Coaching Kids Successfully: 100 Years of Motor Development Research

A summary of what sport science has to say about child development, gender differences, and readiness for sports participation.

Over 100 years of motor development research can be summarized by these four guiding principles. Each one of them is important in understanding how track & field athletes develop and what that means for coaches.

1. CHILDREN ARE NOT MINIATURE ADULTS

Children are obviously smaller than adults. But, if you drew a child and adult to the same scale, they would look very different because children have different proportions and composition (Figure 1). Children have relatively larger heads, shorter extremities, and smaller torsos than adults. Compared to an adult, the younger the child is, the greater the difference in proportion (Malina, 1984). At birth, the head is about 25% of total body length: for an adult the head is about 12% of the total body length. Similarly, adult leg length accounts for at least half of the total height; at birth, the legs are about 30% of total body length. The extremities grow faster than the torso which grows faster than the head. Consider how difficult tasks such as balancing and jumping are for young children based on their short legs and large heads!

Running speed increases during childhood because stride length increases. The stride increases as the legs grow longer and stronger and as the pattern becomes more efficient. As children progress, they take longer steps or strides and stay in the air longer during flight phase. When young children are asked to run faster, they generally take quicker steps—often in place. Rather than saying "Run faster," coaches should say, "Take bigger steps."

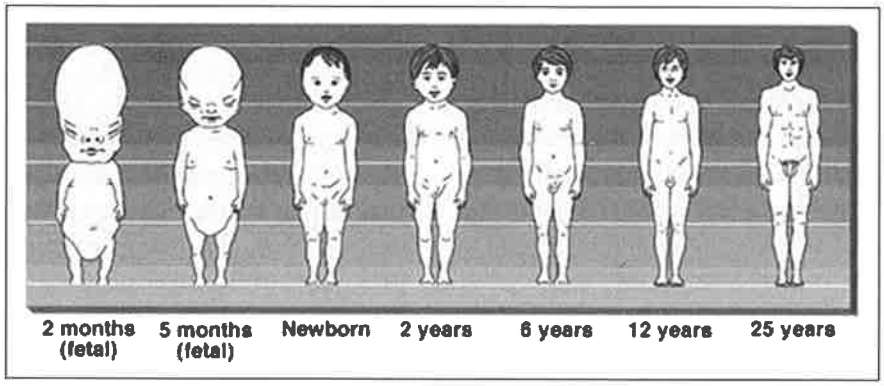

Figure 1: Changes in form and proportion of the human body during fetal and postnal life. From Malina, R.M. (1984). Physical growth and maturation. In *Motor Development During Childhood and Adolescence.* Minneapolis, MN: Burgess.

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The fastest runners use their arms to pull themselves forward. The arms move in opposition, with the upper arm (humerus) driving forward forcefully. In young children the arms may be stationary or may flail in no particular pattern. As skill increases, the arms begin to rotate in opposition, but this movement is generated by a twisting of the spin rather than by conscious movement of the humerus.

Skills change systematically for children from two years of age through elementary school. For example, you would expect to see a 2-year-old run with arms high, extended, and straight (picture Frankenstein walking), feet shoulder-width apart, and a short, flat-footed step. You would not expect to see this kind of movement in an adolescent or an adult.

Why do these skills change? Some change is caused by growth, for example. As legs get relatively longer, the stride length increases. Similarly, as relative head size decreases balance is less of a problem. Also, the central nervous system is maturing with increase in synapses and myelination and better integration of information. These allow better motor control with maturation.

The biological changes work with practice to improve the execution of skills. The developmentally appropriate track & field program is designed to recognize individual differences in rate of change in the fundamental skills and to capitalize on the consistency of the order of these changes. Coaches should plan for the average and then accommodate variation by individualizing up or down within each practice.

The body makes two major adjustments during aerobic exercise such as running. First, muscles do their work during exercise by using fuel (food) and oxygen. The more intense the work is, the more the body uses oxygen and fuel. Generally, respiration and heart rate increase with the intensity of exercise. At some point, the circulatory system can no longer keep up in delivering oxygen and removing waste. Fatigue sets in quickly at that point, and work must be stopped or substantially reduced.

The second effect of exercise is the production of heat. The body dissipates some heat by breathing but removes most of it by sweating. The circulatory system increases blood flow to the skin, and the heat is lost by radiation and evaporation of sweat. Coaches should be conscious of this process, particularly during hot and dry weather, when excessive sweating and evaporation may produce a loss in total body fluid that can result in dehydration.

