

## Rotational Profile of the Lower Limbs of Nigerian Children in Lagos, Nigeria

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When children with rotational problems of the lower limbs present in our clinics, they need objective ways of clinical assessment to differentiate the large percentage of them who fall within the wide range of normal physiological variation from the very minute or occasional ones that will need further investigation and treatment. Various researchers in different regions of the world have measured some parameters in normal children to provide normal values for routine clinical reference in their environments. They have noted some local differences in the value of these parameters which has been attributed to racial, genetic and environmental factors. This study aims to determine and provide normal values of the thigh-foot and hip rotation angles in Nigerian/African children for routine clinical reference and use in our sub-region. Six hundred Nigerian children (1200 limbs) aged 3 – 8 years selected from 12 nursery/primary schools in Lagos had their thigh-foot angles, lateral and medial hip rotation angles measured using clinical methods. Values were recorded in a proforma for later collation and analysis. The mean thigh-foot angle increased from 4.4° at 3 years of age to 9.4° at age 8. Lateral hip rotation was 43.5° at age 3 and decreased to 38.5° at 8 years of age while, medial hip rotation increase from a mean of 35.7° to 44.3° at 3 years and 8 years of age respectively. Total hip excursion increased marginally from 78° at 3 to 82.2° at 8. While the general pattern of rotational parameters in Nigerian children in this study were similar to those from other studies in other regions, some basic differences especially in terms of range of normal value do exist. This should be borne in mind by doctors treating children in this environment. Routine reference to locally generated data as in this study is thus highly advised.

**Key words:** In-toeing, Out-toeing, Thigh-foot angle, Medial hip rotation, Lateral hip rotation, Total hip excursion.

Rotational problems in the lower limbs of children usually present either as in-toeing or out-toeing. Presentation of such children in our clinics is becoming more common as parents are getting more enlightened in our environment. In-toeing may commonly be due to internal tibial torsion, excess femoral neck anteversion, or metatarsus

adductus, while out-toeing may result from similar but opposite causes like lateral tibial torsion, excess femoral retroversion or flat feet. They may also present occasionally as part of other pathological entities or syndromes<sup>1-8</sup>.

The vast majority of the children presenting with such presumed rotational malalignments however, actually fall within the range of normal (mean  $\pm$  2 standard deviations) physiological variations in these parameters that occur with growth as alluded to by various authors<sup>1,2,3,7</sup>. Only a few of such presentations are

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due to pathologies that may eventually need treatment<sup>1,2,3,4,7</sup>.

At presentation, such children after a proper and detailed history with particular attention to the musculo-skeletal system need specific assessment for rotational parameters that will help the clinician to differentiate the wide range of physiological variations from pathological entities that may similarly present. Various methods have been designed and used by many clinicians and researchers for this purpose. These range from: roentgenographic methods like the use of bi-plane X-rays, computerized tomography scan, to the use of photographic and clinical methods or a combination of them<sup>1-4,6,10-19</sup>. Many of these methods are quite complex and technically demanding in addition to high cost and harmful potentials.

The clinical methods as described by Cheng *et al*<sup>[3]</sup> and used in their study on Chinese children have been chosen and used in this study on normal children due to simplicity and the ease of use in our routine clinics. They are easily used to determine those that fall within the normal physiological range and would not need further investigations and treatment.

Using these methods, normal range of the rotational parameters of the lower limbs (thigh-foot angles, medial and lateral hip rotation angles) have been determined in various environments<sup>3,4,7</sup>. From their study in Chinese children Cheng *et al.*,<sup>3</sup> observed some differences in the range of normal values between Chinese children and other races which they attributed to be possibly due to racial, genetic and probably environmental factors.

The need to obtain local range of these parameters in Nigerian and thus African children especially in the age group in which these variations are more marked in order to aid in our daily management of these patients is thus imperative. This study aims to provide a range of normal values for these parameters for routine reference and use by Orthopaedist and other Physicians who treat children with lower limb rotational problems in our sub-region.

## MATERIALS AND METHODS

This study involved the measurement of the following parameters in Nigerian children aged

3-8 years (age last birthday) in Lagos, Nigeria:

- 1) The thigh-foot angles.
- 2) The lateral hip rotation angles
- 3) The medial hip rotation angles
- 4) And the calculation of the total hip excursion for each limb as a sum of the lateral and medial hip rotation angles.

Six hundred (1,200 limbs) normal asymptomatic Nigerian children without any gross musculo-skeletal anomaly were examined and had the above parameters measured in them.

