Children's Motor Behavior: Implications for Teachers, Coaches, and Parents

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Abstract

Implications for teachers, coaches, and parents are drawn from research on children's motor behavior. While considerable attention has been directed to characteristics of teachers and coaches, less attention has been paid to the children who are the learners and performers of motor and sport skills. Important issues discussed in this paper include growth and its impact on motor performance, gender differences (pre- and post-puberty) in motor performance, cognitive factors that develop over childhood and adolescence and how they impact motor behavior, development of motor control in children, and finally, the development of motor and sport expertise. In each area, I discuss the research and suggest issues and implications for parents, coaches, and teachers to consider. Of particular importance is that while there are some biological characteristics that influence motor and sport performance, especially post-puberty, most of the performance differences are caused by different expectations, opportunities, and encouragement from parents, coaches, and teachers. In fact, if children are to become more skilled and thereby more physically active to achieve the associated health benefits, practice is the single most important factor to promote.

Children's Motor Behavior: Implications for Teachers, Coaches, and Parents

In education, physical education, and sport coaching, much time and effort have been devoted to studying teachers and coaches and helping them to develop good instructional strategies and styles. Unfortunately, considerably less time and emphasis have been placed on studying the children who will be learning and performing the motor skills that are taught. In this paper I present some of the research on children's learning and performance of motor skills. Topics included are:

1. growth and development issues and their influence on physical activity and motor skills;
2. gender differences in motor skills and physical activity;
3. cognitive factors in learning and performing motor skills;
4. children's control of motor skills;
5. development of motor expertise.

At the end of my review on each topic, I provide some suggestions about how each topic should influence how teachers and coaches plan and execute their instructional programs.

Children change dramatically in size, shape, maturity, physical activity, and motor performance over childhood and adolescence. However, these changes and how they influence children's learning and performance, particularly with regard to instruction, are not well understood by most parents, teachers, and coaches. Some changes are driven by biological factors – genetics, puberty, maturation, and growth, others by environmental factors – practice, experience, opportunity, and encouragement. Most are driven by the interaction between biology and environment – practice and experience during periods of development (Thomas, 2000; Thomas, Gallagher, & Thomas, 2001).

<u>Growth and Development</u>

The term *growth* refers to changes in overall size or size in specific parts. The term *maturation* refers to the process of becoming mature (change toward adult status). *Development* refers to a behavioral term suggesting increased competence.

Children grow rapidly up to about age two where growth in stature and mass level off to about five to seven centimeters and two to three kilograms per year until the pre-pubertal growth spurt. At that time growth again accelerates for girls (10-12 years) and boys (about 12-14 years) in both stature and mass. Girls begin their growth spurt earlier (about two years) but also stop growing earlier (about two years) than boys. Most of the growth in stature in both boys and girls is in the legs. For example, at age five, leg length is about 45% of total height while at age 10 the legs make up about 52% of total height. Also, during puberty the shoulder width relative to hip width is changing differently in boys and girls so boys have relatively wider shoulders than hips compared to girls. This change is nearly all accounted for by increased shoulder width in boys; boys and girls have about the same hip width, a concept often misunderstood. Girls are fatter than boys (relative to total body mass) at every age. The differences are small, about 2% (13% vs 11%) prior to puberty, but are larger, about 5% (20% vs 15%) after puberty (Malina & Bouchard, 1991).

From these few examples of growth, implications can be seen for teachers, coaches, and parents. Prior to puberty very few differences in size or growth are seen for boys and girls. Thus, separating girls and boys for physical activity and sport has little scientific validity. For example, there is little reason to have different physical activity or fitness standards for girls and boys. Since girls and boys are very similar, expectations and opportunities for their performance in physical education and sport should be similar. Certainly, there will be skill differences among children, but they are not caused by whether one is female or male; skill differences prior to puberty are the result of practice, encouragement, and opportunity.

