

BoneXpert Adult Height Predictor – User Manual



Background

The BoneXpert adult height prediction (AHP) method is the state-of-the-art method to predict adult height from age, bone age, gender and current height. It is the natural successor to the classical Bayley-Pinneau method from 1952 commonly used by paediatric endocrinologists and paediatric radiologists.

The BoneXpert AHP is based on Bayley & Pinneau's concept of growth potential (gp) estimated solely from bone age (BA), chronological age (CA) and gender. The growth potential is the remaining growth divided by the adult height. The BoneXpert AHP features several improvements:

- A non-linear dependency of gp on BA and CA
- A specific gp function for each ethnicity: Caucasians, Asians, Africans and Mexicans
- Adjustment of the height prediction to the population height
- Optional inclusion of parental height
- Prediction of the Age of Peak Height Velocity (APHV)
- Visualisation of the most likely growth path in a growth chart including the corresponding height velocity curve

The method has been validated on normal, healthy children and on children with untreated idiopathic short stature.

The BoneXpert AHP method is freely available online at www.BoneXpert.com/ahp and complements BoneXpert Server and BoneXpert Online for automated bone age reading. In combination, the automated bone age measurement and the AHP method provide the best accuracy for adult height prediction.

The BoneXpert AHP is intended to be used with GP bone age determined by BoneXpert; however, it can also be used with manual GP bone age, but the uncertainties of the predictions are then larger than indicated, due to the rater variability – the extent of which is unknown.

The tool implements the most accurate statistical model, but is not in itself a diagnostic tool, and it should not be used without consulting a pediatric endocrinologist or another medical expert.

The BoneXpert AHP web tool

The tool is available at www.BoneXpert.com/ahp. A screenshot is shown below in Figure 1. The tool consists of a column of boxes for data entry (1), a column of computed results (2) and a visual representation in form of a growth chart (3)¹. A series of buttons provide options for printing or sharing the result (4).

The tool runs entirely in the browser and does not store any patient data or other data.

The result can be saved as a PDF using the “Print as PDF” option built into the web browser, and the PDF can then be used as a final report, and e.g. included in an electronic record system.

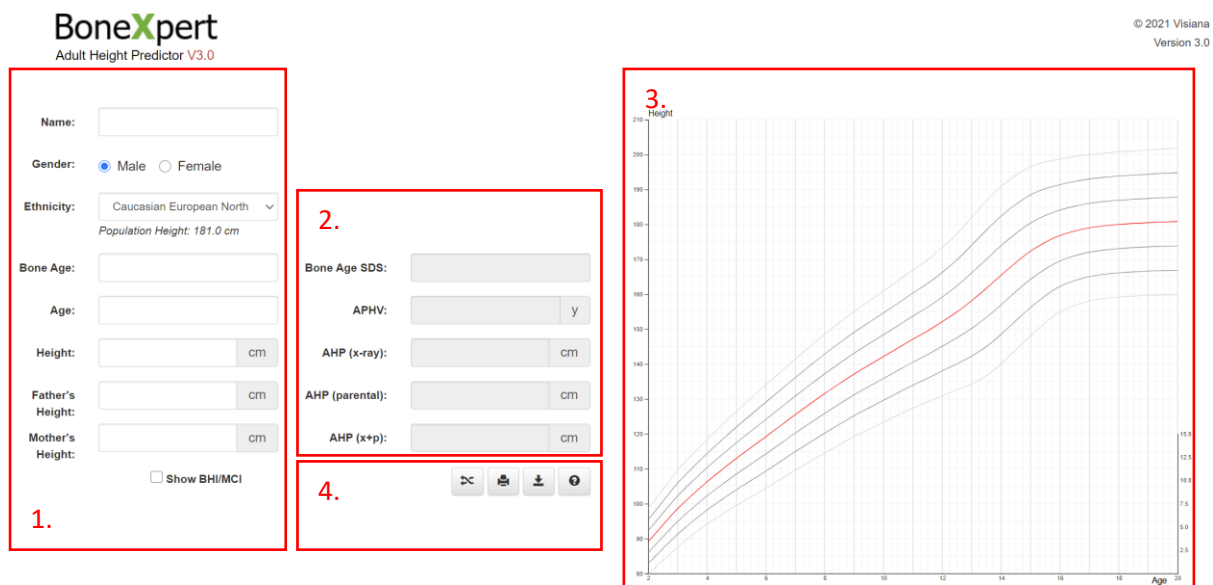


Figure 1: Screenshot of BoneXpert Adult Height Prediction User Interface

¹ The growth chart is currently only available for the Caucasian ethnicity

Input

Inputs marked with * are required. The tool uses dot (.) as decimal point.

