aurelien Sosso[1] MD


Dr. Jean Gustave Tsiagadigui


Dr. Robinson Mbako Ateh


Dr. Marie-Ange Ngo Yamben


Dr. Franck Olivier Ngongang


Pr. Daniel Handy Eone


Dr. Maurice Aurelien Sosso

Address of Correspondence
Dr. Jean GustaveTsiagadigui,
Department of Surgery and Specialties of Faculty of Medicine and Biomedical Sciences, University of Yaoundé 1, BP 1364, Yaoundé, Cameroon
E-mail: jtsiagad@gmail.com

[1]Department of Surgery and Specialties of Faculty of Medicine and Biomedical Sciences, University of Yaoundé 1, BP 1364, Yaoundé, Cameroon
[2]Faculty of Medicine and Pharmaceutical Sciences of the University of Douala, BP 2701, Douala, Littoral Region, Cameroon
[3]Department of Mechanical Engineering, ENSET, University of Douala, BP 2701, Douala, Littoral Region, Cameroon

DOI: https://doi.org/10.13107/ijpo.2023.v09.i01.150

Abstract

Bone problems such as angular deformities of the knee are common in children in Africa. The aim of this survey was to study epidemiologic aspects of frontal plane angular knee deformities in school children in Kribi. A total of 860 school children in Kribi aged 3 to 18 years were surveyed in a cross-sectional descriptive study from December 2019 to March 2020. Each child was examined. Intercodylar distances, intermalleolar distances and the tibiofemoral angles were assessed. The type of knee deformity in the frontal plane was determined from the children`s tibiofemoral angles and compared with reference values of normal children in the same age ranges. One hundred and forty two (142, 16.5%) children surveyed presented with frontal plane knee deformities, with genu varum representing 68.0% (96 cases) of the deformities. The prevalence of these deformities in school children in Kribi varied significantly with age. We did not find any significant difference in the variation of these deformities with gender or ethnic groups. We identified some frontal plane angular knee deformities, including bilateral deformities being predominant 90.71% (127 cases). The mean body mass index was higher than those of normal children. 15.5% (22) of them presented with associated deformity in the sagital plane, dominated by bilateral genu recurvatum and 33.8% (48) of them presented with associated rotational knee deformities, dominated by bilateral medial rotation. Frontal plane knee angular deformities are common amongst school children in Kribi. Their prevalence is 16.51% (142 cases). This prevalence varies with ages. Sagittal plane and rotational plane deformities are equally present in children presenting with these deformities.

Keywords: Bone, Children, Deformities, Cameroon.

Introduction

Musculoskeletal pathologies are a major burden on individuals and social care systems, with indirect high costs. Among these, frontal plane angular deformities of the knee include genu valgum (GVL) commonly called "knock-knees" and genu varum (GVR) also called "bow-legs". In GVL, the knees are curved inward so that they are close together, nearly knocking when the person walks with ankles widely apart from each other. GVR is marked by medial angulation with bowing of the knees. Usually, there is a normal slight outward angulation between the femur and tibia [1-3]. Knock-knees and severe bowlegs are handicapping and even painful at times. Though for majority of children, they represent a physiologic variation and spontaneously correct themselves, they may require orthopaedic or surgical procedure when they become pathological [1,4-17].

Deformities of the knee are studied by measuring the tibiofemoral angle (TFA), the

Submitted: 06/01/2023; Reviewed: 24/01/2023; Accepted: 11/03/2023; Published: 10/0 4/2023

Table I. Various nurseries, primaries and secondaries selected schools in the coastal town of Kribi during the study.

Category of school	Names of school	Reason(s) of choice
Nursery schools	Government Bilingual Nursery School (GBNS) New town	One of the most populated nursery schools in Kribi town, located in Kribi 1 council area and has an enrollment of about 130 pupils.
	Ecole Maternelle Adventiste (EMA)	Is a non- government nursery school run by the Adventist church in Cameroon. It is located in the Kribi 2 council area and has an enrollment of about 120 pupils.
Primary schools	Ecole Publique Pratique d'Application (EPPA) du centre Kribi (EPPA) du centre Kribi	Is the biggest and most populated primary school in Kribi town. It is a teaching practice centre for student teachers. It is located in the Kribi 1 council area. It has 4 groups with a population of about 2,400 pupils.
	Ecole Primaire Adventiste (EPA) Kribi	Is a non-government primary school located in the Kribi 2 council area, with an enrollment of about 700 pupils.
Secondary schools	Government Bilingual High School (GBHS) Kribi	Is the oldest, biggest and most populated secondary school in Kribi town. It is located in the Kribi 2 council area and has an enrolment of about 2,870 students.
	College Billingue Adventiste de Kribi (CABK)	Is a non-government secondary school located in the Kribi 2 council area, with an enrolment of about 980 students.

