Quantitative Sonometric Bone Age (SBA) as a Function of Height and BMI

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Background:
- It is commonly believed that short stature is associated with delayed BA and that obesity is associated with advanced BA.
- For ethical reasons, this assumption was never tested in healthy children.
- We have previously shown that BA assessed by sonographic BAUSTM is reproducible and comparable to both GP and TW3 X-ray assessment of BA.
- This provides a safe, simple and irradiation-free method for the assessment of BA in healthy children.

Aim of the study:
To understand the dependency of SBA on a child’s height and BMI in healthy children with normal stature and BMI.

Hypotheses:
Shorter and thinner pre-pubertal and pubertal children boys and girls will have delayed BA as compared to taller and heavier children.

Study design:
This was a cross sectional study of healthy children with normal stature and BMI in an outpatient pediatric clinic. A total of 650 healthy children (333 boys and 317 girls) Age: 4–17 years
Height range 5-95%.
BMI < 90%
Exclusion criteria were: bone and joint diseases, systemic diseases known to impair growth, hand and wrist deformities, recent fractures, and soft tissue swelling.
SBA was assessed using SonicBone BAUSTM.

The SonicBone (SB) device
The SonicBone device (Rishon Lezion, Israel) is a small (50cm X 25cm X 25cm), portable, bone sonometer. A transmitter probe and a receiver probe are located at the edges of the measured bone area.

Two parameters were measured:
- Speed of propagation through bone (speed-of-sound, SOS, m/sec) of inaudible high frequency waves of a short ultrasound pulse;
- attenuation (ATN, the decay rate) of the sound wave by the bone as a function of the distance (mm) it travels between a transmitter and a receiver.

The Method:
Three sites of assessment:
- A phalange (P), measuring SOS and ATN along the bent proximal third phalanx shaft, growth plate and epiphysis;
- metacarpals (MC), measuring SOS and ATN for the distal metacarpal epiphyses;
- wrist (W), measuring SOS and ATN at the distal radius’ and ulna’s secondary ossification centers.
The average of those three sites was defined as the child’s BA by SBA.

Results:

<table>
<thead>
<tr>
<th></th>
<th>Prepubertal boys</th>
<th>Pubertal boys</th>
<th>Prepubertal girls</th>
<th>Pubertal girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>147</td>
<td>186</td>
<td>120</td>
<td>197</td>
</tr>
<tr>
<td>Height (SOS)</td>
<td>0.40±0.03</td>
<td>0.07±0.04</td>
<td>0.06±0.04</td>
<td>0.005±0.04</td>
</tr>
<tr>
<td>BMI SD (SOS)</td>
<td>0.34±0.10</td>
<td>-0.04±0.1</td>
<td>0.08±0.01</td>
<td>-0.08±0.04</td>
</tr>
<tr>
<td>W SBA [-] (years)</td>
<td>0.61±0.12</td>
<td>-0.48±1.64</td>
<td>0.51±1.30</td>
<td>-0.31±1.88</td>
</tr>
<tr>
<td>P SBA [-] (years)</td>
<td>0.51±0.04</td>
<td>-0.40±1.42</td>
<td>0.39±1.11</td>
<td>-0.24±1.32</td>
</tr>
<tr>
<td>M SBA [-] (years)</td>
<td>0.61±0.10</td>
<td>-0.48±1.67</td>
<td>0.58±1.40</td>
<td>-0.35±1.65</td>
</tr>
<tr>
<td>Mean SBA [-] (years)</td>
<td>0.46±0.08</td>
<td>-0.36±1.40</td>
<td>0.32±1.16</td>
<td>-0.19±1.38</td>
</tr>
</tbody>
</table>

Conclusions:
1. Shorter and thinner pubertal but not pre-pubertal children have delayed SBA as compared to taller and heavier children.
2. The full-length phalanx maturation is affected by height more than the wrist and metacarpals’ epiphyses.
3. The radius-ulna epiphyses are affected by BMI more than the metacarpals and phalanx.
4. These influences have to be accounted for in the assessment of a BA.

* SI is an employee of SonicBone and ZH is an independent consultant to the company.