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Age Estimation Based on Some Cervical Vertebral Measurementsin a Sample of Egyptian Children

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Abstract

The need to estimate the age of living individuals becomes more frequent, because of the increasing number of immigrants (illegal or otherwise) without acceptable identification documents and with missing or uncertain birth dates. In the recent years, evaluation of cervical vertebrae has been increasingly used to determine skeletal maturation. **Aim:**The aim of this study was to establish two new formulae for objectively evaluatingskeletal maturation of cervical vertebrae inmale and female Egyptianchildren usinglateral cephalometric radiographs. **Methods:** The cases were selected from patients attending the clinics of the Faculty of Dental Medicine for girls, Al Azhar University, in Cairo. They were assessed into two groups. The first groupincluded 100 children; 50 males (aging from 8.45 to 15.75 years oldwith a mean age of12.41years) and 50 females (aging from 8.2 to 15.5 years oldwith a mean age of 11.9 years). The cervical vertebral bodies of C3 and C4were traced and measured.Regression formulae were developed to determinecervical vertebral bone age. The second group of lateral cephalometric and hand-wrist radiographs of 50 children; 25 males (aging from 8.25 to 15.85 years old with a mean age of 11.7 years) and 25 females (aging from 8.5 to 15.65 years old with a mean age of 12.12years) was used to verify the reliabilityof these developed regression formulae.**Results:**The results indicated that there was a statistical significant positive correlation between estimated cervical vertebral bone age (CVBA) and chronological age (r = 0.976 in males and 0.931 in females). Also there was a statistical significant positive correlation between estimated cervical vertebral bone age (CVBA) and estimated hand bone age (HBA) (r = 0.960 in males and 0.942 in females). **Conclusion:** These results suggest that cervical vertebral bone age reflects skeletal maturity because it approximates hand bone age, which is considered to be the most reliable method for evaluating skeletal maturation. Using cervical vertebral bone age may be helpful to estimate age in a detailed and objective manner on cephalometric radiographsforEgyptian children.

Introduction

Age estimation of living individuals is increasingly important in criminal matters. If doubts arise regarding the age of a person suspected of a criminal offence, forensic age estimation is prompted by the need to ascertain whether the person concerned has reached the age of criminal responsibility and whether general criminal law in force for elder juveniles or adults is to be applied (Bogin and Loucky, 1997).

Bone age assessment is a procedure frequently performed in pediatric radiology. Based on a radiological examination of skeletal development of the left-hand wrist, bone age is assessed and then compared with the chronological age. A discrepancy between these two values indicates abnormalities in skeletal development (Murata, 1997). This procedure is often used in the management and diagnosis of endocrine disorders and it can also serve as an indication of the therapeutic effect of treatment (Jung, 2000).

The wrist-hand region is the most indicative of skeletal maturation, because it includes many ossific centers in a small area (Schmeling et al., 2001). Many methods have been developed to estimate skeletal age; the main clinical methods are the Greulich and Pyle (GP) method (Greulich and Pyle, 1971) and the Tanner Whitehouse (TW2) method (Tanner and Whitehouse, 1975) (Mora et al., 2001). However, all hand-wrist methods for skeletal maturationevaluation require the acquisition of hand-wristradiographs with the risk of increased exposure of patientsto radiation(Baccetti et al., 2005).

Later on, the cervical vertebral maturationmethod has been started to replace the conventional hand-wristmethods for the evaluation of individual skeletal maturationin the practice of orthodontics (Flores et al., 2006).

The lateral cephalometric radiographs routinely usedin exams for orthodontic and/or functional orthopedictreatment may contain important information thatrequires attention and knowledge of the head and neckanatomy, including the cervical vertebrae. Therefore,changes in the size and shape of the vertebrae during theindividual's growth may be used as an indicator of bonematuration (Caldas et al., 2007).

It is known that the morphologyof the cervical vertebral bodies changes withgrowth, as seen on lateral cephalograms(Remes et al., 2000). Lamparski (1972) published a method that simulatedmorphological changes in cervical vertebral bodiesand found them to be as reliable and as valid as thehand-wrist area for assessing skeletal age. The effectivenessof the cervical vertebrae as a maturationalindicator has been corroborated by Hassel and Farman (1995) and Garcia-Fernandes et al. (1998), whofound a high correlation between cervical vertebralmaturation and the skeletal maturation of the hand-wristarea (Chen et al., 2010).

The cervical vertebral bone age is a relatively newmethod of objectively evaluating the skeletal maturationthrough dimensional measurements of the vertebral body ofthe third (C3) and fourth (C4) cervical vertebrae (Fudalejand Bollen,2010).

Using cervical vertebral measurements, Mito et al., (2002)conducted a study with the purpose of establishing the bone age of cervical vertebrae as a new index for the objective evaluation of skeletal maturation in cephalometric radiographs. The bodies of vertebrae C3and C4 were traced and measured at some points and were used to determine a regression equation. They observed that there was a high correlation between the vertebral and carpal bone ages in comparison with vertebral bone and chronological age. The authors suggested that vertebral bone age reflects skeletal maturity because it was close to the carpal bone age, and thus was considered a reliable method (Mahajan, 2011).

However, there are still insufficient data that show the full effectiveness of the cervical vertebral method to justify replacement of the carpal method(Zhao et al., 2012). Also the sample used to derive the formula conducted by Mito et al. (2002)consisted of Japanese people. Different populations may respond in a distinct manner to the same method of skeletal maturity evaluation, as their growth occurs in different ways(Aguiar et al., 2013).

Aim of the work

The purpose of this work is to establish two new formulae to estimate age in male and female Egyptian children using digital measurements of third (C3) and fourth (C4) cervical vertebrae in cephalometric radiographs, and to evaluate the reliability of formulae developed by comparing age determined by them to standard bone age (in hand-wrist radiographs) and chronological age.

Subjects and Methods

One hundred fifty children of both sexes were selected to participate in this study. They were selected from patients attending the outpatient clinics of the Faculty of Dental Medicine for girls, Al Azhar University, in Cairo, Egypt during the period from June 2013 to December 2014.

The selected cases were from 8 to 16 years old and assessed into two groups. Group 1 was composed of 100children(50 boys and 50 girls), this group was used to derive two different formulas for obtaining cervical vertebral bone age in male and female children. Group II consisted of 50 children(25boys and 25girls) was used to verify the reliability of the newly developed regression formulae, as compared with the bone age data assessed by the Tanner and Whitehouse (TW2)in (1975) in hand-wrist radiographs and chronologic age.

Chronologic age of an individual was calculated by subtracting the birth date from the date on which the radiographs were exposed for that particular individual. Decimal age was taken for simplicity of statistical calculation and ages were estimated on yearly basis e. g. 12 years 9 months as 12.75 years and it was considered in 12 years age group. All male and female subjects involved in the study were Egyptian in origin.

All cases in group I were subjected to lateral cephalometric radiograph, while group II cases were subjected to lateral cephalometric radiograph and hand-wrist X-ray.