Following puberty, differences in size, strength, and fat to muscle ratio exist for girls and boys with boys generally being larger, stronger, and more muscular. That does not mean some girls are not larger, stronger, and more muscular than some boys, but the differences generally favor boys. Given these facts, girls and boys are often provided separate instructional and sport programs following puberty. While separate programs may be reasonable for some girls and boys, the observed performance differences are typically much larger than would be expected due only to biological variables such as growth and size. Considerable overlap in size, strength, and skill continues to exist between girls and boys after puberty. Sport related examples of this are seen regularly at the high school level (and even beyond) where girls may choose to compete on what has typically been labeled Aboys teams@ in football, basketball, baseball, tennis, golf and other sports. In the 1970s and 1980s a number of lawsuits were brought that established girls' rights to these opportunities, especially when they had the size, strength, and skill to be successful

A phenomenon called the relative age effect has been reported. The oldest and most mature children within an age (e.g., 10 year olds who would have a range of 10 years 0 months to 10 years 11 months) are identified by coaches as being more highly skilled (Baxter-Jones, Helms, Maffull, Baines-Preece, & Preece, 1995; Boucher & Mutimer, 1994; Brewer, Balsom, Davis, & Ekblom, 1992). Thus, when sports have a "cut off date" for eligibility based on age, the oldest children at the "cut off date" (10 years 11 months when the "cut off date" is 10 years of age before March 15th) are more likely to be selected for teams and get playing and practice time. They are also more frequently selected for all-star teams. The younger children within an age (10 years 0 months) are less likely to be selected, or if they are selected, may receive less chance to practice and play and become discouraged and drop out of sports. While this might be expected to be a short-term issue, there is evidence that some sports continue to show this relative age effect at older and higher levels – adult ice hockey players are over represented by players closer to the age "cut off dates" for youth league hockey players (Boucher & Mutimer, 1994).

Another aspect of growth related to performance occurs when puberty is reached. In youth sports children who reach puberty earlier (early maturation) are larger and more skilled than late maturing children. However, later maturing children typically end up being larger (e.g., they grow longer). Thus, coaches who select and provide practice and playing time for early maturing children may see benefits at that time but may discourage children who are late maturing (and may be larger and more skilled during high school) from participating in sport and physical activity. Youth sport programs need to focus on developing skill and providing opportunity for all children, rather than letting a "must win" attitude influence the children that receive practice and playing time.

Gender Differences

Despite few differences between girls and boys in growth characteristics prior to puberty, differences do exist in motor performance (Thomas & French, 1985), physical activity (Thomas & Thomas, 1988), and physical fitness (Thomas, Nelson, & Church, 1991). The differences in all of these characteristics are generally small prior to puberty, favor boys, and often increase across the elementary school years. In the papers previously cited, the authors consistently suggested that the differences are present because parents, peers, teachers, and coaches provide opportunity and encourage girls and boys toward different activities; often girls are encouraged to play quietly and practice fine motor skills such as coloring while boys are encouraged to participate in and practice more vigorous movement activities such as running, jumping, and throwing. Thus, we should not be surprised that boys and girls are different. Unfortunately, many girls become less physically active than boys, practice motor skills less often, and are, therefore, less physically fit and less likely to participate in vigorous sports and games that promote health and well-being.

Given these factors, teachers, parents, and coaches all see obvious skill differences among young boys and girls even though growth characteristics are not different. They may assume these skill differences are biological in nature. They are not. Since girls and boys perceive that they are expected to perform and behave differently, in fact they do, and the self-fulfilling prophecy plays out. All of this leads to less physically active girls; yet the known advantages of physical activity for physical and mental health are well documented (Bouchard, Shephard, & Stephens, 1994).

