

Study of Knee Angle Development in Healthy Children aged 3-16 years in Ahwaz, IRAN

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Citation

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Abstract

Introduction and aim: In the evaluation of genu varum-genu valgum, tibiofemoral angle (TF angle) and intercondylar (IC) and intermalleolar (IM) distance are commonly measured. This study was performed to identify the chronological changes of the knee tibiofemoral angle (TF angle) and intercondylar (IC) and intermaleolar (IM) distances in normal healthy children in Khuzestan province. In this study also we considered the effect of epidemiologic factors such as flat foot, height, leg length, weight and delivery kind on TF angle, IC and IM. **Methods and Materials:** this cross-sectional study was carried out in Ahwaz in 853 (M=398, F=455) males and females. The lower limb of children aged from 3-16 years were included in this study. Cases were selected randomly from kinder gardens, preschool care centers and schools of four parts of Ahwaz city. The clinical TF angle was measured with a goniometer in standing position. Superior iliac spine, the center of the patella, and the midpoint of the ankle joint were marked with a pen. After the marking the TF axis, the examiner measured the angle carefully. IC/IM distances were measured using a tape with the child standing with either knees or ankle just touching. The anterior-posterior (AP) radiography of both lower limb were taken in a standing position in some persons, randomly. Weight, height, and leg length were also measured. Information about volunteers delivery have been taken by questionnaires that completed by their families. **Results:** in the current study, TF angle was 6.16 ± 1.45 (Min=3.5, Max 9.3) with range ($4.46 \pm 0.5, 8.45 \pm 0.41$). Mean of TF angle in female 6.18 and in male=6.13. Min and Max of TF angle in female were 3.5 and 9.3 respectively. Min and Max of TF angle in male were 4 and 9 respectively. In both sexes TF angle was decreased when age increment. In boys aged 8-9 yrs and 10-11 yrs, TF angle showed increment. In girls, increment in TF angle was seen in 3-4, 8-10, 11-12, and 14-15 years group. **Conclusion:** TF angle was significantly higher in cases who born with cesarean section than normal vaginal delivery ($p < 0.002$). Mean of TF angle was lower in cases with flat foot ($P < 0.035$). Mean of IM was significantly higher in cases with flat foot than normal cases ($P = 0.03$). Mean of IC in cases with normal feet was higher than cases with flat feet. Correlation coefficient between IC, IM with weight were -0.4, 0.14 respectively. the TF alignment of children living in Ahwaz is similar to Europe, North America and Turkish children but different from Chinese children.

INTRODUCTION AND AIM

Knowledge about changes in alignment of lower extremities during grow and its relationship to age are very important to differentiation pathologic and physiologic lower extremities condition. The bowleggedness and knock-knees are frequently encountered in pediatric orthopaedic clinics. Although benign and self-limiting in most cases, these deformities some times cause a great concern to the parents and the relatives₁. At birth, thibiofemoral angle is varus form, then at age 1-1.5 years reach near 0°. At 2-3 years of age, it is in valgus form. Maximum of valgus angle was seen in aged 3-4 years and in 6-7 years is similar to adults₂. The development of the tibiofemoral angle in children in different ages has been of extensive interest for many years₃. The purposes of the present study were to provide normal

changes on the intermaleolar (IM); intercondylar (IC) distance and tibio-femoral angle (TF angle) in Khuzestan province in IRAN.

METHODS AND MATERIALS

This cross-sectional was carried out in Ahwaz in 853 (M=398, F=455) males and females. The lower limb of children aged from 3-16 years were included in this study. Cases were selected randomly from kinder gardens, preschool care centers and schools of four parts of Ahwaz city. These case had no evidence of anomaly or joint disease. Individuals with deformity in lower limb, dysplasia of hip, cerebral palsy, neuromuscular dysfunction, and metabolic diseases affecting bone, were excluded in this study. The clinical TF angle was measured with a goniometer in

standing position. Superior iliac spine, the center of the patella, and the midpoint of the ankle joint were marked with a pen. After the marking the TF axis, the examiner measured the angle carefully. IC/IM distances were measured using a tape with the child standing with either knees or ankle just touching. TF angle, IM, IC, height, weight, and tibial length were measured for each cases by single experienced examiners. The anterior-posterior (AP) radiography of both lower limb were taken in a standing position in some persons, randomly. Weight, height, and leg length were also measured. Information about volunteers delivery have been taken by questionnaires that completed by their families.