People of all ages are susceptible to dehydration. Always permit children to drink as much water as they want to during and after training. Water is as good a fluid replacement as any of the advertised commercial products. The USDA warns that children do not drink enough water regardless of whether they are exercising or not, so encouraging children to drink water meets the demands of training and a more general nutritional need.

Children and adults handle heat and oxygen production differently during training. Children have higher resting heart rates than adults; at rest, children's hearts are working harder than adult's hearts. For example, a 6-year old boy has a resting heart rate of 86 beats per minute (a girl's at the same age would be 88); by age 13, his resting heart rate would be 66 (hers would be 70). The maximum heart rate for a 6-year-old is 215, as compared with 201 for a 13-year-old.

Anaerobic power, the ability to work without oxygen, is also lower in children than in adults. This is because children have less of an important enzyme (phosphofructokinase or PFK) in their muscles; this enzyme allows the muscles to work without oxygen. Children produce more PFK after puberty. Anaerobic power is important in activities such as sprinting.

Children also have a lower hemoglobin concentration in the blood than adults. Hemoglobin is the part of blood that carries oxygen to the working muscles (e.g., in the heart and legs), so children transport less oxygen per unit of blood than adults. This means that children can do less work than adults. Hemoglobin content in the blood increases at puberty; however, the increase is not as great in women as it is in men.

Children become more fit as a result of fitness training but the responses to training tend to be lower in children than in adults for several reasons:

- Children tend to be more fit at the onset, so training results in less improvement
- Children have higher resting and maximum heart rates, which limits the intensity of training
- Children have less hemoglobin, which limits maximal oxygen uptake.

During exercise, adults are working at closer to their maximum capacity (aerobic capacity) for oxygen delivery than during rest. Children work close to the maximum aerobic capacity all of the time, so they benefit less from cardiovascular training and they fatigue more rapidly during exercise (Bar-Or, 1983). Much of the improvement is attributable to improved technique, for example pacing themselves when they are running a mile.

Exercise training does produce

three benefits for children and adults. First, hearts become stronger as a result of training as stroke volume (the amount of blood the heart can pump in one beat) increases. Second, more capillaries develop as a result of training, which provides a better supply of blood to the heart and working muscles. Third, better extraction of oxygen from blood leads to improved enzymatic reactions.

Weight training for children is a controversial topic. The two most important issues are cost-benefit trade-off and potential for injuries. Weight training takes a lot of time, and, for prepubescent children, the gains are small (Faigenbaum, Westcott, Loud, and Long (1999). Therefore, the time might better spent doing something else. As children are growing, there is risk of injury; however, low-intensity (low-weight) training regimens can be safe when the coach is certified to coach young children.

Children are not miniature adults—if they were, imagine how much easier coaching children would be! Childhood lasts for about 12 years and is followed by adolescence, which continues for several more years. There is a reason for this extended period of development. Development is a process that takes time and nurturing in order to reach a successful conclusion.

2. BOYS AND GIRLS ARE MORE ALIKE THAN DIFFERENT

The bodies of girls and boys are more alike than different during childhood: however, differences emerge during puberty that give males a performance advantage in certain activities. At puberty, or about 12 to 13 years of age, the growth of girls slows dramatically and then stops completely at about 15 to 16 years of age (Figure 2). Males reach puberty about two years later than girls and therefore reach their adult size at about 17 to 19 years of age, thus growing two years longer than girls (Malina, 1984).

Prior to puberty, boys and girls are very similar in height and weight: in fact, in elementary school the advantage may go to the earliest maturing girls, who are likely to be taller than everyone else. What does this mean for grouping athletes? Take care when grouping children. Optimally, children of similar skill should work together because it can be safer and motivations for success peaks when the challenge is appropriate. For young athletes, the motivation to learn and master skills is driven by two questions: Am I getting better? Am I normal? Those who answer these questions positively are likely to continue practicing and improving (Scanlan, 1995).

Coaches should identify the following problems in running for remediation: arms swinging too much or too little, crossing the midline of the body, or flailing; feet toeing in or out or producing flat-footed steps; or trunk leaning too far forward and twisting. The range of performances on most motor skills during elementary school is greater within a gender than the differences between genders.

The average running speed for girls and boys is nearly the same during elementary school. Girls demonstrate the mature running form described earlier at a slightly earlier age than boys; most children demonstrate a mature form by 7 years of age. At puberty, boys continue to increase running speed, whereas girls' running speed tends to level off or decreases slightly (Figure 3).