inter condylar distance (ICD) and inter malleoli distance (IMD). The clinical method is widely used and accepted as it is non-invasive, easy, reliable and reproducible [4, 7, 8-11]. As the mechanical axis is displaced, the child experiences gait disturbance, joint instability, and activity-related pain. The spine, hip and ankle may be involved secondarily. Early correction of these conditions during childhood is less expensive and avoids complications. [8, 12, 14, 18].

The prevalence of frontal plane deformities of the knee, and their developmental patterns of age referenced normal values for TFA, ICD and IMD vary for different populations [1, 4-7, 9-14, 19]. In Primary school children in Iran, the prevalence of GVR and GVL were 7.9% and 2% respectively. Whereas, in Port Harcourt Nigeria, children of the same age range presented 4.6% GVR. In Cameroon, Angular deformities of the knee in children represent 13.2% of all orthopaedic consultations [9, 12, 13]. Association with rickets has become rare in developed countries because of the undertaken measures (diet supplementation, early screening and treatment) [16, 20]. In sub-saharan Africa, several studies have shown that these rickets associated deformities represent a major presenting complain in orthopaedic consultations [12, 14, 21].

It was observed that, no case of GVR or GVL had been documented since 2012 at Kribi District Hospital. This motivated the present research work based on the analysis of frontal plane angular knee deformities within children, the main purpose being to determine epidemiologic aspects of GVL and GVR in school going children in Cameroon.

Methodology

Study design, duration and description of the study area

The study covered a period of four months starting from 5th of december 2019 to 5th of March 2020. It was carried out in selected schools (Nursery, primary and secondary schools) of the coastal town of Kribi. It has an estimated population of 125401 according to data obtained from the Kribi district health services in November 2019. The major ethnic groups are the Mabis, Batangas, Fangs, Bakokos, Bassas, Bulus, Ewondos, Pygmies, and other migrating population. Apart from the Pygmies, the rest of the population of Kribi has a varied morphotype and consume principally cassavas and fish. The total population of school children in Kribi urban city during the 2019-2020 academic years was 18,997 according to data obtained from education officers. There were thirty-two nursery schools, thirty primary schools, and eleven secondary schools. Two nursery, two primary and two secondary schools were selected randomly (Table I).

Sampling and samples size collection

The target population included all children attending nursery, primary or secondary schools in Kribi during the 2019-2020 academic years, aged 3 to 18 years, and whose school authorities and parents gave their consent for the survey. The minimum sample size was determined from Eq.1 known as Cochrane's formula [22-24].

$$n = Z^2 \frac{pq}{e^2} D_{eff}$$

In Eq.1, n is the minimum sample size; Z the confidence level (in this case we used, 1.96 for a 95% confidence level); p the estimated proportion of knee deformities in our population = 0.5; q= 1; e the desired level of precision or confidence interval, in our case we agreed on 0.05 and D_{eff} the design effect imposed on our sample by the sampling model we used. Since no similar studies have been carried out in Cameroon, it was assumed as an equal probability event. For sample size estimation in a two stage cluster sampling design, a value between 1.5 and 2 are accepted [22, 23, 25]. We choose 2 as our design effect for better accuracy.

Study variables

Deformity in the frontal plane was obtained from the right tibio femoral angle (RTFA) and left tibio femoral angle (LTFA) and was organised into nine modalities which were normal, bilateral GVL, bilateral GVR, unilateral right GVL, unilateral left GVL, unilateral right GVR, unilateral left GVR, Right windswept deformity and left windswept deformity. Other dependent variables included knee deformities in the sagittal plane rotational knee deformities and IMD/ICD.

Socio-demographic data included chronological age, sex, class, region of origin and ethnic group. Children were regrouped into four major ethnic groups including the Southern Tropical Forest Peoples, the Western Highlanders, the Coastal Tropical Forest People, and the Northerners. Anthropometric data

included weight, height, BMI, and LLD. Physical examination data included bone deformities.

