

A new model of adult height prediction validated in boys with constitutional delay of growth and puberty

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Background:

For children with retarded bone ages such as in constitutional delay of growth and puberty (CDGP) there are no specific methods to predict adult height based on bone age. The Bayley-Pinneau (BP) tend to overestimate adult height in CDGP.

Objective: To develop a specific adult height prediction model for teen-age boys with retarded bone ages >1 year.

Method:

Based on the adult heights of 68 males with CDGP a new height prediction model was calculated based on height measurements and bone age determinations at pubertal age. The new model was validated in an independent cohort of 32 boys with CDGP.

Characteristics of the study cohorts

| | Study A | Study B |
|------------------------------|-----------------------|-----------------------|
| At last observation | n=68 | n=32 |
| Age [y] | 22.5 (20.3-25.0) | 23.1 (22.5-24.5) |
| Height [cm] | 174.5 (170.9-178.2) | 172.0 (165.5-174.4) |
| Height-SDS | -0.68 (-1.24 - -0.12) | -1.04 (-2.00 - -0.64) |
| Presentation in pubertal age | | |
| Age [years] | 14.0 (13.2 - 15.1) | 15.4 (14.8 - 15.9) |
| Height [cm] | 149.2 (143.5-156.2) | 150.2 (146.3 -156.5) |
| Height [SDS] | -2.17 (-2.61 - -1.41) | -2.96 (-3.23 - -2.3) |
| Bone age [y] | 12.0 (11.0 - 12.5) | 12.5 (11.5 - 13.0) |
| Bone age delay [y] | 1.9 (1.6 - 2.5) | 2.7 (2.3 - 3.3) |
| Target height | | |
| Target height [cm] | 176.5 (174.1- 80.5) | 166.8 (164.1-170.2) |
| Target height [SDS] | -0.37 (-0.74 - 0.22) | -1.79 (-2.16 - -1.30) |

Statistic approach:

Achieved adult height was divided by the measured height at the recent bone age determination. For every bone age, the median of these calculated factors at the respective bone age was chosen. Afterwards, regression models (linear, exponential, potential, logarithmic and hyperbolic) were calculated based on the median factor to predict adult height of each bone age. The model with the highest r² was chosen.

