Setting Up an Automated System for Evaluation of Bone Age

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Abstract. The "Tanner-Whitehouse 2" method is the most popular in evaluating skeletal maturation, but this method has some inherent weak points. We therefore developed the new system to automatically evaluate the skeletal maturation of Japanese children by means of a personal computer. The subjects of this study were 318 healthy Japanese boys and 199 girls ranging from 2 to 15 years of age. The bone age was calculated by multiple regression analysis with parameters for the epiphysis and metaphysis. Successful automatic evaluation was about 80-90% on each phalanx. There was a significant correlation between chronological age and the ratio of epiphyseal width to metaphyseal width. The system developed in this study was useful for evaluating the skeletal maturation.

Key words: Tanner-Whitehouse 2, Bone age, Epiphysis, Metaphysis, Personal computer

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OBJECTIVE evaluation of skeletal maturation is an important research theme in the medical, dental, anthropological and physical fields. The "Tanner-Whitehouse 2" method [1] is the most popular in evaluating skeletal maturation, but this method has some inherent weak points. For instance, the use of this method consumes much time and requires that the operator has adequate training to master it. In addition, the expressions in the manual appear vague, and differences between Caucasians and Japanese in figures and timing are obvious. We therefore developed the new system to automatically evaluate the skeletal maturation of Japanese children by means of a personal computer (Fig. 1).

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Fig. 1. Automated system for evaluation of bone age.
Materials and Methods

The automatic measurements of epiphyseal, metaphyseal and overlapping width were tried on the distal, middle and proximal phalanges of the third finger (Fig. 2). By programming an algorithm, we were able to extract the digital image of the distal, middle and proximal phalanges of the third finger (DP3, MP3 and PP3, respectively) from the computerized scanning of the hand-wrist X-ray.

![Figure 2](image1.png)

**Fig. 2.** Measurements of epiphysis and metaphysis. a+b, metaphyseal width; c+d, epiphyseal width; e+f, overlapping width.

![Figure 3](image2.png)

**Fig. 3.** Input image (300 dpi, 8-bit gray scale) from the computed scanning of the hand-wrist X-ray.

![Figure 4](image3.png)

**Fig. 4.** Algorithm for extraction of ROI (region of interest). a, extraction of 3rd phalanges; b, correction of inclination; c, extraction of each phalanx.
(Figs. 3, 4). Furthermore, we standardized the long axis and set parameters for automatic evaluation of the epiphysis and metaphysis of the phalanges (Fig. 5).

The subjects of this study were 318 healthy Japanese boys and 199 girls ranging from 2 to 15 years of age. The bone age was calculated by multiple regression analysis with parameters for the epiphysis and metaphysis (Fig. 6).

**Results**

Successful automatic evaluation was about 80–90% on each phalanx (Table 1). There was a significant correlation between chronological age and the ratio of epiphyseal width to metaphyseal width (Table 2).

**Fig. 5.** Algorithm for automated measurements of parameters. a, extracted image; b, correction of contrast; c, extraction of outline; d, measurements of parameters.

**Fig. 6.** IBM-PC (Windows 95/98) application for bone age evaluation.
Discussion

The system developed in this study was useful for evaluating the skeletal maturation. We believe that it is necessary to improve existing methods for accurate extraction of digital images and for correct evaluation of the radius. We shall also compare the bone age obtained with our system and the TW2 method for objective evaluation of results. Furthermore, we are planning to program the formula for the prediction of the final height in this system.

Reference