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Original scientific paper

Age Determination on Long Bones in a Skeletal Subadults Sample (b-12 Years)

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A B S T R A C T

The skeletal age on the basis of the diaphyseal length of long bones was assessed. To this aim a sample of subadults skeleton, dated to last century, coming from the cemetery of Bologna was studied. The sample is composed by 79 males and 70 females between 0 and 12 years, whose chronological age and sex are known. Some information can be obtained by the means, standard deviation and graphs of the specimens grouped in age classes. The comparison with other studies confirms the interest of using standards based on direct measurements on long bones of known age and similar to the skeletal populations under study.

Key words: *skeletal age, growth, long bones*

Introduction

To estimate the age at death in subadults skeletons coming from bio-archaeological and forensic contexts, the most used methods are based on teeth calcification and eruption[1–4]. These parameters, and especially teeth calcification, are considered the best age indicators between 0 and 12 years of age, because they show low sex dimorphism and low intra- and interpopulation variability[5,6].

Nevertheless, age at death in juvenile human skeletons can be estimated from other parameters, such as the degree of skeletal maturity, based on the observation of the appearance of ossification centers and their union[7–10].

Among these methods, the last one is affected by the high sex and intra- and interpopulation variability in bone dimensions and growth rate; however this method can be useful especially with fragmentary findings. Some of the studies on age assessment are based on the diaphyseal length of bones measured by

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x-rays on living children[11,12], others are based on bone measurements of skeletal remains, most of them on archaeological remains, in which age of the individual is assessed by dental or skeletal development and sex is unknown[13,16–19]. Most of examined samples come especially from North America, and North Europe. Instead, it would be better for European populations to choose standards based on more similar samples, for example from the Mediterranean area.

Thus, in this study we would like to give a new contribution to age assessment from long bones in children, having at our disposal a sample of subadults (b-12 years) skeletons of known age and sex coming from Bologna population.

TABLE 1
COMPOSITION OF THE SAMPLE (THE CLASSES OF AGE BELOW 2 YEARS ARE INDICATED IN MONTHS)

	Males (N)					
	Humerus	Radius	Ulna	Femur	Tibia	Fibula
0–6 months	27	24	23	30	29	25
7–12 months	8	3	4	9	8	4
13–18 months	5	5	5	4	5	5
19–24 months	5	3	3	4	4	4
2.1–3.0 yrs.	4	3	3	4	4	3
3.1–4.0 yrs.	1	1	1	2	2	1
4.1–5.0 yrs.	1			1	1	1
5.1–6.0 yrs.						
6.1–7.0 yrs.	1	1	1	1	1	1
7.1–8.0 yrs.	1	1	1	1	1	1
8.1–9.0 yrs.	1	1	1	1	1	1
9.1–10.0 yrs.	1	1	1	1	1	1
10.1–11.0 yrs.	2	2	2	2	2	2
11.1–12.0 yrs.	1	1	1	1	1	1
	Females (N)					
	Humerus	Radius	Ulna	Femur	Tibia	Fibula
0–6 months	12	12	11	13	13	12
7–12 months	18	14	10	20	19	12
13–18 months	5	4	4	5	5	3
19–24 months	6	4	4	6	6	4
2.1–3.0 yrs.	3	1	2	3	3	2
3.1–4.0 yrs.	1	1	1	1	1	1
4.1–5.0 yrs.	2	2	2	3	3	2
5.1–6.0 yrs.	1	1	1	1	1	1
6.1–7.0 yrs.	5	5	5	5	5	5
7.1–8.0 yrs.				1		
8.1–9.0 yrs.	2	2	2	2	2	2
9.1–10.0 yrs.						
10.1–11.0 yrs.						
11.1–12.0 yrs.	1	1	1	1	1	1

Material and Methods

The sample studied is made up by infant and juvenile skeletons in good state of preservation, coming from the Cemetery of Bologna (Italy) and housed in the Museum of Anthropology of the University of Bologna. They are dated to the beginning of last Century and are related to 79 males and 70 females between 0 and 12 years (Table 1). The age of death (years and months) is reported in the registers of the Museum.

