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Age estimation in subadults based on general anthropometric parameters in a population of Romania

Antoaneta Pungă[1,], Mariana Roșu[2], Liviu Munteanu[3], Mihai Marinescu[4], Viorel Panaitescu[4]*

Abstract: In Romania the cases of anthropological forensic exams performed in order to estimate the age of subadults include mostly people with an extremely low socioeconomic status, frequently homeless people, whose parents did not have a certified copy of the medical birth certificate issued. Given that the population for which these exams are done is relatively homogeneous in terms of socio-economic and ethnic factors, the purpose of this paper is to identify the utility of the isolated anthropometric exam in order to establish age. The study was conducted on a total of 181 forensic cases which required an anthropological forensic exam so as to estimate the age in subadult individuals (under 13 years old). The cases were selected from among those where one knew the exact age with a reasonable degree of certainty. The variables included in the study were: sex, weight, head circumference, teeth, maximum arm span, arm length, forearm length, left hand length, chest circumference, thigh length, calf length. For each parameter, a linear regression equation for males and respectively females was created. The adjusted R^2 values for the equations created based on the above parameters were in all cases over 0.5; the highest values were obtained, in the case of both sexes, for the waist and the maximum arm span. Conclusions: Based on the regression equations obtained for age estimation based on general anthropometric parameters one can create, either in Excel or in programming languages, algorithms that may, in many cases, allow the age identification with a few weeks as a margin of error. The best results in terms of age estimation were obtained using a combined method. However, even using a small number of markers one can reach a reasonable age estimation (+/-6 months), which is sufficient to correlate the anthropological data with those of the medical birth certificate.

Key Words: forensic anthropology, age estimation, regressive analysis of anthropometric parameters.

The subadults' age estimation is usually based on the analysis of the growth and development processes, while in adults it is based on skeletal and dental degeneration processes. The growth and development processes are much more homogeneous within the population, which makes them have a higher degree of certainty than those based on osteo-dental degeneration processes, which have been proved to have the tendency to overestimate young people's age and underestimate older people's age [1].

The anthropological examination performed in Romania in order to establish age consists of the anthropometric, radiologic and dentistry exams.

- The anthropometric exam measures weight, waist, the circumference of the head, thorax and abdomen, limb segment length, and calculates the cranial index. The age estimation is done by comparing the results with nomograms from pediatric textbooks.

1) "Carol Davila" University of Medicine and Pharmacy, Dept of Physiology, Bucharest, Romania
** Corresponding author: Tel. 0040722562656, Email: antoaneta.punga@yahoo.com*
2) "Mina Minovici" National Institute of Legal Medicine, Dept. of Forensic Anthropology Bucharest, Romania
3) Buzau County Hospital, Dept. of Legal Medicine, Buzau, Romania
4) "Carol Davila" University of Medicine and Pharmacy, Faculty of Medicine, Dept of Forensic Pathology Bucharest, Romania

The anthropological exam results may be approximate due to individual variability, malnutrition and various chronic diseases that would delay the height and weight development. Thus, it is associated with dentistry and radiological exams [2].

- The dentistry exam records erupted teeth or those about to erupt and their pathological aspects.
- The radiological exam is performed after the previous steps and points to the ossification centers and the diaphysial-epiphyseal union.

These methods allow estimating the ages of 14, 16 and 18, which raises the question of the discernment of the minors involved in committing a criminal offense. Specifying the age of 18 is absolutely necessary for people with refugee status. The age assessment is done within 6 months limits (eg. 6 years- 6½ years and 6½- 7 years) [3].

In Romania the cases of anthropological forensic analyses performed in order to estimate the age of subadults include mostly people with an extremely low socioeconomic status, frequently homeless people, whose parents did not have a certified copy of medical birth certificate issued. If the certificate is not claimed within the first year of life, the only way it can be obtained afterwards is through a court order, which in turn requires an anthropological exam. This is mainly aimed at correlating the biological age with the one that is suggested by the medical birth certificate, which is received by the parents at birth, in the maternity ward. Given that the population for which these analyses are done is relatively homogeneous in terms of socio-economic and ethnic factors, the purpose of this paper is to identify the utility of the isolated anthropometric exam in order to establish age.

MATERIALS AND METHODS

The study was conducted on 181 forensic cases which required an anthropological forensic exam so as to estimate the age in subadult individuals (under 13 years old). The cases were selected from among those where one knew the exact age with a reasonable degree of certainty, by using the following inclusion criteria:

- Subjects had the medical birth certificate. According to the Romanian legislation, if the birth parents do not register the birth during the first year of the child's life, the only way he/she can get a certified copy of the medical birth certificate is by court order. In order to obtain this, it is necessary to conduct an anthropological forensic exam to estimate the child's age and see if the age based on the birth date from the medical birth certificate corresponds to the estimated age according to the anthropological examination.
- The estimated age according to the anthropological exam corresponds to the estimated age based on the medical birth certificate.

Over a period of 3 years a total of 185 cases were selected applying the two inclusion criteria. The variables included in the study were: sex, weight, head circumference, cephalic index, teeth, maximum arm span, arm length, forearm length, left hand length, abdominal circumference, thoracic circumference, thigh length, leg length.

The age according to the medical birth certificate was quantified by subtracting the date from the medical birth certificate from the date of the anthropological forensic examination. The values obtained were then converted to numeric variables, one day of the year representing 0.002739% of the period of a year, and 1% from the value of a year corresponding to a number of 3.65 days.

The cases were statistically analyzed with the SPSS software. The statistical analysis techniques used were linear regression analysis and the polynomial regression analysis of the stepwise type, establishing a minimum value of 0.5 for the adjusted R^2 in order to include the equation in the analysis. A value of p less than 0.05 was considered statistically significant.

RESULTS

The study included 93 females (51,4%) and 88 males (48,6%).

The age distribution according to the medical birth certificate is relatively uniform, with a peak around the age of 8-9 years old and a minimum at the age of under 1 year old, when such exams were carried out only in exceptional circumstances. The average age is 6.59+/-3.5 years. The level of correlation between the approximate and exact age is extremely strong, the Pearson test having a value of 0.993, significant at p 1.9044E-166.

The linear regression equations by gender obtained in the study are shown in Tables 1 (males) and 2 (females).

By introducing all of the variables analysed above in a regressive matrix and using the stepwise method to eliminate variables, the following polynomial regression equations were obtained:

- For males: Age = 0.115*Waist(cm)+0.432*Left hand length-12.032, which has an adjusted R^2 of 0.923
- For females: Age = 0.058*Waist(cm)+0.101* Maximum arm span (cm) -0.128* Head circumference (cm) -3.634, which has an adjusted R^2 of 0.950.

Analyzing the estimation done with the help of the regression equations, in relation to the exact age one can notice that the applied algorithm is practically superimposed over the loess line of the scatter-dot approximated age through regression versus age as per the certificate between 2 and 10 years. Therefore, at least within this range, the equations which were obtained can predict with great accuracy the real values of the subjects' age.

Table 1. Regression equations, males

Parameter*)	Equation	Adjusted R^2
Waist	Age=0,166*Waist(cm)-12,281	0,917
Weight	Age =0,306*Weight(kg)-0,036	0,741
Head circumference	Age =1,003 *Head circumference(cm)-43,879	0,580
Maximum arm span	Age=0,149*Maximum arm span (cm)-10,286	0,909
Left arm length	Age =0,583 Left arm length (cm)-7,611	0,797
Left forearm length	Age=0,820*Left forearm length(cm)-8,608	0,837
Left hand length	Age =1,330*Left hand length(cm)-10,583	0,892
Thigh length	Age =0,450 *Thigh length(cm)-7,019	0,744
Calf length	Age =0,473 *Calf length(cm)-5,893	0,860
Thoracic circumference	Age =0,386 *Thoracic circumference(cm)-16,233	0,660

*) the cephalic index and abdominal circumference parameters have not allowed the construction of regression equations with adjusted R2 values above 0.5 and were excluded from the analysis.

Table 2. Regression equations, females

Parameter*)	Equation	Adjusted R^2
Waist	Age =0,148*Waist(cm)-10,163	0,932
Weight	Age =0,321*Weight(kg)-0,143	0,792
Head circumference	Age =0,797 *Head circumference(cm)-32,835	0,533
Maximum arm span	Age =0,137*Maximum arm span (cm)-8,856	0,943
Left arm length	Age =0,567* Left arm length(cm)-6,784	0,873
Left forearm length	Age=0,774* Left forearm length(cm)-7,377	0,862
Left hand length	Age =1,290*Left hand length(cm)-9,791	0,904
Thigh length	Age =0,413 *Thigh length(cm)-5,866	0,817
Calf length	Age =0,501 *Calf length(cm)-6,365	0,910
Thoracic circumference	Age =0,319 *Thoracic circumference(cm)-11,914	0,691

*) the cephalic index and abdominal circumference parameters have not allowed the construction of regression equations with adjusted R2 values above 0.5 and were excluded from the analysis.

The equations can be entered in an Excel sheet and can allow the automatic calculation of the estimated age with an error small enough to be used in practice, in the case of children with a consistent body development. A randomized sample selected by the SPSS is shown in Table 3. The case of a male person born as per the medical birth certificate on 20.07.2002 and examined on 15.12.2011 (9 years 5 months).

The estimated value is of 9.43; the estimated error as per the exact date of birth is about 10 days.

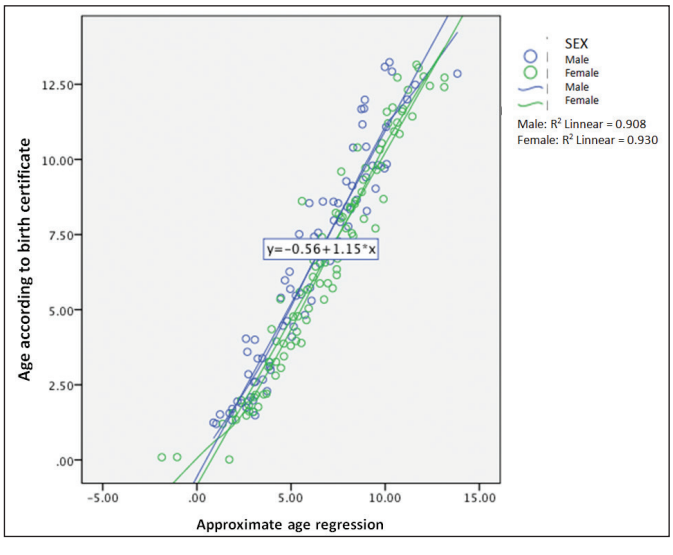

Figure 1. Age estimation based on a regression matrix, compared to the subjects' real age.

DISCUSSIONS

In Romania, the age estimation for a living person is performed on a working protocol derived from the rules developed by the Study Group for Forensic Age Diagnostics. According to this, the investigation methods to be used are:

- physical examination to determine some anthropometric measures (weight, height, constitutional type, sexual maturation, identification of diseases that would cause the abnormal development of the body);

Table 3. Model calculation

Parameter	Input	Estimation	
Waist	134	9,963	
Weight	28	8,532	
Head circumference	50,6	6,8728	
Maximum arm span	138	10,276	
Left arm length	31,5	11,0685	
Left forearm length	23	10,252	
Left hand length	15	9,367	
Thigh length	38,5	10,306	
Calf length	32,5	9,4795	
Thoracic circumference	62	7,699	
Polynomial regression equation		9,858	***Estimation***
	Sum	103,6738	9,424890909

• radiological examination of the left hand;

• dental examination to determine dental status and an odontogram;

• if the skeletal development of the hand is complete, a radiological examination of the clavicle is performed (or alternatively a CT examination).

The above methods should be used together to increase the identification accuracy [4].

When a rough estimate of the age is necessary so as to link it with the one from the medical birth certificate, an analysis performed with the regression equations presented above is extremely useful not only for age group framing but also for a fairly accurate estimation of the real (chronological) age. Although the analysis of the ossification centers of the left hand and the dental examination are extremely useful in limiting the variability range and subsequently the measurement error, they have two disadvantages: the cost and the fact that they require X-rays, known to have more severe effects in children than in adults [5-13].

The population considered for the study is quite homogeneous - most are malnourished people with a low socioeconomic status, who often did not even receive minimal medical care. As such, the anthropometric parameters taken into account resulted in regression equations that would model the study population very well.

Study limits

1. The study was conducted strictly on anthropological forensic exams meant to estimate the age as part of civil matters. Hence the study results are not reproducible in the entire population of Romania. However, the calculation methodology presented in the discussion chapter is intended to be used in order to determine the age in the subpopulation of interest, an objective which is fully achieved.

2. Although some of the applied regression equations lead to results which are relatively remote from the average, if analyzed together the differences seem to diminish considerably, so that the combined use allows an accurate enough estimation of age values.

3. Growth between 0-12 years is not linear, which might suggest the existence of some limits in the applied regression equations (which are linear). However, at least in the range of 2-10 years old the regression line is very close to the loess line, suggesting that at least for this estimated interval, their use has certain advantages.

CONCLUSIONS

1. Based on the regression equations obtained for age estimation from general anthropometric parameters one can create algorithms either in Excel or programming languages which may allow, in many cases, to identify the age with a margin of error of a few weeks.

2. The best results in terms of age estimation are obtained using a combined method. However, even using a small number of markers one can make a reasonable age estimation (+/-6 months), which is enough in order to correlate anthropological data with those from the medical birth certificate.

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