Ethical considerations

- Approval was obtained from chairman of Oral Medicine, Periodontology, Radiology & Diagnosis Department, Faculty of Dental Medicine, Al-Azhar University, Girls Branch.
- Prior to any procedure, all families of the studied cases were informed about the nature, and benefits of participation in the study. An informed written consent was obtained from these families denoting convince and agreement about the research program of the experiment design.
- Confidentiality of cases records was maintained.

Inclusion criteria

All cases included in this study have fulfilled the following criteria: **1-** Clinically free from any developmental endocrine or nutritional disorder,**2-**No past prolonged illness, **3-** No abnormal dental condition, e.g. impaction, transposition and congenitally missing teeth, **4-** No history of trauma or disease to the hand, face & neck, **5-** No history of orthodontic or maxillofacial surgery.

Exclusion criteria

1- Non- Egyptian origin, **2-**Congenital anomalies, **3-**Aplasia, caries, extraction or other abnormal dental conditions, **4-**History of prolonged illness, trauma or disease to the hand, face & neck, orthodontic or maxillofacial surgery.

The Equipment Used

I- Orthopantomogram machine(PM 2002 EC Proline).

II- Films:- Kodak 6x12 (Lateral cephalogram).

-Kodak 8x10 (Hand & Wrist Radiograph).

III- Scanner: vista 4000 U X-ray. The radiographic images were digitized using the scanner.

VI- Computer:the images were recorded in a computer file. Radiographic images were then processed using computer-aided program AutoCAD 2000.

The Procedures Used

I- Lateral Cephalogram:

Each case under studyis standing, the head is placed in a special support on the end of the lateral cephalogram attachment for accurate positioning and an X-ray obtained. The child was required to hold still and bite together on the back teeth. Lips should be relaxed. Lead gowns were put to protect the rest of the body while x-rays were taken.

II- Hand and wrist radiographs:

The dental OPG machine was used to obtain hand and wrist X-ray. The child was asked to remove any accessories, jewelers, rings and metal objects from the hand and wrist that could interfere with the x-ray images. Lead apron was put to protect the rest of the body while x-rays were taken. The child was asked to place his/her left hand on the x-ray machine and spread his/her fingers. The technician left the child's side for a brief moment while the X-ray (picture) was taken.

Group (I) Evaluation

On cephalogramthe third (C3) and fourth (C4) cervical vertebrae were computerized traced and the following parameters were measured according to**Mito et al. (2002)**:anteriorvertebral body height (AH), vertebral bodyheight (H), posterior vertebral body height (PH),and anteroposterior vertebral body length (AP) (Figure 1).

Group (II) Evaluation

Cervical Vertebral Bone Age Estimation (CVBA):

On cephalogramthe same parametersof the third (C3) and fourth (C4) cervical vertebrae were measured as in group (I). Then the formulas developed from group (I) were used to calculatecervical vertebral bone age.

ii) Hand Bone Age Estimation (HBA):

Bone age assessment was done by the Tanner Whitehouse (TW2) method. Twenty regions of interest (ROIs) located in the hand were evaluated (Figure 2). The development of each ROI was determined. The development of each ROI is divided into discrete stages and each stage is given a letter (A,B,C,D, . . ., I) according to degree of ossification. A numerical score is associated with each stage of each bone. Each region of the 20 ROIs was given a score. The sum of the scores of the 20 ROIs was transferred to a bone age according to conversion tables different for males and females (as described in the review of literature; pages from 22 to 28) (Ritz et al., 2000).

Statistical Analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA)(Bourke et al., 1985). Quantitative data were expressed as mean±standard deviation (SD). Qualitative data were expressed as frequency and percentage. The following tests were done:

- Chi- square (x^2)test: The test was used to study the association between different categorical variables and to compare between categorical data.
- Linear regression was used to obtain regression formulae using chronological age as the dependent variable. Other measurements were the independent variables.
- Standard error of the estimate (SE) was also calculated, it predicts the deviation of estimated age from the actual chronological age.
- Student-test of significance was used when comparing between two means. A one-way analysis of variance (ANOVA) when comparing between more than two means.
- Pearson's correlation coefficient (r) test was used for correlating data.
- The significance level was set at $P \leq 0.05$.

Results

A) Group I

Group I included 100 children; 50 males (aging from 8.45 to 15.75 years old with a mean age of 12.41years) and 50 females (aging from 8.2 to 15.5 years old with a mean age of11.9years).

Age and sex distribution of group I children are illustrated in (Table 1).There was non statistical significant difference between age groups in both male and female cases.

The measurements of vertebral body parameters of the third and fourth cervical vertebrae in male subjects of group I studied are illustrated in (Table 2- Figures 3, 4).There is an increase in a significant accelerated manner. The subjects aged (14-15) years showed the highest statistical significant values while subjects aged (8-9) years showed the lowest statistical significant values.

The measurements of vertebral body parameters of the third and fourth cervical vertebrae in female subjects of group I studied are illustrated in (Table 3- Figures 5, 6).There is an increase in a significant accelerated manner. The subjects aged (14-15) years showed the highest statistical significant values while subjects aged (8-9) years showed the lowest statistical significant values.

Comparison of vertebral body parameters of the third and fourth cervical vertebrae between male and female children of group I are illustrated in (Tables 4, 5). Males showed higher mean values than females in all measurements.

Regression analysis was developed in order to determine the formulas to obtain cervical vertebral bone age using C3 and C4 measurements. The following formulas are obtained:

Male cervical vertebral bone age = 1.775 + 13.557 x AH3/AP3 + 6.808 x H4/AP4

Female cervical vertebral bone age =1.582 +7.920 x AH3/AP3 + 10.110 x AH4/AP4

B) Group II

Group II included 50 children; 25 males (aging from 8.25 to 15.85 years old with a mean age of 11.7 years) and 25females (aging from 8.5 to 15.65 years old with a mean age of 12.12years).

Age and sex distributions of group II children are illustrated in (table 6).There was non statistical significant difference between age groups in both males and females.

Comparison of chronological age (CA) and estimated cervical vertebral bone age (CVBA) in male subjects of group II is illustrated in (table 7). Estimated CVBA of all males showed a statistical significant higher mean value than that of the chronological age.

Comparison of chronological age (CA)and estimated cervical vertebral bone age (CVBA) in female subjects of group II is illustrated in (table 8).

Estimated CVBA of all females showed a statistical significant lower mean value than chronological age.

Comparison of estimated cervical vertebral bone age (CVBA) and estimated hand bone age (HBA) in male subjects of group II is illustrated in (Table 9). There was no statistical significant difference between estimated(CVBA)and estimated (HBA)in all age groups.

Comparison of estimated cervical vertebral bone age (CVBA) and estimated hand bone age (HBA) in female subjects of group II is illustrated in (Table 10). There was no statistical significant difference between estimated(CVBA)and estimated (HBA)in all age groups.

Correlation results in male children of group II showed a statistical significant positive correlation between estimated cervical vertebral bone age (CVBA), chronological age (CA) and estimated hand bone age (HBA) (Table 11- Figures 7, 8).

Correlation results in female children of group II showed a statistical significant positive correlation between estimated cervical vertebral bone age (CVBA), chronological age (CA) and estimated hand bone age (HBA) (Table 12- Figures 9, 10).