The measurements were made on six long bones, left side when possible (humerus, radius, ulna, femur, tibia, fibula). Maximum length was recorded in millimeters from an osteometric board[20]. Obviously the taken measurements are diaphyseal, as the epiphyses were not united.

First, graphs were processed with singular data of each individual and approximate curves that show long bone growth for each sex (Figures 1–6).

Moreover was calculated the regression of the diaphyseal length of long bones vs. age (months). Since no significant differences between sexes were observed, the analysis was carried out without taking into account the sex. The regression

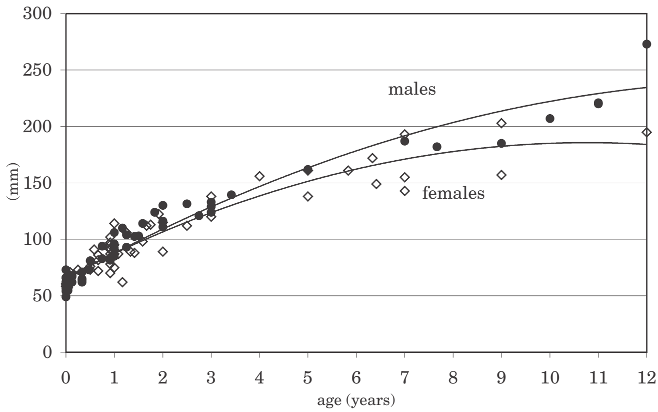

Fig. 1. Individual distribution of the diaphyseal length of humerus.

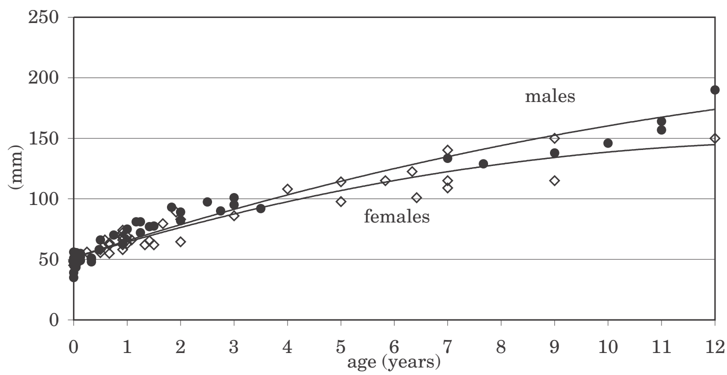

Fig. 2. Individual distribution of the diaphyseal length of radius.

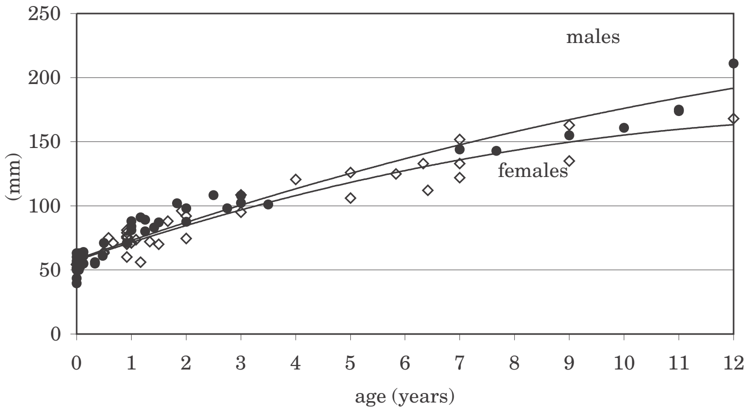

Fig. 3. Individual distribution of the diaphyseal length of ulna.

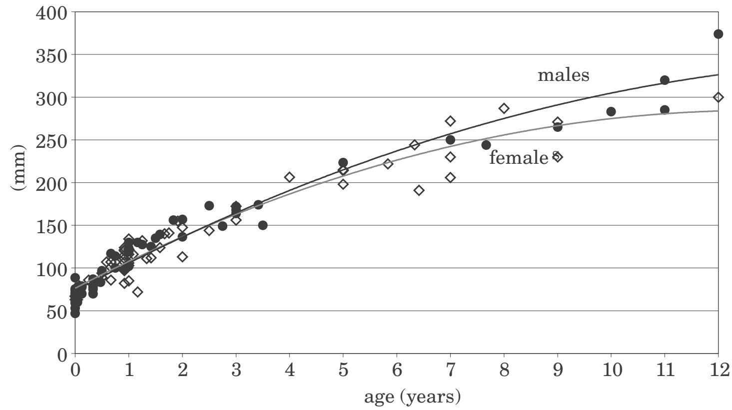

Fig. 4. Individual distribution of the diaphyseal length of femur.

analysis was made with the statistical package »Statistica, 1984–2000, Statsoft, Inc« (Table 2).

To obtain the means for the different age classes, taking into account the low number of subjects in some age classes (especially after 7 years), and low differences shown between the sexes, individual data are combined in biennial age classes (except from 0 to 2 years) with sexes united. For each age class were calculated mean, SD, confidence interval (95%) and the range of variation (Table 3).

Then, means of each sex (for each age class) have been compared to Maresh (1955) standards, based on mid 20th century US white children (Figures 7 and 8).

Finally, means of sexes united have been compared with some other studies, like: Stloukal and Hànàkova (1978), based on a Slave population of IX Century A.D., Sundick (1978), based on Indian Knoll and on a Germanic population of VI–VII Century A.D., Robles et al., based on Hispano-Muslim population from San Nicolàs (Murcia, Spain), dated XI–XIII

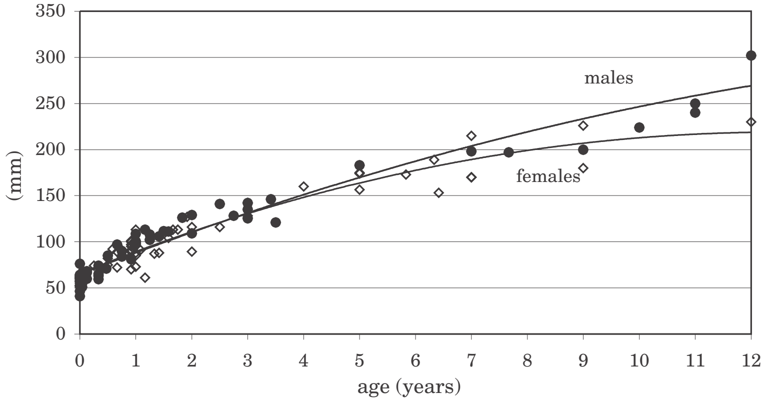

Fig. 5. Individual distribution of the diaphyseal length of tibia.

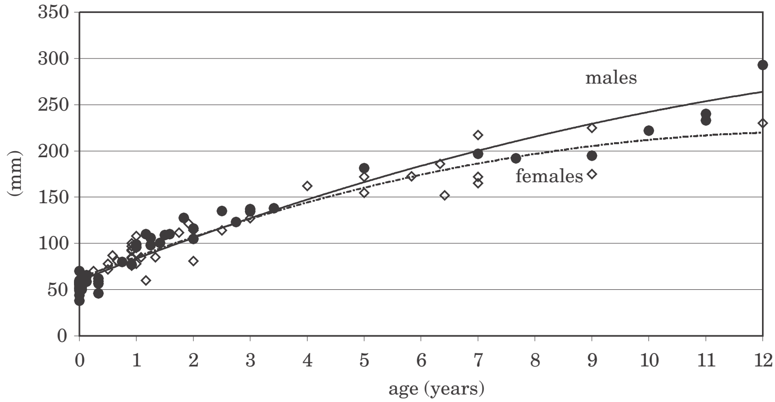

Fig. 6. Individual distribution of the diaphysial length of fibula.

TABLE 2
REGRESSION OF DIAPHYSEAL LENGTH OF LONG BONES VS. AGE

Ulna	age (months) = –59.72 + 1.0273 length (mm)	(r = 0.94840)
Radius	age (months) = –58.27 + 1.1225 length (mm)	(r = 0.95086)
Humerus	age (months) = –50.26 + 0.74658 length (mm)	(r = 0.92388)
Femur	age (months) = –38.16 + 0.49569 length (mm)	(r = 0.93382)
Tibia	age (months) = –42.99 + 0.64868 length (mm)	(r = 0.93445)
Fibula	age (months) = –40.09 + 0.65251 length (mm)	(r = 0.93764)

Centuries A.D., and Saunders et al. (1993), based on a XIX Century population of Belleville (Ontario, Canada, whose origin was North-Western Europe) (Figures 9 and 10). Age at death in these comparison samples is assessed by teeth calcification and eruption.

