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Letters to the Editor

Letter to the Editor Concerning: "Patterns of Rib Growth in the Human Child" by Richard M. Schwend, John A. Schmidt, Julie L. Reigrut, Laurel C. Blakemore, and Behrooz A. Akbarnia. *Spine Deform* 3 (2015):297-302, http://dx.doi.org/10.1016/j.jspd.2015.01.007

Dear Sir

We write in connection with the article on rib growth in the human child by Dr. Richard M. Schwend and colleagues.

We congratulate the authors for this original research on human rib growth from the Hamann–Todd Osteological Collection. But their statement "there are virtually no normative data on the growth of the individual ribs throughout childhood" [1] is not correct. May we draw your readers' attention to two papers we published in basic scientific journals [2,3]. These papers measured the ribcage in chest radiographs of 412 children aged 0–17 years attending hospital with minimal disorder or diseases (boys 193, girls 219). The data were analyzed in three age groups—infancy, childhood, and puberty—after the classification of Karlberg (1989) [4].

In the first paper [2], at each rib, thoracic ratios were calculated for the left hemithorax, right hemithorax, and total thorax relative to T1–T12 distance (Fig. 1).

The hypothesis was made that the relative narrowing of the lower chest with increasing age reduces the rotational inertia of the thorax in human bipedal gait.

In the second paper [3], at each rib, rib–vertebra angles (RVAs) were measured and the asymmetry of RVAs calculated as RVA differences. The pattern of RVA differences is related to age, gender, and level and reflects the common age, gender, and laterality patterns of idiopathic scoliosis (Fig. 2).

It was suggested that extremes of such RVA asymmetries are pathogenetic for both infantile and adolescent idiopathic scoliosis. The hypothesis was suggested that RVAs are determined in part by the central nervous system through its influence on trunk muscle activity.

The above-described cross-sectional studies confirm that the rib-cage remodels by age and gender during growth. It was hypothesized in evolutionary terms of how and when the neonate with a triangular-shaped thorax becomes barrel shaped in adulthood as a mechanism consistent with an adaptation of the rib cage to human bipedal gait.

These findings and how we interpreted them led to a novel multifactorial concept for the pathogenesis of idiopathic scoliosis [5].

Yours faithfully

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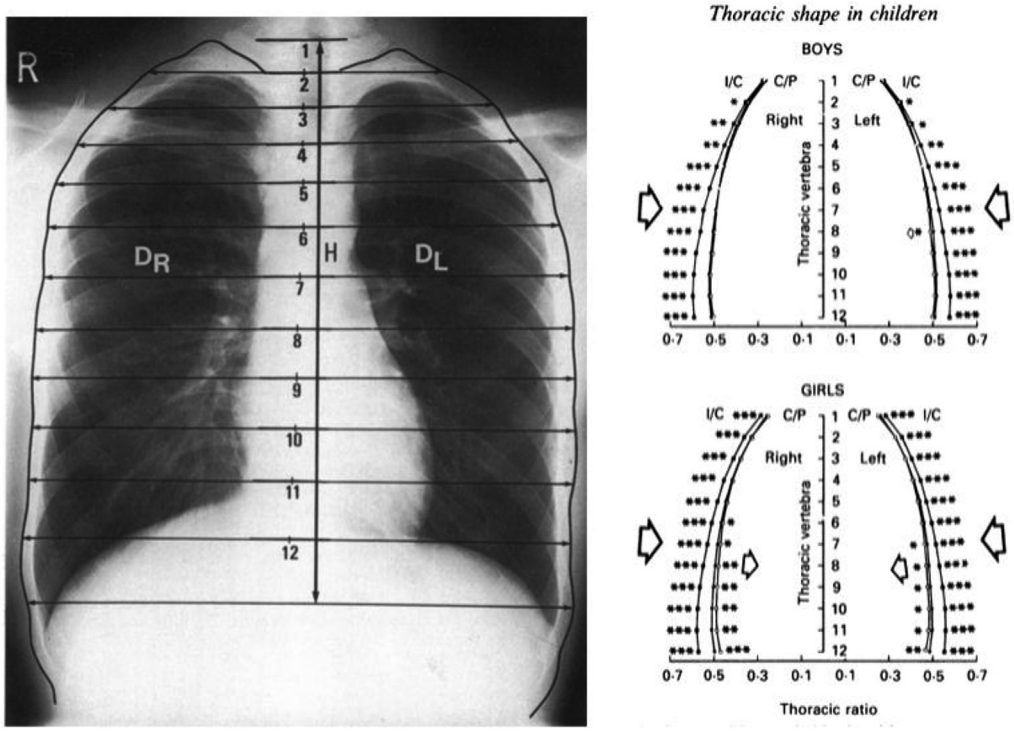

Fig. 1. Thoracic ratios for control boys and girls plotted by age group (infancy, childhood, and puberty; see text). I/C, infancy/childhood; C/P, childhood/puberty. *.001 < p < .005; **.001 < p < .01; ***p < .0001.

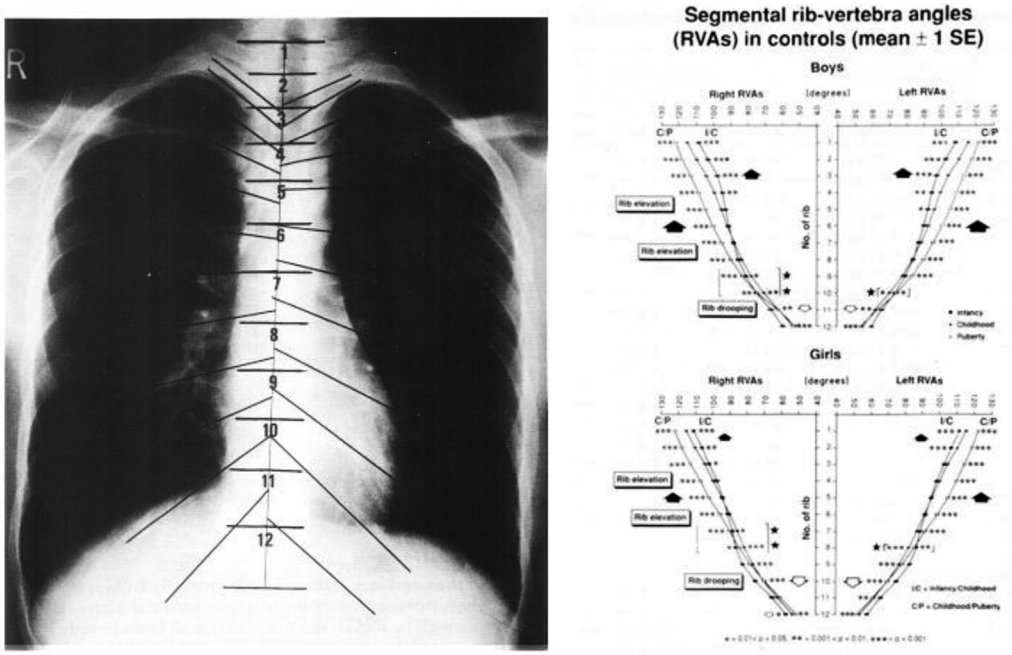

Fig. 2. Segmental rib–vertebra angles (RVAs in degrees) in boys and girls for each of the infancy (I), childhood (C), and puberty (P) groups by rib level. Note that (1) in infancy at rib 6, RVAs are about 90 degrees; (2) between infancy and childhood (I/C) the RVAs increase above rib 6 and decrease below rib 6; (3) between childhood and puberty (C/P), RVAs increase from ribs 1 to 10 in boys and from 1 to 8 in girls; and (4) the junctional ribs (square brackets and stars) droop from infancy to childhood and elevate from childhood to puberty on the right at two levels (boys' ribs 9 and 10, girls' ribs 7 and 8) and on the left at one level (boys' rib 10, girls' rib 8).

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Letter to the Editor: Response to Grivas et al.

Thank you for giving us the opportunity to review and respond to the comments from Drs. Grivas, Burwell, Moulton, and Webb. Grivas et al. are well known for their excellent studies on the underlying growth of the human thorax and spine and their theory of the etiology of scoliosis in relationship to the evolutionary development of bipedal gait [1]. In response to our statement ''there are virtually no normative data on the growth of individual ribs throughout childhood,'' they reference their two articles that were published in 1991 and 1992 [2,3].

During our literature review, we read with much interest their paper on segmental analysis of the thoracic shape and thoracic ratios in chest radiographs in children, because it was one of the few articles that discussed thoracic growth [2]. However, we concluded that it was not specifically relevant to our study of rib growth for two reasons:

1. The purpose of our study was to specifically describe normative data of rib growth during childhood based on direct measurements of the ribs, not to describe overall thoracic growth, which is the topic of a future paper.
2. In their paper, they state, ''Thoracic ratios do not provide any direct measurement of rib growth.''

Their second article on segmental analysis of thoracic shape in chest radiographs of children does not appear in a PubMed search, so we were not aware of it during our literature search [2]. The purpose of our study was not to look at the rib vertebral angles during development of the thorax, and though important for describing the changing shape of the human thorax with development, their article is also not specific to individual rib growth.

Grivas et al. proposed an evolutionary explanation for the development of the barrel-shaped thorax: the relative narrowing of the lower chest with increasing age reduces the rotational inertia of the thorax in gait, which is more pronounced in girls because of their greater rotational inertia generated by the mass of their larger pelves [1]. Although this mechanism has merit, contemporary alternative explanations for the development of the barrel-shaped thorax have been proposed [4]. *Australopithecus afarensis*, such as Lucy (short body and lower limbs and long gut), was vegetarian, and although bipedal, had a triangular-shaped chest. Not until the later appearance of *Homo erectus* (tall body and lower limbs and short gut) approximately 1.9 million years ago did the chest evolve to the modern barrel shape. Modern evolutionary theory is that this was more in response to a warmer climate and a meat-based diet, which favored a taller, thinner body. More efficient digestion of meat and a cooked diet led to a lower need for upper abdominal space and a more tapered barrel chest in this region. These theories of thoracic evolution do not explain the development of the infant triangular thorax to the barrel shape in the adult.

To date, we have collected more than 37,000 separate measurements from the Hamann–Todd collection and have reconstructed the thorax of each of these individuals in three dimensions from T1 to T12, as well as right and left. We hope that our initial studies on the growth of the rib can be utilized in future models of thoracic shape and growth. The early studies of Grivas et al. are an important foundation for understanding thoracic morphology and growth [1–3].

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