Principles of Motor Development for Elementary School Physical Education

Katherine Thomas Thomas
Jerry R. Thomas
Iowa State University

The Elementary School Journal
Volume 108, Number 3

0013-5984/2008/10803-0004$10.00

Abstract

Four principles are drawn from approximately 100 years of research in the area of motor development. The principles are (1) children are not miniature adults, (2) boys and girls (children) are more alike than different, (3) good things are earned, and (4) no body (nobody) is perfect. Five sections of this article introduce some of the major assertions warranted by that research organized around the principles. The sections are Physical Growth and Maturation, Motor Skills, Physical Activity, Psychological Factors, and Developmental Skill Acquisition. Quality physical education programs are evidence based; thus when observing such programs one can see the principles in action. The result is a developmentally appropriate program based on the 3 characteristics of developmentally appropriate physical education: children are more alike than different, children progress through the same stages of development in the same order, and the rate of those developments varies among children.

In the last decade, physical activity has come to be regarded as an important factor in public health. Its role in preventing obesity, diabetes, cardiovascular disease, and other forms of ill health is both well documented and widely recognized (Dietz, 2004). In consequence, the health benefits associated with physically active lifestyles are driving national efforts to be certain that children are physically active and will remain active as adults.

Physical education is one venue where children experience physical activity and where all children have an opportunity to learn the knowledge, skills, and behaviors required to become physically active adults (American Academy of Pediatrics, 2006). That fact has given new visibility to ele-

mentary school physical education, inviting a degree of attention not previously awarded in its traditional role as a somewhat ancillary "special subject." Public health, however, is not the only reason to believe that physical education can play a vital part in children's education.

High-quality physical education programs offer important contributions in several other vital areas of child development. First, physical activity in the form of sport is a central aspect of U.S. culture, as evidenced by the amount of attention it is given in the media, its place in the national economy, and the meaningful role it plays in the lives of many citizens. Enjoying sport as a participant or spectator allows individuals to fully share the experience of being Americans. Accordingly, that adds importance to the fact that it is through elementary school physical education that children receive their first systematic opportunity to learn about sport.

Second, for many people the importance of physical activity rests less in the rituals of competitive sport and much more in the daily satisfactions of living a vigorously active physical life. Whether that takes the form of solitary exercise such as walking or gardening, or more social physical activities such as square dancing and aerobics classes, the personal meanings may be profound and the gratification great. And, again, the initial foundations for active living are laid through sound instruction and positive experiences in the early years of elementary school.

Third, physical activity plays a critical role in the process of children's growth and development. Physical education offers an invaluable opportunity to stimulate, guide, shape, and monitor the unfolding of each child's physical capacities (strength, speed, and flexibility) and expanding repertoire of motor skills.

Fortunately, whether the purpose of physical activity and physical education during childhood is to encourage healthy living, to serve as a vehicle for the transmission of culture, or to assure normal development, the same set of principles for designing a curriculum of movement experiences will apply.

The principles of developmentally appropriate movement experiences are drawn from approximately 100 years of research in the area of motor development. In the next five sections of this article, our task is to introduce some of the major assertions warranted by that research. We have been selective in citing resources from that knowledge base and in most instances have used physical education exemplars to illustrate major concepts. It will require little imagination for the reader to apply the same set of principles to other physical activity venues such as sport, leisure activity, and exercise.

Physical Growth and Maturation

During the elementary school years children's bodies undergo dramatic changes. Some of those are perfectly obvious, but others are subtle and invisible. Physical growth and some aspects of maturation are observable biological characteristics. Physical growth, for example, is both obvious to the eye and easily measurable in centimeters/inches and kilograms/pounds. In contrast, the hormonal shifts and final steps in cellular differentiation that mark full physical maturity are not directly observable.

Because growth and maturation are related through the agency of their underlying mechanisms, they often move in parallel. The prepubescent growth spurt experienced by boys and girls between ages 9 and 11 couples obvious changes in height, weight, body topography, and the distribution of hair with far more subtle internal changes that mark the achievement of puberty.

Puberty is controlled by a biological time clock and is variable among children (Malina, 1984). As facial and body hair appear on young males and breasts develop on pubescent females we know that the process of sexual maturation has begun. What we cannot see, however, is when sexual

maturation is attained. For females, the onset of menstruation is used as a marker of sexual maturation, but that event does not necessarily mean reproductive capacity has been reached. Further, for males there is no visibly clear and entirely reliable marker for that significant step in the process of maturation. Given, then, the complexity and subtlety of physical growth and maturation, several principles have evolved that offer some useful guidance for thinking about how those factors relate to physical education.

Principle 1: Children Are Not Miniature Adults

Children are smaller than adults, but if we drew a child and an adult to the same scale, they would look very different. That is because children's bodies have vastly different proportions and composition.

Children have relatively larger heads, shorter extremities, and smaller torsos than adults (Martorell, Malina, Castillo, Mendoza, & Pawson, 1988). When compared to an adult, the younger the child, the greater the difference in proportion. Progress toward the adult form is gradual across childhood and adolescence. At birth the head is about 25% of the total body length, whereas for an adult the head is about 12% of the total height. Similarly, adult leg length accounts for at least half of the total height, but at birth the legs are about 30% of total body length.