Table (1):Chi- square test for age and sex distribution of group I:

Age groups (years)	**Males**		**Females**		**Total**		**Chi-square**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**x^2**	p
8-9	5	10.0	5	10.0	10	10.0	0.970	0.808
10-11	9	18.0	13	26.0	22	22.0		
12-13	15	30.0	13	26.0	28	28.0		
14-15	21	42.0	19	38.0	40	40.0		
Sum	50	100.0	50	100.0	100	100.0		

**: Significant at P ≤ 0.05*

Table (2): ANOVA one way statistical analysis of vertebral body parameters of the third and fourth cervical vertebrae in male children of group I:

Age groups (years)		**C3 measurements**				**C4 measurements**			
		AH3	**H**3	**PH**3	**AP**3	**AH**4	**H**4	**PH**4	**AP**4
8-9		6.44±0.14	7.80±0.19	9.16±0.15	10.34±0.36	7.09±0.09	7.36±0.26	8.64±0.49	9.84±0.25
10-11		6.88±0.39	8.77±0.53	10.12±0.57	11.50±0.44	7.76±0.45	8.49±0.59	9.62±0.92	11.16±0.38
12-13		8.14±0.34	11.19±1.38	12.39±1.23	12.82±0.75	9.64±0.69	10.41±1.06	12.20±1.15	13.13±1.31
14-15		11.37±1.31	14.93±0.73	15.85±0.60	16.05±0.76	12.82±1.44	13.88±0.96	15.14±0.77	15.61±0.65
ANOVA	**F**	83.393	144.397	159.840	162.406	76.231	123.203	118.975	96.502
	p	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

**: Significant at P ≤ 0.05.*

Table (3): ANOVA one way statistical analysis of vertebral body parameters of the third and fourth cervical vertebrae in female children of group I:

Age groups (years)		**C3 measurements**				**C4 measurements**			
		AH3	**H**3	**PH**3	**AP**3	**AH**4	**H**4	**PH**4	**AP**4
8-9		5.95±0.21	7.19±0.55	7.75±0.32	8.74±0.50	6.51±0.11	6.97±0.29	7.62±0.44	8.93±0.71
10-11		6.68±0.31	7.95±0.54	8.81±0.68	10.45±0.77	7.07±0.26	7.58±0.31	8.62±0.77	10.34±0.46
12-13		7.98±0.22	10.54±1.10	11.33±0.84	12.78±0.84	8.70±0.62	9.57±1.04	10.98±0.75	12.69±1.06
14-15		10.42±1.16	13.13±0.66	14.16±0.87	14.43±0.73	11.20±0.89	12.32±0.92	13.89±0.61	15.17±0.53
ANOVA	**F**	86.953	154.635	163.065	115.336	134.358	115.806	205.964	172.699
	p	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

**: Significant at P ≤ 0.05.*

Table (4): Student-test, comparison of vertebral body parameters of the third cervical vertebrae between male and female children of group I:

Age groups (years)	C3 measurements											
	AH3			H3			PH3			AP3		
	Males	Females	P-value	Males	Females	P-value	Males	Females	P-value	Males	Females	P-value
8-9	6.44 ±0.14	5.95 ±0.21	**0.003**	7.80 ±0.19	7.19 ±0.55	**0.046**	9.16 ±0.15	7.75 ±0.32	**<0.001**	10.34 ±0.36	8.74 ±0.50	**<0.001**
10-11	6.88 ±0.39	6.68 ±0.31	0.200	8.77 ±0.53	7.95 ±0.54	**0.002**	10.12 ±0.57	8.81 ±0.68	**<0.001**	11.50 ±0.44	10.45 ±0.77	**0.002**
12-13	8.14 ±0.34	7.98 ±0.22	0.149	11.19 ±1.38	10.54 ±1.10	0.189	12.39 ±1.23	11.33 ±0.84	**0.015**	12.82 ±0.75	12.78 ±0.84	0.882
14-15	11.37 ±1.31	10.42 ±1.16	**0.020**	14.93 ±0.73	13.13 ±0.66	**<0.001**	15.85 ±0.60	14.16 ±0.87	**<0.001**	16.05 ±0.76	14.43 ±0.73	**<0.001**

*: Significant at $P \leq 0.05$.

Table (5): Studentt-test, comparison of vertebral body parameters of the fourth cervical vertebrae between male and female children of group I:

Age groups (years)	C4 measurements											
	AH4			H4			PH4			AP4		
	Males	Females	P-value	Males	Females	P-value	Males	Females	P-value	Males	Females	P-value
8-9	7.09 ±0.09	6.51 ±0.11	**<0.001**	7.36 ±0.26	6.97 ±0.29	0.052	8.64 ±0.49	7.62 ±0.44	**0.008**	9.84 ±0.25	8.93 ±0.71	**0.028**
10-11	7.76 ±0.45	7.07 ±0.26	**<0.001**	8.49 ±0.59	7.58 ±0.31	**<0.001**	9.62 ±0.92	8.62 ±0.77	**0.012**	11.16 ±0.38	10.34 ±0.46	**<0.001**
12-13	9.64 ±0.69	8.70 ±0.62	**0.001**	10.41 ±1.06	9.57 ±1.04	**0.044**	12.20 ±1.15	10.98 ±0.75	**0.003**	13.13 ±1.31	12.69 ±1.06	0.341
14-15	12.82 ±1.44	11.20 ±0.89	**<0.001**	13.88 ±0.96	12.32 ±0.92	**<0.001**	15.14 ±0.77	13.89 ±0.61	**<0.001**	15.61 ±0.65	15.17 ±0.53	**0.026**

**: Significant at $P \leq 0.05$.*

Table (6):Chi- square test for age and sex distribution of group II cases:

Age groups (years)	Males		Females		Total		x^2	P
	No.	%	No.	%	No.	%		
8-9	2	8	3	12	5	10	1.022	0.796
10-11	8	32	5	20	13	26		
12-13	6	24	7	28	13	26		
14-15	9	36	10	40	19	38		
Sum	25	100	25	100	50	100		

**: Significant at $P \leq 0.05$*

Table (7):Student-test, comparison of chronological age (CA) and estimated cervical vertebral bone age (CVBA) in male children of group II:

Age Groups (years)	Chronological age (CA)	Estimated (CVBA)	Difference	SE	P-value
8-9	8.55±0.21	9.59±0.16	-1.039	0.034	**0.021***
10-11	10.09±0.38	10.35±0.42	-0.269	0.105	**0.037***
12-13	11.91±0.50	11.78±0.66	0.129	0.761	0.481
14-15	14.37±0.74	14.89±1.13	-0.519	0.154	**0.010***
Total Mean	11.94±2.15	12.27±2.24	-0.325	0.098	**0.003***

SE= standard error, *: Significant at $P \leq 0.05$

Table (8):Student-test, comparison of chronological age (CA) and estimated cervical vertebral bone age (CVBA) in female children of group II:

Age Groups (years)	Chronological age (CA)	Estimated (CVBA)	Difference	SE	P-value
8-9	8.77±0.12	8.91±0.47	-0.139	0.232	0.610
10-11	9.94±0.37	10.20±0.49	-0.263	0.192	**0.037***
12-13	11.96±0.63	11.34±0.40	0.616	0.098	**0.002***
14-15	14.28±0.84	13.69±0.77	0.575	0.076	**<0.001****
Total Mean	12.09±2.17	11.76±1.86	0.333	0.091	**0.002***

*SE= standard error, *: Significant at P ≤ 0.05, **: Highly Significant at P ≤ 0.001*

Table (9):Studentt-test,comparisonof estimated cervical vertebral bone age (CVBA)and estimated hand bone age (HBA)in male children of group II:

Age Groups(years)	Estimated(CVBA)	Estimated(HBA)	Difference	SE	P-value
8-9	9.59±0.16	8.30±0.14	1.289	0.017	**0.008***
10-11	10.35±0.42	10.47±0.97	-0.115	0.248	0.658
12-13	11.78±0.66	11.59±0.84	0.193	0.257	0.486
14-15	14.89±1.13	14.97±0.73	-0.079	0.177	0.667
Mean	12.27±2.24	12.18±2.42	0.084	0.137	0.544

*SE= standard error, *: Significant at P ≤ 0.05*

Table (10):Studentt-test,comparison of estimated cervical vertebral bone age (CVBA)and estimated hand bone age (HBA)in female children of group II:

Age Groups (years)	Estimated(CVBA)	Estimated(HBA)	Difference	SE	p
8-9	8.91±0.47	10.10±0.14	-1.190	0.275	**0.049***
10-11	10.20±0.49	11.44±0.38	-1.240	0.138	**0.002***
12-13	11.34±0.40	13.57±0.64	-2.232	0.109	**<0.001****
14-15	13.69±0.76	15.29±0.58	-1.595	0.102	**<0.001****
Mean	11.76±1.86	13.42±1.97	-1.655	0.155	0.866

*SE= standard error, *: Significant at P ≤ 0.05,**: Highly Significant at P ≤ 0.001*

Table (11): Pearson's correlation coefficient for the correlation between estimated cervical vertebral boneage (CVBA), chronological age (CA) and estimated hand bone age (HBA) in malechildren of group II:

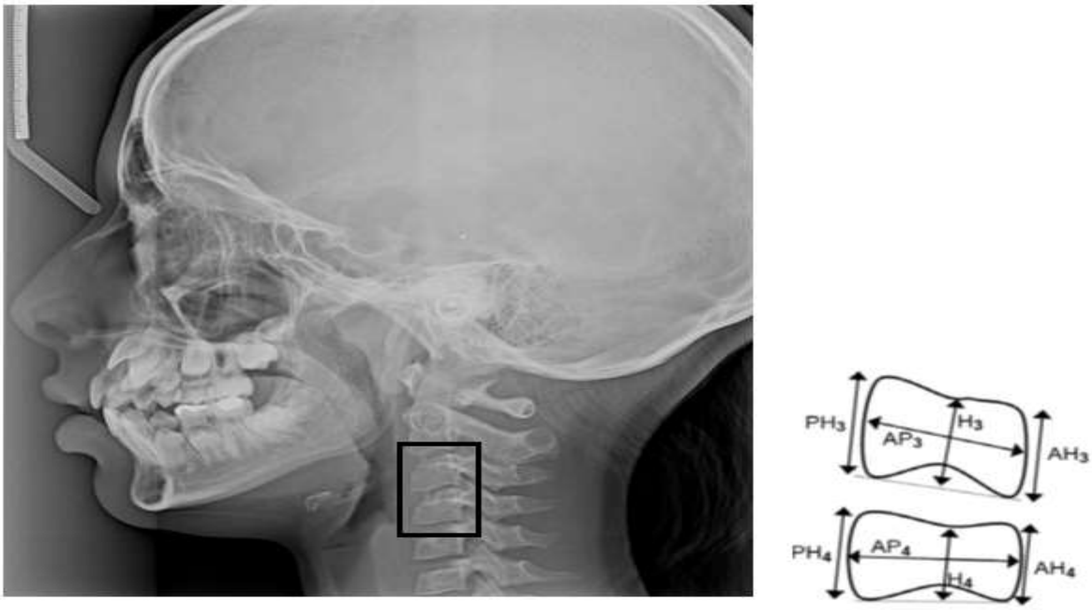
Variables	Correlation coefficient (r)	P-value
Estimated (CVBA)– CA	0.976	**<0.001****
Estimated (CVBA)– Estimated (HBA)	0.960	**<0.001****

***: Highly Significant at P ≤ 0.001*

Table (12): Pearson's correlation coefficient for the correlation between estimated cervical vertebral boneage (CVBA), chronological age (CA) and estimated hand bone age (HBA) in femalechildren of group II:

Variables	Correlation coefficient (r)	P-value
Estimated (CVBA)– CA	0.931	**<0.001****
Estimated (CVBA)– Estimated (HBA)	0.942	**<0.001****

***: Highly Significant at P ≤ 0.001*



Fig, (1): Measurements performed to calculate the cervical vertebral bone age on the third and fourth cervical vertebrae (C3, C4)appearing on lateral cephalometricradiograph. AH: distance from the most superior to the most inferior point on the anterior surface ofthe vertebral body; AP: maximum anteroposterior distance at the middle of cervical vertebral body; H: distance from the top of the middlepart of the vertebral body to a tangent connecting the most inferior points of the lower border; PH: distance from the most superior to themost inferior point on the posterior surface of the vertebral body(Mito et al.,2002).