TABLE 3
MEANS OF DIAPHYSEAL LENGTH OF LIMB LONG BONES (CONFIDENCE INTERVALS 95%)
(THE CLASSES OF AGE BELOW 1 YEAR ARE INDICATED IN MONTHS)

Age (years)		Om	Ra	Ul	Fe	Ti	Fi
0–6 months	N	39	36	33	43	42	37
	X	63.7	50.1	56.1	72.2	62.5	57.8
	SD	6.9	5.7	6.3	10.4	8.7	7.9
	CI	2.2	1.9	2.2	3.2	2.7	2.6
	Max.	81.0	66.0	71.0	97	85	78
	Min.	49.0	35.0	39.5	47	41	38
7 months – 1 year	N	26	17	14	29	27	16
	X	89.1	66.0	75.2	110.2	92.0	89.3
	SD	10.1	5.4	7.1	13.1	10.4	9.6
	CI	3.9	2.6	3.8	4.9	4.0	4.8
	Max.	114.0	75.0	88.0	134	113	108
	Min.	70.0	55.0	60.0	82	70	76
1.1 – 2.0 years	N	21	16	16	19	20	16
	X	104.2	76.5	83.7	130.0	105.6	102.5
	SD	15.7	10.1	12.1	20.2	16.1	17.2
	CI	6.9	5.0	6.0	9.3	7.2	8.6
	Max.	130.0	93.0	102.0	157	129	127.5
	Min.	62.0	62.0	56.0	72	61	60
2.1 – 4.0 years	N	10	7	8	11	11	8
	X	130.4	95.6	105.2	166.3	135.0	133.8
	SD	12.4	7.3	8.0	17.2	12.7	14.0
	CI	7.8	5.5	5.6	10.4	7.7	9.9
	Max.	156	108	120.5	206.5	160	162
	Min.	112	86	95	144	116	114
4.1 – 6.0 years	N	4	3	3	5	5	4
	X	155.5	108.9	119	214.5	172.26	170.15
	SD	11.7	9.7	11.3	10.1	9.8	11.2
	CI	11.7	11.2	13.0	9.1	8.7	11.2
	Max.	162	115	126	223.5	183	181.5
	Min.	138	97.7	106	198	156.3	154.6
6.1 – 8.0 years	N	7	7	7	8	7	7
	X	168.7	121.5	134.1	240.5	184.6	183.0
	SD	19.8	14.0	13.7	31.7	21.2	21.8
	CI	15.0	10.6	10.3	22.4	16.0	16.5
	Max.	193.0	140.3	151.7	287	215	217.2
	Min.	143.0	101.0	112	191	153	152
8.1 – 10.0 years	N	4	4	4	4	4	4
	X	188.0	137.3	153.5	262.3	207.5	204.3
	SD	22.8	15.6	12.8	22.8	21.8	23.7
	CI	22.8	15.6	12.8	22.8	21.8	23.7
	Max.	207.0	150.0	163.0	283	226	225
	Min.	157.0	115.0	135.0	230	153	152
10.1 – 12.0 years	N	4	4	4	4	4	4
	X	227.3	165.3	182.0	319.8	255.5	249.0
	SD	32.8	17.5	19.6	38.9	32.1	29.6
	CI	32.8	17.5	19.6	38.9	32.1	29.6
	Max.	273.0	190.0	211.0	374	302	293
	Min.	195.0	150.0	168.0	285	230	230

