Scientific Paper

# B-230 Skeletal maturity assessment web application

**S. D. Bolboaca** (Cluj Napoca/RO)

**Topic:** Computer Applications

# Purpose

In pediatrics, skeletal maturity, also called bone age, an expression of the biological maturity of a child, is an important quantitative measure for the clinical diagnosis of endocrinological problems and growth disorders. Skeletal maturity may be assessed by analysis of the ossification centers of the hand, foot, knee, elbow or pelvis, though the most frequently used is a hand and wrist radiography.

The bone age evaluation is achieved by assessing the ossification and maturation of the epiphysis of the hands and wrists comparing them with standard radiographs and standard descriptions. There are al least two methods of evaluating wrist and hand bone age, represented by the Tanner-Whitehouse [1] method and the Greulich-Pyle method [2].

To be noted that the Greulich-Pyle method and the Tanner-Whitehouse method do not give equivalent bone ages [3].

The Tanner-Whitehouse method is most frequently applied for skeletal maturity in Romania. The Tanner-Whitehouse method [1] involves the examination of 20 bones of the hand and wrist and the assignment of a stage to each bone depending on the attainment of clearly described bone-specific maturity indicators. In accordance with the Tanner-Whitehouse tables, every bone stage has a numerical score, and the scores are summed for each individual to give a maturity score on a scale of 0 to 1000. Using the Tanner-Whitehouse tables, maturity scores are converted to bone age for each individual and the relative maturation can be assessed by comparing the bone age to the individuals chronological age.

Estimating a childs bone age using the Tanner-Whitehouse method is time-consuming (between 8 and 10 minutes for each patient). In recent years, the increasing speed in computer sciences and decrease of their cost has given us the opportunity to create and use computerized bone age estimation system.

In order to help pediatric radiologists we developed, based on Tanner-Whitehouse standards, a web client-server application that allows managing most of the activities related to skeletal maturity analysis.

# Methods and Materials

In order to develop an application which may be used on a stand-alone computer as well as on a web server we choose to work with Apache [http://www.apache.org] web server, PHP [http://www.php.net] client/server programming language, MySQL [http://www.mysql.com] database server, JavaScript [http://javascript-reference.info] client programming language and a web browser like Microsoft Internet Explorer [http:www.microsoft.com] as client execution program environment that allow to create powerful and fast database web site applications with computational modules. Apache is the most popular and full featured web server and is generally considered more stable than other servers. It is usually installed on UNIX and Linux systems, but is also available for Microsoft Windows platform. PHP, which started as a small project to improve a home page and grew into one of the worlds most powerful server-side script, has the unique distinction of being an open-source server-side scripting language that can be integrated in HTML [http://www.webreference.com].

Databases applications have been around for over 30 years, and many have been deployed using network technology long before the web existed. In order to develop an interactive web application we choose to work with MySQL, a perfect database management system for storing and sharing information directly from a website.

JavaScript programming language was used in order to create the computational part of the program. We chose JavaScript language in order to create this part of the application because it is a simple programming language that can be integrated into HTML documents. On the other hand, Java Script programming language allows interactivity with the users and may be especially used in order to create online calculators.

# Results

Using PHP and MySQL, a program that makes possible an interactive proceeding for the computer-assisted bone age assessment was developed. The program can run on a stand-alone computer or on a web server. The computer requires the prior installation of a PHP Triad [http://sourceforge.net/projects/phptriad] program, program which can be downloaded freely from the Internet and an HTML 4.0 compatible web browser (like Microsoft Internet Explorer, Netscape). The program is also hosted on the educational network of Technical University of Cluj-Napoca, on a FreeBSD (UNIX based) server. The server has also installed an Apache web server (1.3.27 software version), a MySQL database server (3.23.52) and PHP modules (5.0). The application has a friendly interface [http://academicdirect.ro/virtual_library/medical_informatics/bone_age/v1.2] and can be used by any radiologist who knows how to use a web browser. We can say that the program has two important segments. The first is concerned with the input of the patients data by the radiologist
[http://academicdirect.ro/virtual_library/medical_informatics/bone_age/v1.2/patient.php?server=localhost&option=insert]
and compute maturity score
[http://academicdirect.ro/virtual_library/medical_informatics/bone_age/v1.2/tw2.php?server=localhost&PersonalNo=3850827170027].
The first part of the program has some fields where the user may choose the information from a drop list (e.g. sex, place of residence, place of birth). We have established these options in order to reduce the time needed to fill in these fields.