Following puberty, girls and boys do have some growth characteristics that influence their different performance of skills – boys are typically larger and have more muscle. However, the biological factors in these differences are not as substantial as people typically assume. Note the following examples of how female performance becomes more similar to male performance over time as reflected by world records (Ransdell & Wells, 1999):

1. 100 meter dash –in 1923, the men's world record was 19% faster than the women's; in 1993, the difference was 6%;
2. 400 meter dash – in 1923, the men's world record was 28% faster than the women's; in 1993 the difference was 9%;

3. 1500 meter run – in 1953, the men's world record was 19% faster than the women's; in 1993 the difference was 10%;
4. 100 meter swim – in 1923, the men's world record was 20% faster than the women's; in 1993 the difference was 11%;
5. 1500 meter swim – in 1953, the men's world record was 13% faster than the women's; in 1993 the difference was 8%.

Thus, in the world's top performers as of 1993, differences between women and men were about 8-10% and becoming more similar over the years due, of course, to practice, opportunity, and encouragement. However, in typical girls and boys, the differences following puberty are much larger than 8-10% (Thomas & French, 1985). This outcome suggests that while some differences may be biological, differences are mostly environmental because: (a) we have different expectations for typical females and males, (b) we provide different practice opportunities for typical females and males, and (c) we encourage typical males to participate more than females. Therefore, we should not be surprised when typical females and males live up to our expectations and the opportunities they are provided. The implications for parents, teachers, and coaches seem obvious: encourage and provide opportunity and practice for girls and boys to develop motor skill and to be physically active.

One task, overhand throwing, has been shown to be considerably different in its development from most other tasks. Thomas and French (1985) found that as early as three to four years of age the difference between boys and girls in overhand throwing was three times as large as for other motor tasks. These differences favored boys and continued to increase in a relatively linear way up through 18 years of age. In several follow up studies (Nelson, Thomas, Nelson, & Abraham, 1986; Nelson, Thomas, & Nelson, 1991; Thomas & Marzke, 1992;

Thomas, Michael, & Gallagher, 1994; Yan, Hinrichs, Payne, & Thomas, 2000; Yan, Payne, & Thomas, 2000) gender differences in throwing appear to have a biological component prior to puberty (the only motor task in which that has been found) that contributes to gender differences. In addition, the biomechanics of the throwing motion before and after puberty are substantially different in boys and girls particularly with regard to trunk rotation (for boys, the hips rotate forward toward the target ahead of the shoulders) and the forward rotational speed of the upper arm (boys are nearly twice as fast as girls). These two characteristics produce considerably more velocity at ball release for the typical boy when compared to the typical girl. In fact over childhood, girls continue to use an immature throwing motion; they develop more velocity because they become larger. Boys get larger, too, but also develop a better throwing motion (Nelson, Thomas, Nelson, 1991). Speculation (Thomas & Marzke, 1992) about evolutionary causes for this large difference is that early in evolution and over thousands of years, men who could throw well (and thus hunt well) were selected over those who could not. Since women were more likely to have responsibility for child-care than hunting, the ability to throw was not an important evolutionary selection factor for them.

Even with throwing where there may actually be real biological differences in the skill, typical women do not throw nearly as well as they might given practice, opportunity, and encouragement. For example, observe female softball players who throw overhand exceptionally well even though they are throwing a larger ball. Again, parents, coaches, and teachers have all assumed women “could not” throw well – everyone understands the movement pattern implied by the statement “throws like a girl.”

Cognitive Factors

Ample evidence exists that children process information in memory at different rates (Kail, 1986, 1988, 1991) and use memory strategies differently (Chi, 1977) from adults. Evidence has shown that these same phenomena apply when children participate in sport and physical activity (for a review see Thomas, 2000, or Thomas, Gallagher, & Thomas, 2001). This fact is reflected by the following changes across childhood and adolescence:

1. reaction time becomes faster (Thomas, Gallagher, & Purvis, 1981);
2. processing speed increases (Gallagher & Thomas, 1980; Thomas, Solmon, & Mitchell, 1979);
3. perception of body position improves (Thomas & Thomas, 1987);
4. anticipating-timing improves (Dunham & Reid, 1987; Thomas, Gallagher, & Pruvis, 1981);
5. finger tapping speed increases (Burton, 1987; Salmoni & Pascoe, 1979);
6. decision-making improves (Newell & Kennedy, 1978);
7. feedback to improve performance can be used effectively in shorter time periods (Gallagher & Thomas, 1980); and
8. task appropriate cues improve performance – rehearsal (Gallagher & Thomas, 1984); strategy (Thomas, Thomas, Lee, & Testerman, 1983), organization (Gallagher & Thomas, 1986), and labels (Winther & Thomas, 1981).

