# Evidence about the determining role of the body height in the characteristics of the aortic augmentation index in childhood

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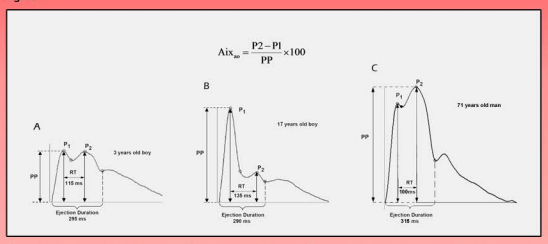
## Introduction

The aortic augmentation index ($Aix_{ao}$) increases with age in adults and the increased $Aix_{ao}$ is a strong predictor of cardiovascular morbidity and mortality. The enhanced wave reflection is a well-known phenomenon in infants and children, the waveforms are very similar to those in older adults (Figure 1).

This phenomenon is explained on the basis of differences in the body length by the majority of the authors. However, this hypothesis has not been proved yet directly.

**Figure 1**




Original pulse pressure curves measured by Arteriograph® in case of 3 years old children (A), 17 years old adolescents (B) and 71 years old man (C).

## Hypothesis

If the return time (RT) of the first systolic pulse pressure wave is longer, the reflected wave will be positioned lower on the declining slope of the first systolic wave. We supposed that if the increase of the body height is proportional with the rhythm of the changes of the RT, the age dependent decrease of the Aix is must be due to the increasing RT.

## Aim

To determine the reference values of $Aix_{ao}$ in a healthy population aged 3-18 years and to find the possible physiological mechanisms of the enhanced aortic pressure wave reflection during infancy and early childhood.

## Methods and Subjects

$Aix_{ao}$ were measured by a new, validated[1,2], non-invasive, occlusive, oscillometric method (Arteriograph, TensioMed Ltd., Hungary) in a healthy population aged 3-18 years with normal BMI and with normal blood pressure (1,802 males, 1,572 females). Smoothed percentile curves of $Aix_{ao}$, body height and RT from 3$^{th}$ to 97$^{th}$ were determined using LMS method. Results were analyzed by Student's t-test. To study causal relationships between $Aix_{ao}$ and other variables graphical analyses were used.

## Results

The physiological changes of $Aix_{ao}$, body height and RT measured in healthy population are shown in Figure 2. The $Aix_{ao}$ decreased, while the body height, and the RT increased proportionally with age in both genders. The simultaneous changes of the studied parameters ($Aix_{ao}$, body height, RT) were moving together in relation to the age. Furthermore the flattening of these parameters happened exactly in the same age; 14,5 and 13,5 years for the boys and girls, respectively.

From the age of 14 years the $Aix_{ao}$ were significantly lower in males than in females ($p<0.02$), and this difference had become even more pronounced from age of 15 years ($p<0.001$) (Table 1).

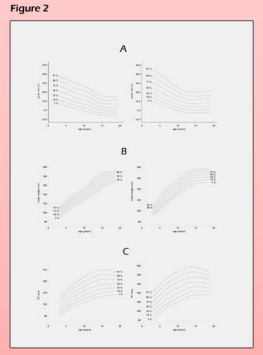
Assessing the background of these differences in $Aix_{ao}$ we have found that the changes of the median of $Aix_{ao}$ are exactly identical to the changes of the median of body height and of the changes of the median of RT (Figure 3).

**Table 1**
$Aix_{ao}$ mean values for healthy boys and girls aged 3-18 years

| age (years) | n | Boys $Aix_{ao}$ (%) ± SD | n | Girls | Student's t-test |
|---|---|---|---|---|---|
| 3 | 44 | **18.6** ± 8.7 | 35 | **20.6** ± 11.7 | NS |
| 4 | 53 | **15.2** ± 5.9 | 43 | **18.7** ± 5.9 | p < 0.01 |
| 5 | 80 | **15.6** ± 5.9 | 44 | **17.3** ± 6.6 | NS |
| 6 | 120 | **13.5** ± 5.2 | 68 | **16.1** ± 6.9 | p < 0.01 |
| 7 | 85 | **12.8** ± 7.1 | 72 | **14.2** ± 7.9 | NS |
| 8 | 74 | **12.2** ± 6.0 | 39 | **12.4** ± 5.7 | NS |
| 9 | 92 | **10.8** ± 5.8 | 64 | **11.1** ± 5.5 | NS |
| 10 | 81 | **9.5** ± 6.3 | 63 | **11.3** ± 7.4 | NS |
| 11 | 80 | **11.3** ± 6.7 | 49 | **9.1** ± 7.2 | NS |
| 12 | 101 | **8.2** ± 6.7 | 85 | **9.9** ± 7.4 | NS |
| 13 | 169 | **6.6** ± 7.7 | 195 | **8.0** ± 6.4 | NS |
| 14 | 187 | **5.6** ± 8.0 | 189 | **7.4** ± 5.8 | p < 0.02 |
| 15 | 171 | **4.6** ± 5.5 | 181 | **8.2** ± 5.7 | p < 0.001 |
| 16 | 162 | **4.3** ± 5.3 | 174 | **8.4** ± 5.4 | p < 0.001 |
| 17 | 197 | **4.8** ± 5.0 | 175 | **8.8** ± 5.9 | p < 0.001 |
| 18 | 106 | **4.7** ± 4.3 | 96 | **8.3** ± 5.0 | p < 0.001 |

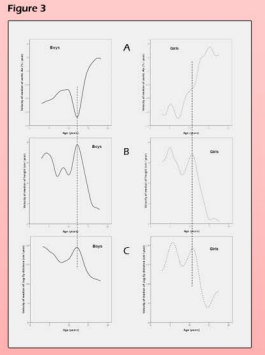
Data are reported as mean and standard deviation. For data comparison, Student's t-test was used after cheking that the assumption of normality was met. A significance level of 0.05 was used for statistical test.

**Figure 2**




Smothed percentile curves from 3 to 97 related with age of Aixao (A), body height (B) and RT (C) for boys and girls.

**Figure 3**




Velocity of median of Aixao (A), body height (B) and RT (C) for boys and girls.

## Conclusions

This is the first large population study involving 3,374 healthy subjects aged 3-18 years which describes the physiological changes of $Aix_{ao}$. Our data provide supporting evidence that the pressure waveforms in infants and children are markedly elevated and similar to those with advanced age. This interesting phenomenon can be explained by the smaller body height and the proportionally shorter RT in early age, and their simultaneous change (increase) toward puberty. In children due to the shorter body height (aortic length) the second systolic wave returns earlier, climbs up on the declining shoulder of the first systolic wave, consequently the position of the peak of the second systolic wave and the Aix becomes higher.

## References

1. Baulmann, J Hypertension 2008, 26:523-528; 2. Horváth, J Hypertension 2010, 28:2003-2006