Two local government council areas were selected by random sampling from Lagos metropolis. The local education authorities for the councils were contacted and consent for the study taken. A list of schools in the council areas were also obtained. The list was used as sample frame and systematic random sampling done to select a total of 12 nursery/primary schools (6 public and 6 private). At each of the schools, consent was obtained from the school authorities and parents/teachers association after which a list of children that fell within the study age group was also obtained. Fifty children were further selected from each of the 12 schools to make a total of 600 children by systematic random sampling using the list of children as sampling frames<sup>20-21</sup>.

Measurements of the above parameters were done and values recorded for each child in a previously prepared proforma for this purpose for later collation and analysis. All measurements were carried out by the first author. Intra-observer variation was evaluated by repeated measurement of the above parameters in six children aged: 3, 4, 5, 6, 7, and 8 years daily for two weeks. The average standard deviations were: 4°, 2.8° and 3.2° respectively for the thigh-foot angle, medial and lateral hip rotation angles respectively.

### Measurement of Thigh-foot Angles

This was done using clinical methods as described by Cheng *et al*<sup>[3]</sup>. The child was positioned prone on a firm couch with the pelvis stabilized by strapping and further maintained by an assistant. The hips were in neutral position, the knees flexed to 90° and the ankle in neutral position. See pic.1. The examiner stood at the leg end of the couch and looked vertically on the axes of the foot and the ipsilateral thigh. Using a standard goniometer placed on the sole of the foot with the arms directed at the axis of the foot and that of the

thigh, the thigh-foot angle was taken. Medially deviated (in-toeing angles) were recorded as negative (-) while laterally deviated angles (out-

toeing angle) were recorded as positive ( $\pm$ ) angles. See. Plate 2.



**Plate 1.** Position for Measurement of Thigh-foot Angles And Hip Rotation Angles



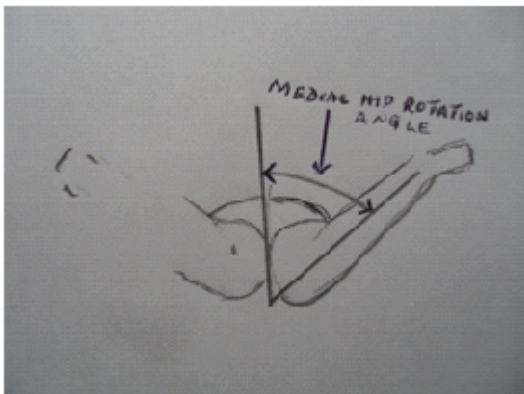
**Plate 2.** Measurement of Thigh-foot Angle

#### Measurement of Hip Rotation Angles (Medial & Lateral)

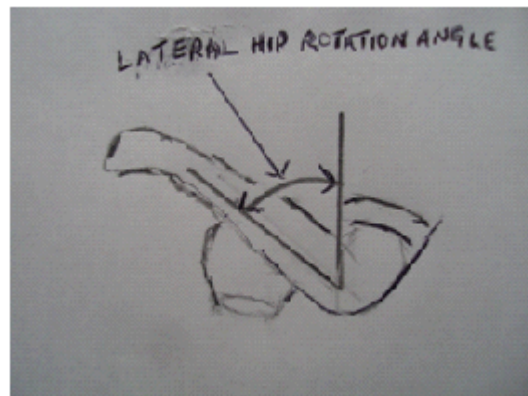
To measure hip rotation angles, the child remained in the position (Plate.1) above. Bending and looking cephalad from the leg end of the couch, the examiner rotated both legs outwards (laterally) at the same time to measure the medial hip rotation angle then, inwards (medially) one leg at a time to measure the lateral hip rotation angles. A standard goniometer with one arm directed at the direction

of the leg and the other arm parallel with the horizontal (top of the couch) was used to take the angles. The angle between the direction of the rotated leg and the vertical midline plane was recorded as the rotation angle for each limb. (See Plate. 3 & 4.)

Total hip excursion was calculated as the sum of the lateral and medial hip rotation angles for each limb.



**Plate 3.** Medial Hip Rotation Angle (Right)



**Plate 4.** Lateral Hip Rotation Angle (Right)

#### Data Handling

The subjects were divided into six age groups. The Statistical Package For Social Science

(SPSS) software version 12 was used for handling and analysis of data. In all statistical tests, the null hypothesis was rejected at  $P < 0.05$ .

## RESULTS

One thousand, two hundred limbs of 600 hundred children were measured in this study. There were 311 males and 289 females. The age/sex frequency distribution is as shown in table. 1. & the bar chart (fig. 1).

### Thigh-foot Angle

Most of the children in the age group studied (98.2%), exhibited a lateral (out-toeing) thigh-foot angles. Only 11(1.8%) of the 600 children showed in-toeing (medially deviated) thigh-foot angles.