Study procedure and data collection

The following procedures were applied step by step with each selected child:

- The child's class, age, gender, and ethnic group were verified in the school's records;
- Body weight (Kg) measured bare footed in school uniform standing on a scale (Fig. 1a) [10, 16];
- Height (cm) measured standing upright, barefooted, heels together, knees straight with the back against the height meter, looking straight forward (Fig. 1b) [16];
- The knee deformities in the sagittal plane (genu procurvatum and genu recurvatum), rotational knee deformities (lateral rotation and medial rotation), other bone deformities, other abnormalities observed on physical examination;
- Anterior Superior Iliac Spine (ASIS), apex of the patella, and mid-point of the ankle were identified by palpation and marked with the skin marker (Fig. 1b) [2, 3];
- Two straight lines were drawn on each lower limb, the first linking the ASIS to the apex of the patella and the second linking the knee to the centre of the ankle using a skin marker (Fig. 1b);
- Lower limb lengths (LLL) for each limb were then measured from the ASIS to the medial malleolus of the ankle (cm) to the nearest whole number with a meter tape, with the child standing;
- ICD, IMD, right and left TFA were measured (Fig. 1c) [10];
- TFA was measured with the child standing, with hips and knees in full extension. The acute angle between the shafts of the femur and the tibia were recorded as positive (+) for genu valgum and negative (-) for genu varum (Fig. 1c) [6, 10];

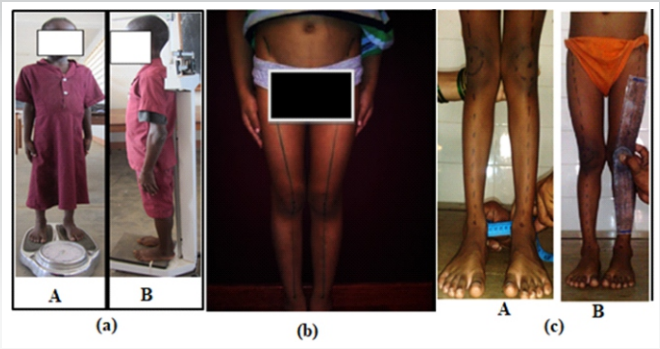

Figure 1 : Measurement of children's physical parameters
(a): setting of parameters of the children
A: measuring of the weight
B: measuring of the height; (b): Skin marks over the anterior superior iliac spine, the apex of the patella, and the mid-point of the ankle with marking of the tibiofemoral axis; (c): measurement of children's leg angulations
A: measuring the inter malleolar distance
B: measuring the tibiofemoral angle.

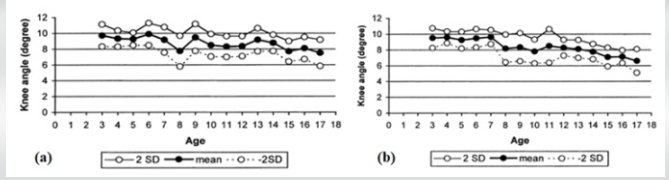

Figure 2 : Tibiofemoral angle versus age in girls (a) and boys (b)

- The type of deformity in the frontal plane was obtained from the TFA (Fig. 2a and b) [18].

Data management and statistical analysis

All the data collected was entered into the data collection form. BMI and LLD were automatically calculated by the software as given in Eq.2 and Eq.3:

$$BMI = \frac{weight(kg)}{(Height)^2(m^2)} \quad (2),$$

$$LLD = |RLL - LLL| \quad (3).$$

These data were analysed using the software Epi Info version 7.1.2.0., Microsft Excel 2010 and IBM SPSS version 20. A descriptive analysis was conducted for age, BMI, IMD, ICD and LLD as well as for type of deformity in the frontal plane for both girls and boys and for the ten most represented ethnic groups. The one-way ANOVA (Analysis of Variance) was used to compare the variation of means within groups. Proportions were compared using the Pearson's Chi-squared test and the results were considered statistically significant when the P-value was < 0.05. The presence of other types of skeletal deformities was signalled when present. The mean TFA was plotted against age to obtain variations with age. For each child, it was calculated by the software using Eq.4:

$$Mean(TFA) = \frac{RTFA + LTFA}{2} \quad (4).$$

Results

Study population

From the 18,997 children attending school in Kribi, 860 were randomly selected using a 2-stage cluster sampling design as described above in the methodology. They were organised as