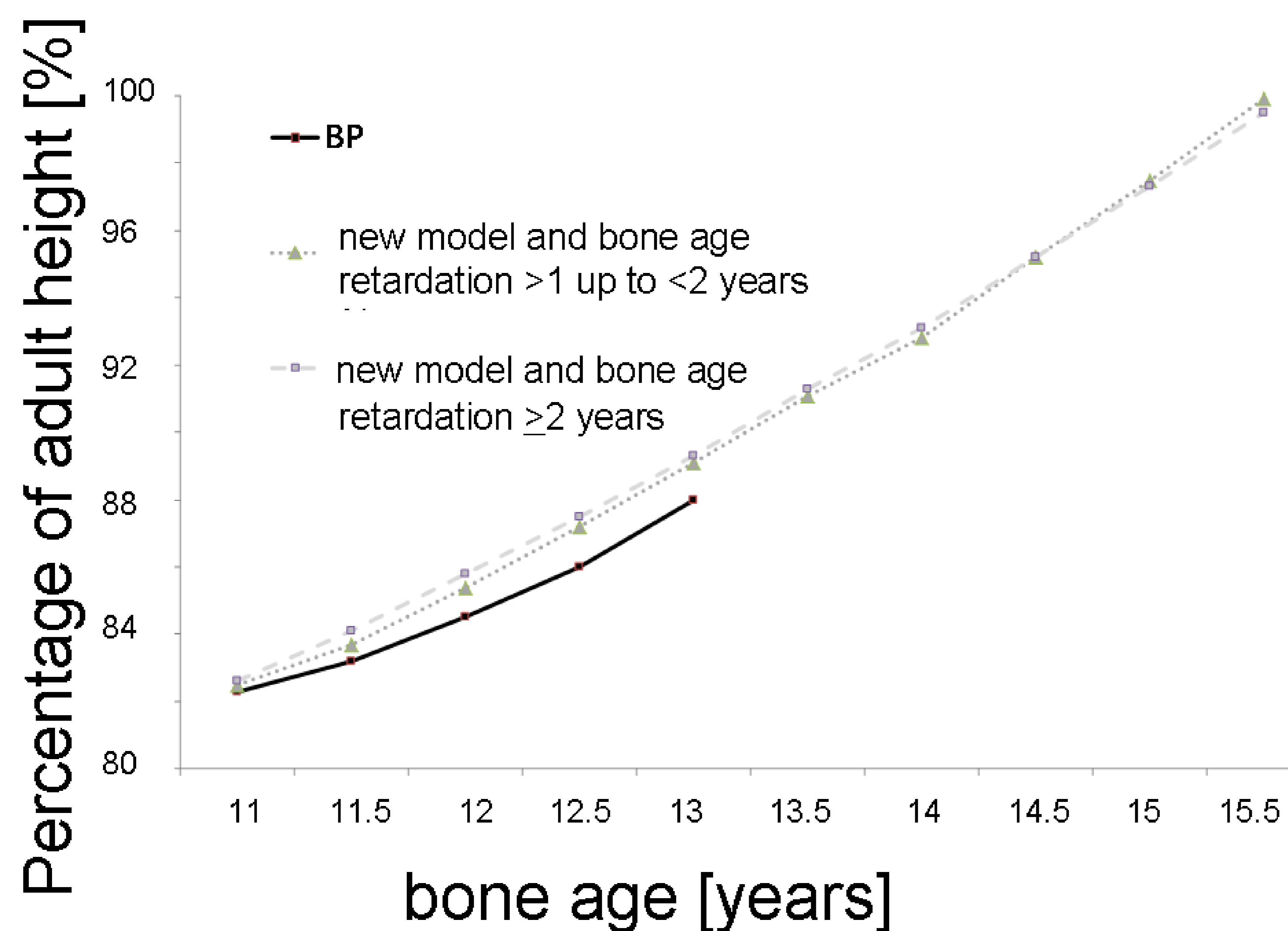
Results: The BP method led to an overestimation of adult height (median +1.2cm; p=0.282), which was more pronounced in boys with a bone age retardation ≥2 years (median +1.6cm; p=0.027). In the validation study, there was no significant difference between reached and predicted adult height based on the new model (p=0.196), while the BP model led to a significant overestimation of predicted adult height (median +4.1cm; p=0.009).

