Assessment Of Skeletal Maturation Of Iraqi Children During The Years Of Sanctions

Sami Salman* PhD
Salam A.Kadir**

Summary:

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Background: *To study the skeletal maturation and appearance of ossification centers in Iraqi children after six years of embargo.*

Materials and Methods: *Eight hundred fifty five children (441 boys and 414 girls) of ages of 1 month to 13 years, from kindergartens and schools, during the periods June 1995- June 1996, were submitted to radiography of the hand and wrist. A comparison of the films was made with a previous study done in Iraq in 1990, and with other studies conducted in USA. east Africa, and other countries.*

Results: *a great delay was found in skeletal maturation reaching up to two years behind that found in an Iraqi study before the sanctions. A delay of about one year behind US children, and almost equal to that of a East Africa.*

Conclusions: *we believe the cause of the delay is multi factorial, and may be at least partially related to the poor nutritional status of children brought on by the embargo.*

Key words: *skeletal maturation, hand radiography, bone age. bone ossification, sanctions, Iraqi children*

Introduction:

ft has long been realized that skeletal development is divisible Into two components :- increase in size and maturity . Although closely integrated in the hearthy child, each follows its own individual pattern . increase in size is relatively easy to asses; skeletal maturation. however is not oniy elusive of measurement, but Is also difficult to define . It is usually accepted as being the metamorphosis of the cartilagenous and membranous skeletal of fetus to the fully ossified bones of the adult . It can be studied conveniently by X-ray (1).

The hand (including the wrist) hcs recieved most attention in the study of skeletal maturation , both because if is easy to radiography , and because it includes a wide range of bones suitable for study as well the X-ray of hand and wrist is the most usefu! single procedure that is at present , available for determining the development status of children . it provides the following usefuil information : (a) ft affords an objective measure of the amount of progress which the child has made toward attaining physical maturity , i.e. , it enables one to determine the child's developmental status and to compare this with that of others of the same sex and age . (b) ft makes it possible to destinguish the poorly from adequacy mineralized skeleton , thus providing an important supplement to the clinical evaluation of nutritional status . (c) rr reveals imbalcnce in skeletal development „ if such exists, and often enables one to infer when and by what those Imbalance were initiated . (d) ft discloses scars of interrupted growth that prcvide a record af past illnesses and other misadventures . (e) If hand films are repeated on the same child after a period of months, one obtains a record of his skeletal status at two points in time , from which it is possible to determine the rate at which skeletal development is proceeding (2).

Historical notes:

Pryor was the first worker to investigate the skeletal development of the hand and wrist by means of X-ray and he was the first to call attention to the skeletal precocity of the femcie as compared with the male . He found also pseudoepiphyses at base of second metacrapai bone and considered it as normal hereditary variation (3), while Stetrner, Weinert, Rochlin, Lachman , Scndgrasse (et al.) beleive such pseudoepiphyses result from distuitjed skeletal development (2) .

The work of Rotch (1908 , 1909) , Rory (1936) , Todd (1937) and Greulich and Pyle (1950) suggests that the hand and wrist offer a fair index of the maturity of the entire skeleton of the healthy child. The most popular method of assessing maturity , therefore has been to base comparison on a series of films which are typical of the

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**Dept. of Medicine, Faculty of Medicine, University of Baghdad*
***Dept. of Surgery, Faculty of Medicine, University of Baghdad*

various age groups of both sexes . Such pictorial standards have been published by Wilms (1902), Rofch (1909). Engibach and McMahon (1924), Siegert (1935), Rory (1936), Todd (1937). Vogt and Vickers (1938). Greulich and Pyle (1950) and Mackay (1952) (1).

Anatomical notes :

Hand and wrist have 30 ossification centres, 8 carpal bones , distal epiphysis of radius and ulna , epiphysis of metacarpal bones (one for each) , 5 epiphysis of proximd phalanges , 4 epiphysis of middle phalanges , 5 epiphysis of distal phalanges end sescmoids (adductor

Materials & Methods:

Population :

855 children (441 boys and 414 girte) from certain areas of Baghdad City were chosen for this study . These areas were Kadumia . Iskan , Wcsfrash , Bayaa , Dora and Kerkh . Children of few days to 13 years old were chosen from schools. kindergardens and out - patient units in pediatric hospitals (Kadumia ped. hosp. Ai-Mansour Pea. Hosp. Saddam Central ped. hosp., Yermouk General Hosp.). Those children were of variable social levels . Any diseases, which affect weight „ growth and development , were excluded . Children beiow the age of 5 years were collected from out-patient units . Those whose ages were new birth, 3 months, 6 months, 9 months. 12 months 1.5 years, 2 years , 2.5 years , 3 years , 3.5 years , 4 years and 4.5 years , were chosen (deviation of + (15-30) days was accepted) . Other children outside the aforementioned age groups were neglected .