Table II: List of selected schools and the respective classes surveyed

Level	Selected Schools	Selected Classes	Number of children surveyed
Nursery	GBNS New Town	Senior section and Junior sections	100
Schools	EMA Kribi	Intermediate sections	51
Primary	EPPA du centre Kribi	Class 1, Class 3, and Class 6	204
Schools	EPA Kribi	Class 2, Class 4, and Class 5	119
Secondary	GBHS Kribi	Form 2, Form 4, and Form 5	171
Schools	CABIK	Form 1, Form 3, Lower Sixth, and Upper Sixth	215
Total	**6**	**16**	**860**

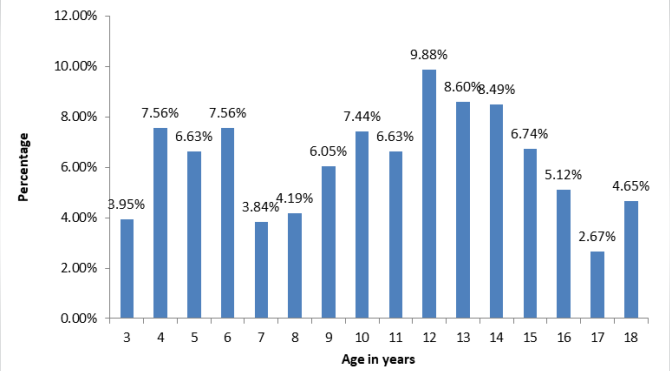

Figure 3 : Distribution of the 860 children surveyed from schools in Kribi by age.

follows: one hundred and fifty-one (151, 17.56%) from nursery schools, 323 (37.56%) from primary schools, and 386 (44.87%) from secondary schools. The following classes were selected (Table II).

Description of the studied population

Majority of children surveyed were girls, with sex ratio of 1.15. The ages ranged from 3 to 18 years old of age. The median age was 11 years (Fig. 3).

The most represented ethnic group was the Coastal Tropical Forest People (307 children) which was made up principally of the Batanga (80 children), the Bassa (60 children), the Ngoumba (48 children), the Mabi (40 children) and the Bakoko (16 children). The mean BMI by age are presented in table III.

The mean LLD of our sample was 0.97 cm (SD of 0.91), with a median and mode of 1 cm, a minimum LLD at 0 and a maximum LLD at 7 cm. The mean IMD for all children examined was 3.15 cm, with a minimum IMD of 0 cm and a maximum of 19 cm. An analysis of variance (ANOVA) test comparing the mean IMD for different ages found a significant relationship between IMD and age with; Mean square= (15, N= 860)= 15.30, p= 0.01. The mean ICD for all children examined was 2.25 cm, with a minimum IMD of 0 cm and a maximum of 7 cm. An ANOVA test comparing the mean IMD for different ages found a significant relationship between IMD and age with; Mean square= (15, N= 860) = 20.44, p<0.001 (Fig. 4).

Table III: The mean BMI by age of school children in Kribi during the study period.

Age	Number of children	Mean	Variance
3	34	15.64	3.33
4	65	16.29	2.15
5	57	15.98	1.77
6	65	15.95	2.22
7	33	16.14	1.79
8	36	15.76	2.84
9	52	17.27	5.08
10	64	16.97	6.68
11	57	18.79	7.26
12	85	19.08	7.79
13	74	20.28	6.17
14	73	20.9	7.13
15	58	21.31	7.23
16	44	21.87	5.89
17	23	21.01	18.13
18	40	20.68	8.34

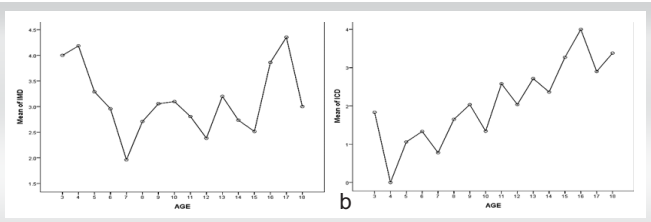

Figure 4 : The mean by age
a : IMD
b : ICD

Prevelance and distribution of deformities by sex, age and ethnic group

The prevalence of frontal plane knee deformities amongst the 860 children examined was, 5.35% (46 cases) for GVL, and 11.16% (96 cases) for GVR. Of the 142 children presenting knee deformities in the frontal plane, those with GVR were twice those with GVL. Pearson's Chi-square test was performed and we found no relationship between gender and the presence of frontal plane knee deformities, X^2= (2, N= 860)= 3.48, p= 0.17 (Fig. 5).