In order to compute a patients bone age, first it is necessary to insert the patient information data into the database (Movie 1 *Links to file type VIDEO/AVI not available in PDF Version) and after that to select the required patient. The patient is selected from a drop list where the user can see the patients name, and personal number.

After the user has selected a patient, a new window is open and the radiologist, using some radio buttons, must to choose a maturity stage for every one of the 20 bones used in Tanner-Whitehouse method (Movie 2 *Links to file type VIDEO/AVI not available in PDF Version).
For every bone the program allows to choose only one stage. At the end of the page, we can see a table with the patient information data. It is also necessary to fill in this table other information regarding the patient, such as date of consultation, diagnosis, weight and height. This information will be saved in the 'consultations' table from the 'TW2' database.

The second part of the program allows users to interrogate the databases in order to find a consultation report (Movie 3 *Links to file type VIDEO/AVI not available in PDF Version)[http://academicdirect.ro/virtual_library/medical_informatics/bone_age/v1.2/info_n.php?server=localhost&option=consultation]
or a general report. The consultation reports may be printed or saved in order to send the consultation results to the specialist or the family doctor.

**Discussion**

There are many computer programs all over the world, most of them using the pattern recognition [4] with algorithms based on the Tanner-Whitehouse methods [5, 6] or using some algorithms based on carpal bones score [7]. All these programs are developed in countries where the radiological devices have the possibility to store digital images

because the pattern recognition is supposed to work with high quality right-hand radiographs in order to compare correctly the particular image with the standard one. Most of the radiological devices used in Pediatric Hospitals in Romania do not have the potential of storing digital images and the assessment of skeletal maturity is performed using manually classic X-rays assessment.

Our project was intended to serve the more specialized needs of pediatric radiologists who work with less sophisticated radiological devices and help them assess easily the childs bone age. The aim of the project was to allow the pediatric radiologists to introduce some general data of the patient into a database, to compute the bone age for the child and to perform interrogations on database in order to obtain reports with the actual and previous examinations.

The advantages of the application are represented by:

[*] The time needed to obtain final bone age is significantly reduced to 3-5 minutes in comparison with the paper evaluation when the radiologist needed 8-10 minutes

[*] The program allows a reduction of computational errors in both score and bone age that often occurs using paper as a support for evaluation

[*] All the data are saving in a database and can be interrogated any time in order to retrieve previous consultations data or in order to perform research.

The performance of the computerized procedure depends on the user interaction and the radiologist skill to use a Web browser. On the other hand, the program performance also depends on the radiologists experience, which is essential.

The application can be used by residents radiology undergoing the pediatric radiology training module and of course by the pediatric radiologists in every work.

The program may be extended in order to compute RUS bone maturity score this score uses the radius, ulna and finger bones, and/or Carpal bone maturity score using only carpal bones. An automated system of bone age maturity evaluation applied on the base of the Tanner-Whitehouse method may also be developed, but for this is necessary first to have the proper radiological devices in the pediatric hospitals.

# Conclusion

With the help of client-server computer-assisted software an application for bone age assessment of children and young people was developed based on Tanner-Whitehouse method. The application has a friendly interface and offers a nice environment for skeletal maturity assessments. The program allows a significant reduction of the time needed to obtain final bone age and a reduction of computational errors in both score and bone age, errors that often occur when radiologists used paper as a support for evaluation and storage of patients information as well as patient consultations data.

The application is also available as a Web application that offers some advantages. If, for example we consult a patient into a hospital in Cluj, who has previously been consulted in another hospital in Romania and these two hospital register the patient data into the same TW2 server database it will be very easy to find the previous consultations data.

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# The Authors

**Sorana BOLBOACA**[1] MD (Cluj-Napoca/Ro). **Lorentz JÄNTSCHI**[2] PHD, (Cluj-Napoca/Ro). **Carmencita DENES**[3], MD (Cluj-Napoca/Ro). **Andrei ACHIMAS CADARIU**[1] MD, PHD (Cluj-Napoca/Ro).

[1] Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania
[2] Technical University, Cluj-Napoca, Romania
[3] Axente Iancu Pediatric Clinical Hospital, Cluj-Napoca, Romania

Application web site:
http://academicdirect.ro/virtual_library/medical_informatics/bone_age/v1.2/

# Keywords

**MeSH-Keywords:**

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Age Determination by Skeleton

**Own Keywords:**

Tanner-Whitehouse method, Online application

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