Coefficients to predict adult height in boys with retarded bone age >1 year

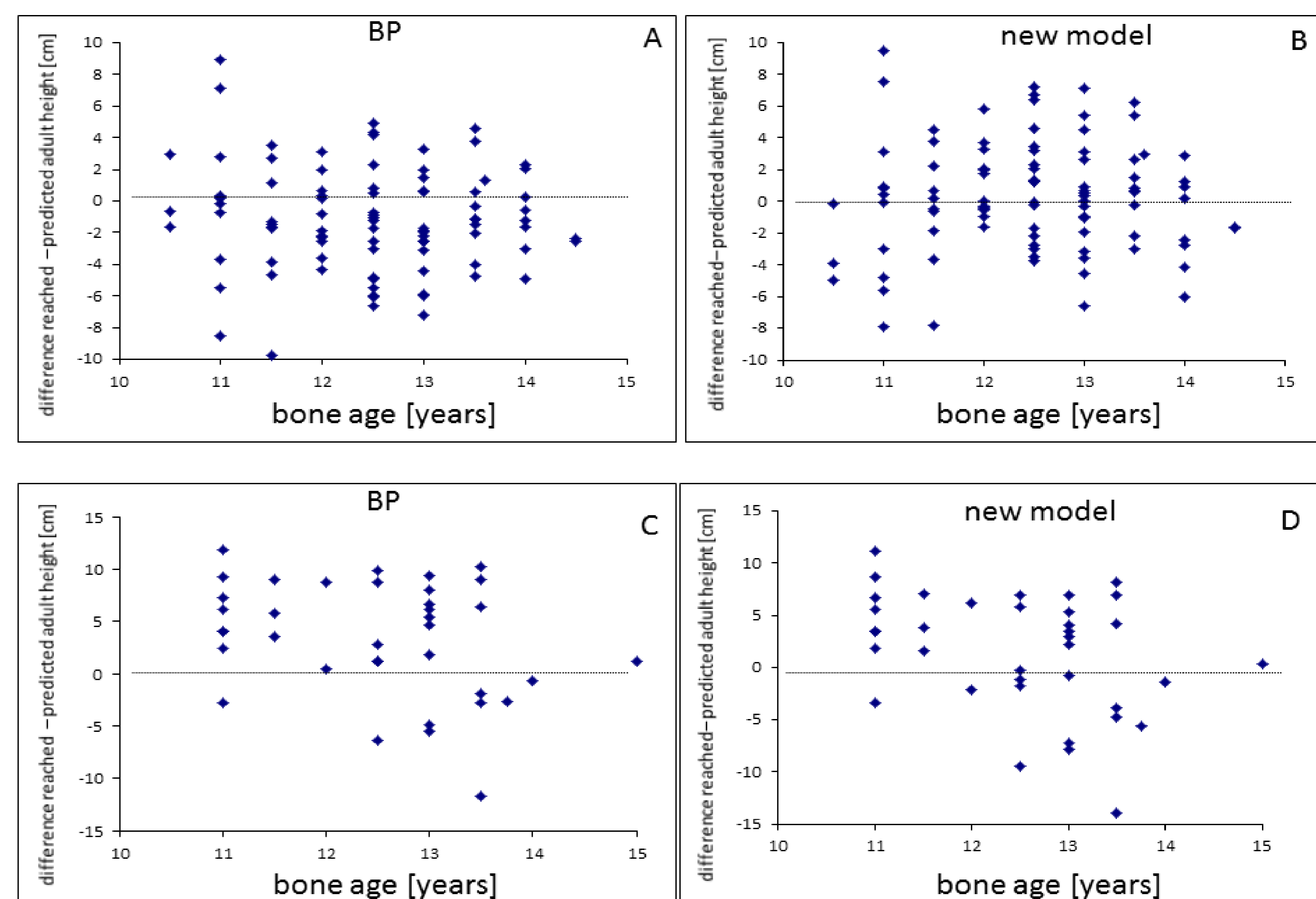
| Bone age [y] | BP | New model in bone age retardation >1 and <2 years | New model in bone age retardation ≥ 2 years |
|--------------|-------|---|---|
| 10.5 | 81.9% | 80.4% | |
| 11.0 | 82.3% | 82.5% | 82.6% |
| 11.5 | 83.2% | 83.7% | 84.1% |
| 12.0 | 84.5% | 85.4% | 85.8% |
| 12.5 | 86.0% | 87.2% | 87.5% |
| 13.0 | 88.0% | 89.1% | 89.3% |
| 13.5 | - | 91.1% | 91.2% |
| 14.0 | - | 92.8% | 93.1% |
| 14.5 | - | 95.2% | 95.2% ¹ |
| 15.0 | - | 97.5% | 97.3% ¹ |
| 15.5 | - | 99.9% | 99.6% ¹ |

Conclusions:

- The new model to predict adult height in boys with CDGP provides novel indices for height predictions in bone ages >13 years and is adapted to degree of bone age retardation.
- The new prediction model has a good predictive capability and overcomes some of the shortcomings of the BP model.



Percentage of reached adult height according to different models separated to bone age



Differences between predicted and achieved adult height at different bone ages separated to the different models and different study cohorts

(A: Bayley-Pinneau in study A (105 bone age determinations), B: new smoothed model adapted to bone age retardation in study A (105 bone age determinations), C: Bayley-Pinneau in study B (37 bone age determinations), D: new smoothed model adapted to bone age retardation in study B (37 bone age determinations))