Physically Active Play and Cognition

An Academic Matter?

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The authors discuss the growing evidence that strenuous physical activity is not only healthy for students but improves their academic performance. Based on such research, they argue that schools in the United States need to stop eliminating physical-education programs under the current political pressures to emphasize academics and instead to reform traditional physical education. Modern physical education should move away from its competitive-sports approach to one that employs a wide range of play involving strenuous physical activity for every student.

There is much discussion both in the growing body of play literature and in public discourse regarding the role of physical activity in healthy child development. Learning, memory, concentration, and mood all have a significant bearing on a student's academic performance, and there is increasing evidence that physical activity enhances each. Moreover, because children and adolescents engage in physical activity primarily through physically strenuous play, an evaluation of the relation between physical activity, cognition, and academic performance helps us better appreciate the role of play in healthy child development.

The potential for physical activity to mitigate childhood obesity and related health risks has often been discussed in scientific and public forums. Evidence that exercise may also improve cognitive development and academic performance provides yet another reason to promote physical activity for students. More specifically, it argues the need for quality physical education in schools because it allows all students to engage in regular physical activity. Although the literature in the field of study called physical education distinguishes physical education, physical activity, and play from each other, for the purpose of this article, we conceive of physical education as a forum during which students have opportunities to engage in physical activity. A good portion of that activity we consider physically strenuous play.

Evidence to support the benefits of exercise for the brain has been mounting

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in the academic fields related to the subject—in molecular science, in cognitive science, in behavioral science, in systems neuroscience, and in psychology—and directly in the schools our children attend. In this article, we present nascent findings regarding the effects of physical activity, both within and outside of the context of physical education, on students' cognitive ability and academic performance. We then introduce a modern model for physical education, one which emphasizes regular exercise that is cognitively, socially, and aerobically demanding, and one which also provides opportunities for students to engage in physically strenuous play. We then describe preliminary results from schools where this new model has been implemented.

Overview: Physical Activity, Physically Strenuous Play, and the Brain

Physical activity presents a physiological stress to the brain that, when balanced with recovery, promotes adaptation and growth, preserves brain function, and enables the brain to respond to future challenges (Mattson 2004). Physical activity has been shown to enhance learning and memory in animals (Vaynman 2004) and to delay or prevent cognitive decline in elderly humans (Kramer 2004). Studies show that exercise benefits learning, memory, and cognitive ability in numerous ways. Evidence from animal research suggests that exercise causes gross structural and vascular plasticity (or adaptive brain modifications), enhances brain activity, and modulates important neurotransmitter systems. Aerobic activity also stimulates the release of neuronal growth factors (molecules that help neurons survive and thrive), promotes synaptic plasticity and long-term potentiation (dynamic modifications of the connections between neurons), and stimulates the growth of new neurons in the hippocampus (a brain region primarily involved in learning and memory) (Hillman 2008).

Emerging theory suggests that, in similar fashion, play facilitates healthy cognitive development by stimulating frontal lobe maturation, by alleviating Attention Deficit Hyperactive Disorder (ADHD) symptoms (such as impulsiveness), and by promoting prosocial minds through the maturation of behavioral inhibition (Panksepp 2003, 2007, 2008). Thus, physically strenuous play synthesizes the neural benefits of both exercise and play by simultaneously providing physical, social, and intellectual stimulation. This synergy of stimuli creates a positive challenge or stress to the brain, which in turn causes the brain to adapt, resulting in healthy cognitive development. In this respect, physically strenuous

play constitutes an enriched environment, which entails physical activity, social interaction, and novel (or intellectual) stimuli. Research with rodents, as well as with elderly humans, shows that an enriched environment stimulates neuroplasticity, enhances cognition (learning and memory), and prevents cognitive decline with aging (Bruel-Jungerman 2005; Lewis 2004; Mora 2007). At school, recess and physical education allow and encourage children to be active and to play, which means they are a good setting for an enriched environment.

Much of the relevant research has focused on the effects of physical activity or physical education on cognitive ability and academic performance. However, since physically strenuous play is an important type of play, and indeed the primary physical activity for young people, and since physical education offers opportunities for children to engage in physical activity, clearly findings about the relationship of physical activity and/or physical education to academic performance are relevant for physically strenuous play. Especially for the young, the words *physically strenuous play* and *physical activity* often seem synonymous, however distinct the thing they actually denote may in fact be.