All of these findings have implications for teachers and coaches. First, the issues with rehearsal, strategy, organization, and labels are that young children do not use them spontaneously; however, they can use all of these memory enhancements when cued to do so. Second, younger children can use feedback effectively if given enough time. However, children, when compared to adults, do have slower reaction times (girls are slower than boys), are not as good at anticipating where balls and other moving objects will end up, do not perceptually discriminate as well, and have slower movement speeds. Thus, changing the characteristics of the task makes sense – bigger balls (softballs) to hit but smaller balls to handle (e.g., footballs), smaller playing areas, targets that are closer (e.g., shorter baskets), striking balls tossed underhand rather than overhand, and shorter hitting implements (e.g., bats and clubs).

<u>Motor Control</u>

Motor control means how the body's neuromuscular system works to produce movements. Frequently, motor control has been studied in hand-eye coordination because it is important in movements of everyday life – typing, writing, reaching, and grasping – as well as in larger movements – catching and striking. In fact as children and adults increasingly use computers for work (schoolwork for children) and games (computer mouse, joystick), fine eye-hand coordination becomes even more important.

Much of the motor control work is relatively theoretical (Meyer, Abrams, Kornblum, Wright, & Smith, 1988; Plamondon & Alimi, 1997) and conducted on adults. However, the development of motor control in children is not explained well by adult models (Stelmach & Thomas, 1997), so there is increasing need to understand how motor control processes develop over childhood and adolescence.

Fitts' law (1954) was developed to explain how speed and accuracy are traded off in rapid aiming movements (like typing or reaching and grasping objects). The initial phase of the movement is under central control where a motor program (think of this like a computer program) controls the movement. As the movement approaches the target, visual feedback begins to be used to hit the target and the movement slows down. The more of the movement is under central control, the faster the movement – said another way, the closer the movement gets to the target before feedback is used, the faster the movement. However, Fitts' law may not apply as well to children since they appear to use only a motor program to get the movement started and then rely on feedback to make adjustments during most of the movement (Yan, Thomas, Stelmach, & Thomas, 2000). But with practice, children's rapid aiming movements and their underlying components begin to look similar to adults' with more of the movement under central control (Thomas, Yan, & Stelmach, 2000). Again, it seems that practice rather than biological limitations is the major factor in improving performance.

Motor and Sport Expertise

How people become expert has been studied across a variety of fields including teaching, airplane piloting, computer programming, game playing, and sports. Here we are interested in how one becomes a motor or sport expert (complete research reviews appear in Starkes & Allard, 1993, or a special issue of the International Journal of Sport Psychology, 1999), particularly how motor expertise develops across childhood and adolescence. While most people agree that initial talent and practice combine in the development of expertise, the talent-practice interaction is not the same in all fields. For example, nearly everyone becomes an expert driver. Driving is based on practice; talent has a limited role (nearly everyone has enough talent to become a good driver). However, if one hopes to become an expert basketball player, it helps to be tall, and one can't teach or practice being tall. Being tall is important, but it is not enough; practice is still required. One point a number of authors agree on is that it takes about 10,000 hours (often presented as 10 years) of practice to become an expert in any area (Ericsson & Charness, 1994; Helson, Starkes, & Hodges, 1998; Thomas & Thomas, 1999). In addition, becoming an expert in some fields is basically cognitive (e.g., chess), while in sport, knowing what to do and doing are not the same (Thomas, French, & Humphries, 1986). Sport expertise requires declarative knowledge (knowing the rules and what to do), procedural knowledge (knowing how to do it), and skill execution (doing it). In fact, in sport expertise (Thomas, Gallagher, & Thomas, 2001, p. 44):

1. the knowledge base, skills, and game performance are context-specific and can be circumscribed (Thomas, French, & Humphries, 1986);
2. the cognitive processing system is stressed because time constraints on decisions are encountered (Abernethy, 1990; Thomas & Thomas, 1994); and
3. knowing when and how to execute a skill is not synonymous with executing the skill (McPherson & Thomas, 1989; Thomas & Thomas, 1994).