As children of 5-13 years old were collected from kindergardens and schools near hosprtais. information about their exact date of birth. were obtained from schools head masters , Then , a table of visits to these schools was compiled . Hence in each visit children who completed the exact age of 5th.. 6th., 7th., 8th 13th. were brought to hospital for a hand and wrist radiography. The deviation which was allowed for these ages was + 1.5 month . This plcn was carried aut on each visit , thus we could be able to get children of certain ages . Before submission to radiography , mecsumnent of height and weight were made , name , age , sex and social level were recorded .

Radiological technique :

Left hand wcs X-rayed , Kv = 45-50 , Mas = 8 , FFD =100 *cm* . The hand wcs put directly on a cassete in PA view, central rays directed on middle of 3rd. metacarpal . Care was taken to place the chiid so that forarm was laid flat on the table.

Atlas :

Radiographic Atlas Of Skeletal Development Of The Hand And Wrist by Greuiich and Pyie . was used as main reference in our study . The standard plates and maturity indicators of that atlas, were used as indices to determine the skeletal age of each hand film in our study.

Every effort was made to ensure that each standard would depict as accurately as possibfe the modal degree of skeletal development attained by the children of the same sex at chronological age in research series of the atlas aforementioned . Thus the chronological ages of children in that atfas, were seme as their skeletal ages .

Period:

From June 1995-June 1996.

Metftod of analysis or data :

Each film was inspected and chronological age and sex of child , presence of ossification centres of bones and epiphyses and also certain features of some bones and epiphyses were recorded on **a** form cards. Each film was inspected carefully and compared with the standard plates and maturity indicators , (which were mentioned in the introduction) , in the atlas of Greuiich and Pyle . We began by comparing the film to be assessed with the standard of same sex and nearest chronotogiccl age in the atlas . Next we compared film with

Result:

All the results are shown in tables and graphs with the details on them . In tabie III, the skeletal age for each child was listed underneath the relevant chronological age indicated on top of the column . Results clearly show . for example . that only 6 girl subjects of 3 years chronological age to have a skeletal maturity of 3 years . 9 girls of the same age group (3 y) to have 25 y skeletal maturity and 3 female subjects have only yielded a skeletal maturity of a mere 2 years . The same goes for ail age groups covered by the study (female) as for males, the same distribution method was as females was used in table No. IV.

After calculation of the mean average end standard deviation for each age group of both sexes a table No. V was created to show all the differences between the chronological age and skeletal age for Iraqi children of both sexes . A chart was drawn, using data from tabie No. V, as follows No. 1 for females, IMo. II for males . By inspecting data in tabie V (present study). we can find the difference between Iraqi children's mean skeletal age and the mean skeletal age of children whom were used as standards . Thus table VI shows the differences in the mean skeletal age of the Iraqi children and that of the standards for both sexes of each age groups . The differences ore shown by months equal to « mean sk. age of children (standard) minus the mean skeletal age of Iraqi children .

Rom this fable the differences reached up to nearly 17 months at age group of 10 years in boys and about 11 months in girls . Chart No. Ill wcs drown fcr boys and giris by using data in table VI . Tabie VII shows the cppecrcnce of carpal bones, including the redid end uinar distal epiphyses , of boys and griis expressed in percentages for each chronological age group . Thus by inspection table VII we can estimate the expected age of appearance of ossification center of carpal bones , radial and ulnar distal epiphyses , (this method mentioned in section of materialand methods), as in tabie IX . Table No. VII! , shows the appearance of metacrpal and proximal phclongeai epiphyses present in Iraqi children .

