

Can Serial Height Measurements in Modern Children be Used to Develop and Update Skeletal Maturity Systems?

Kallie Chen¹, Alexander Wilder Richards², Ryan Furdock³, Raymond W Liu⁴

¹University Hospitals/Case Western University, ²Case Western Reserve University, ³University Hospitals Cleveland Medical Center, ⁴Rainbow Babies and Children's Hospital

INTRODUCTION: Skeletal maturity systems (SMS) are generally developed using historic longitudinal growth data. While recent studies suggest skeletal growth patterns differ in modern children, few modern datasets exist that include both serial height measurements and corresponding radiographs. This study compared the performance of a recalibrated knee-based SMS using modern data routinely collected in pediatric records.

METHODS: Using a retrospective database, we applied superimposed translation and rotation (SITAR) longitudinal growth modeling for patients with 1) ≥ 1 knee radiograph obtained during peripubertal years between 2014-2022 and 2) ≥ 5 height measurements spanning ≥ 5 years and extending to skeletal maturity. Using the SITAR model, age at 90% final height (FH) and corresponding years from 90% FH was calculated for each patient to provide true skeletal age for each radiograph. Chronological age at image, sex, and all seven modified Fels Knee (mFK) system parameters were obtained by a single rater for each radiograph after confirming inter- and intra-rater reliability (ICC 0.63-0.91). Generalized estimating equation procedures were used to estimate skeletal age and generate a recalibrated mFK system. To evaluate system performance, radiographs were divided into 80%/20% train/test subsets. Discrepancy in skeletal age estimates between the original and recalibrated mFK systems compared to the true skeletal age were evaluated using Wilcoxon signed rank testing ($p < 0.05$ as significant).

RESULTS: A total of 250 radiographs of 85 girls and 95 boys were included (Table). Mean ages at 90% FH for females and males were 11.2 and 12.7 years, respectively (Figure 1). Estimates using the recalibrated mFK system had a smaller mean absolute difference to true skeletal age (0.63 ± 0.66 years) compared to the original system (1.03 ± 0.78 years, $p < 0.001$), indicating better performance (Figure 2).

DISCUSSION AND CONCLUSION:

This novel methodology demonstrates that routinely recorded height data and corresponding radiographs can be used to develop or recalibrate new skeletal maturity systems in modern children.

Fig. 1: Longitudinal Growth Curves using Raw Data and SITAR Models

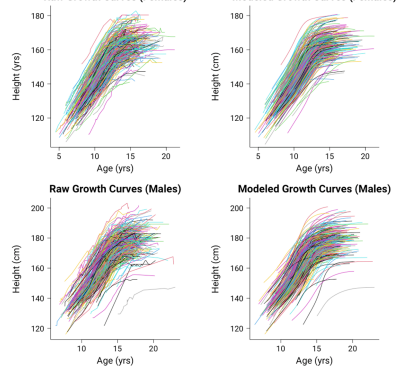


Fig. 2: Skeletal Age Estimates by System

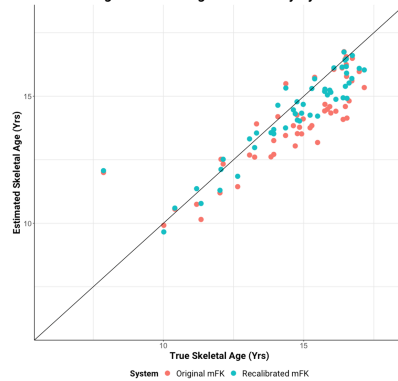


Table 1. Subject Demographics

	No. of Subjects	Mean Age (yr)	Age Range (yr)	No. of Radiographs	Radiographs per Subject
Train Dataset					
Boys	85	14.5 ± 2.1	8.8–17.8	118	1.4 ± 0.8
Girls	57	13.9 ± 2.0	6.8–16.5	82	1.4 ± 0.7
Total	142	14.2 ± 2.1	6.8–17.8	200	1.4 ± 0.8
Test Dataset					
Boys	10	16.1 ± 1.9	9.8–17.5	14	1.4 ± 0.7
Girls	28	13.9 ± 1.9	7.9–17.1	36	1.3 ± 0.5
Total	38	14.5 ± 2.1	7.9–17.5	50	1.3 ± 0.5