T
he scientific literature on the development of human physical aggression has been severely handicapped by the aggregation of disruptive, delinquent, and antisocial behaviors, all under the heading of “aggressive behavior”. This clearly creates an important problem when the aim is to understand the origin and development of any one of these behavior problems. Protection from physical aggression is probably the main reason why there is so much public interest in deviant-antisocial-delinquent behavior. However, most assessments of deviant-antisocial-delinquent behavior confound physical aggression with many other forms of problem behavior. This situation can be observed by examining the content of the “aggression” scales, which have been used over the past decades. Most of the popular scales contain a mix of behaviors that range from physical aggression to attention seeking and disobedience. For example, one of the most frequently used “aggression” rating scales for children and adolescents includes the following items: “argues, brags, demands attention, disobeys, poor peer relations, jealous, lies, shows off, stubborn, moody, sulks, loud”. The common denominator of these items is that they annoy others. Of the 23 items that make up the Achenbach and Edelbrock “aggression” scale, only two clearly refer to physical aggression while two others can be interpreted as describing physical aggression. This review focuses on research that measured physical aggression.

DEVELOPMENT OF PHYSICAL AGGRESSION DURING THE SCHOOL YEARS
Most studies of youth physical violence have concentrated on 12–18 year old adolescents. During this period children become physically stronger, their cognitive competence increases (for example, they are better at hiding their intentions), they become sexually mature, they ask and obtain more freedom with regard to spending time without adult supervision, and they have access to more resources such as money and transportation, which increases their capacity to satisfy their needs.

Although a majority of adolescents will commit some delinquent acts, most of these are minor legal infractions. Population based surveys have systematically shown that a small proportion of adolescents (approximately 6%) account for the majority of violent acts and arrests. The challenge is to explain why some adolescents and some adults frequently resort to physically aggressive behavior while others do not. Although they are relatively small in number, they frighten a large part of the population, and they represent a heavy burden of suffering for their victims, their families, and themselves. Adolescents with behavioral problems are also much more likely to be unemployed, suffer poor physical health, and have mental health problems.

A number of high profile cases have made it poignantly clear that extremely violent behavior does not suddenly appear with adolescence. For example, in March 2000, a Michigan kindergarten boy used a semi-automatic handgun to kill a female classmate in the classroom. These rare cases serve as a reminder that young children can be extremely violent. In fact, longitudinal studies of large samples of boys and girls followed from school entry to the end of adolescence clearly show that younger children are more frequently physically aggressive; as they grow older they generally resort to less and less physical aggression.

Interestingly, these patterns are completely reversed in the case of indirect aggression, which is defined as behavior aimed at hurting someone without the use of physical aggression. For example, a child who is mad at someone may say bad things behind the other’s back or may try to get others to dislike that person. Females tend to have higher levels of indirect aggression compared to males at each age, and the level of indirect aggression increases with age for girls and boys. Thus, the process of socialization may involve learning to use indirect means of aggression rather than physical aggression.

Although recent longitudinal studies of physical aggression have made it clear that the majority of school age children are less and less physically aggressive with time, many continue to believe that a minority of children commence or increase the frequency of their acts of physical aggression as they grow older. This issue was recently addressed by the mapping of different developmental trajectories. Results from the Montreal Longitudinal-Experimental study of boys, assessed regularly from 6 to 15 years of age (fig 1), showed that 17% of the boys appeared never to have been physically aggressive; 4% exhibited a high frequency of physical aggression from 6 to 15 years of age; 28% started with a high level of physical aggression at age 6 and became less and less physically aggressive with time; while the majority (52%) had a low level of physical aggression at age 6 and also became less and less
aggressive with time. In contrast to hypotheses concerning late onset of antisocial behavior, this study and others that followed did not find any group of boys or girls in which there appeared to be an “onset” and maintenance of moderate or high levels of physical aggression for a significant number of years after age 6. They also observed that for every group of boys the peak level for frequency of physical aggression was during the first year of the study when they were in kindergarten.

These results clearly challenge the idea that the frequency of physically aggressive acts increases with age. They also challenge the notion that there is a significant group of children who show chronic physical aggression during late childhood or adolescence after having successfully inhibited physical aggression throughout childhood. If, between kindergarten and high school, children are at their peak level of physical aggression during their kindergarten year, when do they actually start to aggress physically?

**DEVELOPMENT OF PHYSICAL AGGRESSION DURING THE PRESCHOOL YEARS**

There are surprisingly few longitudinal studies that have tried to chart the development of physical aggression during the preschool years. This lack of attention to physical aggression during the early years appears to be the result of a long held belief that physical aggression appears during late childhood and early adolescence as a result of bad peer influences, television violence, and increased levels of male hormones. This view of antisocial development was very clearly described more than 200 years ago by Jean-Jacques Rousseau in his book on the education of Émile (1762/1979).

