Reference values of cortical thickness, bone width, and Bone Health Index in metacarpals of children from age 0 y, as determined with an extension of the fully automated BoneXpert bone age method

Hans Henrik Thodberg\textsuperscript{a}, Peter Thrane\textsuperscript{a} (presenting), & David Martin\textsuperscript{b,c}

\textsuperscript{a}Visiana, Hørsholm, Denmark, \textsuperscript{b}Univ. Children’s Hospital Tübingen, Germany, \textsuperscript{c}Witten/Herdecke University, Germany

\textbf{Introduction}

The BoneXpert method for automated bone age was introduced in 2009, covering the Greulich-Pyle bone age (BA GP) down to 2.5 years for boys and 2.0 years for girls.

The method was recently extended down to newborns.

BoneXpert also performs digital radiogrammetry of the cortical thickness (T), the bone width (W) and length (L) in metacarpals 2-4.

From these, the method derives the cortical area:

\[ A = \pi \cdot W \cdot T \cdot (1 - T/W), \]

the metacarpal index

\[ \text{MCI} = A / W^2, \]

and the Bone Health Index (BHI)

\[ \text{BHI} = A / (W^{1/3} \cdot L^{1/3}). \]

The aim of this study is to report reference curves for bone measurements for children starting at BA GP 0.08 years.

\textbf{Methods}

410 healthy children born in Paris in 1955 were followed with hand X-rays at ages 1, 3, 6, 9, 12 and 18 months, and then annually until age 20 years. Reference curves were defined versus BA GP determined automatically with BoneXpert, averaging over radius, ulna and 19 short bones.

\textbf{Results}

For males, T drops from 0.74 mm at BA GP 0.08 y to a minimum of 0.58 mm at BA GP 1 y, a reduction of 22%.

In the same period, W increases by 38% from 3.2 to 4.4 mm, and A grows by 19%.

Metacarpal length (L) increases 43% from 16.4 to 24 mm. MCI drops from 0.55 to 0.37 (33%) and BHI from 4.8 to 3.4 (29%).

Females display a similar development, but their cortical thickness assumes its minimum already at BA GP 0.9 y.

\textbf{Discussion}

In the first year of life, infants exhibit a dramatic reconfiguration of bone geometry: Bone width and length increase strongly and cortical thickness decreases by 21%. MCI and BHI decrease in this period.

Further studies are needed to investigate if this decrease in cortical thickness is related to the observed increase in fracture-risk in children at age 1.0 years compared to newborns (Hedström 2010).

This new method could be an alternative to DXA in infants because:

1) It is easier to record a hand X-ray
2) The new reference curves provide Z-scores
3) The reference curves are expressed versus bone age rather than chronological age.

\textbf{References}

Thodberg et al., \textit{A paediatric bone index derived by automated radiogrammetry.} Osteoporos Int. 2010 Aug; 21(8): 1391–1400


\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Example of metacarpal bones from a male individual at the age of 1 month, 3 months, 12 months, and 36 months.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Graphs of metacarpal length, width, metacarpal cortical thickness, and metacarpal index versus bone age.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Example of a hand analyzed by BoneXpert version 3.0.}
\end{figure}