Racial and sex differences in timing of the cervical vertebrae maturation stages

Mona A. Montasser,[a] Grace Viana,[b] and Carla A. Evans[b]
Mansoura, Egypt, and Chicago, Ill

Introduction: Our objective was to investigate skeletal maturation of female and male subjects from different racial groups by comparing the cervical vertebrae maturation (CVM) stages. **Methods:** The study included 3 racial groups: white, African American, and Hispanic subjects. Each group was subdivided into female and male. The age range of the subjects was between 7 and 18 years. The sample included 60 lateral cephalographs for each subgroup. Skeletal maturation of the cervical vertebrae was assessed according to a method that described 6 CVM stages. **Results:** Racial differences were evident in the mean ages of CVM stages 2, 3, 4, and 5 ($P = 0.002$; $P = 0.003$; $P = 0.001$; and $P = 0.001$, respectively) among females; among males, only stage 3 was different ($P = 0.001$). Sex differences in the mean ages of stages 1, 2, and 3 in Hispanic subjects ($P < 0.001$), and in stages 2 and 3 in African American subjects ($P = 0.019$ and $P < 0.001$) and white subjects ($P = 0.004$ and $P < 0.001$) were detected. **Conclusions:** In both sexes, racial differences were not apparent between whites and African Americans, but differences were evident between Hispanics vs both whites and African Americans. Sex differences were apparent between the sexes in each of the 3 ethnic groups in CVM stages 2 and 3. No sex differences were detected in stages 4, 5, or 6 in any of the 3 racial groups. It is recommended to consider racial and sex differences when using the CVM stage as a skeletal maturation indicator. (Am J Orthod Dentofacial Orthop 2017;151:744-9)

Growth and development of humans are not uniform. There are periods of acceleration and deceleration, including 2 skeletal growth spurts: juvenile growth spurt and pubertal growth spurt.[1] In a mixed longitudinal study of girls, Marshall and Tanner[2] noted that the sequence of stages of each of the several physical pubertal changes that combine to constitute puberty is fixed, but there is no consistent pattern that characterizes the interrelation pattern of appearance of the different maturation changes on an individual level. In alignment with this, a specific sequence of skeletal maturation of the cervical vertebrae was described as the cervical vertebrae maturation (CVM) stages in previous studies.[3,4]

Over the years, growth prediction including skeletal age assessment has been an integral part of orthodontic diagnosis and treatment planning. Skeletal age assessment is especially important since it is now commonly agreed that chronologic age and skeletal age do not always correlate.[5] Accordingly, if timing of orthodontic treatment were based only on chronologic age, it would be carried out over periods of highly varying growth rates. Skeletal maturational level could also be used to associate a patient's maturational stage with chronologic age; indicating whether development is average, advanced, or delayed.[6] Assessment of skeletal maturation usually is based on bone ossification or morphologic bone changes of certain skeletal maturation indicators. CVM staging is a method commonly used in orthodontic clinics.[7-11]

Although there is evidence of differences in the age and pattern of skeletal maturation between different racial groups, the data are scarce, and the topic is still open for study.[12-16]

Our objective in this study was to investigate the skeletal maturation of female and male subjects from different racial groups by comparing the CVM stages.

MATERIAL AND METHODS

This was a retrospective cross-sectional study that included 3 major groups according to race: African Americans, Hispanics, and whites of European descent.

[a]Orthodontic Department, Faculty of Dentistry, Mansoura University, Mansoura, Egypt.
[b]Department of Orthodontics, University of Illinois at Chicago, Chicago, Ill.
All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Address correspondence to: Mona A. Montasser, Orthodontic Department, Faculty of Dentistry, Mansoura University, Mansoura 35516, Egypt; e-mail, mmontasser11@yahoo.com.
Submitted, May 2016; revised and accepted, September 2016.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2016.09.019

Each group was divided into 2 subgroups: females and males. The sample was collected from the orthodontic department of the University of Chicago.

The data were derived from lateral cephalographs that were part of the orthodontic pretreatment records for patients who attended the clinic seeking treatment. Only cephalographs that fulfilled the set inclusion criteria and were of high quality were selected. The included cephalographs showed at least CVM stage 2, 3, or 4. The medical history of the patients was reviewed to select cephalographs of children in good health with no head and neck abnormalities. Their ages ranged from 7 to 18 years at the start of treatment. The age was calculated by subtracting the patient's birth date from the date when the radiograph was taken.