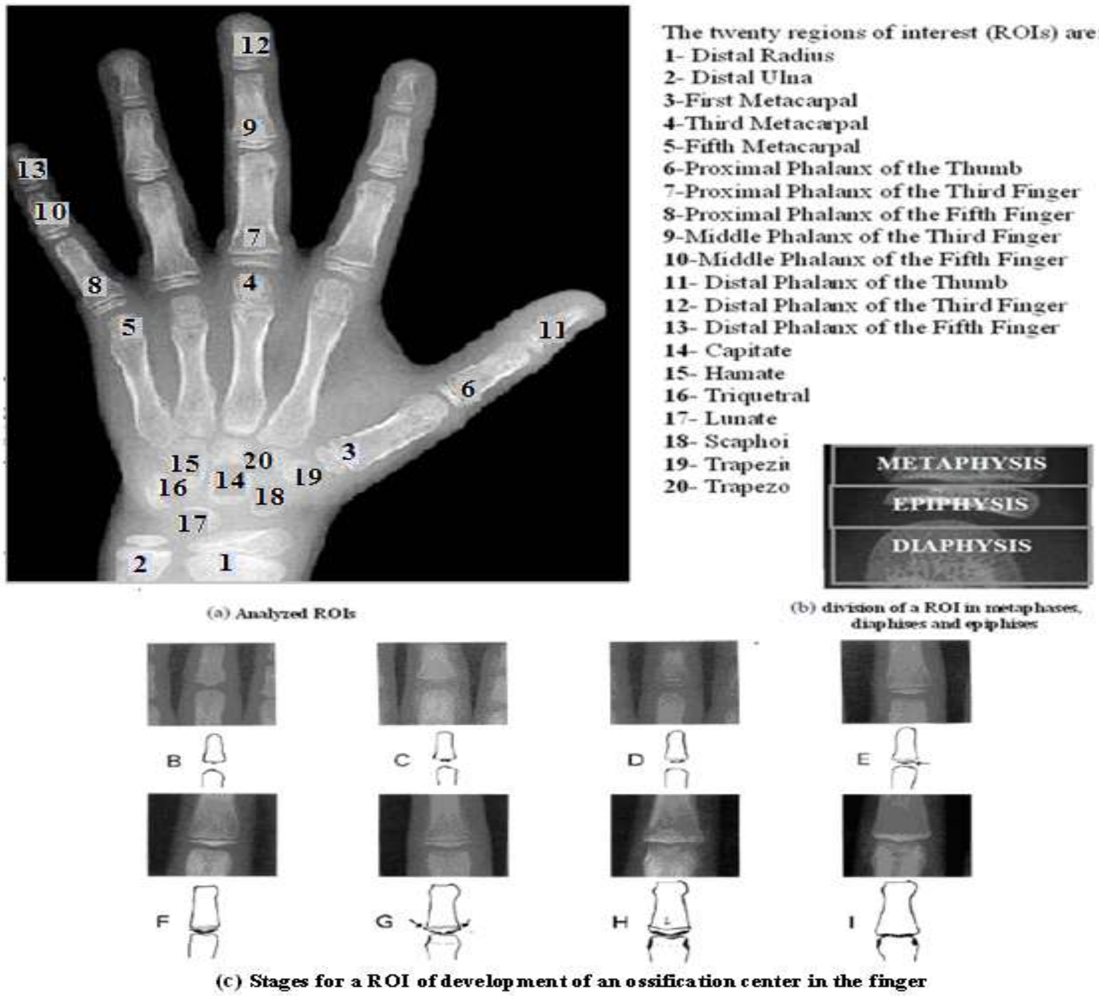


Fig.2: The Tanner Whitehouse (TW2) method (Ritz et al., 2000).

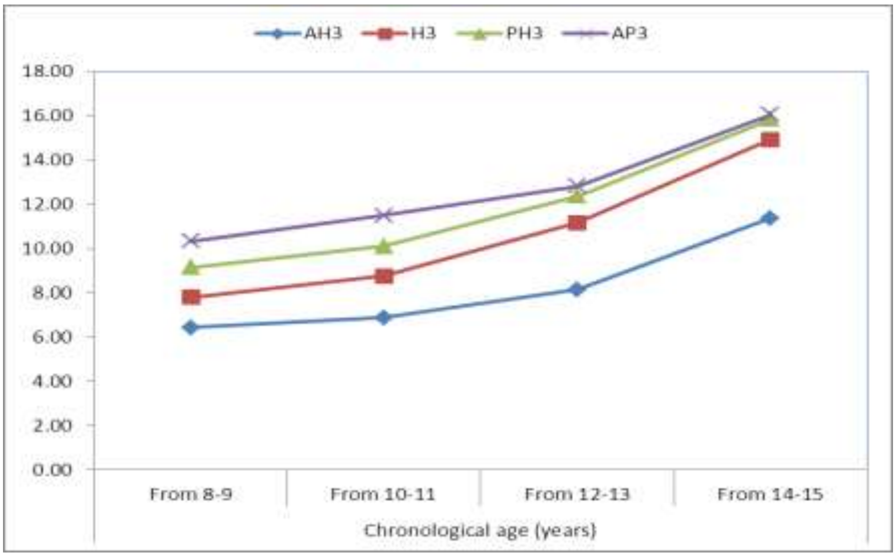


Figure (3): The mean value of vertebral body parameters of the third cervical vertebrae in male children of group I.

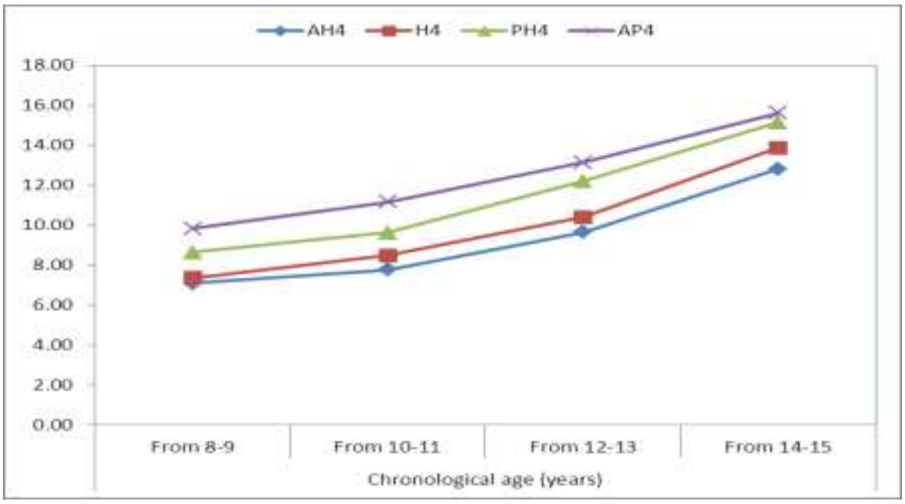


Figure (4):The mean value of vertebral body parameters of the fourthcervical vertebrae in male children of group I.

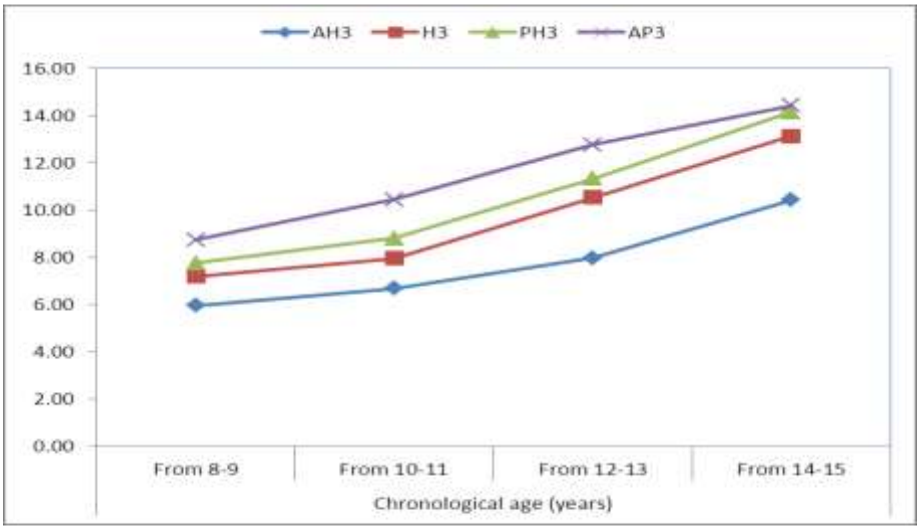


Figure (5): The mean value of vertebral body parameters of the third cervical vertebrae in female children of group I.