RESULTS

A valgus alignment was observed in all. TF angle was 6.16 ± 1.45 (Min=3.5, Max 9.3) with range ($4.46 \pm 0.5, 8.45 \pm 0.41$). Mean of TF angle in female 6.18 and in male=6.13. Min and Max of TF angle in female were 3.5 and 9.3 respectively. Min and Max of TF angle in male were 4 and 9 respectively. In both sexes TF angle was decreased when age increment. In boys aged 8-9 yrs and 10-11 yrs, TF angle showed increment. In girls, increment in TF angle was seen in 3-4, 8-10, 11-12, and 14-15 years group. (Table-I, II). As seen in table-III, TF angle average in cesarean sections was more than in normal labors and the difference was statistically significant ($P=0.002$). Mean of IC and IM had no significant differences among cesarean section and normal vaginal delivery (Table-III).

We found no significant differences between the TF angle in girls and boys ($P=0.59$, Table IV). As shown in table-V, TF angle rate in flat footed persons was less than in normal people and the difference was statistically significant ($P=0.045$). IM distance average in flat footed persons was more than in normal people and the difference was statistically significant ($P=0.03$). IC distance was statistically greater in normal children than flat footed children. ($P=0.04$). The IM distance varied from -0.9 to -3.73 centimeters, and IC distance varied from 0.06 to 2.53 centimeters. IM and IC were significantly higher in female cases (Table-IV). TF angle was less in individual with flat feet (Table-V). Mean of IM distance was significantly higher in individuals with flat feet. IC distance was more in cases with normal feet than cases with flat feet (Table-V). Correlation ship between IC, IM, TF angle with other factor and each other was shown in table-VI. Positive value indicate direct and negative value indicate reverse relationship (Table-VI). As shown in table VII, there is significant differences between Arab and Persian ethnicity

about TF angle, IM, and IC distance ($P<0.05$).

Figure 1

Table-I: TL, IC, IM, and TF angle in children aged 3-16 years. (TL: Tibial Length, IC: Intercondylar distance, IM: Intermaleolar distance, TF angle: Tibiofemoral angle)

age	sex	N	TL		IC		IM		TF angle	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	M	46	22.68	1.86	1.72	0.38	-2.30	0.83	8.47	0.4
	F	26	22.38	1.4	1.88	0.32	-1.89	0.32	8.42	0.45
4	M	59	23.92	1.68	2.4	0.38	-3.15	1.15	8.17	0.25
	F	74	23.78	2.02	2.34	0.35	-3.20	1.13	8.49	0.39
5	M	19	25.84	2.29	2.37	0.38	-2.93	0.87	7.29	0.25
	F	37	25.91	1.5	2.44	0.32	-3.32	1.02	7.33	0.33
6	M	24	23.66	1.04	2.53	0.35	-3.29	1.07	6.49	0.38
	F	59	25.19	1.97	2.41	0.35	-3.17	0.96	6.13	0.31
7	M	30	28.88	2.8	1.54	0.73	-1.91	0.77	5.44	0.48
	F	39	27.69	1.98	1.85	0.46	-1.50	1.01	5.41	0.45
8	M	34	30.20	3.1	1.52	0.86	-1.20	0.82	5.23	0.28
	F	63	29.89	2.1	1.36	1.96	-2.16	1	5.26	0.38
9	M	29	31.86	2.7	1.59	0.63	-1.84	0.74	5.41	0.34
	F	38	32.26	2.2	0.66	0.71	-2.60	0.61	5.36	0.27
10	M	27	33.33	2.6	0.86	0.64	-1.81	0.91	5.08	0.40
	F	20	34.07	2.4	1.6	0.77	-2.59	0.96	5.38	0.34
11	M	41	35.36	2.9	0.95	0.66	-1.56	0.93	5.14	0.48
	F	29	37.20	2.22	1.02	0.84	-2.17	1.16	4.88	0.43
12	M	27	36.74	2.9	1.10	0.63	-1.60	1.4	5	0.39
	F	17	37.32	1.96	1.12	1.02	-1.80	0.75	5.24	0.39
13	M	19	39.31	4.6	1.41	0.77	-1.57	1.1	4.8	0.34
	F	22	37.90	1.82	1.45	1.07	-1.73	1.13	5.15	0.22
14	M	9	41.84	2.1	1.39	1.39	-1.14	1.02	4.7	0.30
	F	31	38.11	2.7	0.70	0.78	-2.75	0.75	4.5	0.36
15	M	10	39.45	2.5	0.40	0.46	-1.41	0.46	4.7	0.42
	F	20	40.10	2.7	0.78	0.85	-2.59	0.76	4.57	0.49
16	M	11	38.63	3.7	0.68	0.56	-1.25	0.40	4.7	0.34
	F	23	39.16	3.4	1.33	0.49	-2.27	1.29	4.22	0.51
Total	M	398	30.55	6.6	1.59	0.87	-2.05	1.19	6.13	1.47
	F	455	29.49	3.4	1.71	0.89	-2.53	1.14	6.18	1.43