Based on their age, a significant relationship was found between age and type of frontal plane angular deformity. Pearson's Chi-square test was X^2= (30, N= 860)= 61.6, p<0.001. The results show that significant difference was found between presence of deformity in the frontal plane and ethnic group (Fig. 6).

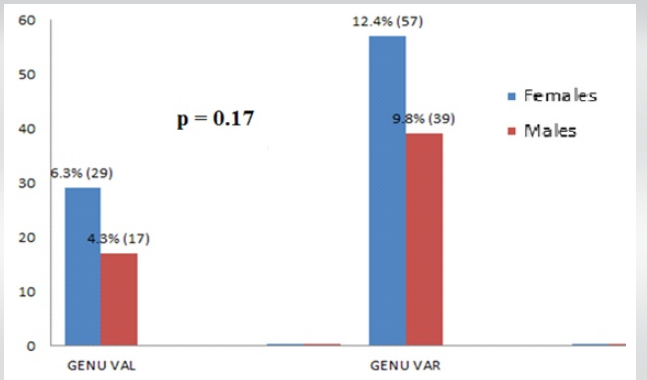

Figure 5 : Distribution of GVL and GVR by sexes in 142 children presenting frontal plane knee deformities in schools in Kribi.

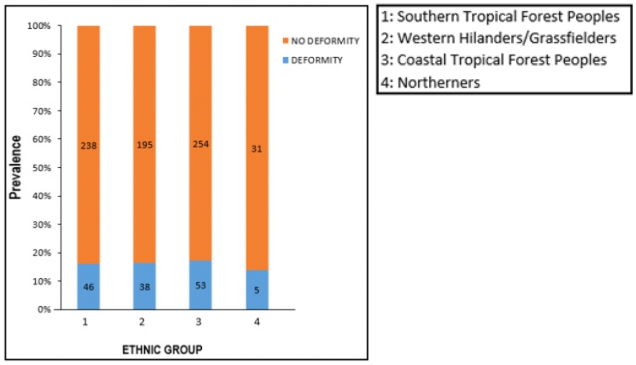

Figure 6: Prevalence of frontal plane knee deformity by ethnic group in school children in Kribi.
Pearson's Chi-square test was $X^2 = (47, N = 860) = 50.85, p = 0.32$.

Characteristic of children with deformities

Table IV depicts the mean BMI by age of children with GVR and/or GVL and Table V depicts the mean TFA by age of the 142 school children in Kribi with frontal plane knee deformities. Amongst the 142 school children presenting frontal plane knee deformities in Kribi, we had a mean varus angle of -1.35 (SD; 10.86). On ANOVA there was no significant difference between TFA and age amongst children who presented deformities. For instance, the mean LLD of our sample was 1.39 cm (SD of 1.24), a minimum LLD at 0 and a maximum LLD at 7.

In table VI, we presented the types of frontal plane knee deformities found in children attending school in Kribi during the 2019-2020 academic year. Most of the deformities presented by children in Kribi were bilateral (90.71%). We did not find any child presenting with a "wind swept" deformity.

Other knee deformities present

Other types of deformities observed include sagittal plane (Fig. 7) and rotational (Fig. 8) deformities in children with GVR and or GVL.

In the former, amongst the 142 school children presenting with frontal plane knee deformities, 22 also presented with a sagittal plane knee deformity (15.5%) with bilateral genu recurvatum being the most frequent with 12 cases (8.5%). 48 children (33.8%) presented with rotational knee deformities in association with the frontal plane deformity. Bilateral medial rotation was the most frequent rotational deformity.

Table IV: Mean BMI by age of children with GVR and/ or GVL.

Age	Mean BMI of children with deformities	Mean BMI of normal children CDC reference values
3	17	16
4	17.28	15.5
5	17.25	15.4
6	16.42	15.4
8	16.75	15.8
9	19.57	16.2
10	18.7	16.6
11	19.21	17.2
12	17.7	17.8
13	19.95	18.4
14	21.54	19.2
15	21.5	19.8
16	21.5	20.8
17	18.66	21.2
18	19.75	21.8

Table V: Mean TFA by age of the 142 school children in Kribi with frontal plane knee deformities.