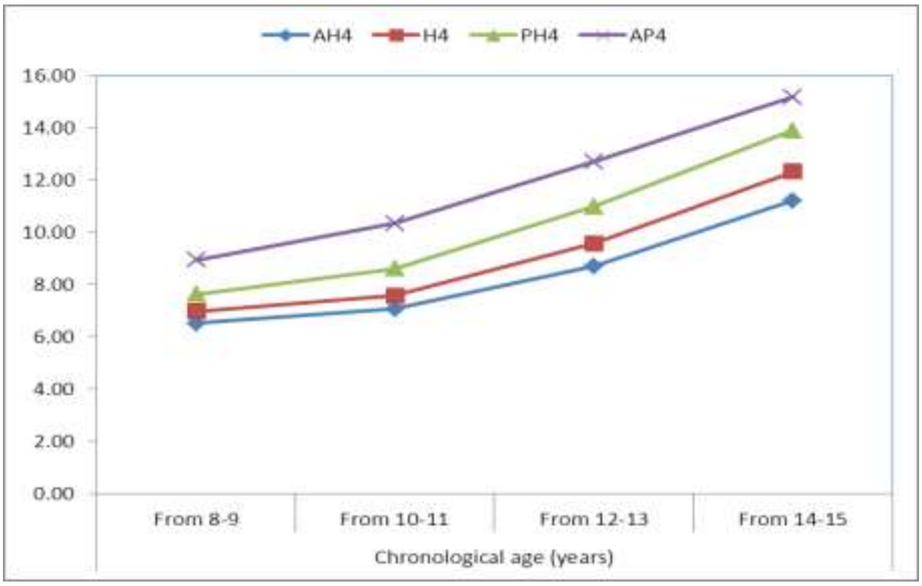


Figure (6):The mean value of vertebral body parameters of the fourth cervical vertebrae in female children of group I.

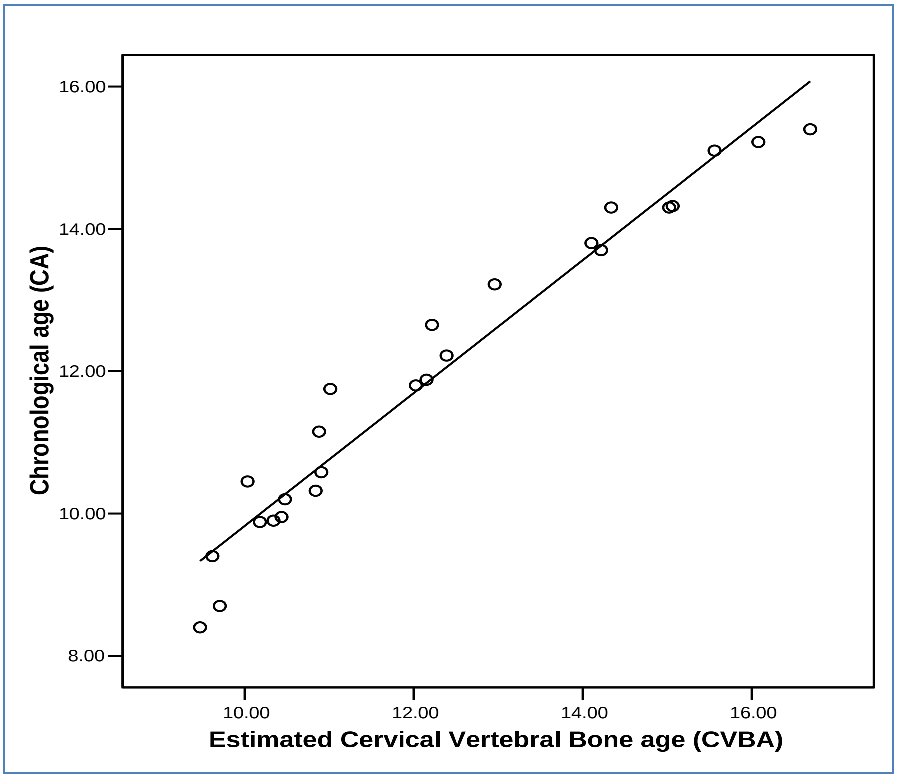


Figure (7):Scatter diagram showing correlation between estimated cervical vertebral bone age (CVBA) and chronological age (CA)in malechildren of group II.

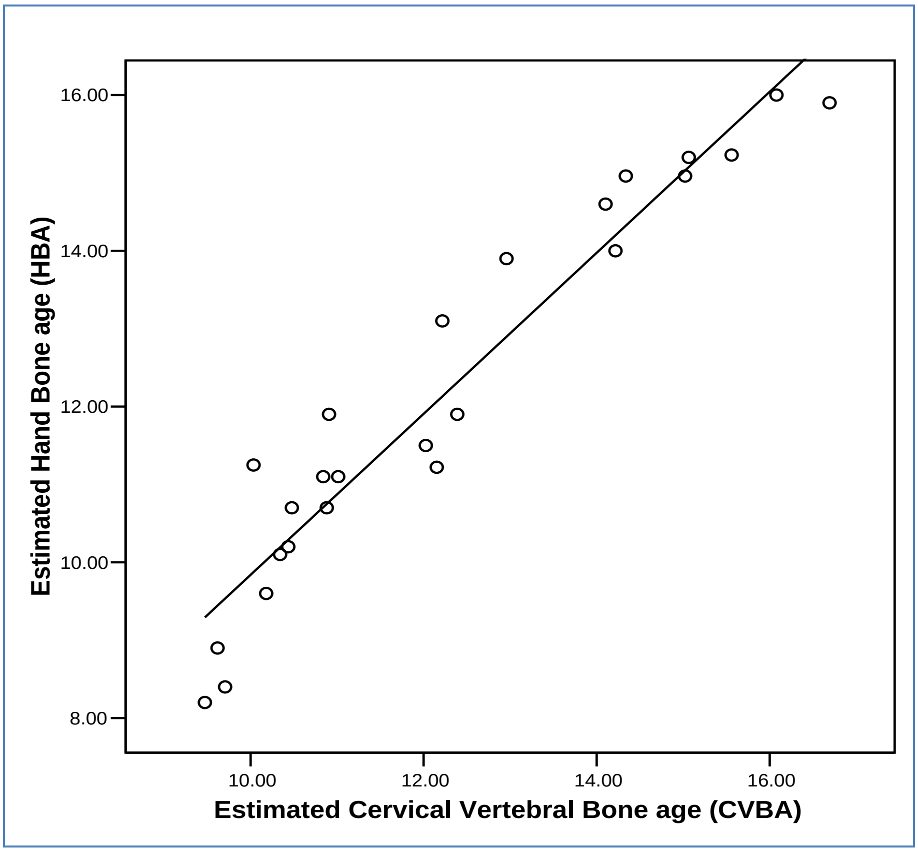


Figure (8):Scatter diagram showing correlation between estimated cervical vertebral bone age (CVBA) and estimated hand bone age (HBA) in malechildren of group II.