Physical Activity and Cognitive Ability among Students

Evidence generally supports a positive relation between levels of activity, physical fitness, and cognitive ability among young persons. Sibley et al. (2003) conducted a meta-analysis showing a positive correlation between physical activity and seven categories of cognitive performance (perceptual skills, intelligence quotient, achievement, verbal tests, mathematics tests, developmental level/academic readiness, and other) among school-aged children. More recently, physical fitness was positively associated with measures of cognitive function (executive control) among preadolescent children (Buck 2008). However, physical activity was found to be unrelated to several components of cognitive function among young adults.

Physical Activity, Physical Fitness, and Academic Performance

Physical activity and physical fitness have been directly correlated with improved academic performance. A cross-sectional survey of school-aged chil-

dren in Iceland revealed that, combined, body mass index and physical activity explain up to 24 percent of variance in academic achievement (Sigfusdottir 2007). Another cross-sectional study involving eight thousand schoolchildren found that academic ratings were significantly correlated with exercise levels and with performance on physical fitness tests (Dwyer 2001). A cross-sectional study conducted in 2002 by the California Department of Education demonstrated a strong association between physical fitness and academic performance (CDE 2005). Using the Fitnessgram, a six-faceted measure of overall fitness, and students' grades on the SAT-9 state standardized test, nearly one million students in grades five, seven, and nine were evaluated. Investigators consistently found that those students with higher levels of fitness scored higher on the SAT-9. There was a positive linear relationship between the number of fitness standards achieved and standardized test scores. This result held for boys and girls in both math and reading, but it was most pronounced in math. A smaller follow-up study (Castelli 2007) replicated this finding. There, physical fitness—and aerobic capacity in particular—related positively to test scores in mathematics and reading, whereas body mass index related inversely to scores. Though these studies consistently showed a strong association between activity and fitness and academic performance, because of the cross-sectional nature of their designs they do not allow us to infer that physical activity or fitness are causes *per se* of enhanced academic performance.

Physical Education and Academic Performance

Physical education in schools presents an advantageous opportunity to promote physical activity among populations of school-aged children. Several studies have assessed the relation between physical education and academic performance. Ahamed et al. (2002) found that a sixteen-month, Canadian, in-school physical activity intervention neither increased nor decreased standardized test scores compared to control schools. Adding physical education to school curricula has previously been correlated with modest improvements in academic performance (Dwyer 1983; Sallis 1999; Dishman 2000). Shephard et al. (1997) found that a reduction of 240 minutes per week of academic class time, replaced with increased time for physical education, led to higher scores on standardized math examinations. A longitudinal analysis conducted by the U.S. Centers for Disease Control and Prevention (Carlson 2008) found that teacher-reported estimates of

the time students spent in physical education correlated with higher academic performance among girls but not among boys. In a review of physical activity and academic outcomes among school-aged children, the author concluded that "there is evidence to suggest that short term cognitive benefits of physical activity during the school day adequately compensate for time spent away from other academic areas" (Taras 2005, 218). Similarly, another recent review asserts that, at the very least, time spent in physical education does not hinder academic performance and may even lead to an improvement (Hillman 2008).

On the other hand, a recent middle-school intervention study found that adding physical education to school curricula did not improve grades or standardized test scores. Instead, it was vigorous exercise performed outside of school that positively predicted grades. Interestingly, the physical education classes under investigation included, on average, only nineteen minutes of adequately vigorous physical activity in a fifty-five minute class (Coe 2006). The authors suggested that achieving activity levels in physical education class high enough to meet recommended activity standards for children will positively affect academics, whereas lower levels, such as those reported in this study, provide little benefit.

Clearly, the *quality* of physical education is vitally important to cognitive and academic outcomes. Physical activity predicts higher academic performance, but physical education with insufficient levels of activity does not. This suggests that the evidence relating physical education to academic outcomes has been limited by the quality of the programs under investigation. Thus, it is likely that the potential academic benefit of daily, quality physical education has been underestimated. Animal and human research primarily supports the importance of *aerobic* activity to enhance cognitive function. Those physical-education classes that fail to encourage sufficient duration and intensity of aerobic activity are unlikely to make notable improvements in fitness, health, weight control, or academic achievement.