AGE	Mean TFA (in degrees)	Number of Children	Standard Deviation	P-Value
3	-8	2	29.69	P= 0.095
4	11.35	7	8.07	
5	-0.75	4	10.59	
6	2.71	7	13.88	
8	0.75	4	13.3	
9	-1.28	7	14.87	
10	3	10	11.28	
11	-2.28	14	10.49	
12	-8.2	10	4.36	
13	-2.05	20	9.92	
14	-1.13	22	9.69	
15	-6.78	14	5.53	
16	-0.3	10	13.46	
17	-0.66	3	10.4	
18	-2	8	10.12	
Total	-1.35	142	10.86	

Table VI: Types of frontal plane knee deformities found in children attending school in Kribi during the study period.

Type of frontal plane knee deformity	Frequency	Prevalence in children in Kribi	95% Confidence interval. [lower-upper]
Bilateral GVL	36	4.19%	[2.99%- 5.81%]
Unilateral left GVL	2	0.23%	[0.04%- 0.93%]
Unilateral right GVL	8	0.93%	[0.43%- 1.90%]
Bilateral GVR	91	10.58%	[8.64%- 12.88%]
Unilateral left GVR	3	0.35%	[0.09%-1.11%]
Unilateral right GVR	2	0.23%	[0.04%- 0.93%]
Left windswept	0	0.00%	[0.01%- 0.55%]
Right windswept	0	0.00%	[0.01%- 0.55%]

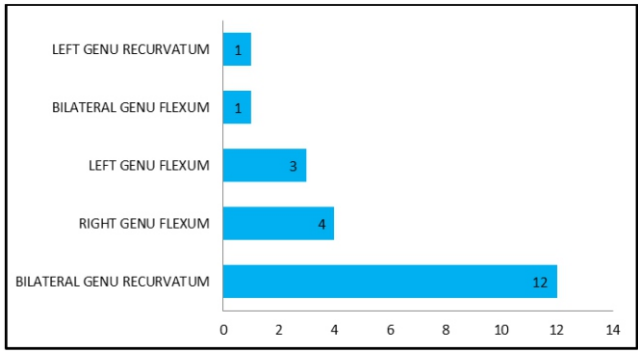

Figure 7 : Sagittal plane deformities in children with GVR and or GVL

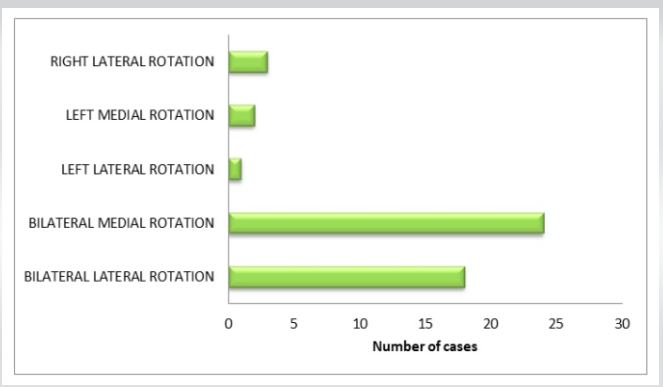

Figure 8 : Rotational deformities in children with GVR and or GVL

Discussion

The study specifically intended to describe the socio-demographic and anthropometric profile of the children, calculate the prevalence of GVL and GVR amongst children attending school in Kribi, and list some characteristic features present in children presenting with GVL and GVR in Kribi. Of the 860 children, 54% were female. That was in line with Yoo et al. (2008) in Korea and Salenius and Vankka (1975) in Finland who studied the development of TFA in children less than 16 years old [7, 26]. More comparable to the present study were the samples from the general children population in Nigeria and children aged from 6 to 10 years or the 3000 children in primary schools in Iran within pupils aged between 7 to 11 years [13, 9].

Few studies have been specified for the prevalence of frontal plane knee deformities in general children's population. Most do study the variations of TFA in normal children [1, 4, 6, 8, 10, 11, 18, 27]. Our prevalence was 5.35% (46 cases) for GVL and 11.16% (96 cases) for GVR. The prevalence of GVR was two times that of GVL, similar to results obtained on primary school children in Iran, and higher than the 4.6% obtained in Nigeria [9, 13]. This high prevalence of GVR in sub Saharan Africa and India could be due to the high prevalence of nutritional rickets in these populations compared to European populations as reported by Thacher et al. [20]. It was found that severe deformities of lower limbs in congolese children were sequelae of rickets, especially GVR (58.2%) [21].