A mean thigh-foot angle of  $4.4 \pm 8.1^\circ$  was displayed by the 3 year old group which gradually increased to  $9.4 \pm 7.4^\circ$  in the 8 year olds. On the average, females exhibited  $0.5-1^\circ$  more out-toeing than males. There was significant difference between the right and the left sides using the paired t-test ( $P < 0.031$ ). The two sides were however, highly correlated with a correlation coefficient of (0.978)  $P < 0.0001$ . Both sides were thus computed together. Table 2. shows the mean for both sides  $\pm 2$  standard deviations (SD) for the six age groups studied. The graph in fig. 2 is plot age group versus mean thigh-foot angle  $\pm 2$  standard deviations (SD).

**Table 1.** Showing Age/Sex Distribution Frequency

Age in Years	SEX		Total
	Male	Female	
3	36	39	75
4	52	55	107
5	55	50	105
6	45	49	94
7	56	62	118
8	45	56	101
Total	289	311	600

### Lateral Hip Rotation

This showed a gradual increase in both sexes with age. A mean value for both sides of  $43.5^\circ \pm 18.6^\circ$  was obtained at three years of age that gradually decrease to a mean of  $38.5^\circ \pm 14.5^\circ$  at 8 years of age. The left hip on the average showed about  $4^\circ$  more lateral hip rotation than the right in the age groups studied. See table. 3. Boys also displayed about  $3^\circ$  more lateral hip rotation than girls. The graph in fig.3 shows the mean  $\pm 2$ SD versus age.

### Medial Hip Rotation

On the other hand, medial hip rotation gradually increased in both sexes and sides from a mean of  $35.7^\circ \pm 20.6^\circ$  at 3 years of age to  $44.3^\circ \pm 20.7^\circ$  at the age of 8 years. On the average, the right hip showed about  $4-5^\circ$  more medial hip rotation than the left. (table 4). In all age groups, females exhibited about  $7^\circ$  more medial hip rotation than males. Fig. 4 is plot of the age in years against the mean medial hip rotation angle  $\pm 2$  SD.

### Total Hip Excursion

There was a marginal increase in the total hip excursion with age in this study. A mean of  $78.8^\circ \pm 18.4^\circ$  was observed at the age of 3 years with a marginal increase to  $82.2^\circ \pm 23.9^\circ$  at the age of 8

**Table 2.** Mean Thigh-foot Angle  $\pm 2$ SD for the Ages Studied

Age in Years	Mean Thigh-foot Angle	Mean +2SD	Mean -2SD
3	4.4	12.5	-3.7
4	6.0	12.3	-0.4
5	6.5	13.0	-0.0
6	7.4	15.0	-0.3
7	8.4	17.0	-0.3
8	9.4	17.0	2.1

**Table 3.** Mean Lateral Hip Rotation (Rt &Lt) Compared. & Combined Average  $\pm 2$ SD

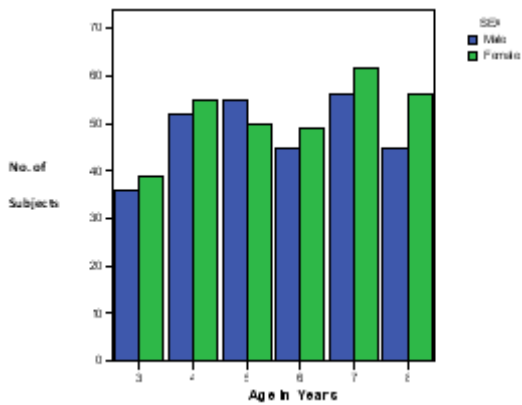
Age In Years	Rt. Lat. Hip. Rotation in Degrees	Lt Lat. Hip Rotation in Degrees	Combined Average Lat. Hip. Rotation in Degrees	Av. +2SD	Av. -2SD
3	41.4	45.4	43.5	62.1	24.8
4	42.1	45.7	43.8	59.0	28.6
5	40.5	44.8	42.6	57.0	28.2
6	40.7	43.9	42.7	59.8	25.6
7	39.8	43.4	42.1	58.9	25.2
8	37.0	40.2	38.5	52.8	24.1