Name: Any text

Gender*: Male or female.

Ethnicity*: The AHP depends on the ethnicity, and within each ethnicity, it depends on the assumed population height. The following population groups are available:

Ethnicity	Lowest bone age	Population	Population code	Population height	
				Males	Females
Caucasian	2 y	Caucasian European North	CauEurN	181	168
		Caucasian European Central	CauEurC	178	165
		Caucasian European South	CauEurS	175	162
		Caucasian Very Short	CauVS	165	152
		Caucasian American	CauAm	178	165
		African American	AfrAm	176	164
		Indian	Ind	165	152
Asian	5 y	Japanese	AsiJap	170	157
		Asian Chinese	AsiChi	172	160
		Asian American	AsiAm	172	160
African	8 y	African	Afr	171	159
Mexican	5 y	Mexican	Mex	169	156
		Hispanic American	HisAm	171	158

There have yet been no suitable height studies with bone age on African Americans and Indians, so for these, the tool uses the Caucasian ethnicity as an approximation, **which makes the results less reliable**.

The model for APHV (age at peak height velocity) is based on the Zurich Longitudinal study, so the APHV as well as the graphics are not shown for non-Caucasians.

Note that the choice of population also affects the computation of standard deviation scores (SDS).

Bone Age*: Greulich-Pyle bone age, entered with decimals (e.g. 5.8) (not as years and months). The tool is intended to be used with automated BoneXpert GP bone age. It can also be used with manual GP bone age, but the prediction uncertainties can then not be trusted, since there is no way to factor in the unknown rater variability. The method accepts bone age which are up to 5 years advanced or 5 years delayed relative to the chronological age.

Age*: Chronological age with decimals (e.g. 6.3), not as years and months. This can be read from the annotated X-ray from BoneXpert Server.

Height*: Height of the child, in cm (e.g. 110.4)

Father's Height and Mother's Height: Height of the parents in cm. This is optional but will improve the accuracy of the prediction.

Height at Menarche: The height in cm right at the time of the menarche. This can be computed by linear interpolation from measurements taken before and after the menarche. If this optional input is provided, it increases the accuracy of the prediction.

Output

The following results are computed. Uncertainties are given as $\pm 1SD$, which means that the true values will be within the indicated range with 68% probability, and within $\pm 2SD$ with 95% probability.

Bone Age SDS: The standard deviation score (SDS, or Z-score), of the bone age, relative to children of same age, gender and ethnicity. It is currently not generated for the Asian, African and Mexican ethnicities. This expresses how many standard deviations the bone age is away from the average for normal children of the same age. The standard deviation of bone age at a given age is approximately one year for ages above 7.

APHV: Age of Peak Height Velocity. This is the predicted chronological age of the peak of the growth spurt.

The BoneXpert AHP method gives up to four different adult height predictions; at lower ages, some of them might be missing. The prediction with the lowest uncertainty is indicated by a green border, to guide the eye to the one that should be used. This is also the one which is shown in the growth chart.

AHP (x-ray): Adult height prediction based on the age, bone age (from the x-ray) and height.

AHP (parental): Adult height prediction based solely on the parents' heights and the ethnicity. This is more accurate than the conventional "target height" (which is mid-parental height ± 6.5 cm), because it comprises a drawing towards the population height. A secular trend in adult height of 1 cm per generation is assumed in this prediction.

AHP (x+p): Adult height prediction based on age, bone age, height and parental height.

AHP (x+m): Adult height prediction based on age, bone age, height and height at menarche.

A large discrepancy between AHP(x-ray) and AHP(parental) indicates that the child grows differently from what is expected from its parental heritage, i.e. it could be a sign of disorder. The evaluating of this is the task of a paediatric endocrinologist – the calculator implements the most accurate statistical model but is not in itself a diagnostic tool.

Below in Figure 2 is an example of a girl of age 12.0 with a GP bone age of 11.0. Height and parental heights are entered. The most accurate prediction is AHP (x+p), as indicated in green, with an SD of ± 2.4 cm.