Figure 2

Table-II: Normal range of TF angle, IC, and IM in both sexes from 3-16 years

Age	Sex	Normal Range					
		IC(cm)		IM(cm)		TF angle(degree)	
		Lower	Upper	Lower	Upper	Lower limit	Upper limit
3	M	1.61	1.84	-2.05	-2.55	8.35	8.59
	F	1.75	1.88	-1.76	-2.02	8.24	8.6
4	M	2.3	2.5	-2.85	-3.45	8.1	8.24
	F	2.26	2.42	-2.94	-3.47	8.39	8.58
5	M	2.1	2.55	-2.51	-3.35	7.17	7.41
	F	2.33	2.54	-2.98	-3.66	7.22	7.33
6	M	2.38	2.53	-3.74	-3.29	6.49	6.65
	F	2.32	2.41	-2.91	-3.42	6.05	6.21
7	M	1.26	1.81	-1.62	-2.19	5.25	5.62
	F	1.7	2	-1.83	-1.17	5.26	5.55
8	M	1.22	1.82	-0.92	-1.49	5.13	5.33
	F	1.2	1.6	-1.9	-2.41	0.17	5.36
9	M	1.35	1.83	-1.55	-2.12	5.28	5.55
	F	0.43	0.9	-2.4	-2.8	5.26	5.45
10	M	0.6	1.1	-1.35	-2.17	4.92	5.24
	F	1.23	1.96	-2.14	-3.05	5.22	5.54
11	M	0.73	1.16	-1.27	-1.85	4.99	5.29
	F	0.7	1.34	-1.73	-2.62	4.71	5.04
12	M	0.85	1.35	-1.02	-2.19	4.85	5.16
	F	0.59	1.64	-1.4	-2.19	5.03	5.44
13	M	1.30	1.79	-1.02	-2.13	4.64	4.98
	F	0.97	1.93	-1.23	-2.24	5.05	5.25
14	M	0.87	1.45	-0.6	-1.6	4.5	4.83
	F	0.09	1.3	-2.1	-3.3	4.21	4.78
15	M	0.06	0.73	-1.07	-1.47	4.39	5
	F	0.08	1.31	-2.03	-3.14	4.21	4.92
16	M	0.3	1.05	-0.9	-1.52	4.49	4.95
	F	1.02	1.64	-1.45	-3.09	3.89	4.55

Figure 3

Table-III: Comparison Between TF angle, IC, and IM among vaginal and cesarean section delivery

Type of delivery	N	TF angle(Mean±SD)	IC(Mean±SD)	IM(Mean±SD)
NVD	573	6.05±1.39	1.62±0.88	-2.27±1.22
CS	278	6.39±1.54	1.71±0.90	-2.37±1.13
P-value		0.02	0.1	0.2

CS: Cesarean section; NVD: Normal vaginal delivery(p-value=0.02)