In our sample, 9.35% of (86) girls and 7.05% of (56) boys presented with frontal plane angular knee deformities without any significant difference (p-value= 0.17). This finding was equally observed by several authors all over the world [7, 11, 19, 26, 28]. Neverthless, Mahmoud et al. (2005) reported that the prevalence of GVR was twice in boys than in girls and that GVL was 3 times higher in girls in Iranian children [9, 12].

The prevalence of frontal plane angular knee deformities varied significantly with age (p-value < 0.001). GVR varied from a prevalence of 2.9% at 3 years to a maximum of 22.4% at 15 years with an average of 11.2%. Equally GVL varied from 2.9% at 3 years to a maximum of 9.6% at 14 years, the average prevalence being 5.3%. It was noted that ICD, IMD and TFA were significantly different for different ages. These findings are in line with those made by Salenius and Vankka (1975) in Findland, Cahuzac et al. (1995) in France, and Omololu et al. (2003) in Nigeria who found significant variations of knee angles for different ages, from varus angles below 2 years to neutral then valgus angles till adult age [6, 7, 27]. The mean TFA for the ages 3 to 13 years was valgus angles (positive angles), which is still in line with the above authors. There is a disparity with the above authors in the ages of 14, 16 and 18 years where we found varus angles (negative angles). This disparity could be explained by the fact that in the present study, both normal children and children presenting with deformities were included.

There were no significant variations in the prevalence of these deformities within the different ethnic groups present in our sample (p-value= 0.32). These findings seems to contradict the general idea that knee deformities vary for different geographical areas [1, 5, 6, 9, 11, 27]. Knee deformities do vary for different geographical areas as reported by the above authors, but in our study the uniform distribution of these deformities in our sample could be explained by the fact that all the sampled children live in that same town. The environment in which they live and grow could have a great impact on their skeleton. Ibrahima et al (2002) reported the socio-ethnic and ecological influence in a series 0f 158 cases studied in Yaounde, where they observed that the Bamileke (53.8%) and Ewondo (13.3%) dominated in the series [12].

The mean BMI by age for children presenting GVR and /or GVL vary from 17.00 kg/m^2 at 3 years to a maximum of 21.54 kg/m^2. Compared to the values for normal children established by CDC (Centre for disease control and prevention) (Table VI), we may conclude that the mean BMI by age for children with deformities is higher than that for children without deformities [29]. They equally concluded that elevated BMI increases loading of the knees and lower extremity. Amongst the 142 school children presenting with frontal plane knee deformities in Kribi, the Mean TFA was varus; -1.35 (SD; 10.86). This could be explained by the fact that in sub Saharan African countries prevalence of nutritional rickets is high [20, 21]. Amongst the deformities presented in our sample, 90.71% (127 cases) were bilateral deformities. Out of the 2,711 cases of knee deformities observed by Ibrahima et al (2014) in 11 years (1998 to 2008), 79.60% (2,158 cases) were bilateral. This result is in accordance with the findings of several other authors [9, 12, 13, 21, 29, 30].

Conclusion

Amongst school children in Kribi, the prevalence of frontal plane knee angular deformities is 16.51% with 11.16% having varum and 5.35% genu valgum. This prevalence is similar to

what is know in sub Saharan African countries. The prevalence of these deformities varies significantly with age as reported by most authors. There is no significant difference in the genders and ethnic groups. Some major characteristics were identified in school children in Kribi with frontal plane knee angular deformities including 90.71% bilateral deformities, higher mean BMI than those of normal children, 15.5% with associated deformity in the sagital plane, and 33.8% with associated rotational knee deformities.

References

1. Ezeuko VC, Owah S, Ukoima HS, Ejimofor OC, Aligwekwe AU, Bankole L. Clinical study of the chronological changes in knee alignment pattern in normal south-east nigerian children aged between 0 and 5 years. Electron J Biomed. 2010;1:16–21.

2. Gale Group. Knee deformities. Gale Encyclopedia of Medecine. The Gale Group; 2008.

3. Houghton Mifflin Company. Genu varum. The American Heritage Medical Dictionary. Houghton Mifflin Company; 2007.

4. Mathew SE, Madhuri V. Clinical tibiofemoral angle in south Indian children. Bone Jt Res. 2013 Aug;2(8):155–61.

5. George HT. Angular deformities of the lower extremities in children. Chapman's Orthopaedic Surgery. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2001. p. 4288–326.

