Studies in Spanish Children to Calculate Bone Age and Predict Adult Height: Forty Years of Own Investigation

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Abstract

Introduction: The authors make a historical review of his research over 40 years dedicated to the study of bone maturation in 5225 healthy children Spanish and Swiss. Bone ages are obtained using their own methodology and it lets you know whether the bone age of the child is normal, early or delayed, significantly or not. Numerical formulas are obtained from measurements of the carpal bones, metacarpals, phalanges and tarsal region, by radiographs of the left hand and foot. Lately, the authors have applied their methodology to all annual radiological cuts made since the child's birth through 20 years of 160 Spanish children.

Materials & methods: The longitudinal case series studied includes 160 Aragon healthy children of both genders (Andrea Prader Center), aged between six months and 20 years old, and studied year after year. We obtained measurements (maximum diameters in mm) of each bone carpal and metacarpal and phalanges of the fingers I, III and V of the left hand. The radiological study has been conducted at Miguel Servet Hospital in Zaragoza. For the statistic work we have used the "Statistix" statistics Packaged, as well as Excel program for the confection of the equation tables.

Results: In this study we applied in our children, indexes: Ebrí metacarpal-palangeal, carpal and carpometacarpal-palangeal Ebrí and called IVO (Index Valuation Ossification) derived of each respective index, serving for very accurate estimate of bone age. The results can bring to a Gaussian shape equivalences, which gives us directly bone age of the child, and if it is late or early or not significant.

Conclusions: The use by the pediatrician and researcher of Ebrí equations for calculating bone age, allow very accurately assess bone maturation from one child to study. With the use of the software we offer, the results are obtained directly, without being required to pocket calculator. With the software, predicting adult height of children is also obtained. With our methodology we can dispense the use of American method of Greulich and Pyle, and English Tanner Whitehouse, at least in children of Hispanic origin. The gold standard of our contribution is that this basic methodology can be applied to different populations in order to create international standards series. Comparative studies between them can be made by the researchers. The possibilities in this regard are many.

Keywords: Ebrí bone ages carpal; Metacarpal; Carpometacarpal; Predictions of adult height Ebrí; Longitudinal and transversal series of Spanish healthy children

Introduction

Bone maturation is the best overall indicator of biological development we have in the human species. Bone age expresses this maturation process, requiring simple radiological studies for determining, with the left hand radiograph in the opinion of most authors, the preferred anatomical region [1].

To calculate bone age, morphological and numerical methods may be used. Our numerical methods have an advantage over morphological because they have greater accuracy, eliminating asynchrony and the subjectivity of the doctor when he chooses the model radiography in the Atlas of Greulich and Pyle [2].

Our original method of studying bone age in the carpus and the tarsus in a large cross number of children has been referenced extensively in the literature. A Spanish population of 5225 healthy children was studied by the method IVO carpal and 540 by the method IVO tarsal. 96 fetuses of both sexes in tarsal region were also studied. This research was published over several years [3-16].

Recently we have studied a longitudinal series of Spanish children to calculate bone age of these children and predict adult height [17-19]. The casuistry of this study comes from the General Survey Anthropometric Aragones “Andrea Prader Somatometric and Radiological Study” [20] promoted by the Endocrinology Unit of Miguel Servet Hospital of Zaragoza. It was authorized by the Research Committee and officially endorsed by the “Direction General of Aragon” in Spain. The 1956 Graffar [21] poll was used for the social economical classification of children.

Material and Methods

The authors have applied their methodology to all annual radiological cuts made since the child's birth through 20 years of Spanish children. The total sample of the study has been 160 healthy children (73 male y 87 female). These children were radiographed in
his left hand on his birthday at Miguel Servet Hospital in Zaragoza (Spain).