Figure 4

Table-IV: Comparison of TF angle among both sex

Sex	N	TF angle(Mean±SD)	IC(Mean±SD)	IM(Mean±SD)
Male	398	6.13±1.47	1.59±0.87	-2.05±1.19
Female	455	6.18±1.43	1.71±0.89	-2.53±1.14
P-value		0.59	0.03	0.0001

Figure 5

Table-V: TF angle, IC, and IM in cases with and without flat foot

	N	TF angle(Mean±SD)	IC(Mean±SD)	IM(Mean±SD)
Normal Foot	771	6.19±1.46	1.68±0.86	-2.27±1.16
Flat Foot	79	5.88±1.37	1.42±1.04	-2.63±1.43
P-value		0.035	0.04	0.03

Figure 6

Table-VI: Correlation between age, weight, and tibial length with TF angle, IC, and IM.

	TF angle	IC	IM
Age	0.845	-0.542	0.355
Weight	0.55	-0.42	0.140
Height	0.769	-0.531	0.291
Leg length	0.742	-0.275	0.146
IC	0.475	-	-0.24
TF angle	-	0.475	-0.399
IM	-0.399	-0.24	-

Figure 7

Table-VII: Comparison of Mean of TF angle, IC, and IM between Arab and Persian ethnicity.

Ethnic	N	TF angle(Mean±SD)	IC(Mean±SD)	IM(Mean±SD)
Persian	467	6.36±1.49	1.78±0.88	-2.4±1.2
Arab	384	5.92±1.36	1.5±0.87	-2.2±1.1
P-value		0.0001	0.0001	0.03

DISCUSSION

Cheng et al. studied 2630 chinese children from birth till 12 years with clinical criteria. They reported maximum of valgus equal to 8 in 3.5 years.⁴ Heath et al. also observed maximum of valgus equal to 8 in 4 years old children.⁵ In the study carried out by Cahuzac et al. in 10-16 years aged children, 5.01 and 5.53 valgus was observed in 10 and 16 years aged girls. Boys after 14 years show decrement in valgus to 4.41°.⁶ Engle and Staheli reported maximum of valgus equal to 6-7 at 2-3 years children.⁷ Salenus et al. also reported maximum of valgus equal to 12 in 3 years and 5-6° in 7 and 12 years old.⁸ Cheng et al also reported 1° valgus

with 8° range at 5-12 years.⁷ In the current study, mean of IC distance was grater than 2 centimeters in children aged 4-6. In the study done in Pakistan, IC distance was less than 2 centimeters in the age range 5 to 13 years.⁹ In our study, in the age 7-16 years, mean of IC distance was less than 2 cm and was equal to 0.4 in 15 years girl and 0.7cm in 14 years boys. In the current study, a significant differences between means of IC distance were observed in the 7,9,10, and 16 years old children group. In the study done by Arazi et al, significant differences between IC distances were observed in the 6,10,12,13, 1nd 15 years aged group of children.¹⁰ In our study, there are significant differences in both sex for IC and IM distances. These distances were significantly greater in females than males(P=0.0001). Cheng⁷ and Javid¹¹ also reported similar finding in their studies. In the study carried out on Korean children, overall pattern of chronological changes in the knee angle or the anatomical tibiofemoral angle was similar to those found in other ethnic groups, but the development of the knee angle was slightly delayed, i.e, genu varum before 1 yr, neutral at 1.5 yr, increasing genu valgum with maximum value of 7.8° by 4 yr followed by gradual decrease to 5-6° of genu valgum to the adult pattern at 7 to 8 yr of age.¹² Relationship between lower limb alignment with height, weight, flat foot, and type of delivery was less studied by others. In the current study, we found that TF angle was less in the cases with flat foot than normal cases(p=0.045). Mean of TF angle was higher in CS delivery than NVD(p=0.02). Mean of IM in cases with flat feet was significantly more than normal cases (p=0.03). in the age group of 8,9,10,11,14,15, and 16 significant differences between IM in both sexes were seen. Arazi et al also reported similar finding.¹³ Mean of IC was significantly greater in normal cases than flat feet cases(p=0.04). Normal range of TF angle in Iranian children was similar to European, North American, and Turkish children and was differ from Chinese children.

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