By analysing the results in tables VII, VUI, IX , the fallowings were noticed:

Table XI
Onset of ossification of wristbones of differentstucies (In months)

Ossification centres	Present study 1995-1996		American children TODD [2]		American children Graham [4]		Wadigo children Mackay [8]		Chicago children Flory [8]		Iraqi children H.Mahmood[10]	Hasan[11]	Bajaj[12]
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Boys	Boys
Capitate	3	3	---	---	3	3	6	6	6	6	2.7	5	---
Hamate	3	3	---	---	4	2	6	6	6	6	2.7	5	---
Distal ep. of Radius	15	12	12.8	9.5	13	10	18	12	15	9	6.2	---	30
Triquetrum	42	30	29.6	21	29	18	34	18	24	23	10.5	48	40
Lunate	54	48	42.4	34.3	49	31	54	42	42	36	20	72	64
Scaphoid	80	63	66	50.9	68	49	72	63	72	56	53	72	81
Trapezium	84	54	67	47.3	70	49	78	66	72	50	54	84	81
Trapezoid	84	56	68	49.2	75	50	78	68	73	53	52	65	86
Distal ep. of ulna	90	70	82.5	69.4	85	64	98	93	80	68	56	---	81
Pisiform	144	108	120.4	94.6	--	---	166	132	140	108	122	144	138
Sesamoids	> 156	132	152.7	123	153	123	172	144	---	--	---	---	---

Table III : The skeletal age of each child (girl) in the present study (age in year - months)

CHRONOLOGICAL AGE GROUPS

0	3 mon	6 mon	9 mon	1y	1y-8m	1y-6m	2y	2-6	3	3y-6m	4y	5y	6y	7y	8y	9y	10y	11y	12y	13y
0	-6	-9	1y	1-6	1-3	1-6	2-6	3	3	3-6	4-2	5-9	6-10	7-10	8	11	11	11	12	13
0	-6	-9	1y	1-3	1-3	1-6	2-6	2-6	3	3-6	4-2	5	5-9	7-10	8	9	10	11	12	13
0	-6	-6	1y	1-3	1-3	1-6	2	2-6	3	3-6	4-2	5	5-9	6-10	8	9	10	11	12	13
0	-3	-6	1y	1-3	1-3	1-6	2	2-6	3	3-6	4-2	5	5-9	6-10	8	8-10	10	11	12	13
0	-3	-6	-9	1-	1-3	1-6	2	2	3	3-6	4-2	5	5-9	6-10	8	8-10	10	11	12	13
0	-3	-6	-9	1-	1-3	1-3	2	2	3	3	4-2	5	5-9	6-10	7-10	8-10	10	11	12	13
0	-3	-6	-9	1-	1-	1-3	1-6	2	2-6	3	3-6	5	5-9	6-10	7-10	8-10	10	11	12	13
0	-3	-6	-9	1-	1-	1-3	1-6	2	2-6	3	3-6	5	5-9	6-10	7-10	8-10	10	11	12	13
0	-3	-6	-9	1-	1-	1-	1-6	2	2-6	2-6	3	5	5-9	6-10	7-10	8-10	10	11	12	13
	-3	-6	-9	1-	1-	1-	1-6	2	2-6	2-6	3	5	5-9	6-10	7-10	8-10	10	11	12	13
	-3	-6	-6	1-	1-	1-	1-6	2	2-6	2-6	3	5	5-9	6-10	7-10	8-10	10	11	12	13
	-3	-6	-6	1-	1-		1-6	2	2-6	2-6	2-6	4-2	5-9	6-10	7-10	8-10	10	10	12	12
	0	-3		1-	1-			1-6	2-6	2-6	2-6	4-2	5-9	6-10	7-10	8-10	10	10	11	12
	0	-3		1-	0-9			1	2-6	2-6	2-6	3-6	5-9	6-10	7-10	8-10	10	10	11	12
	0	-3		0-9	0-9				2-6	2-6		3-6	5	6-10	7-10	8-10	10	10	11	12
		-3		0-9					2			3-6	5	6-10	6-10	8-10	10	10	11	12
									2			3-6	5	5-9	6-10	8-10	10	10	11	12
									2			3-6	5	5-9	6-6	8-10	10	10	10	11
												3-6	5	5-9	5-9	7-10	8-10	8-10	8-10	11
												3	5	5-9	5-9	7-10	8-10	8-10		10
												3	5	5-9	5	7-10	8-10	8-10		
												3	5	5-9	3-6	7-10	8-10	8-10		
												3	4-2	5		7-10	8-10	8-10		
												3	4-2	3-6		7-10	8-10	8-10		
												2-6	4-2			6-10	7-10	8-10		
													4-2			6-10	7-10	7-10		
													4-6			6-10	7-10			
													4-6			6-10	7-10			
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													3-6			6-10	7-10			
													3-6				7-10			
													3-6				7-10			
													3				6-10			
																	6-10			

Table IV : The skeletal age for each child (boy) in the present study (age in years-months)