Longitudinal studies of small samples of preschool children have found that the most physically aggressive toddlers tend to remain the most aggressive preschoolers. However, cross sectional data on a sample of close to 20,000 2–11 year old Canadian children gave the first epidemiological indication that the mean frequency of physical aggression peaks between the second and third year after birth and then steadily declines (fig 1).

So, if the frequency of physical aggression is at its highest at the end of the second year after birth, at what age does physical aggression begin? Within a longitudinal study of a large sample of babies born in the province of Quebec in the mid-1990s, mothers were asked to rate the frequency of physical aggression at ages 17 and 30 months and, at both times, to indicate at what age the child had started to show such behavior. At age 17 months, close to 90% of the mothers reported that their child was physically aggressive toward others at least sometimes. Figure 3 shows the cumulative age of onset of pushing others to get what you want. Very few children are reported to use that behavior before 12 months of age. However, by 24 months more than half of the children have been reported to use that behavior. Note that a difference between males and females starts to appear around 15 months of age. One of the interesting results of that study is the fact that mothers who were reporting at 17 months that their child had started to hit others after 17 months of age. This memory failure as children grow older, taller, and bigger could in part explain why parents of physically aggressive adolescents report that the aggression problems started only a year or two before.

**WHY DOES PHYSICAL AGGRESSION PEAK AT THE END OF INFANCY?**

From an evolutionary perspective, would it make sense that the species that managed to dominate planet earth needed to learn to physically aggress? Research on the development of aggression over the past half century was largely dominated by the social learning hypothesis. The question being asked was “how do children learn to physically aggress?”.

![Figure 1: Developmental trajectories of physical aggression for boys from 6 to 15 years of age.](image1)

![Figure 2: Percent children using physical aggression (NLSCY, 1994).](image2)
from 2 to 3 years of age onwards implies that the right question to ask is “how do children learn not to physically aggress?”.

One would expect that physical, cognitive, and emotional development play an important role in learning not to physically aggress. Within the first 24 months after birth, babies grow in height by more than 70%, and almost triple their weight. At birth babies can hardly lift their heads, nine months later they can move on all fours, by 12 months they can walk, and by 24 months they can run and climb stairs. The ability to grasp objects is an important development for social interactions. At birth babies do not control their arms, at 6 months they can reach and grasp for objects. If they see an interesting toy in the hands of another 9 month old, they will reach and grasp the toy. A struggle for the toy will occur if the other child does not let go. Note that, at 9 months, the child does not have the language ability to ask the other child for the toy—this ability will develop over the next two years—but the frequency and complexity of interactions between babies and other persons in their environments increase at least as rapidly as their physical growth. Infants’ waking time is spent exploring their physical environments. Before 12 months of age, they spend most of their playtime exploring one object at a time. Between 12 and 18 months, they imitate real life activities alone. By the end of the second year they are “pretend playing” with others.25

Thus, over the first 15 months after birth, with increased physical mobility and cognitive competence, children also become more and more able to discover their environment. The frequency of their interactions with peers increases with age, and playing with others increases dramatically from the end of the first year to the end of the second year.25 This is the period when the rate of physical aggression increases to its maximum. At this age, children are exploring social interactions with their newly acquired walking, talking, running, grasping, pushing, kicking, hitting, and throwing skills. Most of their interactions are positive, but conflicts become more frequent.26 Most of these conflicts are over possession of objects and territories. During these conflicts children learn that they can hurt and be hurt. Most children will quickly learn that a physical attack on a peer will be responded to by a physical attack, and that adults will not tolerate these behaviors. Most children will learn to wait for the toy to be free, and that asking for toys rather than taking them away from someone will more likely prevent negative interactions.

Learning to wait for something you want (delay of gratification)28 and learning to use language to convince others to satisfy your needs may be the most important protective factors against chronic physical aggression. Numerous studies have shown an inverse correlation of verbal skills with impulsivity and criminal behavior.29 30 We need to understand the mechanisms underlying these associations. They are clearly operating in the first two years of life.

By 12 months of age, children have the physical, cognitive, and emotional means of being physically aggressive toward others. It appears that most children will at some point hit, bite, or kick another child or even an adult.31 Children’s individual characteristics can explain part of the variance in the frequency and stability of this behavior, but the quality of children’s relations with their environment, and the environment’s reaction to this behavior, will very likely be important factors. If children are surrounded by adults and other children who are physically aggressive, they will probably learn that physical aggression is part of everyday social interactions. On the other hand, if a child lives in an environment that does not tolerate physical aggression, and rewards prosocial behavior, it is likely that the child will acquire the habit of using means other than physical aggression to obtain what he or she wants, or for expressing frustration.