Bone Age:	<input type="text" value="11"/>	Bone Age SDS:	<input type="text" value="-0.73"/>
Age:	<input type="text" value="12"/>	APHV:	<input type="text" value="12.5 ± 0.7"/> y
Height:	<input type="text" value="153.4"/> cm	AHP (x-ray):	<input type="text" value="172.4 ± 2.4"/> cm
Father's Height:	<input type="text" value="182"/> cm	AHP (parental):	<input type="text" value="167.9 ± 4.3"/> cm
Mother's Height:	<input type="text" value="168"/> cm	AHP (x+p):	<input type="text" value="171.8 ± 2.4"/> cm
Height at menarch:	<input type="text"/> cm	AHP (x+m):	<input type="text"/> cm

Figure 2: Example of output of Adult Height Prediction

Bone Health and MCI

BHI: The Bone Health Index (BHI) from the X-ray analysed with BoneXpert can be entered by checking the box “Show BHI/MCI”. The tool will then compute the BHI SDS (Standard Deviation Score) value relative to healthy children with the same bone age. It is currently only available for the Caucasian European ethnicities, and it has no effect on AHP.

MCI: The Meta Carpal Index (MCI) from the X-ray analysed with BoneXpert can be entered by checking the box “Show BHI/MCI”. The tool will then compute the MCI SDS (Standard Deviation Score) value relative to healthy children with the same bone age. It is currently only available for the Caucasian European ethnicities, and it has no effect on AHP.

BHI:	<input type="text"/>	BHI SDS:	<input type="text"/>
MCI:	<input type="text"/>	MCI SDS:	<input type="text"/>

Show BHI/MCI

Growth chart

Below in Figure 3 is the growth chart for the girl from the example given in the previous section. The x-axis is age in years, left y-axis is height in cm. A second y-axis in the right-hand side is used for the height velocity in cm per year.