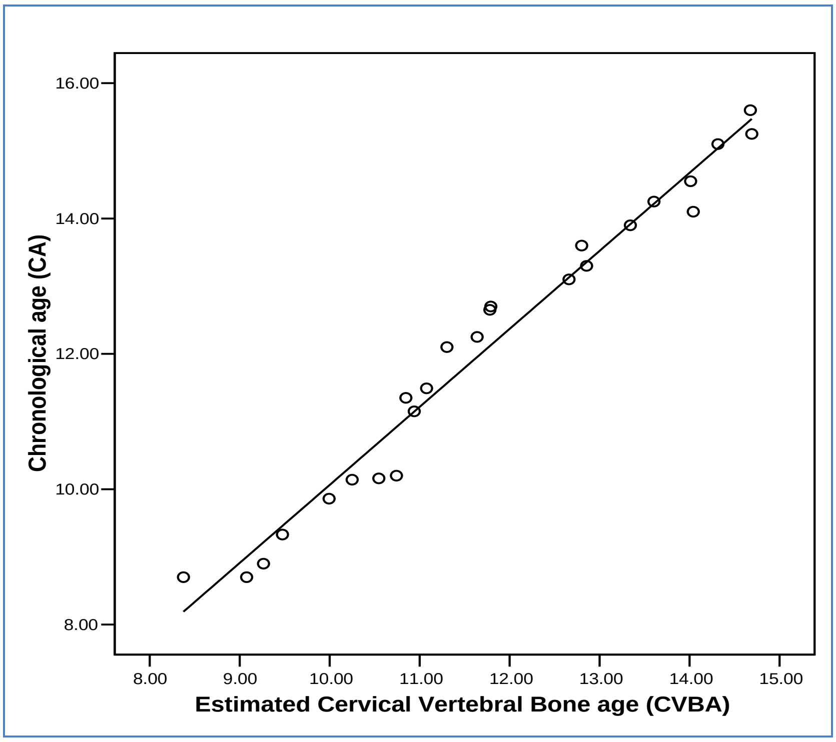


Figure (9):Scatter diagram showing correlation between estimated cervical vertebral bone age (CVBA) and chronological age (CA)in female children of group II.

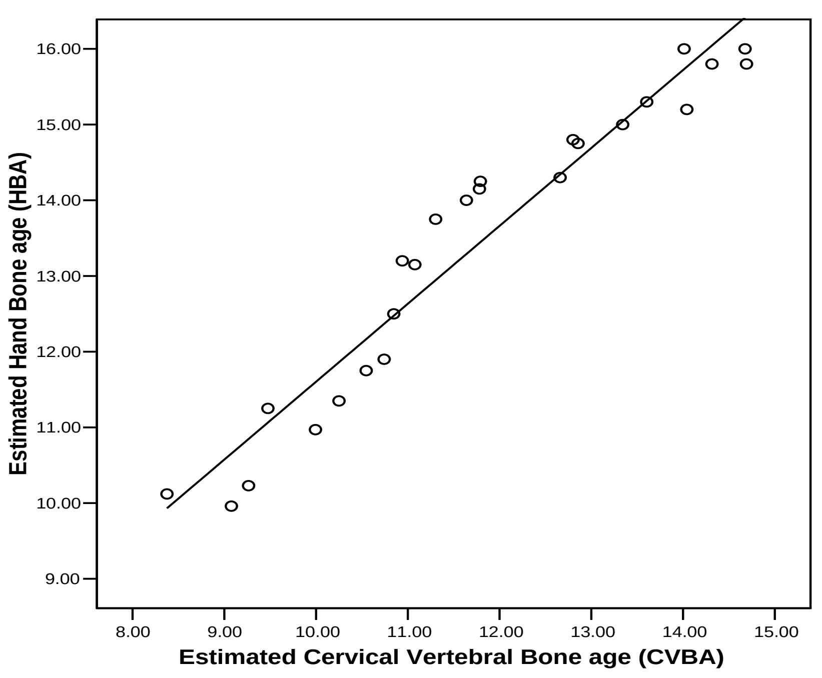


Figure (10):Scatter diagram showing correlation between estimated cervical vertebral bone age (CVBA) and estimated hand bone age (HBA) in female children of group II.

Discussion

The use of skeletal age has been shown to be more reliable and accurate than the use of chronological age in assessing an individual's progress toward maturity(Schmeling et al., 2000).

The method used in the present study, Mito et al. (2002),may be of great importance because it allows skeletal age to be calculated in an objective manner.

Previous investigations have used statistical models to calculate the cervical bone age in different populations(Alhadlaqet al., 2007).However, the study of Mito et al. (2002)was limited to Japanese girls and the formula developed by Caldaset al., (2007)was specific for Brazilians. Children with a different racial back ground and developing under different environmental conditions may exhibit a different growth velocity and/or pattern(Fudalej and Bollen, 2010). Thus, developing a specific formula to calculate the cervical bone age in Egyptian children is useful for indicated clinical implications.

Mito et al. (2002) examined only Japanese girls because of sex-dependent differences with regard to the timing of morphological changes in cervical vertebral bodies(Beker, 2006).In a study by Alhadlaq and Al-Maflehi (2013), only Saudimale subjects were considered toavoid any sex-related variations in growth pattern and timingof maturational changes of the cervical vertebrae.

In the present study, the sample selected was composed of both male and female children in order to establish two different formulae to objectively evaluate skeletal maturation using digital measurements of third (C3) and fourth (C4) cervical vertebrae in cephalometric radiographs in a sample of Egyptian children.

The age group of the sample was selected based on the observed morphological changes in the cervical vertebral body dimensions during this period of growth (Baccetti et al., 2005). The majority of patient population age groups attending the orthodontic clinic ranged from 8 to 16 years. During this age range it is important to evaluate the developmental age for these children to determine the proper treatment method and the timing of orthodontic intervention. Before the age 8 lateral cephalometric radiographs were rarely taken as routine dental radiographs, also children before this age is difficult to implement in practical terms (Al-Emran, 2008).

Cervical vertebral bodies were measured in this study because many investigators have suggested that the size and shape of the cervical vertebrae change from birth to full maturity at each level of skeletal development. The C3 and C4 were chosen for evaluation because of the difficulty in locating and measuring morphological body changes in the first top two vertebrae and the usual lack of appearance of the lower cervical vertebrae in routine lateral cephalometric radiographs (San-Roman et al., 2002).

In the present study, analysis of group I sample showed that vertebral body parameters of the third (AH3, PH3, H3andAP3) and fourth (AH4, PH4, H4andAP4) cervical vertebrae increased significantly in an accelerated manner in both male and female cases. The subjects aged (14-15) years showed the statistically significant highest mean values while subjects aged (8-9) years showed the statistical significant lowest mean values. So different regression equations were put for chronological age estimation in both male and female subjects studied using lateral cephalogramic measurements.

In this study, the use of ratios between the vertebral bodydimensions in developing the statistical model was to negateany possible magnification effect in the radiographic technique.