Thus, if all of our body parts grew at the same rate during childhood, adults would have the same proportions as infants. So, we can see that our extremities grow faster than our torso, which grows faster than our heads. All of this has complex ramifications for the development of motor capacities. Consider, for example, how difficult tasks like balancing and jumping are for young children with their disproportionately short legs and large heads.

Activities and equipment must be carefully selected to meet the needs of each developmental level. For example, using special wedge-shaped mats for gymnastics helps young children overcome the mechanical disadvantages presented by their short arms and legs when learning the simple rolls and turns of tumbling. Professional physical educators understand how to select activities that are appropriate for pupils of each age, developmental level, and experiential background.

Principle 2: Boys and Girls Are More Alike Than Different

The bodies of girls and boys are more alike than different during childhood; however, differences do emerge during puberty that give males a performance advantage in certain activities after puberty (Malina, Bouchard, & Bar-Or, 2004). At puberty, or about 12–13 years of age, the growth of girls slows dramatically and will stop completely at about 15–16 years of age. Males reach puberty about 2 years later than girls and therefore reach their adult size at about 17–19 years of age, thus growing 2 years longer than girls. This means boys are typically taller, have longer legs (and arms), and broader shoulders. Longer levers (arms, shoulder girth, and legs) provide mechanical advantages for males in many tasks. Girls who mature later also typically have longer legs and a performance advantage over earlier-maturing peers.

Prior to puberty, however, boys and girls are similar in height and leg length. In fact, in elementary school the physical advantages may go to the earliest-maturing girls, who are likely to be taller than everyone else. What this suggests is that care must be taken when grouping students for participation in physical education lessons.

For some tasks, children can be distributed randomly into learning and practice groups because differences among them are either small or simply not critical to performance. In other tasks, however, learning is optimized if students with similar ability can work together. That means effective grouping cannot be based on an arbitrary

characteristic, irrespective of the convenience offered to the teacher by doing so.

In elementary school physical education, that same caution concerning grouping applies with particular reference to gender. Sorting pupils by previous experience, level of skill, or even physical size may be far more functional for effective instruction than is the use of gender. For example, the distribution curves for the motor ability and skill achievement of boys and girls in the primary grades overlap to such an extent that they appear virtually congruent. If ability is important for effective learning, groups comprised exclusively of either gender will produce the disadvantage of mixing both high- and low-skilled pupils.

Principle 3: Good Things Are Earned

Bones increase in length, circumference, breadth, and density during childhood. This growth is partially a result of weight-bearing physical activity and the presence of an adequate supply of dietary calcium. Bailey (2000) estimates that 1.5 hours daily of weight-bearing physical activity during growth is necessary to assure bone density. Increased physical activity during childhood is associated with a more robust skeleton (e.g., wider shoulders), increased bone mineralization, slightly increased height, less fat, and more muscle (Broekoff, 1985).

More muscle is important because muscle, like a machine, uses energy, which means that less is stored as fat. Less fat has particular relevance because increased body fat is associated with Type 2 diabetes during childhood. In addition, having more muscle is associated with better performance of many motor skills, greater physical fitness, and better health outcomes.

During puberty, girls gain fat with the onset of menstruation and the increase in estrogen associated with sexual maturation. Unfortunately, for many girls puberty is also a time of decreased physical activity, so fat increases more than is necessary and healthy. Boys typically maintain just under 15% body fat during childhood and adolescence, whereas girls increase from 15% to 25% during the same ages (Morrow, Jackson, Disch, & Mood, 2005). Optimally, girls should maintain 15%–24% body fat and boys should stay below 19% (American College of Sports Medicine, 1995).

The American College of Sports Medicine guidelines for body fat have direct implications for physical education. The dimensions of the recently declared "obesity epidemic" suggest that the accumulation of too much body fat is not a condition limited to adolescents and adults. It is a process that is well under way among elementary school children (U.S. Department of Health and Human Services, 2001).

Physical education classes provide an opportunity to learn about muscle and bone growth and to engage in activities that will keep bones healthy and muscles strong. To strengthen any muscle group, there are multiple exercises from which to choose. For example, if a child cannot do a pull-up, a modified or assisted pull-up can be substituted. With use, bones and muscles become stronger, so the critical issue is to find an activity that works to produce those results. Any focus on a child's failure to accomplish a particular exercise task is unnecessary and inappropriate. For that reason, physical education teachers should vary both warm-up and fitness activities to maintain interest and modify motor skills and practice formats so all children can succeed and improve.

Principle 4: No Body Is Perfect

Physique is described in three body shapes: the apple/pear (endomorph), muscular (mesomorph), and linear (ectomorph) (Carter, 1980). Many of us have balanced physiques, meaning that we are a bit of each primary shape. Early-maturing females tend to be endomorphs, early-maturing males tend to be mesomorphs, and later-maturing children tend to be ectomorphs.

Because maturation is inherited, individuals have little control over the broad outlines of their physique. It is physical ac-

tivity and healthy eating that allow us to make the most of the bodies we inherit. A variety of positive experiences during physical education, however, can encourage children to find activities that are enjoyable and well suited to their physical attributes. Of equal importance, physical education teachers can help children understand that there is no ideal body shape, that we are more alike than different, and that all of us can have healthy bodies.

Physical educators also can help children understand changes that occur in their bodies during puberty, distinguish among things that can be changed (e.g., proportion of body fat) and those that cannot (e.g., stature), and accept responsibility for maintaining a healthy body. So, although the movement of children is the signature characteristic of physical education classes, the integration of knowledge about health and growth should be part of a complete elementary school curriculum in the gymnasium.

Motor Skills

From the moment of birth, the child's motor behaviors are used for a variety of assessment purposes. Pediatricians use the earliest movements, reflexes, reactions, and motor milestones to determine the soundness of the central nervous system and the progress of development. Years later, the same children will use the performance of fundamental motor skills to judge each other.

The acquisition of rudimentary and fundamental motor skills allows children to explore their environment, exert their expanding independence, and socialize through the sharing of physical activity experiences. Over time, increasingly specialized skills allow children to participate in activities with their families and friends, and, ultimately, to engage in both recreational activities and competitive games.

Principle 1: Children Are Not Miniature Adults

Skills generally fall into three categories: (*a*) locomotor (moving from one place to another), (*b*) nonlocomotor (staying in one place while moving), and (*c*) manipulative (working with an object). Locomotor (walking, running, jumping, sliding, galloping, hopping, and skipping) and manipulative skills (throwing, catching, kicking, and striking) evolve systematically from 2 years of age through early elementary school (Roberton, 1984).

For example, we would expect to see a 2-year-old run with arms high, extended, and straight (i.e., picture Frankenstein's monster walking), feet shoulder distance apart, with a short, flat-footed step. We would not expect to see that sort of gait in an adolescent or adult. All such fundamental skills follow a pattern of developmental change from the rudimentary form to the adult form. All healthy children typically progress through the same stages but may do so at different rates.

The underlying processes that produce this evolution of motor skills are not immediately evident. Several factors influence both the changes and the early differences observable in the pace of change among children. Some changes are due to growth; for example, as legs get relatively longer, the stride length in walking (and running) increases. Similarly, as the relative head size decreases and balance is less of a problem, the torso and head move more freely and by doing so facilitate increasingly complex performances. Also, as muscle mass and strength develop, greater stride length can be supported in both walking and running. Thus, growth itself explains a substantial part of the improvement in fundamental motor skills.

Meanwhile, the central nervous system is maturing in several dimensions; there are increases in the number of synapses, development of more complete myelination of nerve trunks, and better central integration of kinesthetic information. These developments allow better motor control as age increases during childhood. All of these biological changes work with opportunities for practice to improve the execution of skills.

The vertical alignment of a developmentally appropriate physical education 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. Teachers plan for the average and accommodate variation by individualizing up or down within the lesson.

This process is evident when observing the differences in lessons about the same concept at two grade levels. For example, when teaching a skill like throwing to younger children (e.g., first grade), there may not be a target, or the target is large. For older children (e.g., fourth grade), however, the teacher may use a smaller target or have children throw to a partner. In the case of jumping, younger children often practice from a stationary standing position, whereas older children can combine jumping with locomotor skills like running.

Principle 2: Boys and Girls Are More Alike Than Different

The difference between boys' and girls' performance of motor skills such as running, jumping, and swimming is very small before puberty (Thomas & French, 1985). The range of performance on most skills during elementary school is greater within a gender than between the genders. In adults, where the biological difference between males and females is fully developed, the difference explained by biology is about 10% (Ransdell & Wells, 1999). The gender difference between world-class atheletes based on Olympic and world records is 10% or less, yet the difference between the mean performance levels of average males and females is often large—for throwing it has been observed at 57% (Nelson, Thomas, Nelson, & Abraham, 1986). Why?

Opportunity, practice, and encouragement are the prime environmental variables that explain gender-based motor-performance differences in the average population. The one skill, throwing, for which large gender differences are commonly observed during childhood helps us to understand these environmental factors. Substantial differences in throwing are found between boys and girls as young as 4 years of age in most cultures worldwide (Thomas & Marzke, 1992).

Unfortunately, most Americans can recognize when a child "throws like a girl," a pattern of movement in which there is no step forward with the opposite foot, the arm motion resembles a dart throw in which the object is pushed straight ahead rather than being whipped around at the end of the arm, and the torso is motionless rather than rotating. The outcome of such a toss is either an arching or a flat trajectory in which the ball travels little distance forward.

Further, we can predict what would happen if a father were to observe his little girl throwing that way. He would likely think, "Well, she is a girl." If his son threw using the same motion, however, we would predict an intervention and a different result. Practice with dad until throwing improves is just one of the many gender inequities of opportunity, practice, and encouragement that produce early and substantial differences in the performance of boys and girls.

Since the time when Title IX imposed federal mandates, opportunities to learn and perform have opened dramatically for elite female athletes. For the typical female, however, things remain much the same. Impoverished opportunities and low expectations during childhood surely have negative consequences for many females as they reach puberty. The decrease in physical activity observed among adolescent girls has its origins in culture rather than biology.

High-quality elementary school physical education is organized so that all children have an equal opportunity to practice important motor skills and the encouragement required to master them. Students have the guidance of a teacher who understands that gender differences should be very small or even nonexistent. Motor development research suggests that boys and

girls should have the same physical education experience in terms of curriculum, expectations for learning, and assessment of achievement.

Principle 3: Good Things Are Earned

Earlier in this section we discussed skills that children in every culture perform (e.g., fundamental skills that are grounded in simple reflexive reactions). Conversely, skills that are specific to either a culture or a peer group are called ontogenetic skills. Many of these are extensions of or variations on fundamental skills. For example, bowling a cricket ball and pitching a baseball are extensions of throwing, but the skills are very different in execution.

These activity-specific skills—including dance and gymnastics, team and individual sports, and an enormous variety of exercise activities ranging from calisthenics and swimming to rollerblading and fly casting—do not develop naturally. They are learned as a result of effortful practice and, for fortunate children, through the agency of systematic instruction. Consider the challenge of an infant beginning to walk; infants master this fundamental skill without lessons or coaching. Contrast that with the effort, time, and money spent trying to learn to strike a golf ball! That contrast demonstrates the centrality of instruction and practice in the acquisition of ontogenetic skills.

A developmentally appropriate physical education curriculum in the elementary school begins with fundamental skills, builds to transitional skills, and then provides all children the opportunity to begin learning ontogenetic skills. For many children, especially low-income students, physical education may be the only opportunity to learn these skills. For that reason, skill practice, rules and strategy, and an introduction to opportunities for participation in the community are important components of the elementary school physical education curriculum. Although children may play at recess, and some may participate in after-school programs or in community-based youth sport, physical education is the only place where all children are systematically exposed to these important activity-specific skills.

Principle 4: No Body Is Perfect

As children get older, performance on motor skills improves in process and outcome. Process is the way the skill looks and how closely this performance resembles the "ideal." Outcome (defined as the result produced by a motor performance) is usually measured in speed, distance, or accuracy. With practice and instruction, most children can master a basic repertoire of movement skills (e.g., manipulative and locomotor skills). If they do not have the advantage of such assistance and are simply left to their own devices, children's motor skills may improve up to a point, but then progress typically slows or stops (Haubenstricker & Seefeldt, 1986). At that point, the combination of guided practice and accurate feedback from an external source is necessary for improvement to continue.

Because opportunities for practice and feedback are both critical and not uniformly available, it is inevitable that children will vary greatly in the quality of their motor-skill performances. Such differentials are entirely normal, but they also can be misleading to children—and to adults.

Skill varies within a child, so the child may be very good at kicking due to soccer practice but not be as proficient at throwing because that skill is not used in soccer. This, of course, means that the mastery of individual skills also will vary among children. Thus, one child may have outstanding skills in soccer, whereas another is superior at baseball. Most children (and many adults) believe that these differences are due to inherent characteristics—talent—when, in fact, most are due to learning (e.g., opportunities for instruction, practice, and feedback).

Physical Activity

Unfortunately, there is ample evidence that many children do not maintain an adequate level of physical activity. The Centers for Disease Control and Prevention (2000) has established the national goal for children as a minimum of 1 hour of physical activity on most days of the week. A realistic example of the degree of compliance with that goal can be seen in the report from a recent phone survey (Centers for Disease Control and Prevention [CDC], 2003). A sample of 9- to 13-year-old males and females (children in the fourth through eighth grades) were asked whether they had participated in any organized sport or free-time physical activity during the previous week. Only 38% of the children reported engaging in sport, and 23% indicated they had engaged in neither sport nor free-time activity. Based on data such as those, it is reasonable to assume that many children do not obtain even the minimum recommended amount of physical activity (CDC, 2006).

Principle 1: Children Are Not Miniature Adults

By their nature, children are physically active, but much of their activity is produced in short bursts rather than in sustained bouts. That characteristic pattern reflects fundamental physiological differences between children and adults. When adults move from rest to vigorous exercise, their cardiovascular systems can make substantial adjustments that deliver more oxygen to the working muscles. Adults have greater capacity to meet the demands of exercise stress and therefore more endurance for sustained physical activity than do children. Further, adult bodies respond to repeated bouts of exercise with the training effect of increased cardiovascular efficiency.

In contrast, children's systems for delivering oxygen are continuously operating at levels that are much closer to their maximum capacity. Accordingly, they reach their maximum more quickly, fatigue more rapidly, and do not acquire the same training benefits from repeated short bouts of exertion (Bar-Or, 1983).

With regular opportunities to practice a physical activity, children do show some performance improvements in the areas of flexibility, strength, and muscular endurance, but a significant part of those gains often can be attributed to improvements in technique. This is true, for example, when simply learning how to pace themselves produces dramatic early improvements in time for the mile run.

Children often "exercise" in natural settings by playing backyard games after school and riding bikes. In that free form of physical exertion, the typical child will be significantly more active on a Saturday than on a school day (here, "significantly" may mean as much as 5 hours of physical activity on a Saturday compared to 1 hour on a typical Wednesday). In recent years, however, the weekly number of entirely sedentary days has been expanding from the occasional school day to virtually every day.

On a casual visit, physical education classes may look like fun and games rather than a day at the fitness center. That immediate impression is no accident. For reasons that will be obvious to all, enjoyment is one of the most important characteristics of quality physical education programs (Wechsler, McKenna, Lee, & Dietz, 2004). While having fun, children will be breathing hard, sweating, improving their level of fitness, learning skills, and preparing the dispositions required to sustain the lifelong habit of vigorous physical activity.

Principle 2: Boys and Girls Are More Alike Than Different

Several measures of muscle strength and endurance demonstrate this principle, for example, sit-ups, vertical jump, and grip strength (Thomas & French, 1985). On these tasks, boys and girls have similar average scores and ranges of scores during childhood. At puberty, most muscle strength and endurance tasks begin to favor boys due to the increase in testosterone, a hormone as-

sociated with increased muscle mass and sexual maturation in males.

Even before puberty, upper-body strength is often lower in girls as demonstrated in tasks such as push-ups and chin-ups. Elementary-school-age boys typically can complete between one and 10 chin-ups, whereas girls complete 0–1 at the same ages. There is considerable overlap between the performance distributions, however, and for both genders poor performance is largely due to lack of practice rather than innate factors of growth and development.

Principle 3: Good Things Are Earned

Fitness is an outcome of physical activity. Children improve on fitness tests from fall to spring in part because they grow, but their scores also rise because of the practice associated with physical education classes and experience with testing itself. Children often perform more poorly on fitness tests in the fall than they did in the previous spring, suggesting the loss is due to both their more sedentary vacation lives and the value of physical education classes as a source of fitness training during the school year.

Physical activity in adults appears to be positively associated with four aspects of childhood: enjoying physical activity, acquiring competence, gaining confidence (Whitehead & Corbin, 1997), and opportunities to try out a variety of activities (Robertson-Wilson, Baker, Derbinshyre, & Côté, 2003). In more general terms, we can be certain that the most active children tend to remain active as adults, and the least active children tend to remain sedentary as adults. Whatever the particular mechanisms of influence may be, there is no doubt that childhood experiences are important predictors for adult physical activity and health.

Many children do not enter elementary school with a clear understanding of the relation between the act of practice and the result of improvement. Accordingly, physical education teachers often spend class time helping children observe and understand the process of skill acquisition. For example, students often practice skill tests so that they can see how their own progress is directly linked to previous practice trials. In that manner, the apparent fun and games of elementary physical education may reflect the teaching of important understandings—as well as valuable motor skills.

Principle 4: No Body Is Perfect

The obesity epidemic has focused considerable attention on body weight, often as expressed in terms of the body mass index (BMI) (the ratio of weight to height) and the relative proportion of fat in body composition. Many physical fitness tests include items that reflect one or both of these factors (Morrow et al., 2005).

Particularly in the case of children, however, great care must be taken when interpreting what test data really can tell us about such constructs as overweight and obesity. The goal of these measures is to determine whether or not an individual child is at a "healthy weight." The essential issue is whether too much of the body weight is fat, and any measure that uses only body weight cannot make that determination. For example, it is possible for a muscular individual with an appropriate percentage of body fat to be placed in the "overweight" category because muscle weighs proportionately more than other tissues. The potential for an overemphasis on weight presents two additional problems: (1) an exclusive focus on weight shifts attention away from vigorous physical activity, a positive health behavior at virtually any body weight, and (2) an overemphasis on weight may, in some vulnerable individuals, encourage unhealthy eating and a desire to be "too thin."

In terms of health outcomes, it is more important to be physically fit than to be of precisely normal weight (Lee, Blair, & Jackson, 1999). Increasing physical activity does have some long-term potential for reducing body fat and, for some children, may pre-

vent overweight. To the extent, then, that physical education can contribute to a child's daily or weekly accumulation of physical activity, it is reasonable to regard it as a health resource for all children.

Psychological Factors

One of the challenges of physical education is that performance is public. Unlike the classroom, where many performances are private, a mistake or poor performance in physical education is visible to all. Therefore, even though the educative process may be the same in the classroom and gym, the psychological meaning of performance in physical education may be profoundly different for the child.

Principle 1: Children Are Not Miniature Adults

During elementary school, the motivation to learn and master skills is driven by the answers children obtain for two questions: "Am I getting better?" and "Am I normal?" [as skillful as most other classmates]. Children who answer those questions positively are likely to continue practicing and learning (Scanlan, 2002). To answer those questions, children must select a basis for evaluating their performance and then test themselves. One means of evaluation is to compare a personal performance to that of other children. Another source of judgment is to ask an adult. Children who find cause to deem themselves successful on the basis of their comparisons, or in the judgment of adults, tend to select challenging future tests. Children who regard themselves as consistently unsuccessful either avoid self-evaluation in the future or select tests that are not challenging.

Because we know that learning is greatest when the task is challenging but also attainable, it is important to assure that children are encouraged to employ appropriate measures for evaluating their performance. For that purpose, evaluations based on improvement are almost always more helpful than those based on peer comparisons. A key role for the teacher in this process is to select learning tasks that are appropriate to the varying skill levels and experiences of children and to encourage tests that are sufficiently challenging to sustain interest and a sense of accomplishment, by allowing success in return for effortful practice.

Principle 2: Boys and Girls Are More Alike Than Different

The three reasons children most commonly give for voluntary participation in physical activity are having fun, being with friends, and learning new skills (Weiss, 2000). These reasons are broadly the same for boys and girls. Among elementary school children, however, there is a difference in the emphasis. Boys are most motivated by opportunities to be with their friends, whereas girls are more likely to seek activities that are fun (a fact that can make them willing to give more attention to learning new skills) (Robertson-Wilson et al., 2003; Weiss, 2000). The end result, however, is the same. Experiences in physical education that meet children's needs for fun and accomplishment within a social context will encourage future participation.

Principle 3: Good Things Are Earned

Most children want to be successful in school, that is, they have the desire to learn. The problem is that achieving the desired outcome requires both a belief in its possibility and a clear understanding that success will be linked to the behavior practiced. A useful test of that understanding is contained in how children "explain" successful performance of motor skills, that is, to what agency they attribute mastery of a skill.

Such "attributions" describe the factor by which the child explains a performance. Among elementary school children, the most common attributions for successful performance are hard work and practice, good luck, innate ability, and easiness. Those explanations are commonly translated as effort, chance, talent, and difficulty.

Physical education teachers, however,

can influence children's attributions for success (Horn, 1987). In attempting to do so, their usual goal is to encourage the belief that success is correctly attributed to practice and hard work. That pedagogical emphasis on effort is more important than may be immediately obvious. The other three attributions (luck, ability, and task difficulty) are unstable and/or out of the child's control. Thus, those explanations for success do not support engagement and effort (Weiss & Horn, 1990).

Achievement-goal approaches to motivation theory identify two classes of goals: task and ego. Ego goals focus on comparisons with peers, winning, and recognition, and task goals focus on individual improvement and personal mastery (Roberts, 1992). Younger children tend to adopt a mastery or task approach, whereas older children may not. For many children, ego-oriented goals are associated with decreased motivation and attrition. Because teachers can influence children's thinking, the primary emphasis should be on devising performance goals that are task oriented (Weiss & Horn, 1990).

Principle 4: No Body Is Perfect

In isolation, competition is neither good nor bad for children. Consistently losing, however, whether in competitive contexts for individuals or for groups, has the negative consequence of distorting children's expectations for success. For example, children on a consistently losing team predicted a loss in the next game even after a win (Smith, Smoll, & Curtis, 1978). In contrast, children who were on winning teams predicted a win in the next game, even after a loss. Accordingly, physical education teachers monitor practice and competition with great care so that no child is exposed to consistent failure. For some children, other negative consequences of competition are anxiety, a decline in the quality of performance, and a decrease in willingness to participate (Passer & Wilson, 2002).

For the most part, physical education teachers de-emphasize competition so that the primary focus of class activities is learning rather than winning. Often, at the end of a game, children will ask the teacher, "Who won?" Experienced teachers have an extensive repertoire of responses and probes that redirect attention to more fruitful questions: "Did you see improvement?" "Did you have fun?" "Did everyone play fairly?" "How would you change the rules?" "Were there examples of good sportsmanship?" and "Give me an example of how cooperation helped to make the team successful."

Developmental Skill Acquisition

Children have to learn how to learn motor skills. That involves both learning how to interpret the outcomes of their practice performances and acquiring all of the necessary procedural knowledge about when to do what in the course of a lesson. Of course, some developmental changes in learning motor skills parallel learning in other areas such as math or reading. The major difference is in the execution phase. Generally, the error in math is computational, not in actually writing the answer. In contrast, in motor-skill performance, the error can be in either area. That is, the child may know what to do but can't execute the needed movement, may have no problem with producing motor responses but does not know what movement is required, or may have difficulty with both aspects of performance.

Principle 1: Children Are Not Miniature Adults

Prior to age 11, children need help with the activities that support learning (Thomas, Gallagher, & Thomas, 2000). One part of learning is remembering the desired elements of the task to be performed. There are many strategies to assist memory, for example, repeating the information to be remembered. At 5 years of age children do not repeat unless told to do so. By age 7 some children will spontaneously repeat salient

aspects of directions, but it is not until age 11 that adult-like memory strategies appear in consistent use.

In physical education class children have both sequential orders and key skill components to remember (e.g., first bend the knees, then look forward, use your fingertips on the ball). If they can recall all of that, they still must execute the skill as indicated. Physical education teachers help students remember sequences and key aspects of performance by using mnemonic strategies. For example, BEEF describes the characteristics of a good free throw in basketball (Bend knees, Eyes up, Elbows in, Feet still).

Principle 2: Boys and Girls Are More Alike Than Different

Feedback and reinforcement are critical factors in improving motor performance, and the two appear to operate independently from gender. Feedback about performance allows girls and boys to identify and correct errors, whereas teacher reinforcement is valuable for consolidating correct performances and sustaining motivation.

Principle 3: Good Things Are Earned

In several studies, investigators have examined the differences between expert and novice children in sport and dance. One misconception is that expert child athletes are "naturals" or possess special talent. The research suggests that a more appropriate way to describe the child who is a particularly proficient performer would be "hard worker."

During childhood, two types of expert performers are found: short term and long term. The short-term experts have an expiration date and are no longer experts as adults. The explanation is the relative-age effect, an advantage for older children (Thomas & Thomas, 1999). The oldest children in a cohort or group have a temporary advantage over the younger (and less mature) children. For example, in baseball the oldest players on a youth team will play the skill positions—pitching and infield. When all the children reach maturity, the advantage of the relative-age effect disappears. Unfortunately, an outcome of the relative-age effect is that some children who might become true long-term experts do not have the same level of practice, experience, and encouragement as the initially older and more mature children. Those deficits often lead to less mature and younger children dropping out of participation altogether.

Among children, the long-term expert performers of motor skills differ from their peers primarily in their game-play competence (knowledge of what to do and when to do it). Interestingly, among youth basketball players, the factor that changes most during a season for experts and their journeyman teammates is knowledge (French & Thomas, 1987). Skill does not improve, especially for the novices—probably a consequence of the fact that experts tend to get more skill practice and playing time.

The form of knowledge that best explains the game-playing competence of high-performing children is their ability to make decisions. As novices, children begin with limited knowledge about what to do, and, in turn, knowing what to do often precedes being able to perform the skill. For example, youth tennis players were able to explain what they wanted to do in a match well before being able to execute the requisite skill (McPherson & Thomas, 1989). Expert players (at any age) can accurately and rapidly make decisions that combine playing context with a tactical response in the form of "if-then-do" statements. "If this happens, then I do ___."

Principle 4: No Body Is Perfect

When considering the skills required for participation in various physical activities, one question that always attracts interest is, How much in the acquisition of a skill is due to genetics and how much to practice? (Starkes, 2003). That question is not easily answered and varies by the activity. For example, becoming an expert basketball

player is far more difficult if one is short rather than tall. In contrast, being tall is a disadvantage in mastering almost any of the component activities within the sport of gymnastics. Girls and boys in elementary school physical education classes clearly display all of the advantages and disadvantages provided by such heritable characteristics.

Nevertheless, opportunity, encouragement, instruction, and practice are also important to skill development. In fact, for the typical child, opportunity, encouragement, and practice are the central elements in acquiring the level of skill needed to participate in most physical activities. No more than a moderate level of skill is required to enjoy most forms of physically vigorous exercise, and, certainly, one does not have to be an expert to enjoy participation in recreational sports and activities.

Thus, the task for elementary physical education is to provide all children with a solid foundation of basic movement skills, plus an introduction to a wide variety of activity-specific performance skills. All of that must be accomplished in a learning context that allows the joys and satisfactions of movement to permeate the class experience. The end objective is to produce a learner who is confident in his or her individual capacities and positively disposed to discover and master new ways of remaining physically active throughout life.

Summary

Quality physical education programs are evidence based. The results from 100 years of research on children's motor development are the foundation for developmentally appropriate physical education. From that body of knowledge we can derive three assertions that are foundational: children are more alike than different, children progress through the same stages of development in the same order, and it is the rate of those developments that varies among children.

In this article we have used four principles to tie together five aspects of motor-development research (e.g., growth and development, biomechanics, pediatric exercise physiology, psychological factors, and the process of motor-skill acquisition). We selected those principles because each is important in understanding how children develop and what that information means for physical education.

- *Children are not miniature adults.* In the rush to have children grow up all too quickly, adults must not forget that childhood lasts 12 or more years for a reason. Development is a process that takes time and nurturing care if it is to reach a successful conclusion.
- *Boys and girls are more alike than different.* Although we have given attention here to the particular matter of gender, the fact is that all children are more alike than different. The primary outcome of applying this principle in education is, of course, inclusion.
- *Good things are earned.* Education is an intervention based on the notion that environment does matter and that nurture is an important factor in development. The practical implication of this principle is that teachers and students are jointly responsible for learning in physical education. Both must cultivate an attitude that focuses on effort, practice, and improvement. Motor-development research does confirm, unconditionally, that good things come to those who work hard.
- *No body is perfect.* One of the joys of being an educator is appreciating the uniqueness of each individual. Accepting the variability within and among individual children and maximizing the potential that results from the endless combinations of their characteristics is one of the great secrets to success as an educator.

Note

The authors may be contacted at the following e-mail addresses: ktthomas@iastate.edu and jrthomas@iastate.edu.

References

American Academy of Pediatrics. (2006). Active healthy living: Prevention of childhood obesity through increased physical activity. *Pediatrics,* **117,** 1834–1841.

American College of Sports Medicine. (1995). *ACSM's guidelines for exercise testing and prescription.* Philidelphia: Lea & Febiger.

Bailey, D. A. (2000). Is anyone out there listening? *Quest,* **52,** 344–350.

Bar-Or, O. (1983). *Pediatric sports medicine for the practitioner.* New York: Springer-Verlag.

Broekoff, J. (1985). The effects of physical activity on physical growth and development. In G. A. Stull & H. M. Eckert (Eds.), *The academy papers. Effects of physical activity on children,* no. 19 (pp. 75–87). Champaign, IL: Human Kinetics.

Carter, J. E. L. (1980). *The Heath-Carter somatotype method.* San Diego: San Diego State University Syllabus Service.

Centers for Disease Control and Prevention. (2000). *Promoting better health for young people: A report to the President from the Secretary of Health and Human Performance and the Secretary of Education fall 2000.* Silver Spring, MD: CDC Healthy Youth.

Centers for Disease Control and Prevention. (2003). Physical activity levels among children aged 9–13 years: United States 2002. *MMWR Morbidity and Mortality Weekly Report,* **52,** 785–788.

Centers for Disease Control. (2006). YRBSS national youth risk behavior survey: 1991–2005 [On-line]. Available: http://www.cdc.gov/healthyyouth/yrbs/pef/trends/2005_YRBS_Risk_Behaviors.pdf

Dietz, W. H. (2004). The effects of physical activity on obesity. *Quest,* **56,** 1–11.

French, K. E., & Thomas, J. R. (1987). The relation of knowledge development to children's basketball performance. *Journal of Sport Psychology,* **9,** 15–32.

Haubenstricker, J., & Seefeldt, V. (1986). Acquisition of motor skills during childhood. In V. Seefeldt (Ed.), *Physical activity and well-being* (pp. 41–102). Reston, VA: American Alliance for Health, Physical Education, Recreation and Dance.

Horn, T. S. (1987). The influence of teacher-coach behavior on the psychological development of children. In D. Gould & M. R. Weiss (Eds.), *Advances in pediatric sport science* (Vol. **2,** pp. 121–142). Champaign, IL: Human Kinetics.

Lee, C. D., Blair, S. N., & Jackson, A. S. (1999). Cardiorespiratory fitness, body composition and all-cause mortality and cardiovascular disease mortality in men. *American Journal of Clinical Nutrition,* **69,** 373–380.

Malina, R. M. (1984). Physical growth and maturation. In J. R. Thomas (Ed.), *Motor development during childhood and adolescence* (pp. 2–26). Minneapolis: Burgess.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity* (2d ed.). Champaign, IL: Human Kinetics.

Martorell, R., Malina, R. M., Castillo, R. O., Mendoza, F. S., & Pawson, I. G. (1988). Body proportions in three ethnic groups: Children and youths 2–17 years in NHANESII and HHANES. *Human Biology,* **60,** 205–222.

McPherson, S. L., & Thomas, J. R. (1989). Relation of knowledge and performance in boys' tennis: Age and expertise. *Journal of Experimental Child Psychology,* **48,** 190–211.

Morrow, J. R., Jackson, A. W., Disch, J. G., & Mood, D. P. (2005). *Measurement and evaluation in human performance* (3d ed.). Champaign, IL: Human Kinetics.

Nelson, J. K., Thomas, J. R., Nelson, K. R., & Abraham, P. C. (1986). Gender differences in children's throwing performance: Biology and environment. *Research Quarterly for Exercise and Sport,* **57,** 280–287.

Passer, M. W., & Wilson, B. J. (2002). At what age are children ready to compete? In F. L. Smoll & R. E. Smith (Eds.), *Children and youth in sport: A biopsychosocial perspective* (2d ed., pp. 83–103). Dubuque, IA: Kendall/Hunt.

Ransdell, L. B., & Wells, C. L. (1999). Sex differences in athletic performance. *Women in Sport and Activity,* **8,** 55–81.

Roberton, M. A. (1984). Changing motor patterns during childhood. In J. R. Thomas (Ed.), *Motor development during childhood and adolescence* (pp. 48–90). Minneapolis: Burgess.

Roberts, G. C. (1992). Motivation in sport and exercise: Conceptual constraints and convergence. In G. C. Roberts (Ed.), *Motivation in sport and exercise* (pp. 3–29). Champaign, IL: Human Kinetics.

Robertson-Wilson, J., Baker, E., Derbinshyre, E., & Côté, J. (2003). Childhood sports involvement in active and inactive female adults. *AVANTE,* **9,** 1–8.

Scanlan, T. K. (2002). Social evaluation and the competition process: A developmental perspective. In F. L. Smoll & R. E. Smith (Eds.), *Children and youth in sport* (2d ed., pp. 393–408). Dubuque, IA: Kendall/Hunt.

Smith, R. E., Smoll F. L., & Curtis, B. (1978). Coaching behaviors in little league baseball. In F. L. Smoll & R. E. Smith (Eds.), *Psychological perspectives in youth sport* (pp. 173–201). Washington, DC: Hemisphere.

Starkes, J. L. (2003). The magic and science of sport expertise: Introduction to sport expertise research and this volume. In J. L. Starkes & K. A. Ericsson (Eds.), *Expert performance in sports: Advances in research on sport expertise* (pp. 3–16). Champaign, IL: Human Kinetics.

Thomas, J. R., & French, K. E. (1985). Gender differences across age in motor performance: A meta-analysis. *Psychological Bulletin,* **98,** 260–282.

Thomas, J. R., & Marzke, M. (1992). The development of gender differences in throwing: Is human evolution a factor? In R. Christina & H. Eckart (Eds.), *The Academy papers—enhancing human performance in sport* (pp. 60–76). Champaign, IL: Human Kinetics.

Thomas, K. T., Gallagher, J. D., & Thomas, J. R. (2000). Motor development and skill acquisition during childhood and adolescence. In R. N. Singer, H. A. Hausenblas, & C. Janelle (Eds.), *Handbook of sport psychology* (2d ed., pp. 20–52). New York: Wiley.

Thomas, K. T., & Thomas, J. R. (1999). What squirrels in the trees predicts about expert athletes. *International Journal of Sport Psychology,* **30,** 221–234.

U.S. Department of Health and Human Services. (2001). *The Surgeon General's call to action to prevent and decrease overweight and obesity.* Washington, DC: U.S. Government Printing Office.

Wechsler, H., McKenna, M. L., Lee, S. M., & Dietz, W. H. (2004). The role of schools in preventing childhood obesity. *State Education Standard,* **5,** 4–12.

Weiss, M. R. (2000). Motivating kids in physical activity. *President's Council on Physical Fitness and Sport Research Digest,* **3**(11), 1–8.

Weiss, M. R., & Horn, T. L. (1990). The relation between children's accuracy estimates of their physical competence and achievement-related characteristics. *Research Quarterly for Exercise and Sport,* **61,** 250–258.

Whitehead, J. R., & Corbin, C. B. (1997). Self-esteem in children and youth: The role of sport and physical education. In K. R. Fox (Ed.), *The physical self: From motivation to well-being* (pp. 175–203). Champaign IL: Human Kinetics.