**Table 4.** Mean Right & Left Medial Hip Rotation Compared & Combined Mean  $\pm$  2SD

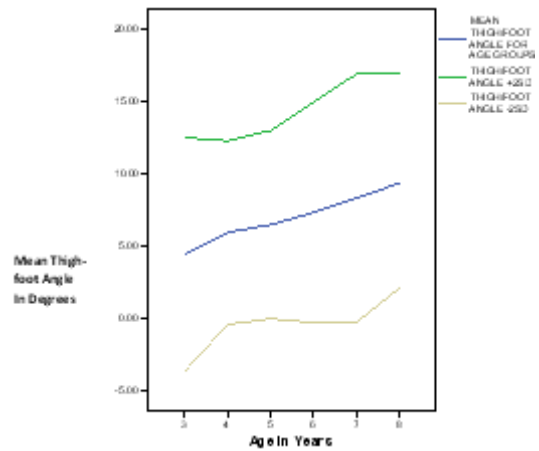
Age in Years	Mean. Rt Med. Hip Rotation in Degrees	Mean Lt. Med. Hip Rotation in degrees	Rt. & Lt. Av. Med. Hip Rotation in degrees	Mean. +2SD	Mean -2SD
3	37.2	32.5	35.7	56.3	15.1
4	39.0	33.5	36.3	55.8	17.8
5	41.3	35.9	39.2	58.3	20.3
6	42.3	36.4	39.3	59.4	19.3
7	45.9	40.1	43.0	61.8	24.2
8	46.8	41.7	44.3	65.1	23.6

years of age. As shown in table. 5, there is about 1-2° more total hip excursion in the right hip than in the left hip. Girls also displayed about 4-5° more

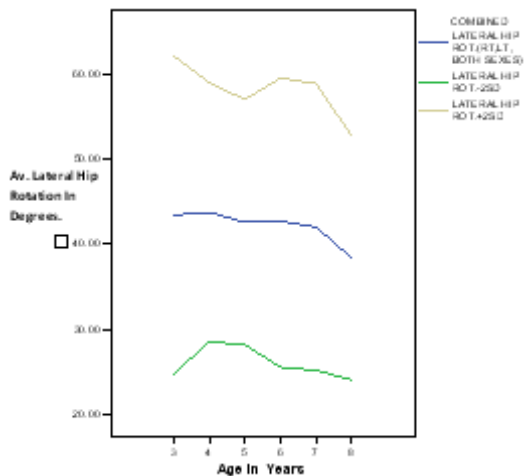
total hip excursion than boys on the average in all six age groups Fig. 5 shows mean  $\pm$  2SD versus age.



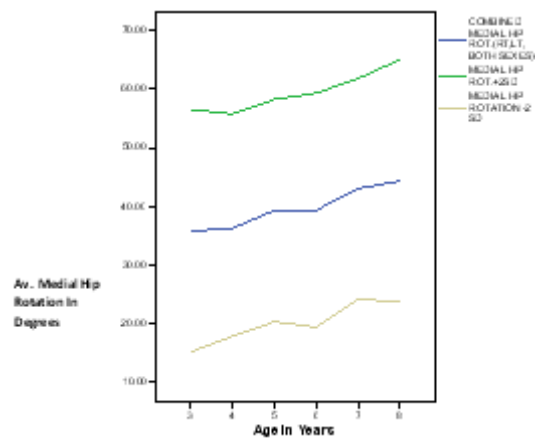
**Fig. 1.** Bar Chart Showing Frequency Distribution, Age and Sex of Subjects



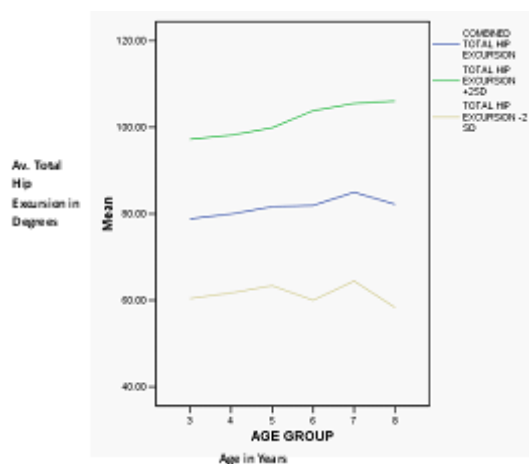
**Fig. 2.** Mean Thigh-foot Angle  $\pm$  2SD Versus Age in years



**Fig. 3.** Combined (Rt. & Lt), Mean Lateral Hip Rotation + 2SD versus Age in Years



**Fig. 4.** Mean Medial Hip Rotation (Rt. & Lt) Combined)  $\pm$  2SD versus Age in Years



**Fig. 5.** Combined Mean (Rt & Lt) Total Hip Excursion Versus Age in Years

## DISCUSSION

Children presenting with rotational problems of the lower limbs in our clinics are no longer rare given the level of societal awareness that has increased over the years. This has attracted the attention of many researchers who have largely concluded that most of these perceived problems are part of the normal physiological developments of the presenting children<sup>2,3,4,7</sup>.