A large number of lateral cephalographs were selected based on the inclusion criteria. The cephalographs were sorted according to race and sex into cephalographs for white females and males, African American females and males, and Hispanic females and males. The cephalographs of each of the 6 subgroups were kept in separate folders on the computer system, and the folders were named A, B, C, D, E, and F. Subjects' information was protected by replacing names with codes; the codes were the only reference to the subjects during assessment of the radiographs and in the data sheets prepared for the statistical analyses. Skeletal age assessment was done randomly for each subgroup, with the evaluator (M.A.M.) blinded regarding each subject's chronologic age, race, and sex. After the skeletal assessments, the data of each subgroup were separated and arranged according to the CVM stage. The radiographs were found to be distributed unevenly between the 6 CVM stages in each subgroup. The smallest number was in stage 1 followed by the radiographs assessed as stage 6. However, the final sample, divided by race and sex, included 60 lateral cephalographs in each of the 6 subgroups, where each of the 6 CVM stages in each subgroup was represented by 10 radiographs. We used the method described by Hassel and Farman[3] to assess skeletal maturation from the cervical vertebrae (CV). The method divides skeletal maturation into 6 stages (Fig) based on the morphology of the 3 CV—CV2, CV3, and CV4. Thus, their classification included CVM stage1 (initiation) in which the CV2, CV3, and CV4 inferior vertebral body borders are flat, and the superior vertebral borders are tapered posterior to anterior taking the shape of a trapezoid; CVM stage 2 (acceleration) with concavities developing in the lower borders of CV2 and CV3, whereas the lower border of CV4 vertebral body is still flat; CVM stage 3 (transition) characterized by distinct concavities in the lower borders of CV2 and CV3 and a developing concavity in the lower border of CV4, and in this stage CV3 and CV4 are rectangular; CVM stage 4 (deceleration) with distinct concavities in the lower borders of CV2, CV3, and CV4 clearly seen on the lateral cephalograph, and CV3 and CV4 are nearly square; CVM stage 5 (maturation) shows accentuated concavities of the inferior borders of CV2, CV3, and CV4, and CV3 and CV4 are distinctively square; and CVM stage 6 (completion) representing the maturation stage with deep concavities for the inferior vertebral body borders of CV2, CV3, and CV4, which are vertical rectangular.

Before the assessment of the whole x-ray sample, intraexaminer agreement of the assessment was statistically tested. Twenty randomly selected lateral cephalographs were assessed according to the method described and were then reassessed after a month by the same examiner. Evaluation of the intraexaminer agreement between repeated evaluations of the CVM stages was done by the Cohen kappa test. Descriptive statistics including means, standard deviations, and maximum and minimum values for chronologic age were calculated. A 3-way analysis of variance (ANOVA) was used to study the main effects: first- and second-order interactions among the 3 factors (race, sex, and CVM stage) on chronologic age followed by the post hoc Bonferroni multiple comparison test when needed. Independent-sample Student t tests were used to compare the mean differences in age on sex at each CVM stage and for each ethnicity.

The duration of the skeletal maturation was calculated as the difference between the ages at CVM stage 1 and at CVM stage 6. One-way ANOVA and independent Student t tests were used to detect possible racial effects on each sex and to compare the sexes in each racial group. respectively. For all calculations, $P \leq 0.05$ was set as the level of statistical significance. and statistical tests were carried out using SPSS Statistics for Windows (version 22.0; IBM, Armonk, NY).

RESULTS

For intraobserver agreement testing for the CVM stages, a kappa value of 0.90 strongly indicated intraevaluator reliability.

The results of the 3-way ANOVA showed no statistically significant interaction among the 3 factors (race, sex, and CVM stage); $F(10,324) = 0.539$, $P = 0.862$. The results of the ANOVA indicated a significant main effect of race, sex, and CVM stage; $F(2,324) = 15.884$; $F(1,324) = 44.929$, and $F(5,324) = 469.448$, respectively, $P < 0.001$. There was no statistically significant interaction between sex and race; $F(2,324) = 0.033$, $P = 0.967$. However, there were statistically significant interactions between sex and CVM stages, and race and CVM stages: