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HIGHLIGHTED TOPIC | *Biology of Physical Activity in Youth*

## Learning from children: the emergence of pediatric exercise science

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WHICH UNIQUE INSIGHTS can be gained from the investigations of the physiology of the growing child? Are there pragmatic outcomes to research in children's exercise science that bear specific utility to this age group or to their future life? What importance do exercise responses in youth bear to our understanding of the nature of human movement?

The reviews appearing in this highlighted topic series have been selected with the goal of providing answers to these questions. Each contribution not only examines a current issue in the field but also highlights specific aspects of exercise research that are particular to children—the problems of identifying causality in growing subjects, surmounting obstacles created by ethical constraints, and translating maturational differences in physiological features to motor performance outcomes. As a prelude to these discussions, it is appropriate to introduce the reader to some general considerations regarding exercise science in youth.

Other than the obvious factor of chronologic age, the feature most distinguishing children's exercise responses from those of adults is change. From the moment of birth to becoming a grownup teenager, the human body is engaged in a continuous process of evolving physically, psychologically, socially, biochemically, physiologically—by any marker one wants to measure—from an undeveloped state of dependency to that of the complex mature adult. Name the exercise markers (mechanical efficiency, peak oxygen uptake, sprint and endurance performance, standing jump height, daily caloric expenditure), the myriad of determinants of such variables are in constant change over the course of this temporal journey. Some of these simply reflect increases in body dimension. Maximal cardiac output rises with growth, a reflection of increase in stroke volume, which in turn reflects augmentation of left ventricular size. Other variables contributing to the evolution of physiological responses to exercise are size independent, such as glycolytic capacity and other metabolic functions. Which are which? And how do they relate? What determines the *rate* of change in exercise physiological determinants as children grow? Those seeking to define causal relationships in responses to exercise in youth have, in effect, a moving target.

Confounding the issue, the rate of biological maturation does not necessarily mirror that of chronological age—at any given age a group of children can be expected to exhibit significant developmental diversity. Pediatric exercise physiologists must, as a requisite of their trade, be constantly attentive

to the variations created by growth and biological development in their investigations. They need to confront, as well, the question of how physiological variables, such as  $\dot{V}O_{2\max}$ , should be best “normalized” for body size or level of biological development. The issue is clearly critical in assessing individual changes over time or performing group comparisons. Allometric scaling appears to be most appropriate in many situations, but when the more traditional “ratio standard” (i.e., per kg body mass) should be used instead remains problematic.

The nature of this evolving physiology creates some unique ways of approaching exercise-related issues. For example, one can traditionally consider the etiology of obesity in thermodynamic terms—there must exist an imbalance of energy in and energy out, possibly biologic (an intrinsic “error” in energy regulation), possibly extrinsic (an effect of influences of our contemporary culture that facilitates food intake and discourages regular exercise). But in youth, the major factors that contribute to energy balance are all in the process of constant change. During the growing years, relative to body size, food intake steadily declines and basal metabolic rate falls, as does relative energy expenditure in the form of daily physical activity. A central regulator must be in charge of matching them up (or almost—something must be left over for growth). So, the process of becoming an obese 10 year old must relate to an imbalance in the relative *rates* of these changes, and one might consider biological determinants of obesity in children in respect to factors that are responsible for changes in these factors over time. Such an understanding might have therapeutic or preventive implications. By contrast, factors in adults affecting energy balance should, at least intrinsically, be more static over time.

Investigating the physiological responses to exercise specific to children may prove enlightening in our understanding of basic physiological principles. For example, it is well-established that prepubertal children respond to a period of endurance training with very little improvement in peak  $\dot{V}O_2$  compared with adults, and some studies report no change in maximal aerobic power at all. Why is this? It's a difficult question to answer, given that the primary factors effecting changes in aerobic capacity with training are not entirely clear at *any* age. Until recently, spontaneous physical activity during childhood has been thought to be sufficient to elicit the phenotype potential for aerobic fitness.

But, if one could identify the variables that explain the dampened aerobic trainability in children, such insights might be provided.