**PREVENTION OF CHRONIC PHYSICAL AGGRESSION**

The normal course for the development of physical aggression during the life span of humans appears to be a rapid increase during infancy and a continuous decrease up to adulthood.32 33 However, some infants use physical aggression more often than others, and a subset of these maintain high levels of physical aggression up to late adolescence.34 35–39 Research has identified a number of predictors for chronic physical aggression, which could be used to plan prevention experiments. The predictors can be divided into three categories: (a) individual characteristics such as obstetric complications, testosterone, serotonin, body mass, sex, race, ethnicity, temperament, hyperactivity, anxiety, opposition, impulsivity, and cognitive development; (b) physical environmental characteristics such as cigarette smoke and lead content; and (c) social environmental characteristics such as social cohesion of neighborhood, parent characteristics, family characteristics, and school characteristics.

**The role of individual characteristics**

From a developmental perspective, genetic inheritance is the original individual characteristic. The number of genetic studies of behavior problems has increased substantially in the past decade. There are very few genetic studies of childhood physical aggression,40 and no genetic studies of chronic physical aggression trajectories to our knowledge. However, twin and adoption studies have shown substantial genetic influence, and gene-environment interactions on risk regarding different assessments of broadly defined antisocial behavior.41–45 A number of molecular genetic studies have
linked genes to the risk of impulsive and aggressive behavior through neurotransmitter metabolizing enzymes (MAOA) and serotonin receptors. In cases where impulsive and aggressive behavior would be due to genetically determined levels of MAOA and serotonin, one would expect these behaviors to be present in early childhood when extra environmental support could be given to help the child learn to regulate his aggressive behavior.

Many other individual characteristics have been linked to physical aggression and antisocial behavior: hormones, cardiovascular activity, brain physiology, brain functioning, temperament, physical development, cognitive functioning, emotional responses, social development, and moral development. In most studies only a small number of individual characteristics were studied, and most did not take into account genetic information and physical environmental characteristics. A small subset of social environmental characteristics was usually taken into account.

The role of physical environments
The list of physical environment characteristics that could potentially lead to chronic physical aggression, as well as to occasional physical aggression is very long. Most chemicals, which have an effect on the developing nervous system, could have an impact on the control over physical aggression. There is accumulating evidence that cigarette and alcohol use during pregnancy increases the risk of cognitive and behavior problems. Among chemicals that could have an impact after birth, studies of lead exposure during childhood show links to externalizing behavior problems.

Other important physical environmental determinants of physical aggression are the availability of weapons. Most studies have focused on availability of guns during adolescence, but many children have access to firearms and knives, and are often trained to use them. Children with chronic physical aggression are likely to be more attracted by weapons, more likely to live in environments where they are easily available, and less likely to be trained to use them safely. Housing studies have also shown that the physical organization of living, schooling, and leisure environments can increase or decrease the likelihood of deviant behavior, including physical aggression.

The role of the social environment
Most developmental studies of aggression have concentrated on psychosocial determinants. Associations have been shown with characteristics of parents, families, parenting behavior, siblings, peers, teachers, schools, and neighborhoods. Two important limits to these studies are that physical aggression was not specifically targeted, and other determinants, especially physical environments and genetics, were not considered. Some studies have shown important interactions between social and biological determinants.

A major problem with research on the development of physical aggression is that most studies had relatively small samples, most did not start during pregnancy, most did not measure physical aggression during the preschool years, and each assessed only part of the risk factors. We clearly need large scale longitudinal studies, which will measure the developmental course of physical aggression from infancy to late adolescence, and measure all the putative risk factors from pregnancy onwards to study the interplay among the factors. Within these longitudinal studies, we should also experiment the most likely effective interventions to prevent the development of chronic physical aggression.

CONCLUSIONS
No longitudinal studies have yet mapped the development of physical aggression from early childhood to adulthood. However, separate longitudinal studies of large samples of children during early childhood, and during the school years, have helped understand that children start to learn to regulate physical aggression during early childhood. These studies indicate that the best time to start preventing the development of chronic physical aggression is early childhood. However, since humans need to learn not to physically aggress, situational prevention is necessary throughout the life span to prevent the primitive instincts from piercing through the thin veneer of civility we acquire.

Large prospective longitudinal studies with repeated measurement of appropriate individual and environmental characteristics, from pregnancy onwards, will provide an opportunity to study the developmental sequences of risk factors associated with physical aggression. However, to understand developmental mechanisms we need experimental research. From a practical perspective, the most cost effective and ethical way of doing research on child development is to nest prevention trials within longitudinal studies. Preventive interventions during pregnancy and early childhood are likely to have beneficial effects on numerous outcomes, including physical health, mental health, school performance, criminal behavior, labor activity, and family socioeconomic status. Such experiments would help test cumulative effect hypotheses, and hypotheses of multiple outcomes of early biological embedding of environmental effects.

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