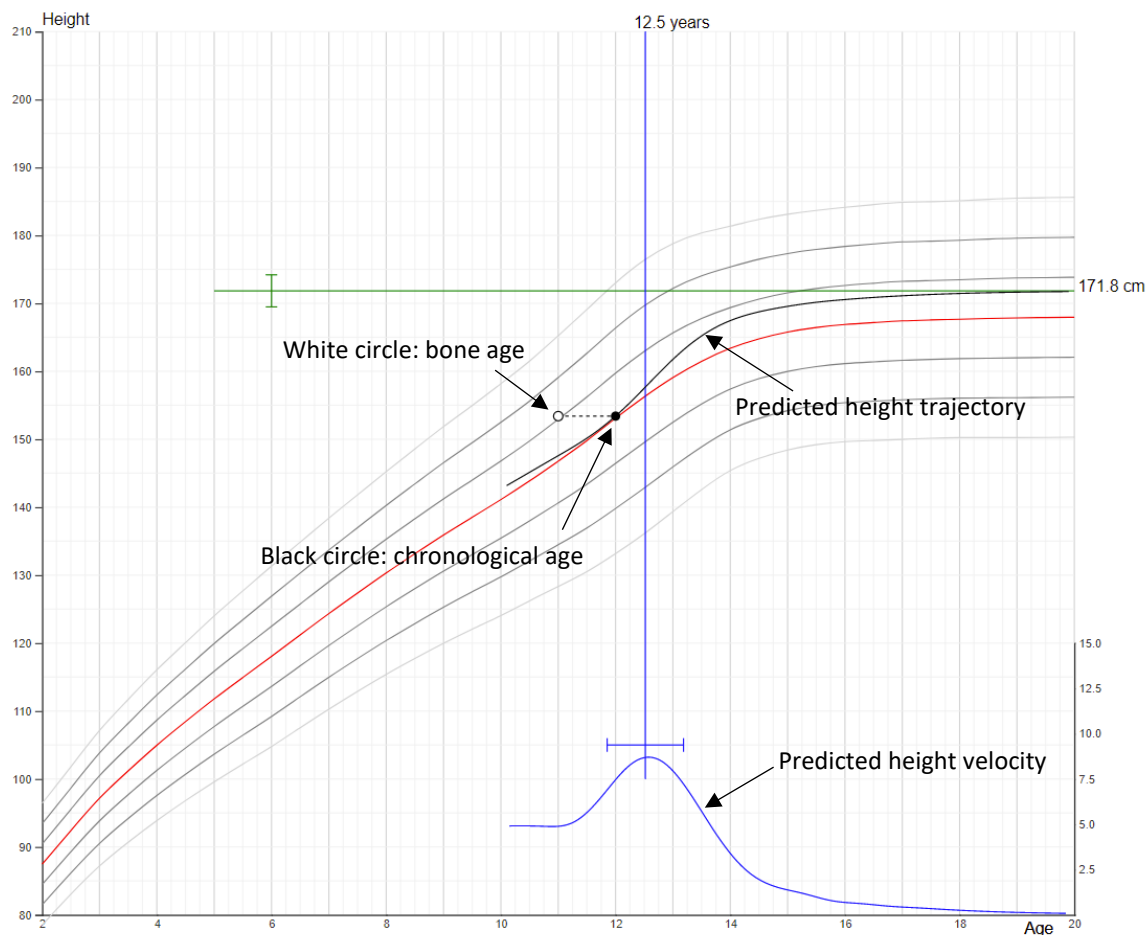


Figure 3: Example of Growth chart

The most accurate adult height prediction, AHP (x+p) of 171.8 cm, is plotted and indicated by a green line, and the green whisker indicates the SD = 2.4 cm





The black disk on the growth curve is at the chronological age and the white circle is at the bone age. In this case, the girl's bone age is 1.0 year advanced.

The red curve on the chart indicates the average height versus age in the population, in this example the European Caucasian North. The grey lines indicate the average height plus minus 1, 2 and 3 standard deviations.

The most likely growth path to adult height is drawn in solid black. The corresponding most likely height velocity curve is plotted in blue; this is the derivative of the growth path. The velocity peaks at the APHV, marked as a vertical blue line, including a whisker for the 1 SD uncertainty of the APHV prediction.

Buttons

Four buttons provide useful features:

	This button allows to see results for Adult height prediction in version 2.23. This functionality is only for historical purposes
	This prints the page. It is the same as pressing CTRL + P. If you use the built-in “Save as PDF” function in your browser, you can save the page as a PDF which may be used as a report.
	This updates the URL, storing all information in the address field. Please note: This will also store the patient name, so you might want to leave this field blank. This is a convenient way of sharing the calculation, e.g. by copying the updated URL into an email.
	This will take you to the link: https://bonexpert.com/what-is-bone-age/#ahpexplained where some background on the method is provided.

Offline access, smart phones, and tablets

The BoneXpert AHP web tool can be accessed offline once you have accessed it online. Whenever you go online, the newest version will be loaded and saved for offline access.

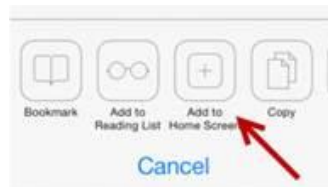
The web page is “responsive” – it will re-scale to fit if you zoom using the browser or if you display the page on a tablet or smartphone.



On Apple devices (iPhone and iPad), the web page can be stored on the home screen similarly to an app, available in offline mode. To do this, navigate to the website in Safari: www.BoneXpert.com/ahp. Then press “Share”:



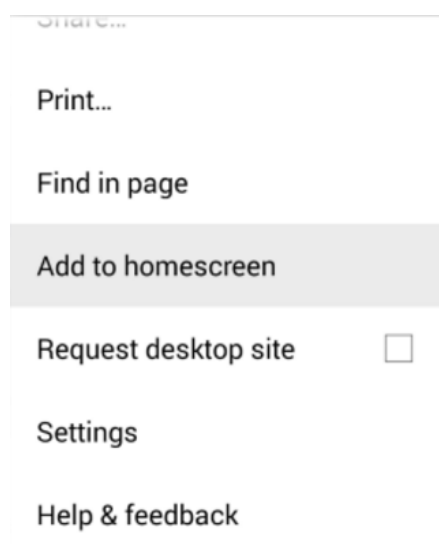
And choose “Add to home screen”:



A new thumbnail of the website named “BX AHP” will appear on your home screen among your apps.



On Android devices, from the standard internet browser or Chrome, press “More” or “...” next to the address field and select “Add to homescreen”.



A new thumbnail of the website named “BX AHP” will appear on your home screen among your apps.