The current burgeoning interest in this field is being driven, however, by more pragmatic matters. Relationships between

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children's physical activity and physical fitness with health and well being have been most prominent in the public eye, particularly surrounding the presumed contribution of sedentary habits to current childhood obesity. Addressing exercise and health in children is a tricky issue. In general, the well-documented physical health outcomes from exercise (maintained insulin sensitivity, reduced risk of coronary artery disease, hypertension, osteoporosis, etc.) present in the adult years are not observed in children other than in rare cases or as subtle deviations from the normal range. Yet, for the most part, these are life-long processes (accrual of bone density, insulin resistance, atherosclerosis, obesity), with antecedents in the pediatric years. Promoting exercise habits during childhood is thus an intuitively attractive strategy for ameliorating future health risks. Such a strategy necessitates, however, defining means of assessing physical activity, identifying forms, motivation, and amount of exercise necessary for future health benefits, and creating effective, age-appropriate strategies for altering sedentary lifestyles. Such tasks are clearly challenging but bear promise of important population-wide health rewards.

The articles in this mini-series can be examined with these challenges to pediatric exercise scientists in mind. In this issue, Steele et al. (6) begin by examining issues surrounding health risk factors in youth. Cross-sectional and interventional studies in children have, in general, inexplicably failed to demonstrate the expected relationships between individual cardiovascular risk factors (lipid profile, blood pressure) and physical activity that are observed in adults. This review suggests that examining health risk in respect to clustering of such factors may demonstrate a more clear-cut rationale for promoting regular exercise in youth. Such considerations may also provide us with an objective estimate of quantity of activity—very much lacking at present—necessary to minimize risk factors in this age group.

A growing number of elite-level child athletes involved in intensive training and competition has prompted concerns regarding risk that such regimens might pose to the growing organism. Little data are available by which recommendations can be provided for safe (yet effective) training and competition that are specific to the young athlete, however. Traditionally, the child athlete has been considered to be at increased risk for heat injury during training in hot, humid environments, based on certain well-documented variations in physiological responses compared with adults (particularly lower sweating rate). In this issue, Rowland (5) outlines recent data suggesting that despite such physiological differences, the thermoregulatory responses and performance outcomes in children and adults, at least when well hydrated, are no different—and by implication—that children are no more at risk than adults for heat injury. These data teach us that physiological differences related to biological maturation may not necessarily translate into performance outcomes.

Differences in cellular metabolic capacities between children and adults should be expected to be manifest by alterations in substrate utilization during exercise, linked to endocrinologic responses. As Riddell et al. (4) point out, much of the research addressing this issue has supported the concept that the metabolic machine of the child is a high-aerobic, low-glycolytic one, running to a greater extent on fat fuel than adults.

Pediatric exercise scientists are plagued by the difficulty of assessing levels of physical activity in youth. Patterns of activity in children (typically repetitive short, nonsustained bursts) are not only different than adults but change during the course of childhood. Without adequate quantification of activity, efforts to define exercise-health connections or to create useful exercise recommendations in youth are seriously hampered. As a consequence, measurement methodology has become a prime focus for a growing body of pediatric exercise scientists. Corder et al. (1) provide us with an update regarding this critical challenge.

Arterial dysfunction has been identified as a marker of cardiovascular risk in adults, and modification of vascular health via exercise have been described. Now we see studies that are beginning to indicate that here is yet another risk factor with origins early in the life span. Fernhall and Agiovlasitis (2) review current information that tells us that factors such as childhood obesity may adversely influence arterial reactivity and, by implication, future cardiovascular risk in youth. That level of physical activity or fitness in otherwise healthy children might also be related to early progression of vascular features associated with atherosclerosis is a tantalizing, although not yet well documented, possibility.

Behind much of the impetus to improve exercise habits in children is the assumption that risk factors, including level of physical activity itself, are environmentally induced, and thus potentially modifiable. Yet, as Teran-Garcia et al. (7) point out in their review, much data suggest that genetic factors may play an important role in defining the exercise-health link in young people. That such information might be useful in identifying youth a risk remains a potentially exciting but undeveloped concept.

Perhaps the most "solid" line of thinking regarding the link of exercise in children and their future health lies in the prevention of osteoporosis and bone fractures in the elderly by optimizing bone mass during the early years of life. Research information indicating a positive effect of exercise on bone density at the time of peak accrual in childhood and adolescence substantiates this concept. But much more needs to be learned regarding the effects, both quantitative and qualitative, of exercise on bone health in youth. What types, frequency, duration of exercise are best? Maybe animal models, as described in the review by Forwood (3), could give us valuable information.

This series of mini-reviews nicely exemplifies the means by which important insights may be gained from understanding the science of exercise specific to the childhood population. Such insights have potential for promoting health and well being at all ages, assuring the safe competition of young athletes, and understanding basic mechanisms that govern physiological responses to exercise.

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