The New Physical Education

In recent years, budget restrictions and pressure to increase class time devoted to programs for improving standardized test scores has lead many schools to reduce or eliminate physical-education requirements. These reductions may have been made easier because traditional physical-education programs have not ef-

fectively improved the health and fitness of students, much less their academic performance. Traditional physical education notoriously emphasizes competitive sports rather than physical activity. Such programs marginalize students who are not athletes and fail to provide adequate opportunities for all students to exercise aerobically. Little wonder physical education has become dispensable.

We do not argue for a return to traditional physical education. However, we strongly advocate a program of physical education that emphasizes cognitively, socially, and aerobically demanding activity on a daily basis, one that focuses on personal progress and lifelong fitness activities by encouraging modes of physically strenuous play that are engaging, challenging, and enjoyable to students. This type of physical education can increase activity levels, improve physical fitness, help control weight, *and* enhance academic performance—and it should be an integral component of our educational systems. Such a program, whether implemented at the state or at the national level, could benefit the lives of millions of children, regardless of their economic circumstances or their social backgrounds.

For example, consider the Madison Junior High School in Naperville, Illinois. Physical-education director Phil Lawler has sparked a revolution in his school's approach to physical education (Viadero 2008). The program, described in *Spark: The Revolutionary New Science of Exercise and the Brain* (Ratey 2008), focuses on cognitively, socially, and aerobically demanding physical activity. It aims to provide the skills and to establish the behavioral patterns students need to lead physically active lives and achieve lifelong fitness. The program focuses on the individual, encouraging each student to progress towards his or her personal fitness goals. Students engage in a wide variety of activities, many them physically strenuous play. These include traditional games and more novel forms of play, such as climbing rock walls, dancing in *Dance Dance Revolution* systems, and riding video-game-like interactive stationary bikes. Students wear heart monitors all the while to make sure that they are exercising in their optimal aerobic zones. PE4life, a nonprofit organization dedicated to promoting quality physical education in U.S. schools, has adopted and is now exporting the Naperville model by setting up PE4life Academies in schools around the country. With the support of federal funds and forward-thinking school leaders, these schools are setting a new standard for physical education. So far, PE4life Academies have trained over one thousand educators and 350 schools to emulate their program.

Though mostly anecdotal, preliminary results from PE4life academy schools are very promising (PE4life 2007). The academies report higher measures of

physical fitness, reduced rates of obesity, lower incidents of disciplinary action, and improved academic achievement among students. The students of Naperville were found to be far fitter and healthier than national averages. Less than 3 percent of Naperville students were overweight versus 30 percent in California (CDE 2005). Eighty percent of Naperville students achieved the recommended level of aerobic capacity versus only 50 percent in California. Since PE4life began in Titusville, Pennsylvania, standardized test scores have gone from below the state average to 17 and 18 percent above average in reading and math, respectively. The incidents of fighting have dropped dramatically. After one year of daily physical education, students at Woodland Elementary School in Kansas City, Missouri, showed dramatically improved fitness measures, as well as a 67 percent drop in suspensions from the previous year, reduced academic probation, and improved literacy. Encouraged by preliminary results, researchers are pursuing further studies aimed at better assessing the impact of daily physical activity on fitness, health, obesity, academics, and behavior by comparing students who participate in a daily physical activity program to students who maintain typical activity levels.

Conclusion

Optimal physical-education programs engage students on a daily basis in cognitively, socially, and aerobically demanding physical activity and provide opportunities for physically strenuous play in order to inspire and instill lasting healthy behavioral patterns. We need more research in order to assess better the effects of such programs on the fitness, health, weight management, and academic performance of students. The PE4life case study, though anecdotal, provides a glimpse of some of the benefits. This is certainly not the only model for quality physical education. However, it does suggest the key elements of effective physical-education reform.

Providing quality physical education for every student in the United States will require the investment of political, social, and financial capital from lawmakers, educators, parents, and students. If we do not act, the obesity epidemic will continue, helping to fuel the looming health-care crisis and lowering the quality of educational achievement of our children. If we do act now, we can help decrease the incidents of obesity, alleviate some of the pressure on our health-care system, and improve our education system. Thus, quality physical

education is a goal worthy of our aspirations. There is abundant evidence that regular physical activity benefits the brains and bodies of school-aged children. Whether this evidence will lead to quality physical education in U.S. schools is more than an academic worry.

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