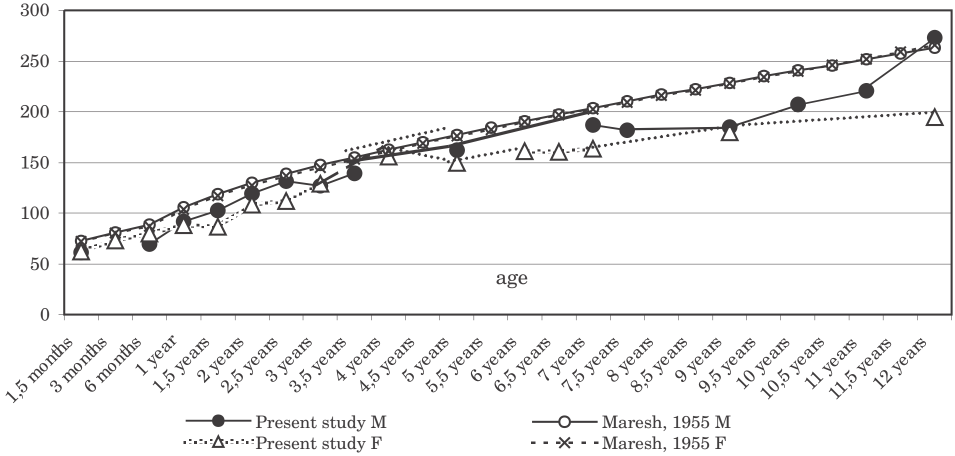

Fig. 7. Comparison between humerus diaphyseal length in the examined sample and in Maresh sample.

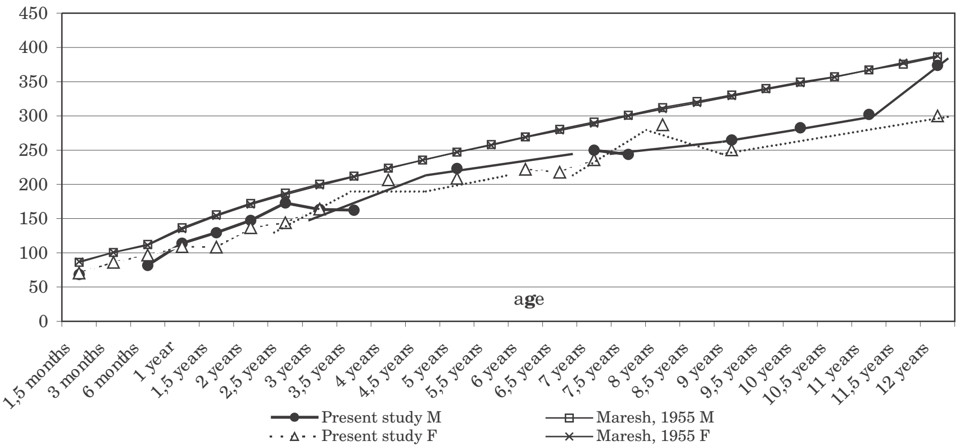

Fig. 8. Comparison between femur diaphyseal length in the examined sample and in Maresh sample.

Results

The results are shown in Figures 1–6 and in Tables 2 and 3. In general, the values obtained confirm some auxological aspects about growth: a little prevalence in bone dimensions in males than in females, that seems to be emphasized by age (even if after 7 years the sample is not very large). It can also be remarked an increase of the variability with age.

About age assessment on long bone length, in spite of the lack of the sample in some age classes, we can obtain some information by the figures, comparing the measurement of long bone length of the specimen with the respective curve. Moreover, the regression values allow to estimate the age (in months) on the basis of the diaphyseal length of long bones.