In each radiograph of left hand we measured the epiphysis cores of the metacarpal and phalanges, and the carpals bones, including those of the radius and ulna bones. The maximum core distances were measured with a nonius that optimally expresses the measurements done, which have been the basis to elaborate the IMF (metacarpalfalangeal index) ICMF (carpometacarpalfalangeal index) and IC (Carpal index) These indexes are expressed in millimeters (mm), and its result is the sum of the maximum diameters of the carpal bones, epiphysis cores of the metacarpal and phalanges bones: I, III, y V, as well as the ulna and radius distal epiphysis, with a total of 21 cores for ICMF index; 13 for IMF index; and 11 for IC index. Figures 1 and 2 show the maximum distances of the ossifying cores to be measured. Once the sum of the existing cores at the moment of radiography measurement is obtained, it is divided by 13 (IMF index), by 11 (IC index) and for 21 (ICMF index) for index numerical simplification purposes (a fixed number in all cases, although at the time of measurement not all cores were available).

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Equations:

**Males**

\[
IVOIC = 62.3 + 13.2 \times IC - 0.05 \times CA \\
IVOIMF = 41.3 + 17.8 \times IMF - 0.04 \times CA \\
IVOICMF = 49.4 + 17.5 \times ICMF - 0.05 \times CA
\]

**Female**

\[
IVOIC = 41.7 + 12.2 \times IC - 0.04 \times CA \\
IVOIMF = 24.8 + 15.5 \times IMF - 0.03 \times CA \\
IVOICMF = 30 + 15.2 \times ICMF - 0.04 \times CA
\]
Results

We offer the equations for the IVOS derived of each index in children of both sexes. The chronological age (CA) is expressed in days and the various indexes: IC, IMF, and ICMF in mm.

To simplify the work of practical, we performed a computer program, so that introducing the measures of each bone radiography, date of birth of the child, their size and their parents, the program gives directly his bone age and also predicting adult height. It has a manual easy to use. We expose as an example, the case of a twelve and a half years with a delay in bone age, and his prediction of adult height (Figure 4). The software will be required to authors via email. They will send the software for free also by email.
The authors had conducted a longitudinal study in Swiss child [22-23], however there was a gap in own longitudinal studies regarding the calculation of bone age and predicted adult height, in Spanish-speaking countries and Anglo. We adjust our methodology to the Swiss population (36 healthy children between 10 and 19 years in the case of males, and 10 and 18 years in the case of females were studied) and this population was compared with the Spanish population [24]. In this study we applied in our children, indexes: Ebrí metacarpalfalangeal, carpal and carpometacarpalfalangeal Ebrí and called IVOS derived of each respective index. With our methodology we can dispense the use of American method of Greulich and Pyle, and English Tanner Whitehouse, at least in children of Hispanic origin, since these methods distortive calculate bone age when applied to populations they are not Anglo-Saxons. Comparisons between our method and the Greulich-Pyle [2] and Tanner [25] were made , demonstrating its validity. We have studied equivalence between our method and commented [26-29].

This methodology can be applied by the pediatrician in their daily practice, in order to diagnose normal, early or delayed bone maturation from one child to study. With the use of the software we offer, the results are obtained directly, without being required to pocket calculator. With the software, predicting adult height of children is also obtained. With our methodology we can dispense the use of American method of Greulich and Pyle, and English Tanner Whitehouse, at least in children of Hispanic origin. The gold standard of our contribution is that this basic methodology can be applied to different populations. The possibilities in this regard are many.

Conclusions

The use by the pediatrician and researcher of Ebrí equations for calculating bone age, allow very accurately assess bone maturation from one child to study. With the use of the software we offer, the results are obtained directly, without being required to pocket calculator. With the software, predicting adult height of children is also obtained. With our methodology we can dispense the use of American method of Greulich and Pyle, and English Tanner Whitehouse, at least in children of Hispanic origin. The gold standard of our contribution is that this basic methodology can be applied to different populations in order to create international standards series. Comparative studies between them can be made by the researchers. The possibilities in this regard are many.
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