Contrasting the differences between experts and novices (Abernethy, Thomas, & Thomas, 1993) is the primary way that expertise has been studied across all fields including sports: badminton (Abernethy, 1988), baseball (Chiesi, Spilich, & Voss, 1979; French, Nevett, Spurgeon, Graham, Rink, & McPherson, 1996; French, Spurgeon, & Nevett, 1995; Nevett & French, 1997), basketball (Allard, Graham, & Paarsalu, 1980; French & Thomas, 1987), field hockey (Starkes, 1987; Starkes & Deakin, 1984), squash (Abernethy, 1990), ballet (Starkes, Deakin, Lindley, & Crisp, 1987), and tennis (McPherson, 1999; McPherson & Thomas, 1989). By studying what experts do that novices don’t, the path to expertise can be discovered and used as a basis for instruction and coaching.

During childhood and adolescence, growth and maturation are occurring along with the development of expertise. Older children, on average, perform motor skills better than younger children. However, practice to develop expertise has consistently been shown to overcome age with more expert younger children performing better than novice older children (French & Thomas, 1987; McPherson & Thomas, 1989). For basketball and tennis, the younger experts had greater sport specific knowledge, better specific sport skills, and used their skill and knowledge more effectively during games. French et al. (1996) and McPherson (1999) found that more expert children not only had higher skill levels during games but consistently represented games situations at more advanced levels than novices.

However, these developmental studies, particularly in team sports (French & Thomas, 1987; French et al., 1996; Nevett & French, 1997), have also reported that in both practice and game situations, coaches tend to work and give cues on strategic skills rather than motor skills. For example, in basketball French and Thomas (1987) reported that coaches spent most of their practice time on getting the ball into the hands of the best shooter rather than working on shooting skills for all players, and these children were 10-12 years of age. As a result, when considering basketball skills and knowledge, all that changed over a full season was improved decision-making; children's skills did not get better. French et al. (1996) also reported that during baseball games, coaches consistently called out cues to players prior to pitches (e.g., if the ball is hit to Tommy at shortstop, go for the double play) rather than allowing children to plan and make their own decisions.

Of course, practice alone does not assure expertise. Starkes et al. (1987) reported that dancers with similar amounts of practice demonstrated substantially different levels of expertise. Thomas and Thomas (1999) have suggested that the quality of practice is what is essential. They reported results in which two expert elementary physical education teachers with over 20 years experience in the same schools had each taught one "true" expert (the player went on to an exceptionally high level of performance at the university or professional level) out of about 2,000 students. These teachers, in a retrospective interview, suggested they had each taught a number of children with motor skill and fitness levels similar to or even better than these two experts. However, they reported that the two experts not only practiced a lot, but worked harder and got more out of practice than any other children they had ever observed.

So, the message for teachers, coaches, and parents who want their children to become more expert is that children should be encouraged to:

1. practice correctly – receiving good instruction early so that incorrect skills don't have to be unlearned and then learned correctly is important;
2. practice the "right" things – certainly developing cognitive knowledge of what to do and when to do it is important; however, that cannot replace practice time on the basic skills of the sport;
3. practice a lot – there is simply no substitute for practice if one wants to be a sport expert; and
4. practice as they will perform – learning to hit a pitched ball is best learned by hitting a ball that is pitched; hitting a ball from a ball machine or one being swung around and around on a string is not the same.