The differences during elementary school are attributed to different treatment of boys and girls. For example, boys tend to have great opportunity, expectation, and encouragement—but there is no biological reason to expect differences during elementary school. Therefore coaches need to provide equal opportunity, have similar expectations, and encourage boys and girls equally.

Respiration response is the

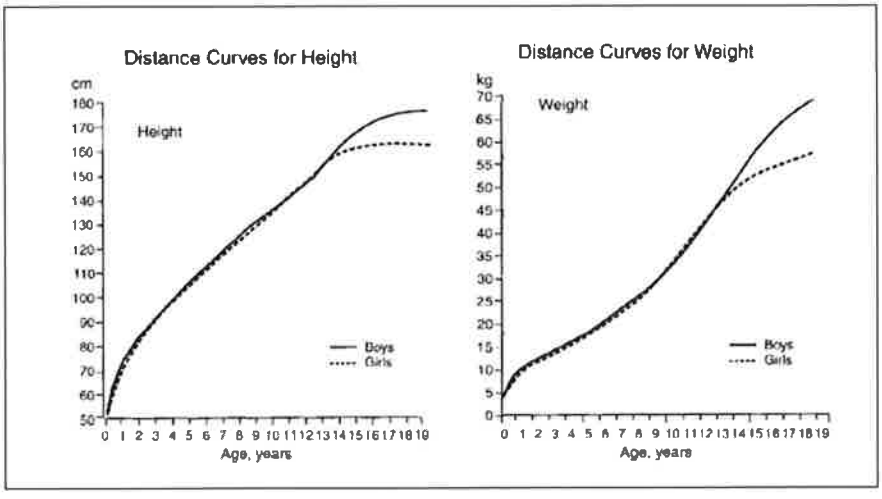

Figure 2: Average height and weight curves for American boys and girls. Malina, R.M. (1984). Physical growth and maturation. In *Motor Development During Childhood and Adolescence. Minneapolis*, MN: Burgess.

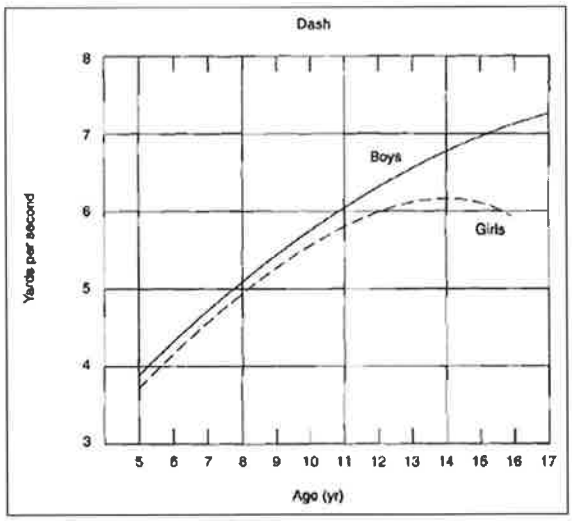

Figure 3: Running speed during childhood. From Espenschade, A. and Eckert, H. (1974). Motor development. *Science and Medicine of Exercise and Sport* (2nd ed.). New York, NY: Harper and Howl.

same for girls and boys. As children train, respiration rate can provide information about level of fatigue. For example, a child who can talk easily while jogging is probably breathing steadily; when respiration interferes with talking, the child is moving toward fatigue. Although this article has spent some time discussing gender differences, the fact is that all children are more alike than different. The focus of this principle is, of course, inclusion—whether the difference between two children is race, ethnicity, culture, gender, disability, or socioeconomic status.

3. GOOD THINGS ARE EARNED

Figure 4 compares overhand throwing by girls and boys using effect sizes. An effect size of .5 is moderate, and .8 is large. By using effect sizes, this figure shows the results of a large number of studies (so not just one sample of throwers). Most of us are aware what the phrase "throws like a girl" means: The throw is a slow, weak lower-arm motion accompanied by a short step on the same foot as the throwing hand. The arm motion often looks like a dart throw. Contrast this motion with the typical throw for a boy, which is vigorous: the entire body coils backward; as a large step is taken forward, the hips rotate forward, followed by the shoulder, then the upper arm, and finally the lower arm and hand. The throw ends with the body leaning forward over the stepping leg.

Why these differences in throwing motion? A few theories exist on this, the most likely is that the sociocultural importance of throwing well for males creates an atmosphere in which girls who throw poorly are allowed to continue to throw poorly and boys who throw poorly are trained until they throw well. The fact remains that training reduces those differences but does not eliminate them. All children should be expected to throw with an efficient pattern. As boys and girls practice, encourage them to take a large step, throwing with force. Do not worry about accuracy until a mature pattern is well established (5 for boys, 8 for girls).

Table 1 shows how both males and females improved in the 400-meter dash over this 70-year span although females clearly improved more. Why? Opportunity, expectations, and encouragement are much different today than in 1923 for females. World-class athletes are all motivated, well trained, and well coached. At this level, males and females differ by about 10% in performance—this likely represents a true biological difference. The differences within a gender are also large; that is, some males are much better at a particular activity than other males, and likewise some females are much better at a particular activity than other females. Thus, depending on the particular track & field event or task, biological and inherited factors make a relatively small contribution.

Sportswriters, broadcasters, and parents often use terms such as

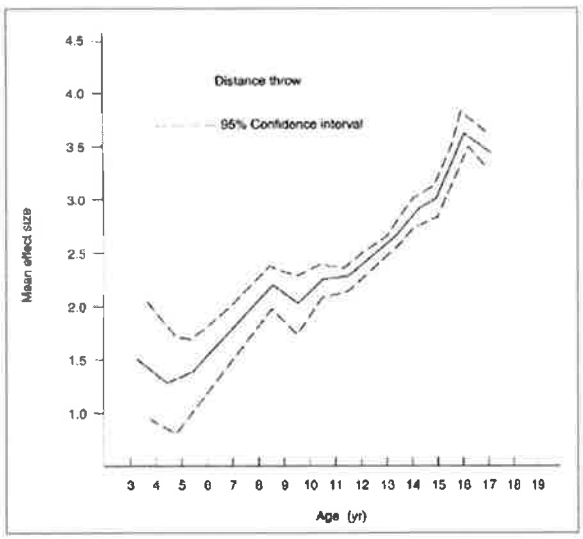

Figure 4: Effect size for overarm throwing (gender differences increase with age). From Thomas, J.R. and French, K.E. (1985). Gender differences across age in motor performance; A meta-analysis. *Psychological Bulletin*, 98, 260-282.

Table 1: Sex Differences in World-Record Performance in Track (400 meters)

Record	Women's 400m Record (sec)	Men's 400m Record (Sec)	% Difference
1923	60.50	47.10*	28
1933	56.50	46.10*	18
1943	56.50	46.00	19
1953	55.70	45.70	18
1963	51.90	44.60	14
1973	51.00	43.86	14
1983	47.99	43.71	8
1993	47.60	43.29	9
2003	47.60	43.18	9

*Times extrapolated based on conversion from yards to meters.
Percentage difference = men's speed – woman's speed/men's speed x 100

"natural athlete" to describe superstars. Less often they use the terms "hard worker" or "dedicated". When working with young athletes, it is hard work and practice that should be emphasized, because that is within their control. The characteristics leading to performance are biological (physical size), psychological (motivation) and cognitive (knowledge and practice).

Many professional athletes report being discouraged during childhood and adolescence. However, they persisted and became successful. This is likely attributable to the relative age effect—which means the oldest athletes in youth sport are identified as the best and the youngest and least mature as the poorest (Thomas & French, 1999). The relative age effect was discovered by examining the age of players on youth all-star teams, where the players with birthdays just after the cut-off date were most frequently all-stars. Similarly, in baseball the skilled position players (pitcher, catcher, and shortstop) are all about a year older than outfielders and bench players.

If environment did not matter, practice would be unnecessary—as would coaches. If innate 'talent' is all that matters, practice becomes unimportant. A coach's training philosophy is based on the notion that environment (and nurturing) does matter. The foundation for youth sport is effort, practice, and improvement. Motor development research suggests that good things do come to those who work hard.

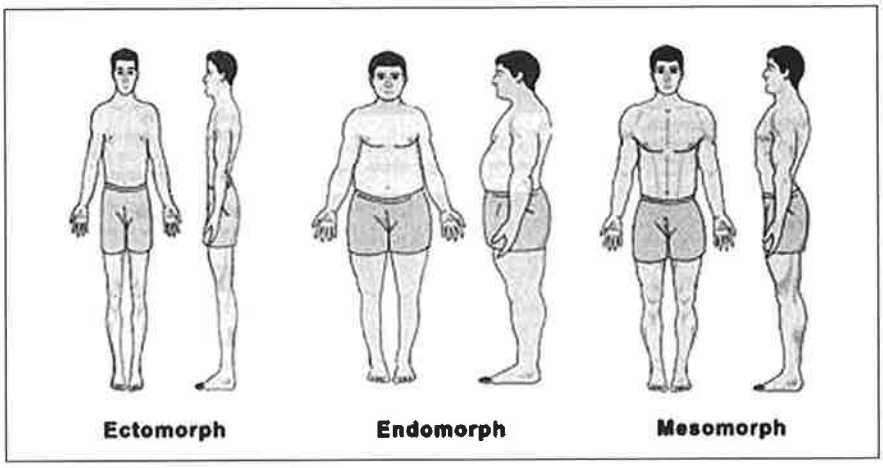

Figure 5: The three types of body types.

4. NO BODY (NOBODY) IS PERFECT

Effective coaches embrace the uniqueness of each athlete. There is variability between athletes and within each athlete. The coach's job is to leverage the potential of each athlete by understanding how children are different, how they develop, and how they learn.

Physique is described by three body shapes (Figure 5). The apple-or pear-shaped body (endomorph), the muscular body (mesomorph), and the linear body (ectomorph). Most people are a combination of two.

Early maturing females tend to be endomorphs, and later maturing children tend to be ectomorphs. Individuals usually have little control over their physique. Physical activity and healthy eating allow people to make the most of their physique. As a coach you can help children understand that a) there is no ideal body shape, b) we are all more alike than different and c) all of us can have healthy bodies. The emphasis on body type creates two additional problems:

- It shifts the focus away from athletic improvement, a positive behavior, and toward body weight
- In some people, it may encourage unhealthy eating and a desire to be "too thin."

What is also important for children and adolescents to understand is that larger bones and a healthy amount of muscle are good. Their participation in track & field can

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"That's it, go home. You do not look right," and I would do that. I could walk out there and tell them. I do not want you to do that. Change the workout totally. You have to stay in tune with your athletes. And what they look like and what they feel like. Carl was great for feeling. He'd tell me how he felt. And I listened to him; I listened to the athlete.

You are one of the founding fathers of coaching education and coached a number of the dominant sprinters and jumpers of the last 25 years. What do you feel has been your greatest contribution to sport or what do you hope to be seen as?

TT: I don't want to be judged by the people I produced. I want to be judged by what I know. How I teach. It does not make any difference if it is Carl or anybody . . . I want to be known as a person who teaches, a good teacher. That's it. I helped the athlete, I helped Carl and those guys get to where they wanted to be. I helped them by being, I thought, a good teacher. And that is what I like to do.

In retrospect what has been your greatest memory?

TT: (pauses) Most people would think the '84 Games would be the greatest memory, but no. It was exciting but I was so relieved when it was over with. The pressure was tremendous. I mean telling Carl exactly what to do, not meeting with the press a lot. Concentrate on what you were doing. Don't get involved with the spectators. Do exactly what we practiced. Stuff like that. Being there to help him out. Whatever.

Greatest memory?

I think I have told people this before but I'll tell it again. My greatest memory is getting back to practice and doing things better. And having athletes respond to it and making them better. That is the thrill I get out of coaching. The thrill I got out of coaching was helping those athletes get there. It was not them getting medals of anything like that. They got the medals, they ran, they did it, but the thrill I got was helping them get there. And making it come alive. They had some idea of what they were doing and they actually did it to be good. And it was not guesswork, it was not some magical thing. This is what you do, you go out and do it and you will be successful. That's what I really enjoyed.

With all the success you've had have you ever given much thought why God or whoever picked you to be in this place? Why it happened to you and I don't mean that in a bad way. . .

TT: No, I understand, I understand what you are doing. Well, (pauses) I guess I was just meant to coach. I don't think I could do anything else successfully. I guess from the very beginning God gave me the ability to coach. And I've really enjoyed it. It has just been a passion with me to coach and teach young kids, and help coaches. But God has a lot to do with it in my opinion. I think that there is a design and he gave me this ability. Yup.

Thank you.

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help by increasing muscle and bone growth, and reducing fat. Although a moderate level of skill is important in order to enjoy most sports, you do not have to be an expert to enjoy track & field. The task for youth coaches is to provide all children with a variety of skills so they can choose events in which they can enjoy success. Success does not mean winning; success means participating regularly and performing effectively relative to skill level and expectations.

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