The ratio AH/AP of C3 and C4 was implicatedin the formula to calculate the CVBA. The same ratio was used by Alhadlaq and Al-Maflehi (2013)to analyze Saudi children.This was in contrast toMito et al.(2002)who utilized the ratio AH4/PH4 in theirformulafor Japanese people. However,Caldaset al. (2007)used the same ratios(AH3/AP3, AH4/AP4) in their formula to calculate the CVBAin females, whereas the ratios AH3/AP3 and H4/AP4 wereused for the male subjectsin Brazilians. These differences in the ratios selectedby the multiple regression analysis models demonstrateand confirm the variation in morphological changesduring cervical vertebral maturation related to gender and ethnicbackground.

To determine the reliability of the formulaedeveloped fromgroup I, cervical vertebral bone age (using the formulaedeveloped), bone age (using TW2 method), andchronological age in group II were calculated.

The TW2 method to determine the skeletal/bone age was selected to evaluate the ability of the derived formula in establishingthe bone age because of its established reliability andwide clinical use (Kim et al., 2010).

Results of Pearson's correlation coefficient indicate that there was a significant positive correlation betweenthe estimated cervical vertebral bone age (CVBA) and chronological agein both males and females.

Also there was a significant positive correlation betweenthe estimated cervical vertebral bone age (CVBA) andestimated hand bone age (HBA)in both males and females.

Additionally, the ability of thederived formula in establishing bone age was further assuredby that there wasno significant difference between the estimated cervical vertebral bone age (CVBA) andestimated hand bone age (HBA)in both male and female children.

This means that these developed formulaeare reliable for estimating age in Egyptian children.

In general, these findings arein accordance with related previous studies in other populations.Mito et al.(2002) found a strong positive correlation between cervical vertebral bone age (CVBA) calculated by their formulae andboth chronological age and hand boneage in Japanese girls.

Caldaset al. (2007) established two new formulaeto determinevertebral bone agein Brazilians),both female and male subjects showed no statisticallysignificant difference between cervical vertebral bone age and bone age estimated by hand X ray. The results suggested that the method is reliable and could be applied to both boys and girls (Sachan et al., 2011).

Ying-xinget al. (2011) derived new equations by quantitative measurements of cervical vertebrae in young Chinese.The results showed a strong correlation between skeletal age (by the Hand-wrist X-rays) and the age estimated by theirequations.They suggested that cervical vertebral bone age reflects skeletal maturity because it approximates bone age,which is considered to be the most reliable method for evaluating skeletal maturation.

Alhadlaq and Al-Maflehi (2013)tested the validity of a newly developed statistical modelin establishing the cervical vertebral bone age in male Saudichildren.No significantdifference and high correlation were found between the calculated cervical vertebralbone age and the bone/skeletal age established by the hand-wrist method.

Conclusion

The results of this study indicate that thecervical vertebralbone age CVBA established bythe described statistical formula is as dependable in determiningthe skeletal age as the other well-established hand-wristmethods of TW2 in a sample of Egyptian children. Using cervical vertebral bone age it is possible to evaluate skeletal maturation objectively in cephalometric radiographs.

Recommendation

Further research and studies are needed with extensive and large number of samples from different districts of Egypt to study the environmental and nutritional factors and their effects on skeletal maturation, in order to establish a specific formula to estimate age in Egyptian children from cervical vertebrae.

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الملخص العربي

تقديرالعمر بناء على بعض قياسات الفقرات العنقية في عينة من الأطفال المصريين

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أصبحت الحاجةإلى تقدير عمر الأشخاص الأحياء أكثر تواترا ،بسبب العدد المتزايد من المهاجرين (الغير قانونيين أوغيرذلك) من دون وثائق هوية مقبولة ومعتواريخالميلاد المفقودة أوغير المؤكدة. وفي السنوات الأخيرة، قدتم استخدام الفقرات العنقية بشكل متزايد لتحديد نضوج الهيكل العظمي.

الهدف: كان الهدف من هذه الدراسة وضع صيغتين جديدتينللتقييم الموضوعي (القياسي)لنضوج الهيكل العظمي (عمر العظام) للفقرات العنقية لبعض الذكور والإناث منالأطفالالمصريين وذلك باستخدام أشعة الرأس الجانبية .وقد تم اختيار الحالات من المرضى الذين يراجعون عيادات كلية طب الأسنان للبنات، جامعة الأزهر بالقاهرة.

الطريقة:هذا وقد تم تقسيم الحالات المختارة إلى مجموعتين.وقد شملت المجموعة الأولى ١٠٠ طفلاً، ٥٠ من الذكور (تتراوح أعمارهم من ٨,٤٥-١٥,٧٥ سنة مع متوسط العمر ١٢,٤١ سنة) و٥٠ من الإناث (تتراوح أعمارهن من ٨,٢-١٥,٥ سنة مع متوسط العمر ١١,٩ سنة).وقد تم تتبع وقياس الفقرات العنقية الثالثة والرابعة (C3وC4)بأشعة الرأس الجانبيةلكل طفلمنهم وتم الحصول علي معادلات انحدار مختلفة لتقدير العمر الزمني لكل من الذكور والإناث باستخدام تلك القياسات..

أما المجموعةالثانية فقد اشملت علي٥٠ طفلاً، ٢٥ من الذكور (تتراوح أعمارهم من ٨,٢٥- ١٥,٨٥ سنة مع متوسط العمر ١١,٧ سنة) و٢٥ من الإناث (تتراوح أعمارهن من ٨,٥-١٥,٦٥ سنة مع متوسط العمر ١٢,١٢ سنة).وقد تم تتبع وقياس الفقرات العنقية الثالثة والرابعة (C3 و C4) بأشعة الرأس الجانبية لكل طفل منهم وتم حساب العمر العظمي بإدخال تلك القياسات في معادلات الانحدار التي تم الحصول عليها من المجموعة الأولى، كماتمأيضاحسابالعمرالعظميلهذهالمجموعةمنأشعةاليدوالرسغباستخدام طريقة TW2 وذلك لمقارنته بالعمر العظمي للفقرات العنقية لإثبات مدي فاعلية قياسات الفقرات العنقية لتحديد العمر وامكانية تطبيقه علي المصريين.

النتائج: وقد خلصت هذه النتائج إلي وجود علاقة إيجابية ذات دلالة إحصائية بين العمر العظمي للفقرات العنقية وكل من العمر الزمني وكذلك العمر العظمي لليد والرسغ في كل من ذكور وإناث الأطفال.

الخلاصة:تشير هذه النتائج إلى أن قياسات الفقرات العنقية بأشعة الرأس الجانبية تعكس نضج الهيكل العظمي لاقترابها من العمر العظمي باستخدام أشعة اليد والرسغ، والتي تعتبر الطريقة الأكثر موثوقية لتحديد العمر.فعن طريق تلك القياسات،قديكون من الممكن تحديدعمر الأطفال المصريين بطريقة مفصلة وموضوعية بأشعة الرأس الجانبية.

التوصيات:إجراء المزيد من الدراسات والأبحاث علي عدد كبير من الأطفال المصريين من مناطق مختلفة وذللك لدراسة تأثير العوامل البييئية والعادات الغذائية علي نمو العظام لوضع صيغة محددة للمساعدة في التعرف على عمر الأطفال المصريين من الفقرات العنقية.

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