Summary and Conclusions

From this research review on growth, gender, cognition, motor control, and motor expertise, insight is provided into characteristics of children's learning and performance of motor and sport skills. However, parents, teachers, and coaches need to understand how their behaviors and instructional practices influence children pre- and post-puberty. These findings and implications are equally important for children and adolescents who are participating in physical activity for the health benefits and fun as for youth sport athletes who hope to become more expert performers. The critical issue is not the child's age, gender, or expertise. The critical issue is to provide opportunity, encouragement, and practice for all children.

Conclusions from this review follow. However, it is important that the reader recall and review the context under which these conclusions are drawn.

First, few growth and maturation differences are observed between boys and girls before puberty. However, following puberty girls are typically smaller and have less muscle than boys – characteristics that are likely to impact motor and sport performance. Thus, little rationale exists for separate physical fitness standards or sports teams for girls and boys prior to puberty.

Second, in youth sports the relative age effect (players within the same age but older) has been shown to operate when team selection is involved – if the “cut off date” for selection is 10 years of age, boys closer to but not yet 11 are more likely to be selected and receive practice and playing opportunities. This, of course, is unfair and quite discouraging for younger youth sport athletes.

Third, late maturing children, while not as large at the time (or often as skilled), will on average be larger than early maturing children. If early maturing children are selected for youth sport teams because of their size and skill, later maturing children often drop out even though their potential may be greater for high school sports.

Fourth, prior to puberty, differences observed between boys and girls in motor skills are caused by different expectations, treatments, and opportunities provided by parents, teachers, and coaches. The lone exception to this statement may be in overhand throwing.

Fifth, overhand throwing is an unusual skill in that differences between boys and girls appear earlier and are greater. It may be one skill in which biological differences (and maybe evolution) play a role. However, the typical girl would still be much better at throwing if she were encouraged and received more practice opportunities.

Sixth, elite female performance is becoming more similar to elite male performance in all speed, skill, strength, and endurance events and sports. Differences favoring male performance, when compared to female performance, have decreased from 19-28% down to 8-10% over the past 50-70 years. Clearly, encouragement, opportunity, and practice have been and remain the critical features in reducing gender differences. Unfortunately, this same reduction in gender differences in performance for typical boys and girls has not occurred.

Seventh, cognitive factors do influence age differences in motor performance in spite of the fact that reaction time, speed of processing, perception of position, anticipating-timing, and speed of movement all improve across childhood and adolescence. Younger children will perform much better if they are provided task appropriate cues (rehearsal, strategy, organization, and labels) for performance by teachers, coaches, and parents.

Eighth, children's fine eye-hand coordination improves across age, but task specific practice at rapid aiming tasks (writing, computer mouse, joystick, and reaching and grasping) clearly improve performance so that it becomes similar to adult performance.

Finally, sport and motor expertise result from an interaction of talent and practice as children grow and mature. While talent and biological factors such as size are important in some sports, the critical factor is lots of correct practice with good instruction.

How Might School and Youth Sport Policy Be Influenced by these Outcomes

The positive and unambiguous benefits of physical activity on the short- and long-term health benefits for children are without question. Children who participate in physical activity are healthier and more likely to become adults who participate in physical activity. Two important ways to promote physical activity in children are through: (a) regular and required physical education instruction by qualified elementary physical education teachers, and (b) instruction in youth sport by qualified coaches. Correct practice is what leads to increased skill, and skill leads to participation in physical activity. If we want these benefits for our children, then we must insist on policy at the national, state, and local levels that provides:

1. Daily physical education in elementary and middle schools taught by qualified physical education teachers;
2. Trained and concerned youth sport coaches who focus on the value of increasing skill level and physical activity in children rather than the outcome of the contest.

In addition, parents must encourage children to participate in physical activity at home, school, and in recreational settings. As parents, educators, and coaches, we must provide equal encouragement, opportunity, and practice for girls and boys as well as for the skilled and unskilled. Our policies in schools, recreational settings, and youth sport organizations must reflect these points.

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