CHRONOLOGICAL AGE GROUPS

0	0-3	0-6	0-9	1y	1y-3m.	1y-6m	2y	3y	4y	5y	6y	7	8	9	10	11	12	13
0	-6	-9	1y	1-	1-	1-6	2-	3	4-6	6-	7	7	10	10	10	11	12-6	13
0	-6	-9	1y	1-	1-	1-6	2-	3	4-6	5	7	7	9	9	10	11	12-6	13
0	-6	-6	1y	1-	1-	1-3	1-6	3	4	5	6	7	9	9	10	11	12-6	13
0	-3	-6	-9	1-	1-	1-3	1-6	3	4	5	6	7	8	9	10	11	12	13
0	-3	-6	-6	1-	1-	1-3	1-6	2-8	4	5	5-6	7	8	9	10	11	11-6	13
0	-3	-6	-6	1-	1-	1-	1-3	2-8	4	5	5	7	8	9	10	11	11-6	12
0	-3	-6	-6	-9	1-	1-	1-3	2-8	4	5	5	6	8	9	10	11	11-6	12
0	-3	-6	-6	-9	1-	1-	1-3	2-8	3-6	4-6	5	6	8	9	10	11	11-6	12
0	-3	-6	-3	-9	-9	1-	1-3	2-	3-	4-6	5	6	7	9	10	11	11	12
0	-3	-3	-3	-9	-9	-9	1	2-	3-	4-6	5	6	7	9	10	11	10	12
	-3	-3		-9	-9			2-	3-	4-6	5	6	7	9	9	11	10	11-6
	0	-3		-9				1-6	3-	4-6	5	6	7	9	9	10	9-6	11-6
	0			-6				1-6	3-	4-6	5	6	7	9	9	10	9-6	11-6
	0			-6				1-3	3-	4	5	6	7	8	9	10	9-6	11-6
									2-8	4	5	6	7	8	9	10	8-10	11-6
									2-8	4	5	6	7	8	9	10	8-10	10
									2-8	4	4-6	6	7	8	9	10		10
										4	4-6	6	7	8	9	10		
										4	4-6	6	6	8	9	10		
										3-6	4-6	6	6	7	9	10		
										3-6	4-6	6	6	7	9	10		
										3-6	4-6	6	6	7	9	10		
										3	4-6	6	6	7	9	10		
										3	4-6	6	6	7	8	10		
										3	4-6	5	6	7	8	10		
											4	5	6	7	8	10		
											4	5	6	7	10	10		
											4	5	6	7	8	10		
											4	5	6	7	8	9		
											3-6	5	6	7	8	9		
											3	5	6	7	8	9		
												5	6	7	8	9		
												5		7	8	9		
												5		7	7	9		
												5		6	7	9		
												5		6	7	9		
												5		6	7	9		
														6	7	9		
														6	7	8-6		
															7	8-6		
															7	8-6		
															7	7-6		

Table V : The Variability of Skeletal Age of Boys and Girls in Iraqi Children

	Boys Skeletal age (in months)			Girls Skeletal age (in months)		
Chronological age	No.	MEAN	S.D.	No.	MEAN	S.D.
New born	10	0	----	9	New born	---
3months	14	3	2.03	15	3	1.96
6months	12	5.75	1.83	16	5.62	1.85
9months	10	7.5	3.53	12	9.5	2.38
12months	15	9.8	2.11	20	11.85	2.47
15months	11	11.18	1.4	15	12.8	2.11
18months	10	13.8	4.7	11	15.6	2.6
24months	11	17.18	4.04	13	21.69	4.6
30months				14	25.88	5.85
36months	15	28.8	7.93	18	31	7.58
42months				15	35.2	5.5
48months	18	41.16	7.5	14	41.57	8.42
60months	26	51	10.14	25	48.88	11.85
72months	31	57.87	10.22	35	59.05	11.28
84months	37	70.05	8.72	25	77.36	10.88
96months	32	83.25	12.91	24	86.08	18.17
108months	39	92.30	14.6	32	98.31	17.78
120months	41	103.02	13.14	36	108.59	13.28
132months	44	117.82	11.94	26	120.3	12.05
144months	17	128.46	17.34	19	137.58	10.43
156months	17	142.5	18.81	20	148.32	10.5
Total	410			414		

