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Reference values for pulse doppler and tissue doppler velocities in pediatric echocardiography.

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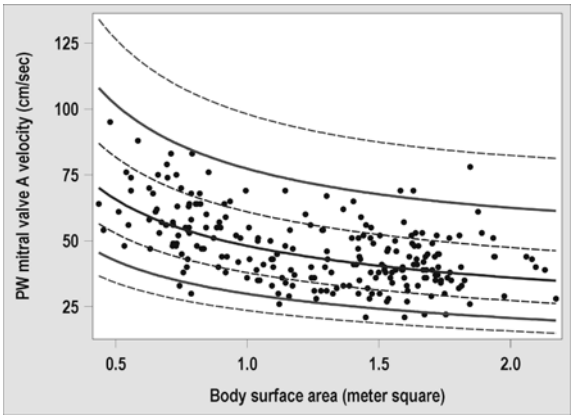
Introduction: Blood flow and tissue velocities measured by pulse Doppler are widely used tools for the evaluation of cardiac function. In healthy children, many of these parameters vary with growth, often in a non-linear fashion. Reference values for blood flow and tissue Doppler velocities are limited by inconsistent methodologies and small sample size. Furthermore, standardized approaches to perform normalization in pediatric echocardiography, especially in the presence of heteroscedasticity and non-linear relationships, are lacking. We aimed to determine reference values and Z scores equations for blood flow and tissue velocities in a large healthy pediatric population.



Methods: 233 healthy pediatric subjects 1-18 years of age were prospectively recruited. Fifteen pulse Doppler and 22 tissues Doppler measurements were recorded. Normalization for growth was done via a complete and standardized approach for parametric non-linear regression modeling. Several analyses were then performed to ensure adequate Z scores distribution and to detect potential residual associations with growth or residual heteroscedasticity.

Results: Most measurements adopted a non-linear relationship with growth and displayed significant heteroscedasticity. Compared to age, height and weight, normalization for body surface area was more efficient in removing the effect of growth. In general, polynomial models and allometric models yielded adequate goodness-of-fit. Residual values for several measurements had significant departure from the normal distribution. Logarithmic or reciprocal transformation was often sufficient to restore adequate distribution. Overall, weighed parametric non-linear models allowed us to compute Z score equations with adequate normal distribution and without residual association with growth. An example of Z scores boundaries for mitral A wave velocities is presented in the figure. Measurements known to be strongly dependent on heart rate often continued to have a residual association with heart rate despite adequate normalization for growth.

Conclusions: Here, we present Z scores for normalized blood flow and tissue velocities in pediatric echocardiography. Because Z scores describe the normal limit of a healthy population, further studies are needed to define the threshold beyond which health becomes disease by integrating other important factors such as ventricular morphology, loading conditions and heart rate.