The clinical methods of assessing the rotational parameters of the lower limbs as described by Cheng *et al.*,<sup>3</sup> were used in this study.

Similar to findings in other previous studies<sup>2,3,4,7</sup> the mean thigh-foot angle in this study, increased from  $4.4 \pm 8.1^\circ$  at age 3 years to  $9.4 \pm 7.3^\circ$  at the age of 8 years. This is in line with the general observation that lateral tibial torsion tend to occur with normal growth as reported by Cheng *et al.*,<sup>3</sup> and Staheli *et al.*,<sup>4</sup> in other races. The observation by Cheng *et al.*,<sup>3</sup> of about  $15^\circ$  higher thigh-foot angle in Chinese children than in white American and Nigerian children used in this study, can only be attributed to racial differences as methods of measurement were essentially the same. What this means is that, a thigh-foot angle value that is within normal range in a Chinese child may be abnormal in a white American or Nigerian child.

The observed differences in the values of thigh-foot angles between the two sides found in this study, has not been previously reported by

other researchers.

The lateral hip rotation was found to decrease with age in the age groups studied here. This trend has also been previously reported by other authors. Staheli *et al.*,<sup>4</sup> reported a mean of  $55^\circ$  lateral hip rotation at 3 years of age with a decrease to  $40^\circ$  at 8 years, while Cheng *et al.*<sup>[3]</sup> recorded  $40^\circ$  and  $30^\circ$  at 3 years and 9 years respectively. A mean lateral hip rotation angle of  $43^\circ$  was observed in this study at age 3 that reduced to  $38^\circ$  at 8 years of age. It also obvious here that though, the trend is similar, the degree of variation differs. That this trend of reduction in lateral hip rotation angle with growth tends to contrast the fact that femoral neck anteversion usually decreases with growth has been appropriately explained by Cheng *et al.*,<sup>3</sup> who opined that soft tissue contractures around the hip and acetabular inclination also contribute to hip rotation. Boys on the average, showed about  $3^\circ$  more lateral hip rotation than girls in this study. Hormonal and other sex related factors may be responsible for this. The observed  $4^\circ$  more lateral hip rotation in the left than in the right hip, needs further investigation and corroboration by other researchers.

At 3 years of age, medial hip rotation was  $35.7^\circ \pm 20.6^\circ$  in this study. This increased to  $44.3^\circ \pm 20.7^\circ$  at age 8. Girls displayed a mean of about  $7^\circ$  or more medial rotation than boys for the same age group, while there was about  $4-5^\circ$  more medial hip rotation on the right than on the left. Both the increase in medial hip rotation angle with age and the higher degree of medial hip rotation seen in girls, have been previously reported by Cheng *et al.*,<sup>3</sup> and Staheli *et al.*,<sup>4</sup> in their studies in Chinese and Caucasian American children respectively. However, this study revealed that on the average, Nigerian children exhibited about  $4-5^\circ$  more medial hip rotation than the white American children studied by Staheli and others<sup>4</sup>. Cheng *et al.*,<sup>3</sup> reported an even higher difference in Chinese children. Both environmental and racial/genetic factors may be responsible for this observation. Chinese children in the study by Cheng and others<sup>3</sup>, displayed an overall mean total hip excursion of  $80^\circ$  for boys and  $83^\circ$  for girls while Staheli *et al.*,<sup>4</sup> reported an average range of  $95^\circ-110^\circ$  for both sexes in Caucasian American children respectively. A mean total hip excursion of  $79.3^\circ$  for boys and  $83.7^\circ$  for girls were observed in the

Nigerian children in this study. The observed higher total hip excursion in girls than in boys might be related to sex, genetic and hormonal factors that may account for more soft tissue laxity. About 1-2° more total hip excursion was found in the right than in the left hip in this study. The simple fact that most persons in this environment are right handed/legged which would tend to confer more tissue flexibility on the right than on the left hip may explain this observation.

### CONCLUSION

The need to have simple and dependable clinical ways of assessing children presenting with lower limb rotational problems cannot be overemphasized.

The normal range of thigh-foot angle, the medial and lateral hip rotation including total hip excursion angles have been investigated and documented for Nigerian children aged 3-8 years in this study. The finding here showed that though the trend/pattern is similar to the report of other authors from other regions, some differences in the range of values exist. For doctors practicing in our sub-region, it therefore, advisable that clinical reference to the data locally generated like the type in this study, will provide for better patient management. This should help to reassure parents/guardian and aid decision making whether to do further investigations or observe patient on a regular basis.

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