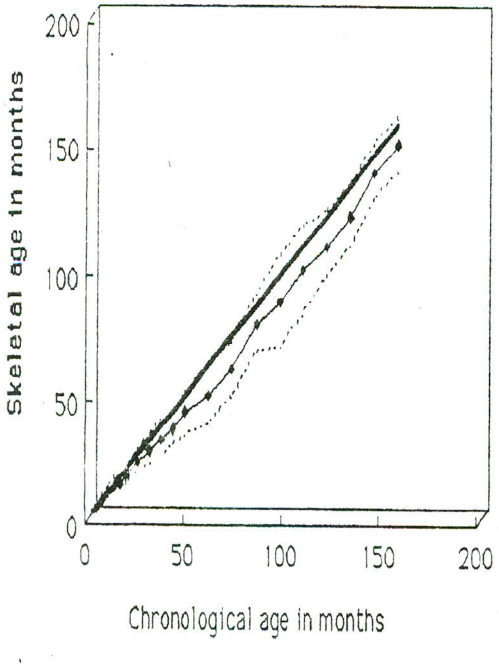

Fig. I : The linear developmental graph of Iraqi Girls. The irregular central line represents the mean skeletal age at each chronological age ; the irregular dotted lines above and below it indicate one standard deviation above and below the mean. The stright bold line, on this graph represents the curve of the standards of reference.

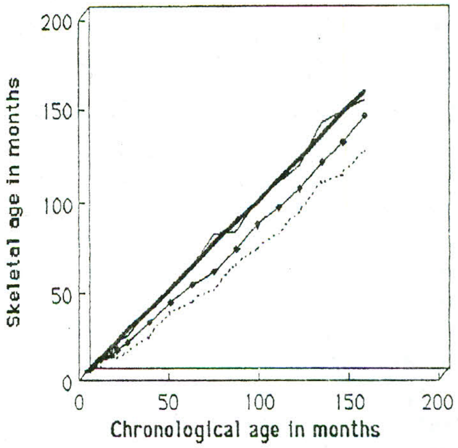

Fig. II : The linear developmental graph of Iraqi Boys. The irregular central line represents the mean skeletal age at each chronological age ; the irregular dotted lines above and below it indicate one standard deviation above and below the mean. The stright bold line, on this graph represents the curve of the standards of reference.

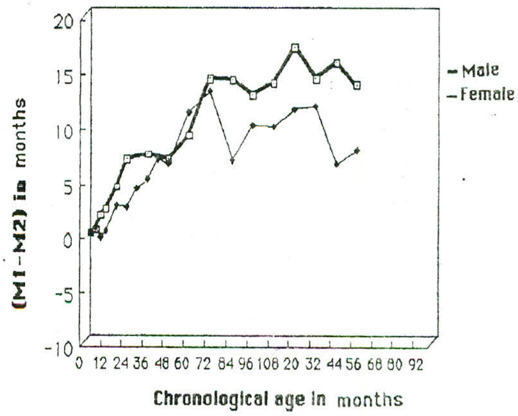

Fig. III : This shows the difference between mean skeletal age of standard (M1) and of Iraqi children (M2).

(1) The appearance of the carpal bones and other wrist epiphytes:

The capitate and hamate were invariably the first bones to appear , usually together . The radiai epiphyses follow and then successively Triquetrum , Lunate and Scaphoid . Trapezium and Trapezoid next appeared , but the order in which scaphoid , Trapezoid and Trapezium appeared was subject to much variation . The ulnar epiphyses followed the Trapezoid and was in turn followed by the pisiform . The sesamoid bones at the distal end of metacarpal were the last to make their appearance . The order of appearance of ossification centres of wrist bones was as below :

Male subjects : Hamate & Capitate , distal ep. of Radius , Triquetrum , Lunate ,, Scaphoid , Trapezium , Trapezoid ,, Distal ep. of Ulna , Pisiform and Sesamoids.

Female subjects : Same *as* male pattern except that scaphoid appears after Trapezium and Trapezofd .

This means that the crder of cppecranca of wrist centres is similar to that of other races other than Ircqi.

(2) **Sex differences in the onset of ossification and skeletci maturation:**

There are sex difference in the onset of ossification . These are slight at first. but in each succeeding year, girls become more advanced than boys . it is also apparent from comparison of the two sexes that male subjects tcke longer to reach skeletal maturity in the hand and wrist, then femcie subjects,

(3) **Comparison between Table IX and X:**

Table X shows the order and the cue at which the ossification centres of wrist begin to Gppear, in the Meshigan children , regarded as standards in this study . Thus inspecting table IX and X reveals , that the order of ossification was similar but the age of onset of Iraqi children ages 1-1.5 year behind American Standards.

(4) **Pseudoepiphvses of second metacarpaJ bone:**

This was found to occur in 16 boys and in 6 giris distributed on age groups seen in following table .

