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 BAUS™, 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 BAUS™.

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>130</td>
<td>197</td>
</tr>
<tr>
<td>Height SDS</td>
<td>0.40±0.83</td>
<td>0.07±0.84</td>
<td>0.06±0.90</td>
<td>-0.005±0.88</td>
</tr>
<tr>
<td>BMI SDS</td>
<td>0.24±1.10</td>
<td>-0.04±1.0</td>
<td>0.06±1.01</td>
<td>-0.06±0.91</td>
</tr>
<tr>
<td>W SBA (-) CA (“years”)</td>
<td>0.61±1.22</td>
<td>-0.48±1.64</td>
<td>0.51±1.30</td>
<td>-0.31±1.88</td>
</tr>
<tr>
<td>P SBA (-) CA (“years”)</td>
<td>0.51±1.04</td>
<td>-0.40±1.42</td>
<td>0.39±1.11</td>
<td>-0.24±1.32</td>
</tr>
<tr>
<td>M SBA (-) CA (“years”)</td>
<td>0.61±1.10</td>
<td>-0.40±1.67</td>
<td>0.58±1.46</td>
<td>-0.35±1.65</td>
</tr>
<tr>
<td>Mean SBA (-) CA (“years”)</td>
<td>0.46±0.98</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.

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

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) A phalange (P), measuring SOS and ATN along the bent proximal third phalanx shaft, growth plate and epiphysis;
B) Metacarpals (MC), measuring SOS and ATN for the distal metacarpal epiphyses;
C) 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.