Table 3 provides some indications for age assessment from means of diaphyseal

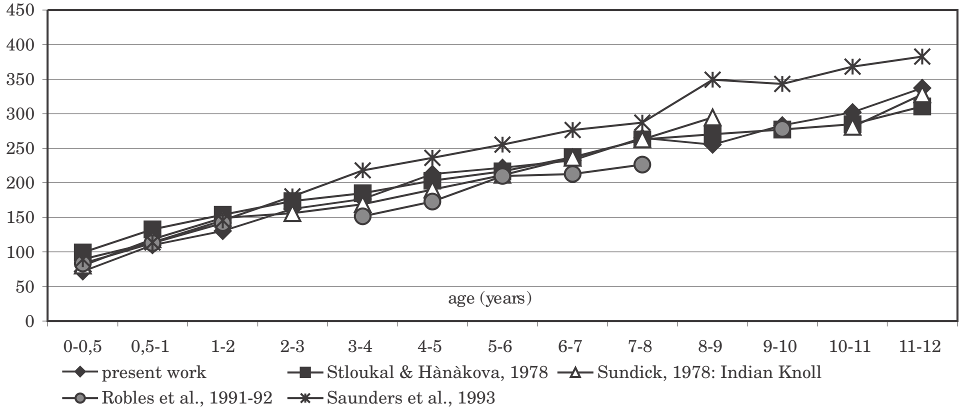

Fig. 9. Comparison among humerus diaphyseal length in different archaeological series.

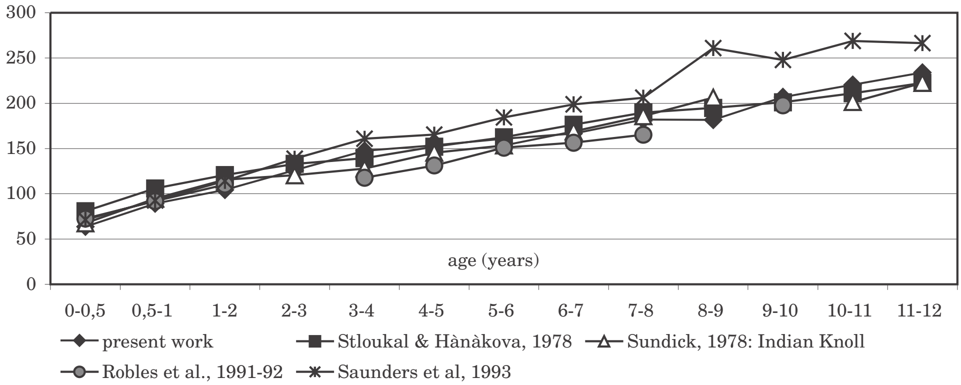

Fig. 10. Comparison among femur diaphyseal length in different archaeological series.

measurements and the confidence intervals (95%).

Compared to Maresh (1970) standards, our sample shows lower values, and the differences are very marked; this can be due to the different composition of the samples and to the different methods of study (American living children for Maresh, examined by X-rays; direct measurements of long bones of died children for our sample) (Figures 7 and 8).

Looking at the comparison among other studies on skeletal samples (Figures 9, 10), for which the age classes were assessed by dental age, we can observe higher values in Saunders et al. (1993) sample, especially after 3 years of age. Compared to Stloukal and Hànàkova (1978) and Sundick (1978) samples, the values obtained in our study are almost similar. Instead, compared to Robles et al. (1991–92) data, our sample shows generally higher values for the age of 2–3 years. The differences observed could be caused by the different ethnic composition of the samples, and by the different assessment of age: actually, the age of children of the comparison samples were estimated using dental development, while for our subjects the chronological age was known exactly.

The comparisons confirm the interest of using the diaphyseal length of long bones to estimate the age at death of archaeological and forensic findings in conjunction or in absence of other aging methods and suggests to utilize standards elaborated on the direct measurements of the bones of individuals of chronological age and sex known, possible referred to a similar population. The elaborated data in our research could be especially useful for populations coming from the Mediterranean area.

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ODREĐIVANJE DOBI DJECE MLAĐE OD 12 GODINA POMOĆU DUGIH KOSTIJU

S A Ž E T A K

U radu je proučavana starost kostura na temelju dužine dijafiza dugih kostiju. Proučavana je skupina dječjih skeleta iz prošlog stoljeća s groblja u Bologni. Uzorak se sastoji od skeletnih ostataka 79 muške i 70 ženske djece, starosti od 0 do 12 godina, poznate kronološke dobi i spola. Podatke je moguće dobiti izračunavanjem srednjih vrijednosti, standardne devijacije, te grafičkim prikazom uzoraka podijeljenih u starosne razrede. Usporedba s literaturnim podacima potvrđuje interes za korištenje standarda koji bi se temeljili na direktnom mjerenju dugih kostiju poznate dobi i sličnoj populaciji.