Aae in years	3	4	5	6	7	3	9
No. of boys	2	-	3	3	3	4	1
No. of girls	-	1	-	3	2	-	-

Table VII. The appearance of carpal bones for boys , and girls expressed in percentage present in Iraqi children.

Chronological age in years		B-	0.5-	1-	1.5-	2-	3-	4-	5-	6-	7-	8-	9-	10-	11-	12-	13-
Capitate	F	50	100														
	M	50	100														
Hamate	F	50	100														
	M	50	100														
Distal ep. of Radius	F	0	14	78	100												
	M	0	0	53	70	81	100										
Triquetral	F	0	0	12	12	45	83	88	100								
	M	0	0	9.6	9.6	27	40	88	82	91	95	97	97	100			
Lunate	F			0	0	17	38	66	83	100	95	100					
	M					0	26	66	37	80	86	95	97	100			
Scaphoid	F					0	6	38	46	91	95	100					
	M						0	33	6	16	71	83	89	100			
Trapezium	F					3.7	9	44	72	91	95	100					
	M						0	16	24	11	60	78	87	100			
Trapezoid	F					0	9	44	63	94	95	100					
	M						0	0	10	13	60	73	89	100			
Distal ep. of ulna	F						0	33	18	61	80	95	100				
	M								0	2	44	71	84	100			
Pisiform	F								0	2	14	29	62	68	88	89	100
	M											0	5	15	30	52	64
Sesamoids	F											0	6	37	65	78	95
	M												0	0	0	0	0

Discussion:

855 children (441 boys *and* 414 girls) of ages ranging from birth up to 13 years constituted the subjects of Our research.Many studies were conducted on the skeletal maturation of the hand and wrists . such as the one conducted by Greullch & Pyie on Michigan children In 1952 . which was used *as* a standard reference in the present study in the section of results . We also compared our results with other studies conducted by Rory on Chicago children in 1936 , GS well as Mackay's study on East African children in 1952 (8), and also Graham on American children in 1964 (4), and on Iraqi children by Dr. Hussein Mahrnood GS a thesis for M.Sc. in Fornsic medicine in 1990 (10) and other studies in the orient (Hasan (11)&Bcjaj(12) & Others) .

(A) **Results of comparison with the standard subject of reference:**

Iraqi children showed a delay in both skeletal maturiation and the onset of ossification (both sexes) as was seen in tabies 6,9,10 and Figure 3 . The delay exceeded one year for the boys while in girls it fell within the proximity of one year. We think the causes for this delay are due to poor nutritional status , *as* well as the effect of illnesses during infancy and early childhood . The above mentioned causes are probably direct results of the sanctions.

(B) **Results of comparison wftirthe study conducted in East Africa bv -- Vlackcv, 1952:**

Dr. Mackay found in his study on Wadjgo children (in east Africa), 'that there was a delay in the skeletal maturation and onset of ossification of the hand and wrist ,, compared with Fiery study (Chicago children) 1936 as in table XI. Dr. Mackay decoded that his results were due to the bed nutritional end environmental factors (3).

it is quite note worthy that the results of our study are nearly identical to those yielded by Dr. Mackay's , as a whole , maintaining the same margin of differences with the children of Chicago in 1936 . Again , it is only too obvious the Influence of the sanctions has on the whole matter.

(C) **Results of comparison with the study conducted on Iraqi children before 1990 by Dr. Hussein Mahmood.**

Due to feet that Dr. Hussein Mahmood was preparing a thesis for MSc. in forensic medicine , a greet emphesis was plccsd in that study on Maie subjects ,, due to legal reasons end the fact that males are needed for recrutement for national service . The males, therefore , formed the greater majority of his study subjects . Dr. Mahmood compared his resutts with Oriental studies and European ones , and found that Iraqi children (before 1990) as having much earlier maturation and onset than other children of same age and sex groups in other areas of the world . There was a major difference between the results of this study in 1996 and that of Dr. Mahmood before 1990 as shown in/X and XI.

In Conclusion:

Again „ this comparison with dr. Mahmood's study which was conducted on the same children (Iraqi) only with a different timing (before 1990 and in 1996) give a clear indication of the negative influence the sanctions has on the growth of the Iraqi children off-setting it way behind the normal pattern. even when compared with children of this same country , studied by Dr. Mahmood . Thus it is evident that the factor responsible for this lag is the sanctions being the only variable that changed between the circumstances at which both studies (Dr. Mahmood and Ours) were conducted .

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