6. Cahuzac JP, Vardron D, Sales 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 Jt Surg. 1995 Sep;77B(5):729–32.

7. Salenius P, Vankka E. The Development of the Tibio-femoral Angle in Children. J Bone Jt Surg. 1975;(57 A):259–61.

8. Samia AA , Wafa BA. Normal Development of the Tibiofemoral Angle in Saudi Children from 2 to 12 Years of Age. World Appl Sci J. 2011;12(8):1353–61.

9. Mahmoud KM, Alireza K, Zahra Y. The prevalence of genu varum and genu valgum in primary school children in Iran 2003-2004. J Med Sci. 2005;5:52–4.

10. Heath CH, Staheli LT Normal limits of knee angle in white children genu varum and genu valgum. J Pediatr Orthop. 1993;(13):259–62.

11. 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 Apr;11(2):154–61.

12. Ibrahima F, Pisoh T, Abolo ML, Sosso MA, Malonga EE. Déformations angulaires de genu varum/genu valgum chez l'enfant et l'adulte jeune : Revue préliminaire de 158 cas observés à Yaoundé. Médecine Afr Noire. 2002;49(4):169–75.

13. Udoaka AI, Olotu J, Oladipo GS. The Prevalence of Genu Varum in Primary School Children in Port Harcourt, Nigeria. Sci Afr. 2012 Dec;11(2):115–7.

14. Oginni LM, Badru OS, Sharp CA, Davie MW, Worsfold M. Knee angles and rickets in Nigerian children. J Pediatr Orthop. 2004;24:403–7.

15. Singh O, Maheshwari TP, Hasan S, Ghatak S, Ramphal SK. A study of Tibiofemoral angle among Healthy Male Maharashtrian population. Int J Biomed Res. 2013;4(7):323–9.

16. Ramin E, Seyed MM, Taghi B. Angular Deformities of the Lower Limb in Children. Asian J Sports Med. 2010 Mar;1(1):46–53.

17. Sharrard WJ. Knock knees and bow legs. Br Med J. 1976;1:826–7.

18. Mehmet A, Tunc¸ OC, Recep M. 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.

19. Engel GM, Staheli LT. The natural history of torsion and other factors influencing gait in childhood. Clin Orthop. 1974;991:12–7.

20. Thacher TD, Fischer PR, Tebben PJ, Ravinder J Singh, Cha SS, Maxson JA, et al. Increasing incidence of nutritional rickets: a population-based study in Olmsted County, Minnesota. Mayo Clinic Proceedings [Internet]. Elsevier; 2013.

21. Echarrri JJ, Bazeboso JA, Gullen GF. Rachitic deformities of lower members in congolese children. An Sist Sanit Navar. 2008 Sep;31(3):235–40.

22. Ahmed S. Methods in sample survey: Cluster Sampling. Johns Hopkins Bloomberg School of Public Health; 2009.

23. William C. Sampling Techniques. 3rd Edition. New York: John Wiley & Sons; 1977. 233-290 p.

24. Ross K. Sample design for educational survey research. Quantitative research methods in educational planning [Internet]. Paris, France: International Institute for Educational Planning/UNESCO; 2005. p. 17–25.

25. Naing L, Winn T, Rusli B. Practical Issues in Calculating the Sample Size for Prevalence Studies. Arch Orofac Sci. 2006;1:9–14.

26. Yoo JH, Cho TJ, Chung CY, Yoo WJ. Development of tibiofemoral angle in Korean children. J Korean Med Sci. 2008;23:714–7.

27. 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;22:301–4.

28. Qureshi MA, Soomro MB, Jokhio IA. Normal limits of knee angle in Pakistani children. Prof Med J. 2000;7:221–6.

29. Rahmani NF, Daneshmandi H, Irandoust KH. Prevalence of Genu Valgum in Obese and Underweight Girls. World J Sport Sci. 2008;1(1):27–31.

30. Ibrahima F, Bernadette NN, Bahebeck J. A study of 2711 cases observed at the National Centre for the Rehabilitation of the Disabled of Yaoundé (Cameroon). Oral presentation presented at: Socot; 2014; Brazil.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/her images and other clinical information to be reported in the journal. The patient understands that his/her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

How to Cite this Article

Tsiagadigui JG, Ateh RM, Yamben MAN, Ngongang FO, Eone DH, Sosso MA | Frontal Plane Angular Knee Deformities in School Children in Kribi, South Region of Cameroon | International Journal of Paediatric Orthopaedics | January-April 2023; 9(1):13-20 | https://doi.org/10.13107/ijpo.2023.v09.i01.150